EA amendment – supporting information

Barbara Copper Project

Aeris Resources Limited May 2024

Aeris RESOURCES

SGMenvironmental

This page is intentionally blank.

EA amendment – supporting information

Barbara Copper Project

Prepared for Aeris Resources Limited | 30 May 2024

Project number:	23B044
Document title:	EA amendment – supporting information | Barbara Copper Project
Revision:	V1-1
Date:	30 May 2024
Client:	Aeris Resources Limited
Project manager:	T Rohde
Author:	J Carr

Legal Name:	SGM Environmental Pty Limited		
Address:	PO Box 5622, Stafford Heights, Qld 4053		
ACN:	621 989 866	ABN:	65 621 989 866
Representative:	T Rohde	Phone:	+61 7 3148 6288
Email:	trohde@sgmenvironmental.com		

Honest | Trust | Innovation | Safety

This Report is provided to you the abovenamed Client (Client, you or your) in respect of the above Project and in accordance with our Standard Terms. Capitalised terms that are not specifically defined in this Report have the meanings given to them in our Standard Terms.

© Copyright 2023 SGM Environmental Pty Limited. The concepts and information contained in this document are the property of SGM Environmental Pty Limited. Use or copying of this document in whole or in part without the written permission of SGM Environmental Pty Limited constitutes an infringement of copyright.

Data / confidentiality: This report contains information and data that is confidential and / or subject to restrictions in respect of Intellectual Property Rights (IP). Readers agree to be bound by confidentiality and IP provisions contained in our Standard Terms and the obligation not to cause any damage or hardship to SGM Environmental Pty Limited or the Client.

Document history and status

Revision	Date	Description	By	Review	Approved
V0-1	28/02/24	Draft	J Carr	D Borombovits	T Rohde
V1-0	28/03/24	Final	J Carr	G Brown	T Rohde
V1-1	30/05/24	Final	J Carr	L Purdy	T Rohde

Table of contents

1.0 Introduction 1
1.1 Purpose and scope 1
1.2 Pre-lodgement meeting outcomes 1
1.2.1 First pre-lodgement meeting 1
1.2.2 Second pre-lodgement meeting 2
2.0 Regulatory framework 3
2.1 Minor and major EA amendment triggers 3
2.2 EA amendment application requirements 4
3.0 EA amendments 7
3.1 Approved mining and ancillary activities 7
3.2 Proposed EA amendments 7
4.0 PRC plan schedule amendments 10
5.0 Scoping assessment 17
5.1 Risk assessment 17
5.1.1 Risk identification, analysis and evaluation 17
5.1.2 Risk treatment 18
5.2 Environmental scoping assessment 18
6.0 Impacts to air 21
6.1 Environmental values 21
6.1.1 Surrounding land 21
6.1.2 Site topography 24
6.1.3 Wind direction 24
6.1.4 Description of ambient air quality 26
6.2 Possible impacts and associated risks to identified environmental values 27
6.2.1 Overview of emissions and processes 27
6.2.2 Emissions 27
6.2.3 Evaluating impacts of emissions 28
6.2.4 Odour 28
6.2.5 Dust 28
6.2.6 Visibility reducing particles 29
6.2.7 Air dispersion modelling 29
6.3 Proposed management practices 29
6.3.1 Describe proposed control measures 29
6.3.2 Contingency plans 30
7.0 Impacts to noise 31
7.1 Environmental values of the site 31
7.1.1 Sensitive places 31
7.1.2 Site description 32

7.1.3 Background noise levels 33
7.2 Possible impacts to identified environmental values 33
7.2.1 Noise sources 33
7.2.2 Emission characteristics 35
7.2.3 Noise management hierarchy 36
7.2.4 Noise impact assessment 38
7.2.5 Noise impact assessment 39
7.2.6 Background creep 39
7.3 Proposed management practices 39
7.3.1 Noise mitigation strategies 39
8.0 Impacts to water 40
8.1 Identifying environmental values of receiving waters 40
8.1.1 Site plan 40
8.1.2 Surface water 40
8.1.3 Groundwater 40
8.2 Possible impacts to identified environmental values 54
8.2.1 Discharges and releases 54
8.2.2 Unplanned and uncontrolled releases 54
8.2.3 Water infrastructure 54
8.2.4 Groundwater 55
8.2.5 Terrestrial GDEs 55
8.2.6 Wetlands 55
8.2.7 Great Barrier Reef catchment waters 55
8.2.8 Ecology and hydrology of receiving water 56
8.2.9 Risk assessment 56
8.2.10 Hazards 56
8.2.11 Mixing zones 56
8.2.12 Discharges to groundwater 56
8.2.13 Groundwater impact assessment 56
8.2.14 Strategic environmental areas 56
8.3 Proposed management practices 56
8.3.1 Management hierarchy 57
8.3.2 Unavoidable discharges 57
8.3.3 Proposed limits 57
8.3.4 Stormwater management 57
8.3.5 Extraction near a watercourse 57
8.4 Management plans 57
8.4.1 Monitoring program 57
8.4.2 Groundwater monitoring program 58
8.4.3 Stormwater management 58

8.4.4 Water management plan 58
8.5 Rehabilitation of the site 58
8.5.1 Rehabilitation 58
9.0 Impacts from waste 59
9.1 Possible impacts and associated risks to identified environmental values 59
9.1.1 Site plan 59
9.1.2 Types of waste 59
9.1.3 Suitability of data for modelling, and validation sampling 60
9.1.4 Waste treatment processes 60
9.2 Waste and resource management hierarchy 60
9.2.1 Disposal of waste rock 60
9.2.2 Cleaner production or waste management strategies 63
9.2.3 Reuse 63
9.3 Waste transport 63
9.3.1 Appropriate machinery — vehicles, tanks and containers 63
9.3.2 Waste transport 63
9.4 Proposed management practices 63
9.4.1 Facilities and procedures 63
10.0 Impacts from subsidence 64
11.0 Conclusions 65
References 66
Appendix A Risk Assessment 68
Appendix B Environmentally Sensitive Areas — Mining Activities 74
Appendix C Air Quality Impact Assessment 76
Appendix D NPI Report 78
Appendix E Terrestrial Flora and Fauna Assessment 80
Appendix F Memorandum: Supporting Technical Information for Potential Impacts from Change in Blasting Practices 82
Appendix G Groundwater Technical Report 84
Appendix H Water Balance Model 86
Appendix I South Pit CCA 88
Appendix J Memorandum: Groundwater Impact Assessment — Sensitivity / Uncertainty Analysis and Long-term Water Quality 90
Appendix K Memorandum: Barbara Total Carbon Assays 92
Appendix L Geotechnical Assessment 94

Figure

Figure 1 *Schedule J — Map 1 Location of authorised disturbance* (updated map) 9
Figure 2 Risk management process (ISO 2018) 17
Figure 3 Scaled map 22

Figure 4 Sensitive receptors — MSES 23
Figure 5 Site topography 25
Figure 6 Mean monthly rainfall and temperature 32
Figure 7 Scaled map 34
Figure 8 Site plan (with bore locations) 41
Figure 9 Piper diagram — results since going into care and maintenance 47
Figure 10 Piper diagram — results from most recent sampling event 48
Figure 11 Terrestrial GDE within 5 km of the site 53
Figure 12 Existing WRD — source location for waste rock deficit (blue polygon) 61
Figure 13 Site plan 62

Table

Table 1 Minor amendment triggers and preliminary outcomes 3
Table 2 Requirements for amendment applications for an EA 4
Table 3 *Table A1 – Authorised disturbance (EA EPML02840015)* 7
Table 4 *Table D2 — Blasting noise limits (EA EPML02840015)* 8
Table 5 *Rehabilitation area milestones* 11
Table 6 *(RA1) Rehabilitation area 1* 12
Table 7 *(RA2) Rehabilitation area 2* 13
Table 8 *(RA3) Rehabilitation area 3* 14
Table 9 *(RA4) Rehabilitation area 4* 15
Table 10 Project timeline 16
Table 11 Potential impacts and scope of environmental assessment 18
Table 12 Ambient air quality at the Gap air monitoring network station 26
Table 13 Metal concentrations at the Gap air monitoring network station 26
Table 14 Dust deposition monitoring results 26
Table 15 Dust deposition gauge monitoring locations 29
Table 16 Sound power levels for operational equipment 35
Table 17 *Table D1 — Noise limits (EA EPML02840015)* 37
Table 18 Blasting limits for underground mining 38
Table 19 Background quality of surface water 42
Table 20 Registered groundwater bores within 10 km of ML 90241 44
Table 21 Groundwater classification by water type 48
Table 22 Baseline quality of groundwater 50
Table 23 Total carbon and sulfur percentages 59
Table 24 Risk matrix 69
Table 25 Likelihood ratings and descriptions 69
Table 26 Consequence categories and definitions 70
Table 27 Risk assessment and risk treatment plan 71

Important note about your report

This Report is provided for the exclusive use of the Client pursuant to the Scope of Works dated 13 September 2023, which requires us to provide Services relating to an Environmental Authority (EA) amendment application.

This Report is provided to the Client on the terms and conditions set out in the Standard Terms of SGM Environmental Pty Limited (SGME, we, us or our).

We derive data in this Report from information (or confirmation of the absence thereof) sourced from the Client, designated laboratories and / or information that has been made available in the public domain at the time or times outlined in this Report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the EA amendment application and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this Report.

SGME has prepared this Report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to any applicable standards, guidelines, procedures and practices outlined in the Scope of Works as at the date of issue of this Report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this Report, to the extent permitted by law.

This Report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by SGME for use of any part of this Report in any other context.

Reporting of the EA amendment application is based on a desktop assessment of data that has been measured by the Client and other third parties.

SGME does not accept any Liability whatsoever for, or in respect of, any use of, or reliance upon this Report by any person contrary to the above or our Standard Terms.

1.0 Introduction

Barbara copper project (the project) is a former opencut copper and gold mine, which operated from 2019 to 2021. It has subsequently been in care and maintenance. Aeris Resources Limited (Aeris Resources, the proponent) plans to extract a significant copper-gold resource which remains under the South Pit, through underground (UG) mining. Round Oak Minerals Pty Limited (Round Oak), wholly owned by Aeris Resources is the Environmental Authority (EA) holder.

SGM Environmental Pty Limited (SGME) has been engaged by the proponent to complete the technical information requirements for an EA amendment application. Changing the operations to UG mining requires amendment of the EA as detailed in Section 3.2.

1.1 Purpose and scope

The purpose of this report is to identify environmental risks associated with the EA amendment, and their planned controls. To achieve this, the following scope of works has been undertaken:

- a scoping assessment to determine which environmental areas require supporting information;
- a desktop review to determine:
  - environmental values (EVs) of the receiving environment;
  - potential impacts on EVs; and
  - mitigation strategies to limit potential impacts.

This report includes the following sections:

- Section 1.0 — introduction;
- Section 2.0 — regulatory framework;
- Section 3.0 — EA amendments;
- Section 4.0 — PRC plan schedule amendments;
- Section 5.0 — scoping assessment;
- Section 6.0 — impacts to air;
- Section 7.0 — impacts to noise;
- Section 8.0 — impacts to water;
- Section 9.0 — impacts from waste;
- Section 10.0 — impacts from subsidence; and
- Section 11.0 — conclusions.

1.2 Pre-lodgement meeting outcomes

1.2.1 First pre-lodgement meeting

A pre-lodgement meeting was held with the Department of Environment and Science (DES) on 10 November 2023. The purpose of this meeting was to identify the supporting information required by DES and the likelihood that it would be considered a minor EA amendment.

Several critical matters (high risk / concerning areas) were identified during this meeting, including:

- groundwater:
  - extensive groundwater studies and modelling should be done to demonstrate how groundwater may be impacted by the project and to determine where groundwater interacts with surface water on and surrounding the site;

  - depending on where groundwater interacts with surface water, it may be necessary to examine the impact of the project on terrestrial / aquatic ecology and cultural heritage; and
  - an assessment of the impacts on groundwater caused by disposing potentially acid forming (PAF) material (used as backfill) and water together (underground);
- surface water:
  - an assessment to determine where groundwater interacts with surface water on and surrounding the site and how this may be influenced by the project;
- water balance:
  - water balance models should be provided with the application;
- EA conditions:
  - EA conditions to be amended should be clearly defined, along with a description of what amendments to these conditions are required;
  - sufficient information should be supplied to demonstrate compliance with existing limits imposed by the EA, in cases where no EA amendments have been proposed, regardless of the change to operations;
- PRC plan / EA intersect:
  - confirm if a joint EA / PRC plan is required.

1.2.2 Second pre-lodgement meeting

A second pre-lodgement meeting was held with the Department of Environment, Science and Innovation (DESI) on 13 March 2024. The purpose of this meeting was to confirm that supporting information provided is sufficient for the final application, and to reaffirm that it is likely to be considered a minor EA amendment.

Several critical matters (high risk / concerning areas) were identified during this meeting, including:

- EA conditions:
  - confirm whether existing conditions are applicable;
- PRC plan / EA intersect:
  - if the PRC schedule is amended, it must be accompanied by an amended rehabilitation planning part for the holder's PRC plan.

2.0 Regulatory framework

The project operates under EA EPML02840015 and mining lease (ML) 90241. An EA amendment is required to permit UG mining. This section assesses the planned amendments against the minor and major EA amendment triggers to determine a preliminary EA amendment process, and examines the EA amendment application requirements and determines if they can be met.

2.1 Minor and major EA amendment triggers

The planned amendments have been assessed against minor and major EA amendment triggers (Table 1), which are provided in *Guideline Environmental Protection Act 1994 Major and minor amendments* (DES 2023). As indicated in Table 1, the planned amendments meet the requirements for a minor EA amendment.

Table 1 Minor amendment triggers and preliminary outcomes

Minor amendment (threshold)	Outcome
a) is not a change to a condition identified in the authority as a standard condition, other than— *i. a change that is a condition conversion; or* *ii. a change that is not a condition conversion but that replaces a standard condition of the EA with a standard condition for the ERA to which the EA relates; or* *iii. a change that will not result in a change to the impact of the relevant activity on an environmental value; and*	Yes. It is not a change to the conditions. Supporting information confirms that the current EA conditions can be met.
b) does not significantly increase the level of environmental harm caused by the relevant activity; and	Yes. The EA amendment does not significantly increase the level of environmental harm caused by the relevant activity, as confirmed by supporting information.
c) does not change rehabilitation objectives in the EA in a way likely to result in significantly different impacts on environmental values than the impacts previously permitted under the EA; and	Yes. The EA amendment will not change rehabilitation objectives in a way likely to result in significantly different impacts on EVs.
d) does not significantly increase the scale or intensity of the relevant activity; and	Yes. The EA amendment will not significantly increase the scale or intensity of the relevant activity.

Minor amendment (threshold)	Outcome
e) does not relate to a new relevant resource tenure for the EA that is— *i. a new mining lease; or* *ii. a new petroleum lease; or* *iii. a new geothermal lease under the Geothermal Energy Act 2010; or* *iv. a new greenhouse gas injection and storage lease under the Greenhouse Gas Storage Act 2009; and*	Yes.
f) involves an addition to the surface area for the relevant activity of no more than 10% of the existing area; and	Yes. No increase in disturbance area is intended.
g) for an EA for a petroleum activity: *i. involves constructing a new pipeline that does not exceed 150km in length; or* *ii. involves extending an existing pipeline by no more than 10% of the existing length of the pipeline; and*	Not applicable. This is not an EA for a petroleum activity.
h) if the amendment relates to a new relevant resource tenure for the EA that is an exploration permit or greenhouse gas permit – the amendment application seeks an EA that is subject to the standard conditions for the relevant activity, to the extent it relates to the permit.	Not applicable.

2.2 EA amendment application requirements

Planned amendments have been assessed against the EA amendment application requirements specified in Section 226A of the EP Act (Table 2). The EA amendment application requirements and a reference to where they have been addressed in this report is in Table 2.

Table 2 Requirements for amendment applications for an EA

Requirements for amendment applications for EA	Report reference
1. If the amendment application is for the amendment of an environmental authority, the application must also—	
a) describe any development permits in effect under the Planning Act for carrying out the relevant activity for the authority; and	Not applicable. No development permits are in place under the *Regional Planning Interests Act 2014* (RPI Act).

Requirements for amendment applications for EA		Report reference
b)	*state whether each relevant activity will, if the amendment is made, comply with the eligibility criteria for the activity; and*	Not applicable. The project operates under a site-specific EA as the eligibility criteria for standard conditions was not met.
c)	*if the application states that each relevant activity will, if the amendment is made, comply with the eligibility criteria for the activity—include a declaration that the statement is correct; and*	Not applicable. The project operates under a site-specific EA as the eligibility criteria for standard conditions was not met.
d)	*state whether the application seeks to change a condition identified in the authority as a standard condition; and*	Not applicable. The application does not seek to change a standard condition.
e)	*if the application relates to a new relevant resource tenure for the authority that is an exploration permit or GHG permit—state whether the applicant seeks an amended environmental authority that is subject to the standard conditions for the relevant activity or authority, to the extent it relates to the permit; and*	Not applicable.
f)	*include an assessment of the likely impact of the proposed amendment on the environmental values, including—*	
i.	*a description of the environmental values likely to be affected by the proposed amendment; and*	Sections 6.0-10.0.
ii.	*details of emissions or releases likely to be generated by the proposed amendment; and*	Sections 6.0-10.0.
iii.	*a description of the risk and likely magnitude of impacts on the environmental values; and*	Sections 6.0-10.0.
iv.	*details of the management practices proposed to be implemented to prevent or minimise adverse impacts; and*	Sections 6.0-10.0.
v.	*if a PRC plan schedule does not apply for each relevant activity—details of how the land the subject of the application will be rehabilitated after each relevant activity ends; and*	Not applicable. A Progressive Rehabilitation and Closure (PRC) Plan schedule applies for each relevant activity.
g)	*include a description of the proposed measures for minimising and managing waste generated by amendments to the relevant activity; and*	Section 9.0.

Requirements for amendment applications for EA	Report reference
h) include details of any site management plan or environmental protection order that relates to the land the subject of the application.	Not applicable. No site management plan or environmental protection order is in place.

3.0 EA amendments

This section gives a brief overview of the approved mining activities and describes the planned amendments.

3.1 Approved mining and ancillary activities

The following environmentally relevant activities (ERAs) have been approved under EA EPML028400015:

- Schedule 3 17: mining copper ore;
- Schedule 3 18: mining lead, silver or zinc separately or in any combination;
- Ancillary 08 — chemical Storage 3: Storing more than 500 cubic metres of chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous goods class 3 under subsection (1)(c);
- Ancillary 15 — fuel burning using fuel burning equipment that is capable of burning at least 500 kg of fuel in an hour;
- Schedule 3 16: mining gold ore;
- Schedule 3 19: mining metal ore, other than a metal or mentioned in items 11, 12, 14, 15, 16, 17 or 18;
- Schedule 3 14: mining iron ore;
- Ancillary 63 — sewage treatment 1: operating sewage treatment works, other than no-release works, with a total daily peak design capacity of (a-i) 21 to 100EP if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme; and
- Ancillary 30 — crushing, milling, grinding or screening more than 5000 t of material in a year.

3.2 Proposed EA amendments

Table A1 - Authorised disturbance (Table 3) and *Schedule J — Map 1 Location of authorised disturbance* (Figure 1) must be amended to include the entrance portal to the underground mine and surface vent fan located within the South Pit. There will be no change to the area of disturbance in Table A1. *Table D2 — Blasting noise limits* (Table 4) must also be amended to the **standard blasting conditions for UG** mining to allow blasting at shift change slightly outside of the current times (day). This amendment has been proposed to ensure that the mine operates as efficiently and safely as possible (ie most mines blast at shift changes to ensure that personnel are outside of the blast area).

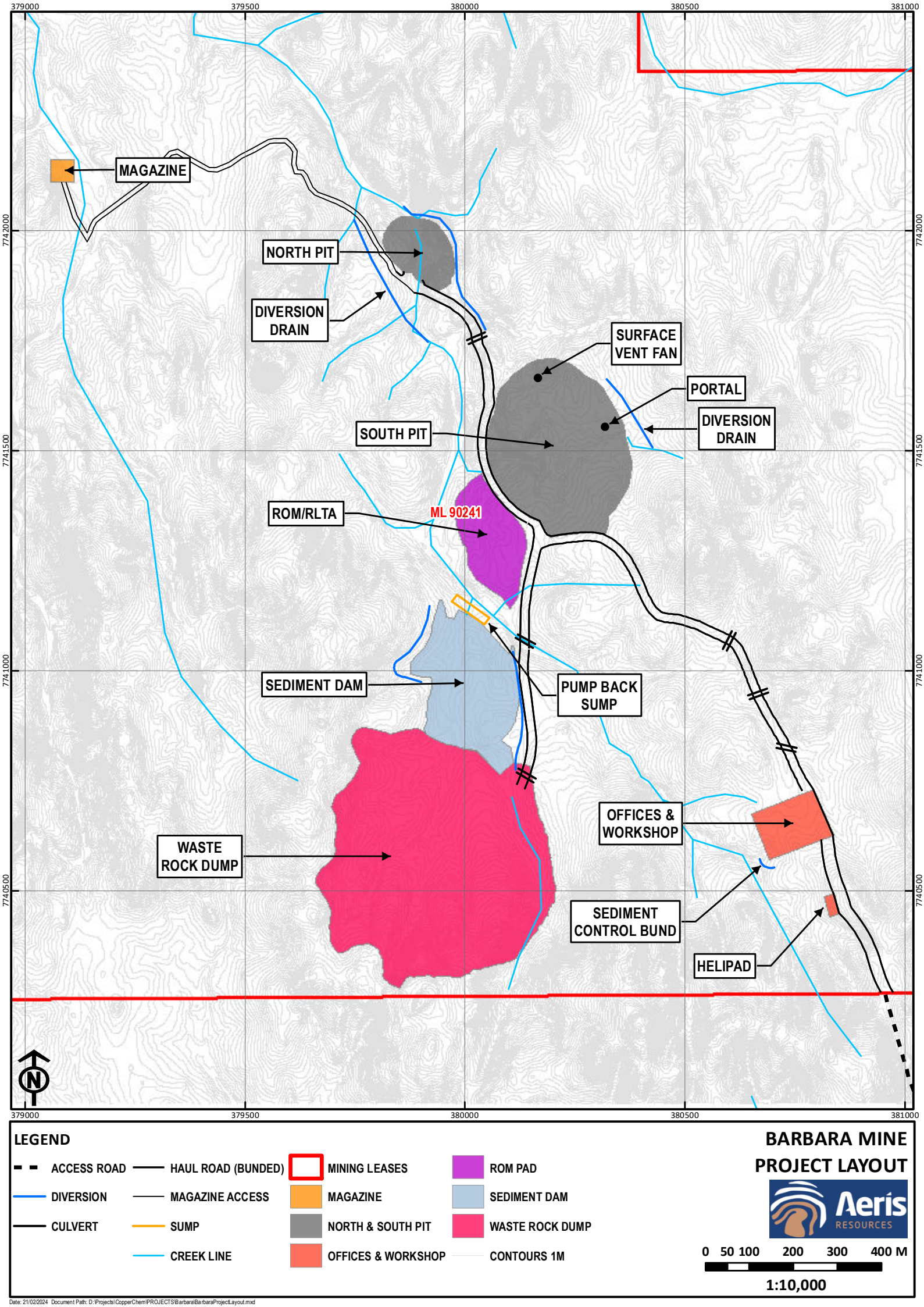
Table 3 ***Table A1 – Authorised disturbance (EA EPML02840015)***

Name of disturbance area	Maximum area of disturbance (hectares (ha))	Mining Lease	Purpose
Run-of-mine (ROM) pad	3.0	ML90241	Temporary storage, crushing and handling of ore.
North Pit	3.3	ML90241	Mining of ore and site water management. Note: The North pit is a regulated dam with minimum hydraulic performance criteria detailed in *Table H1* of this environmental authority.

Name of disturbance area	Maximum area of disturbance (hectares (ha))	Mining Lease	Purpose
South Pit	10.2	ML90241	Mining of ore and site water management. *Entrance portal to underground mine and location of the surface vent fan.* Note: The South pit is a regulated dam with minimum hydraulic performance criteria detailed in *Table H1* of this environmental authority.
Abandonment bund	1.7	ML90241	
Waste rock dump (WRD)	23.4	ML90241	Storage and disposal of waste rock.
WRD dam	6.0	ML90241	Water management for stormwater runoff from the WRD area.
Diversion drain	1.4	ML90241	Water management to prevent stormwater runoff entering mine workings.
Access Road, Haul Road and tracks	11.0	ML90241	Site access.
Light Infrastructure Area: including Administration buildings, Fuel storage, Power facility, sewage treatment, and Workshop area.	2.7	ML90241	Site administration, Fuel storage and power generation, Maintenance and storage.

Table 4 *Table D2 — Blasting noise limits (EA EPML02840015)*

Blasting noise limits	Sensitive or commercial blasting noise limits place limits	
	7am to 6pm	6pm to 7am
Airblast overpressure	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB (Linear) Peak at any time	*115 dB (Linear) Peak*
Ground vibration peak particle velocity	5mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time	*2 mm/second peak*


379000
379500
380000
380500
381000
7742000
7741500
7741000
7740500
MAGAZINE
NORTH PIT
DIVERSION DRAIN
SURFACE VENT FAN
PORTAL
DIVERSION DRAIN
SOUTH PIT
ROM/RLTA
ML 90241
SEDIMENT DAM
PUMP BACK SUMP
OFFICES & WORKSHOP
WASTE ROCK DUMP
SEDIMENT CONTROL BUND
HELIPAD
N
LEGEND
ACCESS ROAD
HAUL ROAD (BUNDED)
MINING LEASES
ROM PAD
DIVERSION
MAGAZINE ACCESS
MAGAZINE
SEDIMENT DAM
CULVERT
SUMP
NORTH & SOUTH PIT
WASTE ROCK DUMP
CREEK LINE
OFFICES & WORKSHOP
CONTOURS 1M
BARBARA MINE
PROJECT LAYOUT
Aeris RESOURCES
0 50 100 200 300 400 M
1:10,000
Date: 21/02/2024 Document Path: D:\Projects\CopperChem\PROJECTS\Barbara\BarbaraProjectLayout.mxd

4.0 PRC plan schedule amendments

Milestone criteria must be added to rehabilitation milestone (RM) 1 to include rehabilitation of the portal and vent fan (Table 5). Rehabilitation area (RA) 1 (Table 6) must be amended to include the portal. This is required as the portal and vent fan shall be within South Pit. Note that the total rehabilitation area and PMLU do not change. Timings must be amended for RAs as they will not become available for rehabilitation until the end of UG mining which is expected to last for approximately (~) 4 years. Table 10 provides justifications for updated timings.

The following timings must be amended for RA1:

- commencement of first milestone date;
- date area is available for RMs 1, 3, 4, 7 and 11; and
- milestone completion dates for RMs 1, 3, 4 and 7.

The following timings must be amended for RA2:

- commencement of first milestone date;
- date area is available for RMs 1, 3, 4, 5, 8, 12 and 14; and
- milestone completion dates for RMs 1, 3, 4, 5, 8 and 14.

The following timings must be amended for RA3:

- commencement of first milestone date;
- date area is available for RMs 1, 2, 3, 4, 6, 9 and 13; and
- milestone completion dates for RMs 1, 2, 3, 4, 6 and 9.

The following timings must be amended for RA4:

- commencement of first milestone date;
- date area is available for RMs 1, 3, 6 and 10; and
- milestone completion dates for RMs 1, 3 and 6.

Proposed timings are in Table 6 for RA1, Table 7 for RA2, Table 8 for RA3 and Table 9 for RA4. Timings must be amended to reflect the current mine schedule and to reduce risks arising from mining delays to ensure that PMLUs can be achieved by their completion dates. This has been updated in the submitted PRC Plan schedule.

Table 5 *Rehabilitation area milestones*

Milestone reference	Rehabilitation milestone	Milestone criteria
RM1	Infrastructure Decommissioning	1. All services disconnected to redundant infrastructure. 2. All road materials (bitumen, concrete, gravel) removed (ripped and revegetated) where not to be retained. 3. All pipelines drained and removed unless otherwise agreed with landowner. 4. All fencing that is not part of the PMLU removed. 5. All buildings are demolished and removed. 6. Any remaining infrastructure to be removed unless agreed to be retained by the landholder. 7. All machinery and equipment removed. 8. All surface water drainage infrastructure including foundations not required in the PMLU has been removed (Where drains or bunding are not required for flood and/or erosion protection they will be levelled or used as fill). 9. All diversions and levees not to be retained are removed. 10. All waste material, explosives, hazardous chemicals and dangerous goods to be handled, removed, and disposed of in accordance with environmental authority (EA) EPML02840015. 11. Areas which contained ancillary infrastructure cannot contaminate receiving waters or surface waters or cause offsite environmental impacts. 12. *The portal is backfilled (minimum 50 m down the decline) with benign waste rock and a shotcrete bulkhead is placed in front of the backfill. An inert bund will be installed just outside the portal entrance and a metal grate gate fitted at the portal.* 13. *The surface vent fan is decommissioned and sealed.*

Table 6 ***(RA1) Rehabilitation area 1***

Post-mining land uses (PMLU)				
Rehabilitation area				RA1
Relevant activities				North Pit, South Pit ***(Portal & Vent)***, WRD Sediment Dam
Total rehabilitation area size (ha)				19.5
Commencement of first milestone: RM1				***10/12/2028***
PMLU				Water Storage for Stock Water
Date area is available	***10/12/2028***	***10/12/2030***		
Cumulative area available (ha)	19.5	19.5		
Milestone completed by	***10/12/2030***	10/12/2033		
Milestone reference			Cumulative area achieved (ha)	
RM1	19.5			
RM3	19.5			
RM4	19.5			
RM7	19.5			
RM11		19.5		

Table 7 ***(RA2) Rehabilitation area 2***

Post-mining land uses (PMLUs)

Rehabilitation area					RA2
Relevant activities					Waste Rock Dump (WRD)
Total rehabilitation area size (ha)					23.4
Commencement of first milestone: RM1					***10/12/2027***
PMLU					Water Storage for Stock Water
Date area is available	***10/12/2027***	***10/12/2030***	***10/12/2035***		
Cumulative area available (ha)	23.4	23.4	23.4		
Milestone completed by	***10/12/2030***	***10/12/2035***	10/12/2038		
Milestone reference				Cumulative area achieved (ha)	
RM1	23.4				
RM14	23.4				
RM3	23.4				
RM4	23.4				
RM5	23.4				
RM8		23.4			
RM12			23.4		

Table 8 *(RA3) Rehabilitation area 3*

Post-mining land uses (PMLUs)				
Rehabilitation area				RA3
Relevant activities				Ancillary Infrastructure, ROM Pad, Roads, Exploration, Abandonment Bund
Total rehabilitation area size (ha)				18.4
Commencement of first milestone: RM1				*10/12/2028*
PMLU				Low Intensity Grazing
Date area is available	*10/12/2028*	*10/12/2030*	*10/12/2035*	
Cumulative area available (ha)	18.4	18.4	18.4	
Milestone completed by	*10/12/2030*	*10/12/2035*	10/12/2038	
Milestone reference	Cumulative area achieved (ha)			
RM1	18.4			
RM2	18.4			
RM3	18.4			
RM4	18.4			
RM6	18.4			
RM9		18.4		
RM13			18.4	

Table 9 ***(RA4) Rehabilitation area 4***

Post-mining land uses (PMLUs)			
Rehabilitation area			RA4
Relevant activities			Water infrastructure (retain North Pit Creek Diversion and Levee, Diversion Northeast of North Pit, Diversion east of WRD Sediment Dam. Decommission all other diversions)
Total rehabilitation area size (ha)			1.4
Commencement of first milestone: RM1			***10/12/2028***
PMLU			Water Management Infrastructure
Date area is available	***10/12/2028***	***10/12/2030***	
Cumulative area available (ha)	1.4	1.4	
Milestone completed by	***10/12/2030***	10/12/2033	
Milestone reference			Cumulative area achieved (ha)
RM1	1.4		
RM3	1.4		
RM6	1.4		
RM10		1.4	

Table 10 Project timeline

Project stage	Activities	Years														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Operating	Underground mining[1]															
Closure and rehabilitation	RMs 1, 14, 3, 4 and 5[2]															
	RMs 1, 2, 3, 4, 5, 6 and 7[3]															
	RMs 10 and 11															
	RMs 8 and 9															
	RMs 12 and 13															

1. Underground mining will commence at the end of 2024 and run for ~4 years.
2. RMs 1, 14, 3, 4 and 5 for RA2 will commence on 10/12/2027 when the area becomes available.
3. RMs 1, 2, 3, 4, 5, 6 and 7 for RA1, RA3 and RA4 will commence on 10/12/2018 when the area becomes available.

Sufficient time has been provided to achieve the milestone criteria for each RM, and to achieve the nominated PMLUs following underground mining. The timestep in Table 10 visually shows when rehabilitation will occur over a 12-year period.

5.0 Scoping assessment

This section describes the risk assessment process used to assess potential impacts from the EA amendment. It includes the scope of works undertaken to ensure potential impacts were appropriately assessed. Key factors discussed during the pre-lodgement meeting held on 10 November 2023 were used as a guide, including the likely EA amendment approval process and EA amendment application technical information requirements. Section 1.2 summarises the pre-lodgement meeting outcomes.

5.1 Risk assessment

This risk assessment focuses on risks directly resulting from the EA amendment.

5.1.1 Risk identification, analysis and evaluation

International Organisation for Standardisation (ISO) 31000:2018 Risk Management — Guidelines describe risk management as the overall process of risk identification, risk analysis, risk evaluation and risk treatment (Figure 2).

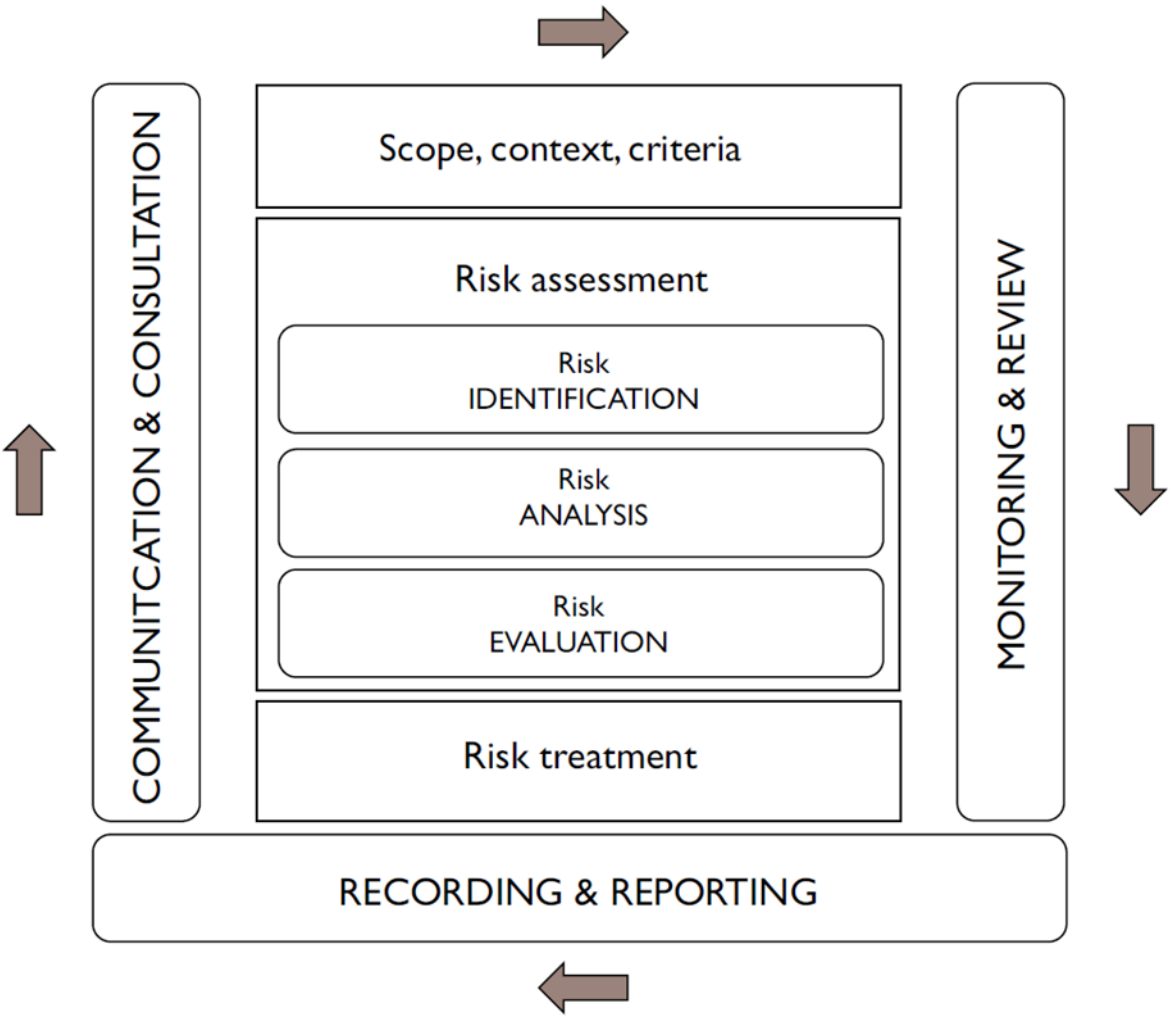


Figure 2 Risk management process (ISO 2018)

The following risk events were identified through the ISO risk management process:

- groundwater contamination;
- unstable void / underground workings;
- increased permeability of geological units surrounding the mined area;
- additional sources of noise pollution; and
- additional sources of air pollution.

5.1.2 Risk treatment

Results of the risk assessment and risk treatment plan are in Appendix A. The risk treatment plan summarises treatment options, why treatment options were selected, who is responsible for approving and implementing the plan, resource requirements, performance measures and constraints, reporting and monitoring requirements, and timing and scheduling.

5.2 Environmental scoping assessment

The following information sources were considered to determine the scope of this environmental assessment:

- key factors discussed during the pre-lodgement meeting with DES (Section 1.2); and
- results from the risk assessment (Appendix A).

Results of the environmental scoping assessment are in Table 11.

Table 11 Potential impacts and scope of environmental assessment

Potential impacts	Scope of environmental assessment
Groundwater Commencement of UG mining may result in additional groundwater contamination risk. It may also increase the permeability of geological units surrounding the mined area, which can result in groundwater drawdown and subsequently impact groundwater dependent ecosystems (GDEs).	A technical assessment of groundwater, which complies with guideline: application requirements for activities with impacts to water (ESR/2015/1837) (PDF, 528KB)
Surface water and mine water management Commencement of UG mining will change water usage rates and mine water management, which could result in additional surface water contamination risk. The current EA requires both a water management plan and an erosion and sediment control (ESC) plan. It also has conditions for the release of contaminants to receiving water. The technical assessment of groundwater will determine if water courses traversing the mine site interact directly with groundwater. A geotechnical assessment will determine if potential surface subsidence effects, including changes to drainage may impact on surface water.	A technical assessment of surface water and mine water management, which complies with guideline: application requirements for activities with impacts to water (ESR/2015/1837) (PDF, 528KB) A geotechnical assessment, which assesses the risk from subsidence.

Potential impacts	Scope of environmental assessment
Subsidence Backfilling waste rock underground and then mixing it with water may cause subsidence. This may result in unstable void or unstable underground workings.	A geotechnical assessment, which assesses the risk from subsidence.
Terrestrial ecology Commencement of UG mining will not result in an increased disturbance area. UG mining will be done within the current disturbance area, with no additional vegetation clearance proposed. Assuming that there are no GDEs (none were identified in preliminary mapping), which will be assessed through the technical assessment of groundwater, an assessment of terrestrial ecology is not warranted.	UG mining will not result in significant additional impacts on terrestrial ecology, assuming that there are no GDEs within or surrounding the mine site. Therefore, assessment of terrestrial ecology is not warranted. This is dependent on the technical assessment of groundwater.
Aquatic ecology Assuming that there are no direct interactions between groundwater and surface water, such as surface expression to streams, there is unlikely to be a significant additional impact on aquatic ecology. Preliminary mapping shows that there are no GDEs within the mine site or surrounding area. As previously mentioned, both a water management plan and ESC plan will be in place and there are conditions for the release of contaminants to receiving waters.	UG mining will not result in significant additional impacts on aquatic ecology, assuming that there are no direct interactions between groundwater and surface water. Therefore, assessment of aquatic ecology is not warranted. This is dependent on the technical assessment of groundwater.
Rehabilitation, soils and land suitability There is unlikely to be any significant additional impact on rehabilitation, soils and land suitability. The current EA stipulates that all significantly disturbed land, caused by mining activities, must meet the following rehabilitation objectives: a. safe for humans and wildlife; b. non-polluting; c. stable; d. able to sustain a post-mining land-use (PMLU); e. revegetated with species endemic to the area with no declared pest species; and f. compliant with all conditions in the EA. It also stipulates that a post mine land-use plan (PMLUP) describing how the above rehabilitation objectives will be achieved, must be prepared and documented within two years from commencement of mining.	UG mining will still comply with the EA conditions on land and rehabilitation, and will not result in significant additional impacts on rehabilitation, soils and land suitability. Therefore, an assessment of rehabilitation impacts is not warranted.

Potential impacts	Scope of environmental assessment
Amenity impacts (noise, air quality and visual amenity) West Leichhardt station homestead and camp is the closest sensitive receptor, located ~23 kilometres (km) away. UG mining will not result in significant change in noise, or dust emissions, or significant change to noise and dust impacts at sensitive receptors. The current EA requires the development of an air quality program prior to commencing mining activity. Air quality objectives that must also be complied with. The current EA requires a noise monitoring program and that noise generated from mining activities, including blasting, do not exceed set criteria at sensitive or commercial places. Visual amenity is unlikely to be impacted due to the distance to sensitive receptors and because new infrastructure is not required.	A technical assessment on impacts to noise, which complies with guideline: application requirements for activities with noise impacts (ESR/2015/1838) (PDF, 399KB) A technical assessment on impacts to air, which complies with guideline: application requirements for activities with impacts to air (ESR/2015/1840) (PDF, 528KB)
Cultural heritage No additional disturbance is intended. Therefore, there is unlikely to be a significant additional impact on cultural heritage.	Further assessment of cultural heritage is not warranted.
Waste management Consistent with EA condition C1, all waste generated from mining activities, excluding treated sewage effluent and waste rock, is disposed of at an off-site facility. This includes: • putrescible waste; and • waste oil / hydrocarbons. A sewage bio-treatment (anaerobic digestion) subsurface irrigation system exists and will be used for treatment of sewage, consistent with EA condition C1. The management of waste rock has changed. Therefore, its potential impacts must be assessed.	A technical assessment of waste management, which complies with guideline: application requirements for activities with waste impacts – (ESR/2015/1836) (PDF, 167KB)

6.0 Impacts to air

Consistent with Schedule 8, Part 3, Division 1 of the *Environmental Protection Regulation 2019* (EP Regulation), this section describes how the following environmental objective, along with its performance outcomes will be achieved:

Environmental objective
The activity will be operated in a way that protects the environmental values of air.

6.1 Environmental values

This section identifies EVs of the receiving environment (air), including the identification of nearby sensitive receptors.

6.1.1 Surrounding land

Surrounding land was examined to identify the primary land use and distance to nearby sensitive receptors.

According to the Australian Land Use and Management (ALUM) Classification System, grazing native vegetation is the primary land use surrounding the project (Queensland Government 2024). West Leichhardt Station homestead and camp is located ~23 km away. It has previously been, and continues to be, the nearest sensitive receptor (Figure 3). It has been included in this supporting information document to confirm that there are no significant additional impacts to this sensitive receptor from changing operations to UG mining.

Matters of state environmental significance (MSES) mapped within or near the ML are identified in Section 6.1.1.1 (Figure 4). No environmentally sensitive areas (ESAs) were mapped within the ML. However, there are endangered regrowth and remnant regional ecosystem ESAs nearby (Appendix B).

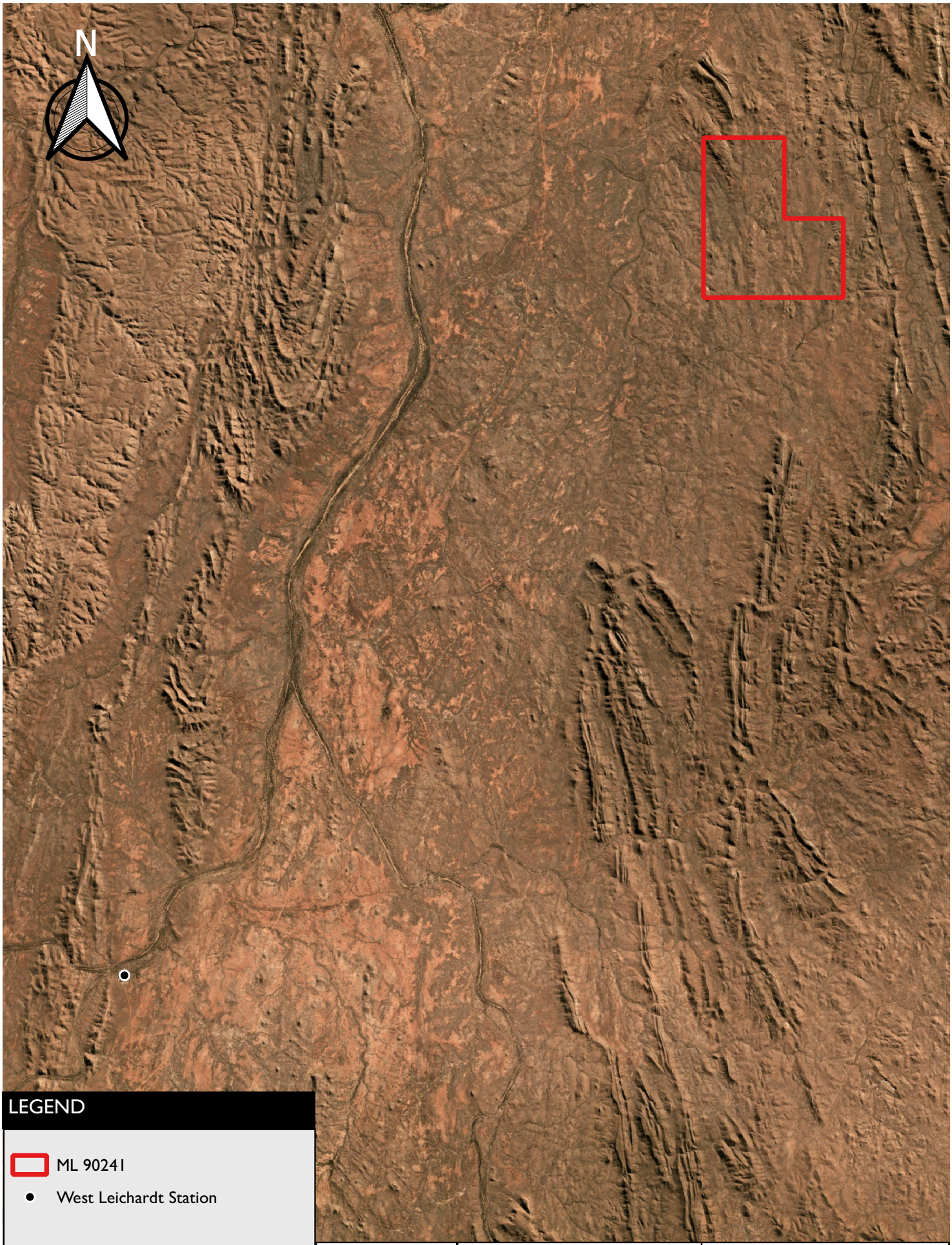
6.1.1.1 MSES

The following MSES were mapped within the ML:

- wildlife habitat (endangered or vulnerable);
- wildlife habitat (special least concern animal);
- regulation vegetation (essential habitat); and
- regulated vegetation (defined watercourse).

The following MSES were mapped within 10 km of the ML:

- wildlife habitat (endangered or vulnerable);
- wildlife habitat (special least concern animal);
- regulated vegetation (essential habitat);
- regulated vegetation (defined watercourse);
- regulated vegetation (100 m from wetland); and
- regulated vegetation (category B — endangered or of concern).



LEGEND

ML 90241

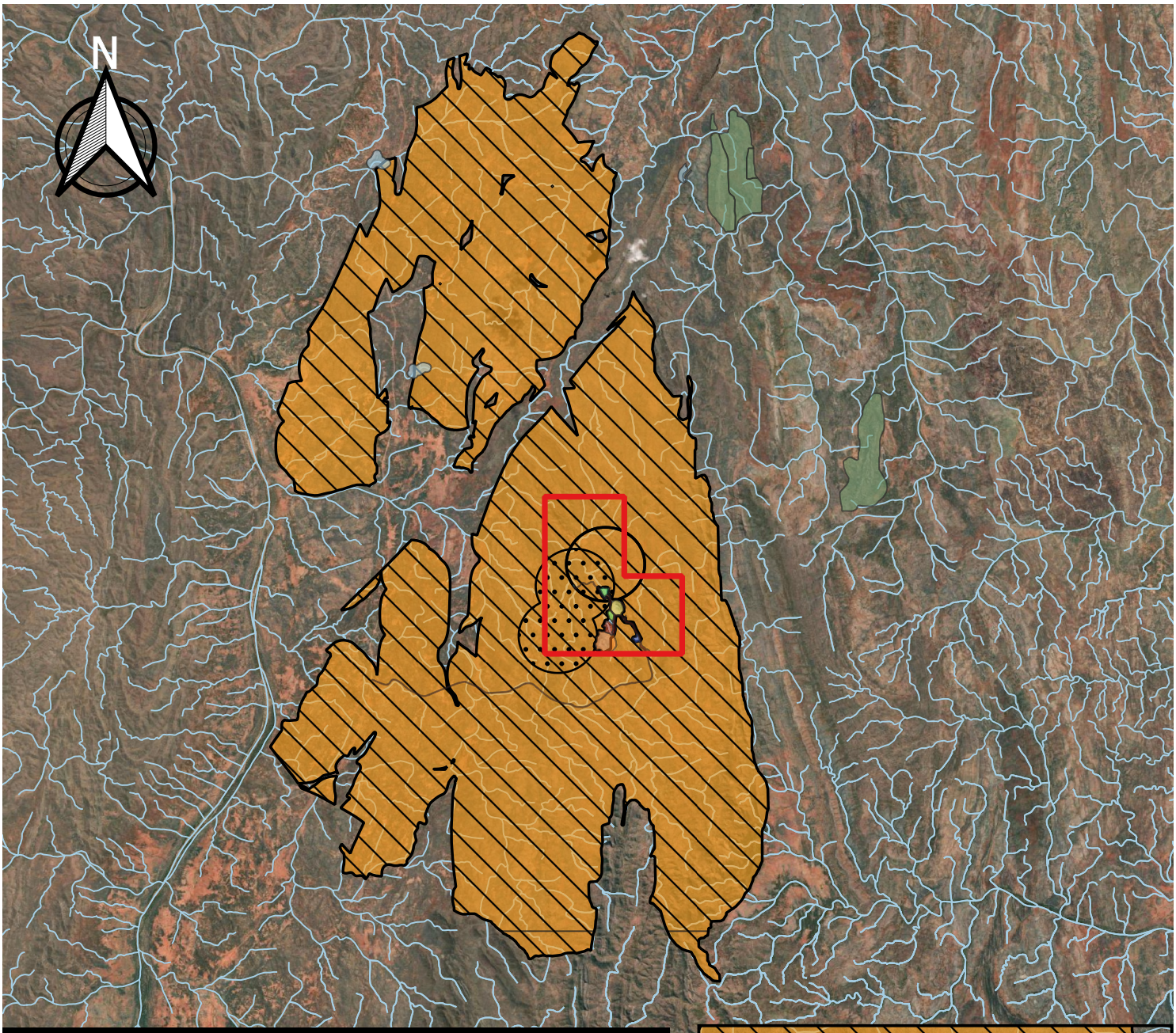
West Leichardt Station

Scale 1 : 100 000

0 1 2 km

	Client: Aeris Resources Limited	Project: Barbara EA amendment	
	Design: SGM Environmental Pty Ltd 29.11.2023 Scale: 1 : 100 000 CRS: GDA2020	Title: Scaled map	Figure: 3

© SGM Environmental. While every care is taken to ensure the accuracy of this data, SGM Environmental makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and liability (including without limitaiton liability in negligence) for all expenses, losses, damages (including indirect consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.



LEGEND

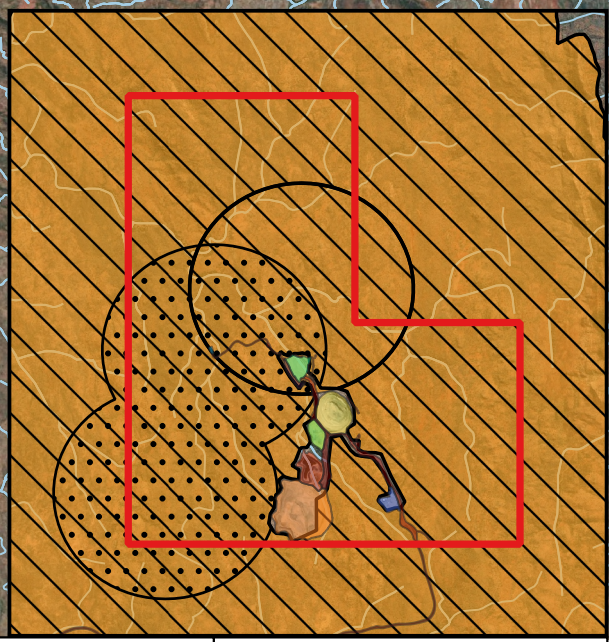
- ML
- WRD
- WRD sediment dam
- Other

Site domains

- Creek diversion
- Light infrastructure area
- Magazine
- North Pit
- ROM pad
- South Pit

MSES

- Regulated vegetation (essential habitat)
- Wildlife habitat (endangered or vulnerable)
- Wildlife habitat (special least concern animal)
- Regulated vegetation (100 m from wetland)
- Regulated vegetation (category B - endangered or of concern)
- Regulated vegetation (defined watercourse)



Scale 1 : 125 000

0 2.5 5 km

SGM environmental

Client	Aeris Resources Limited
Project	Barbara EA amendment
Design:	SGM Environmental Pty Ltd 30.04.2024
Scale:	1 : 125 000
CRS:	GDA2020
Title	Sensitive receptors - MSES
Figure	4

6.1.2 Site topography

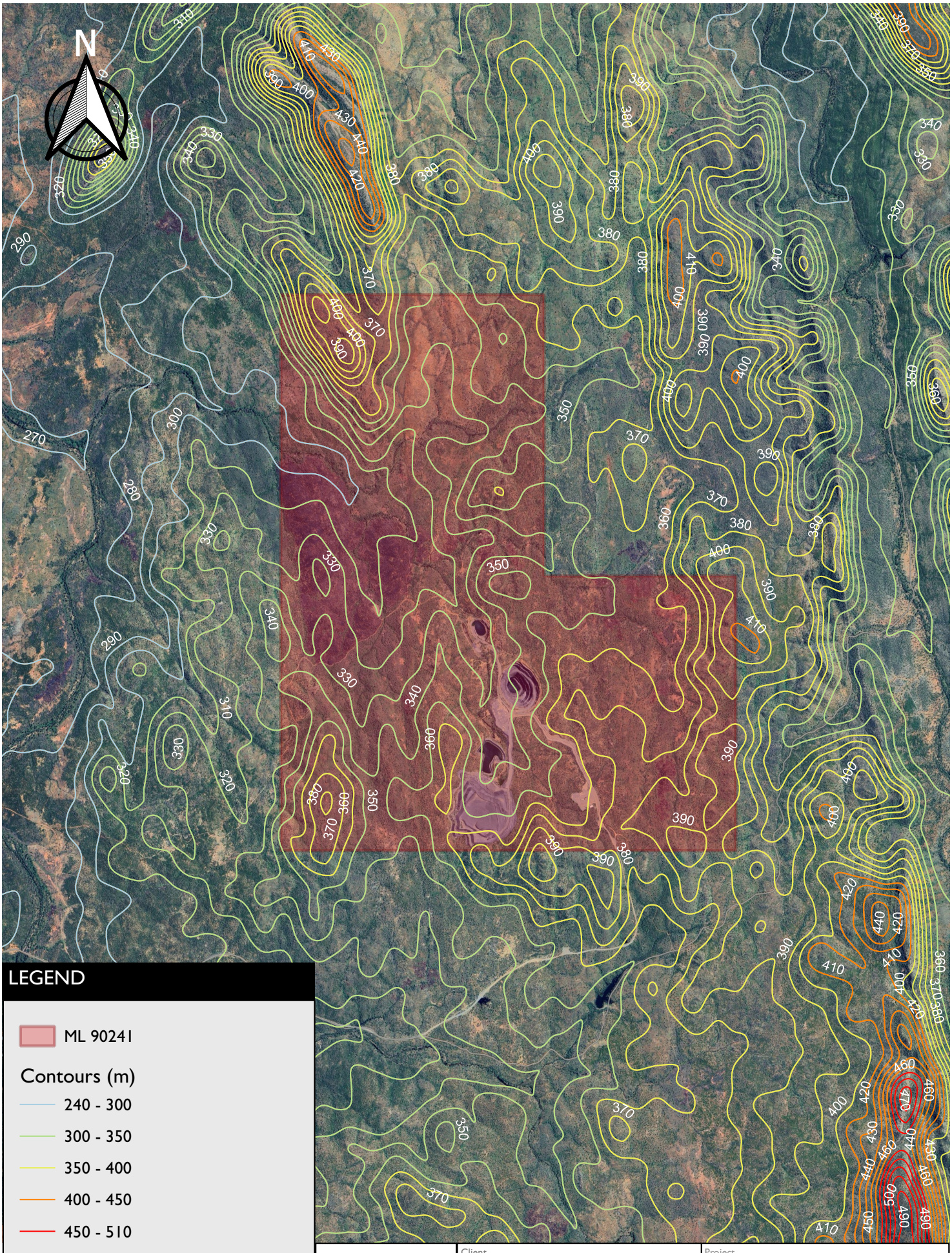
Site topography is characterised by three main landform types: erosional hills, ridges and plateaus, colluvial footslopes and alluvial channels. With exposed and subcropping Proterozoic rocks forming the hills and plateaus that dominate the surrounding landscape (ATC Williams 2019).

Elevation ranges from ~300 metres (m) Australian Height Datum (AHD) to ~410 m AHD across the site (Figure 5).

6.1.3 Wind direction

According to the Bureau of Meteorology (BOM) (2023), the prevailing wind direction at Mount Isa Airport Weather Station (site name: Mount Isa Aero) is northwest at 9 am (>20%) and north at 3 pm (>20%), and the prevailing wind speed is 15.2 kilometres per hour (km/h) at 9 am and 13.8 km/h at 3 pm. Note that these values are the average for November.

Also, according to BOM (2023), the annual wind direction at Mount Isa Aero is northwest at both 9 am (>20%) and 3 pm (>20%), and the annual wind speed is 12.6 km/h at 9 am and 13.6 km/h at 3 pm.



SGM environmental	Client: Aeris Resources Limited	Project: Barbara EA amendment	
	Design: SGM Environmental Pty Ltd 29.11.2023 Scale: 1 : 40 000 CRS: GDA2020	Title: Site topography	Figure: 5

© SGM Environmental. While every care is taken to ensure the accuracy of this data, SGM Environmental makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and liability (including without limitaiton liability in negligence) for all expenses, losses, damages (including indirect consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.

6.1.4 Description of ambient air quality

The Gap air monitoring network station, located in the centre of Mount Isa, monitors particulate matter 2.5 ($PM_{2.5}$), particulate matter 10 (PM_{10}) and sulfur dioxide (SO_2), giving an overview of ambient air quality at the site. As seen in Table 12, these parameters have been classified as 'good' (green) under the BOM's air quality category system. The Gap air monitoring network station also monitors metals, including lead (Pb), arsenic (As), cadmium (Cd), copper (Cu), zinc (Zn) and nickel (Ni). Running averages for these metals are in Table 13.

Table 12 Ambient air quality at the Gap air monitoring network station

Parameter	Running average	BOM air quality category
$PM_{2.5}$ (micrograms per cubic metre ($\mu g/m^3$))	7.9 (24 hour (hr) average)	Good
PM_{10} ($\mu g/m^3$)	14 (24 hr average)	Good
SO_2 (particles per million (ppm))	0.001 (1 hr average)	Good

These measurements are correct at 11 am on 27 November 2023.
This table was created using data from the Queensland Government (2023).

Table 13 Metal concentrations at the Gap air monitoring network station

Parameter	Running average (ug/m^3) (24 hr average)
Pb	0.109
As	0.010
Cd	0.001
Cu	0.196
Zn	0.048
Ni	0.000

These measurements are correct at 11 am on 27 November 2023.
This table was created using data from the Queensland Government (2023).

It is highly likely that ambient air quality and metal concentrations at the Gap air monitoring network station are influenced by local industry, including mining.

The site has previously had an air quality monitoring program which measured dust deposition (total insoluble matter (TIM)), Pb, As, Cd and Cu. These parameters were measured at three locations (two on site and one east of the site) during opencut mining between 2019 and 2021. The minimum and maximum recorded measurements for each of these parameters is in Table 14.

Table 14 Dust deposition monitoring results

Parameter	BDG01	BDG02	BDG03	Air quality objective[1]
TIM (milligrams per metre squared per day ($mg/m^2/day$))	2.22-67.86	3.33-100.00	2.33-39.29	120 $mg/m^2/day$

Parameter	BDG01	BDG02	BDG03	Air quality objective[1]
Pb (milligrams per litre per day (mg/L/day))	<0.0003-0.0630	<0.0003-0.0313	<0.0003-0.1875	250 micrograms per metre squared per day ($\mu g/m^2$/day)
As (mg/L/day)	<0.0003-0.0037	<0.0003-<0.0300	<0.0003-<0.0520	Must not exceed background concentration
Cd (mg/L/day)	<0.0003-<0.0030	<0.0003-<0.0010	<0.0003-<0.0030	
Cu (mg/L/day)	<0.001-1.375	<0.001-1.031	<0.001-0.875	

3. Annual average over a calendar year is the measurement period for each air quality objective.

6.2 Possible impacts and associated risks to identified environmental values

This section examines potential impacts and their associated risk to identified EVs (air).

6.2.1 Overview of emissions and processes

The following sections give an overview of known emission sources. They focus on additional emission sources generated from UG mining, most importantly the ventilation system. It also examines the impact of dust emissions and blasting emissions, as they can have a significant influence on air quality. Other emission sources, including emissions from vehicle exhaust systems, are not discussed in this report as they have previously been examined in an air quality impact assessment by ASK Consulting Engineers Pty Limited (ASK Consulting Engineers) (2014) (Appendix C) and are unlikely to result in a significant additional impact on EVs (air).

6.2.2 Emissions

Both particulates and gaseous emissions are expected from UG mining. Particulates may include:

- total suspended particles (TSP);
- airborne particles less than (<) 2.5 micrometres in diameter ($PM_{2.5}$); and
- airborne particles < 10 micrometres in diameter (PM_{10}).

Gaseous emissions may include:

- nitrogen oxides (NO_x), carbon monoxide (CO) and volatile organic compounds (VOCs) from combustion engine exhausts;
- NO_x and CO from blasting procedures; and
- fugitive emissions, including VOCs from storage tanks.

6.2.2.1 Emissions from the ventilation system

Limited information is publicly available on the emissions generated from UG mine ventilation systems. However, the potential impact from this source is not expected to exceed the impact from dust emissions or emissions from blasting.

6.2.2.2 Dust emissions

Vehicle movement on unsealed roads, blasting, and material handling, crushing and dumping may contribute to dust emissions. Particulates from dust emissions include:

- Total suspended particles;
- $PM_{2.5}$; and
- PM_{10}.

Dust generated from mining activities may also contain contaminants, including Pb, As, Cd and Cu.

6.2.2.3 Emissions from blasting

The frequency and charge size from blasting is similar to the proponents nearby Mt Colin operation, and less than previous opencut mining at the site. Therefore, emissions generated from blasting at Mt Colin UG have been used as an estimate (Appendix D). Appendix D is a national pollution inventory (NPI) report for financial year 2022 / 2023 for Mount Colin UG. It indicates the emissions generated from explosives and diesel during the reporting period. Note that there were only 338 blasts during this period, which is notably less than the peak blasts of 1,340 during financial year 2019 / 2020. However, the amount of explosives used was significantly greater with 394 tonnes (t) used during financial year 2022 / 2023 compared to the 22 t used during financial year 2019 / 2020.

6.2.3 Evaluating impacts of emissions

Emissions generated from UG mining are unlikely to have a significant additional impact on EVs (air). Human health is unlikely to be affected due to the distance to sensitive places (closest being ~23 km away). Agriculture may be affected due to dust deposition on livestock drinking water and grazing pastures. However, this is unlikely to exceed the impact from opencut mining. Ecosystem health and biodiversity, and the aesthetics of the immediate environment may also be affected. However, this too is unlikely to exceed the impact from opencut mining as both opencut and UG mining have similar emission sources and rates. Section 6.3.1 describes the control measures which will be used to minimise the impact from air emissions.

6.2.3.1 MSES

MSES mapped within or immediately surrounding the ML may be impacted by dust emissions or emissions from blasting. However, this is not expected to exceed the impact from opencut mining as the operation scale and intensity has notably reduced for UG mining.

6.2.4 Odour

An odour impact assessment has not been done due to the distance to sensitive receptors and because UG mining is unlikely to result in significant additional odour impacts.

6.2.5 Dust

Dust caused by mining activities, especially dust generated from vehicle movement during peak production, may impact EVs (air). The following mining activities have been considered:

- vehicle movement on unsealed roads;
- blasting; and
- material handling, crushing and dumping.

Dust deposition gauges will be reinstated consistent with the pre-existing air quality monitoring program. Dust deposition monitoring has previously occurred on site during opencut mining between 2019 and 2021. The locations are in Table 15 and the results are in Table 14.

Table 15 Dust deposition gauge monitoring locations

Site ID	Latitude (GDA94 Z54)	Longitude (GDA94 Z54)	Location description
BDG01	-20.4252	139.8711	East of mining lease
BDG02	-20.4307	139.8596	Near site administration
BDG03	-20.4040	139.8382	Northwest of infrastructure area

This table has been taken from Round Oak (2019).

Dust deposition (TIM) did not exceed the air quality objective in EA EPML02840015 (120 mg/m^2/day) during opencut mining. Considering this, the project scale compared to previous mining, distance to sensitive receptors and planned dust control measures (Section 6.3.1), the dust caused by UG mining activities is unlikely to have a significant additional impact on EVs (air).

6.2.6 Visibility reducing particles

Both $PM_{2.5}$ and PM_{10} can impact visibility. Visibility reducing particles generated from UG mining should not be greater than visibility reducing particles generated from opencut mining. Ambient air quality for these parameters is in Table 12.

6.2.7 Air dispersion modelling

Air dispersion modelling has not been done due to the distance to sensitive receptors and because UG mining is unlikely to result in significant additional impacts to air.

6.3 Proposed management practices

This section describes planned controls for the identified risks.

6.3.1 Describe proposed control measures

An air quality monitoring program has been prepared for the project and will be implemented prior to commencing mining activities. It has been designed to measure compliance with the air quality objectives in EA EPML02840015.

Dust emissions are expected to have a significant impact on air quality within and immediately surrounding the site. Several control measures will be implemented to mitigate this:

- high traffic areas:
  - monitoring of high traffic areas for the generation of excessive dust;
  - unless there is a valid reason, only travelling within designated traffic areas;
  - operating vehicles at 20 km/h at administration and 40 km/h around site as sign posted to avoid the generation of excessive dust; and
  - grading spilt ore off the road as soon as practicable, before pushing the graded ore into a heap for future recovery;
- loader / shovel operations:
  - minimising drop heights when placing material into haul trucks; and

  - ensuring haul trucks are not overloaded;
- mining equipment:
  - ensuring cab windows are closed when operating mining equipment;
  - regular maintenance of cab dust filter systems to ensure they are operating efficiently; and
  - ensuring operators are within the dust filtered cab, with the doors closed, when trucks are being loaded and unloaded;
- drilling:
  - fitting drill rigs with effective dust control and collection equipment;
  - where practicable, using dust curtains, water sprays and air extraction systems;
  - spraying drill cuttings with water;
  - spraying drill pads and adjacent hardstand areas with water;
  - ceasing operations when drill rig dust suppression systems are considered faulty;
- stemming and blasting:
  - following the drill and blasting procedure;
- waste rock dump:
  - blocking vehicle access on unused roads;
  - spraying actively used roads and work areas to minimise the generation of airborne dust;
  - to limit the impact from wind, scheduling tipping operations that occur at an elevated height; and
  - progressively rehabilitating as soon as is practicable.

The following control measures will be implemented to minimise the impact from the UG mine ventilation system:

- regular and ongoing maintenance to ensure equipment is running efficiently; and
- ceasing operations during adverse weather events, especially when wind is travelling in the direction of sensitive receptors.

The following control measure will be implemented to minimise the impact from blasting:

- ceasing operations during adverse weather events, especially when wind is travelling in the direction of sensitive receptors.

6.3.2 Contingency plans

Assuming the controls in Section 6.3.1 are implemented, there are no foreseeable failures in emission control systems. However, if a valid complaint is made regarding dust nuisance, dust deposition monitoring will be implemented at a site representative of the complainant's residence, consistent with *AS3580.10.1 2003 Methods for sampling and analysis of ambient air – Determination of particulate matter – Deposited matter – Gravimetric method*. Dust deposition monitoring would continue for at least 12 months.

7.0 Impacts to noise

Consistent with Schedule 8, Part 3, Division 1 of the EP Regulation, this section describes how the following environmental objective, along with its performance outcomes, will be achieved:

> ***Environmental objective***
> *The activity will be operated in a way that protects the environmental values of the acoustic environment.*

7.1 Environmental values of the site

This section identifies EVs of the receiving environment (noise), including the identification of nearby sensitive receptors.

7.1.1 Sensitive places

MSES mapped within or surrounding the ML that have the potential to be impacted by noise emissions are identified in Section 7.1.1.1 (Figure 4). No ESAs were identified within the ML. However, there are endangered regrowth and remnant regional ecosystem ESAs mapped nearby (Appendix B), identified as regional ecosystem 1.3.7 — River Red Gum woodland. West Leichhardt Station homestead and camp, located ~23 km away, is the nearest sensitive receptor (Figure 7). It has been included in this supporting information document to confirm that there are no significant additional impacts to this sensitive receptor from changing operations to UG mining. Sensitive receptors further than this have not been considered as they are unlikely to receive detectable impacts from the mine.

7.1.1.1 MSES

The following MSES were identified in, or within 10 km of, the ML and have the potential to be impacted by noise emissions:

- wildlife habitat (endangered or vulnerable); and
- wildlife habitat (special least concern animal).

Environmental values (EVs) such as ecosystem health and biodiversity may be impacted by noise emissions including ground vibration and airblast overpressure noise from blasting due to the location of MSES (Figure 4). However, the impact is not expected to exceed the impact from opencut mining, as the operation scale and intensity has notably reduced. Management practices have been proposed in Section 7.3 to ensure that the impact is as low as reasonably practicable.

A terrestrial flora and fauna assessment was completed in 2014 by Australasian Resource Consultants Pty Limited (AARC) (Appendix E) to identify the EVs of flora and fauna communities within the project area. The assessment consisted of four site surveys which occurred during wet and dry periods in 2011 and 2014. No threatened flora species were identified during field surveys. The following fauna species were identified within the project area during field surveys and are (or were) considered near threatened or threatened under the *Queensland Nature Conservation (Wildlife) Regulation 2006*:

- Golden-backed Honeyeater (*Melithreptus gularis laetior*); and
- Purple-necked Rock-wallaby (*Petrogale purpureicollis*).

Mapped ESAs are greater than 1 km from the operational area (Appendix B) and, therefore, are not expected to exceed the limits imposed by DESI or be significantly more impacted when compared to previous opencut mining activities.

Due to the site's remote location and distance to sensitive receptors, impacts to human health and public amenity EVs would be negligible.

7.1.2 Site description

7.1.2.1 Topography and built environment

A description of site topography is in Section 6.1.2.

7.1.2.2 General climate

Monthly rainfall and temperature data have been plotted for the nearest weather station (Lake Julius AWS — station number 029181) (Figure 6), which is located ~31 km north-east of the site. Rainfall is summer dominant with an average annual rainfall of 504.4 millimetres (mm) (BOM 2023). The wetter months occur from November to March and the drier months occur from April to October. The monthly mean maximum temperature ranges from 26.9 degrees Celsius (°C) in July to 38.9°C in December (BOM 2023) and the monthly mean minimum temperature ranges from 13.0°C in July to 26.1°C in December (BOM 2023).

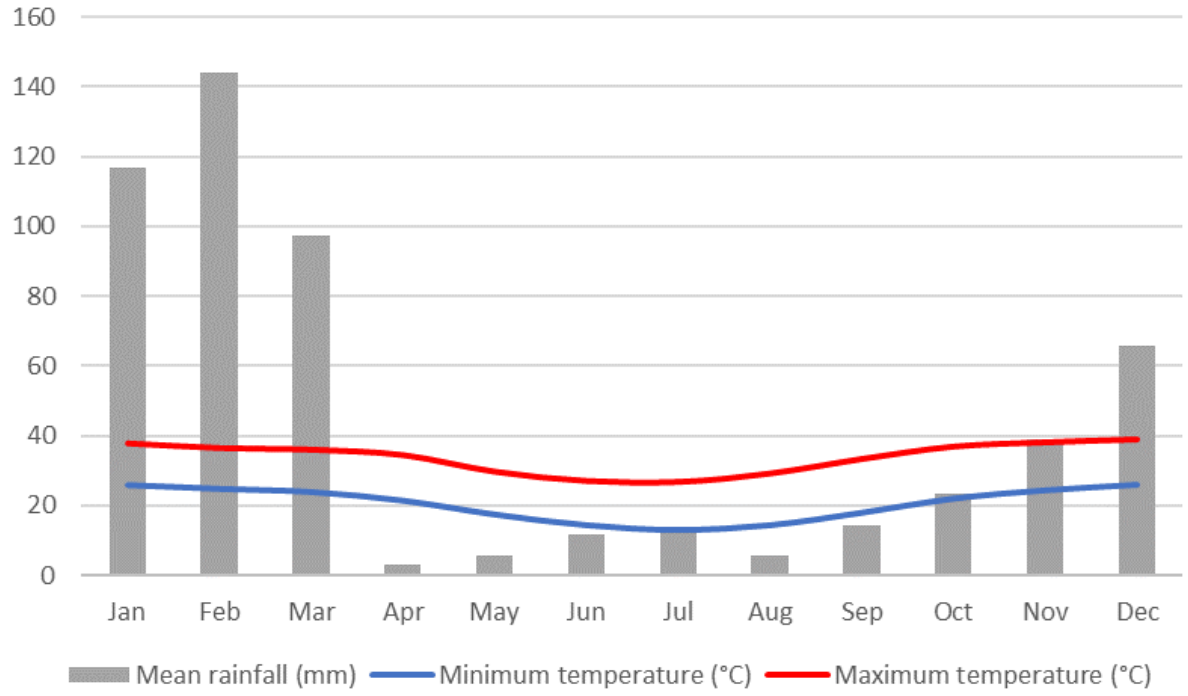


Figure 6 Mean monthly rainfall and temperature

7.1.2.3 Prevailing wind characteristics

A description of the prevailing wind characteristics is in Section 6.1.3.

7.1.3 Background noise levels

Background noise levels have not recently been measured on site. A site noise assessment prior to opencut mining assumed background noise levels were below 30 decibels A (dBA) for 90% of the monitoring period (L_{90}) at sensitive receptors (ASK Consulting Engineers 2014).

Existing noise sources may include:

- natural sounds;
- livestock; and
- minor traffic from transport along Lake Julius Road.

7.2 Possible impacts to identified environmental values

This section describes potential impacts to identified EVs (noise). More specifically, it identifies potential sources of noise emissions, their characteristics (where possible) and how noise emissions will be mitigated through the noise management hierarchy. It focuses on new noise sources and / or increases in the rate of noise emissions resulting from UG mining. Because of this, it only briefly examines the potential impacts caused by mining activities shared between opencut and UG mining. This includes:

- drilling;
- blasting;
- extraction of ore using loaders and dump trucks;
- transport of ore and waste from pits / underground workings;
- unloading of ore at the run of mine (ROM) pad;
- unloading waste in dumps or within pits / underground workings (backfilling);
- crushing and sorting of ore;
- loading crushed ore into road trains for transport off-site; and
- operation of fixed plant, including generators, pumps and lighting equipment.

These have been examined in a noise assessment prepared by ASK Consulting Engineers (2014), which helped define the conditions in EA EPML02840015. A brief examination is considered sufficient as the project scale for UG mining does not exceed the project scale for previous opencut mining, and equipment used will be the same or downsized.

Construction activities have not been examined as they are unlikely to impact EVs (noise) due to the distance to sensitive receptors and off-site haulage has not been examined as it has previously been examined by ASK Consulting Engineers (2014).

7.2.1 Noise sources

New noise sources and / or noise sources which may contribute additional noise emissions include:

- A permanent ventilation system. The surface vent fan will be permanently fixed on a bench on the northern side of South Pit. The approximate location is in Figure 7.

LEGEND

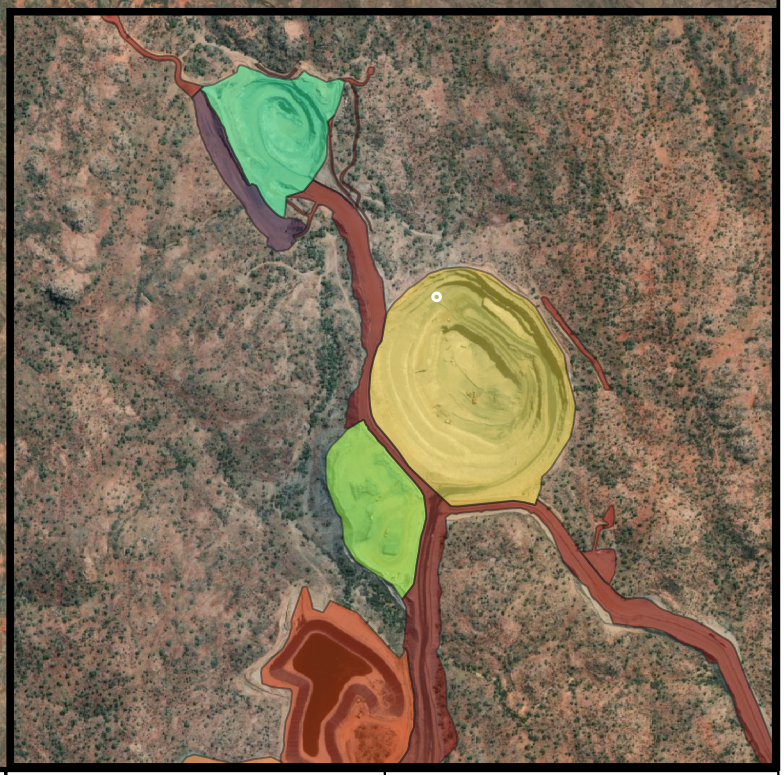
- ML 90241
- Surface vent fan
- West Leichardt Station

Site domains

- Creek diversion
- Light infrastructure area
- Magazine
- North Pit
- ROM pad
- South Pit
- WRD
- WRD sediment dam
- Other

Scale 1 : 125 000

0 2.5 5 km



SGM environmental

Client: Aeris Resources Limited	Project: Barbara EA amendment
Design: SGM Environmental Pty Ltd 29.11.2023 Scale: 1 : 125 000 CRS: GDA2020	Title: Scaled map Figure: 7

7.2.2 Emission characteristics

The following emission characteristics (Table 16) are based on operational equipment used during opencut mining. These have been used as a conservative substitute, as an inventory of mobile equipment and fixed plant has not been finalised. In addition to these emission sources, UG mining requires a ventilation system. A noise impact assessment prepared for Integra Underground Coal Project (ERM 2009) indicated a sound power level of 104 dB(A) (representative $L_{eq,\ 15\text{-minute sound power level}}$) for their ventilation system. This measurement was calculated from existing Integra UG mining on 16 July 2008 and is considered an appropriate substitute for this project.

Noise generated from ventilation systems are generally considered tonal. Blasting has previously been examined by ASK Consulting Engineers (2014) and is further examined in Section 7.2.2.1. It is unlikely to have a significant additional impact on EVs (noise) due to the reduction in scale and intensity from previous opencut mining.

Table 16 Sound power levels for operational equipment

Plant or equipment item — make and model	Quantity	Overall sound power level (Lw) per equipment type for maximum quarter
Excavator — Komatsu PC1250	1	117
Front-end loaders — CAT 966H	1	110
Off-road haulage CAT 777	4	126
On-road haulage — RT 2 (triple road trains)	10	120
Track dozer — CAT D10	1	125
Grader — CAT 16G	1	110
Water cart — CAT 773	1	120
Drill — Sandvik DP1100	3	121
Service truck — 8-ton single axle	1	105
Light vehicle — Toyota Landcruiser Ute	3	109
Light vehicle — Toyota Hilux Ute	5	111
Pump — dewatering pump diesel	1	105
Lighting — diesel lighting towers	6	123
Diesel generator — Cummins Diesel 200KVA	2	123
Crusher – unspecified	1	106

This information has been derived from *Barbara Copper Project — Noise Impact Assessment* (ASK Consulting Engineers 2014).

7.2.2.1 Emissions generated from blasting

The emissions generated from blasting, and potential impacts to EVs have been evaluated in Appendix F. The key points are:

- blasting sizes will be similar to Aeris Resource's Mt Colin Mine;
  - 0.5 t ANFO or equivalent per 4 m round for development; and
  - 5-10 t ANFO or equivalent per blast for stoping.
- development blasting will generally occur at each shift, and stope blasting will generally occur several times per week;
- blasting will generally occur at shift changes, consistent with industry standards;
- the potential impacts from blasting were predicted (for the nearest sensitive place) using a desktop assessment. The desktop assessment used industry standard methods and relevant parameters from Aeris Resource's Mt Colin Operations; and
- ground blasting and airblast overpressure is not expected to exceed the current EA conditions at sensitive places.

a Potential impacts from blasting

No additional disturbance is required for UG mining. Therefore, the habitat suitable for near threatened and threatened species is expected to remain unchanged. The impact on threatened species, specifically the Purple-necked Rock-wallaby, from ground vibration and airblast overpressure is expected to be minimal as they are not overly sensitive to blasting or noise. Purple-necked Rock-wallabies are grazers; therefore, they do not require sound for foraging.

A previous assessment by ASK Consulting Engineers Pty Limited (ASK Consulting) (2014) determined that vibrations would be less than 5 millimetres per second (mm/s) for peak particle velocity at 0.2 km and less than 2 mm/s at 0.6 km using a maximum instantaneous charge of 90 kilograms (kg). Further modelling was done by the proponent and is in Appendix F. It contains the combination of parameters used for modelling, including K and B parameters (K parameter is a scaling factor that correlates explosive charge weight and distance with its effects, and B parameter is a constant related to the distance and site). The peak particle velocity for maximum instantaneous charges of 150 kg, 250 kg and 750 kg were determined at 1,000 m, 10,000 m and 23,000 m. 150 kg is based on a typical underground development blast, 250 kg is based on a typical stope blast and 750 kg is based on a specialised stope blast. Peak particle velocity from ground vibrations complies with the DESI limit at 10,000 m and 23,000 m. It complies with the DESI limit at 1,000 m under 'average site conditions', but there were four exceedances of the night guideline (for blasting limits — underground mining). Two of these exceedances comply with the day time guideline of 5 mm/s peak particle velocity. Therefore, this can be managed by only using these combinations during day time hours. Peak particle velocity exceeded 10 mm/s in only one instance. Therefore, this combination would be avoided.

The assessment by ASK Consulting (2014) also determined that the 115 dB (Lin) airblast overpressure limit could be achieved at ~0.4 km. Further modelling was done by the proponent and is in Appendix F. It contains the parameters used for modelling, including the K parameter. Maximum instantaneous charge amounts and observation distances were the same as those used for ground vibration modelling. Airblast overpressure noise only exceeded the DESI limits in one instance, at 1,000 m with a maximum instantaneous charge of 750 kg. However, this can be managed by avoiding this combination.

Modelling scenarios completed by Aeris are overly conservative. This ensures management and mitigation measures are developed on a worst-case scenario to effectively protect EVs.

7.2.3 Noise management hierarchy

Noise management must be consistent with the management hierarchy for noise in Section 8 of the EPP (Noise), which includes the following steps:

1. avoid the noise;
2. minimise the noise; and
3. manage the noise.

7.2.3.1 Avoid the noise

It is not possible to avoid generating noise from general mining activities or blasting. However, it may be possible to avoid generating additional noise. For example, avoiding blasting during adverse weather events, including strong winds, when sound may be carried towards sensitive receptors.

7.2.3.2 Minimise the noise

The noise mitigation strategies in Section 7.3.1 will be used to minimise noise.

7.2.3.3 Manage the noise

To manage mining activities, underground mining will remain compliant with the noise limits specified in EA EPML02840015 (Table 17) for sensitive and commercial places.

Table 17 ***Table D1 — Noise limits (EA EPML02840015)***

Sensitive place

Noise level dB(A) measured as:	Monday to Saturday			Sundays and public holidays		
	7am to 6pm	6pm to 10pm	10pm to 7am	9am to 6pm	6pm to 10pm	10pm to 9am
$L_{Aeq,\ adj,\ 15\ mins}$	CV = 50 AV = 5	CV = 45 AV = 5	CV = 40 AV = 0	CV = 45 AV = 5	CV = 40 AV = 5	CV = 35 AV = 0
$L_{A1,\ adj,\ 15\ mins}$	CV = 55 AV = 10	CV = 50 AV = 10	CV = 45 AV = 5	CV = 50 AV = 10	CV = 45 AV = 10	CV = 40 AV = 5

To ensure these limits are not exceeded, the noise mitigation strategies in Section 7.3.1 will be used and monitoring will occur, consistent with condition D3 of EA EPML02840015.

To manage noise generated from blasting activities, underground mining will be compliant with the standard conditions for air blast overpressure and ground vibration peak particle velocity limits for UG mining (Table 18

Blasting limits for underground mining

Blasting noise limits	**Sensitive or commercial blasting noise limits place limits**	
	7am to 6pm	6pm to 7am
Air blast overpressure	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB (Linear) Peak at any time.	115 dB (Linear) peak
Ground vibration peak particle velocity	5 mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time.	2 mm/second peak

If a valid complaint is made, monitoring will occur and the following information recorded (as recommended by the Queensland Government (2018)):

- maximum instantaneous charge in kg;
- blast location (including bench level);
- air blast overpressure level, dB (linear) peak;
- peak particle velocity (mm/second);
- date and time of recording;
- meteorological conditions; and
- distance from blast site to noise-affected buildings and structures, or the boundary of noise affected sensitive receptors.

7.2.4 Noise impact assessment

A recent noise impact assessment has not been done as underground mining is unlikely to have a significant additional impact on EVs (noise) when compared to opencut mining. Impacts associated with identified noise sources can be managed and underground mining can remain compliant with the conditions in the EA, assuming that *Table D2 — Blasting noise limits (EA EPML02840015)* can be amended to the standard conditions for UG mining

A noise impact assessment was done by ASK Consulting Engineers (2014) prior to opencut mining. It assessed general mining activities, blasting, and off-site haulage. Construction activities were excluded due to the distance to sensitive receptors. This assessment reviewed noise impact assessments from similar metalliferous and coal extraction projects to determine if model mining conditions could be complied with. Results indicated that each of the reviewed projects could comply with the nominated limits and therefore, it was highly likely that Barbara Copper project could comply with these same limits.

Table 18 Blasting limits for underground mining

Blasting noise limits	Sensitive or commercial blasting noise limits place limits	
	7am to 6pm	6pm to 7am
Air blast overpressure	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB (Linear) Peak at any time.	115 dB (Linear) peak
Ground vibration peak particle velocity	5 mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time.	2 mm/second peak

If a valid complaint is made, monitoring will occur and the following information recorded (as recommended by the Queensland Government (2018)):

- maximum instantaneous charge in kg;
- blast location (including bench level);
- air blast overpressure level, dB (linear) peak;
- peak particle velocity (mm/second);
- date and time of recording;
- meteorological conditions; and

- distance from blast site to noise-affected buildings and structures, or the boundary of noise affected sensitive receptors.

7.2.5 Noise impact assessment

A recent noise impact assessment has not been done as underground mining is unlikely to have a significant additional impact on EVs (noise) when compared to opencut mining. Impacts associated with identified noise sources can be managed and underground mining can remain compliant with the conditions in the EA, assuming that *Table D2 — Blasting noise limits (EA EPML02840015)* can be amended to the standard conditions for UG mining

A noise impact assessment was done by ASK Consulting Engineers (2014) prior to opencut mining. It assessed general mining activities, blasting, and off-site haulage. Construction activities were excluded due to the distance to sensitive receptors. This assessment reviewed noise impact assessments from similar metalliferous and coal extraction projects to determine if model mining conditions could be complied with. Results indicated that each of the reviewed projects could comply with the nominated limits and therefore, it was highly likely that Barbara Copper project could comply with these same limits.

7.2.6 Background creep

Ventilation fans required for underground mining may contribute to background creep as they are continuously operated. Control measures have been nominated in Section 7.3.1 to mitigate noise.

Background creep modelling has not been done as the nominated control measures are considered sufficient to prevent / manage background creep.

7.3 Proposed management practices

This section describes planned controls, based on identified risks.

7.3.1 Noise mitigation strategies

The following mitigation strategies will be used to minimise the impact on EVs (noise):

- monitoring noise, including ground vibration, in the event of a complaint;
- fitting mobile equipment with industry standard noise silencing equipment;
- ensuring all equipment receives ongoing and regular maintenance consistent with manufacturers specifications;
- ceasing blasting activities during adverse weather events, including strong winds (when they are travelling towards sensitive receptors);
- if necessary, limiting charge mass charge to reduce the distance that ground vibration travels;
- for airblast overpressure and ground vibration peak particle velocity, only using combinations that exceed the night guideline (for blasting limits — underground mining) during day time hours;
- for airblast overpressure, avoiding combinations that exceed 120 dB (Linear) Peak at all times;
- for ground vibration peak particle velocity, avoiding combinations that exceed 10 mm/s peak particle velocity at all times; and
- monitoring meteorological measurements in real time to identify changes in site conditions.

8.0 Impacts to water

Consistent with Schedule 8, Part 3, Division 1 of the EP Regulation, this section describes how the following environmental objectives, along with their performance outcomes, will be achieved:

Environmental objective
The activity will be operated in a way that protects environmental values of waters.

Environmental objective
The activity will be operated in a way that protects the environmental values of wetlands.

Environmental objective
The activity will be operated in a way that protects the environmental values of groundwater and any associated surface ecological systems.

8.1 Identifying environmental values of receiving waters

This section identifies EVs of the receiving environment (water).

8.1.1 Site plan

The following features have not been included in the site plan, as there is no potential impact from the EA amendments:

- rivers in strategic environmental areas (SEAs); and
- Great Barrier Reef (GBR) catchment waters.

The site plan is in Figure 8. Topography can be seen in Figure 5 and a conceptual groundwater model is in Appendix G.

8.1.2 Surface water

No EVs or water quality objectives (WQOs) have been specified for surface waters found on the site, under the *Environmental Protection Policy (Water)* (EPP (Water)).

8.1.2.1 Background quality of surface water

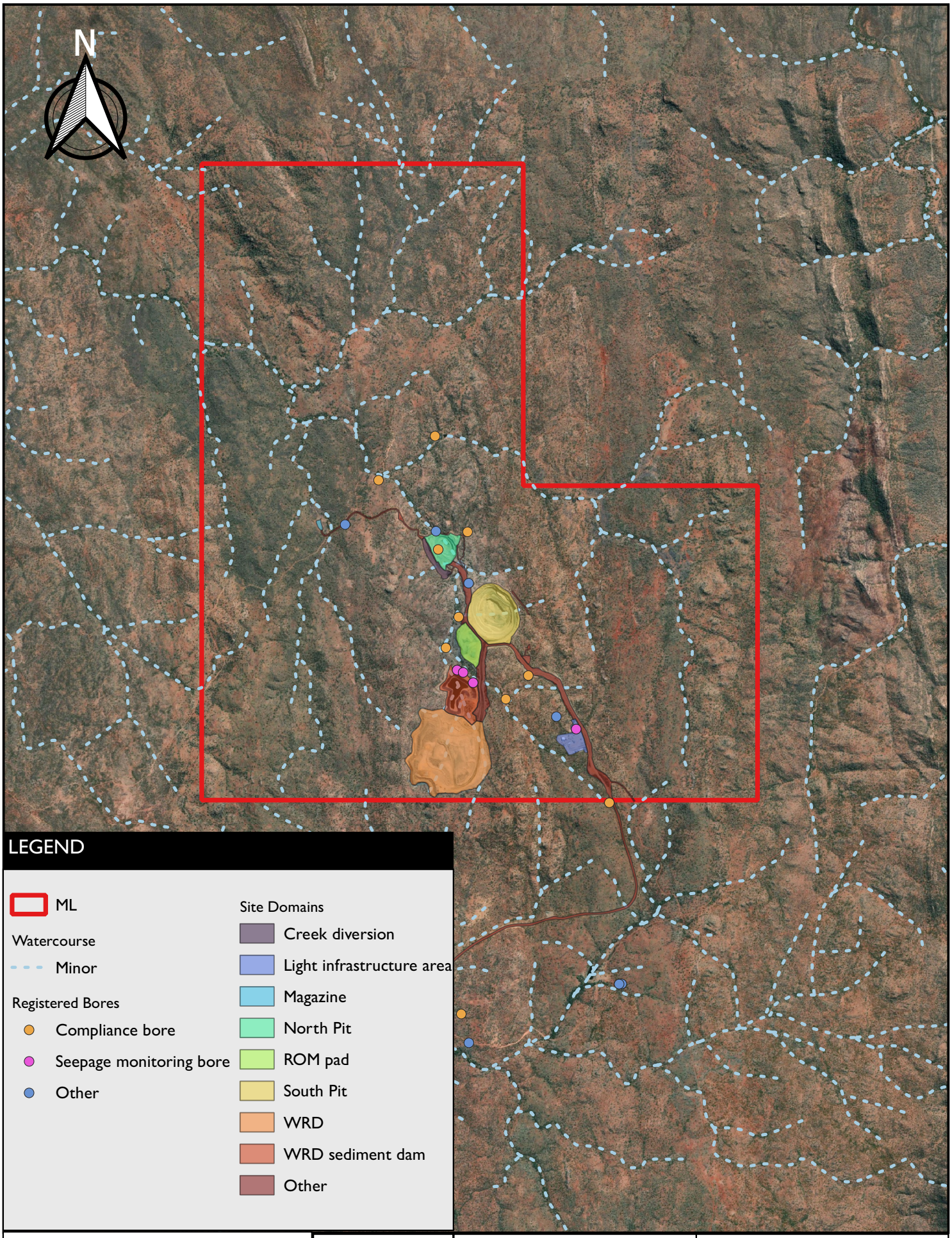
Baseline quality of surface water is provided in Table 19. It includes values for physico-chemical parameters, major ions, alkalinity, total metals and dissolved metals for select reference and compliance monitoring sites.

8.1.3 Groundwater

A detailed groundwater report is in Appendix G. It includes a summary of the different bore types, including seepage and monitoring bores. Note that Aeris Resources does not plan to exercise its groundwater access rights.

8.1.3.1 Groundwater bores in the vicinity of the site

33 groundwater bores are located within 10 km of the site. General details, including the location, registration number and use of each of these bores is in Table 20. Additional details have been included for compliance and monitoring bores listed in EA EPML02840015, which are located within the immediate vicinity of the site. This includes depth to groundwater (as available).



Scale 1 : 25 000

0 0.5 1 km

SGM environmental

Client: Aeris Resources Limited		Project: Barbara EA amendment	
Design: SGM Environmental Pty Ltd 29.11.2023 Scale: 1 :25 000 CRS: GDA2020		Title: Site plan (with bore locations)	Figure: 8

Table 19 Background quality of surface water

Parameter	Unit	BASW09	BASW05	BASW01	BASW04	BASW11
		(minimum-maximum (median))				
Physico-chemical parameters						
Electrical conductivity (EC)	Microsiemens per centimetre (µS/cm)	39-207 (147)	77-282 (193)	57-256 (162.5)	120-244 (194)	57-352 (141)
pH	pH units	6.8-7.88 (7.42)	7.05-8.21 (7.33)	6.85-8.12 (7.44)	7.23-7.86 (7.39)	7.07-7.8 (7.41)
Total hardness as calcium carbonate ($CaCO_3$)	mg/L	9-77 (55)	28-114 (41)	16-97 (39)	30-53 (48)	18-75 (29)
Turbidity	NTU	1.1-54.8 (14.4)	4.2-54.6 (9.6)	1.7-137 (11.6)	3.2-29 (9.5)	3.7-29.9 (12.9)
Major ions						
Calcium (Ca)	mg/L	3-20 (12)	7-36 (10)	4-31 (10.5)	7-13 (11)	4-21 (6.5)
Chloride (Cl^-)	mg/L	1-7 (4)	2-9 (5)	2-12 (4)	7-14 (8)	3-15 (6)
Fluoride (F^-)	mg/L	<0.1-0.2 (0.1)	<0.1-0.2 (0.1)	<0.1-0.2 (0.1)	<0.1-0.1 (0.1)	<0.1-0.2
Magnesium (Mg)	mg/L	2-9 (6)	3-9 (5)	2-6 (4.5)	3-6 (4)	2-9 (3.5)
Potassium (K)	mg/L	4-8 (5)	4-8 (7)	3-10 (4)	4-5 (4)	3-19 (4.5)
Sodium (Na)	mg/L	8-15 (9)	3-26 (13)	4-31 (6.5)	14-35 (24)	4-35 (18.5)
Sulfate (SO_4^{2-})	mg/L	<1-3 (<1)	<1-8 (1)	<1-11 (<1)	3-9 (6)	<1-4
Alkalinity						
Bicarbonate alkalinity as $CaCO_3$	mg/L	17-94 (72)	38-140 (77)	24-109 (66)	40-103 (99)	27-154 (60.5)
Carbonate alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1
Total alkalinity as $CaCO_3$	mg/L	17-94 (72)	38-140 (77)	24-109 (66)	40-103 (99)	27-154 (60.5)
Total metals						
Arsenic (As)	mg/L	<0.001-0.001 (<0.001)	<0.001-0.002 (0.001)	<0.001-0.001 (0.001)	<0.001-0.001 (0.001)	<0.001-0.004 (<0.001)
Barium (Ba)	mg/L	0.012-0.053 (0.027)	0.026-0.094 (0.032)	0.017-0.074 (0.0265)	0.02-0.03 (0.027)	0.013-0.07 (0.027)
Bismuth (Bi)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)	mg/L	<0.001	<0.001-0.016 (<0.001)	<0.001-0.003 (<0.001)	<0.001-0.002 (<0.001)	<0.001
Cobalt (Co)	mg/L	<0.001-0.001 (<0.001)	<0.001-0.004 (<0.001)	<0.001-0.003 (<0.001)	<0.001-0.002 (<0.001)	<0.001-0.002 (<0.001)
Copper (Cu)	mg/L	0.001-0.003 (0.002)	0.002-0.039 (0.015)	0.004-0.038 (0.0075)	0.01-0.043 (0.012)	0.002-0.008 (0.004)

Parameter	Unit	BASW09	BASW05	BASW01	BASW04	BASW11
		(minimum-maximum (median))				
Molybdenum (Mo)	mg/L	<0.001	<0.001-0.001 (<0.001)	<0.001	<0.001	<0.001
Nickel (Ni)	mg/L	<0.001	<0.001-0.009 (<0.001)	<0.001-0.004	<0.001-0.003 (<0.001)	<0.001-0.001 (<0.001)
Selenium (Se)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium (U)	mg/L	<0.001	<0.001-0.001 (<0.001)	<0.001	<0.001	<0.001
Dissolved metals						
As	mg/L	<0.001	<0.001-0.001	<0.001-0.001 (<0.001)	<0.001-0.001 (0.001)	<0.001-0.002 (<0.001)
Ba	mg/L	0.005-0.049 (0.023)	0.015-0.088 (0.023)	0.009-0.064 (0.0205)	0.019-0.023 (0.021)	0.01-0.034 (0.017)
Bi	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cr	mg/L	<0.001	<0.001	<0.001-0.002 (<0.001)	<0.001	<0.001
Co	mg/L	<0.001-0.001 (<0.001)	<0.001	<0.001-0.001 (<0.001)	<0.001-0.001 (<0.001)	<0.001-0.002 (<0.001)
Cu	mg/L	<0.001-0.002 (0.001)	0.002-0.018 (0.008)	0.002-0.016 (0.0075)	0.007-0.03 (0.012)	<0.001-0.006 (0.002)
Mo	mg/L	<0.001	<0.001	<0.001-0.002 (<0.001)	<0.001-0.001 (<0.001)	<0.001-0.002 (<0.001)
Ni	mg/L	<0.001	<0.001	<0.001-0.008 (<0.001)	<0.001	<0.001-0.003 (<0.001)
Se	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
U	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001

Table 20 Registered groundwater bores within 10 km of ML 90241

Registered number	Monitoring point[1]	Latitude	Longitude	Status	Depth to groundwater	Use
37655	-	-20.4068254	139.813691	Abandoned and destroyed	-	Private
146898	-	-20.3083993	139.871099	Existing	-	Unspecified
146948	BAWB03	-20.4068254	139.848289	Existing	-	Mine monitoring
146949	BAWB04	-20.4160841	139.850251	Existing	14.46	Mine monitoring
146950	BAWB01	-20.424750	139.853915	Existing	16.33	Mine monitoring
146951	BAWB05	-20.4324213	139.858801	Existing	25.81	Mine monitoring
146952	BAWB02	-20.4129705	139.844879	Existing	9.00	Mine monitoring
146954	-	-20.4191827	139.850315	Existing	-	Private
163352	BAWBR1	-20.4261718	139.852560	Existing	-	Mine monitoring
163353	-	-20.4156453	139.842863	Abandoned and destroyed	-	Mine monitoring
163354	Bore E	-20.4451634	139.849869	Existing	-	Mine monitoring
163355	-	-20.4469011	139.850326	Abandoned and destroyed	-	Mine monitoring
163356	-	-20.4433479	139.859554	Abandoned and destroyed	-	Mine monitoring
163357	-	-20.4658707	139.775696	Abandoned and destroyed	-	Mine monitoring

Registered number	Monitoring point[1]	Latitude	Longitude	Status	Depth to groundwater	Use
163358	-	-20.4285718	139.811664	Abandoned and destroyed	-	Mine monitoring
163359	BAWBR3	-20.42122	139.849712	Abandoned and destroyed	-	Mine monitoring
163360	BAWBR2	-20.4230761	139.848941	Abandoned and destroyed	-	Mine monitoring
163368	-	-20.4433574	139.859395	Abandoned and destroyed	-	Mine monitoring
163369	-	-20.4272295	139.855607	Abandoned and destroyed	-	Mine monitoring
163370	-	-20.3908895	139.819700	Existing	-	Mine monitoring
163371	-	-20.3815216	139.806405	Abandoned and destroyed	-	Mine monitoring
184209	-	-20.3627075	139.80284	Existing	-	Private
184264	Seepage Bore 3a	-20.4244177	139.849621	Existing	-	Mine monitoring
184265	Seepage Bore 3b	-20.4244177	139.849621	Existing	-	Mine monitoring
184266	Seepage Bore 2a	-20.4245647	139.849984	Existing	-	Mine monitoring
184267	Seepage Bore 2b	20.4245647	139.849984	Existing	-	Mine monitoring
184268	Seepage Bore 1a	-20.425183	139.850583	Existing	-	Mine monitoring
184269	Seepage Bore 1b	-20.425183	139.850583	Existing	-	Mine monitoring
184270	Seepage Bore 4a	-20.4279796	139.856802	Existing	-	Mine monitoring

Registered number	Monitoring point[1]	Latitude	Longitude	Status	Depth to groundwater	Use
184271	Seepage Bore 4b	-20.4279796	139.856802	Existing	-	Mine monitoring
184272	-	-20.4160442	139.848344	Existing	-	Private
202068	-	-20.4422229	139.940272	Existing	-	Unspecified

8.1.3.2 Baseline quality of groundwater

Piper diagrams have been provided in Figure 9 (results since going into care and maintenance) and Figure 10 (results from most recent sampling event). Basic parameters have been measured for groundwater (since going into care and maintenance) and are in Table 22.

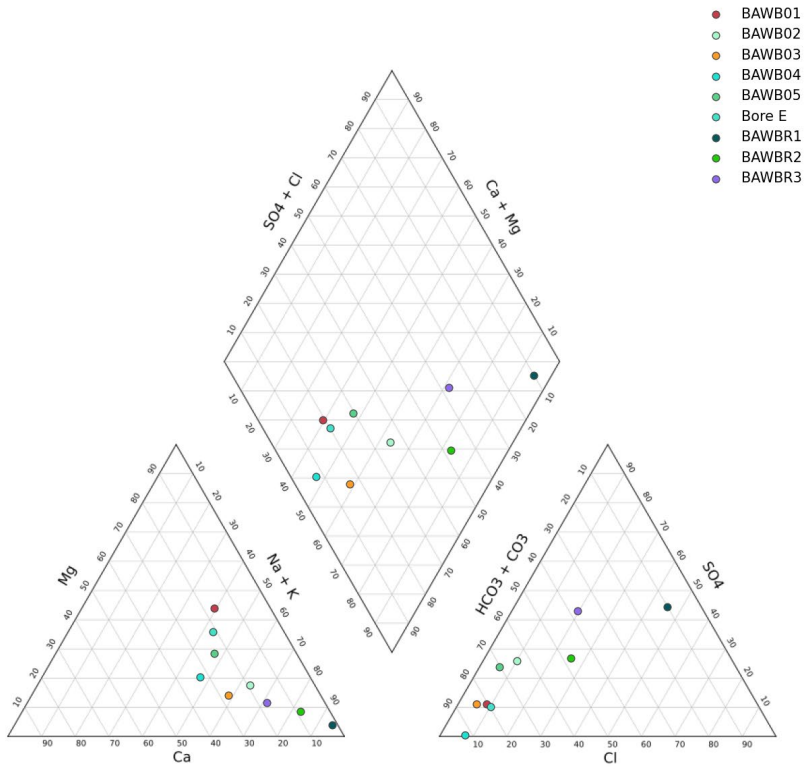


Figure 9 Piper diagram — results since going into care and maintenance

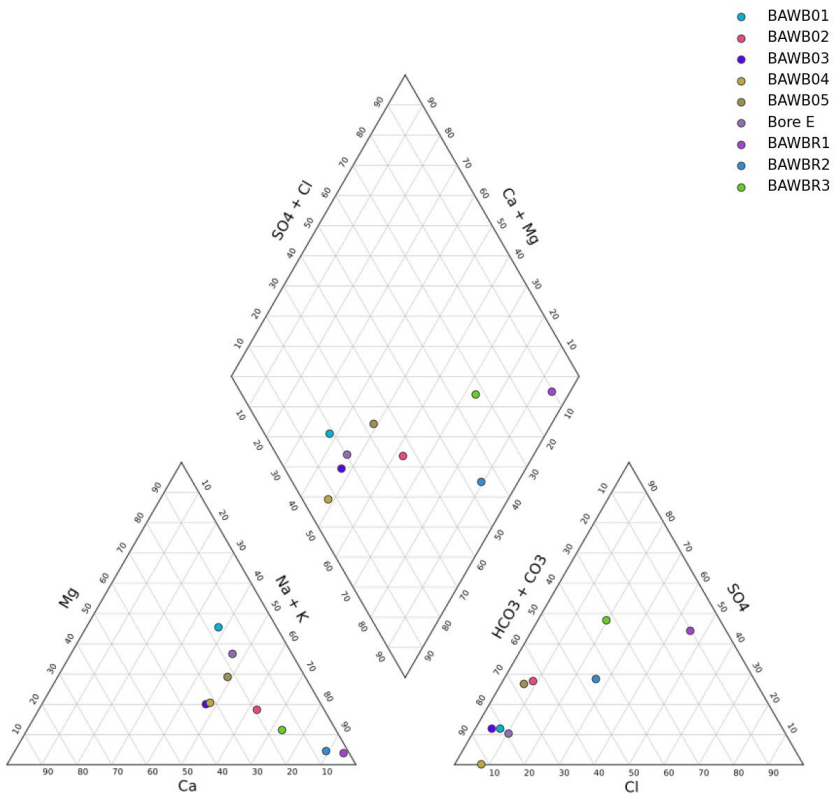


Figure 10 Piper diagram — results from most recent sampling event

Groundwater has been classified based on water type in Table 21. Results indicate that magnesium bicarbonate is the most common groundwater type.

Table 21 Groundwater classification by water type

Bore ID	Water type	
	Since going into care and maintenance	Most recent results
BAWB01	Magnesium bicarbonate	Magnesium bicarbonate
BAWB02	Mixed	Mixed
BAWB03	Mixed	Magnesium bicarbonate
BAWB04	Magnesium bicarbonate	Magnesium bicarbonate
BAWB05	Magnesium bicarbonate	Magnesium bicarbonate
Bore E	Magnesium bicarbonate	Magnesium bicarbonate
BAWBR1	Sodium chloride	Sodium chloride
BAWBR2	Sodium chloride	Sodium chloride
BAWBR3	Sodium chloride	Sodium chloride

8.1.3.3 Results of any testing to confirm aquifer properties

Testing has been done to confirm aquifer properties of the ore body and is in Appendix G. This includes airlift yield testing.

8.1.3.4 Underground ecosystems or groundwater dependent ecosystems

To determine if GDEs are present within the vicinity of the site, information was sourced from the following:

- *Queensland Globe* (Queensland Government 2023); and
- *Groundwater Dependent Ecosystems Atlas* (GDE Atlas) (BOM 2023).

Queensland Globe did not identify GDEs within 25 km of the site. As the only national inventory of GDE in Australia, GDE Atlas provides more accurate GDE mapping, describing GDE as aquatic, terrestrial or subterranean ecosystems. No aquatic or subterranean ecosystems were identified within 5 km of the site. However, the following terrestrial ecosystems were identified:

- high potential GDE — Eucalyptus spp. (*E. leucophloia, E. leucophylla, E. persistens, E. normantonensis*) low open-woodlands often with Triodia spp. dominated ground layer;
- moderate potential GDE — Eucalyptus spp. (*E. leucophloia, E. leucophylla, E. persistens, E. normantonensis*) low open-woodlands often with Triodia spp. dominated ground layer; and
- low potential GDE — Eucalyptus spp. dominated open-forest and woodlands drainage lines and alluvial plains.

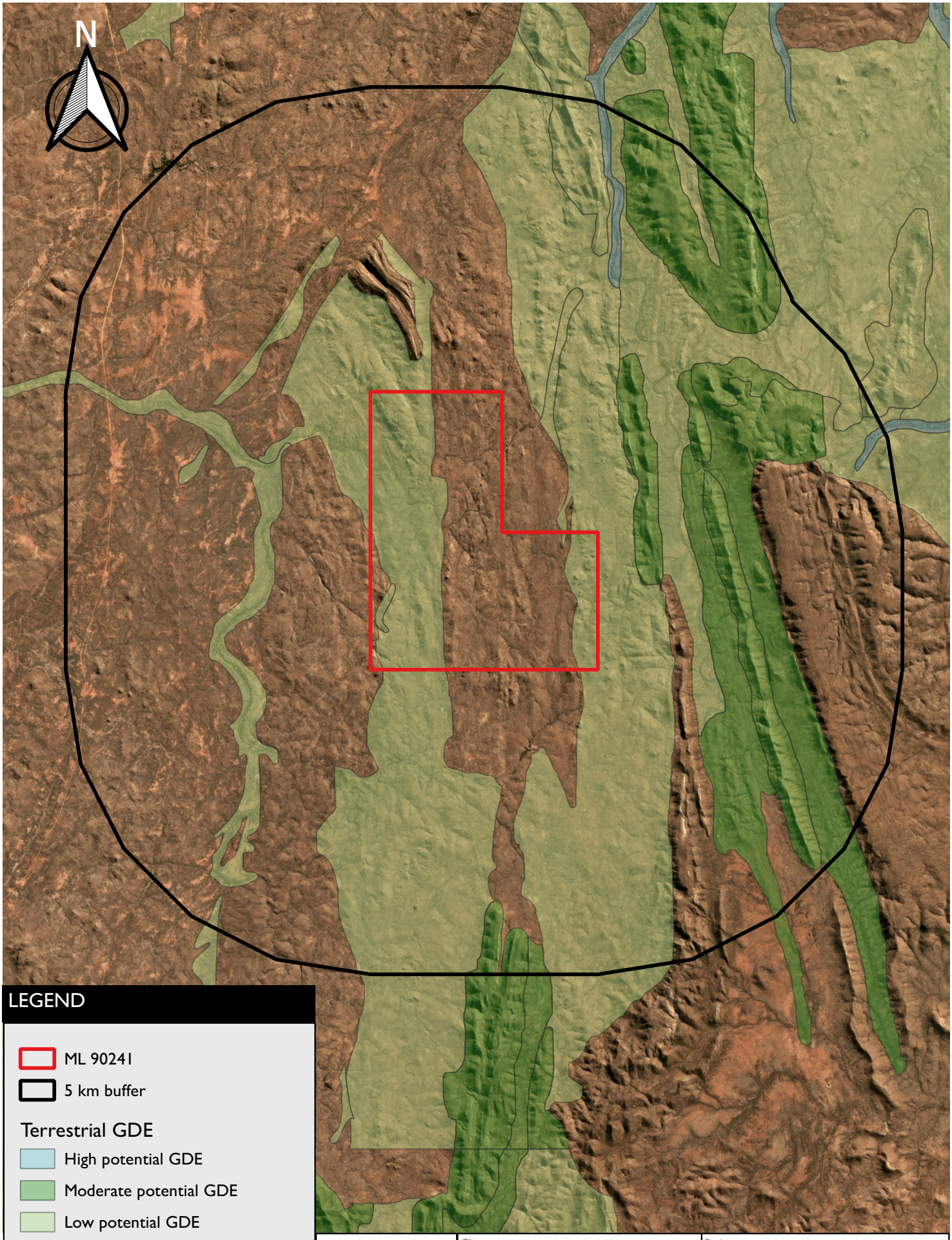
Terrestrial GDE within 5 km of the site have been mapped in Figure 11.

Table 22 Baseline quality of groundwater

Parameter	Unit	BAWB01	BAWB02	BAWB03	BAWB04	BAWB05	Bore E	BAWBR1	BAWBR2	BAWBR3
		(minimum-maximum (median))								
Physico-chemical parameters										
EC	µS/cm	758-1200 (1135)	726-1340 (1250)	773-1060 (984)	570-950 (870)	579-966 (649)	741-1280 (1045)	28,600-31,300 (29,950)	1,190-7,280 (2,210)	1,620-3,190 (3,000)
pH	pH units	7.19-8.06 (7.545)	7.57-8.13 (8.01)	7.49-8.05 (7.735)	7.37-8.03 (7.735)	7.54-8.28 (8.05)	7.01-8.39 (7.735)	8.07-8.09 (8.08)	7.46-8.24 (7.995)	7.97-8.06 (7.98)
Total hardness as $CaCO_3$	mg/L	265-420 (398.5)	166-278 (246.5)	199-279 (240)	173-269 (250.5)	168-316 (185)	224-405 (326)	1140	80-1300 (197.5)	416-517 (433)
Turbidity	NTU	0.1-8.4 (0.95)	0.3-3.4 (0.8)	0.5-1.4 (0.9)	0.4-26.3 (7.15)	0.3-18.5 (0.7)	0.2-23.8 (1.15)	9.6-16.6 (13.1)	1.9-20 (5.9)	0.6-1.8 (1.6)
Major ions										
Ca	mg/L	34-50 (45)	37-61 (53.5)	53-75 (61.5)	47-70 (63)	32-58 (36)	37-59 (50)	125-134 (129.5)	20-184 (41.5)	97-118 (112)
Cl^-	mg/L	20-39 (30.5)	18-82 (41)	14-22 (17)	13-67 (20.5)	12-22 (12)	25-77 (34.5)	5,420-5,490 (5,455)	89-950 (188)	60-220 (191)
F^-	mg/L	1.1-1.8 (1.65)	0.5-0.9 (0.8)	0.3-2.4 (0.8)	0.4-0.6 (0.5)	0.5-0.6 (0.6)	1-1.6 (1.3)	2-2.4 (2.2)	0.3-0.8 (0.45)	0.2-0.4 (0.2)
Mg	mg/L	41-80 (70)	17-32 (29)	17-26 (19)	17-26 (23.5)	23-92 (25)	41-76 (50.5)	173-185 (179)	9-277 (23.5)	44-53 (44)
K	mg/L	4-8 (6.5)	6-14 (10)	7-14 (12)	4-9 (6)	13-20 (19)	9-12 (10)	35-36 (35.5)	4-19 (9)	6-8 (8)
Na	mg/L	70-136 (115.5)	106-219 (194)	69-150 (142)	66-119 (100)	63-92 (68)	84-125 (109.5)	7,790-7,920 (7,855)	209-1,540 (431.5)	228-627 (516)
SO_4^{2-}	mg/L	41-65 (58)	78-166 (144.5)	40-53 (48)	<1-39 (2)	22-75 (67)	31-63 (47.5)	7,220-7,360 (7,290)	143-1,290 (272)	455-737 (581)
Alkalinity										
Bicarbonate alkalinity as $CaCO_3$	mg/L	358-583 (514)	279-477 (456)	358-477 (451.5)	306-474 (440)	218-458 (250)	261-515 (468)	2,120-2,220 (2,170)	352-2,140 (610)	255-662 (643)
Carbonate alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1
Hydroxide alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total alkalinity as $CaCO_3$	mg/L	358-583 (514)	279-477 (456)	358-477 (451.5)	306-474 (440)	218-458 (250)	261-515 (468)	2,120-2,220 (2,170)	352-2,140 (610)	255-662 (643)

Parameter	Unit	BAWB01	BAWB02	BAWB03	BAWB04	BAWB05	Bore E	BAWBR1	BAWBR2	BAWBR3
		(minimum-maximum (median))								
Total metals										
As	mg/L	<0.001-0.002 (0.002)	<0.001-0.002 (<0.001)	<0.001-0.001 (<0.001)	<0.001-0.002 (0.001)	<0.001-0.003 (0.001)	0.001-0.003 (0.002)	0.006-0.007 (0.0065)	0.001-0.011 (0.0045)	0.002-0.003 (0.002)
Ba	mg/L	0.027-0.164 (0.062)	0.083-0.197 (0.175)	0.084-0.14 (0.1305)	0.297-0.529 (0.48)	0.153-0.399 (0.167)	0.109-0.258 (0.194)	0.076-0.096 (0.086)	0.069-0.182 (0.1175)	0.031-0.05 (0.047)
Bi	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05-0.2	<0.05
Cr	mg/L	<0.001	<0.001	<0.001-0.001 (<0.001)	<0.001-0.006 (<0.001)	<0.001	<0.001-0.007 (0.003)	<0.001	<0.001-0.013 (0.0015)	0.002-0.005 (0.003)
Co	mg/L	<0.001-0.002 (0.002)	<0.001	<0.001-0.001 (<0.001)	<0.001	<0.001	<0.001-0.002 (0.002)	0.013-0.014 (0.0135)	<0.001-0.009	<0.001-0.002 (0.002)
Cu	mg/L	0.001-0.005 (0.0025)	<0.001-0.008 (0.0015)	<0.001-0.003 (0.002)	<0.001-0.005 (0.0015)	<0.001-0.009 (0.003)	<0.001-0.005 (0.001)	<0.001-0.009	0.009-0.89 (0.127)	0.004-0.011 (0.006)
Mo	mg/L	0.002-0.004 (0.004)	0.001-0.004 (0.003)	0.002-0.004 (0.003)	0.002-0.004 (0.0025)	0.007-0.027 (0.025)	0.002-0.004 (0.003)	0.195-0.216	0.001-0.017 (0.004)	0.004-0.011 (0.004)
Ni	mg/L	<0.001-0.003 (<0.001)	<0.001-0.004 (<0.001)	<0.001-0.004 (<0.001)	<0.001-0.004 (<0.001)	<0.001-0.014 (<0.001)	<0.001-0.007 (0.0025)	<0.001	0.001-0.033 (0.0075)	<0.001-0.001 (<0.001)
Se	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
U	mg/L	0.004-0.007 (0.006)	0.003-0.006 (0.005)	0.003-0.007 (0.006)	<0.001-0.002 (0.002)	0.002-0.004 (0.002)	0.003-0.007 (0.006)	0.448-0.459 (0.4535)	0.007-0.156 (0.0225)	0.005-0.1 (0.019)
Dissolved metals										
As	mg/L	<0.001-0.002 (0.001)	<0.001	<0.001-0.001 (<0.001)	<0.001-0.001 (0.001)	<0.001-0.002 (0.001)	0.001-0.003 (0.002)	0.006	0.001-0.01 (0.0025)	0.002-0.003 (0.002)
Ba	mg/L	0.03-0.146 (0.057)	0.088-0.179 (0.1555)	0.085-0.135 (0.1205)	0.286-0.493 (0.425)	0.141-0.374 (0.157)	0.1-0.474 (0.1765)	0.091-0.096 (0.0935)	0.03-0.162 (0.0765)	0.031-0.049 (0.047)
Bi	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05-0.06 (<0.05)	<0.05
Cr	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001-0.007	0.001-0.006 (0.003)
Co	mg/L	<0.001-0.002 (0.001)	<0.001	<0.001-0.001 (<0.001)	<0.001	<0.001	<0.001-0.002 (0.001)	0.013-0.015 (0.014)	<0.001-0.005	<0.001-0.001 (0.001)
Cu	mg/L	<0.001-0.002 (<0.001)	<0.001-0.005 (<0.001)	<0.001	<0.001-0.02 (<0.001)	<0.001-0.002 (<0.001)	<0.001-0.004 (<0.001)	<0.001-0.007	0.005-0.247 (0.021)	0.002-0.008 (0.004)
Mo	mg/L	0.002-0.004 (0.003)	0.001-0.004 (0.002)	0.002-0.005 (0.002)	0.002-0.003 (0.002)	0.005-0.023 (0.02)	0.001-0.004 (0.003)	0.209-0.212 (0.2105))	<0.001-0.018 (0.003)	0.003-0.011 (0.007)
Ni	mg/L	<0.001-0.003 (<0.001)	<0.001-0.004 (<0.001)	<0.001-0.002 (<0.001)	<0.001-0.004 (<0.001)	<0.001	<0.001-0.005 (0.001)	<0.001	<0.001-0.025 (0.004)	<0.001

Parameter	Unit	BAWB01	BAWB02	BAWB03	BAWB04	BAWB05	Bore E	BAWBR1	BAWBR2	BAWBR3
		(minimum-maximum (median))								
Se	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
U	mg/L	0.004-0.006 (0.005)	0.003-0.006 (0.0045)	0.003-0.006 (0.005)	<0.001-0.002 (0.002)	0.002-0.003 (0.002)	0.002-0.006 (0.005)	0.461-0.496 (0.4785)	0.003-0.143 (0.0165)	0.004-0.096 (0.018)



SGM environmental	Client: Aeris Resources Limited	Project: Barbara EA amendment	
	Design: SGM Environmental Pty Ltd 04.12.2023 Scale: 1 : 80,000 CRS: GDA2020	Title: Terrestrial GDE within 5 km of the site	Figure: 11

© SGM Environmental. While every care is taken to ensure the accuracy of this data, SGM Environmental makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and liability (including without limitaiton liability in negligence) for all expenses, losses, damages (including indirect consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.

8.2 Possible impacts to identified environmental values

This section examines potential impacts and their associated risk to identified EVs (water).

8.2.1 Discharges and releases

The EA amendment does not require additional release points to receiving waters.

8.2.2 Unplanned and uncontrolled releases

No new infrastructure is required to manage contaminants, specifically mine affected water. Mine affected water will be held in regulated dams registered in EA EPML02840015. Dams are inspected each year for compliance and are monitored to ensure that they do not exceed specified design storage allowances (DSA). DSA and hydraulic performance will not change. A water management plan and water balance model have been prepared to support this (Appendix H). South Pit and North Pit did not overtop or spill in any of the realisations, and the WRD Sediment Dam only overtopped or spilled in two realisations. However, this was following sequentially very wet years.

8.2.3 Water infrastructure

The EA amendment does not require additional water infrastructure. A consequence category assessment (CCA) has been completed for South Pit by ATC Williams Pty Limited (ATC Williams) (Appendix I) to reflect the change to operations, with proposed UG mining including underground workings via a portal in South Pit. Findings have been summarised in Section 8.2.3.1.

8.2.3.1 Consequence category assessment for South Pit

EA EPML02840015 currently lists the consequence category of South Pit as 'Significant'. However, reassessment indicates that it should only be considered 'Low' and, therefore, should not constitute a regulated structure. The following failure event scenarios have been assessed:

- failure to contain — seepage;
- failure to contain — overtopping; and
- failure to contain — dam break.

These failure event scenarios have been assessed to determine the potential for:

- harm to humans,
- general environmental harm; and
- general economic loss or property damage.

a Failure to contain — seepage

Harm to humans has been assessed as low because there are no bores registered for human consumption or usage within 5 km of South Pit. General environmental harm has been assessed as low because water balance modelling indicates that there is no seepage outflow. General economic loss or property damage has been assessed as low because there are no third-party assets located near South Pit.

b Failure to contain — overtopping

Harm to humans and general economic loss or property damage have been assessed as low because peak water surface elevation in the void would not reach the portal elevation (310 m AHD) under operational conditions. Therefore, overtopping would not occur. This is supported by the water balance model (Appendix H). General environmental harm has been assessed as low for the same reason with the inclusion that if overtopping did

occur, flows would enter the underground workings via the portal and would not enter the surrounding environment.

c Failure to contain — dam break

This is not a credible failure scenario as South Pit does not contain a dam wall.

8.2.3.2 Development of an emergency response plan

A trigger action response plan (TARP) will be developed with consideration of the following recommendations listed in the South Pit CCA (Appendix I):

- regular and ongoing monitoring of water levels;
- using the modelled maximum of South Pit (290 m AHD) as the trigger level for initiating emergency actions; and
- including specific actions for rapid water management.

8.2.4 Groundwater

The site contains no major watercourses or permanent waterbodies. Surface water is limited to drainage lines and ephemeral watercourses which only flow after heavy rainfall (WMV Environmental 2022). Semi-permanent springs and seeps occur in some of these watercourses, and have limited interaction with groundwater. This is discussed in Appendix G. Surface-groundwater interactions are limited as drainage lines and ephemeral watercourses are shallow and the depth to groundwater exceeds 8 mbgl throughout the site (WMV Environmental 2022).

8.2.5 Terrestrial GDEs

Groundwater drawdown from UG mining would have negligible impact on terrestrial GDEs as the maximum drawdown extent does not overlap with mapped terrestrial GDEs (Appendix J). Post-mining, drawdown extent would reduce as water levels in the open pits and underground voids recover, further mitigating any potential risk. Mitigation measures are provided in the risk assessment (Appendix A) as a precautionary measure. They are considered sufficient as there is no interaction between groundwater drawdown extent and mapped terrestrial GDEs, the nearest mapped terrestrial GDEs are classified as "low potential GDEs" and previous mining did not have a significant impact on groundwater levels.

8.2.6 Wetlands

To determine if wetlands are present within the vicinity of the site, information was sourced from the following:

- Queensland Globe (Queensland Government 2023); and
- Australian Wetlands Database (DCCEEW 2021).

No high ecological significance (HES) wetlands were identified on or adjacent to the site. The closest wetland area is ~1.2 km west of the site, with both lacustrine and riverine wetland areas identified within 5 km of the site.

8.2.7 Great Barrier Reef catchment waters

There are no potential impacts from the EA amendment on Great Barrier Reef catchment waters.

8.2.8 Ecology and hydrology of receiving water

The EA amendment is unlikely to result in a significant additional impact on aquatic ecology of waters as there are no additional release points, and only limited surface-groundwater interactions on the site. There is also no significant alteration to flow patterns in receiving surface waters.

8.2.9 Risk assessment

The risk assessment is in Appendix A and discussed in Section 5.1.

8.2.10 Hazards

Both waste rock and extracted ore can contribute contaminants to water. The previous water management plan (ATC Williams 2019) and a geochemistry investigation (EGi 2014) indicate that waste rock can contribute the following contaminants to water:

- elevated Cu, S, Se, Bi and Co; and
- increased acidity from acid mine drainage (AMD).

Sulfuric acid can be generated when PAF material, rich in S, reacts with surface water and oxygen. It is a natural process, but can be exacerbated through mining as buried PAF material is exposed to water and oxygen. Iron oxidising bacteria can accelerate acid generation. Therefore, common treatments focus on inhibiting these bacteria. Furthermore, heavy metals can be leached from rocks that come into contact with sulfuric acid.

Sulfuric acid can have both moderate acute and moderate chronic toxicity on aquatic organisms (DCCEEW 2022). This is generally caused by sulfuric acid mixing with water and subsequently lowering pH levels. Sulfuric acid does not bioaccumulate, but can leach heavy metals which have the potential to bioaccumulate.

8.2.11 Mixing zones

The EA amendment does not require additional planned / controlled releases to water. Contaminated water will be released from release points specified in EA EPML02840015, following all EA conditions. Furthermore, no HES waters, as defined in the *Environmental Protection Policy (Water)* (EPP water), have been identified on or surrounding the site.

8.2.12 Discharges to groundwater

The EA amendment does not require direct discharge of contaminants to groundwater.

8.2.13 Groundwater impact assessment

The groundwater impact assessment is in Appendix F.

8.2.14 Strategic environmental areas

There is no potential impact from the EA amendment on SEAs.

8.3 Proposed management practices

This section describes planned management practices.

8.3.1 Management hierarchy

Consistent with the management hierarchy for surface and groundwater in Section 14 of the EPP water, the release of waste water or contaminants to waters must be managed through the following steps:

1. water use must be minimised to limit the production of waste water and contaminants;
2. prevent waste and implement appropriate waste prevention measures;
3. evaluate treatment and recycling options and implement appropriate treatment and recycling; and
4. evaluate the following options for waste water and contaminants:

- appropriate treatment and release to waste facility or sewer;
- appropriate treatment and release to land; and
- appropriate treatment and release to surface waters or groundwaters.

AMD and metal leaching are the most likely contaminants to seep into water. Step 4 of the management hierarchy is most appropriate as the amount of PAF waste rock cannot be prevented, nor can PAF waste rock be recycled through earlier steps. However, the potential impact can be mitigated through appropriate waste rock management, including waste characterisation and appropriate disposal.

8.3.2 Unavoidable discharges

The EA amendment does not require additional storage, which may lead to an unavoidable discharge.

8.3.3 Proposed limits

Proposed limits have not been provided as the EA amendment does not require activities with unavoidable discharge.

8.3.4 Stormwater management

The EA amendment does not require additional stormwater release discharge points.

8.3.5 Extraction near a watercourse

The EA amendment does not require extraction near a watercourse.

8.4 Management plans

This section describes the management plans that have been implemented to prevent unnecessary impacts to EVs (water).

8.4.1 Monitoring program

The current site monitoring program includes:

- stormwater monitoring;
- waste water release monitoring;
- receiving environment monitoring; and
- quality assurance, assessment of results and reporting outcomes.

8.4.1.1 Waste water release monitoring

Waste water release monitoring will be compliant with the stipulations for contaminant release in EA EPML02840015, which includes:

- Monitoring at the frequency specified in EA *Table E2* — once within two hours of a release event commencing. For release events which exceed twenty-four hours, once daily for one week and then once a week until the release event ceases.
- Testing samples for all contaminants listed in EA *Table E2*.

8.4.1.2 Receiving environment monitoring

Receiving environment monitoring will be compliant with the stipulations in EA EPML02840015, which includes:

- Monitoring at locations specified in EA *Table E3*;
- Monitoring at the frequency specified in EA *Table E4* — for water quality, once within two hours of a release event and then daily until the release event ceases. It must be sampled at least once every three months if surface water is present. For sediment quality, it must be sampled at least twice per year, once at the end of the wet season and once at the end of the dry season.
- Testing for all contaminants in EA *Table E4*.

8.4.2 Groundwater monitoring program

The site currently has a groundwater monitoring program.

8.4.3 Stormwater management

The site currently has an erosion and sediment control (ESC) plan, which includes strategies for managing stormwater.

8.4.4 Water management plan

The site currently has a water management plan.

8.5 Rehabilitation of the site

8.5.1 Rehabilitation

The site will be rehabilitated consistent with the PRC Plan and progressive rehabilitation and closure plan schedule (PRC Plan Schedule).

9.0 Impacts from waste

Consistent with Schedule 8, Part 3, Division 1 of the EP Regulation, this section describes how the following environmental objective, along with its performance outcomes, will be achieved:

> ***Environmental objective***
> *Any waste generated, transported, or received as part of carrying out the activity is managed in a way that protects all environmental values.*

This section only examines waste rock as its management has changed. All other waste sources and their impacts have previously been examined.

9.1 Possible impacts and associated risks to identified environmental values

9.1.1 Site plan

The site plan is in Figure 13.

9.1.2 Types of waste

Waste rock is the primary type of waste generated, consisting of both non-acid-forming (NAF) and potentially acid-forming (PAF) material. It is solid in nature and generated from mining, where it has been removed to access the target material or contains only trace amounts of the target material and it is not considered economically feasible to recover.

Core sampling has been done for environmental characterisation of waste rock. *Memorandum: Barbara Total Carbon Assays* (Appendix K) describes the sulfur and carbon (C) percentage of different lithologies in the footwall of the deposit. Noting that samples from the hanging wall have been used (in addition) where there are limited samples to describe the lithology of the footwall. The results are in Table 23.

Table 23 Total carbon and sulfur percentages

Lithology	Count	Total C %				S %				C:S ratio	Correl Coeff
		Min	Max	Mean	Std Dev	Min	Max	Mean	Std Dev		
Amphibolite	3	0.21	1.84	0.78	0.92	0.08	0.37	0.19	0.16	4.0	-0.67
Biotite Schist	10	0.06	0.68	0.26	0.23	0.01	0.16	0.07	0.06	3.5	0.86
Dolerite	25	0.06	0.85	0.25	0.19	0.05	0.87	0.18	0.15	1.4	0.18
Mafic Intrusive	2	0.01	0.05	0.03	0.03	0.05	0.06	0.06	0.01	0.5	-1
Mafic Schist	6	0.05	1.15	0.73	0.48	0.09	0.26	0.17	0.07	4.4	0.86
Rhyodacite	48	0.01	3.34	0.29	0.56	0.01	0.52	0.10	0.11	2.8	0.15
Schist	10	0.03	0.42	0.11	0.11	0.01	0.40	0.09	0.12	1.2	0.29

This information has been derived from *Memorandum: Total Carbon Assays* (Aeris Resources 2023).

Results indicate that most lithologies have a S% less than (<) 0.3%, which is the threshold for defining waste rock material as NAF or PAF. This included Rhyodacite and Dolerite, which are the most common lithologies present in the footwall.

The waste balance indicates that ~390,747 t of waste rock is expected from UG mining, with ~306,456 t being NAF material and ~84,292 t being PAF material. This is likely to occur over 2 years and 8 months, giving an average rate of 12,211 tonnes per month (t/month).

9.1.3 Suitability of data for modelling, and validation sampling

Validation sampling will be completed during operations. Material that is closer to the ore body is likely to be PAF and shall be treated appropriately once verified, with validation sampling and an updated block model expected during operations. Kinetic leach column (KLC) results provide detailed information on the waste materials at site to be encapsulated or used for rehabilitation (ie NAF cover on WRD). Void water quality modelling uses the KLC results, which represent material (NAF & PAF) proposed to be returned back underground. KLCs offer a more detailed evaluation of acid generation, salt and metal release than static tests, which is crucial for understanding waste behaviour and its potential environmental impacts. KLCs are more representative of site conditions as there is a continuous flow of water to simulate natural rainfall and / or groundwater flow. Because testing occurs at various intervals, they can quantify leaching rates for different contaminants over time which is critical for modelling and predicting long-term environmental impacts.

KLCs were run over a 52-week period, with leachate concentrations either stable or declining at the end of the test period and within the *ANZECC 2000 Water Quality Guidelines* for livestock drinking.

9.1.4 Waste treatment processes

The EA amendment does not result in additional waste treatment processes.

9.2 Waste and resource management hierarchy

This section describes how waste rock will be managed, consistent with the waste rock and resource management hierarchy in the *Waste Reduction and Recycling Act 2011*.

9.2.1 Disposal of waste rock

Waste rock generated from UG mining is untreated. Most of it, including all PAF material, will be used to backfill stope voids. Additional waste rock (~139,000t) will be sourced from the existing WRD's upper level, preferentially PAF, to backfill stope voids as there is a known deficit (Figure 12). The remainder of the WRD landform will remain unchanged.

Figure 12 Existing WRD — source location for waste rock deficit (blue polygon)

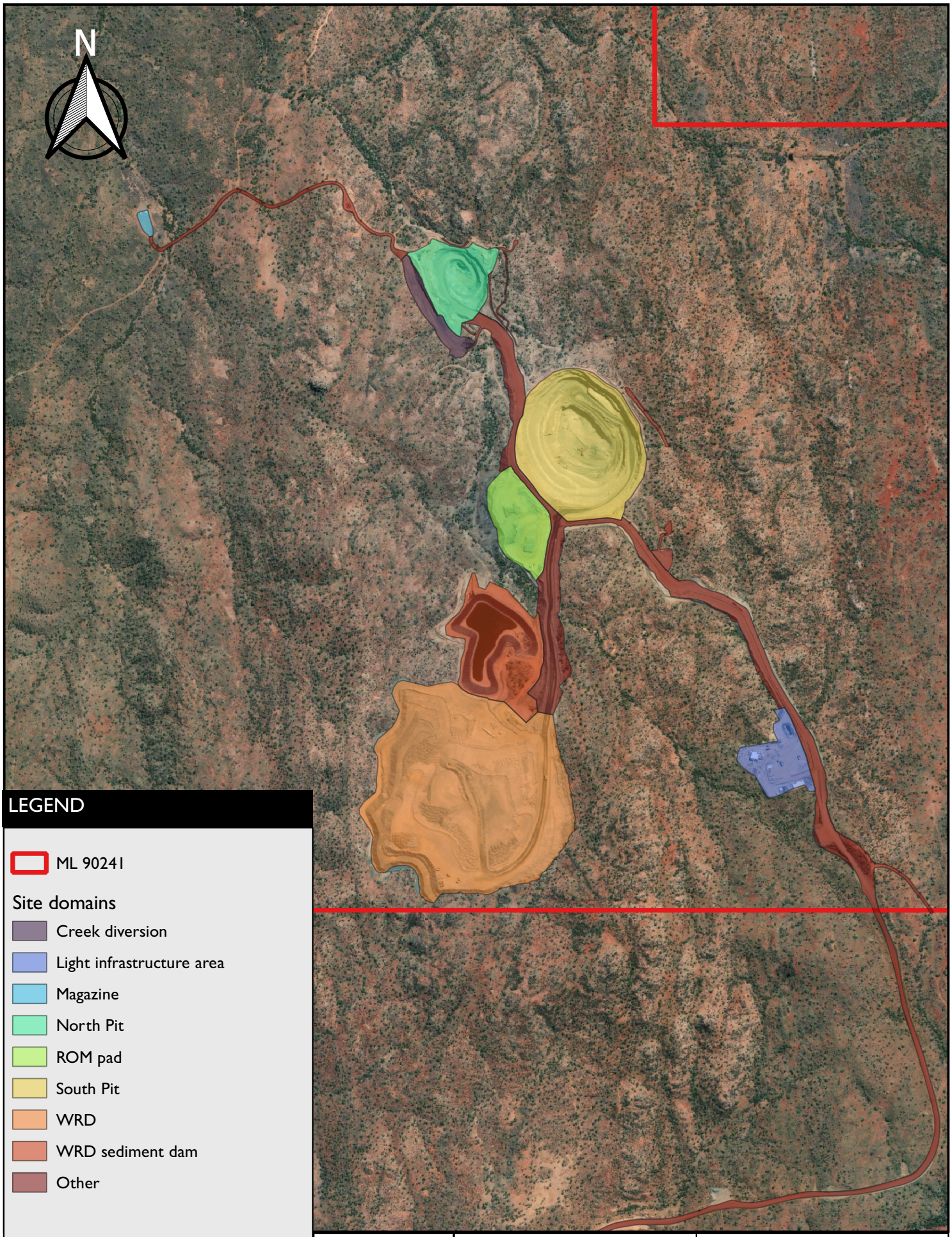
Removal of the small volume of waste rock from the upper level of the existing WRD is not expected to cause environmental harm to identified EVs. Removing the upper level of the WRD will not change the erosion risk because the cover design and slope design will be the same for the remaining levels. Therefore, erosion modelling is still relevant and has not been updated in the PRC plan. The average gradient on the upper surface will continue to be 3 % to facilitate rapid runoff and avoid pooling.

Placing PAF material in underground voids can cause acid mine drainage if PAF material comes into contact with oxygen over time. The placement of PAF material underground has been considered in Section 10.7.3 (Appendix F), with water quality modelling of the final void underground workings factoring in PAF placement underground. Despite the potential for groundwater contamination, this is unlikely to occur as demonstrated by the results from the mixing model (Appendix G and Appendix J). The model determined that groundwater quality remains within relevant guideline values for the final void underground workings and is suitable for a PMLU of livestock watering. Sensitivity analysis was completed to verify the results (Appendix J). There were no modelled groundwater outflows, indicating that groundwater contamination would be relatively confined if it did occur.

The WRD final cover is NAF material (ie no change from PRC plan). Therefore, it is unlikely to result in a significant additional impact on identified EVs.

Waste rock from underground will be characterised in accordance with EA condition C3 during operations to validate its classification as NAF / PAF in the block model and handling. If waste rock cannot be properly characterised prior to placement, it will be considered PAF material for management purposes.

PAF material brought to surface will be temporarily stored on the ROM pad prior to returning it back underground where it will become saturated below the groundwater return level, thereby reducing oxidating conditions.



LEGEND

ML 90241

Site domains

- Creek diversion
- Light infrastructure area
- Magazine
- North Pit
- ROM pad
- South Pit
- WRD
- WRD sediment dam
- Other

Scale 1 : 10 000

0 100 200 m

SGM environmental

Client: Aeris Resources Limited		Project: Barbara EA amendment	
Design: SGM Environmental Pty Ltd 29.11.2023 Scale: 1 : 10 000 CRS: GDA2020		Title: Site plan	Figure: 13

9.2.2 Cleaner production or waste management strategies

Generation of waste rock cannot be avoided or further minimised. However, UG mining is an effective waste management strategy when compared to opencut mining as it generates less waste rock for every tonne of ore mined.

9.2.3 Reuse

As previously mentioned, NAF material generated from UG mining may be used as part of the cover system for the existing WRD, as per the PRC plan. All PAF material will be placed back underground to fill UG workings, along with waste rock from the existing WRD's upper level as there is a known deficit. The latter will slightly reduce the onsite storage volume.

9.3 Waste transport

This section describes the machinery and methods which will be used for waste transport.

9.3.1 Appropriate machinery — vehicles, tanks and containers

An inventory of mobile equipment has not been finalised. Therefore, the CAT AD45 underground truck and CAT R1700 underground loader have been used as proxy. These vehicles are deemed appropriate as they are industry standard equipment.

9.3.1.1 CAT AD45 underground truck

Caterpillar Inc. (CAT) designs and manufactures mining equipment on a world scale. The CAT AD45 underground truck can have a body capacity between 18.0 and 25.1 cubic metres (m^3) and a shipping mass between 42,825 and 43,645 kg. The body is made from high quality materials (including steel), making it suitable for carrying waste rock. Regular and ongoing maintenance will be done to ensure safe operation and to limit the chance of spills. This includes servicing the tailgate as necessary.

9.3.1.2 CAT R1700 underground loader

The CAT R1700 underground loader is an ideal pairing with the CAT AD45 underground truck. It has a bucket capacity between 5.7 and 8.6 m^3, which is made from high quality steel. As with the CAT AD45 underground truck, it will undergo regular and ongoing maintenance to ensure safe operation.

9.3.2 Waste transport

Waste will be loaded and transported using industry standard underground loaders and trucks.

9.4 Proposed management practices

This section describes the proposed management practices, more specifically the facilities and procedures, that will be used to limit the impact from waste.

9.4.1 Facilities and procedures

Field-based and laboratory-based testing will be used to characterise waste rock prior to handling and disposal, consistent with EA conditions C1 and C3. This includes recording and retaining details until the EA is surrendered.

10.0 Impacts from subsidence

A geotechnical assessment has been done to determine the impact that UG mining may have on the stability of the South and North Pit, and surrounding area. The full report in Appendix L was completed by Sidney Chisala, Senior Geotechnical Engineer (RPEQ 15151), who is considered an appropriately qualified person. The following points summarise the main findings:

- no stress related issues are expected from UG mining due to the shallow depth of the opencut mine;
- mining induced stresses may include rock mass relaxation in and around stoping areas;
- stopes below the South Pit are located in fresh rock, giving stope crown stability;
- backfilling stope voids and / or using rib and sill pillars (as required) should be used to improve stope stability;
- to minimise hanging wall overbreak when weak ground conditions are encountered, stopes should be backfilled immediately following stope completion;
- up-hole blind stopes are not expected to be a subsidence risk, despite being unfilled, due to the size of the crown pillar;
- stope sizes should be adjusted based on ground conditions to maintain stability;
- up-hole blind stope voids are unlikely to break through to the surface as they have been designed with sufficient cover (~80 m);
- **subsidence risk is low** due to the mining method (sub-level open stoping with waste rock backfill), which does not require caving;
- surface disturbance is restricted to the base of the South Pit, where a void will form from mining the pit crown stopes;
- **no surface disturbance will occur outside the Barbara Open Pit Closure boundary bund**; and
- the main portal will be backfilled with NAF waste rock and contain a shotcrete bulkhead in front of the backfill;
- the shotcrete bulkhead will contain drainage holes so that surface runoff can drain underground (Aeris Resources 2024).

Based on these findings, the risk of subsidence is low, assuming that the recommended control measures are implemented. There is limited potential for EVs to be significantly impacted.

11.0 Conclusions

The proponent seeks to amend *Table D2 — Blasting noise limits* (Table 4) to permit blasting at shift change, slightly outside of the currently accepted hours. The limits would be amended to meet the standard blasting conditions for UG mining. This is unlikely to result in a significant additional impact as the closest sensitive receptor is ~23 km away.

Table A1 (Table 3) and *Schedule J — Map 1 Location of authorised disturbance* (Figure 1) must also be amended to include the entrance portal to the underground mine and surface vent fan.

A desktop review was used to assess the impact of UG mining on EVs (air and noise). This was deemed appropriate as the operation scale and intensity has notably reduced, and no air quality objectives were exceeded during opencut mining. For these same reasons, there is unlikely to be a significant additional impact on EVs (air and noise).

A water balance model and conceptual groundwater model have been used to assess the potential impact on surface water and groundwater. The water balance model indicates that water can be managed using the existing water management infrastructure, with no change in DSA or hydraulic performance required. It indicates that overtopping does not occur under normal conditions in any realisations for South Pit and North Pit, and that overtopping only occurs in two realisations for the WRD Sediment Dam. However, this is not expected to be an issue as the current water level for the WRD Sediment Dam is higher than the median expected water level over time.

Water quality modelling of the open pits, sediment dam and UG workings indicate that water will be compliant with the *ANZECC 2000 Water Quality Guidelines* for livestock watering at all times. Therefore, they are suitable for the PMLU livestock watering.

The conceptual groundwater model determined that the open pits are unlikely to impact surface water as there is limited (close to non-existent) interaction between deeper groundwater and creeks within the ML. And concluding that there is no surface water / groundwater interaction from UG mining.

The impacts from waste can be managed by characterising waste rock prior to disposal, and separating NAF and PAF material during temporary storage and final placement. Assuming these control measures are in place, there is unlikely to be a significant additional impact on EVs from waste from that which occurred during opencut activities.

A geotechnical assessment was done to assess the risk of subsidence. It indicates that there is only a low risk of subsidence and therefore, there is unlikely to be a significant additional impact on EVs. It also confirms that no surface disturbance will occur outside of the Barbara Open Pit Closure Boundary, and recommends that the portal be backfilled with NAF waste rock (minimum 50 m down the decline) and contain a shotcrete bulkhead in front of the backfill at completion. This has been added to the milestone criteria for RM1 (infrastructure decommissioning) of the PRC schedule.

Based on the assessments completed, UG mining is not expected to have a significant additional impact on EVs or result in an increase in scale or intensity above that which occurred during opencut mining.

References

Aeris Resources 2023, *Memorandum: Total Carbon Assays*, prepared for Aeris Resources Limited by Aeris Resources Limited.

Aeris Resources 2024, *Memorandum: Geotechnical Assessment for the Barbara Underground — Subsidence Risk*, prepared for Aeris Resources Limited by Aeris Resources Limited.

ASK Consulting Engineers 2014, *Barbara Copper Project — Air Quality Impact Assessment*, prepared for CopperChem Limited and Syndicated Metals Limited by ASK Consulting Engineers Pty Limited.

ASK Consulting Engineers 2014, *Barbara Copper Project — Noise Impact Assessment*, prepared for CopperChem Limited and Syndicated Metals Limited by ASK Consulting Engineers Pty Limited.

AS/NZS 3580.10.1 2003: Methods for sampling and analysis of ambient air — Determination of particulate matter — Deposited matter — Gravimetric method.

ATC Williams 2019, *Barbara Copper Project — Water Management Plan Update*, prepared for Round Oak Minerals Pty Limited by ATC Williams Pty Limited.

BOM 2023a, Climate Statistics for Australian Locations, viewed 29 November 2023, http://www.bom.gov.au/climate/averages/tables/cw_029127.shtml

BOM 2023b, Monthly Rainfall, viewed 28 November 2023, http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_stn_num=029181

BOM 2023c, Monthly Mean Maximum Temperature, viewed 28 November 2023, http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=36&p_display_type=dataFile&p_stn_num=029181

BOM 2023d, Monthly Mean Minimum Temperature, viewed 28 November 2023, http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=38&p_display_type=dataFile&p_stn_num=029181

BOM 2024, *Groundwater Dependent Ecosystems Atlas*, viewed 8 February 2024, http://www.bom.gov.au/water/groundwater/gde/map.shtml

DCCEEW 2021, *About the Australian Wetlands Database*, viewed 8 February 2024, https://www.dcceew.gov.au/water/wetlands/australian-wetlands-database

DCCEEW 2022, *Sulfuric Acid*, viewed 8 February 2024, https://www.dcceew.gov.au/environment/protection/npi/substances/fact-sheets/sulfuric-acid

DES 2023, *Guideline Environmental Protection Act 1994 Major and minor amendments*, Department of Environment and Science.

EGi 2014, *Barbara Copper Project — Assessment of Waste Rock Geochemistry*, prepared for Round Oak Minerals Pty Limited by Environmental Geochemistry International Pty Limited.

ERM 2009, *Integra Underground Coal Project — Noise Impact Assessment*, prepared for Integra Coal Operations Pty Limited by Environmental Resources Management Australia Pty Limited.

ISO 2018, *ISO 31000:2018 — Risk management guidelines*, International Organisation for Standardisation.

WMV Environmental 2022, *Barbara Copper Project Progressive Rehabilitation and Closure Plan — Groundwater Technical Report*, prepared for Round Oak Minerals Pty Limited by WMV Environmental Pty Limited.

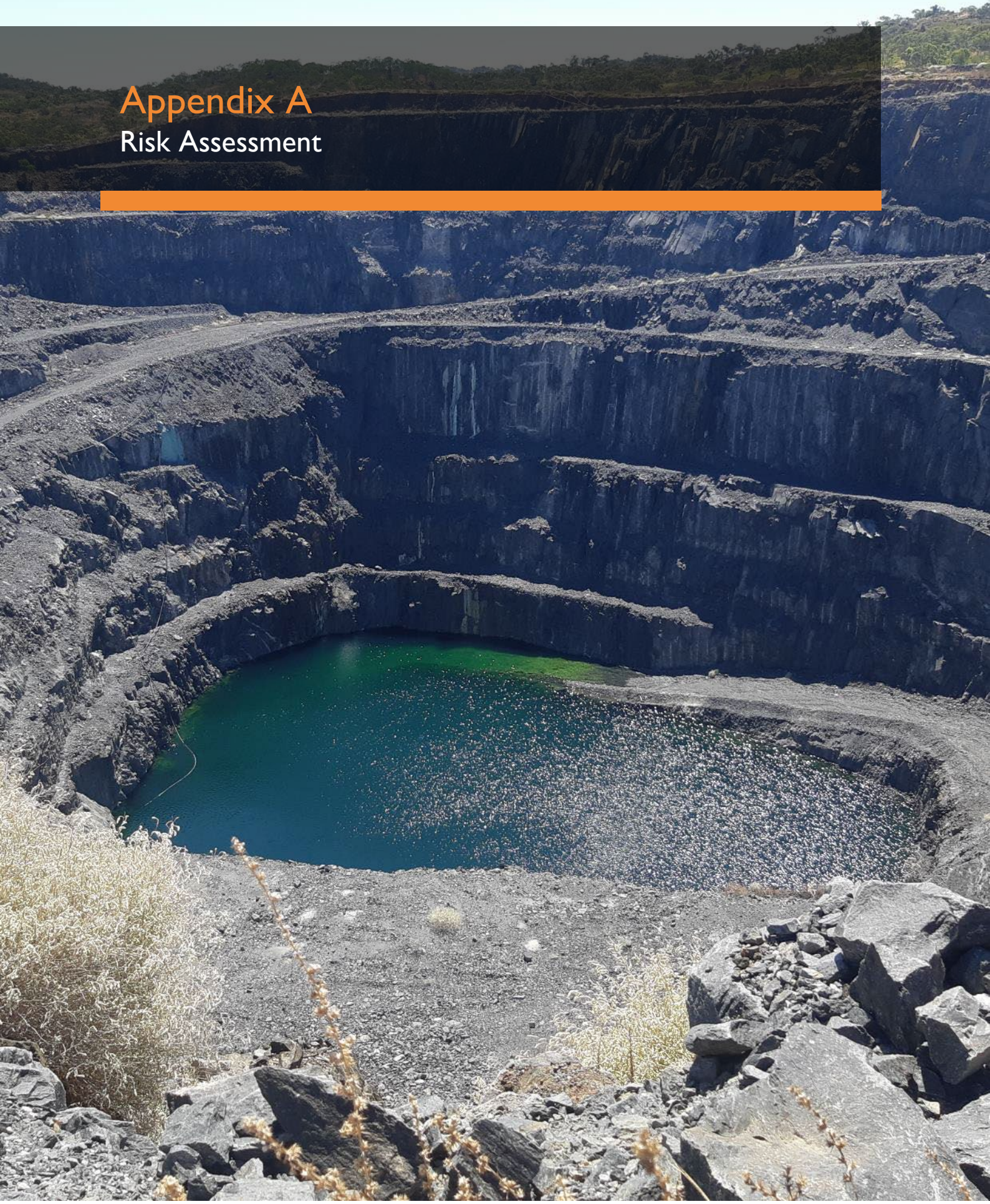
Queensland Government 2018, *Minimising Noise and Vibration from Blasting Activities*, viewed 2 February 2024, https://www.business.qld.gov.au/industries/mining-energy-water/explosives-fireworks/requirements/blasting/minimising-noise

Queensland Government 2023, Station Overview – The Gap, viewed 27 November 2023, https://apps.des.qld.gov.au/air-quality/stations/?station=oai

Queensland Government 2024, *Queensland Globe*, viewed 29 January 2024, https://qldglobe.information.qld.gov.au/

Round Oak 2019, *Air Quality Management Plan*, prepared for Round Oak Minerals Pty Limited by Round Oak Minerals Pty Limited.

Appendix A
Risk Assessment



Risk Assessment

A.1 Method

The risk matrix used to evaluate each risk is in Table 24.

The likelihood ratings and descriptions are in Table 25.

The consequence categories and definitions are in Table 26.

Table 24 Risk matrix

Likelihood	Consequence					
	1	2	3	4	5	6
A	Medium	High	High	Very high	Very high	Very high
B	Medium	Medium	High	High	Very high	Very high
C	Low	Medium	Medium	High	High	Very high
D	Low	Low	Medium	Medium	High	High
E	Low	Low	Low	Medium	Medium	High

Table 25 Likelihood ratings and descriptions

Likelihood	Rating	Description
Almost certain	A	Likely to occur multiple times a year
Likely	B	Might occur once a year
Possible	C	Might occur multiple times during operation
Unlikely	D	Might occur once during operation
Rare	E	Unlikely to occur during operation

Table 26 Consequence categories and definitions

Consequence	Definition				
	Financial loss	**Safety and people**	**Environment**	**Legal compliance**	**Reputation**
6 — Catastrophic	>$50 million	• multiple fatalities; or • major injury / illness among multiple employees	• offset impact requiring long-term remediation (years) with residual damage; • species extinction or permanent impairment of ecosystem function; or • irreversible loss of cultural heritage value	• regulatory, permit or community agreement non-compliance with probable fine of >$20 million, involving criminal investigation of officers / directors	• significant international media / public criticism or condemnation
5 — Major	$10-50 million	• single fatality; • total and permanent disability; or • major irreversible health effects	• offsite impact requiring long-term remediation (years); • impact requiring long-term remediation (years); • change to ecosystem function; or • irreversible damage of cultural heritage value	• regulatory, permit or community agreement non-compliance with probable fine of $5-20 million	• international adverse media / public criticism or concern
4 — Significant	$1-10 million	• permanent disabling / illness; • multiple lost time injuries; or • multiple community medical treatment injuries	• offsite impact requiring medium-term remediation (months); • impact requiring long-term remediation (years); • temporary impairment to ecosystem function; or • repairable damage of cultural heritage value	• regulatory, permit or community agreement non-compliance with probable fine of $1-5 million	• national adverse media / public criticism or concern
3 — Moderate	$100,000-1 million	• reversible disability / illness; • single lost time injury; or • single community medical treatment injury	• offsite impact requiring short-term remediation (weeks); or • impact requiring medium-term remediation (months)	• regulatory, permit or community agreement non-compliance with probable fine of $100,000-1 million	• regional media / public concern or local criticism
2 — Minor	$10,000-100,000	• medical treatment / illness; or • restricted work injury	• impact requiring short-term remediation (weeks)	• regulatory, permit or community agreement non-compliance with probable fine of $10,000-100,000	• local media or public concern
1 — Low	<$10,000	• first aid treatment	• impact confined to a small area with a prompt (within a day) clean-up	• regulatory, permit or community agreement non-compliance with probable fine of <$10,000	• minor impact, no media / public concern

A.2 Results

The risk assessment and risk treatment plan are in Table 27.

Table 27 Risk assessment and risk treatment plan

Risk event	Likely cause / s (including source)	Likely impact / s	Proposed treatment option	Reason for selecting risk treatment option	Resource requirements	Performance measures and constraints	Reporting and monitoring requirements	Timing and scheduling	Responsibility	Residual risk rating
Groundwater contamination	Failure to test water for EA compliance before placing it in underground workings	Contamination of groundwater	Sampling water before placing it in underground workings Treating water that exceeds EA compliance before placing it in underground workings	To minimise contaminants entering groundwater	Sampling equipment and / or laboratory testing Sampling	NA	Internal reporting	Prior to placing water underground	Site management	Medium (D x 3)
	Mixing water (including tested and / or treated water) with PAF material underground and subsequently, failure to contain — seepage (ie contaminant seepage into groundwater)		Characterising waste rock upon extraction Backfilling PAF material within six months of exposure to atmospheric conditions			NA	Internal reporting	Prior to backfilling PAF material		
Terrestrial GDEs impacted by groundwater drawdown	Drawdown from UG mining	Decline in plant community diversity	Monitor standing groundwater levels, and groundwater quality	To minimise the impact from groundwater drawdown	Sampling equipment and / or laboratory testing Sampling	NA	Internal reporting	Prior to and during operation	Site management	Medium (D x 3)
Failure to contain — overtopping	South Pit overtopping	Flows into underground workings via the portal Casualties if TARP is not followed	Monitor water levels in South Pit Develop TARP	To minimise the impact from overtopping	Personnel to monitor and report on water levels in South Pit regularly and ongoing	NA	Internal reporting	Prior to, during and post operations	Site management	Low (E x 3)
Unstable void / underground workings	Subsidence caused by mixing water (including tested and / or treated water) waste rock underground	Subsidence of the local land surface	Assessment by a suitably qualified person (SQP)	To limit subsidence and ensure the void / underground workings are stable post-mining	SQP	NA	Internal reporting	Prior to and during operation	Site management	Medium (D x 3)

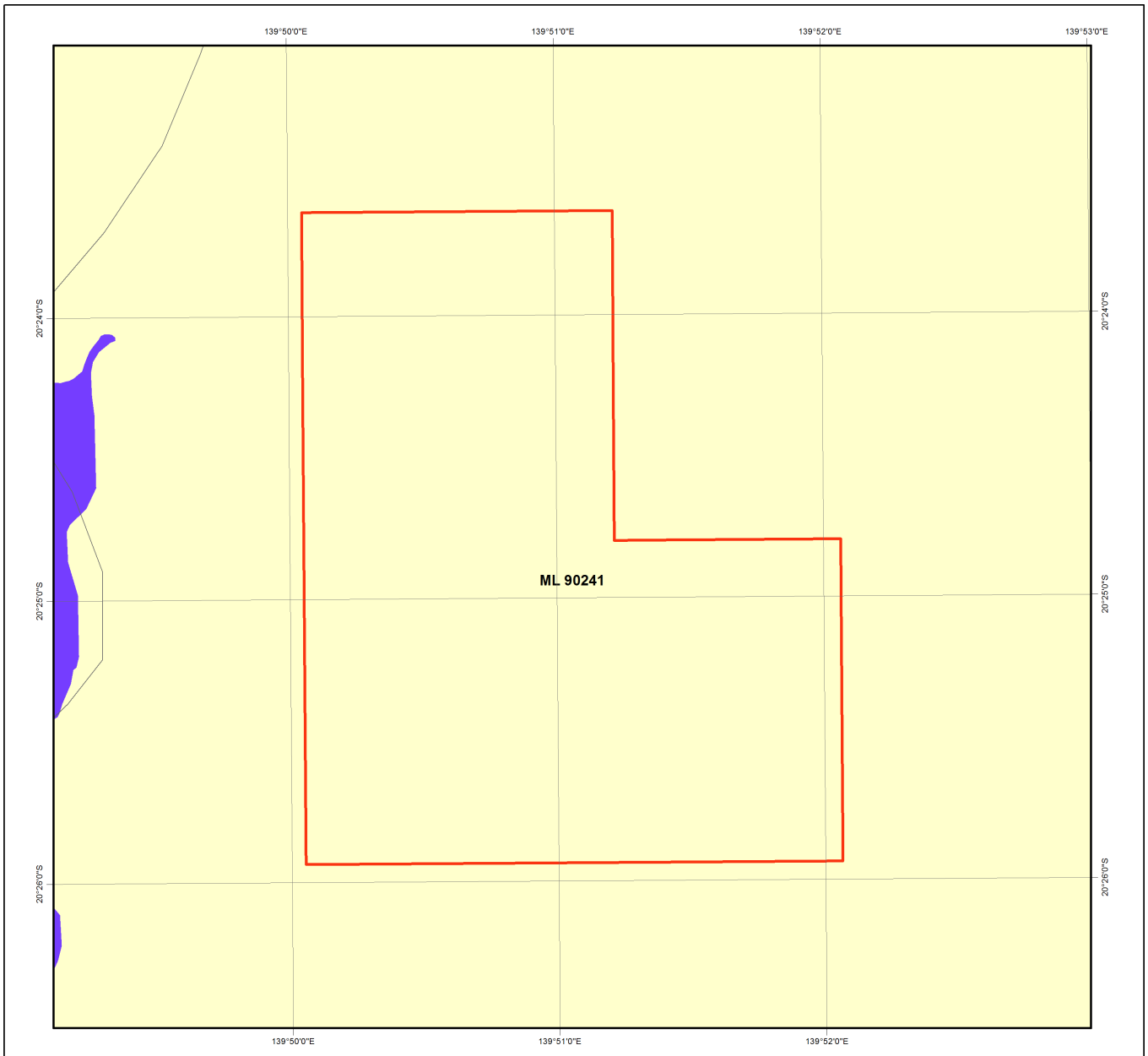
Risk event	Likely cause / s (including source)	Likely impact / s	Proposed treatment option	Reason for selecting risk treatment option	Resource requirements	Performance measures and constraints	Reporting and monitoring requirements	Timing and scheduling	Responsibility	Residual risk rating
Increased permeability of geological units surrounding the mined area	UG blasting	Subsidence of the local land surface	Assessment by a suitably qualified person	To limit subsidence and ensure the void / underground workings are stable post-mining	SQP	NA	Internal reporting	Prior to and during operation	Site management	Medium (D x 3)
Sensitive receptors impacted by additional sources of noise pollution	Operation of underground ventilation systems and mining fans	Noise pollution on the surrounding area, including sensitive receptors	Fitting exhaust systems with an industrial muffler	To minimise noise pollution	Industrial muffler for each exhaust system	Industrial mufflers must be in sound condition	Visual inspection	Prior to operation	Site management	Medium (C x 2)
			Regular and ongoing maintenance of ventilation systems and mining fans Ensuring industrial mufflers are in working order		Maintenance record	Maintenance record	Internal reporting	Prior to and during operation		
Sensitive receptors impacted by additional sources of air pollution	Operation of underground ventilation systems and mining fans	Air pollution on the surrounding environment, including sensitive receptors	Regular and ongoing maintenance of ventilation systems	To minimise the impact from air pollution	Maintenance record	Maintenance record	Internal reporting	Prior to and during operation	Site management	Medium (C x 2)
			Ceasing operations during adverse weather events, especially when wind is travelling in the direction of sensitive receptors		Access to live weather monitoring data	NA	Internal reporting	Prior to and during operation	Site management	

This page is intentionally blank.

Appendix B
Environmentally Sensitive Areas — Mining Activities

Centred on tenure: ml: 90241

Map requested: 30/01/2024 16:13:32



ENVIRONMENTALLY SENSITIVE AREAS - Mining Activities

- Selected Mining Lease (ML)

CATEGORY A

- National Parks
- Conservation Parks
- Forest Reserves
- Special Wildlife Reserve
- Wet Tropics World Heritage Area
- Great Barrier Reef Marine Park Area
- Marine Parks other than General Use Zones

CATEGORY B

- Queensland Heritage Register Places
- Ramsar Sites
- Cultural Heritage Registered Areas and DLA's other than Stanbroke
- Special Forestry Areas
- Seaward Side of Highest Astronomical Tide
- Fish Habitat Areas
- Coordinated Conservation Areas
- Endangered Regional Ecosystems - regrowth and remnant (Biodiversity Status)
- General Use Zones of Marine Parks
- Marine Plants

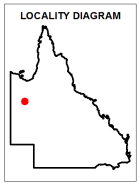
CATEGORY C

- Nature Refuges
- Resources Reserve
- State Forests
- Timber Reserves
- River Improvement Areas
- Stanbroke DLA
- Coastal Management District
- Dams and Weirs

OTHERS

- Towns
- Roads
- Repealed Wild River Nominated Waterways
- Repealed Wild River Preservation Areas
- Repealed Wild River High Preservation Areas
- Mahogany Glider Habitat
- Directory of Important Wetlands
- Queensland

LOCALITY DIAGRAM



N

0 360 720 1,080 1,440 1,800 m

This product is projected into GDA 1994 MGA Zone 54

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, The State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The State of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

NOTE TO USER: Themes presented in this map are indicative only. Field survey may be required to verify the 'true' spatial extent and value. Not all environmentally sensitive areas are presented in this map. A user should refer to the particular circumstances relevant to their situation to assess the 'completeness' of themes provided.

The user should note that some boundaries and indicated values are ambient and may change over time (e.g. regional ecosystem boundaries and conservation status, watercourse mapping etc).

The user should be aware that due to multiple overlapping themes/ layers present, some themes/layers may be obscured by others. Ordering in the Legend does not accurately reflect the order by which themes/layers are displayed.

© The State of Queensland, 2024

Queensland Government

This page is intentionally blank.

Appendix C
Air Quality Impact Assessment

Barbara Copper Project

Lake Julius Road, north-east of Mt Isa, Queensland

Air Quality Impact Assessment

7344R01V01.docx
03/09/14

Prepared for

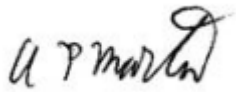
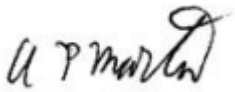
CopperChem Ltd and Syndicated Metals Ltd

ASK Consulting Engineers Pty Ltd

ABN: 55 622 586 522 - ACN: 128 491 967
PO Box 3901, South Brisbane. QLD. 4101.

P: 07-3255-3355 **F:** 07-3844-7180 **W:** www.askconsulting.com.au **E:** mail@askconsulting.com.au

Document Control				
W:\7300\7344 - Barbara\ASKout\Air\7344R01V01.docx				
Document Ref	**Date of Issue**	**Status**	**Author**	**Reviewer**
7344R01V01_draft	21/08/14	Draft	AM	MR
7344R01V01	03/09/2014	Final	AM	MR

Document Approval			
Author Signature		**Approver Signature**	
Name	Andrew Martin	Name	Andrew Martin
Title	Air Quality Manager	Title	Air Quality Manager

Disclaimer: This document and associated tasks were undertaken in accordance with the ASK Consulting Engineers Quality Assurance System, which is based on Australian Standard / NZS ISO 9001:2008. This document is issued subject to review, and authorisation by a Senior Consultant noted in the above table. If the table is incomplete, this document shall be considered as preliminary or draft only and no reliance shall be placed upon it other than for information to be verified later.

This document is prepared for our Client's particular requirements which are based on a specific brief with limitations as agreed to with the Client. It is not intended for and should not be relied upon by a third party and no responsibility is undertaken to any third party without prior consent provided by ASK Consulting Engineers. The information herein should not be reproduced, presented or reviewed except in full. Prior to passing on to a third party, the Client is to fully inform the third party of the specific brief and limitations associated with the commission.

The information contained herein is for the identified purpose of air quality assessment only. No claims are made and no liability is accepted in respect of design and construction issues falling outside of the specialist field of air quality assessment including and not limited to structural integrity, fire rating, architectural buildability and fit-for-purpose, waterproofing, safety design and the like. Supplementary professional advice should be sought in respect of these issues.

Copyright: This report and the copyright thereof are the property of ASK Consulting Engineers Pty Ltd (ABN 55 622 586 522). It must not be copied in whole or in part without the written permission of ASK Consulting Engineers Pty Ltd. This report has been produced specifically for the Client and project nominated herein and must not be used or retained for any other purpose. www.askconsulting.com.au

Contents

1 Introduction 5
2 Study Area Description 7
3 Proposed Development 8
3.1 Project Description 8
3.2 Open-Cut Mine Methodology 8
3.3 Plant and Production Quantities 10
4 Air Quality Criteria 11
4.1 Anticipated Emissions 11
4.1.1 Particulates 11
4.1.2 Gases 11
4.2 Queensland Legislative Instruments 11
4.2.1 State Development Requirements 11
4.2.2 Queensland Environmental Protection Policy 11
4.3 Dust Deposition 12
4.4 Summary of Relevant Pollutant Concentration Criteria 12
5 Regional Climate & Existing Air Quality 13
5.1 Regional Climate 13
5.2 Existing Air Quality 13
5.2.1 Overview 13
5.2.2 Suspended Particulates 13
5.2.3 Dust Deposition 13
6 Review of Previous Similar Air Quality Impact Assessments 14
6.1 Overview 14
6.2 SCONI Project 14
6.2.1 Overview & Modelling Assessment 14
6.2.2 Air Quality Impacts 15
6.3 Mungana Gold Open Pit Development 15
6.3.1 Overview & Modelling Assessment 15
6.3.2 Air Quality Assessment Results 16
6.4 Red Dome Pit Extension (RDPE) Project 17
6.4.1 Overview & Modeling Assessment 17
6.4.2 Air Quality Assessment Results 17
6.5 Rocklands Copper Project 18
6.5.1 Overview & Modeling Assessment 18
6.5.2 Air Quality Assessment Results 19

7 Discussion 20
7.1 Impacts from Mining Lease 20
7.2 Impacts from Road Haulage 21
7.3 Recommendations 21
7.3.1 Emission Controls 21
7.3.2 Monitoring 21
8 Conclusion 21
References 22
Appendix A Glossary 23

1 Introduction

ASK Consulting Engineers Pty Ltd (ASK) was commissioned by CopperChem to provide air quality consultancy services for the proposed Barbara Copper Project (BCP). The BCP is a joint venture open cut copper mine proposed by CopperChem Ltd and Syndicated Metals. The BCP is proposed to be located approximately 10 kilometres east of Lake Julius Road and approximately 50 kilometres north-east of Mount Isa as shown in **Figure 1.1**.

This report presents an assessment of the air quality impacts associated with the proposed mine and access route. It is supporting information for the Environmental Authority application for consideration by Queensland Department of Environment and Heritage Protection (EHP).

The purpose of this report is to assess air emission impacts based on the following tasks:

- Review the BCP and the associated potential air emissions.
- Review the location of the nearest sensitive receptor identified by CopperChem.
- Review existing air quality monitoring data applicable to the project site.
- Review other mine projects of similar production rates and note their air quality impacts at similar buffer distances.
- Provide discussion of significance of potential air quality impacts, and recommendations on any control measures.

To aid in the understanding of the terms in this report a glossary is included in **Appendix A**.

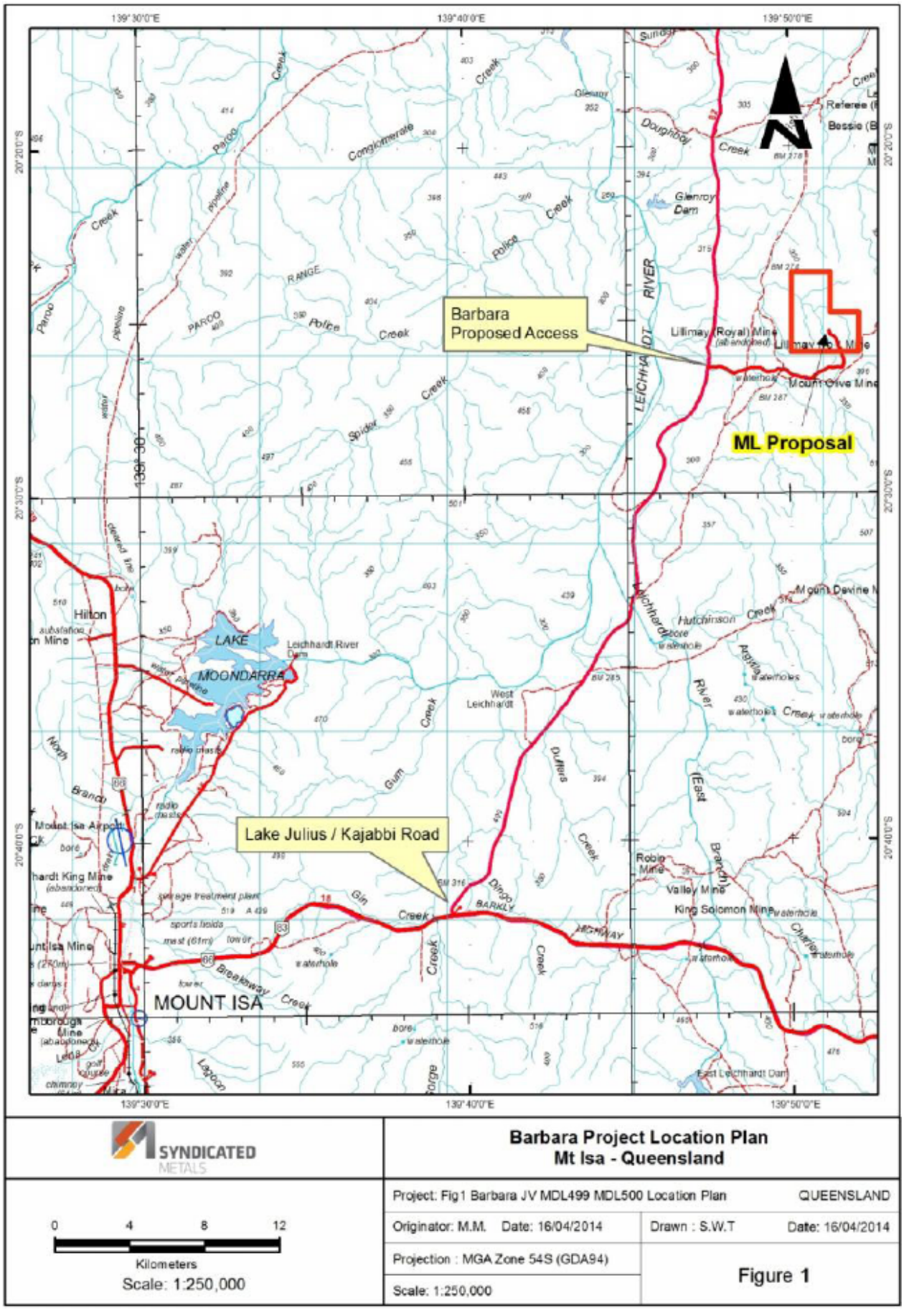


Figure 1.1 Location of Mining Lease (provided by CopperChem)

2 Study Area Description

The proposed location of the BCP is approximately 10 kilometres east of Lake Julius Road. Access to the site and the transport of ore off-site will require the construction of a private access road from Lake Julius Road. Ore will be transported along Lake Julius Road before travelling along the Barkly Highway to its processing destination at the Great Australia Mine in Cloncurry or another third party processing facility.

The BCP site is on and surrounded by a pastoral lease currently used for low intensity cattle grazing and exploration activities.

It is understood that the nearest sensitive receptor to the proposed development is the West Leichardt Station homestead and camp located approximately 25 kilometres south-west of the site and 2.2 kilometres to the west of Lake Julius Road. Based on aerial photography, the coordinates of the nearest edge of a residential building are 363986 metres E, 7722010 metres N (AMG94 zone 54). The location of the homestead is shown in **Figure 2.1**. Both the homestead and the proposed mine are located on Lot 1 of AAA9.

Air quality at sensitive receptors more distant than the West Leichardt Station homestead would not receive any detectable impacts from the proposed mine.

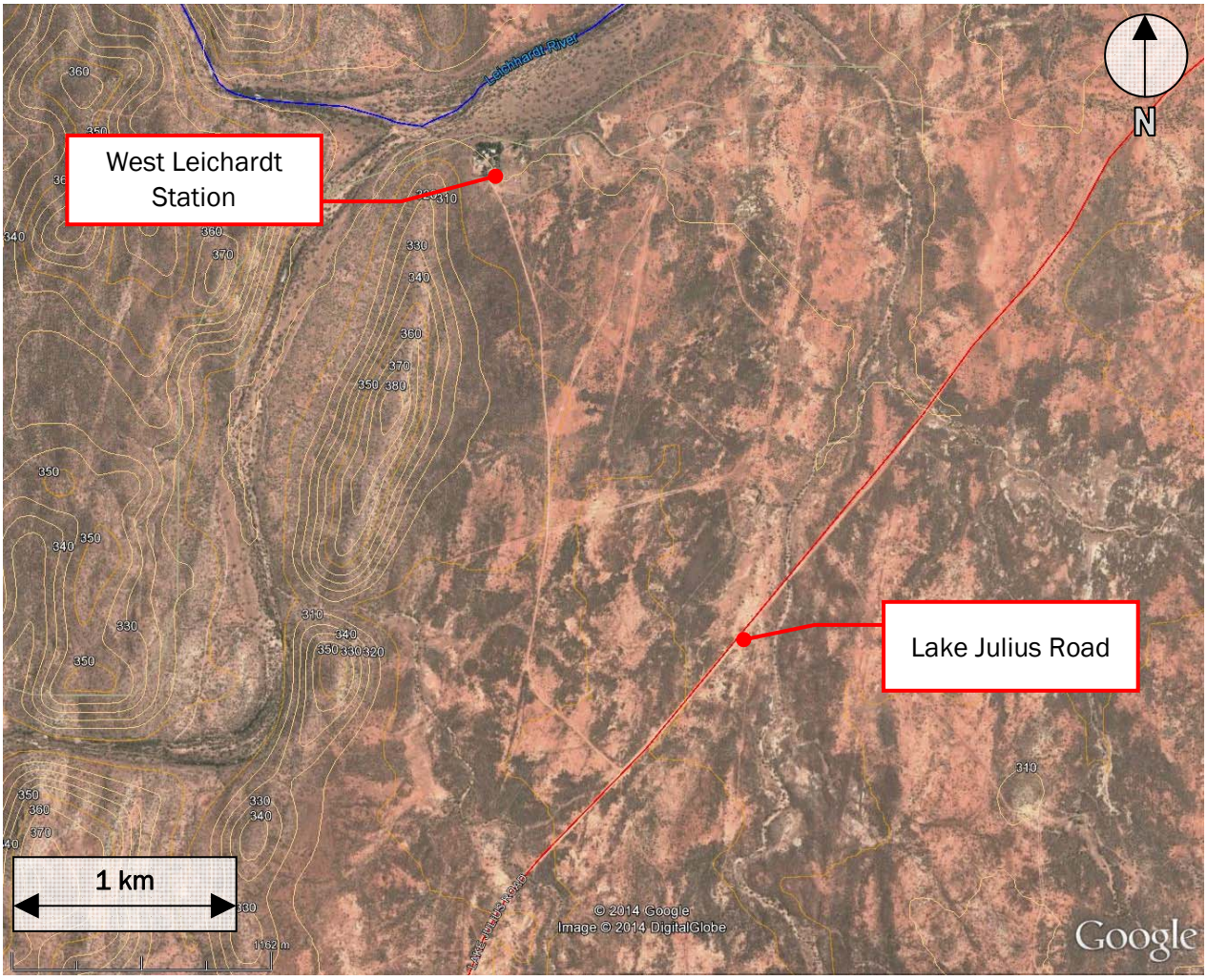


Figure 2.1 Location of Sensitive Receptor and Haul Route (Image from Google Earth Pro)

3 Proposed Development

3.1 Project Description

ASK understands that copper ore will be extracted from an open cut pit with haul trucks utilised to transport ore to the ROM pad for stockpiling, crushing and sorting, where it will then be loaded onto road trains. Ore will be transported along Lake Julius Road before travelling along Barkly Highway to its processing destination at the Great Australia Mine in Cloncurry or another third party processing facility.

Major activities proposed for the Project include:

- open cut mining of copper ore using conventional open cut drill, blast and excavation methods
- waste rock disposal in the pit (as backfill) and in out-of-pit waste rock dump/s
- transportation of ore off-site for processing.

Supporting mine infrastructure proposed to be constructed includes:

- Run-of-Mine (ROM) pad with ore stockpiles, crushing area and ore sorting piles
- road train loading area
- water management structures to be located around pit and infrastructure
- topsoil stockpiles
- access road, internal roads and laydown areas
- administration and office buildings
- sewage treatment facility
- fuel and explosives storage area
- power facility
- stores and workshop/s.

3.2 Open-Cut Mine Methodology

Key elements of the open cut mining operations are:

- Two pits are proposed:
  - South pit, 130 metres deep and 350 metres long, mined over 18 months.
  - North pit, 50 metres deep and 150 metres long, mined over 4 months.
- The estimated mine life is approximately 2 years with anticipated commencement in early 2015.
- The ore to be mined consists of approximately 0.8 megatonnes copper with trace gold.
- On-road haul trucks will be triple road trains with haulage capacity of 90t.
- Based on haulage capacity and ore production, anticipated annual haul truck traffic is estimated at approximately 5,000 trips per year, or 20 trips per day.
- Mining will be by open cut drill, blast and excavation methods.
- Water for dust suppression is projected as 0.5 ML/day.
- On-site haul trucks will operate 2 x 12 hour shifts with nominal 8 engine hours per shift.
- On-road road trains will operate 1 x 12 hour shift with nominal 8 engine hours per shift.
- Overburden to spoil piles will be 8 Mt over the mine life.
- Overburden density is 3 t/m^3.
- Blasting will occur approximately 100 times per year.

A basic plan of the proposed mine site layout as provided by CopperChem is shown in **Figure 3.1** below.

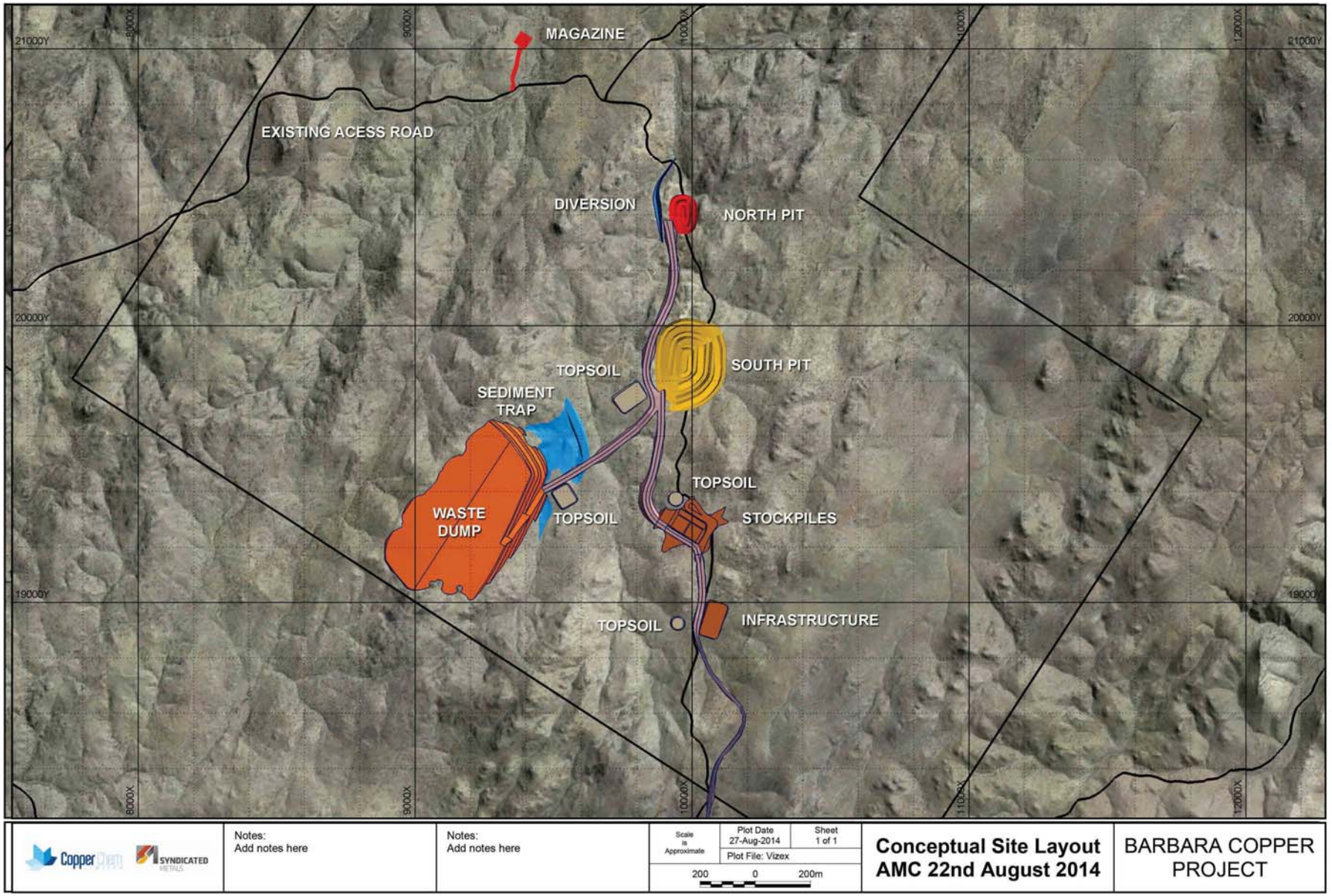


Figure 3.1 Site Layout Plan

3.3 Plant and Production Quantities

The proposed mobile equipment fleet for open-cut mining operations as provided by CopperChem is presented in **Table 3.1**, with equipment numbers nominated based on yearly operational quarters.

Table 3.1 Equipment List

Equipment Type	Model #	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 5	Qtr 6	Qtr 7	Qtr 8	Qtr 9
Excavator	Komatsu PC1250	1	1	1	1	1	1	1	1	-
Front-end loaders	CAT 966H	1	1	1	1	1	1	1	1	-
Off-road haulage	CAT 777	2	2	4	4	4	4	2	2	-
On-road haulage	RT 2 (Triple Road Trains)	-	-	2	3	4	4	4	4	-
Track Dozer	Cat D10	1	1	1	1	1	1	1	1	1
Grader	CAT 16G	1	1	1	1	1	1	1	1	1
Water Cart	CAT 773	1	1	1	1	1	1	1	1	1
Drill	Sandvik DP1100	1	1	2	3	3	3	3	3	3
Service Truck	8 Ton Single Axle	1	1	1	1	1	1	1	1	-
Light Vehicles	Toyota Landcruiser Ute	3	3	3	3	3	3	3	3	-
	Toyota Hilux Ute	2	2	5	5	5	5	5	5	3
Pump	Dewatering Pump Diesel	1	1	1	1	1	1	1	1	1
Lighting	Diesel Lighting Towers	3	3	6	6	6	6	6	6	-
Diesel Generator	Cummins Diesel 200KVA	1	2	2	2	2	2	2	2	1

4 Air Quality Criteria

4.1 Anticipated Emissions

4.1.1 Particulates

The proposed project's operation will result in the emission of particulates characterised as:

- total suspended particulate matter (TSP)
- particulate matter with equivalent aerodynamic diameters of 10 µm or less (PM_{10})
- particulate matter with equivalent aerodynamic diameters of 2.5 µm and less ($PM_{2.5}$).

4.1.2 Gases

Gaseous emission sources from mining include the following:

- Combustion engine exhausts emit NO_x, carbon monoxide (CO) and VOCs.
- Blasting produces CO and NO_x.
- Fugitive emissions from fuel storage tanks include VOCs.

However, from mining operations that apply standard control measures, gases normally have substantially less air quality impact than particulates, and compliance with particulate criteria should ensure that gas concentrations also meet criteria. The remainder of this report is therefore based on the impact of particulate emissions.

4.2 Queensland Legislative Instruments

4.2.1 State Development Requirements

Table 4.1.2 of the State Development Assessment Provisions (2013) contain Performance Outcomes and Acceptable Outcomes for environmentally relevant activities. Essentially it requires developers to minimise or offset impacts. It does not contain any specific criteria on how to assess impacts from proposed activities.

The State Planning Policy (2013) requires development to be assessed against the following requirements:

1) It must be designed to avoid or minimise adverse impacts from emissions that will affect the health and safety, wellbeing and amenity of communities and individuals.
2) It must support the achievement of the relevant objectives of the Environmental Protection (Air) Policy 2008 (which are reproduced in Appendix 5 of the Policy).
3) It must not compromise the viability of existing or future industrial development.

4.2.2 Queensland Environmental Protection Policy

The criteria for suspended particulates are primarily derived from air quality objectives specified in the Environmental Protection (Air) Policy 2008 (EPP(Air)). The objectives relevant to this project and human health and wellbeing have been summarised in **Table 4.1**. The EPP (Air) incorporates the goals nominated within the National Environmental Protection (Ambient Air Quality) Measure (NEPM).

4.3 Dust Deposition

Whilst there are no quantitative limits specified in legislation, there are guidelines designed to avoid nuisance caused by dust deposition fallout onto near horizontal surfaces.

The Department of Environment and Heritage Protection (EHP 2013a) suggests the guideline that deposited matter averaged over one month should not exceed 120 mg/m^2/day (3.6 g/m^2/month). For extractive industries, it is the insoluble component of analysed dust that is used.

The NSW Department of Environment and Conservation (2005) specifies an annual average limit of 4 g/m^2/month (130 mg/m^2/day), and states that it is the insoluble component of analysed dust that is to be used.

It should be noted that these values are a guideline for the level that may cause nuisance at a sensitive receptor such as a residence or sensitive commercial land use. It is not normally necessary to achieve this level at the boundary, but boundary measurement can assist in the assessment of whether there is risk of nuisance occurring or not.

4.4 Summary of Relevant Pollutant Concentration Criteria

The objectives relevant to this project and human health and wellbeing have been summarised in **Table 4.1**.

Table 4.1 Air Quality Criteria (EPP Air) for Health and Wellbeing

Air Quality Indicator	Period	Criteria (µg/m^3)
TSP	1 year	90
PM_{10}	24 hours	50 [1]
$PM_{2.5}$	24 hours	25
	1 year	8
Dust deposition	1 year	120 mg/m^2/day

Notes:

1. The intent of the five allowable exceedances in the NEPM is to cater for regional events. However EHP has permitted these exceedances to be used in assessment of the impact of major developments.

5 Regional Climate & Existing Air Quality

5.1 Regional Climate

Information regarding the regional climate of the BCP site was presented in Section 4.1 of the Barbara Project Pre-lodgement Advice for Environmental Authority Application (CopperChem Ltd 2014), based on data for Mount Isa available on the Australian Bureau of Meteorology (BOM) website.

In the driest month (June) when dust emissions are more likely, prevailing winds (both high and low wind speeds) are from the south-east.

5.2 Existing Air Quality

5.2.1 Overview

Based on the rural nature of the regional area, it is expected that the air quality for the study area would be acceptable for the majority of the time with possible exceptions including dust and particulates. The existing air quality would be influenced by wind erosion, sporadic traffic on unsealed roads as well as cattle grazing, bushfires and controlled burning.

Monitoring data from similar locations is normally used to represent the existing background. In the absence of continuous monitoring data, it is recommended (Victoria (2001)) to use the 70th percentile as a background concentration so that the cumulative impact can be compared to criteria.

5.2.2 Suspended Particulates

Any suspended particulate data for the local area is not publicly available, so data from similar locations has been assessed. Monitoring data from the Queensland Department of Science, Information Technology, Innovation and the Arts (DSITIA) monitoring site at The Gap, Mount Isa, is the most relevant location, although it will be heavily influenced by local mining and industrial sources. Monitoring of PM_{10} at Mount Isa commenced in 2009. For the period 2009 to 2012, the 75th percentile 24 hour PM_{10} concentration was 21 µg/m^3. The annual average was 14 µg/m^3.

Based on a typical ratio of PM_{10} to TSP around Australian mines being 0.39 (ACARP, 1999), the annual average TSP is estimated as 36 µg/m^3. Based on an assumed $PM_{2.5}$ to PM_{10} ratio of 0.25, the background $PM_{2.5}$ concentration has been estimated to be an annual average of 3 µg/m^3 and a maximum 24 hour value of 5 µg/m^3.

These values are similar to those assumed in other assessments for dust from mining activities discussed in **Section 6**.

5.2.3 Dust Deposition

Any dust deposition data for the local area is not publicly available.

The criterion for dust deposition from mining activities in Queensland is based on the EHP guideline that insoluble deposited matter should not exceed 120 mg/m^2/day (3.6 g/m^2/month). Based on this guideline and applying a conservative approach to the impact assessment, the existing dust deposition level for the study area is assumed to be half the guideline level, 60 mg/m^2/day (1.8 g/m^2/month).

6 Review of Previous Similar Air Quality Impact Assessments

6.1 Overview

Due to the size of the Project and the separation distances between the Project and the nearest sensitive receptors, air quality impacts are anticipated to be minimal and it is considered very unlikely that the nominated air quality criteria (see **Section 4**) will be exceeded at the location of sensitive receptors (see **Section 2**). On this basis, the assessment of potential air quality impacts resulting from the BCP operation has been conducted based on the review of air quality assessment reports for similar projects.

The key elements listed in **Section 3.2** include extraction of 0.8 megatonnes of product ore and 7.5 megatonnes of overburden over two years. Comparable mine projects include the Munguna Gold Open Pit Development (MGOPD), the Red Dome Pit Extension (RDPE) Project, the Rocklands Copper Project and the SCONI Project. This section provides a review of the air quality impact assessments completed for these projects.

6.2 SCONI Project

6.2.1 Overview & Modelling Assessment

The SCONI Project is a proposed metaliferous mining development located near Greenvale, approximately 190 kilometres north-west of Charters Towers in North Queensland. It involves the mining of scandium, cobalt and nickel resources from three pits (Lucknow, Greenvale and Kokomo) using open cut mining methods. An air quality impact assessment was conducted for the project by ASK Consulting Engineers Pty Ltd (ASK) in 2013. The SCONI Project site is located approximately 500 kilometres to the north-east of the BCP site.

The SCONI Project utilises conventional open cut mining techniques consisting of drilling, blasting and excavation. The project also incorporates on-site processing of extracted ore and utilises road haulage for the transport of product ore off-site. The projected total mine life is approximately 28 years.

As part of the assessment, two mining year scenarios were modelled to determine air quality impacts from the operation of the project, with modelling undertaken using the modelling software program Calpuff. The production details for these mining phases are included in **Table 6.1** below.

Table 6.1 Modelling Scenario Production Rates

Mining Phase	Lucknow Ore (kt)	Lucknow Waste (kt)	Greenvale/Kokomo Ore and Waste (kt)
Phase 1	200	100	N/A
Phase 2	200	361	2,500

The SCONI Project is to employ a typical open cut mine mobile equipment fleet including excavators, dozers, haul trucks, front end loaders and graders. Due to the increase in production from phase 1 to phase 2, the number of mobile equipment will be significantly larger in the later phase of operations. In comparison to the proposed BCP mobile equipment fleet, the SCONI Project is comparable in phase 1 and significantly higher in phase 2.

As part of the SCONI Projects operations, approximately 15 x 73 tonne road haul trucks are scheduled to carry ore from the northern Kokomo deposit to the processing plant at Greenvale each day. A homestead is located approximately 1 kilometre to the west of the road from Kokomo to Greenvale. In comparison, the BCP will have approximately 20 trucks per day travelling along Lake Julius Road.

In regards to modelling parameters, the following notes were included in the assessment report:

- Due to low production volumes mining operations only occurred during daytime hours.
- The haul-out route was both sealed and unsealed and modeling included emissions from vehicles on unpaved surfaces along the haul route.
- Modelling included emissions from processing (crushing, handling etc).
- Winds were predominantly easterly or north-easterly.
- Control techniques assumed in the modeling were limited to the application (spray) of water to haul roads at a rate of 1 litre/m^2/hr, providing a control efficiency of 50%.

6.2.2 Air Quality Impacts

Based on the modelling methodology employed for the assessment, air quality impacts were predicted onto the nearest sensitive receptors and surrounding environment. Based on the predicted contours and point receptor results, the highest predicted concentration and dust deposition levels for distances of approximately 6 kilometres from mining operations have been extracted and are summarised in **Table 6.2**. The air quality assessment presented predicted PM_{10} concentrations in terms of the 6th highest predicted concentrations.

Table 6.2 Predicted Highest Concentration and Dust Deposition Levels (Greenvale and Lucknow)

Buffer Distance (km)	TSP Annual Average (µg/m^3)	6th Highest 24h PM_{10} (µg/m^3)	Maximum 24h $PM_{2.5}$ (µg/m^3)	Annual Average $PM_{2.5}$ (µg/m^3)	Dust Deposition (mg/m^2/day)
Criterion	90	50	25	8	120
6	<4	<10	<3	<1	<5

Note: Values are approximate only based on interpolation of contours and receptor predictions.

Particulate concentrations and deposition levels 1 kilometre to the west of the haul road were well within criteria. The implications of these results for the BCP are discussed in **Section 7**.

6.3 Mungana Gold Open Pit Development

6.3.1 Overview & Modelling Assessment

The Mungana Gold Open Pit Development (MGOPD) is a metaliferous mine project proposed to be located 15 kilometres to the west of Chillagoe in North Queensland. The project involves the mining of gold and copper resources from the red dome pit and on-site processing of the extracted ore. An air quality assessment was conducted by Noise Mapping Australia Pty Ltd for the development in 2010. The site is located approximately 600 kilometres to the north-east of the BCP Site.

The MGOPD involved the open cut mining of gold and copper deposits using conventional open cut mining techniques consisting of drilling, blasting and excavation. The project also incorporates on-site processing of extracted ore and is assumed to have utilised road haulage for the transport of product ore off-site, however, this aspect of the project was not included within the assessment.

The air quality assessment for the development was based on a single modelling year scenario. The modelling scenario was based on a completely developed mine with dispersion modelling undertaken using the software program TAPM. The production rates utilised in the modelling scenario included a total waste component of 25 Mt with an ore production component of 1.2 Mt. No mining year was specified for the modelling scenario.

The MGOPD included similar items to the proposed BCP mobile equipment fleet including excavators, dozers, haul trucks, front end loaders and graders. Due to on-site processing, the MGOPD also included fixed plant such as crushers and conveyors. Although no detailed information regarding the number of items of mobile equipment is included in the assessment report, based on the production volumes it is anticipated that the MGOPD project would have comprised a larger mobile equipment fleet than the BCP (see **Section 3**).

Similar to the BCP, sensitive residential receptors are at large distances from the MGOPD mining infrastructure. The three sensitive receptor locations of interest included in the assessment are as follows:

- Rookwood Station: A residential homestead located approximately 8 kilometres to the north-west of the project site.
- Chillagoe Township: Small township located approximately 15 kilometres to the east of the project site.
- Spring Tower: A sensitive environmental receptor within the Chillagoe-Mungana National Park located approximately 5 kilometres to the south-east of the project site.

It was noted that the meteorological conditions used in the modelling were dominated by easterly winds.

6.3.2 Air Quality Assessment Results

Based on the modelling methodology employed for the assessment, air quality impacts were predicted at sensitive receptor locations. The results of the air quality assessment with regards to particulate concentrations and dust deposition for the nominated receptors (Rookwood Station, Chillagoe Township and Spring Tower) have been presented in **Table 6.3**.

Table 6.3 Predicted Concentration and Dust Deposition Levels

Receptor	Buffer Distance	TSP Annual Average ($\mu g/m^3$)	5th Highest 24h PM_{10} ($\mu g/m^3$)	Maximum 24h $PM_{2.5}$ ($\mu g/m^3$)	Annual Average $PM_{2.5}$ ($\mu g/m^3$)	Dust Deposition ($mg/m^2/day$)
Criterion		90	50	25	8	120
Spring Tower	5 kilometres	<1	1	<1	<1	<1
Rookwood Station	8 kilometres	<1	2	4	<1	3
Chillagoe Township	15 kilometres	<1	1	<1	<1	2

The implications of the predicted impacts from MGOPD in relation to the BCP are discussed in **Section 7**.

6.4 Red Dome Pit Extension (RDPE) Project

6.4.1 Overview & Modeling Assessment

Following the Mungana Gold Open Pit Development (MGOPD) project the Red Dome Pit Extension (RDPE) project involved additional mine operations to be located at the site of the existing MGOPD focusing on open cut mining of gold and copper deposits. The project involves additional mining to the existing red dome pit, the development of the new mungana pit (approximately 2.7 kilometres to the south-east) and the re-mining of a heap leach stockpile left over from the MGOPD project.

An air quality assessment was conducted by ASK Consulting Engineers Pty Ltd (ASK) for the development in 2013. The RDPE site is located approximately 600 kilometres to the north-east of the BCP Site.

The RDPE project involves the open cut mining of gold and copper deposits using conventional open cut mining techniques consisting of drilling, blasting and excavation. The project also incorporates on-site processing of extracted ore and road haulage for the transport of product ore off-site. Open cut mining and processing plant equipment for the project is to operate 24 hours a day, 7 days a week. The RDPE project also includes an underground mining component, however the air quality impact assessment did not include airborne emissions from underground mining.

The air quality assessment for the development was based on two modelling scenarios, Year 2 and Year 11. However, only the Year 11 scenario is appropriate for comparison with the BCP due to the ore and waste production tonnages. The modelling scenario for Year 11 was based on a completely developed mine with dispersion modelling undertaken using the software program Calpuff. The production rates utilised in the modelling scenario included a total ore production amount of 0.7 megatonnes. No overburden handling was included in the modelling scenario as Year 11 of operations involved the reprocessing of previously discarded heap leach stockpile which contained no waste rock.

Year 11 operations included a similar number and type of mobile equipment fleet to the proposed BCP including excavators, dozers, haul trucks, front end loaders and graders. Due to on-site processing, the RDPE project also included fixed plant such as crushers and conveyors.

Due to the presence of sensitive ecological receptors at close distances to the proposed project site, the air quality assessment was limited to the projects surrounding areas with the modelling grid approximately 4.5 kilometres by 5.0 kilometres in area.

The following modelling parameters were noted in the assessment report:

- The haul-out route was unsealed and modelling included emissions from vehicles on unpaved surfaces along the haul route.
- Modelling included emissions from processing (crushing, handling, etc).
- Winds were predominantly easterly.
- Control techniques assumed in the modelling were limited to the application (spray) of water to haul roads at a rate of 1 litre/m^2/hr, providing a control efficiency of 50%.

6.4.2 Air Quality Assessment Results

Based on the modelling methodology employed for the assessment, air quality impacts were predicted onto the nearest potentially affected sensitive receptors and the surrounding area in the form of both point receptor results and emission contours. Due to the location of sensitive receptors the size of the modelling grid was only 4.5 kilometres x 5.0 kilometres. Based on the location of the heap leach stockpile and working areas, air quality impacts from the mine were determined at a distance of 2 kilometres. The highest predicted concentration and dust deposition levels from contours within the air quality assessment at a distance of 2 kilometres are presented in **Table 6.4**

below. The air quality assessment presented predicted PM_{10} concentrations in terms of the 6th highest predicted concentration level.

Table 6.4 Predicted Concentration and Dust Deposition Levels at 2 Kilometres

Scenario	TSP Annual Average (µg/m³)	6th Highest 24h PM_{10} (µg/m³)	Maximum 24h $PM_{2.5}$ (µg/m³)	Annual Average $PM_{2.5}$ (µg/m³)	Dust Deposition (mg/m²/day)
Criterion	90	50	25	8	120
Year 11	<30	<30	<15	<2	<50

The implications of these predicted impacts for the BCP are discussed in **Section 7**.

6.5 Rocklands Copper Project

6.5.1 Overview & Modeling Assessment

The Rocklands Copper Project is a metaliferous mining project located approximately 15 kilometres west of Cloncurry in Central Queensland. It involves the mining of copper resources from 2 pits using open cut mining methods. An air quality impact assessment was conducted for the project by Australasia Pacific Environmental Consultants (APEC) Pty Ltd in 2009. The project site is located approximately 60 kilometres to the south-east of the BCP site.

The Rocklands Copper Project involves the mining of copper deposits using conventional open cut mining techniques consisting of drilling, blasting and excavation. The project was estimated to produce approximately 8 Mt of ore and waste per year over the anticipated 10 year life of the mine, with the projects operations to also include the on-site processing of extracted ore. The maximum extraction rate for ore for the project was estimated at 3 Mtpa from Years 6 to 10. Transportation of product ore off-site was to occur via road haulage, however this aspect of the project was not included in the assessment. Mine operation for the project were to occur 24 hours per day, 7 days per week.

The air quality assessment for the development was based on a single modelling year scenario. The modelling scenario was based on a completely developed mine with dispersion modelling undertaken using Ausplume. The production rates utilised in the modelling scenario were not clearly specified, however it is considered likely that emissions were based on the maximum ore extraction rate of 3 Mtpa with a resulting waste component of 5 Mtpa. No mining year was specified for the modelling scenario.

The mobile equipment fleet for the Rocklands Copper Project includes similar items to those proposed for the BCP and includes excavators, dozers, haul trucks, front end loaders and graders. Due to on-site processing, the project also included fixed plant such as crushers and conveyors which were included the assessment. In comparison the Rocklands Copper Project had a larger mobile equipment fleet than that proposed for the BCP (see **Section 3**).

The nearest sensitive receptor to the Rocklands Copper Project, the Chumvale Homestead, is located to the east of the project site at distances of approximately 2 kilometres from the lease boundary, 2.6 kilometres from processing plant and 3.7 to 3.9 kilometres from the pit areas. It is noted that an additional receptor located at 13 kilometres from the site was noted, however this receptor was not included in the assessment due to the minimal chance of impact. Despite the smaller setback distance, the comparison of predicted air quality impacts is considered appropriate due to the similar nature of the projects.

The following modelling parameters were noted in the assessment report:

- Report notes significant ridgeline between pit/infrastructure and receptor, however the magnitude of the ridgeline is not discussed in detail. Results are still considered relevant for comparison.
- Control techniques assumed in the modelling included:
    - the application (spray) of water to haul roads at a rate of 1 litre/m^2/hr, providing a control efficiency of 50%
    - ore stockpiles being sprayed with water, providing a control efficiency for wind erosion of 50%
    - application of water to crusher, providing a control efficiency of 50%
    - application of water to handling and transfer points, providing a control efficiency of 50%.

6.5.2 Air Quality Assessment Results

Based on the modelling methodology employed for the assessment, air quality impacts were predicted onto the Chumvale Homestead. The pollutant species included within the air quality assessment were limited to TSP and PM_{10} with the predicted PM_{10} concentration referred to in terms of the maximum 24 hour predicted concentration level. The results of the air quality assessment for the Rocklands Copper Project are presented in **Table 6.3**.

Table 6.5 Predicted Concentration Levels

Receptor	Buffer Distance (km)	TSP Annual Average (µg/m^3)	Maximum 24h PM_{10} (µg/m^3)
Criterion		90	50
Chumvale Homestead	2 – 4	1	26

The implications of these predictions in relation to the BCP are discussed in **Section 7**.

7 Discussion

7.1 Impacts from Mining Lease

The air quality assessments for similar mining projects are presented and discussed in **Section 6** and include the SCONI project, the Munguna Gold Open Pit Development (MGOPD), the Red Dome Pit Extension (RDPE) Project and the Rocklands Copper Project. These projects have similar mining methodologies and have similar or larger waste and ore production rates and mobile equipment fleet, with the exception of the RDPE Project. These mines are anticipated to be representative of potential air quality impacts from the BCP. Althought the RDPE Project is to produce less ore than the BCP, it is still considered relevant due to similar activities and is useful for assessment of impacts from road haulage.

The predicted concentration and deposition levels from these projects have been summarised in **Table 7.1**. These have been combined with the anticipated background concentration and dust deposition levels discussed in **Section 5.2** to show the anticipated cumulative range of pollutant levels. For reference, the anticipated background concentration and dust deposition levels and the relevant air quality criteria (see **Section 4**) have also been included separately in **Table 7.1**.

Table 7.1 Predicted Concentration and Deposition Levels for Similar Mining Projects Including Background

Project & Model Scenario	Receptor Distance (km)	TSP Annual Average (µg/m³)	6th Highest 24h PM_{10} (µg/m³)	Maximum 24h $PM_{2.5}$ (µg/m³)	Annual Average $PM_{2.5}$ (µg/m³)	Dust Deposition (mg/m²/day)
	Criterion	90	50	25	8	120
	Typical Background	36	21	5	3	60
SCONI	6	<58	<31	<8	<6	<65
MGOPD	5	<55	22[1]	<6	<6	76
	8	<55	23[1]	9	<6	79
	15	<55	22[1]	<6	<6	78
RDPE	2	<84	<51	<20	<7	<110
Rocklands Copper Project	2 – 4	55	47[2]	N/A	N/A	N/A

Notes:

1. PM_{10} concentration presented in assessment of MGOPD was the 5th highest concentration.
2. PM_{10} concentration presented in assessment of Rocklands Copper Project was the highest (1st rank) predicted concentration.
3. N/A = not available.

It is noted that the predicted concentration and dust deposition levels based on the RDPE project approach the nominated criteria for TSP and dust deposition and slightly exceed the nominated criteria for PM_{10}. However, the receptor distance (see **Table 7.1**) is substantially less than the distance to the nearest receptor from the BCP.

Based on the predicted concentration and dust deposition levels for other mines, it is considered very unlikely that the mining lease activities of the BCP would be a substantial contributor to any exceedances of criteria at the West Leichardt Station located 25 kilometres to the south-west.

7.2 Impacts from Road Haulage

West Leichardt Station is located 2.2 kilometres to the west of the BCP haul route being Lake Julius Road. Daily haul traffic is anticipated as approximately 20 trips per day.

For the SCONI project, PM_{10} concentrations and deposition levels one kilometre to the west of the haul road do not exceed 5 µg/m^3 and 1 mg/m^2/day respectively, well within the criteria. Daily haulage traffic for SCONI was anticipated as 15 x 73 tonne road haul truck trips.

Impacts from the RDPE mine were predicted at a site 2 kilometres to the south-east of the main haul route but substantially closer to the pit and exposed areas in comparison to West Leichardt Station. Predicted particulate concentrations and deposition levels were 26 µg/m^3 and 20 mg/m^2/day respectively, well within criteria. Based on an ore transport rate of 0.7 megatonnes per year by B-double trucks, the haul traffic assumed was approximately 7 trips per day, lower than that of the BCP, but most of the dust predicted at this site was from dust sources not associated with road haulage such as large on-site haul trucks and dozers.

Based on the results predicted for other mines, it is considered unlikely that ore haulage would be a substantial contributor to any exceedances of criteria at the West Leichardt Station.

7.3 Recommendations

Compliance with the relevant criteria is anticipated based on the application of standard mitigation measures. This section contains three recommendations arising from this assessment.

7.3.1 Emission Controls

1. Undertake watering of all haul routes using both mine haul road water trucks and light on-road water trucks at a rate suitable for the conditions.
2. Incorporate water injection in drill rigs.

7.3.2 Monitoring

3. Should a complaint regarding dust nuisance be received, undertake dust deposition monitoring at a site representative of the complainant's residence according to AS3580.10.1 2003 Methods for sampling and analysis of ambient air – Determination of particulate matter – Deposited matter – Gravimetric method. This monitoring would be undertaken for 12 months and the results reviewed to determine the extent of future monitoring.

8 Conclusion

An air quality assessment has been conducted for the proposed BCP. Based on assessment of similar projects, annual and short term concentration and deposition levels are anticipated to be within the relevant air quality criteria at West Leichardt Station. The dust control measures recommended in **Section 7.3** should be implemented and maintained.

References

AS/NZS 3580.1.:2007 “Methods for sampling and analysis of ambient air - Guide to siting air monitoring equipment”.

AS/NZS 3580.10.1 2003: Methods for sampling and analysis of ambient air – Determination of particulate matter – Deposited matter – Gravimetric method

Department of Environment and Heritage Protection (2013a), *Guideline: Application requirements for activities with impacts to air,* Queensland Government.

Environmental Protection Agency (2008), *Environmental Protection (Air) Policy*, Queensland EPA.

National Environmental Protection Council (2003), *National Environment Protection (Ambient Air Quality) Measure*, NEPC, Canberra.

Appendix A Glossary

Parameter or Term	Description
ASK	ASK Consulting Engineers Pty Ltd
BCM	Bank Cubic Metres (volume of material in the ground prior to mining)
Dust fallout deposition	Dust that has fallen out of the air onto a horizontal surface
EHP	Queensland Department of Environment and Heritage Protection
EPA	Queensland Environmental Protection Act 1994
EPP (Air)	Queensland Environmental Protection (Air) Policy 2008
FEL	Front end loader
g/m^2/month	Grams per square metre per month
m/s	Metres per second
mg/m^2/day	Milligrams per square metre per day
mg/m^3	Milligrams per cubic metre
NEPM	National Environmental Protection (Ambient Air Quality) Measure
$PM_{2.5}$	Particulates suspended in air with aerodynamic diameter less than 2.5 microns
PM_{10}	Particulates suspended in air with aerodynamic diameter less than 10 microns
TSP	Total particulates suspended in air
µg/m^3	Micrograms per cubic metre

This page is intentionally blank.

Appendix D
NPI Report

NPI Report for 22/23 Mount Colin Mine Q020MCM001 Financial Year

Facility Information

Registration

Registered Business Name

Round Oak Minerals Pty Ltd

Facility Name

Mount Colin Mine

Australian Company Number(ACN)

130641691

Australian Business Number(ABN)

64130641691

Registered Address

Street	Level 10, 120 Edward Street
Suburb	Brisbane
State	Queensland
Postcode	4000

Postal Address

Street	PO Box 28
Suburb	Cloncurry
State	Queensland
Postcode	4824

Location

Site Address

Street	Mount Colin Mine, off Barkly Highway
Suburb	Cloncurry
State	Queensland
Postcode	4824

Site Location

Latitude	-20.779548	Longitude	140.048171

Details

Jurisdiction ID

Q020MCM001

Licence Number

EPML00715513

Primary ANZSIC

0803 - Copper Ore Mining

Main Activites

Mining Copper Ore

WWW Address

No. of Employees

	60

Public Contact

Name	
Position	Information and Queries
Telephone	(07) 3835 6200
Mobile	
Fax	
Email	
Street	
Suburb	
State	
Postcode	

Technical Contact

Name	David Eason
Position	Senior Environment and Community Advisor
Telephone	0480 266 094
Mobile	
Fax	
Email	deason@aerisresources.com.au
Street	
Suburb	
State	
Postcode	

Fuel and Energy Usage

1) How much fuel or waste does your facility burn in a year?

Fuel	Quantity	Unit	Tonnes/Yr
Diesel	2963544	Litres	2477.522784
Explosives	394	Tonnes	394
		Total	2871.522784

2) Has your facility burned one tonne of fuel or waste in any hour during the reporting period?	No
3) Please enter the annual energy usage for your facility in MW-hr?	0
4) Is your facility rated at 20MW (megawatts) or higher?	No

Emissions Data

Substance	Usage (t/year)	Air Point (kg/year)	EET	Air Fugitive (kg/year)	EET	Total	Water (kg/year)	EET	Land (kg/year)	EET
Arsenic & compounds	8.5667532			9.089946165	2	9.089946165			0.17	2
Beryllium & compounds	0.69156306			0.40584167	2	0.40584167				
Cadmium & compounds	0.03783652			0.407151245	2	0.407151245			0.017	2

Carbon monoxide		36381.24471	4	24866.94291	2	61248.18762				
Chromium (III) compounds	15.773426			81.97349149	2	81.97349149			0.17	2
Cobalt & compounds	60.9859954			24.89163955	2	24.89163955			0.17	2
Copper & compounds	6833.57594		3	1883.239313	2	1883.239313			0.34	2
Cumene (1-methylethylbenzene)	32.12760665			1.878229312	2	1.878229312				
Fluoride compounds				227.2591702	2	227.2591702				
Lead & compounds	1.6919776			40.12464342	2	40.12464342			0.34	2
Manganese & compounds	352.90572			1191.092492	2	1191.092492			0.68	2
Mercury & compounds	0.01338358			0.071602541	2	0.071602541				
Nickel & compounds	71.8337045			75.09018087	2	75.09018087			0.17	2
Oxides of Nitrogen		169079.5027	4	32088.36985	2	201167.87255				
Particulate Matter 10.0 um		11893.86846	4	380169.4166	2	392063.28506				
Particulate Matter 2.5 um		11614.01273	4	2378.080928	2	13992.093658				
Polycyclic aromatic hydrocarbons (B[a]Peq)	11.862500920	0.000564376	4	1.163601725	2	1.164166101				
Sulfur dioxide		38.946588879	4	43.90432571	2	82.8509146				
Total Volatile Organic Compounds	188.2917316	12360.29468	4	3100.262467	2	15460.557147				
Xylenes (individual or mixed isomers)	11.368230005	10.937694672	4	1.120347309	2	12.058042029				
Zinc and compounds	14.8461275			105.6477211	2	105.6477211			0.68	2

Emissions Data Notes

Substance	Notes

Emissions Data Advisories

Substance	Advisory Message	Advisory Reason/Comment
Chromium (VI) compounds	Category 2b threshold exceeded, emission expected for this substance	Other No EF available for this substance
Cobalt & compounds	Substance not reported in last Report	Other Different assay concentration
Copper & compounds	Significant Emission Increase From Last Report to Air Fugitive	Other Different assay concentration
Copper & compounds	Significant Emission Increase From Last Report to Air Total	Other Different assay concentration
Copper & compounds	EET Method has changed since previous report	Other Different assay concentration
Fluoride compounds	Destination (or Air source) has changed since previous report	Other No assay concentration available

Hydrochloric acid	Category 2b threshold exceeded, emission expected for this substance	Other No EF available for this substance
Hydrochloric acid	Category 2a threshold exceeded, emission expected for this substance	Other No EF available for this substance
Lead & compounds	Significant Emission Increase From Last Report to Land	Other Different assay concentration
Magnesium oxide fume	Category 2b threshold exceeded, emission expected for this substance	Other No EF available for this substance
Polychlorinated dioxins and furans (TEQ)	Category 2b threshold exceeded, emission expected for this substance	Other No EF available for this substance
Zinc and compounds	Substance not reported in last Report	Other Different assay concentration

Reductions

Cleaner Production Activities and Pollution Control Equipment (PCE)

Type	Date Installed	Description	Comments
Activity		Changed production schedules to minimise equipment/feedstock changeovers	
Activity		Dust suppression - water sprays/chemical suppression	

Transfers

Substance	Amount (kg/year)	TET	Destination / Containment Type / Treatment Type

Transfers Notes

Substance	Notes

Transfer Advisories

Substance	Advisory Message	Advisory Reason/Comment
Chromium (III) compounds	Category 1 threshold exceeded, substance expected	Other No waste containing this NPI substance is sent to mandatory reporting destinations
Cobalt & compounds	Category 1 threshold exceeded, substance expected	Other No waste containing this NPI substance is sent to mandatory reporting destinations
Copper & compounds	Category 1 threshold exceeded, substance expected	Other No waste containing this NPI substance is sent to mandatory reporting destinations
Cumene (1-methylethylbenzene)	Category 1 threshold exceeded, substance expected	Other Constituent of diesel fuel
Manganese & compounds	Category 1 threshold exceeded, substance expected	Other No waste containing this NPI substance is sent to mandatory reporting destinations
Nickel & compounds	Category 1 threshold exceeded, substance expected	Other No waste containing this NPI substance is sent to mandatory reporting destinations
Xylenes (individual or mixed isomers)	Category 1 threshold exceeded, substance expected	Other Constituent of diesel fuel
Zinc and compounds	Category 1 threshold exceeded, substance expected	Other No waste containing this NPI substance is sent to mandatory reporting destinations

Resources and Statements

Internal Costs	
External Costs	
Public Statement	

Confidential Statement	

Status Information

Report Status	Submitted
Date Submitted	01/09/2023
Report Submitted By	David Eason
Receipt Number	R2023-128527

Certification

I certify that I have reviewed this report, and to the best of my knowledge and ability, all the information provided in this report:

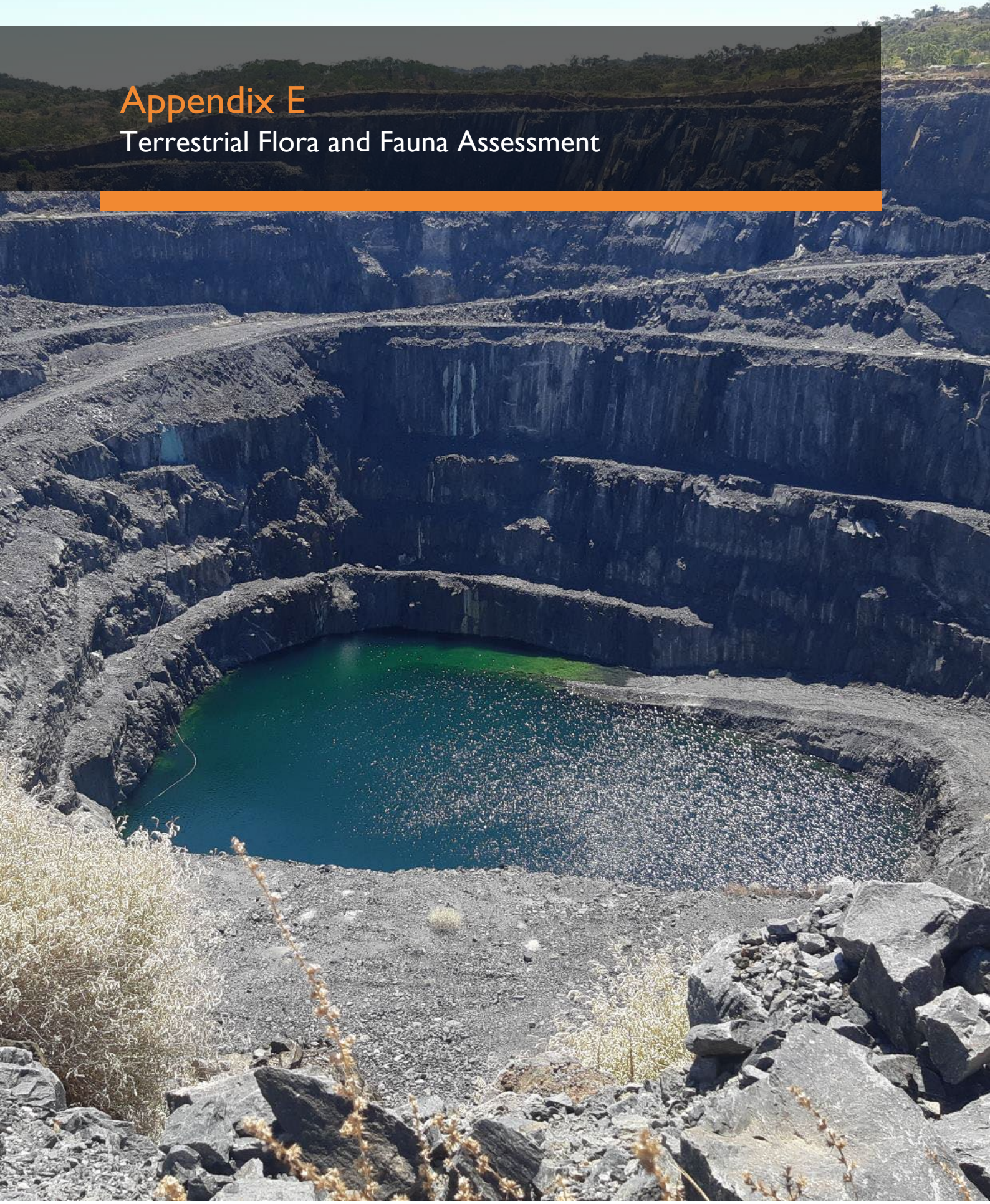
☑ Has been estimated or extrapolated using all due care and diligence and in accordance with the relevant industry estimation techniques.

☐ Has been estimated or extrapolated using all due care and diligence and in accordance with estimation techniques agreed by my state or territory environment agency.

Name	David Eason
Position	Senior Environment and Community Advisor
Signature	
Date	01/09/2023

This page is intentionally blank.

Appendix E
Terrestrial Flora and Fauna Assessment



Barbara Copper Project

Terrestrial Flora and Fauna Assessment

Prepared for:
CopperChem Limited

November 2014

AustralAsian Resource Consultants

Document History and Status

Issue	Rev.	Issued To	Qty	Date	Reviewed	Approved
1	0	G. Connolly	1	22/10/14	AGP	AGP
1	1	G. Connolly	1	21/11/14	GC	AGP

Author:	Hollie Dick
Project Manager:	Julie Byrd
Name of Client :	CopperChem Limited
Name of Project:	Barbara Copper Project
Title of Document:	Terrestrial Flora and Fauna Assessment
Document Version:	Final Rev 1

This controlled document is the property of AustralAsian Resource Consultants Pty Ltd and all rights are reserved in respect of it. This document may not be reproduced or disclosed in any manner whatsoever, in whole or in part, without the prior written consent of AustralAsian Resource Consultants Pty Ltd. AustralAsian Resource Consultants Pty Ltd expressly disclaims any responsibility for or liability arising from the use of this document by any third party.

Opinions and judgments expressed herein, which are based on our understanding and interpretation of current regulatory standards, should not be construed as legal opinions. Information obtained from interviews and contained in the documentation has been assumed to be correct and complete. AustralAsian Resource Consultants Pty Ltd does not accept any liability for misrepresentation of information or for items not visible, accessible, nor able to be inspected at the sites at the time of the site visits.

TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

1.0 INTRODUCTION 4

1.1 SCOPE OF STUDY 4

2.0 PROJECT DESCRIPTION 5

2.1 PROJECT LOCATION 5

2.2 LOCAL WATERWAYS AND TOPOGRAPHY 7

2.3 GEOLOGY 9

2.4 REGIONAL CLIMATE 9

2.5 CURRENT LAND USE 10

3.0 RELEVANT LEGISLATION, POLICY AND GUIDELINES 11

3.1 LEGISLATION 11

3.1.1 Commonwealth Environment Protection and Biodiversity Conservation Act 1999 11

3.1.2 Queensland Nature Conservation Act 1992 11

3.1.3 Queensland Vegetation Management Act 1999 12

3.1.4 Queensland Land Protection (Pest and Stock Route Management) Act 2002 13

3.2 POLICIES AND GUIDELINES 13

3.2.1 Offsets under the Environmental Protection and Biodiversity Conservation Act 1999 13

3.2.2 Queensland Environmental Offsets Policy 14

3.2.3 Biodiversity and Mapping Methodology (BAMM) 15

3.2.4 Queensland Biodiversity Planning Assessments and EHP Biodiversity Status 16

3.2.5 Back on Track Species Prioritisation Framework 16

4.0 DATABASE SEARCH AND LITERATURE REVIEW 18

4.1 FLORA 18

4.1.1 Threatened Ecological Communities 18

4.1.2 Regional Ecosystems 19

4.1.3 Species of Conservation Significance 21

4.1.4 Back on Track Flora Species 21

4.2 FAUNA 22

4.2.1 Fauna Species of Conservation Significance 22

4.2.2 Back on Track Fauna Species 24

4.2.3 Migratory Fauna Species 25

4.3 ENVIRONMENTALLY SENSITIVE AREAS 27

4.4 WETLAND MAPPING 29

5.0 METHODOLOGY 31

5.1 INITIAL SITE SCOPING 31
5.2 FLORA SURVEY METHODOLOGY 31
5.2.1 Flora and Regional Ecosystem Identification 33
5.2.2 Surveys for Species of Conservation Significance 33
5.3 FAUNA SURVEY METHODOLOGY 33
5.3.1 Fauna Survey Sites 34
5.3.2 Detection Methods 36
5.3.3 Survey effort 39
6.0 RESULTS AND DISCUSSION 41
6.1 SURVEY TIMING 41
6.2 WEATHER CONDITIONS 41
6.3 FLORA SURVEY RESULTS 42
6.3.1 Community 1 – Low Open Woodland of Snappy Gum (*Eucalyptus leucophloia*) on metamorphic hills 44
6.3.1.1 Community Description 44
6.3.1.2 Conservation Value 45
6.3.1.3 Vegetation Condition and Habitat Value 46
6.3.2 Community 2 – Low Open Woodland of Cloncurry Box (*Eucalyptus leucophylla*) and Bloodwood (*Corymbia terminalis*) on Metamorphic hills 46
6.3.2.1 Community Description 46
6.3.2.2 Conservation Value 47
6.3.2.3 Vegetation Condition and Habitat Value 48
6.3.3 Community 3 – Low Open Woodland of Cloncurry Box (*E. leucophylla*) on Alluvial Flats 48
6.3.3.1 Community Description 48
6.3.3.2 Conservation Value 49
6.3.3.3 Vegetation Condition and Habitat Value 50
6.3.4 Community 4 – River Red Gum (*Eucalyptus camaldulensis*) and Northern Swamp Box (*Lophostemon grandiflorus*) Riparian Woodland 50
6.3.4.1 Community Description 50
6.3.4.2 Conservation Value 51
6.3.4.3 Vegetation Condition and Habitat Value 52
6.3.5 Community 5 – Low Open Woodland of Arid Peach (*Terminalia aridicola*) on Rocky Outcrops 52
6.3.5.1 Community Description 52
6.3.5.2 Conservation Value 53
6.3.5.3 Vegetation Condition and Habitat Value 54
6.3.6 Community 6 – Capricornia (*Corymbia Capricornia*) Ridges 54
6.3.6.1 Community Description 54
6.3.6.2 Conservation Value 55
6.3.6.3 Vegetation Condition and Habitat Value 55

6.3.7 Community 7 – Low Open Woodland of Cloncurry Box (*E. leucophylla*) and Bloodwood (*C. terminalis*) on granites 56
6.3.7.1 Community Description 56
6.3.7.2 Conservation Value 56
6.3.7.3 Vegetation Condition and Habitat Value 57
6.3.8 Flora Species of Conservation Significance 57
6.3.9 Weeds of Management Concern 57
6.4 FAUNA SURVEY RESULTS 58
6.4.1 Amphibians 58
6.4.1.1 Habitat Values 58
6.4.2 Observed Species 58
6.4.2.1 Amphibian Species of Conservation Significance 59
6.4.3 Reptiles 59
6.4.3.1 Habitat Values 59
6.4.3.2 Observed Species 60
6.4.3.3 Reptile Species of Conservation Significance 63
6.4.4 Birds 63
6.4.4.1 Habitat Values 63
6.4.4.2 Observed Species 64
6.4.4.3 Bird Species of Conservation Significance 64
6.4.4.4 EPBC Act Listed Migratory and Marine Species 64
6.4.5 Mammals 65
6.4.5.1 Habitat Values 65
6.4.5.2 Observed Species 66
6.4.5.3 Mammal Species of Conservation Significance 68
6.4.6 Pest Species 70
6.4.7 Regional Fauna Species of Conservation Significance 71
7.0 ENVIRONMENTAL VALUES, POTENTIAL IMPACTS AND MITIGATION .. 78
7.1 SUMMARY OF ENVIRONMENTAL VALUES 78
7.2 POTENTIAL IMPACTS 79
7.3 MITIGATION AND MANAGEMENT STRATEGIES 83
7.3.1 Flora Management 83
7.3.2 Fauna Management 83
7.3.3 Threatened Species Management 84
7.3.4 Weed and Pest Management 84
7.3.4.1 Weed Management 84
7.3.4.2 Pest Management 85
7.3.4.3 Emission Management 85
7.3.4.4 Training and awareness 86
7.4 ENVIRONMENTAL OFFSET ASSESSMENT 86

REFERENCES 90

LIST OF FIGURES

Figure 1 Project Locality 6
Figure 2 Waterbodies on and Surrounding the Project Site 8
Figure 3 Mean Temperature and Rainfall Data for the Region 9
Figure 4 Regional Ecosystem Mapping over the Project Site 20
Figure 5 Environmentally Sensitive Areas on and Surrounding the Project Site 28
Figure 6 Queensland Wetland mapping over the Project Site 30
Figure 7 Flora Survey Locations on the Project Site 32
Figure 8 Terrestrial Fauna Survey Locations on the Project Site 35
Figure 9 Vegetation Communities within the Study Area 43
Figure 10 Threatened Species Records 69
Figure 11 PNRW Habitat Areas 70
Figure 12 Impacts on Vegetation Communities 80
Figure 13 Potential Impacts on Watercourses and PNRW Habitat 87

LIST OF TABLES

Table 1 Regional Ecosystems Mapped within the Project Site 19
Table 2 Flora Species of Conservation Significance within the Project Region 21
Table 3 Southern Gulf NRM Region Back on Track Priority Flora Species 21
Table 4 Fauna Species of Conservation Significance Occurring within the Project Region 22
Table 5 Back on Track Priority Fauna Species in the Southern Gulf NRM region 24
Table 6 Migratory and Marine Species within the Project Region 25
Table 7 Summary of Sampling Effort 40
Table 8 Community 1 Profile 44
Table 9 Community 2 Profile 46
Table 10 Community 3 Profile 48
Table 11 Community 4 Profile 50
Table 12 Community 5 Profile 52
Table 13 Community 6 Profile 54
Table 14 Community 7 Profile 56
Table 15 Flora of Conservation Significance known from the Region - Not Identified on the Project 57

Table 16 Threatened Fauna known from the Region Not Observed on the Project site 72
Table 17 Potential Impacts on Vegetation Communities 81
Table 18 Summary of Environmental Offset Requirements 88

LIST OF PHOTO PLATES

Photo Plate 1 Low open woodland of Snappy Gum (*E. leucophloia*) on metamorphic hills 45
Photo Plate 2 Low open woodland of Cloncurry Box and Bloodwood on metamorphic hills 47
Photo Plate 3 Low open woodland of Cloncurry Box on alluvial flats 49
Photo Plate 4 River Red Gum and Northern Swamp Box Riparian Woodland 51
Photo Plate 5 Low open woodland of Arid Peach on rocky outcrops 53
Photo Plate 6 Capricornia ridges 55
Photo Plate 7 *Litoria coplandi* recorded in a small sandstone gorge (OBSO2) 59
Photo Plate 8 Hosmer's Skink (*Egernia hosmeri*) captured in an Elliott trap at FA6 60
Photo Plate 9 Northern Spiny-tailed Gecko at FA5 61
Photo Plate 10 Northern Hooded Scaly-foot (*Pygopus steelescotti*) captured at FA1 62
Photo Plate 11 Robust Blind Snake (*Ramphotyphlops ligatus*) captured at FA5 63
Photo Plate 12 Common Planigale (*Planigale maculata)* captured at FA5 67
Photo Plate 13 Purple-necked Rock-wallaby at FA8 68
Photo Plate 14 Pitfall Line at DSFS1 ..... A
Photo Plate 15 Pitfall Line at DSFS2 ..... A
Photo Plate 16 Pitfall Line at Study Site DSFS3 ..... B
Photo Plate 17 Pitfall Line at DSFS4 ..... B
Photo Plate 18 Pitfall Line at DSFS5 C
Photo Plate 19 Pitfall Line at TR01 C
Photo Plate 20 Pitfall Line at TR02 ..... D
Photo Plate 21 Pitfall Line at TR03 ..... D
Photo Plate 22 Pitfall Line at TR04 ..... E
Photo Plate 23 Pitfall Line at TR05 ..... E
Photo Plate 24 Pitfall Line at TR06 ..... F
Photo Plate 25 Pitfall Line at TR07 ..... F
Photo Plate 26 Pitfall Line at TR08 ..... G
Photo Plate 27 Pitfall Line at FA1 ..... H
Photo Plate 28 Pitfall Line at FA2 I
Photo Plate 29 Rocky outcrop habitat at FA3 I
Photo Plate 30 Pitfall Line at FA4 ..... J
Photo Plate 31 Pitfall Line at FA5 ..... K

Photo Plate 32 Low Open Snappy Gum Woodland on Hillsides at FA6 ..... K
Photo Plate 33 Rocky outcrop habitat at FA7 L
Photo Plate 34 Harp trap in River Red Gum / Northern Swamp Box Creek at FA8 ..... M

LIST OF APPENDICES

Appendix A Database Search Results ..... A
Appendix B Fauna Study Sites ..... B
Appendix C Flora Species Inventory C
Appendix D Fauna Species Inventory ..... D
Appendix E Bat Call Analysis Results ..... E
Appendix F Pest Species Fact Sheets ..... F

LIST OF ABBREVIATIONS

°C	-	degrees Celsius
AARC	-	AustralAsian Resource Consultants Pty Ltd
BAMM	-	Biodiversity and Mapping Methodology
BoT	-	Back on Track
BPA	-	Biodiversity Planning Assessments
CAMBA	-	China-Australia Migratory Bird Agreement
cm	-	centimetre
CopperChem	-	CopperChem Limited
DBMP	-	Direct Benefit Management Plan
DOE	-	Department of the Environment
E	-	Endangered
EHP	-	Department of Environment and Heritage Protection
EM Plan	-	Environmental Management Plan
EPBC Act	-	*Environment Protection and Biodiversity Conservation Act 1999*

EPM	-	Mineral Exploration Permit
ESA	-	Environmentally Sensitive Area
GIS	-	Geographical Information System
ha	-	hectare
JAMBA	-	Japan-Australia Migratory Bird Agreement
km	-	kilometres
km/h	-	kilometres/hour
km^2	-	square kilometres
LC	-	Least Concern
LP Act	-	*Land Protection (Pest and Stock Route Management) Act 2002*
Ma	-	Marine
Mi	-	Migratory
MLA	-	Mining Lease Application
MNES	-	Matter of National Environmental Significance
MSES	-	Matters of State Environmental Significance
mm	-	millimetres
NC Act	-	*Nature Conservation Act 1992*
NCWR	-	*Nature Conservation (Wildlife) Regulation 2006*
NL	-	Not Listed
NRM	-	Natural Resource Management
NT	-	Near Threatened
PNRW	-	Purple-necked Rock-wallaby
RAD	-	Recovery Actions Database
RE	-	Regional Ecosystem
REDD	-	Regional Ecosystem Description Database
SL	-	Special Least Concern
V	-	Vulnerable

VMA	-	*Vegetation Management Act 1999*
VMR	-	*Vegetation Management Regulation 2012*
WoNS	-	Weeds of National Significance

EXECUTIVE SUMMARY

AustralAsian Resource Consultants was commissioned by CopperChem Limited to undertake a Terrestrial Flora and Fauna Assessment of the proposed Barbara Copper Project (the Project). This assessment forms part of a series of baseline studies required for the Project's Environmental Authority application. To assess the environmental values of flora and fauna communities on the Project site, AustralAsian Resource Consultants undertook the following scope of works:

- Completion of a literature and database review to identify species, regional ecosystems and ecological communities of conservation significance within the region in which the Project is located;

- Compilation of an inventory of the ecological communities, regional ecosystems, vertebrate fauna and flora inhabiting the Project site, with a particular focus on species and communities of conservation significance; and

- Preparation of a report describing significant ecological factors, potential impacts and outlining possible management strategies, in order to reduce any foreseeable impacts associated with the proposed activities.

The Project is located approximately 50 kilometres north-east of Mount Isa and 100 kilometres west of Cloncurry in the Northwest Highlands Bioregion. The Project is a proposed copper and gold mining operation which will involve open-cut mining and associated activities on the Project site. Historically the Project site has been subject to cattle grazing and mining activities, whilst more recent activities have been limited to low intensity cattle grazing and mineral exploration activities.

Database searches revealed that no threatened ecological communities and species occur in the region in which the Project site is located. One Environmentally Sensitive Area identified as an Endangered Regional Ecosystem is mapped on the Project site.

Four site surveys were undertaken during the wet and dry season periods in 2011 and 2014. In 2011, a wet season survey was conducted between the 28th March and 3rd of April, and a dry season survey was undertaken between the 19th and 25th October. Recent surveys were conducted from 30th January to 7th February 2014 during the wet season and between the 1st and 8th August 2014 in the dry season.

To provide a comprehensive assessment of biodiversity values on the Project site, a total of thirty-six secondary flora transects and twenty-one fauna trapping sites were conducted throughout the Project site. Fauna survey techniques utilised included Elliott trapping, pitfall and funnel trapping, camera trapping, harp trapping and bat call recording, habitat searching, spotlighting and bird surveying.

A total of one-hundred and sixty-seven species of plants were recorded during the Project surveys. Seven vegetation communities were identified on the Project site, all of which are classified as remnant vegetation. The vegetation communities are representative of five different Regional Ecosystems. Vegetation communities identified on the Project site include:

- Community 1 - Low Open Woodland of Snappy Gum (*Eucalyptus leucophloia*) on Metamorphic Hills;

- Community 2 - Low Open Woodland of Cloncurry Box (*Eucalyptus leucophylla*) and Bloodwood (*Corymbia terminalis*) on Metamorphic Hills;

- Community 3 - Low Open Woodland of Cloncurry Box (*E. leucophylla*) on Alluvial Flats;
- Community 4 - River Red Gum (*Eucalyptus camaldulensis*) and Northern Swamp Box (*Lophostemon grandiflorus*) Riparian Woodland;
- Community 5 - Low Open Woodland of Arid Peach (*Terminalia aridicola*) on Rocky Outcrops;
- Community 6 - Capricornia (*Corymbia capricornia*) Ridges; and
- Community 7 - Low Open Woodland of Cloncurry Box (*Eucalyptus leucophylla*) and Bloodwood (*Corymbia terminalis*) on granites.

Community 1 occupies the vast majority of the Project site, while all other communities occur in patches throughout the site.

No threatened flora species were identified on the Project site during field surveys. Six weed species were recorded in low densities across the Project site. None of the recorded weed species are listed as declared weeds under the Queensland *Land Protection (Pest and Stock Route Management) Act 2002* or Weeds of National Significance.

A total of one-hundred and forty-four fauna species were identified on the Project site, consisting of nine amphibians, eighty birds, twenty-seven reptiles and twenty-eight mammals. One threatened bird species, the Golden-backed Honeyeater (*Melithreptus gularis laetior*) and one threatened mammal species, the Purple-necked Rock-wallaby (*Petrogale purpureicollis*) were recorded on the Project site. Under the Queensland *Nature Conservation (Wildlife) Regulation 2006,* the Golden-backed Honeyeater is classified as Near Threatened and the Purple-necked Rock-wallaby is listed as Vulnerable. One migratory bird species, the Rainbow Bee-eater was also recorded on the Project site. Site surveys recorded a suite of five pest species consisting of the Cane Toad (*Rhinella marina)*, Wild Dog/Dingo (*Canis familiaris)*, Feral Pig (*Sus scrofa*), House Mouse (*Mus domesticus*) and domestic Cow (*Bos taurus*). The Wild Dog/Dingo and Feral Pig are both classified as Class 2 declared pest animals under the *Land Protection (Pest and Stock Route Management) Act 2002*.

The following potential impacts were identified for the Project:

- Clearing of remnant vegetation will result in the loss of small areas of Regional Ecosystems, as well as the loss of habitat for flora species;
- Reduction in the availability of fauna habitat, leading to the displacement of native fauna and an increase in competition for resources in retained habitats;
- Reduction in the size and connectivity of habitat, particularly within riparian corridors and the south-east portion of the Project site;
- Removal of mature trees will lead to loss of habitat for hollow-dwelling fauna;
- Removal of potential shelter and forage habitat for threatened fauna species leading to fauna displacement and increased competition;
- Fauna injury or death may result from Project clearing activities and increased vehicle movements on-site;
- Project disturbances such as artificial lighting and noise pollution may impact on local fauna, particularly nocturnal birds and mammals;

- Soil erosion, sedimentation and vegetation smothering;
- Introduction, spread and increased abundance of weed species due to vegetation clearing, which alters micro-climate conditions and increased vehicle presence and movement across the Project site;
- Increased pest abundance where Project disturbance creates favourable conditions including increased resource availability (e.g. food and water) and enhanced site access through vegetation clearing and the creation of new tracks; and
- Increased risk of fire.

To address these potential impacts, mitigation and management strategies are recommended as summarised below.

- The vegetation clearing footprint should be restricted to approved disturbance areas;
- Disturbed areas should be rehabilitated progressively throughout the life of the mine, where possible, and at Project completion;
- Removed topsoil should be retained, stockpiled and re-used in rehabilitation works on the Project site;
- Appropriate erosion controls should be implemented;
- To prevent fauna injury and mortality, an appropriately qualified and experienced fauna spotter/catcher should be present during clearing operations and speed limits shall be implemented across the Project site;
- Potential environmental offsetting for impacts on matters of State Environmental Significance such as Purple-necked Rock-wallabies and Regional Ecosystems on watercourses;
- Emission control measures should be implemented to minimise dust and noise generation, control artificial lighting;
- Chemicals and hazardous substances should be stored in accordance with the relevant Material Safety Data Sheets;
- Waste receptacles and artificial water sources should be fenced or sealed to prevent increases in pest abundance;
- A Bushfire Management Plan should be developed to minimise the risk of uncontrolled fires;
- A Weed Management Plan should be developed and implemented;
- A Pest Management Plan should be developed and implemented; and
- All staff and contractors are to receive environmental awareness and mitigation training.

1.0 INTRODUCTION

AustralAsian Resource Consultants Pty Ltd (AARC) was commissioned by CopperChem Limited (CopperChem) to conduct a Terrestrial Flora and Fauna Assessment of the proposed Barbara Copper Project (the Project). This work constitutes one of the baseline studies required for the Project's Environmental Authority Application.

This study provides an assessment of the presence of flora and fauna species on the Project site and identifies potential impacts that the proposed mining activities (construction, operation and decommissioning) may have on the local biota.

The Barbara Copper Project is a proposed copper-gold mining operation in north-west Queensland. The Project is a joint venture between CopperChem Limited and Syndicated Metals Limited. The Project site occurs within the Mineral Exploration Permit (EPM) tenements 16112 and 15564 and encompasses Mining Lease Application (MLA) 90241. This assessment covers approximately 1945 hectares (ha) of land which is referred to herein, as the Study area. The location of the Barbara Copper Project is shown in Figure 1.

To gain an understanding of the site's ecological values under various climatic conditions, four terrestrial flora and fauna surveys have been conducted during the 2011 and 2014 wet and dry seasons. The Project area assessed during the 2011 surveys was limited to Mining Lease Application (MLA) 90241. As the Study area has since expanded, additional surveys were conducted in 2014 to encompass the entire area of interest. Flora and fauna surveys were conducted as follows:

- A preliminary wet season survey was conducted over seven day period between the 28th March 2011 and 3rd of April 2011;
- A dry season survey conducted over a period of seven days between the 19th and 25th October 2011;
- A second wet season survey was conducted over nine consecutive days from the 30th January to 7th February 2014; and
- A second dry season survey was conducted over eight consecutive days from the 1st to 8th August 2014.

1.1 SCOPE OF STUDY

To assess the ecological values of flora and fauna communities within the Project site, the following scope of works was undertaken:

- Database searches to identify species of conservation significance known from the region (provided in Appendix A). This enabled these species to be targeted during the field survey component of the study;
- Field surveys employing standard methodologies to determine the composition of terrestrial flora and fauna species inhabiting the Project site, particularly species of conservation significance; and
- The preparation of a report to CopperChem describing the ecological features identified and outlining possible management strategies to reduce any foreseeable impact associated with the proposed mining activities.

2.0 PROJECT DESCRIPTION

Sections 2.1 to 2.5 describe the relevant aspects of the Project site, including location, local geography, topography, local watercourses, regional climate and current land uses.

2.1 PROJECT LOCATION

The Barbara Copper Project is situated in the Mount Isa Inlier, of the Northwest Highlands Bioregion, approximately 50 kilometres (km) north-east of Mount Isa and 100 km west of Cloncurry. The city of Mount Isa is the closest residential area. The regional location of the Project site is shown in Figure 1.

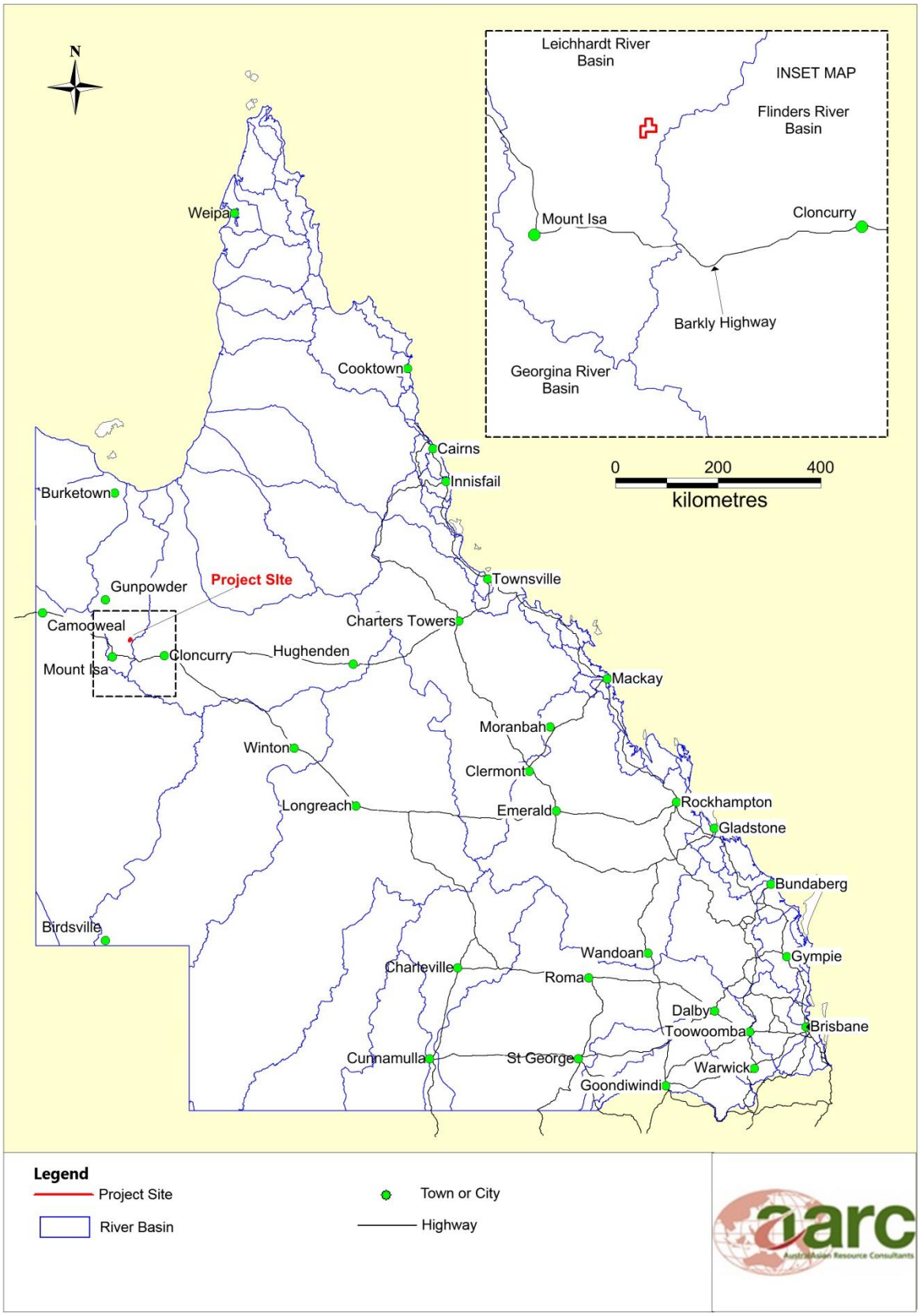


Figure 1 Project Locality

2.2 LOCAL WATERWAYS AND TOPOGRAPHY

The Project site is largely situated on rocky, undulating hills and outcropping, rocky ridgelines. The Project site lies within the Leichhardt drainage basin which spans an area of approximately 32, 878 square kilometres (km^2), originating to the south of Mount Isa and draining via the Leichhardt River into the Gulf of Carpentaria.

The Project is traversed by numerous drainage lines and ephemeral watercourses which drain into the Leichhardt River (refer to Figure 2). With the exception of one stream order 3 watercourse ('Watercourse A'), all other watercourses on the Project are classified as stream order 1 and 2. The third order watercourse passes from the east, through the south-west portion of the site, flows west, off-site and returns through the western boundary in the north before heading off-site and draining north-west into the Leichhardt River. All other drainage lines and tributaries occurring on the Project site drain into the third order watercourse. The Leichhardt River eventually drains into the Gulf of Carpentaria.

One permanent and several semi-permanent waterholes occur on watercourses throughout the Project site (refer to Figure 2). There are no wetlands or pastoral dams on the Project site.

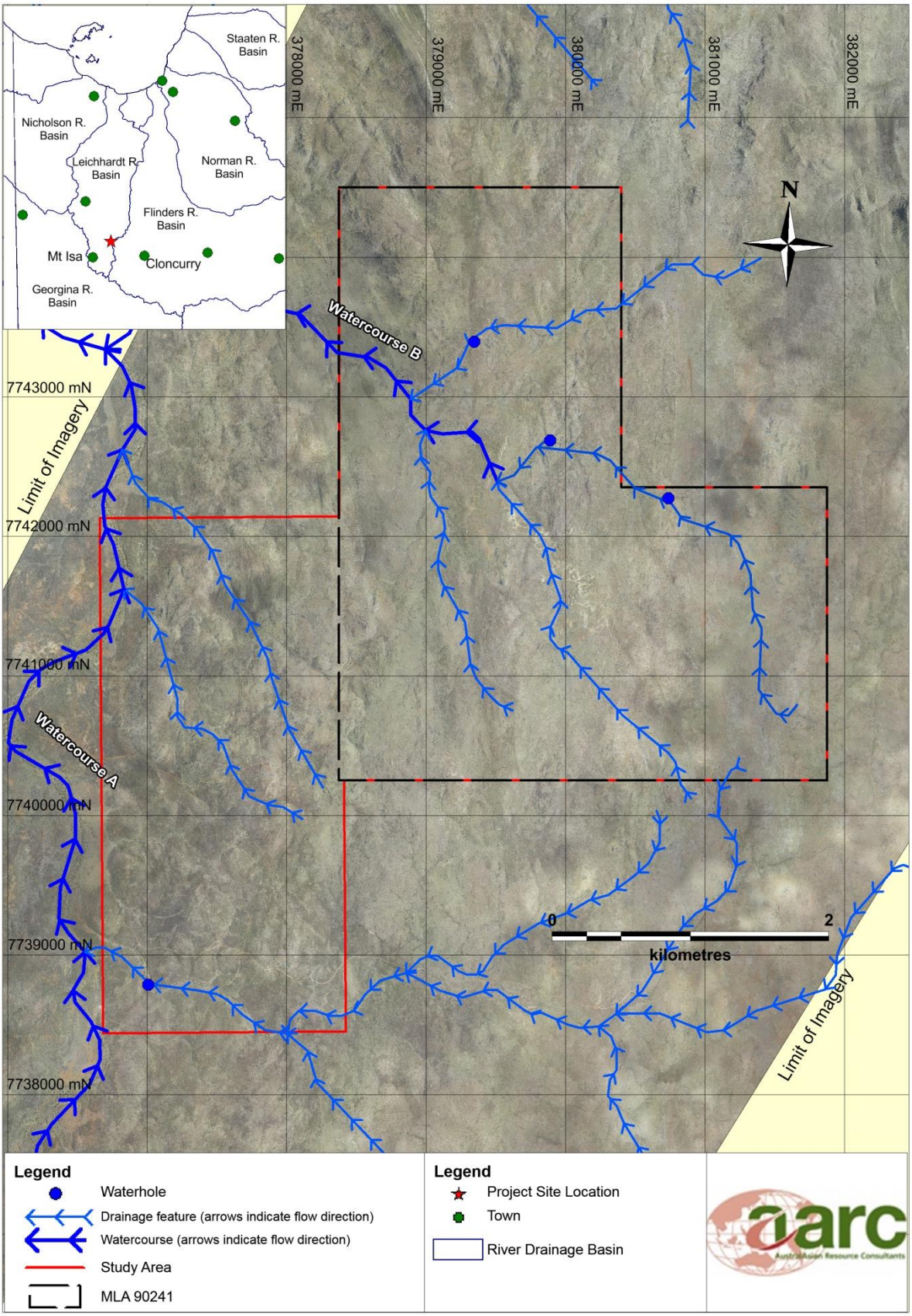


Figure 2 Waterbodies on and Surrounding the Project Site

2.3 GEOLOGY

The underlying geology on the project site is comprised predominantly of old Leichhardt Metamorphics from the Proterozoic era. Leichhardt metamorphics are made up of old metamorphic rock of volcanic origin and includes rhyolite, rhyodacite and dacite, phyllonite, acid gneiss, minor tiff, siltstone and quartzsite.

The copper sulphide starts close to surface and is up to 45 metres in thickness and consists of massive sulphide through to stringer veins within an alteration zone of biotite, tourmaline and quartz.

The near surface copper mineralisation is recoverable through open pit mining with the higher grade material below the limits of an open pit potentially recoverable by underground mining methods.

2.4 REGIONAL CLIMATE

The climate is characterised by semi-arid conditions with hot, wet summer months influenced by monsoonal activity and dry, cold winter months. The mean annual rainfall for the region (based on data from the West Leichhardt Station weather station between 1893 and 2014) is approximately 430 millimetres (mm). Mean monthly rainfall recorded from the West Leichhardt Station (station no. 29121) since 1893 is shown in Figure 3. This graph indicates the wet season occurs between December and March and dry season conditions occur between April and November.

Mean minimum and maximum temperatures for the region have been sourced from the Mount Isa Aero weather station (station no. 29127) which provides data recorded over a period of 48 years between 1966 and 2014. Monthly mean minimum and maximum temperatures for the region are shown in Figure 3. Generally, the hottest months occur between October and March and the coldest months occur between May and August. The highest mean maximum temperature occurs in December while the lowest mean minimum temperature occurs in July. The annual mean maximum temperature for the region is 31.8°C while the annual mean minimum temperature is 17.2°C.

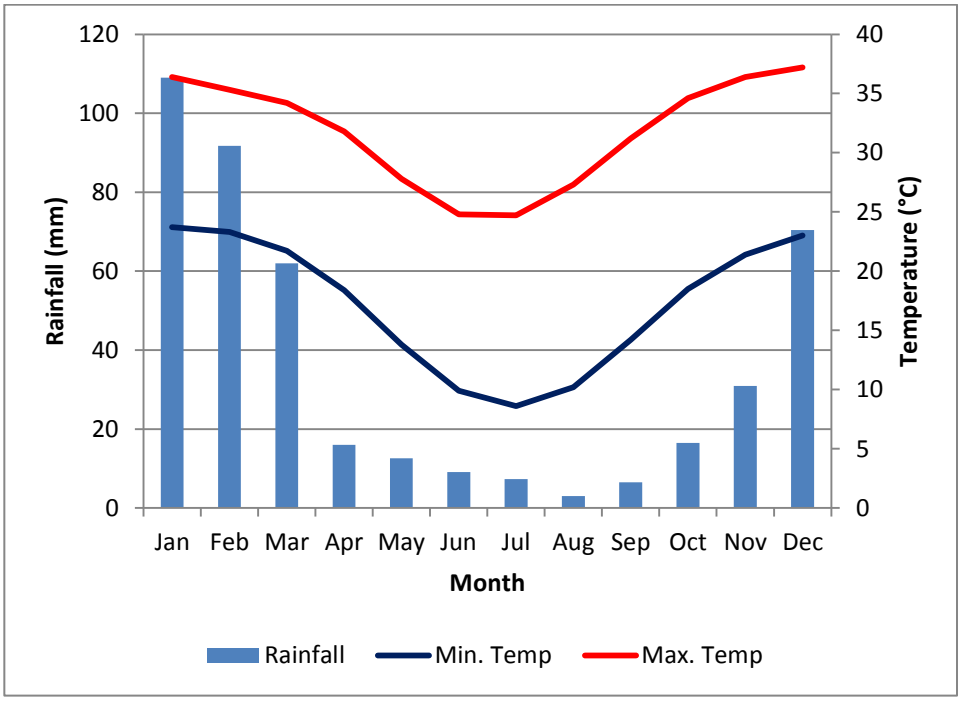


Figure 3 Mean Temperature and Rainfall Data for the Region

2.5 CURRENT LAND USE

Current land uses on the Project site include low intensity cattle grazing and mineral exploration activities. Historically, mining activities and cattle grazing have dominated the land-use, evidence of this is noted throughout the site, with fences, cattle grids and disused mine shafts obvious.

3.0 RELEVANT LEGISLATION, POLICY AND GUIDELINES

3.1 LEGISLATION

Commonwealth and State legislation relevant to the assessment of flora, fauna and biodiversity on the Project site is discussed below.

3.1.1 Commonwealth Environment Protection and Biodiversity Conservation Act 1999

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), an action will require approval from the Federal Environment Minister if the action has, will have, or is likely to have a significant impact on a Matter of National Environmental Significance, where a Matter of National Environmental Significance is:

- World Heritage Properties;
- National Heritage Places;
- RAMSAR wetlands of international importance;
- Listed threatened species and communities;
- Migratory species protected under international agreements;
- Nuclear actions; and
- The Commonwealth marine environment.

Of the above Matters of National Environment Significance, the following is applicable to the Project site:

- Migratory species protected under international agreements.

The Project is unlikely to affect any MNES therefore no EPBC referral has been submitted and no controlled actions are to be applied.

3.1.2 Queensland Nature Conservation Act 1992

The most relevant components of the *Nature Conservation Act 1992* (NC Act) to the Project are the sections which pertain to Wildlife and Habitat Conservation. The classes of wildlife[1] to which the NC Act applies include protected wildlife, which is defined as:

- Extinct wildlife;
- Endangered wildlife;
- Vulnerable wildlife;
- Near Threatened wildlife; and

[1]Under the NC Act, wildlife is defined to be any taxon of an animal, plant, protist, prokaryote or virus.

- Least Concern wildlife.

Species listed under the above classes are published in the associated *Nature Conservation (Wildlife) Regulation 2006* (NCWR).

The NC Act defines 'threatening processes' as any process that is capable of:

a) Threatening the survival of any protected area, area of major interest, protected wildlife, community of native wildlife or native wildlife habitat; or

b) Affecting the capacity of any protected area, area of major interest, protected wildlife, community of native wildlife or native wildlife habitat to sustain natural processes.

The NC Act is relevant to the Project site should any protected[2] flora or fauna species (as detailed in the NCWR) be found on the Project site.

3.1.3 Queensland Vegetation Management Act 1999

The *Vegetation Management Act 1999* (VM Act) is a part of a planning framework for the management of native vegetation across Queensland. The *Vegetation Management Regulation 2012* (VMR) prescribes the status of each of the REs identified within Queensland.

Although the VM Act does not apply to the clearing of vegetation on the Project site, the scientific basis for biodiversity conservation is still valid and can be used to assess the conservation significance of the vegetation communities on the Project site. This includes the conservation status categories of each RE under the VM Act, which are listed below, as is the definition of Remnant Vegetation.

Endangered Regional Ecosystems:

- <10% of pre-clearing extent remaining; and
- 10 - 30% of pre-clearing extent remaining and remnant <10,000 ha.

Of Concern Regional Ecosystems:

- 10 - 30% of pre-clearing distribution remains; and
- 30% of the pre-clearing extent remains and the remnant vegetation remaining is <10,000 ha.

Least Concern Regional Ecosystems:

- >30% of the pre-clearing distribution remains and remnant vegetation remaining is >10,000 ha.

Remnant Vegetation:

'Remnant Vegetation' for an area of Queensland for which there is no RE map or remnant vegetation map is any vegetation where the predominant canopy:

[2] Under the *Nature Conservation Act 1992*, a protected plant is any threatened, near threatened or least concern wildlife. Similarly, protected fauna is defined as being any native wildlife prescribed under the Act.

- covers more than 50% of the undisturbed predominant canopy;
- averages more than 70% of the vegetation's undisturbed height; and
- is composed of species characteristic of the vegetation's undisturbed dominant canopy.

3.1.4 Queensland Land Protection (Pest and Stock Route Management) Act 2002

The objectives of the Land Protection (Pest and Stock Route Management) Act 2002 (LP Act) are to provide for:

a) Pest Management; and

b) Stock route network management.

Chapter 2 of the LP Act relates directly to the management, control, prohibition, and regulation of the introduction, spread and keeping of certain plants and animals declared under the Act.

Classes of pests described in the LP Act include:

- Class 1 – one that is not commonly present in Queensland, and if introduced would cause an adverse economic, environmental or social impact;
- Class 2 – one that is somewhat established in Queensland and has, or could have, a substantial adverse economic, environmental or social impact; and
- Class 3 – one that is extensive in Queensland and has, or could have, an adverse economic, environmental or social impact.

Chapter 3 of the LP Act relates to the protection and management of the state stock route network.

The LP Act is relevant to the Project site in regards to the control and management of declared pest plant (weed) and animal species.

3.2 POLICIES AND GUIDELINES

Current policies and guidelines, conservation, recovery and management plans that have been produced by government or non-government organisations relevant to flora, fauna and biodiversity on the Project site are discussed below.

3.2.1 Offsets under the Environmental Protection and Biodiversity Conservation Act 1999

The purpose of the draft policy *Use of Environmental Offsets under the Environment Protection and Biodiversity Conservation Act 1999* statement is to outline the Australian Government's position on the use of environmental offsets under the EPBC Act. Environmental offsets can be used under the EPBC Act to maintain or enhance the health, diversity and productivity of the environment as it relates to matters protected by the EPBC Act.

Environmental offsets can be applied as an approval condition under the EPBC Act for developments that have undergone assessment. They may be used when a development will result in impacts on a matter protected by the EPBC Act. Environmental offsets are not applicable to all approvals under the EPBC Act. Offsets should not be applied where the impacts of a development are considered to be

minor in nature or could reasonably be mitigated. In some circumstances suitable offsets may not be available to adequately compensate for the impacts of a development and a decision on the overall acceptability of the project will need to be made.

Eight principles have been identified by the Australian Government for the use of environmental offsets under the EPBC Act. These principles are used in assessment of any proposed environmental offsets. The eight principles include:

1. Environmental offsets should be targeted to the matter protected by the EPBC Act that is being impacted.

2. A flexible approach should be taken to the design and use of environmental offsets to achieve long-term and certain conservation outcomes which are cost effective for proponents.

3. Environmental offsets should deliver a real conservation outcome.

4. Environmental offsets should be developed as a package of actions - which may include both direct and indirect offsets.

5. Environmental offsets should, as a minimum, be commensurate with the magnitude of the impacts of the development and ideally deliver outcomes that are 'like for like'.

6. Environmental offsets should be located within the same general area as the development activity.

7. Environmental offsets should be delivered in a timely manner and be long lasting.

8. Environmental offsets should be enforceable, monitored and audited.

3.2.2 Queensland Environmental Offsets Policy

The *Queensland Environmental Offsets Policy (Version 1.0)* requires offsets for a broad range of activities, including mining projects. Offsets are required when an applicant has demonstrated that despite all efforts to avoid or minimise impacts on Matters of State Environmental Significance (MSES) there is still residual impact. MSES (as outlined in Schedule 2 of the *Environmental Offsets Regulation 2014*) include:

- Regulated vegetation including:
    - i. Endangered and Of Concern regional ecosystems;
    - ii. Regional ecosystems that intersect areas shown as wetlands on the Vegetation Management Wetlands map;
    - iii. Regional ecosystems located within a prescribed distance from the defining banks of a watercourse; or
    - iv. Essential habitat;
- Areas that provide connectivity;
- Mapped wetlands and watercourse including:

i. wetland protection areas, or areas of high ecological significance as shown on the Map of referable wetlands;

ii. high ecological value waters (as defined und the Environmental Protection (Water) Policy 2009);

- High preservation areas within a Wild Rivers area;
- Protected wildlife habitat;
- Protected areas;
- Highly protected zones of State marine parks;
- Fish habitat areas;
- Waterways providing for fish passage;
- Marine plants; and
- Legally secured offsets.

Offsets can be delivered as proponent-driven offset, by financial settlement offset or a combination of both delivery options. A proponent-driven offset means that the authority holder (or proponent) is responsible for undertaking the delivery of the offset which may be delivered as a 'land-based' offset or as a Direct Benefit Management Plan (DBMP), or a combination. A DBMP is a strategy that delivers an offset through priority management actions that address threats to, and provide substantial benefits for the impacted prescribed environmental matter, including on a landscape scale. A DBMP may also be used to deliver a conservation outcome from a financial settlement offset.

The Project has the potential to have residual impacts on the following state significant environmental values:

- Protected wildlife habitat; and
- Regional ecosystems on watercourses.

No other MSES occur on the Project site.

Offsets proposed must comply with the criteria and offset rules set out in the *Queensland Environmental Offset Policy*.

3.2.3 Biodiversity and Mapping Methodology (BAMM)

The Biodiversity and Mapping Methodology was developed in 2002 and has application for identifying areas with various levels of significance for biodiversity. These include threatened ecosystems or taxa, large tracts of habitat in good condition and buffers to wetlands or other types of habitat important for the maintenance of biodiversity. Essential Habitat, RE Mapping, habitat quality and connectivity are all addressed in BAMM.

3.2.4 Queensland Biodiversity Planning Assessments and EHP Biodiversity Status

In 2002 Expert Panels were established to appraise biodiversity values in each of Queensland's bioregions. A specialised panel was established to assess biodiversity values for Fauna, Flora or Landscape. Findings from these panels were made in conjunction with Biodiversity Assessment Mapping Methodology (BAMM) and contributed to the Biodiversity Planning Assessments (BPA) for each subregion.

Biodiversity components included in the BPA consisted of threatened ecosystems or taxa, large tracts of habitat in good condition, ecosystem diversity, landscape context and connection, and buffers to wetlands or other types of habitat important for the maintenance of biodiversity or ecological processes. Assessments were all integrated into GIS maps and databases.

Biodiversity Planning Assessments are occasionally updated to address changes in status, taxonomy or mapping.

The Department of Environment and Heritage Protection (EHP) 'Biodiversity Status' is derived from the BAMM and is regulated under the Environment Protection Act. It is a conservation prioritisation system involving assigning status to particular REs to assist with biodiversity planning in Queensland. Unlike the status of REs under the VM Act, the EHP Biodiversity status is based on an assessment of criteria derived from BAMM in addition to knowledge of the pre-clearing and extent of the RE (taken from data collected under the VM Act). It takes into account other threatening processes in addition to land clearing. Such processes include:

- The reduction in biodiversity within the REs;
- Weed invasion;
- Grazing pressures;
- Inappropriate fire management;
- Fragmentation; and
- Infrastructure development.

Geographical Information System (GIS) data output displays spatial information on the significant features identified during the BPAs.

No significant BPA values have been identified on the Project site as a BPA has not yet been prepared and approved for the Northwest Highlands Bioregion.

3.2.5 Back on Track Species Prioritisation Framework

The "Back on Track" (BoT) species prioritisation framework is a Queensland government initiative developed to:

- Prioritise Queensland's native species to guide conservation management and recovery;
- Enable the strategic allocation of limited conservation resources for achieving greatest biodiversity outcomes; and

- Increase the capacity of government, Natural Resource Management (NRM) bodies and communities to make informed decisions by making information widely accessible.

The framework prioritises all fauna and flora species irrespective of their classification under the NC Act or EPBC Act. A series of criteria are used to prioritise each species or taxon. This allows relevant parties to identify species that are at risk and species which have the greatest chance of recovery with available resources.

The framework also identifies actions and threats common to a range of species encouraging a multi-species or landscape approach to conservation.

A “Back on Track Actions for Biodiversity Document” has been produced to address priority species and associated impacts and actions for each NRM region. A list of priority species/taxa has been developed for each NRM region and a ‘Back on Track’ priority ranking has been given to each. A separate priority ranking for NRM region and state wide has been given to each species. The list of Priority Species for state and NRM region can be accessed from the Back on Track Actions for Biodiversity Document or by searching the Recovery Actions Database (RAD).

Desktop research may reveal that some of the species identified as ‘priority’ taxa for the NRM region and the state of QLD may occur on the Project site or in the surrounding area. These species have been addressed in this report.

4.0 DATABASE SEARCH AND LITERATURE REVIEW

Database searches collate information on flora and fauna species, regional ecosystems and important habitat areas identified in the region from previous surveys, community records and other sources. A review of such databases facilitates the formulation of specific field survey techniques to target certain flora and fauna species known from the region.

The following database searches were completed using a 100 km buffer around a central coordinate:

- Protected Matters Search, administered by the Department of the Environment (DOE). This search was used to ascertain if any Matters of National Environmental Significance are likely to occur on the Project site; and

- EHP's Wildlife Online database. This search provides a list of all flora and fauna species recorded in the search area, including any threatened species.

EHP's RE mapping was reviewed to determine which remnant vegetation communities were mapped on the Project area. The RE mapping also shows any mapped Essential Habitat for threatened species.

EHP's Environmentally Sensitive Area (ESA) mapping was consulted to identify any ESAs on the Project site. ESAs include endangered REs, national parks, state forests, Ramsar wetlands and other protected areas.

The 'Back on Track' Species Prioritisation Framework Recovery Actions Database (RAD) for the Southern Gulf Catchment was consulted to identify the regionally significant fauna and flora species in the Project region.

Queensland Wetland Mapping Database was searched to determine if there are any wetlands mapped on the Project site.

Relevant literature and reports from previous ecological surveys conducted in the vicinity of the Project were also reviewed. The following reports were consulted to gain an understanding of the ecology of the Project area:

- Mount Remarkable Project: Interim Terrestrial Flora and Fauna Report (EcoSmart Ecology 2011); and

- Mount Remarkable Project: Terrestrial Flora and Fauna Assessment (AARC 2012).

The database searches and literature review revealed that a number of flora and fauna species of conservation significance are known from the Project site and surrounding area. Database search results are included in Appendix A and summarised below.

4.1 FLORA

4.1.1 Threatened Ecological Communities

The Protected Matters Search tool indicates that no Threatened Ecological Communities occur within 100 km of the Project site.

4.1.2 Regional Ecosystems

A review of the Regional Ecosystem mapping revealed the Project site contains five REs as listed in Table 1 below. These REs are present as either whole or mixed polygons. All five REs are listed under the VM Act as Least Concern. Under the EHP Biodiversity Status, RE 1.3.6 is listed as Of Concern and RE 1.3.7 is listed as Endangered. The RE map for the Project site is shown in Figure 4.

Table 1 Regional Ecosystems Mapped within the Project Site

Regional Ecosystem	Description	VM Act Status	EHP Biodiversity Status
1.3.6	*Corymbia aparrerinja*, *Corymbia terminalis* open woodland on sandy terraces	Least Concern	Of Concern
1.3.7	*Eucalyptus camaldulensis* woodland on channels and levees	Least Concern	Endangered
1.11.2	*Eucalyptus leucophloia* low open woodland	Least Concern	No Concern at Present
1.11.3	*Corymbia terminalis* low open woodland on basic metamorphics	Least Concern	No Concern at Present
1.12.1	*Eucalyptus leucophloia* low open woodland on granites	Least Concern	No Concern at Present

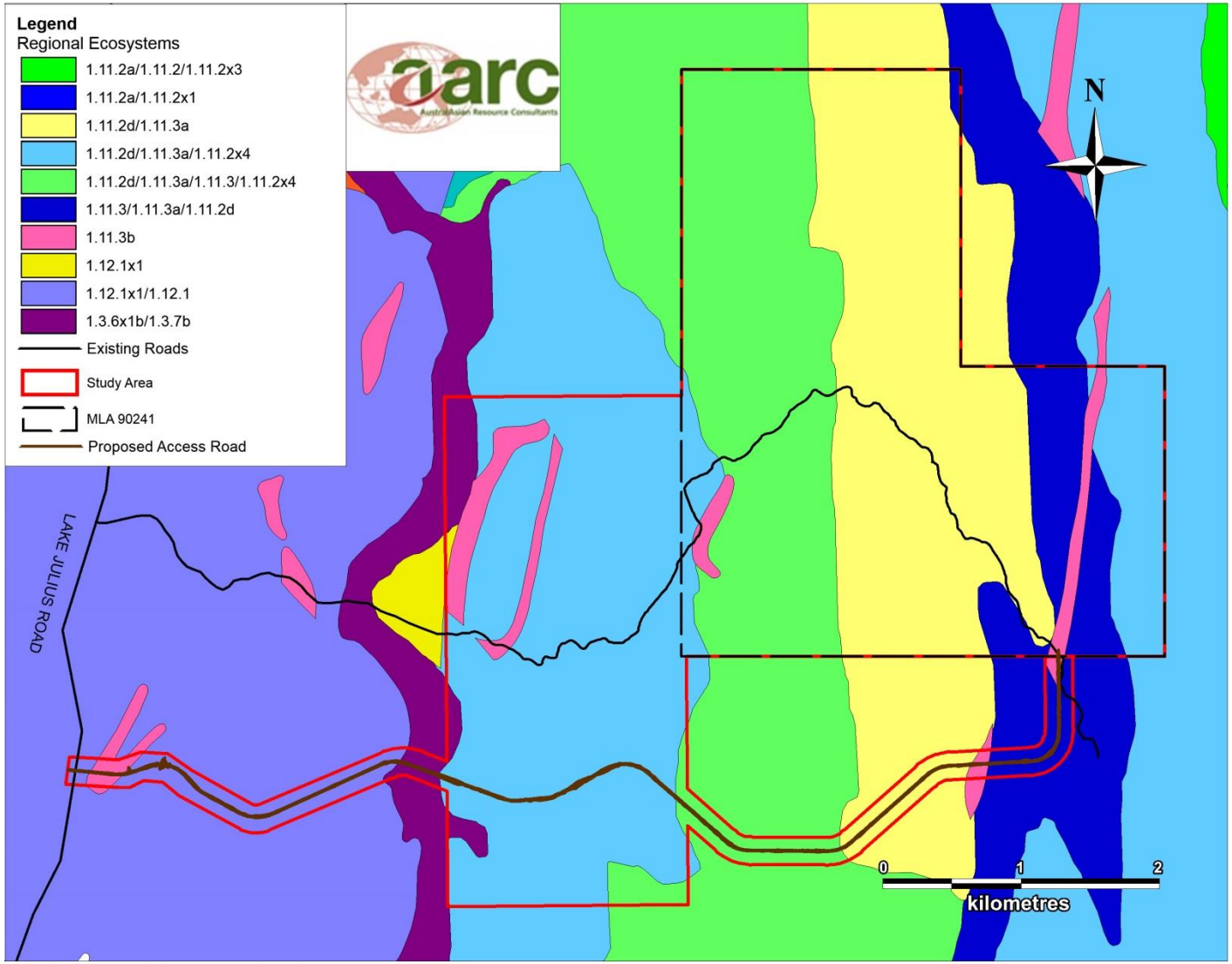


Figure 4 Regional Ecosystem Mapping over the Project Site

4.1.3 Species of Conservation Significance

A protected plants flora survey trigger map was generated using co-ordinates centred on the Project site. This search was undertaken to identify any areas at high risk of supporting protected flora species on the Project or surrounding lands. Areas shown on the map as high risk are subject to particular requirements under Queensland legislation. This search identified no high risk areas on the Project or surrounding region.

Database searches identified two flora species of conservation significance that have been recorded within the region in which the Project is located (Appendix A). These species are listed in Table 2 along with a summary of the habitat requirements and the conservation status of each.

Table 2 Flora Species of Conservation Significance within the Project Region

Scientific Name	Conservation Status		Habitat Description
	NC Act	EPBC Act	
Ptilotus maconochiei	NT	NL	*Eucalyptus leucophloia* and *Corymbia aspera* woodland, with *Triodia pungens* groundcover. On quartzite ridge tops, hillsides, slopes and shale
Ipomoea antonschmidii	NT	NL	*Eucalyptus leucophloia, Corymbia capricornia, Corymbia aparrerinja* and *Eucalyptus camaldulensis* woodlands. Grows in a variety of habitats, including rocky, sandy and red clay substrates. Occurs along the Lake Julius pipeline, Gunpowder and north of Mount Isa

Key:

NL - indicates this species is not listed under the EPBC Act.
NT - indicates this specie is listed in the schedules of the NCWR as a Near Threatened species

4.1.4 Back on Track Flora Species

The RAD search results indicate two BoT priority flora species occur in the Southern Gulf NRM region. These species are listed in Table 3. This table also details the BoT level of priority, NC Act and EPBC Act classifications for each species.

Table 3 Southern Gulf NRM Region Back on Track Priority Flora Species

Scientific Name	Common Name	NRM BoT Priority Ranking	State BoT Priority Ranking	NC Act Status	EPBC Act Status
Cycas couttsiana	-	High	Critical	NT	NL
Eriocaulon carsonii	-	Critical	High	E	E
Pandanus aquaticus	River Pandanus	High	Medium	LC	NL
Aponogeton queenslandicus		High	Medium	LC	NL

Key: NT – Near Threatened, E – Endangered, LC – Least Concern, NL – Not Listed

C. couttsiana is known only to occur in the southern Gregory Range, approximately 430 km to the north-east of the Project site. It occurs in open grassy woodlands in red sandy loams derived from basalt or dolerite, on flat to steeply sloping country (Hill 1998). Suitable habitat for this species is not likely to occur on the Project site.

E. carsonii is known to occur only in spring fed wetlands in relatively flat landscapes where permanent groundwater occurs. Suitable habitat for this species does not occur on or adjacent to the Project site.

Pandanus aquaticus occurs in tropical regions of north-western Queensland, Northern Territory and Western Australia. It grows in shallow water and along the margins of watercourses. Suitable habitat for this species is restricted to the gulf estuaries to the far north of the Project.

Aponogeton queenslandicus is a perennial aquatic plant that grows in temporary freshwater bodies, typically 30 – 60 cm in depth, in drier regions. It prefers clay substrates and occurs in gilgais, melon-holes and roadside ditches. The Project site does not provide suitable habitat for this species.

4.2 FAUNA

4.2.1 Fauna Species of Conservation Significance

Thirty-one fauna species have been identified or potentially occur in the region surrounding the Project site. These species are listed in Table 4.

No essential habitat for threatened fauna was identified on the Regional Ecosystem mapping for the Project site.

Table 4 Fauna Species of Conservation Significance Occurring within the Project Region

Scientific Name	Common Name	Status	
		EPBC Act	NC Act
Birds			
Accipiter novaehollandiae	Grey Goshawk	NL	NT
Amytornis dorotheae	Carpentarian Grasswren	NL	NT
Ephippiorhynchus asiaticus	Black-necked Stork	NL	NT
Epthianura crocea crocea	Yellow Chat (gulf)	NL	V
Erythrotriorchis radiatus	Red Goshawk	V	E
Erythrura gouldiae	Gouldian Finch	E	E
Falco hypoleucos	Grey Falcon	NL	NT
Grantiella picta	Painted Honeyeater	NL	V
Heteromunia pectoralis	Pictorella Mannikin	NL	NT
Lophoictinia isura	Square-tailed Kite	NL	NT

Scientific Name	Common Name	Status	
		EPBC Act	NC Act
Malurus coronatus	Purple-crowned Fairy-wren	NL	V
Melithreptus gularis laetior	Golden-backed Honeyeater	NL	NT
Nettapus coromandelianus	Cotton Pygmy-goose	NL	NT
Numenius madagascariensis	Eastern Curlew	Ma, Mi	NT
Pezoporus occidentalis	Night Parrot	E	E
Poephila cincta cincta	Black-throated Finch (southern)	E	E
Polytelis alexandrae	Princess Parrot	V	NL
Rostratula australis	Australian Painted Snipe	E	V
Stictonetta naevosa	Freckled Duck	NL	NT
Mammals			
Hipposideros stenotis	Northern Leaf-nosed Bat	NL	V
Macrotis lagotis	Greater Bilby	V	E
Petrogale purpureicollis	Purple-necked Rock-wallaby	NL	V
Pseudantechinus mimulus	Carpentarian Antechinus	V	NL
Sminthopsis douglasi	Julia Creek Dunnart	E	E
Tachyglossus aculeatus	Short-beaked Echidna	NL	SL
Reptiles			
Acanthophis hawkei	Plains Death Adder	V	NL
Elseya lavarackorum	Gulf Snapping Turtle	E	V
Emydura subglobosa worrelli	Diamond Head Turtle	NL	NT
Sharks			
Pristis pristis	Freshwater Sawfish	V	NL

Key:
E – indicates this species is listed as Endangered under the NC Act or the EPBC Act
V – indicates this species is listed as Vulnerable under the NC Act or the EPBC Act
NT – indicates this species is listed as Near Threatened under the NC Act or the EPBC Act
LC – indicates this species is listed as Least Concern under the NC Act or the EPBC Act
SL – indicates this species is listed as Special Least concern under the NC Act
Mi – indicates this species is classified as a Migratory species under the EPBC Act
Ma - indicates this species is classified as a Marine species under the EPBC Act
NL - indicates this species is not listed as a threatened species under either the NC Act or the EPBC Act

4.2.2 Back on Track Fauna Species

The RAD search results indicate 14 BoT priority terrestrial fauna species occur in the Southern Gulf NRM region. These species are listed in Table 5. This table details the BoT priority ranking at the state and regional level, as well as the NC Act and EPBC Act classifications for each species. It should be noted that marine animals have been excluded from these results.

Table 5 Back on Track Priority Fauna Species in the Southern Gulf NRM region

Scientific Name	Common Name	BoT Priority Ranking		NC Act Status	EBBC Act Status
		NRM Region	State		
Birds					
Amytornis ballarae	Kalkadoon Grasswren	High	High	LC	NL
Amytornis dorotheae	Carpentarian Grasswren	High	High	NT	NL
Erythrotriorchis radiatus	Red Goshawk	High	High	E	V
Esacus magnirostris	Beach Stone-curlew	High	High	V	NL
Grantiella picta	Painted Honeyeater	High	High	V	NL
Lophochroa leadbeateri	Major Mitchell's Cockatoo	High	High	V	NL
Malurus coronatus	Purple-crowned Fairy-wren	High	High	V	NL
Neochmia ruficauda clarescens	Star Finch (northern subspecies)	High	High	LC	NL
Rostratula australis	Australian Painted Snipe	High	Medium	V	E
Sternula albifrons	Little Tern	High	High	E	NL
Mammals					
Macroderma gigas	Ghost Bat	Critical	Critical	V	NL
Sminthopsis douglasi	Julia Creek Dunnart	Critical	Critical	E	E
Reptiles					
Acanthophis antarcticus	Common Death Adder	High	Medium	NT	NL
Elseya lavarackorum	Gulf Snapping Turtle	High	High	V	E

Key:
E – indicates this species is listed as Endangered under the NC Act or the EPBC Act
V – indicates this species is listed as Vulnerable under the NC Act or the EPBC Act
NT – indicates this species is listed as Near Threatened under the NC Act or the EPBC Act
LC – indicates this species is listed as Least Concern under the NC Act or the EPBC Act
NL - indicates this species is not listed as a threatened species under the NC Act or the EPBC Act

4.2.3 Migratory Fauna Species

The Protected Matter Search identified 40 listed migratory, marine and/or Special Least Concern (as classified under the NC Act) species that may inhabit the Project region. Special Least Concern (SL) species are those species which are classified as least concern under the NC Act and are subject to a special bilateral or international agreement[3]. A full list of migratory species is presented in Table 6.

Table 6 Migratory and Marine Species within the Project Region

Scientific Name	Common Name	NC Act Special Least Concern	Listed Marine Species	Listed Migratory Species		
				Marine Species	Terrestrial Species	Wetland Species
Acrocephalus australis	Australian Reed-warbler	X	-	-	-	-
Actitis hypoleucos	Common Sandpiper	X	X	-	-	-
Anseranas semipalmata	Magpie Goose	-	X	-	-	-
Apus pacificus	Fork-Tailed Swift	X	X	X	-	-
Ardea alba	Great Egret	X	X	-	-	X
Ardea ibis	Cattle Egret	X	X	-	-	X
Arenaria interpres	Ruddy Turnstone	X	X	-	-	-
Calidris acuminata	Sharp-tailed Sandpiper	X	X	-	-	X
Calidris ferruginea	Curlew Sandpiper	X	X	-	-	X
Calidris ruficollis	Red-necked Stint	X	X	-	-	X
Calidris subminuta	Long-toed Stint	X	X	-	-	-
Charadrius mongolus	Lesser Sand Plover	X	X	-	-	X
Charadrius ruficapillus	Red-capped Plover	-	X	-	-	-
Charadrius veredus	Oriental Plover	X	X	-	-	X
Chlidonias leucopterus	White-winged Black Tern	X	X	-	-	-
Cuculus optatus	Oriental cuckoo	X	X	-	-	-
Gallinago hardwickii	Latham's Snipe	X	X	-	-	-
Gallinago megala	Swinhoe's snipe	X	X	-	-	-

[3] Such agreements include Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA) & Bonn Convention.

Scientific Name	Common Name	NC Act Special Least Concern	Listed Marine Species	Listed Migratory Species		
				Marine Species	Terrestrial Species	Wetland Species
Glareola maldivarum	Oriental Pratincole	X	X	-	-	X
Haliaeetus leucogaster	White-Bellied Sea-Eagle	X	X	-	X	-
Himantopus himantopus	Black-winged Stilt	-	X	-	-	-
Hirundo rustica	Barn Swallow	X	X	-	-	-
Hydroprogne caspia	Caspian tern	X	X	-	-	-
Limosa lapponica	Bar-tailed Godwit	-	X	-	-	X
Limosa limosa	Black-tailed Godwit	X	X	-	-	X
Merops ornatus	Rainbow Bee-eater	X	X	-	X	-
Numenius minutus	Little Curlew	X	X	-	-	X
Numenius phaeopus	Whimbrel	-	X	-	-	X
Pandion cristatus	Eastern Osprey	X	-	-	-	-
Pandion haliaetus	Osprey	-	X	-	-	-
Phalaropus lobatus	red-necked phalarope	-	X	-	-	-
Plegadis falcinellus	Glossy Ibis	X	X	-	-	-
Pluvialis fulva	Pacific Golden Plover	X	X	-	-	X
Recurvirostra novaehollandiae		-	X	-	-	-
Rostratula australis	Australian Painted Snipe	-	X	-	-	X
Stiltia isabella		-	X	-	-	
Tringa glareola	Wood Sandpiper	X	X	-	-	X
Tringa nebularia	Common Greenshank	X	X	-	-	-
Tringa stagnatilis	Marsh Sandpiper	X	X	-	-	X
Xenus cinereus	Terek Sandpiper	X	X	X	-	-

4.3 ENVIRONMENTALLY SENSITIVE AREAS

A review of EHP's ESA mapping revealed a Category B ESA is mapped as occurring in the west of the Project site (refer to Figure 5). This ESA presents as a narrow strip of RE 1.3.7 - River Red Gum (*Eucalyptus camaldulensis*) woodland on channels and levees, occurring along the western boundary and adjoining lands. RE 1.3.7 is classified under EHP's Biodiversity Status as Endangered. No conservation parks, declared fish habitat areas, wilderness areas, aquatic reserves, heritage or historic areas, national estates, World Heritage listings, sites listed under international treaties or agreements or biodiversity and scientific reserves are located within or adjacent to the Project site.

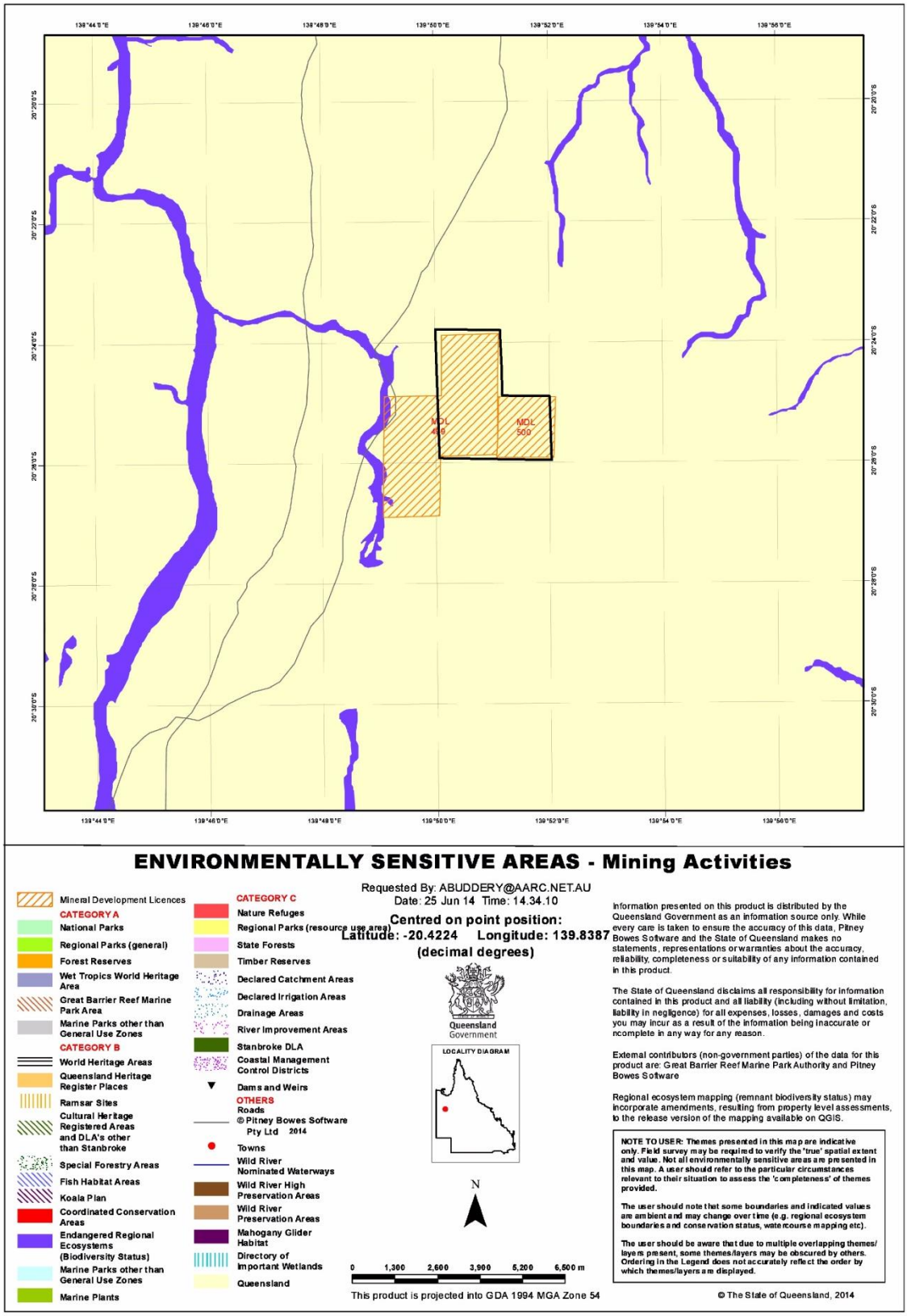


Figure 5 Environmentally Sensitive Areas on and Surrounding the Project Site

4.4 WETLAND MAPPING

The WetlandMaps database indicates that the Project site contains riverine systems (drainage lines) only (refer to Figure 6). No palustrine wetlands, lacustrine wetlands or springs are mapped within or adjacent to the Project site. The nearest wetlands are lacustrine in nature and are located approximately 2 km south-west and 7.5 km north-east (Glenroy Dam) of the Project. Neither of these wetlands occurs within the downstream receiving environment of the Project. Lake Julius occurs approximately 17 km downstream of the Project on the Leichhardt River. This wetland occurs within the downstream flow path of the Project and could be impacted by Project activities during heavy flow events.

No wetlands of international importance as nominated under the Ramsar Convention have been recorded within the Project site or surrounding region.

Wetland values are discussed in further detail in the Barbara Copper Project Aquatic Ecology Assessment (AARC, 2014).

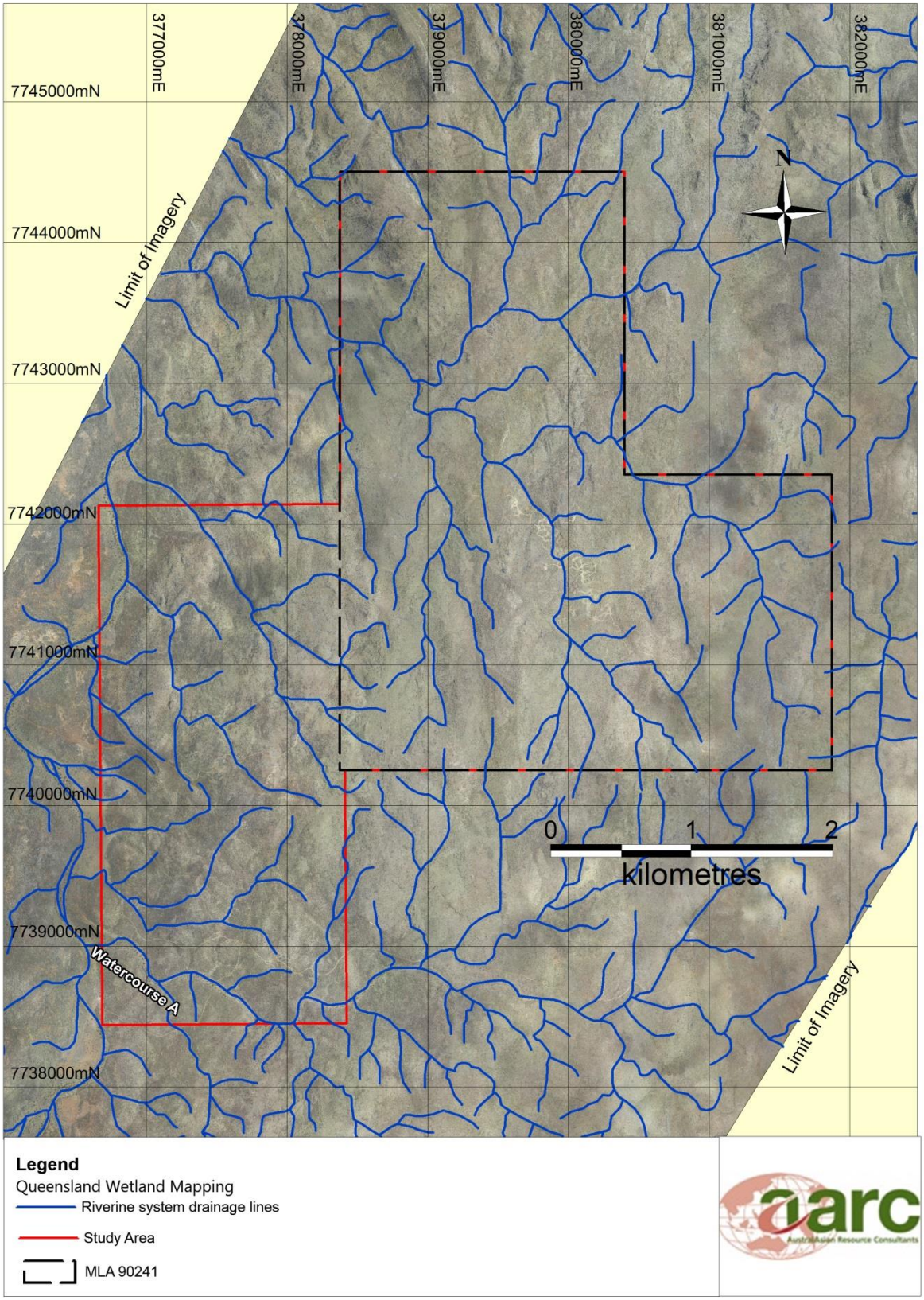


Figure 6 Queensland Wetland mapping over the Project Site

5.0 METHODOLOGY

5.1 INITIAL SITE SCOPING

Site scoping was conducted through the examination of aerial photography, satellite imagery and existing EHP RE and Essential Habitat Mapping. This enabled the ecologists to gain an overall perspective of the vegetation distribution and landscape features on the Project site. Desktop analysis also allowed the survey team to predict the location of trapping efforts according to the basic understanding of REs and landforms from government maps.

Vehicle-based reconnaissance was carried out, where possible, to assist in locating suitable survey sites, maximising the representative vegetation and fauna habitat survey coverage. This also aided in targeting habitats potentially occupied by species of conservation significance. Areas of potential sensitivity (for example, creek lines and rocky outcrops) were surveyed on foot. This allowed further ecological familiarisation and comprehensive survey coverage.

5.2 FLORA SURVEY METHODOLOGY

The flora sampling regime was designed and conducted in accordance with the *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland* (Neldner *et al*., 2012) in order to meet the following objectives:

- Obtain a detailed floristic summary of the Project site through the compilation of a flora species list;
- Define distinct vegetation communities and compile detailed descriptions of the floristic assemblages in each community;
- Identify threatened or conservation significant flora species and ecological communities; and
- Produce a comprehensive site vegetation map at a 1:10 000 scale, using the EHP vegetation maps to plan appropriate Quaternary and Secondary sites.

Neldner *et al*. (2012) describes four levels of sampling. Two of these sampling techniques (Secondary transects and Quaternary plots) were used in the flora assessment for the Project. Each survey technique was undertaken as follows:

- *Secondary* – consist of a 20 m x 50 m transect, precisely marked using a Global Positioning System (GPS) and accurately measured with a marking tape. Data recorded at each Secondary site included a complete floral assemblage (all species observed from each vegetation layer). Species that fall outside the plot but are deemed typical of the community are also listed. Where a plant could not be positively identified to species level, a voucher specimen was collected for identification by the Queensland Herbarium. Relative abundance for individual woody species in each stratum, stem density, foliage projection cover and height of the tree and shrub layers was recorded. Percentage composition of each ground cover species was recorded in five 1 m x 1 m quadrats located at 10 m intervals along the transect line. A minimum of one representative Secondary plot was positioned in each of the REs known to exist on the Project site. A total of 26 secondary transects were sampled during the 2011 wet and dry season surveys. A further 10 Secondary flora sites were assessed during the 2014 wet and dry season surveys.

- *Quaternary* – These rapid vegetation surveys include marking the GPS location, recording the dominant species in the characteristic layers along with soil/landform and structural data. Recording soil and landform data is essential as many REs can only be differentiated by the land zone they occur on, due to their floristic assemblage descriptions being virtually identical. Quaternary plots are commonly used in the ground truthing of mapping previously completed for the local area. The plots are projected on a geographical information system and used in conjunction with local geological maps (which determine land zone) to effectively map the vegetation of the site. A total of 598 Quaternary plots were surveyed on and surrounding the Project site during the 2011 surveys. A further 137 Quaternary assessments were conducted during the 2014 survey, to ensure adequate site coverage over the revised Project area and to meet the minimum observation requirements for vegetation mapping at the 1:10 000 scale (i.e. 25 Observations/100ha).

All transect locations were first identified in conjunction with assessment of the RE Vegetation maps obtained from EHP. Flora and habitat values identified in the desktop assessment were also targeted in the site selection process. Different flora transects were sampled in the dry season and wet season to best account for both annual and perennial species assemblages.

The condition and quality of vegetation at each survey site was assessed. Attention was paid to identifying the presence of weeds, species of conservation significance or potential habitat for species of conservation significance.

The locations of the flora survey sites are shown in Figure 7.

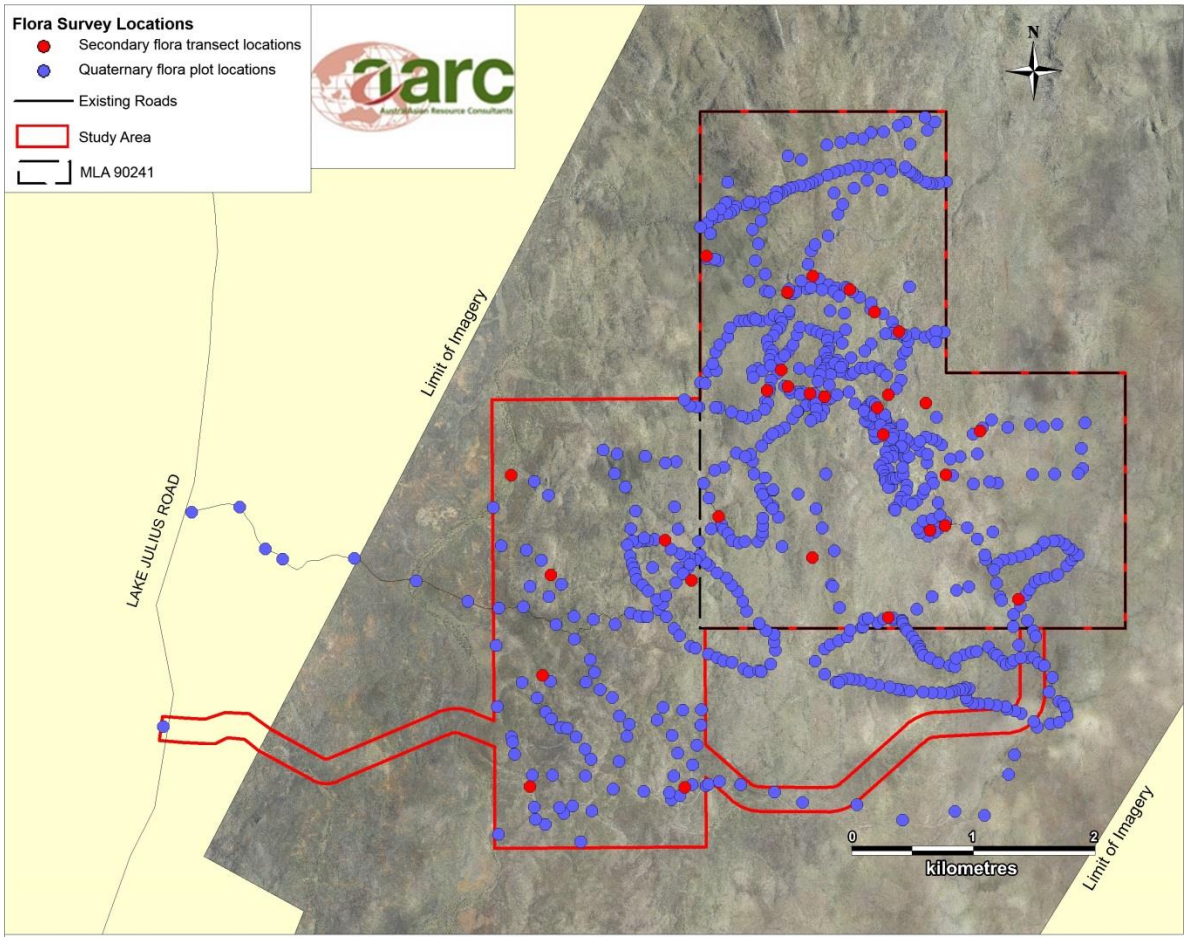


Figure 7 Flora Survey Locations on the Project Site

5.2.1 Flora and Regional Ecosystem Identification

All plants encountered during the survey were identified by experienced ecologists using a number of field guides and other reference material where necessary. All REs were described and classified according to EHP's Regional Ecosystem Descriptions Database (EHP, 2012). For any plant species that could not be identified in the field, a voucher specimen was collected and sent to the Queensland Herbarium for identification.

Vegetation (RE) maps of the Project site were produced at a minimum scale of 1:10 000 following the completion of field surveys. The maps were developed based upon survey results, satellite images, aerial photographs, and geological maps featuring the Project site. Where possible, each RE was mapped as a homogenous polygon wherever it occurs on the Project site. Occasionally vegetation patches occur that consist of more than one RE. When the least common RE in the remnant patch is smaller than the minimum mappable area defined in Neldner *et al*. (2012) or the structure of the vegetation does not allow clear delineation of each RE, all contributing REs may be mapped together as a "mixed polygon".

5.2.2 Surveys for Species of Conservation Significance

A number of flora species of conservation significance were highlighted in the desktop searches undertaken prior to the field survey. Targeted searches for species of conservation significance were undertaken upon the identification of suitable habitat in the field. Such searches involved the use of methods discussed in Neldner *et al*. (2012).

The targeted survey technique utilised in this study was the 'Random Meander' survey. This technique involves traversing areas of suitable habitat along a meandering route whilst searching for the plant species of interest. If there was any uncertainty in identification of a species, a voucher specimen was collected for identification by the Queensland Herbarium.

5.3 FAUNA SURVEY METHODOLOGY

The fauna sampling methodology employed for the Project site during the 2011 surveys was based on survey techniques provided in *Recommended Fauna Survey Methodology for Environmental Impact Assessments* (DERM 2009). Sampling of vertebrate fauna was conducted primarily along transects established in each of the major fauna habitat types and at changes in vegetation community groups. Secondary sites were established to provide important information on fauna species associated with preferred habitat, as well as increasing the chances of finding species of conservation significance. Their inclusion in the assessment provides a more robust survey methodology and greater survey coverage.

The fauna survey methodology employed for the Project during the 2014 wet and dry season surveys was based on the Terrestrial Vertebrate Fauna Survey Guidelines for Queensland (DSITIA, 2012). The survey was conducted in compliance with AARC's scientific purposes permit and animal ethics approval. All fauna trapping efforts were conducted over four consecutive nights (unless otherwise stated). Motion detector cameras and micro-bat acoustic detection devices were set at each of the survey sites. Fauna sites sampled during the wet season survey were largely positioned in the same habitat types during the dry season survey to identify seasonal variation in species diversity and abundance. Fauna survey methods undertaken during the 2014 wet and dry season surveys are described in detail in Section 5.3.2.

During all surveys, observations of species outside the specific fauna study locations were noted as incidental observations.

Many fauna species, notably frogs and reptiles, do not have widely accepted common names. Scientific names for species often change with taxonomic revisions. For the purpose of this report, all nomenclature used will follow that used in the EHP Wildlife Atlas.

5.3.1 Fauna Survey Sites

Fauna transects were positioned to maximise the potential for sampling all wildlife present by targeting the full range of habitat types present on site. During the 2011 survey periods, a total of 13 primary transects and 10 secondary transects were established for fauna sampling. Fauna survey sites were established at seven locations during the 2014 wet and dry season surveys. One fauna site located in Snappy Gum woodland habitat on metamorphic hills (FA3) was replaced during the dry season survey due to access restrictions and the need to increase sampling effort in River Red Gum Riparian habitat since ground truthing revealed a greater habitat presence than indicated by current RE mapping. All fauna survey locations, including the fauna site which was added during the dry season (FA8) are shown in Figure 8.

Descriptions and photos of each survey site are provided in Appendix B.

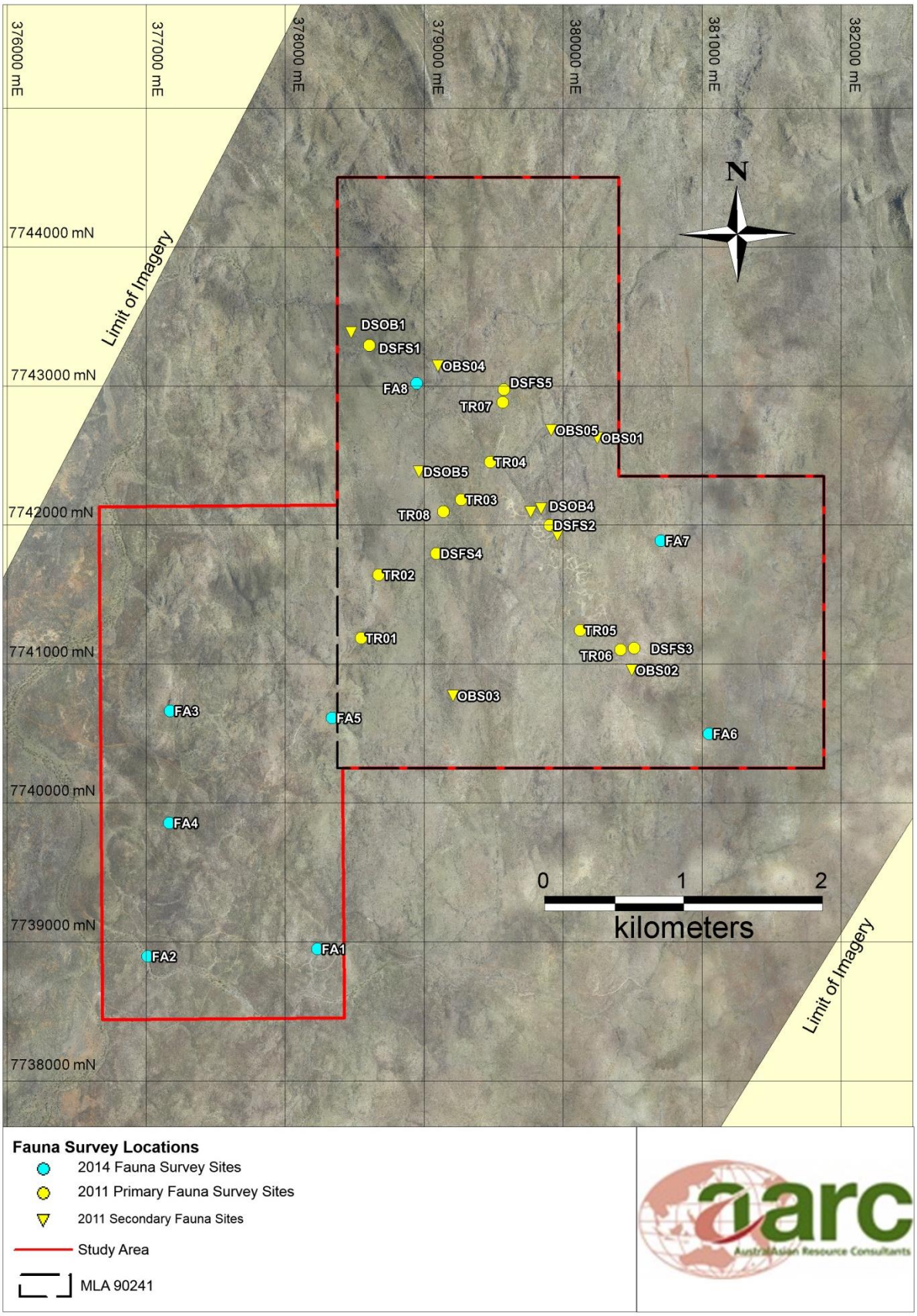


Figure 8 Terrestrial Fauna Survey Locations on the Project Site

5.3.2 Detection Methods

A description of the techniques employed to survey the fauna occurring on the Project site is provided below.

Elliott trapping

Type 'A' Elliott traps (aluminium boxes with doors triggered by a floor treadle) were used to target small ground-dwelling mammals inhabiting the Project site during the field survey period. Traps were baited with a mixture of oats, honey, peanut butter, sesame oil and vanilla essence (referred to here-in as 'marsupial bait'). At each site, 20 Elliott traps were deployed at 5-10 m intervals along a 100 m transect. The methodology was altered slightly during the 2014 survey to meet the *Terrestrial Vertebrate Fauna Survey Guidelines*, such that 20 Elliott traps were deployed at 10 m intervals along two 100 m transects within a 100x100 m plot or one 200 m transect, depending on the nature of the target habitat (i.e. linear riparian habitats typically featured a 200m trap line). Traps were strategically positioned under shrubs or beside logs to reduce exposure of trapped animals to the sun, wind and rain and maximise trap success.

Elliott trapping was conducted at 5 locations within the Project site during the 2011 wet season survey and a further 5 different locations during the 2011 dry season survey. During the 2014 wet season survey, Elliott traps were deployed across seven fauna sites, resulting in an overall survey effort of 560 trap nights. Elliott trapping was also conducted at seven fauna sites during the dry season survey providing another 560 nights of trap effort.

Automated camera trapping

Automated camera trapping is a less invasive method of surveying medium and large-sized nocturnal terrestrial species. Cameras are usually attached to a tree in a position that offers an unobstructed view over a track or clearing. A bait tube constructed of a PVC pipe and filled with 'marsupial bait' and in some cases, sardines, was pegged to the ground and positioned in clear view of the camera. Motion-sensing technology in the camera picks up movement by target fauna which then triggers an automatic photographic response. This is a highly effective survey method and is now widely used instead of cage trapping (DSITIA, 2012). Automated cameras were deployed for four nights at all seven fauna survey locations during the 2014 wet and dry season surveys. Survey effort comprised 28 camera trap nights during each survey.

Pitfall trapping

A pitfall trap line was established at most the survey sites to target small ground-dwelling fauna (reptiles, mammals and amphibians). Each line consisted of a 20 centimetre (cm) tall drift fence running along the ground and crossing the middle of four 20 litre buckets buried flush with the soil surface. Each pitfall trapping line was constructed in a T-shape design with 45 m of drift fence and buckets placed at approximately 7.5 m intervals. The bottom edge of each drift fence was buried to guide target animals towards the buckets. A small amount of soil, vegetation litter, a damp sponge and a small plastic pipe were placed in the bottom of each bucket to provide shelter and moisture for captured wildlife. Given that the Project site is dominant by rocky hills and outcrops, pitfall trapping efforts have largely been restricted to the lower alluvial areas. During the 2011 wet and dry season surveys, pitfall trapping was conducted at four fauna sites. Pitfall trapping was also conducted at an additional four survey sites during each of the 2014 wet and dry season surveys with a total of 64 trap nights in each survey.

Funnel trapping

Funnel traps are elongated box-shaped traps made of wire and fine mesh. They have two funnel shaped entrances which allow fauna to enter with ease but make exiting difficult. Six funnel traps were positioned at each fauna sites in order to catch medium and large-sized terrestrial reptiles, snakes and some species of medium-sized skinks, dragons and geckos, which are able to climb out of pitfall traps. Funnel traps were placed either at the end of each drift fence at all pitfall trapping lines or along fallen timber or rocky outcrops at all other sites. Four funnel traps were used at each fauna site during both the 2011 wet season and dry season surveys. During the each of the 2014 surveys, six funnel traps were placed in association with each pitfall trapping line. Where a pitfall line could not be established, 10 funnel traps were placed in suitable habitat within the fauna site (100x100m plot). Total funnel trap effort during each of the wet and dry season surveys was 216 trap nights.

Micro-bat surveying

Micro-bats (Microchiropterans) form an extremely diverse group of wildlife and the identification of individual species requires the use of specialised survey methods due to the superficial similarity of many species, their small size, and largely inaudible calls.

In order to navigate and hunt at night micro-bats use high frequency echolocation calls, most of which are above the frequency range audible to humans (i.e. ultrasound). These echolocation calls provide an opportunity to unobtrusively survey and identify micro-bats through the use of a specialised ultrasonic recorder such as an ANABAT or Songmeter. An ANABAT recorder was strategically positioned to detect micro-bat calls at five fauna trapping sites during the 2011 wet season survey event. Another ANABAT was strategically located at seven different fauna trapping locations during the 2011 dry season survey. A Songmeter was also deployed at each of the seven fauna trapping locations during the 2014 wet season survey. Songmeters were left at each site for 3 nights. Sound recordings were sent to an experienced bat-call analyst (Greg Ford of Balance Environmental, Toowoomba, Queensland) for analysis.

Successful harp trapping relies on the availability of flyways consisting of narrow gaps in dense vegetation, typically along roadways or watercourses. Suitable flyways are rare on the Project site due to the very open and sparse nature of the canopy vegetation. Harp trapping was conducted at one site over four nights during the 2011 wet season survey. Harp trapping was also conducted at two sites during the 2014 dry season survey. Trapping was conducted over two nights at each site, providing a total of four trap nights.

Bird surveying

A dedicated search for diurnal birds was conducted visually and aurally on mornings and afternoons in the immediate vicinity of each fauna transect during each of the 2011 and 2014 survey periods. In addition, opportunistic diurnal searches were also conducted on foot in areas considered likely to have high avian diversity (e.g. vegetated watercourses), or likely to contain cryptic or threatened bird species. During each survey period, diurnal bird searching was conducted over a period of 5 to 13 hours with a total of 30 hours spent searching for birds across the Project site.

Spotlighting

Spotlighting was carried out at night in various sections of the Project site in order to observe nocturnal wildlife (i.e. owls and arboreal mammals) unlikely to be detected by other survey methods. Two spotlighting techniques were employed:

1. Walk searches: Areas within the Project site considered likely to contain cryptic or threatened species, or high fauna diversity were investigated on foot. These areas were randomly traversed by two ecologists equipped with spotlights and binoculars, and wherever possible, bark crevices and tree hollows were examined. A slow walking speed (approximately 1 km per hour) was maintained across the length of the survey area to fully facilitate intensive listening and thorough visual searching. While this technique improves the likelihood of detecting small cryptic species, it is a time consuming activity that does not permit the coverage of large areas. A total of 20 spotlight hours were undertaken on foot within the Project site during the 2011 wet and dry season surveys. The total spotlight hours undertaken on foot within the Project site was seven person hours during the 2014 wet season survey and four person hours during the 2014 dry season survey. Cool and particularly windy conditions prevailed throughout the dry season survey, most likely hindering the potential for fauna detection.

2. Vehicle searches: Spotlighting was also conducted from a slow-moving vehicle where established roads/tracks permitted driving through areas considered likely to have high wildlife diversity or cryptic or threatened species. One 55-watt 12-volt spotlight was used to scan roadside vegetation for arboreal and ground-dwelling wildlife. An advantage of this survey technique is the efficiency with which large areas can be covered. A total of 14 hours of vehicle spotlighting were undertaken on the Project site during the 2011 dry and wet surveys. A total of one person hour of vehicle spotlighting was undertaken on the Project site during the 2014 wet season survey. Approximately three hours of vehicle spotlighting was conducted during the dry season survey.

Habitat searching

To further enhance the likelihood of detecting small cryptic species, opportunistic diurnal searches of likely micro-habitats were conducted at each fauna site and in other selected areas on the Project site. Searching techniques involved the rolling of rocks and logs, rustling through leaf litter, and peeling back of exfoliating bark from standing trees. In addition, notes were made on habitat features such as tree hollow numbers or the presence of fallen logs and bark. Observed animals were caught where possible to aid positive species identification. A total of seven person hours were spent active searching during each of the 2014 surveys.

Scat/track searching

At each survey site a search of the immediate area was conducted for evidence of the presence of wildlife through the identification of obvious tracks, scats and other signs of occupation (e.g. tree trunk scratchings).

Scats were collected and sent to a scat analysis expert (i.e. Barbara Triggs) for identification of the species responsible for the scat and/or where possible, the identification of prey species material present in predator scats.

Incidental recordings

Throughout each survey period, numerous wildlife species were observed or heard on the Project site during the course of routine activities (i.e. driving between sites, checking traps, vegetation surveys etc.). Where required, a closer inspection of detected wildlife was carried out to ensure positive species identification. All incidental observations were recorded.

5.3.3 Survey effort

Survey effort undertaken during each survey event is detailed in Table 7 below for each fauna sampling techniques.

Table 7 Summary of Sampling Effort

Sampling Technique	2011 Wet Season Survey	2011 Dry Season Survey	2014 Wet Season Survey	2014 Dry Season Survey
Elliott Trapping	5 sites x 20 traps over 4 nights = 400 trap nights	5 sites x 20 traps over 4 nights = 400 trap nights	7 sites x 20 traps over 4 nights = 560 trap nights	7 sites x 20 traps over 4 nights = 560 trap nights
Automated Camera Trapping	N/A	N/A	7 sites x 1 camera over 4 nights = 28 trap nights	7 sites x 1 camera over 4 nights = 28 trap nights
Pitfall Trapping	4 sites x 5 buckets over 4 nights = 80 trap nights	4 sites x 5 buckets over 4 nights = 80 trap nights	4 sites x 4 buckets over 4 nights = 64 trap nights	4 sites x 4 buckets over 4 nights = 64 trap nights
Funnel Trapping	8 sites x 4 funnels over 4 nights = 128 trap nights	5 sites x 4 funnels over 4 nights = 80 trap nights	4 sites x 6 funnels over 4 nights = 96 trap nights 3 sites x 10 funnels over 4 nights = 120 Total = 216 trap nights	4 sites x 6 funnels over 4 nights = 96 trap nights 3 sites x 10 funnels over 4 nights = 120 Total = 216 trap nights
Micro-bat Surveying	Bat Detector: 5 sites x 1 detector for 1 night = 5 trap nights Harp Trapping: 1 site x 1 harp trap for 4 nights = 4 trap nights	Bat Detector: 7 sites x 1 bat detector for 1 night = 7 trap nights	Bat Detector: 7 sites x 1 bat detector for 3 nights = 21 trap nights	Bat Detector: 7 sites x 1 bat detector for 3 nights = 21 trap nights Harp Trapping: 2 sites x 2 nights = 4 trap nights
Bird Surveying	13 hrs total search time across Project site	5 hrs total search time across all 5 fauna sites	7 hrs total search time across all 7 fauna sites	5 hrs total search time across all 7 fauna sites
Spotlighting	2 x 30 person minute searches at each site = 20 person hours in total		2 x 30 person minute searches at each site = 7 person hours	2 x 30 person minute searches at four sites = 4 person hours
Habitat Searching	2 x 30 person minute searches at 13 sites = 13 person hours	2 x 30 person minute searches at 5 sites = 5 person hours	2 x 30 person minute searches 7 sites = 7 person hours	2 x 30 person minute searches 7 sites = 7 person hours

6.0 RESULTS AND DISCUSSION

6.1 SURVEY TIMING

Survey timing was selected in accordance with the *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland* (DSITIA, 2012). These guidelines recommend that fauna surveys within the North West Highlands bioregion should be conducted during or immediately following the wet season (i.e. December to May) and during the dry season (i.e. August to October). Surveys were conducted during the wet and dry season periods in 2011 and 2014. Wet season surveys were conducted from 28th March to 3rd of April, 2011 and 30th January to 7th February, 2014. Dry season surveys were conducted from 19th to 25th October, 2011 and 1st to 8th August, 2014.

6.2 WEATHER CONDITIONS

Seasonal surveys are imperative for a comprehensive and scientifically valid ecological assessment. Complementing wet season and dry season surveys are conducted to ensure species which are migratory, transient or responsive to particular environmental conditions are captured, in addition to identifying seasonal variation in both species diversities and abundances. Survey timing is based on conceptual seasonal months. That is, they correspond to historic rainfall data and known weather patterns. Often however, the yearly weather cycle is more than wet and dry and includes the build-up period before the wet season that brings high humidity as moisture builds up in the air and post wet season as waterholes and creeks slowly dry up and dry winds strengthen. These transitional periods in combination with localised ecological response produce an environment that is continually adapting and adjusting. It is imperative that these periods be included, in combination with consideration to changing weather pattern behaviours when determining timing of wet and dry surveys as part of any seasonal flora and fauna assessment. The window of survey often needs to be adjusted to suit local conditions.

March/April 2011

Climate data preceding the 2011 wet season survey was consistent with average temperatures for January with minimum and maximum temperatures between 23.0°C and 35.7°C, and above average rainfall with a total of 267.2 mm. February 2011 had slightly lower temperatures (22.6°C to 33.47°C) accompanied by less rainfall (195 mm). Total rainfall in March 2011 was higher than previous months with 303 mm of rain along with average temperatures of 21.6°C to 30.2°C. During April 2011, a total of 11.0 mm of rainfall was recorded with temperatures averaging in the range of 16.1°C to 29.6°C.

During the survey period (28th March and 3th April 2011), a total of 11 mm rainfall was recorded and temperatures were recorded in the range of 17.2°C to 32.2°C.

October 2011

The second survey was conducted towards the end of the 2011 dry season period (19th - 25th October 2011). Conditions were typical for the season, with a mean minimum temperature of 18.1 ºC and a mean maximum of 35.2 ºC during the month of October 2011. A small amount of rain fell during the survey period with a total of 1mm recorded. A total 30mm rainfall was recorded in the 4 months prior to the survey.

January/February 2014

A second wet season survey was conducted between 30th January and 7th February 2014 when conditions varied from hot, fine and sunny at the beginning of the survey to partly cloudy or overcast

with cooler temperatures for the remainder of the survey. Conditions on the 3rd February saw a rapid drop in maximum temperature (up to 5°C), afternoon storms and light evening rain resulting in a total of 43 mm rainfall being recorded in a 24 hour period. Maximum temperatures recorded during the survey period ranged from 30.6°C to 39.8°C. Minimum temperatures were recorded in the range of 19.4°C to 27.2°C. A total of 50.4 mm of rainfall was recorded at the West Leichhardt Station (29121) in the wet season months leading up to the survey (November 2013 – January 2014). It should be noted that no rainfall readings were recorded at this Station during the month of January 2014. The next closest weather station (Lake Julius – 29171) recorded 33.4 mm of rainfall. Therefore, the actual rainfall for the November 2013 to January 2014 period was likely closer to 84 mm.

August 2014

A second dry season survey was conducted from the 1st to the 8th of August 2014. Weather conditions during this survey typically consisted of cooler temperatures, extended periods of cloud cover clearing toward the end of the survey, a brief period of rainfall and very windy conditions. Throughout the survey, daily wind gusts recorded at the Mount Isa Aero station ranged from 33 to 52 kilometres/hour (km/h).

Climate readings from the Mount Isa Aero station (029127) revealed minimum temperatures in the range of 1.2 to 17.6 °C and maximum temperatures ranging from 22.2 to 29.1 °C. A very light and brief shower occurred on the afternoon of August 2nd but has not been recorded by any of the nearby weather stations (i.e. West Leichhardt Station, Lake Julius station or the Mount Isa Aero station). Since the previous survey, a total of 166.8 mm of rainfall has been recorded from the West Leichhardt Station with 152.8 mm recorded to the end of February and no rainfall recorded since April 2nd.

6.3 FLORA SURVEY RESULTS

A total of 167 flora species were identified on the Project site during field surveys. A full list of species observed is provided in Appendix C.

Seven vegetation communities were recorded across the Project site, all of which are classified as remnant vegetation. These communities are representative of five REs as described below.

Each vegetation community is discussed in detail below. The location and extent of each vegetation community on the Project site is presented in Figure 9.

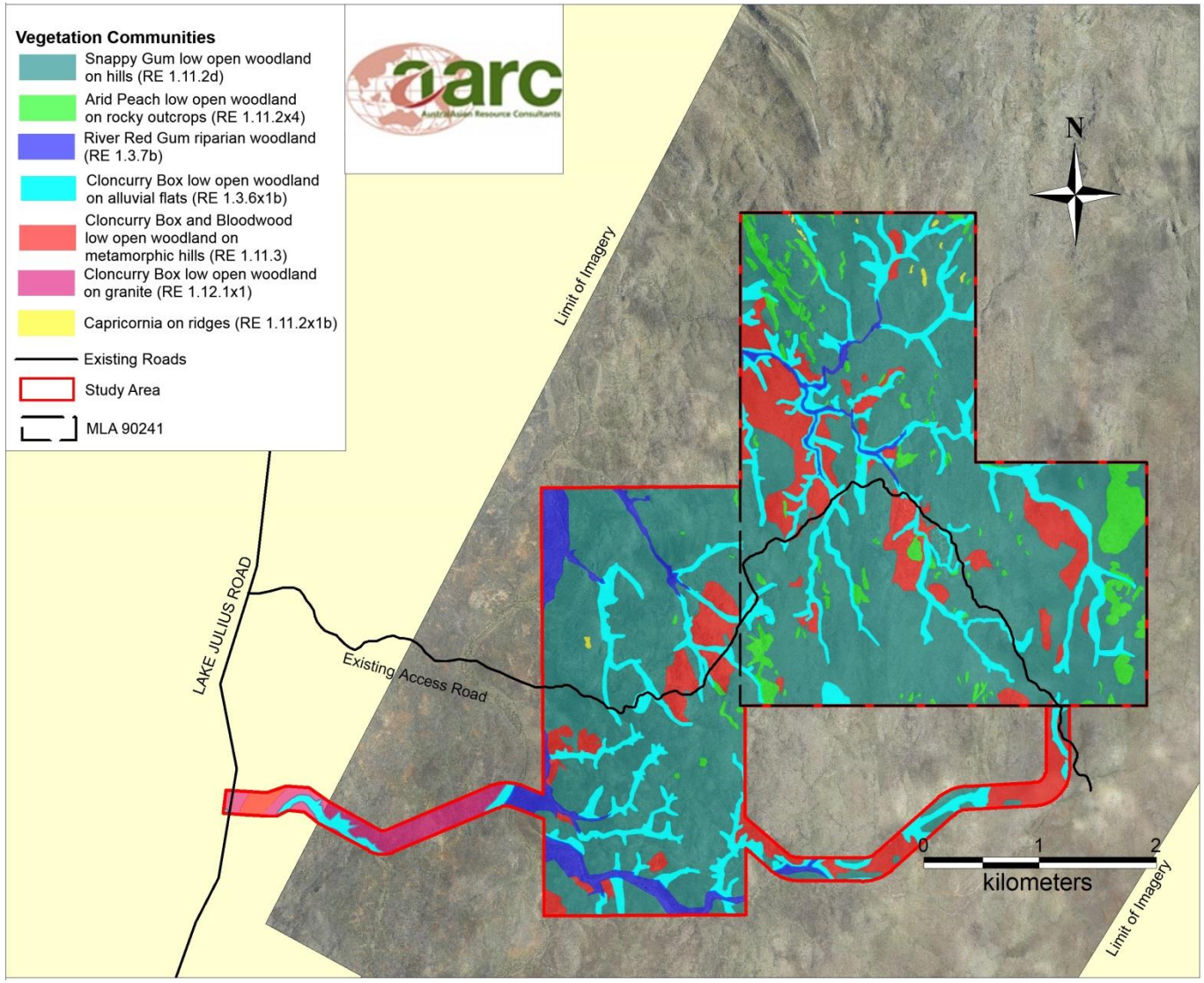


Figure 9 Vegetation Communities within the Study Area

6.3.1 Community 1 – Low Open Woodland of Snappy Gum (*Eucalyptus leucophloia*) on metamorphic hills

6.3.1.1 Community Description

Community 1 is described as low open woodland on metamorphic hills and occurs throughout the majority of the Project site. This community typically consists of a five to eight metre tall canopy that is dominated by Snappy Gum (*E. leucophloia*) and provides a canopy cover of approximately 2 to 10 %.

This community is consistent with RE 1.11.2d. Detailed information on Community 1, including the dominant species in each stratum of vegetation is presented in Table 8.

Table 8 Community 1 Profile

Regional Ecosystem	1.11.2d - Low open woodland of *Eucalyptus leucophloia* often with *E. leucophylla*, *Corymbia* spp., *Terminalia aridicola* and/or *Brachychiton collinus* on rock outcrops with a very sparse shrub layer of *Acacia* spp. and a sparse to very sparse ground layer of *Triodia pungens*. Occurs on steep rocky slopes and crests on metamorphosed igneous rocks.
Extent within Study Area	1, 348 ha
EPBC Status	Not listed
VM Act Status	Least Concern
Biodiversity Status	No concern at present
Tree Layer	*Eucalyptus leucophloia* (D), *Corymbia terminalis* (A), *Terminalia aridicola* (A), *Brachychiton collinus* (A), *Corymbia aparrerinja* (O), *Corymbia capricornia* (O), *Eucalyptus leucophylla* (O)
Shrub Layer	*Acacia phlebocarpa* (D), *Acacia chisholmii* (SD), *Acacia holosericea* (A), *Acacia monticola* (A), *Acacia melleodora* (A)
Ground Layer	*Triodia pungens* (D)
Weed Species	*Cenchrus ciliaris (O), Vachellia farnesiana (O), Aerva javanica (O)*
Canopy Height	5 to 8 m
Crown Cover	2 – 10%

Key: D = Dominant, CD = Co-dominant, SD = Sub-dominant, A = Associated, O = Occasional

This community of low open woodland on hills intergrades with other communities on hills, such as *Corymbia capricornia* ridges, with the latter usually occurring on the top most quartz-stony ridges. Western Bloodwood (*Corymbia terminalis*), Whitewood (*Atalaya hemiglauca*), Arid Peach (*Terminalia aridicola)* and Hill Kurrajong (*Brachychiton collinus*) are commonly associated with this community. Wattles such as Tabletop Wattle (*A. phlebocarpa*) and Turpentine *(A. chisholmii*) dominate the shrub layer. Other common wattles include Soap bush (*A. holosericea), A. melleodora* and *A. retivenea.* Other less common shrub species occurring in this community include *Acacia orthocarpa*, *Gossypium australe* and *Grevillea wickhamii*.

Spinifex dominates the ground layer, primarily Soft Spinifex (*Triodia pungens)*, but with Grey Spinifex (*Triodia longiceps)* common on the lower slopes and Feathertop Spinifex (*Triodia bitextura)* on a few rocky ridges. Other common grasses are Silky Oilgrass (*Cymbopogon bombycinus)*, Conetop Nineawn (*Enneapogon lindleyanus)*, Mountain Wanderrie Grass (*Eriachne mucronata)*, Silkytop Grass (*Mnesithea Formosa),* Whitegrass *(Sehima nervosum)* and Australian Dropseed (*Sporobolus australasicus)*.

The herbs are mainly annuals or short-lived perennials, including *Bulbostylis barbata*, Grey Jute (*Corchorus sericeus)*, Orange Spadeflower (*Hybanthus aurantiacus)*, Rusty Indigo (*Indigofera colutea)* and Copper Plant (*Polycarpaea spirostylis)*.

Photo Plate 1 Low open woodland of Snappy Gum (*E. leucophloia*) on metamorphic hills

6.3.1.2 Conservation Value

Species

Targeted searches for species of conservation significance were conducted. Ground-truthing identified no species of conservation significance within this community. The potential on site occurrence of threatened species identified in the database searches is described in Table 15.

Community

Low open woodland of Snappy Gum (*Eucalyptus leucophloia*) on metamorphic hills (RE 1.11.2d), is listed as 'Least Concern' under the VM Act and 'No Concern at Present' under the EHP Biodiversity Status. This ecological community is not listed under the EPBC Act. Areas in which RE 1.11.2 is under reserve include Lawn Hill (Gregory) Resources Reserve and the Boodjamulla (Lawn Hill) National Park.

Intact stands of this community are vast and abundant throughout the region and it is unlikely disturbance within the Project site will significantly impact on the regional occurrence of this community.

6.3.1.3 Vegetation Condition and Habitat Value

Evidence of low intensity cattle grazing was observed throughout this community with visible impacts limited to faecal evidence. Weed diversity and abundance is relatively low within this RE. Seed dispersal vectors likely include wind transport as well as cattle and avian dispersal. Introduced flora species Buffel Grass (*Pennesetum ciliare*) and Kapok (*Aerva javanica*) were observed to be widespread throughout the community, however present in low densities. No weeds of national significance were found within RE 1.11.2d. Overall, the condition of Snappy Gum low open woodland (RE 1.11.2d) on the Project site is healthy.

The landform and vegetation throughout this community provides habitat for macropods, small mammals, reptiles and open woodland birds.

6.3.2 Community 2 – Low Open Woodland of Cloncurry Box (*Eucalyptus leucophylla*) and Bloodwood (*Corymbia terminalis*) on Metamorphic hills

6.3.2.1 Community Description

This vegetation type tended to occur on the pediment slopes and flat open areas below the steeper metamorphic hills. This community features a variable canopy height ranging from 8 to 15 m with an equally variable crown of 5 to 25 % cover.

Community 2 is consistent with RE 1.11.3 - *Corymbia terminalis* low open woodland on basic metamorphics. The community composition is described in terms of dominant species in each stratum of vegetation as detailed in Table 9.

Table 9 Community 2 Profile

Regional Ecosystem	1.11.3 - Low open woodland of *Corymbia terminalis* usually with *Eucalyptus leucophylla* or *E. leucophloia* with *Acacia* spp. dominated shrub layer and ground layer of *Triodia* spp. and/or tussock grasses. Includes areas of *Acacia* spp. shrubland and *Triodia* spp. grassland. Occurs on metabasalts and dolerites; skeletal soils, some shallow loams.
Extent within Study Area	236.8 ha
EPBC Status	Not listed
VM Act Status	Least Concern
Biodiversity Status	No concern at present
Tree Layer	*E. leucophylla* (CD), *C. terminalis* (CD), *E. leucophloia* (A), *Terminalia aridicola* (A), *Atalaya hemiglauca* (O), *Brachychiton collinus* (O)
Shrub Layer	*A. holosericea* (CD), *A. Chisholmii* (CD), *A. phlebocarpa* (A), *A. meleodora* (A), *Gossypium australe* (A).
Ground Layer	*Triodia pungens* (D)
Weed Species	*C. ciliaris (O), V. farnesiana (O), A. javanica (O)*
Canopy Height	8 – 15 m
Crown Cover	5 – 25 %

Key: D = Dominant, CD = Co-dominant, SD = Sub-dominant, A = Associated, O = Occasional

The RE Cloncurry Box (*E. leucophylla*) and Western Bloodwood (*C. terminalis*) on metamorphic hills and lower slopes, often exhibits a sub-dominant presence of Western Bloodwood and associated Snappy gum, Arid Peach and Whitewood. Other occasional canopy species include *Corymbia*

aparrerinja and Hill Kurrajong. The shrub layer includes Soap Bush, Turpentine, *Eremophila longifolia* and *Gossypium australe*.

The ground layer is dominated by Soft Spinifex with a sub-dominant presence of Whitegrass. Other commonly occurring ground cover species include Grey Spinifex, Kangaroo grass (*Themeda triandra*) and the twining herbs *Galactia tenuiflora* and *Vigna radiata*.

A photograph of a secondary transect surveyed within this community is shown in Photo Plate 2.

Photo Plate 2 Low open woodland of Cloncurry Box and Bloodwood on metamorphic hills

6.3.2.2 Conservation Value

Species

Targeted searches for species of conservation significance were conducted throughout this community. Ground-truthing failed to identify any species of conservation significance within RE 1.11.3 at the time of the surveys. The potential for threatened species identified in database searches, to occur on site is described in Table 15.

Community

RE 1.11.3 is listed as 'Least Concern' under the VM Act and 'No Concern at Present' under the EHP Biodiversity Status. This community is not classified as a listed ecological community under the EPBC Act.

Intact stands of this community are abundant throughout the region, with greater than 10, 000 ha of the state-wide extent of this RE remaining. It is unlikely disturbance within the Project site will significantly impact on the regional occurrence or integrity of this community.

6.3.2.3 Vegetation Condition and Habitat Value

While this community was typically subject to low intensity cattle grazing, the impacts were more prominent in areas adjacent to watercourses. As a result of increased grazing pressure, these areas exhibit greater disturbance and weed abundances. Buffel Grass was occasionally observed in high densities and was recorded as co-dominant with Soft Spinifex in areas adjacent to ephemeral watercourses. Introduced flora species were otherwise found to have a sparse presence within this community. Native species tended to dominate the drier open plains and lower slopes of the surrounding hills. No weeds of national significance were recorded within this community.

This community provides good habitat variety for birds, large macropods and reptiles in particular through the provision of rocky substrates, leaf litter, fallen timber and Spinifex tussocks.

6.3.3 Community 3 – Low Open Woodland of Cloncurry Box (*E. leucophylla*) on Alluvial Flats

6.3.3.1 Community Description

This vegetation community occurs on alluvial soils adjacent to ephemeral watercourses. It is consistent with RE 1.3.6x1b which is described as *Eucalyptus leucophylla* woodland with a mid-dense ground layer dominated by tussock grasses. The characteristics of this community and the dominant species within each stratum of vegetation are detailed in Table 10.

Table 10 Community 3 Profile

Regional Ecosystem	1.3.6x1b - Floodplain (other than floodplain wetlands*). Eucalyptus leucophylla* woodland with a mid-dense ground layer dominated by tussock grasses. Occurs on narrow terraces.
Extent within Study Area	163.5 ha
EPBC Status	Not listed
VM Act Status	Least Concern
Biodiversity Status	Of Concern
Tree Layer	*E. leucophylla* (D), *Lophostemon grandiflorus* (A), *C. terminalis* (O),
Shrub Layer	*A. holosericea* (D), *Terminalia aridicola* (A), *A. Chisholmii* (A), *Melaleuca bracteata* (A), *A. phlebocarpa* (A), *Flueggea virosa subsp. melanthesoides (*O), *Gossypium australe* (O)
Ground Layer	*Triodia pungens* (D)
Weed Species	*C. ciliaris (O), V. farnesiana (O), A. javanica (O)*
Canopy Height	8 – 15 m
Crown Cover	25 %

Key: D = Dominant, CD = Co-dominant, SD = Sub-dominant, A = Associated, O = Occasional

This low open woodland community is dominated by Cloncurry box while Northern Swamp Box (*Lophostemon grandiflorus*) occurs in association and Western Bloodwood has a sparse presence. The canopy of this community varies from 8 to 15 m in height and has a cover of approximately 25 %. Common shrubs include Soap Bush, Arid Peach, Turpentine, White Currant Bush *(Flueggea virosa subsp. melanthesoides)*, River Teatree (*Melaleuca bracteata*), Tabletop Wattle and *Gossypium australe*.

Soft Spinifex dominates the ground layer and is largely accompanied by Grey Spinifex and Silky Browntop (*Eulalia aurea*) with Conetop Nineawn occurring occasionally. On average the ground cover

comprised 19.9 % native grasses, 0.8 % native forbs/shrubs, 46 % litter, 22.3 % rock and 11 % bare ground.

Photo Plate 3 Low open woodland of Cloncurry Box on alluvial flats

6.3.3.2 Conservation Value

Species

Targeted searches for species of conservation significance determined that no species of conservation significance were found to inhabit the Cloncurry Box open woodland community (RE 1.3.6x1b) at the time of surveys. The potential for threatened species identified in database searches, to occur on site is described in Table 15.

Community

RE 1.3.6x1b is listed as being 'Least Concern' under the VM Act and is not classed as a threatened ecological community under the EPBC Act. It has been given an 'Of Concern' DERM Biodiversity status due to a high grazing pressure, changed fire regimes and subjection to Buffel Grass invasion. Areas within the Northwest Highlands bioregion where RE 1.3.6 is protected include the Boodjamulla (Lawn Hill) National Park, Lawn Hill (Gregory) Resources Reserve, Camooweal Caves National Park and Lawn Hill (Gregory River Base) Resources Reserve.

Intact stands of this community are abundant within this Queensland bioregion, with the total regional mapped extent of this RE compromising of greater than 10,000 ha. The Project is not likely to impact on the regional extent or health of this community.

6.3.3.3 Vegetation Condition and Habitat Value

Overall, the condition of Cloncurry Box creek flats on the Project site is healthy, with a relatively high diversity of flora species. This is one of the most fertile habitats on the property and is susceptible to greater weed invasion. Introduced species recorded within this community include Mimosa *(V. farnesiana*), Buffel Grass and Kapok. On some drainage lines, Buffel was recorded as co-dominant with native grasses. Kapok was found to occur sporadically throughout the community.

With a ground layer that is comprised predominantly of litter and rock this community provides an abundance of habitat suited to reptiles. This community also provides habitat for birds and large macropods as well as amphibians during wet periods.

6.3.4 Community 4 – River Red Gum (*Eucalyptus camaldulensis*) and Northern Swamp Box (*Lophostemon grandiflorus*) Riparian Woodland

6.3.4.1 Community Description

The River Red Gum and Northern Swamp Box riparian woodland community occurs in association with the major creeks on the Project site. It is consistent with RE 1.3.7b which, in short, is described as fringing woodland of *Eucalyptus camaldulensis*, usually with *Lophostemon grandiflorus* and *Melaleuca bracteata* and/or *M. dissitiflora*. The characteristics of this community and the dominant species within each stratum of vegetation are detailed in Table 11.

Table 11 Community 4 Profile

Regional Ecosystem	1.3.7b - Riverine wetland or fringing riverine wetland. Fringing woodland of *Eucalyptus camaldulensis*, usually with *Lophostemon grandiflorus* and *Melaleuca bracteata* and/or *M. dissitiflora*. Occurs on recent levees and channel deposits of medium and smaller tributaries which are dry for most of the year; alluvial soils.
Extent within Study Area	75.19 ha
EPBC Status	Not listed
VM Act Status	Least Concern
Biodiversity Status	Endangered
Tree Layer	*Eucalyptus camaldulensis (*CD*), Lophostemon grandiflorus* (CD)
Shrub Layer	*Melaleuca bracteata* (CD), *Sesbania javanica* (CD), *A. holosericea* (A), *Flueggea virosa subsp. melanthesoides (*O)
Ground Layer	*Cenchrus ciliaris (*D*)*
Weed Species	*Cenchrus ciliaris (O), V. farnesiana (O)*
Canopy Height	10 – 14 m
Crown Cover	35 %

Key: D = Dominant, CD = Co-dominant, SD = Sub-dominant, A = Associated, O = Occasional

The community is dominated by River Red Gum and Northern Swamp Box (*Lophostemon grandiflorus*). River Teatree and *Sesbania javanica* have a co-dominant presence within the understorey. Other common shrub species present include Soap Bush, White Currant Bush and *Acacia hemsleyi*. Upstream areas, which dry out early in the year, lack the presence of *Eucalyptus camaldulensis*, but remain dominated by *Lophostemon grandiflorus*. Black tea-tree (*Melaleuca bracteata*) can form dense thickets in the upstream areas.

This community is typically dominated by Buffel Grass. Other grasses present include *Triodia* spp., *Paspalidium constrictum,* Elastic Grass *(Eragrostis tenuifolia*), Button Grass (*Dactyloctenium radulans*) and Whitegrass,

A variety of annual or short-lived perennial plants were recorded in association with the riparian community, including Hairy Indigo, Tar Vine (*Boerhavia schomburgkiana*), *Heliotropium cunninghamii*, Rhyncho, *Galactia tenuiflora*, *Ipomoea plebeia* and *Polymeria longifolia.*

Photo Plate 4 River Red Gum and Northern Swamp Box Riparian Woodland

6.3.4.2 Conservation Value

Species

Targeted searches for threatened flora species were conducted throughout RE 1.3.7b. At the time of the surveys no flora species of conservation significance were recorded within the community. The potential for threatened species identified in database searches, to occur on site is described in Table 15.

Community

The River Red Gum and Northern Swamp Box riparian woodland community (RE 1.3.7) is listed as Least Concern under the VM Act and is not listed under the EPBC Act as a threatened ecological community. However, this RE is classified as an Endangered community under the EHP Biodiversity Status. This listing is due to severe degradation as a result of high grazing pressure. Within

Queensland, protected areas containing RE 1.3.7 are limited to Boodjamulla (Lawn Hill) National Park. RE 1.3.7 is considered abundant with greater than > 10, 000 ha remaining within Queensland.

6.3.4.3 Vegetation Condition and Habitat Value

This riparian community provides good habitat variety for reptiles, amphibians, birds and mammals through the presence of hollow bearing trees, rocky substrates, leaf litter and fallen timber as well as temporary aquatic habitats.

This riparian community (RE 1.3.7b) is subject to invasion by introduced species that are known to occur commonly throughout the region including Buffel Grass, Red Natal Grass (*Melinis repens*) and Mimosa. No weed species, listed under the LP Act or listed as of national significance, were observed within the riparian community. This zone was dominated mostly by native vegetation with only low levels of introduced species found in the dry waterways and on stream banks.

Overall the condition of this RE on the Project site is good with only a low diversity of introduced species recorded throughout.

6.3.5 Community 5 – Low Open Woodland of Arid Peach (*Terminalia aridicola*) on Rocky Outcrops

6.3.5.1 Community Description

This community occurs on most rocky outcrops in the northern and eastern portions of the Study area. This community is consistent with RE 1.11.2x4. RE 1.11.2x4 can be described in short, as low open woodland of *Terminalia aridicola* +/- *Brachychiton collinus*, *Alphitonia* spp. and *Corymbia aspera* on rock outcrops on hills and ranges. The characteristics of this community and the dominant flora species in each stratum of vegetation are outlined in Table 12.

Table 12 Community 5 Profile

Regional Ecosystem	1.11.2x4: Low open woodland of *Terminalia aridicola*, often with *Brachychiton collinus*, *Alphitonia* spp. and *Corymbia aspera* with mid-dense shrub layer of *Acacia* spp. and ground layer of mixed tussock grasses and *Triodia* spp. Occurs on rock outcrops on hills and ranges on strongly folded siliceous sedimentary and metamorphic pre-Cambrian rocks.
Extent within Study Area	81.05 ha
EPBC Status	Not Listed
VM Act Status	Least Concern
Biodiversity Status	No concern at present
Tree Layer	*Terminalia aridicola* (D), *Brachychiton collinus* (SD), *E. leucophloia* (A)
Shrub Layer	*Trema tomentosa* (D), A*. phlebocarpa* (A), *A. chisholmii* (A)
Ground Layer	*Triodia pungens* (D), *Cymbopogon bombycinus* (A), *Sehima nervosum* (A)
Weed Species	*Cenchrus ciliaris* (O)
Canopy Height	4 – 7 m
Crown Cover	4 – 50 %

Key: D = Dominant, CD = Co-dominant, SD = Sub-dominant, A = Associated, O = Occasional

This community is dominated by Arid Peach (*Terminalia aridicola*) with associated Hill Kurrajong (*Brachychiton collinus*) and often occurs in association with Snappy Gum woodlands. The shrub layer typically contains Turpentine, Tabletop Wattle and Poison Peach (*Trema tomentosa*).

The ground layer is dominated by Soft Spinifex with associated grasses such as Silky Oilgrass and Whitegrass. Herbs recorded in this community include New Holland Rattlepod (*Crotalaria novae-hollandiae)* and Narrow-leafed Indigo (*Indigofera linifolia)*.

Photo Plate 5 Low open woodland of Arid Peach on rocky outcrops

6.3.5.2 Conservation Value

Species

Despite the completion of targeted searches for species of conservation significance, no threatened flora species were recorded within this community at the time of the Project surveys. The potential for threatened species identified in database searches, to occur on site is described in Table 15.

Community

RE 1.11.2x4 is listed as 'Least Concern' under the VM Act, 'No Concern at Present' under the DERM Biodiversity Status and is not listed under the EPBC Act.

RE 1.11.2 is not protected within the Northwest Highlands bioregion and is not under current threat from clearing or non-native species encroachment. RE 1.11.2 is considered abundant within the region, with the state-wide remnant extent greater than 10,000 ha.

6.3.5.3 Vegetation Condition and Habitat Value

Flora surveys revealed that native flora species dominated the dry rocky outcrops with only a scattered presence and low abundance of the introduced Buffel Grass recorded. No weed species listed under the LP Act or listed as Weeds of National Significance were recorded from this community.

Habitat features in this community include rocky substrates, Spinifex tussocks, leaf litter and fallen timber. This community provides plentiful habitat value for birds, reptiles and rock-dwelling mammals (e.g. Rock Rats and Purple-necked Rock-wallabies) in particular.

6.3.6 Community 6 – Capricornia (*Corymbia Capricornia*) Ridges

6.3.6.1 Community Description

Capricornia (*Corymbia capricornia*) dominates narrow rocky, typically quartz, ridges in the north east of the property. This community is consistent with RE 1.11.2x1b, which is described in short as low open woodland of *Corymbia Capricornia* on hills. The characteristics of this community and the dominant flora species in each stratum of vegetation are outlined in Table 13.

Table 13 Community 6 Profile

Regional Ecosystem	1.11.2x1b: Low open woodland of *Eucalyptus herbertiana* and/or *Corymbia capricornia*, mixed shrub layer and ground layer of *Triodia pungens* and tussock grasses. Occurs on hills on Surprise Creek Formation.
Extent within Study Area	1.92 ha
EPBC Status	Not Listed
VM Act Status	Least Concern
Biodiversity Status	No concern at present
Tree Layer	*Corymbia capricornia* (D), *Eucalyptus leucophloia* (A), *Alphitonia excelsa* (A), *Terminalia aridicola* (A)
Shrub Layer	*Acacia monticola (A), A. orthocarpa (A)*
Ground Layer	*Triodia bitextura (D), Cymbopogon bombycinus (A)*
Weed Species	N/A
Canopy Height	4.5 – 6.5 m
Crown Cover	<5 %

Key: D = Dominant, CD = Co-dominant, SD = Sub-dominant, A = Associated, O = Occasional

This community occurs on small isolated ridges that form a distinct change in ecotone as the terrain rises sharply and the geology becomes dominated by quartz rock. Associated trees include Snappy gum, *Alphitonia excelsa* and *Terminalia aridicola*. Shrubs include *Acacia monticola* and *A. orthocarpa*.

The groundlayer is often sparsely dispersed amongst the rocks. Normally an uncommon spinifex (*Triodia bitextura*) dominates this community rather than the more common *T. pungens*. Other grasses include *Cymbopogon bombycinus*, *Digitaria gibbosa* and *Mnesithea formosa*. Herbs include *Hybanthus aurantiacus* and *Spermacoce auriculata*.

Photo Plate 6 Capricornia ridges

6.3.6.2 Conservation Value

Species

Targeted searches for species of conservation significance determined that no species of conservation significance inhabit the Capricornia ridges. The potential for threatened species identified in database searches, to occur on site is described in Table 15.

Community

The community of Capricornia on ridges (RE 1.11.2x1b) is listed as 'Least Concern' under the VM Act, 'No Concern at Present' under the DERM Biodiversity Status and is not listed under the EPBC Act.

Although RE 1.11.2 is not protected within the Northwest Highlands bioregion, intact stands are abundant throughout this Queensland bioregion. RE 1.11.2x1b is not under threat from clearing and is considered abundant within the region, with the state-wide remnant extent greater than 10,000 ha. This community occurs outside the Project's proposed disturbance areas.

6.3.6.3 Vegetation Condition and Habitat Value

A low diversity and density of introduced species was recorded in association with the Capricornia ridges. Weed species recorded in low densities included including Buffel Grass and Beggar's Ticks (*Bidens bipinnata*). No weed species, listed under the LP Act or listed as of national significance, were observed within the Capricornia ridges community.

This community occupies very small areas of rocky quartz ridges, which are likely to provide limited habitat value for reptiles, birds and mammals.

6.3.7 Community 7 – Low Open Woodland of Cloncurry Box (*E. leucophylla*) and Bloodwood (*C. terminalis*) on granites

6.3.7.1 Community Description

This low open woodland community of Cloncurry Box (*E. leucophylla*) and Western Bloodwood (*C. terminalis*) occurs in association with stony hills and rises on granite to the west of the Project site.

This community closely resembles RE 1.12.1x1, which can be described in short as 'Low open woodland of *Eucalyptus leucophylla* often with *Corymbia terminalis* or *C. aparrerinja*. The defining characteristics of this community including the dominant flora species in each stratum of vegetation are outlined in Table 14.

Table 14 Community 7 Profile

Regional Ecosystem	1.12.1x1: Low open woodland of *Eucalyptus leucophylla* often with *Corymbia terminalis* or *C. aparrerinja*, shrub layer of *Acacia chisholmii* with hummock grass ground layer of *Triodia* spp. Includes areas of treeless *Triodia* spp. grasslands and *Acacia* spp. shrublands. Occurs on ranges and stony hills and rises on igneous rocks; skeletal soils and some shallow red earths.
Extent within Study Area	38.26 ha
EPBC Status	Not Listed
VM Act Status	Least Concern
Biodiversity Status	No concern at present
Tree Layer	*Eucalyptus leucophylla* (CD), *C. terminalis* (CD), *Atalaya hemiglauca* (A)
Shrub Layer	*Acacia chisholmii* (D), *Carissa lanceolata* (A)
Ground Layer	*Triodia* spp. (D)

Key: D = Dominant, CD = Co-dominant, SD = Sub-dominant, A = Associated, O = Occasional

This low open woodland community generally comprises a co-dominant canopy of Cloncurry Box (*E. leucophylla*) and Western Bloodwood (*C. terminalis*) on stony hills, rises and undulating plains. Whitewood commonly forms a low tree layer throughout the community. The shrub layer is typically dominated by Turpentine, while Conkerberry occurs commonly.

The ground layer was dominated by Triodia tussocks with occasional *Aristida* spp. and large patches of bare earth occurring sporadically.

6.3.7.2 Conservation Value

Species

Field surveys completed to date have not included targeted searches for threatened flora species within this community. Such surveys will need to be completed prior to construction of the proposed access road. The potential for threatened species identified in database searches, to occur on site is described in Table 15.

Community

RE 1.12.1 is listed as 'Least Concern' under the VM Act, 'No Concern at Present' under the DERM Biodiversity Status and is not listed under the EPBC Act.

This RE is not under current threat from clearing or non-native species encroachment. RE 1.12.1 is considered abundant within the region, with the state-wide remnant extent greater than 10,000 ha. RE 1.12.1 is protected in the Boodjamulla (Lawn Hill) National Park area in the Northwest Highlands bioregion.

6.3.7.3 Vegetation Condition and Habitat Value

This community occurs as part of a large patch of remnant vegetation. Previous disturbance within this community is limited to low intensity cattle grazing activities.

This community provides good habitat variety for birds, large macropods and reptiles in particular through the provision of rocky substrates, fallen timber and Spinifex tussocks. The small rocky hills and low rock outcrops are likely to support reptiles and small mammals. Highly mobile species such as birds and macropods are likely to utilise this community as forage habitat.

6.3.8 Flora Species of Conservation Significance

Database searches identified two threatened flora species within the region of the Project site. An assessment of the likelihood of these species occurring on the Project site is provided in Table 15.

Table 15 Flora of Conservation Significance known from the Region - Not Identified on the Project

Scientific Name	Habitat Description	Likelihood of Occurrence
Ptilotus maconochiei	*Eucalyptus leucophloia* and C*orymbia aspera* woodland, with *Triodia pungens* groundcover. On quartzite ridge tops, hillsides, slopes and shale	Potential habitat for this species occurs on the small quartzite ridgetops located on the Project site. Despite extensive field surveys, this species was not observed.
Ipomoea antonschmidii	*Eucalyptus leucophloia, Corymbia capricornia, Corymbia aparrerinja* and *Eucalyptus camaldulensis* woodlands. Grows in a variety of habitats, including rocky, sandy and red clay substrates. Occurs along the Lake Julius pipeline, Gunpowder and north of Mount Isa	This species grows on shallow, red, stony soils in a variety of habitats, some of which are represented on the Project. It is known to occur within 15 km of the Project. While this species was not observed during field surveys, there is potential for this species to occur on the Project site.

Targeted searches across the Project site failed to detect the presence of any plants of conservation significance. Given that no threatened flora species have been recorded on the Project site, it is highly unlikely that the Project will impact on any flora species of conservation significance.

6.3.9 Weeds of Management Concern

Six introduced weed species were recorded in low densities across the Project. Introduced weeds present on the project site included the following:

- Buffel Grass (*Cenchrus ciliaris*);
- Red Natal Grass (*Melinis repens*);

- Asthma Plant (*Chamaesyce hirta);*
- Beggar's Ticks (*Bidens bipinnata*);
- Kapok Bush (*Aerva javanica*); and
- Mimosa Bush (*Vachellia farnesiana*).

All weed species recorded on the Project site are known to occur commonly throughout the broader region. No weed species recorded on the Project are listed as declared weeds under the Queensland *Land Protection (Pest and Stock Route Management) Act 2002.* No Commonwealth listed Weeds of National Significance (WoNS) were identified on the Project site. Introduced plant species are classified by the Commonwealth Government as WoNS if they present a serious threat to industry, water supply, human health/safety, plant communities and/or cultural values.

6.4 FAUNA SURVEY RESULTS

A total of 144 fauna species were identified during wet and dry season surveys on the Project site. The suite of fauna species recorded included nine amphibians, twenty-seven reptiles, eighty birds and twenty-eight mammals. A complete list of fauna species recorded on the Project site is provided in Appendix D.

Each of the major vertebrate groups observed on the Project site is discussed below in Sections 6.4.1 to 6.4.5. Pest species observed on the Project site are discussed in Section 6.4.6. Fauna species of conservation significance are discussed in Section 6.4.7.

6.4.1 Amphibians

6.4.1.1 Habitat Values

Amphibian habitat on the Project site varies seasonally due to the ephemeral nature of creeks and associated drainage lines. During the dry season (May-October), sandy drainage lines offer the majority of the potential habitat for burrowing species capable of spending extensive period's underground awaiting rain. The waterholes present on the Project site function as three temporary and one permanent water source, all of which would support amphibian habitation to some extent. However, the limited availability of permanent water restricts the habitat potential for any non-burrowing amphibians to persist during the dry season. During the wet season (November-April), habitat variation and suitability increases in response to increased rainfall.

6.4.2 Observed Species

A total of 9 amphibian species were noted throughout the Project site. Two amphibian species observed during the 2011 wet season survey, Sandstone Frog (*Litoria coplandi)* and Wotjulum Frog (*Litoria wotjulumensis)* were noted to be at the limits of their distribution in the Mount Isa area. Other species noted during the Project surveys include the Green Tree Frog (*Litoria caerulea),* Northern Snapping Frog (*Cyclorana australis*), Long-footed Frog *(Cyclorana longipes),* Northern Laughing Treefrog *(Litoria rothi),* Ruddy Treefrog *(Litoria rubella),* Ornate Burrowing Frog (*Platyplectrum ornatum*) and the introduced Cane Toad *(Rhinella marina*).

The Cane Toad was first recorded on the Project site during the 2011 terrestrial flora and fauna surveys. While it was not observed during the 2014 wet or dry season field surveys, it was recorded in low numbers during the 2014 wet and dry season aquatic ecology surveys (refer to the Barbara

Copper Project Aquatic Ecology report). The Cane Toad is not listed as a declared pest species under the LP Act.

While two species were recorded outside their normal distribution (i.e. *Litoria coplandi* and *Litoria wotjulumensis*), all other amphibian species observed during the Project surveys are known to occur commonly throughout the local region. A full list of observed amphibian species is included in Appendix D of this report.

Photo Plate 7 *Litoria coplandi* recorded in a small sandstone gorge (OBSO2)

6.4.2.1 Amphibian Species of Conservation Significance

No amphibians of conservation significance have been previously recorded within the region (Appendix A). It is considered unlikely that any amphibian species of conservation significance occur on the Project site.

The presence of *Litoria coplandi* and *Litoria wotjulumensis* on the Project site indicates a potential extension to the known distribution of each species, however, neither is considered species of conservation significance.

6.4.3 Reptiles

6.4.3.1 Habitat Values

Australia's environment supports an extremely diverse assemblage of reptile species which exploit a wide array of micro-habitats (e.g. tree hollows, rock crevices, soil cracks) and food sources (e.g. succulent leaves, termites, grasshoppers, birds, and other reptiles) (Pianka 1969a; 1969b). This diversity encompasses species of widely different body sizes (skinks *v.* monitors), and life history strategies (burrowing blind snakes *v*. arboreal geckos).

The Project site provides a variety of habitat types thought to be suitable for reptile species occurring in the region. Micro-habitats such as those associated with tree hollows, vegetated watercourses, open woodlands scattered with fallen timber and rocky outcrops may suit a variety of reptile species.

6.4.3.2 Observed Species

The two wet season surveys and two dry season surveys conducted in 2011 and 2014, recorded a total of 27 reptile species on the Project site. All reptile species recorded on the Project site are listed in Appendix D.

A large variety of skinks comprising 11 species were encountered on the Project. These species include Gravelly-soil Ctenotus (*Ctenotus lateralis),* Rock Ctenotus (*Ctenotus saxatilis*)*,* Leopard Ctenotus (*Ctenotus pantherinus),* Eastern Striped Skink (*Ctenotus robustus*), Carpentarian Ctenotus (*Ctenotus striaticeps*)*,* Shaded-litter Rainbow-skink *(Carlia munda)*, Two-spined Rainbow-skink (*Carlia amax),* Agile Snake-eyed Skink (*Cryptoblepharus zoticus),* Metallic Snake-eyed Skink *(Cryptoblepharus metallicus),* Northern Soil-crevice Skink (*Proablepharus tenuis*) and Hosmer's Skink (*Egernia hosmeri)* (Photo Plate 8)*.*

Photo Plate 8 Hosmer's Skink (*Egernia hosmeri*) captured in an Elliott trap at FA6

Four gecko species were identified, predominantly whilst spotlighting in watercourses. These included Northern Spiny-tailed Gecko (*Strophurus ciliaris*) (Photo Plate 9), Robust Dtella (*Gehyra robusta),* Tree Dtella *(Gehyra variegata) and* Bynoe's Gecko *(Heteronotia binoei)*.

Photo Plate 9 Northern Spiny-tailed Gecko at FA5

The remaining reptile species observed on the Project site were Gilbert's Dragon *(Amphibolurus gilbertii*), Merten's Water Monitor (*Varanus mertensi*), Ridge-tailed Monitor (*Varanus acanthurus*), Children's Python (*Anteresia childreni*), Olive Python (*Liasis olivaceus*), Northern Hooded Scaly-foot *(Pygopus steelescotti*) (Photo Plate 10), Burton's Legless Lizard (*Lialis burtonis*), Northern Blind Snake (*Ramphotyphlops diversus*), Robust Blind Snake (*Ramphotyphlops ligatus*) (Photo Plate 11), Curl Snake (*Suta suta*), Sombre Whipsnake (*Demansia quaesitor*) and Collared Whipsnake (*Demansia torquata*).

Photo Plate 10 Northern Hooded Scaly-foot (*Pygopus steelescotti*) captured at FA1

Photo Plate 11 Robust Blind Snake (*Ramphotyphlops ligatus*) captured at FA5

6.4.3.3 Reptile Species of Conservation Significance

No reptiles of conservation significance were observed on the Project site during either of the wet or dry season surveys. Database searches identified three reptile species of conservation significance within the region of the Project site. All three reptiles have specific habitat requirements. The Death Adder occurs on flat, treeless, cracking-soil riverine floodplains (Cogger 2000), while the Gulf Snapping Turtle and Diamond Head Turtle require permanent rivers and waterbodies to survive. The Project area lacks suitable habitat for reptile species of conservation significance that are known from the region.

6.4.4 Birds

6.4.4.1 Habitat Values

Avian assemblages are generally determined by factors such as food sources (e.g. fruit, nectar, seeds, and insects), as well as a mosaic of habitat structures such as grasses, thick understorey, midstorey and canopy vegetation (i.e. vertical habitat complexity). Generally, the more food sources available and the more complex the structure of the vegetation, the more diverse the avifauna will be.

Food sources on the Project site are generally restricted to seeds, nectar, insects and vertebrate prey items (or carrion). The Project Site and also the surrounding area largely lacked a permanent or abundant supply of fruit producing plant species, suggesting fructivorous species are less likely to occur.

6.4.4.2 Observed Species

A combined total of 80 bird species were recorded on the Project site during the 2011 and 2014 flora and fauna surveys, with all species considered common throughout the region. The suite of birds recorded on the Project site included one listed Marine and Migratory species, the Rainbow Bee-eater (*Merops ornatus*) and one State listed near threatened species, the Golden-backed Honeyeater (*Melithreptus gularis laetior*). These species are discussed in more detail in Section 6.4.4.3 and 6.4.4.4. All bird species recorded on the Project site are listed in Appendix D.

A large diversity of granivorous birds were recorded on Project site including the Peaceful Dove (*Geopelia striata*), Diamond Dove (*Geopelia cuneata)*, Spinifex Pigeon (*Geophaps plumiferal*), Crested Pigeon (*Ocyphaps lophotes*), Common Bronzewing (*Phaps chalcoptera*), and a variety of finches and parrots common to the region such as the Zebra Finch (*Taeniopygia guttata*), Long-tailed Finch (*Poephila acuticauda*), Double Barred Finch (*Taeniopygia bichenovii*), Red-winged Parrot (*Aprosmictus erythropterus*) and Budgerigar (*Melopsittacus undulatus*).

The site contained a large variety of honeyeaters with many species observed. The most commonly recorded honeyeater species were the Brown Honeyeater (*Lichmera indistincta*), Grey-headed Honeyeater (*Ptilotula keartlandi*) and Yellow-throated Miner (*Manorina flavigula*).

Four raptor species were observed on the Project site during the surveys, including the Wedge-tail Eagle (*Aquila audax*), Brown Falcon (*Falco berigora*), Collared Sparrowhawk (*Accipiter cirrocephalus*) and Black-shouldered Kite (*Elanus axillaris*). In addition to these species, several other birds that are known to feed on vertebrate species were detected, including the Magpie (*Cracticus tibicen*), Australian Raven (*Corvus coronoides*), Blue-winged Kookaburra (*Dacelo leachii*), Pied Butcherbird (*Cracticus nigrogularis*), Red-backed Kingfisher (*Todiramphus pyrrhopygius*) and Magpie Lark (*Grallina cyanoleuca*).

Two nocturnal birds were observed whilst spotlighting during the 2011 and 2014 surveys. Both were observed to be nocturnal predators including Spotted Nightjar (*Eurostopodus argus*), and Australian Owlet Nightjar (*Aegotheles cristatus*).

6.4.4.3 Bird Species of Conservation Significance

Golden-backed Honeyeaters (*Melithreptus gularis laetior*) were observed on the project site during the 2011 wet and dry season surveys. This species was later observed on the Project during the 2014 dry season survey. This species is listed as Near Threatened under the Nature Conservation Act 1992. The Golden-backed Honeyeater is a widely roaming species, able to cover large distances quickly. While they may exploit any habitats within the study area, they are most likely to frequent creek lines and riparian vegetation associations (RE's 1.3.6 and 1.3.7a,b) where flowering tree species such as *Lophostemon grandiflorus* and *Eucalyptus camaldulensis* are common. The locations in which the Golden-backed Honeyeater has been recorded on the Project site are shown in Figure 10. The operational works of the project are not concentrated along the watercourses and there is a large abundance of suitable habitat located throughout the surrounding region. Impacts from the Project are unlikely to influence the regional populations of this species. No other bird species of conservation significance were recorded on the Project at the time of the surveys.

6.4.4.4 EPBC Act Listed Migratory and Marine Species

One bird species observed on the Project site at the time of the surveys, the Rainbow Bee-eater (*Merops ornatus*) is listed under the EPBC Act as Marine and Migratory. The Rainbow Bee-eater inhabits all of mainland Queensland, as well as Indonesia, New Guinea and the Solomon Islands. This species is widespread and breeds throughout most of its range, with the exception of southern birds,

which move north to breed. Species which utilise the Project site are not at the extent of their known range and the population in the area does not constitute an 'ecologically significant proportion' of the total population of this species. Impacts from the Project are highly unlikely to meet the significant impact criteria for migratory species as defined in the Matters of National Environmental Significance. While the species does inhabit the site, the surrounding region provides suitable habitat that can be utilised and impacts from the project are unlikely to significantly impact the habitat or distribution of this species in the region.

6.4.5 Mammals

6.4.5.1 Habitat Values

The morphology of mammal species varies widely from small rodents to larger kangaroos and even bats. The ecology of each of these groups is equally variable and they are assessed separately in the following sections.

Small Mammals

Habitats suitable for small mammals include areas that provide a plentiful food source and suitable shelter sites. The highest density of small mammal species is usually associated with reliable rainfall which is reflected in a reliable source of food and dense ground vegetation, particularly shrubs and grasses.

The diversity of small mammals is often limited by the lack of a predictable food supply and open ground vegetation. Consequently, small mammal populations can fluctuate dramatically in response to rainfall which increases seed production and insect abundance. During less favourable periods, small mammal populations can be very low.

The Project site provided a variety of habitat types suitable for small ground-dwelling mammals, including vegetated open woodlands, vegetated water courses and rocky outcrops and escarpments.

Medium and Large Mammals

Factors affecting the occurrence of medium and large sized mammals are varied. Important factors can include land-clearing, feral animal predation and grazing pressures. Consequently, medium-sized mammals are considered to be highly populated in most of eastern Australia.

Habitats on the Project site do not include large areas of dense native vegetation. Rather, the open grassy woodland is typical of the region is likely to be reflected in the medium-sized mammal community. Rocky outcrops provide habitat for rock-wallabies to roost and forage.

Larger mammals such as kangaroos have been much less affected by predation and land clearing activities. In fact, many species have flourished in response to increased areas of grassland and open vegetation. Habitat on the Project site for this mammal group is favourable.

Arboreal Mammals

The majority of arboreal mammals that occur in Australia utilise tree hollows for nesting and shelter (Menkhorst and Knight 2004). A shortage of nest hollows is likely to limit arboreal mammal populations where the density of hollow bearing trees is less than two to eight trees per ha (Smith and Lindenmayer 1988).

Hollow-bearing trees in the broader region of the Project generally occur along creek-lines, separated by open areas that would be difficult for arboreal mammals to cross without venturing onto the ground. This vegetation structure occurs throughout the Project site, with hollow bearing trees largely restricted to the River Red Gum and Northern Swamp Box creeks (RE 1.3.7a).

Bats

The density and diversity of Australian bat species is determined primarily by the availability of suitable nesting and roosting sites. Roosting sites can include locations such as thick foliage, loose exfoliating bark, rock caves or cavities, tree hollows or even fabricated structures such as old buildings and culverts (Churchill 1998).

Consequently, areas with a large number of hollow-bearing trees that occur within remnant vegetation are of high value to many bat species. As bats have a small body size, these hollows can be much smaller in size than required by arboreal mammals. Possible roosting sites were present on the Project site and included tree hollows in the River Red Gum and Northern Swamp Box creeks (RE 1.3.7a), caves and crevices in the rocky outcrops areas and disused mining shafts. Some hollows were also noted in the *Eucalyptus leucophloia* (Snappy Gum) located throughout the more open areas of the site.

6.4.5.2 Observed Species

In total, twenty-eight mammal species were observed on the Project site, comprising 24 native species and 4 introduced species. Introduced species recorded as having a presence on the Project site include the House Mouse (*Mus domesticus*), Dingo/Wild Dog (*Canis familiaris),* Feral Pig (*Sus scrofa*) and Cow (*Bos taurus*). One introduced species, the House Mouse (*Mus domesticus*) was captured in an Elliott trap at Fauna Site 3 during the 2011 dry season survey. All other pest species were recorded either through direct observation or analysis of faecal scats.

Two of the introduced species, the Dingo/Wild Dog and Feral Pig are classified as Class 2 pest animals under the LP Act. Discussion of these introduced species is provided in Section 8.6. All mammal species recorded on the Project site are listed in Appendix D.

Twenty-four native mammal species were recorded on the Project site and include Desert Mouse (*Pseudomys desertor*), Delicate Mouse (*Pseudomys delicatulus*), Long-haired Rat (*Rattus villosissimus*), Long-tailed Planigale (*Planigale ingrami*), Common Planigale (*Planigale maculata*), Stripe-faced Dunnart (*Sminthopsis macroura*), Echidna (*Tachyglossus aculeatus*), Common Wallaroo (*Macropus robustus*), Red Kangaroo (*Macropus rufus*), Spectacled Hare-wallaby (*Lagorchestes conspicillatus*) and Purple-necked Rock-wallaby (*Petrogale purpureicollis*). A photograph of a Common Planigale captured at FA5 is provided in Photo Plate 12.

Photo Plate 12 Common Planigale (*Planigale maculata)* captured at FA5

A total of 12 micro-bat species were positively identified on the Project site, all of which are not listed under the EPBC Act or NCWR. Commonly identified species, with more than 20 positive calls recorded most nights, included Gould's Wattled Bat (*Chalinolobus gouldii*), Inland Broad-nosed Bat (*Scotorepens balstoni*), Inland Forest Bat (*Vespadelus baverstocki*) and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*). Additional species identified included the Beccari's Freetail Bat (*Mormopeterus beccarii*), Northern Freetail Bat (*Chaerephon jobensis*), Eastern Dusky Leaf-nosed Bat (*Hipposideros ater*), Hoary Wattled Bat (*Chalinolobus nigrogriseus*), Troughton's Sheathtail Bat (*Taphozous troughtoni*), Common Sheathtail Bat (*Taphozous georgianus*), Little Broad-nosed Bat (*Scotorepens greyii*), Finlayson's Cave Bat (*Vespadelus finlaysoni*), Little-red Flying-fox (*Pteropus scapulatus*), an unknown Long-eared Bat (*Nyctophilus* sp.) and an unknown Freetail Bat (*Mormopterus* sp.). The Long-eared Bat (*Nyctophilus* sp.) could not be identified to species level because it cannot be reliably differentiated from call data. Long-eared Bats generally produce distinctive calls. The species most likely to be present in the Project area is *N. geoffroyi*. Three other species (*N. arnhemensis*, *N. bifax* and *N. walkeri*) also occur in the far northwest of Queensland but are primarily restricted to moist habitats such as watercourses lined with pandanus and paperbark, which occur in small isolated fragments on the Project Site. The unresolved calls of the Freetail Bat (*Mormopterus* sp.) were considered to be representative of a small *Mormopterus* sp. with the calls being similar to those calls produced by *Mormopterus* sp. 3 (Balance Environmental, 2014).

The alluvial areas such as River Red Gum and Northern Swamp-box Riparian Woodland (RE 1.3.7a) held the highest abundance of microbats, although areas such as rocky outcrops on hills, Snappy Gum (*Eucalyptus leucophloia*) hollows and manmade structures such as abandoned mine shafts and the current exploration camp also provided ample roosting and feeding habitat.

Appendix E details the ANABAT analysis results.

6.4.5.3 Mammal Species of Conservation Significance

One mammal species of conservation significance, the Purple-necked Rock-wallaby (PNRW) has been recorded on the Project site. This species was observed on the Project site during both the 2011 and 2014 wet season surveys. A photo of a Purple-necked Rock-wallaby captured on a sensor camera at FA8 during the 2014 dry season survey is provided in Photo Plate 13. The Purple-necked Rock-wallaby is listed in the schedules of the NCWR as a Vulnerable species but is not listed under the EPBC Act.

Photo Plate 13 Purple-necked Rock-wallaby at FA8

This species is known in the region and occupies rock outcrops, boulder piles, cliffs, gorges, rocky slopes and gullies within dry Eucalypt and acacia woodlands where Spinifex dominates the understorey (Curtis and Dennis 2012). Large successful populations generally have access to permanent freshwater and populations may wither without it during extended droughts. However, Purple-necked Rock-wallabies are highly adapted to dry conditions and can obtain their water from dew and by extracting it from herbage (Van Dyck and Strahan 2008). Rock-wallabies exhibit strong fidelity to home ranges and their movements between roosting sites and feeding areas are highly predictable (Horsup 1994).

Rocky habitat used by Rock-wallabies provides protection from predation by species such as Dingo (*Canis lupus dingo*), Fox (*Vulpes vulpes*) and Wedge-tail Eagle (*Aquila audux*) as well as temperature extremes during the day. At night they move over larger areas to feed on plants growing in deeper soils (Law and Dickman 1988). Caves within rocky outcrops provide a micro environment that buffers temperatures and maintain higher levels of humidity than outside the rocks (Short 1982).

Purple-necked Rock-wallabies are less likely to occur widely over the study area. Rather, the species is associated with large rock outcrops and screed slopes that provide overhangs, cracks and small cavernous structures. While many individuals are sedentary, remaining at the same rock outcrop for extended periods, some individuals (particularly young males) may move several kilometres in search of new habitats.

These individuals are probably responsible for scats and other traces that can often be located in small isolated outcrops, which are unlikely to support a resident individual or family group in the long-term. Within the study area, most suitable habitat was observed on hill-tops and along two small gorges. Site coordinates were recorded where all threatened species were observed and are demonstrated in Figure 10 below.

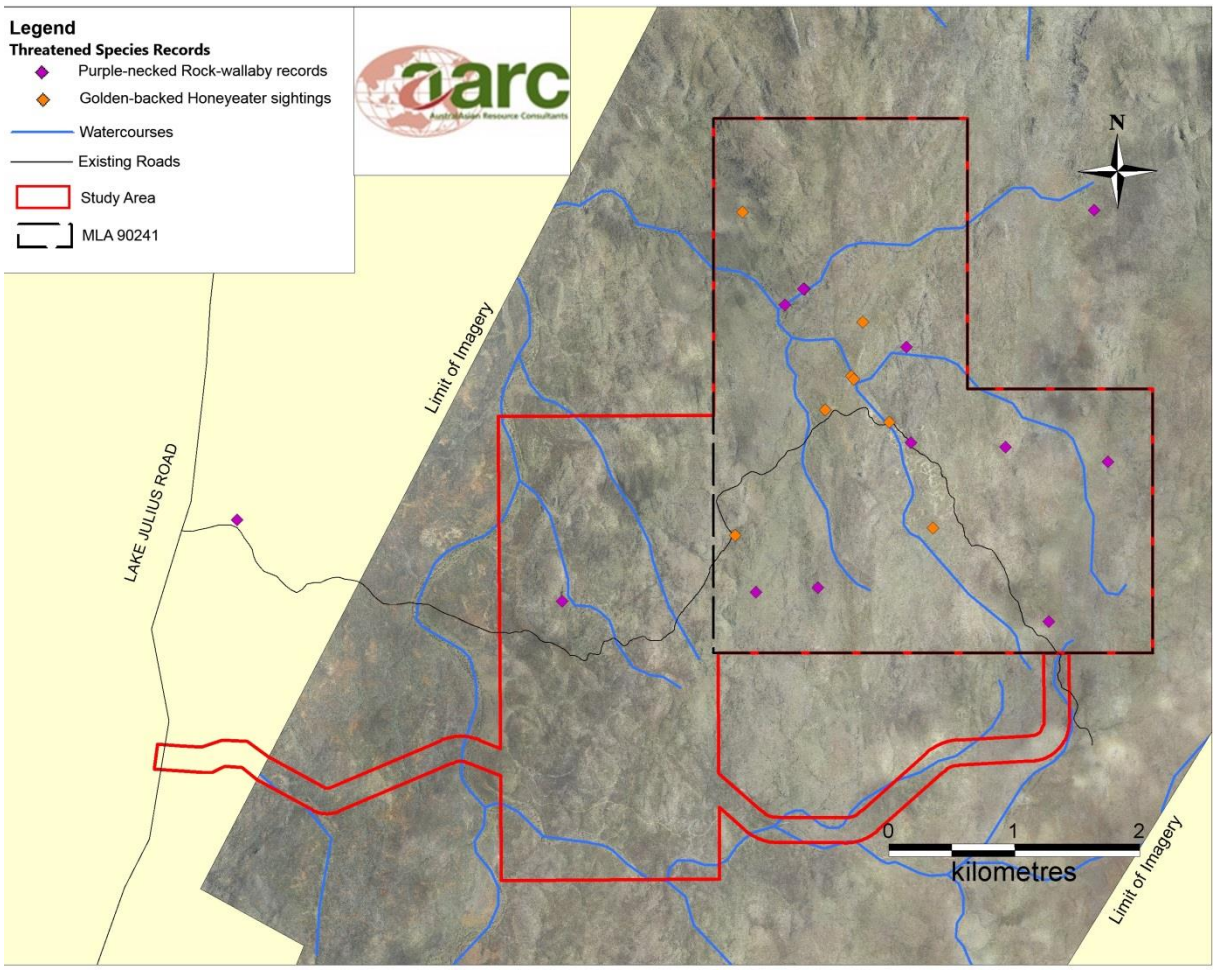


Figure 10 Threatened Species Records

During the 2011 wet season survey, a number of individuals (e.g. more than five) were located within these two gorges, along with abundant scat evidence, suggesting these locations may support semi-permanent and sizable populations. While no sightings were recorded during the 2011 dry season surveys, at least one individual was observed at three different locations across the Project (including one of the gorges) during the 2014 wet season survey. Both gorges and the bulk of outcropping hill-top habitat lie outside the main resource areas. Areas of potential PNRW habitat are shown in Figure 11. Potential Project impacts on PNRW habitat are discussed in Sections 7.2 and 7.4.

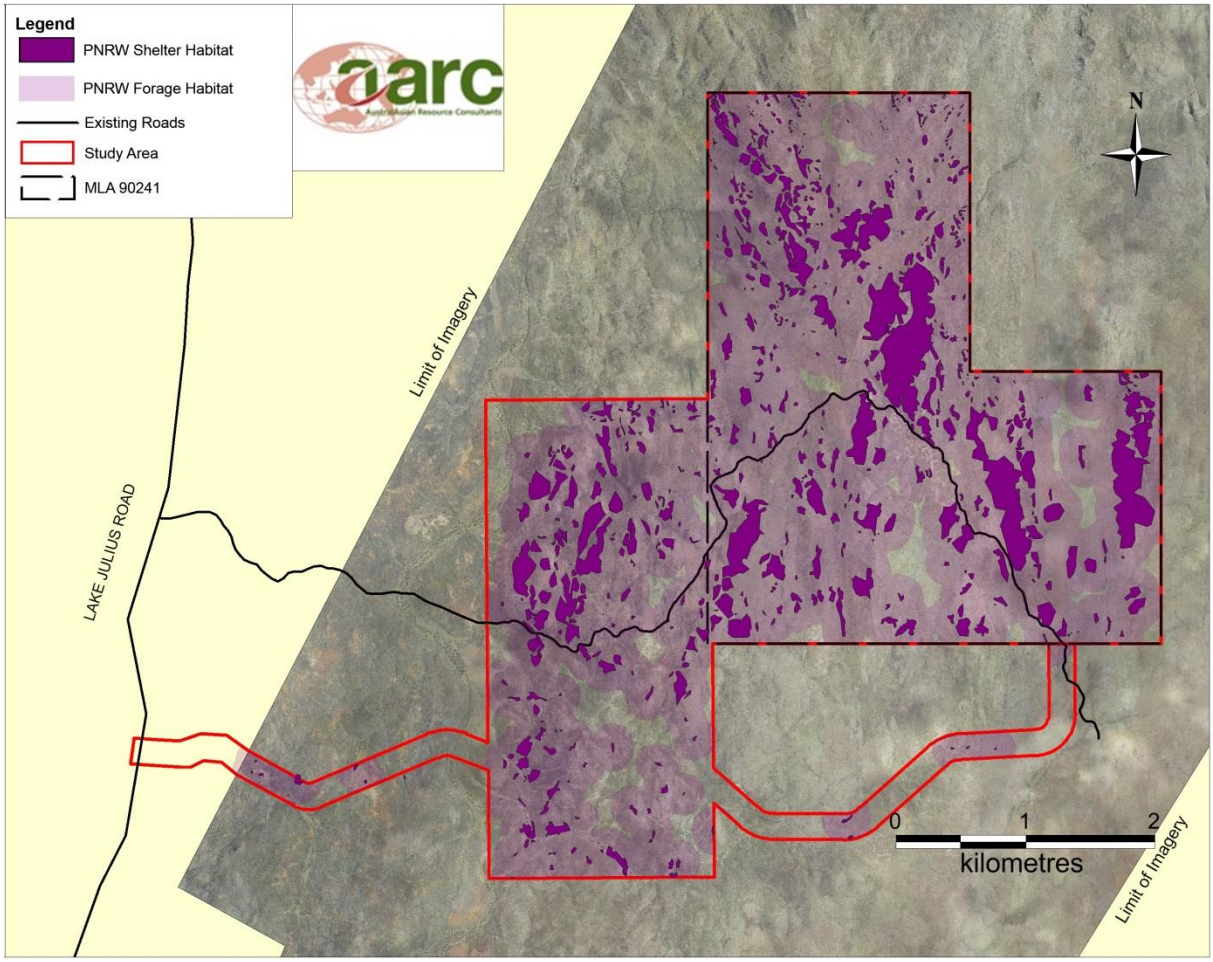


Figure 11 PNRW Habitat Areas

Species of conservation significance known from the region which were not detected during the survey are discussed in Section 6.4.7.

6.4.6 Pest Species

Field surveys positively identified five introduced fauna species as having a presence on the Project site either through direct observation or detection of species presence indicators (i.e. faecal scats, tracks, etc.). Pest species present include the Cane Toad, Wild Dog/Dingo, Feral Pig and House Mouse as well as domestic cattle. Two of the introduced species, the Wild Dog/Dingo and Feral Pig are classified as Class 2 pest animals under the LP Act. Pest species fact sheets outlining appropriate management controls for each species are provided in Appendix F.

Dingos/Wild Dogs are natural predators and present a threat to native wildlife in the area. Feral Pigs can have significant impacts on the environment including weed dispersal, degradation of waterbodies, soil erosion, predation on native species and potentially dispersal of diseases to native fauna.

While Cane Toads are not a declared species, they present a serious threat to native wildlife. The Cane Toad consumes a wide variety of native animals including frogs, small reptiles, mammals and birds and causes the death of native predators that consume their toxins.

6.4.7 Regional Fauna Species of Conservation Significance

As previously mentioned, two fauna species of conservation significance (i.e. Golden-backed Honeyeater and Purple-necked Rock-wallaby) have been identified on the Project site. Under the NCWR, the Golden-backed Honeyeater is listed as Near Threatened and the Purple-necked Rock-wallaby is listed Vulnerable. No fauna species listed as threatened under the EPBC Act were identified on the Project site. Furthermore, no Back on Track Priority fauna species identified in the region were recorded on the Project.

Table 16 below discusses species of conservation significance that are known from the broader region and have been identified from desktop searches (Appendix A), but were not observed on the Project site during surveys.

The assessment of potential for presence and impact on each species is based on the knowledge of ecologists, information obtained from field surveys on the Project site, previous surveys conducted on or near the Project site and scientific literature.

Table 16 Threatened Fauna known from the Region Not Observed on the Project site

Scientific Name **Common Name**	**Status**		**Habitat Requirements**	**Likelihood**
	EPBC Act	**NC Act**		
Birds				
Accipiter novaehollandiae Grey Goshawk	NL	NT	This species prefers rainforests, forests, forested gullies and valleys, taller woodlands, timbered watercourses and may be found in open country during autumn dispersal	**Possible.** The Project site lacks habitat preferred by this species. It is likely that any occurrence of this species on the Project site would be of a temporary nature during periods of dispersal. Given the species primarily occupies coastal and sub-coastal regions, the Project is unlikely to have an impact on this species
Amytornis dorotheae Carpentarian Grasswren	NL	NT	The Carpentarian Grasswren has a highly restricted distribution from the 'Gulf fall' escarpments in NT, south-east to Lawn Hill National Park and East to Gunpowder-Mount Isa. Preferred habitats typically incorporate areas of Spinifex, sparse shrubs and eucalypts on sandstone escarpments and gullies (Pizzey & Knight 2007).	**Unlikely.** Preferred habitat for this species does not occur on the Project site.
Ephippiorhynchus asiaticus Black-necked Stork	NL	NT	This species is a wetland indicator species occurring where wetland habitat exists throughout Queensland.	**Unlikely**. As suitable habitat does not occur on the Project site it is unlikely that this species would occur on the Project.

Scientific Name **Common Name**	**Status**		**Habitat Requirements**	**Likelihood**
	EPBC Act	**NC Act**		
Epthianura crocea crocea Yellow Chat (gulf)	NL	V	This species inhabits low vegetation around the margins of ephemeral wetlands, floodplains, swamps and bore drains, vegetated dams, salt lakes, clay pans and lagoons, sewerage ponds or reservoirs. The Gulf subspecies of Yellow Chat is distributed across the Lake Eyre and Gulf of Carpentaria drainage basins (Curtis & Dennis 2012).	**Unlikely.** Suitable habitat for this species does not occur on or adjacent to the Project site.
Erythrotriorchis radiatus Red Goshawk	V	E	This species generally prefers coastal and sub-coastal open forest and woodland that supports a mosaic of vegetation types. They tend to nest in tall emergent trees located in close proximity to permanent freshwater (Curtis & Dennis 2012).	**Unlikely**: Suitable habitat does not occur on the Project site.
Erythrura gouldiae Gouldian Finch	E	E	This species occupies open tropical woodlands with a grassy understorey dominated by annual Sorghum (*Sarga* spp.) grasses and breeds in Eucalypt open woodlands on ridges, rocky foothills or escarpment country; during the wet season it feeds in Spinifex dominant habitats and wet lowlands with diverse perennial grasses. (Curtis & Dennis 2012).	**Possible:** This species may occur on the Project site as it prefers to feed in Spinifex grasslands during the wet season and typically nests in hollow-bearing Eucalypts including *E. leucophloia* (DoE 2014, Curtis and Dennis 2012). Both habitat types occur on the Project site. While the Project may remove some habitat for this species, suitable habitat occurs in abundance throughout the surrounding region. The Project is not likely to have a significant impact on the species.
Falco hypoleucos Grey Falcon	NL	NT	This species occupies lightly treed inland plains, gibber deserts, sandridges, pastoral lands, timbered watercourses and seldom the driest deserts (Pizzey & Knight 2007).	**Unlikely.** Preferred habitat for this species does not occur on the Project.

Scientific Name Common Name	Status		Habitat Requirements	Likelihood
	EPBC Act	NC Act		
Grantiella picta Painted Honeyeater	NL	V	This species prefers deep, productive soils, in Acacia dominant woodlands and relies on abundant mistletoes for food (Curtis & Dennis 2012).	**Unlikely.** The Project site does not provide suitable habitat for this species.
Heteromunia pectoralis Pictorella Mannikin	NL	NT	Pictorella Mannikin is found in open country with sparse trees and a groundlayer of grass or Spinifex, tall grass in Acacia woodlands near water and on grassy flats along creeks (Pizzey & Knight 2007). The species distribution extends from the Fitzroy River Valley in central north QLD across north west QLD, NT and WA.	**Possible:** The Project site contains suitable habitat for the Pictorella Mannikin. However, suitable habitat is highly available throughout the surrounding region, signifying it is unlikely the Project provides critical habitat. Furthermore, given the extent of the species range, it is unlikely the Project will have an adverse impact on the species should it occur intermittently.
Lophoictinia isura Square-tailed Kite	NL	NT	This species is widely distributed across mainland Australia and is known to inhabit heathlands, woodlands, forests, tropical and subtropical rainforest, timbered watercourses, hills and gorges.	**Possible**: Portions of the Project site provide suitable habitat for this species including timbered watercourses, hills and gorges. Given the availability of habitat for this species throughout the region, the Project is unlikely to have an impact on the species should it occur in the area.
Malurus coronatus Purple-crowned Fairy-wren	NL	V	Primary habitat for the Purple-crowned Fairy-wren consists of river-fringing vegetation with a dense mid-storey and a high tree canopy, typically dominated by River Pandanus (*Pandanus aquaticus*) or Rivergrass (*Chionachne cyanthopoda*) beside permanent freshwater pools (Curtis & Dennis 2012).	**Unlikely.** Suitable habitat for this species is highly restricted to the well vegetated margins of permanent freshwater rivers or billabongs. The Project site lacks suitable habitat.
Nettapus coromandelianus Cotton Pygmy-goose	NL	NT	This species occupies deeper freshwater swamps, lagoons and dams with semi-emergent aquatic plants (Pizzey & Knight 2007)	**Unlikely**. The Project site lacks wetland habitats which are a strict habitat requirement for this species.

Scientific Name Common Name	Status		Habitat Requirements	Likelihood
	EPBC Act	NC Act		
Numenius madagascariensis Eastern Curlew	Ma, Mi	NT	This species occupies estuaries, tidal mudflats, sandpits, salt marshes, mangroves, occasionally fresh or brackish lakes or bare grassland near water (Pizzey & Knight 2007)	**Unlikely.** The Project site lacks estuarine and freshwater habitats required by this species.
Pezoporus occidentalis Night Parrot	E	E	The Night Parrot occupies Spinifex hummock grasslands on rocky ranges, breakaways or open herbaceous flats around salt lakes and occasionally Mitchell Grass (*Astrebla* spp.) downs and flats (Curtis & Dennis 2012).	**Possible.** This species, whilst rare, has been recorded using Spinifex grasslands to the south of the Project site. Little is known of this species however, due to the proximity of this site to a cluster of confirmed sightings, it is possible this species may occur on the Project site (Curtis and Dennis 2012).
Poephila cincta cincta Black-throated Finch (southern)	E	E	This species occupies grassy, open woodlands and forests that are Eucalyptus, Corymbia and Melaleuca dominant and located within a few kilometres of water (Curtis & Dennis 2012).	**Unlikely.** Whilst suitable habitat for this species occurs on the Project site, it is unlikely that this species will occur on the Project site as the site is located outside its known distribution.
Polytelis alexandrae Princess Parrot	V	NL	The Princess Parrot inhabits open savanna woodlands and shrublands on sand dunes and flats in the arid zone of western and central Australia (DoE 2014a).	**Unlikely.** It is unlikely that this species will occur on the Project site as it lacks suitable habitat and occurs outside the species known distribution.
Rostratula australis Australian Painted Snipe	E	V	This species has a scattered distribution and is typically found utilising shallow inland freshwater or brackish wetlands with low vegetation (Curtis & Dennis 2012). This species is nomadic and exists where suitable habitat occurs temporarily.	**Unlikely.** No suitable habitat for this species occurs on the Project site.

Scientific Name Common Name	Status		Habitat Requirements	Likelihood
	EPBC Act	NC Act		
Stictonetta naevosa Freckled Duck	NL	NT	This species prefers large, well-vegetated swamps and moves to open lakes during dry periods (Pizzey & Knight 2007).	**Unlikely.** Suitable habitat for this species does not occur on or adjacent to the Project site.
Mammals				
Hipposideros stenotis Northern Leaf-nosed Bat	NL	V	This species requires escarpments, rocky ranges or boulder piles for roost habitat. Adjacent habitats include tussock and Spinifex grasslands, open woodland vine thickets and riparian forests (Curtis & Dennis 2012).	**Possible**. Suitable habitat for this species occurs throughout the Project site and surrounding lands. The Project may impact on habitat for this species. However, given that suitable habitat is vastly available throughout the broader region, it is unlikely that the Project will impact on the species.
Macrotis lagotis Greater Bilby	V	E	The Greater Bilby inhabits primarily clay areas and some stony plains in the Channel Country in south-western QLD (Curtis & Dennis 2012).	**Unlikely**. There are no records of this species near the Project site and is unlikely to be noted. The closest records are near the Northern Territory border. There is suitable habitat of the Project site as this species inhabits Spinifex grasslands (*Triodia* sp.); however, due to the distance of the Project from existing records this species' presence is unlikely.
Pseudantechinus mimulus Carpentarian Antechinus	V	NL	The Carpentarian Antechinus occupies rocky areas, or woodlands close by. They inhabit open woodlands of *Eucalyptus leucophloia*, *E. normantonensis*, *Corymbia terminalis*, *Atalaya hemiglauca* and *Acacia* spp. over hummock grasslands, sandstone boulders, pavements and outcrops (Curtis & Dennis 2012).	**Possible.** Suitable habitat for this species occurs throughout the Project site and surrounding lands. While the Project may impact on habitat for this species, it is not likely to impact on the species itself, given that suitable habitat is abundant throughout the region and the species has not been recorded on the Project site.

Scientific Name Common Name	Status		Habitat Requirements	Likelihood
	EPBC Act	NC Act		
Sminthopsis douglasi Julia Creek Dunnart	E	E	This species is restricted to the Mitchell Grass Downs in north-west QLD. Primary habitat for this species consists of grass-covered cracking clay soils of ashy or stony nature (Curtis & Dennis 2012).	**Unlikely.** This species is predominantly found in Mitchell Grass regional ecosystems, which occurs north-west and south-east of the Project site. Due to the absence of suitable habitat on or near the Project site, it is unlikely that this species occurs in the vicinity of the Project.
Reptiles				
Acanthophis hawkei Plains Death Adder	V	NL	This species occurs on flat, treeless, cracking-soil riverine floodplains (Cogger 2000).	**Unlikely.** Suitable habitat for this species does not occur on the Project site.
Elseya lavarackorum Gulf Snapping Turtle	E	V	The Gulf Snapping Turtle occupies slow flowing freshwater rivers and streams of the Gulf of Carpentaria and may occur in either alluvial or rocky areas (Curtis & Dennis 2012).	**Unlikely**: The Project site lacks flowing stream habitats and is thereby unlikely support this species.
Emydura subglobosa worrelli Diamond Head Turtle	NL	NT	The Diamond Head Turtle inhabits larger rivers and permanent lakes and lagoons (Cogger 2000).	**Unlikely.** The Project site lacks permanent waterbodies that would otherwise support the Diamond Head Turtle.
Sharks				
Pristis pristis Freshwater Sawfish	V	NL	The Freshwater Sawfish occupies rivers and estuaries during the juvenile and sub-adult life stages while large mature Sawfish tend to occur in coastal and offshore waters up to 25 m deep (DoE 2014a).	**Unlikely.** There is no suitable habitat (i.e. permanent watercourses) located on or near the Project site.

7.0 ENVIRONMENTAL VALUES, POTENTIAL IMPACTS AND MITIGATION

This section provides a summary of the environmental values of the Project site. Suggested strategies to minimise Project impacts upon the local native flora and fauna, and recommendations regarding rehabilitation of the Project site are also outlined below.

7.1 SUMMARY OF ENVIRONMENTAL VALUES

The following environmental values have been identified on the Project site, which are potentially subject to Project impacts:

- The watercourses located on the Project site provide the most floristically diverse vegetation communities. Vegetation communities located on the watercourses such as Regional Ecosystem 1.3.6x1b (Cloncurry Box creek flats) and 1.3.7b (River Red Gum and Northern Swamp Box riparian woodlands) help maintain the environmental integrity of the watercourses by stabilising the banks with the root system and prevent erosion during flooding events. The fertile soils also leave these communities most vulnerable to invasion by introduced flora species such as Buffel Grass and Mimosa;

- The watercourse communities provide foraging and roosting habitat for a wide variety of birds, and bats, as well as shelter for reptile and amphibian species. These watercourses also provide breeding habitat for amphibians during wet season periods. The threatened Golden-backed Honeyeater has been observed in association with several watercourses on the Project site;

- One permanent and several semi-permanent waterholes are scattered throughout the Project site and provide important habitat and water sources for amphibians, birds and macropods during drier periods. In conjunction with the watercourses, these waterholes potentially play a vital role in supporting amphibian breeding cycles during and post wet season periods.

- The vegetation communities associated with Regional Ecosystem 1.11.2 dominate the rocky escarpments located on the Project site. Rocky escarpments provide microhabitat for a number of fauna (e.g. bats and reptiles) that utilise the shelter and protection provided by the many crevices. The rocky escarpments also provide forage and shelter habitat for the threatened Purple-necked Rock-wallaby (*Petrogale purpureicollis*) which has been observed in several locations throughout the Project site.

- Overall, the Project site contains a low diversity and abundance of introduced weed species. All weed species recorded on the Project are common and naturalised throughout the Mount Isa region. No State declared weed species or WoNS were recorded on the Project.

- A number of pest species are known to have a presence on the Project site. The suite of pest species includes two State declared Class 2 pest species, the Wild Dog/Dingo and Feral Pig. Wild Dogs and Feral Pigs both present significant predation threats to native fauna. Feral Pigs also have the potential to cause significant environmental disturbance. It is a responsibility of land owners and managers to control declared Class 2 pest animals on their land. The Cane Toad appears to have a sparse distribution and small abundance on the Project site. Due to the arid conditions in the region the Cane Toad can be managed effectively by preventing access to artificial water sources.

7.2 POTENTIAL IMPACTS

Development of the Project will create several areas of disturbance for the purposes of constructing mine infrastructure, open cut mining and associated processing areas. The Project will require the removal of remnant vegetation in designated areas causing a reduction in the total area of remnant vegetation across the Project site. For the most part, those areas of remnant vegetation that will be impacted by the Project have previously been subject to grazing and mineral exploration activities and are subsequently degraded. Previously undisturbed areas, particularly in the north of the Study area will be conserved in their natural state. The potential impacts of the Project on each vegetation community are illustrated in Figure 12 and detailed in Table 17.

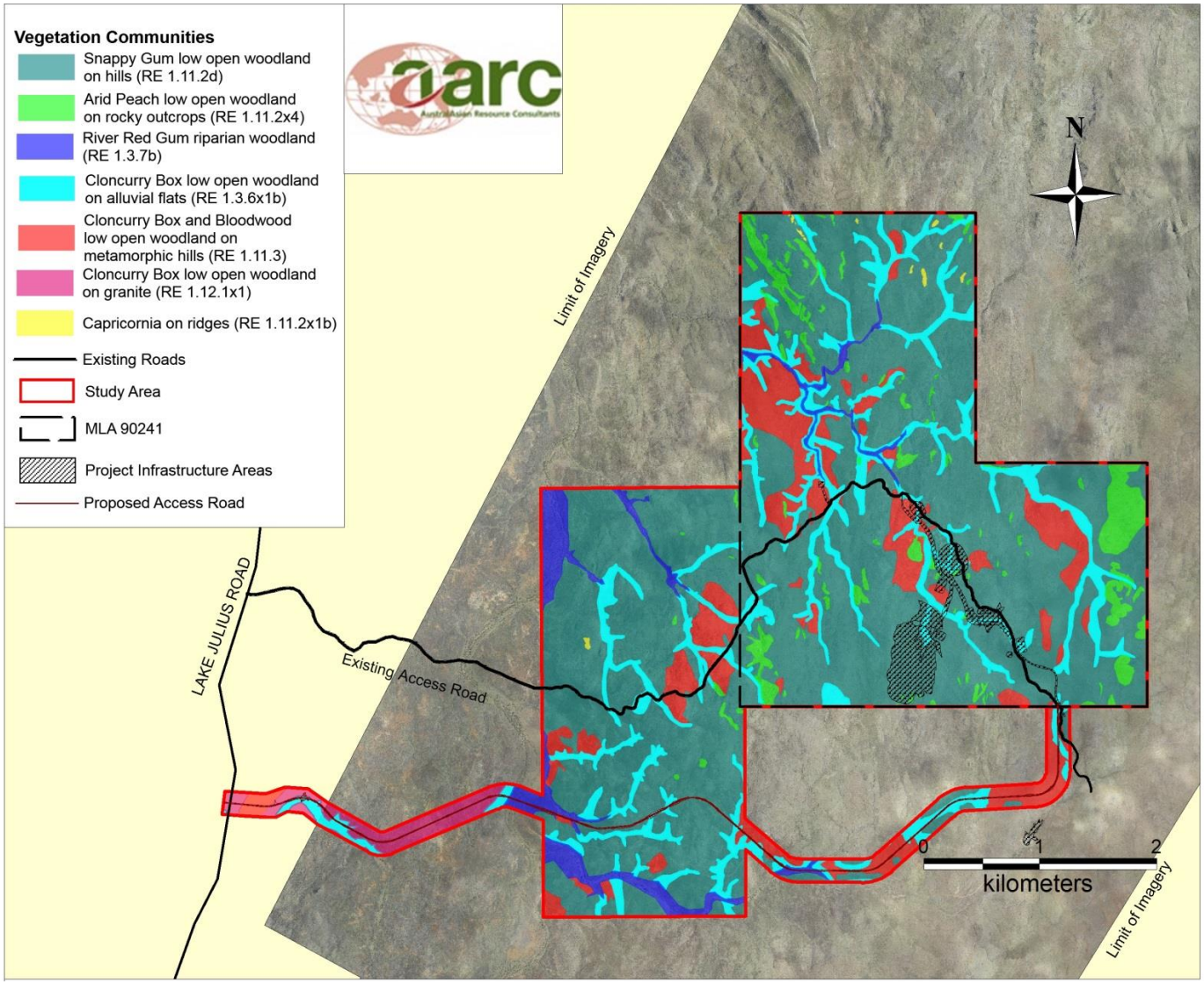


Figure 12 Impacts on Vegetation Communities

Table 17 Potential Impacts on Vegetation Communities

Vegetation Community	VM Act Status/ Biodiversity Status	Current extent on the Project site (ha)	Loss (ha)			Extent to Remain on the Project site (ha)	Current extent of RE in NW Highlands Bioregion
			Project	Proposed Access Road	Total		
Community 1 / RE 1.11.2d	LC / NC	1, 348	41.47	6.01	47.48	1, 288	1,329,179
Community 2 / RE 1.11.3	LC / NC	236.8	3.28	4.78	8.06	220.1	474,619
Community 3 / RE 1.3.6x1b	LC / OC	163.5	3.44	3.09	6.53	151.6	145,707
Community 4 / 1.3.7b	LC / E	75.19	0	1.72	1.72	72.02	72,708
Community 5 / RE 1.11.2x4	LC / NC	81.05	0.67	0	0.67	80.38	1,329,179
Community 6 / RE 1.11.2x1b	LC / NC	1.92	0	0	0	1.92	1,329,179
Community 7 / RE 1.12.1x1	LC / NC	38.26	0	2.96	2.96	30.31	242,957
TOTAL		1,944.7	48.86	18.56	67.42	1,844.3	

As shown in Table 17, the Project will have the greatest impact on Community 1 (loss of 47.48 ha of vegetation), which also has the greatest presence in Study area (1,348 ha). In total, the Project will impact on 48.15 ha or 3.36% of the current extent of RE 1.11.2 in the Study area. Of all regional ecosystems present, RE 1.11.2 is the most well represented community within both the Study area and the Northwest Highlands Bioregion where 1,329,179 ha of the RE remains. Project related impacts on RE 1.11.2 comprise less than 0.004% of the bioregional extent of the RE and are therefore not likely to constitute a significant impact. The Project will have no impact on Community 6 or RE 1.11.2x1b.

The Project will result in the loss of 8.06 ha or 3.4% of the current extent of RE 1.11.3 occurring within the Study area and just 0.0017% of the bioregional extent. The construction of the proposed access road has the potential to remove up to 2.96 ha or 7.7% of the current extent of RE 1.12.1x1 occurring within the Study area and just 0.003% of the bioregional extent.

While all REs on the Project site are listed as Least Concern under the VM Act, the Project will impact on one RE listed as Of Concern under the EHP Biodiversity Status (RE 1.3.6) and another listed as Endangered under the Biodiversity Status (RE 1.3.7). Project development has the potential to result in the loss of 6.53 ha (or approximately 3.99%) of the current extent of RE 1.3.6 occurring within the Study area (163.5 ha). The Project and access road construction will impact on 1.72 ha (or 2.29%) of the current extent of RE 1.3.7 within the Study area (75.19 ha). Overall, the Project will impact on just 0.0044% of the bioregional extent of RE 1.3.6 and 0.0024% of the bioregional extent of RE 1.3.7.

In summary, the potential impacts of the Project and access road development will not have significant impacts on any REs at the bioregional level. While the Project has the potential to disturb approximately 3.5% (67.4 ha) of the existing 1,944.7 ha of remnant vegetation, the majority of the existing remnant vegetation will be retained in its current state.

The removal of remnant vegetation will result in the direct loss of habitat for flora and fauna species. Native fauna will be displaced and left to compete for habitat in undisturbed areas. Clearing of mature trees in particular, will result in an immediate and long-term reduction in habitat availability for hollow-

dwelling fauna. The availability of forage habitat will also be reduced leading to increased competition. Lighting of Project infrastructure and roads may disturb nocturnal birds and bats and lead to avoidance behaviours in which the animal is forced to disperse to undisturbed lands.

Riparian corridors are major sources of connectivity for local faunal communities. The Project will result in the partial removal of some regional ecosystems on drainage features and one watercourse. In particular, the construction of the proposed access road will require the removal of a small area of the River Red Gum riparian woodland community adjacent to the western boundary of the Project. Clearing in the Project areas will also impact on a few drainage lines at the top of the catchment which may reduce habitat connectivity in the area. Habitat fragmentation is most likely to occur as a result of clearing in the south-east of the Project, where Project disturbance will be concentrated. For less mobile species this may have an impact on fauna dispersal and breeding activities. Given the extent of retained habitat across the site, the Project is not expected to have any detrimental impacts on habitat connectivity.

The Project has the potential to cause fauna injuries or even mortality. This risk is particularly high during the clearing operations, when smaller, less mobile species are most likely to be harmed. Construction of roads and increased vehicle movements will increase the risk of collisions with fauna. There is also potential for ground-dwelling fauna to become harmed should they attempt to access mine voids.

Development of the Project and proposed haul road will result in the removal of approximately 4.3 ha of potential shelter habitat and associated foraging habitat for the Purple-necked Rock-wallaby (refer to Figure 13). While suitable habitat will remain in abundance in the undisturbed portions of the Project site and surrounding lands, the Project may have a significant impact on the local population of PNRWs. Disturbance within riparian habitats along creeks, drainage lines and gullies will impact on the availability of habitat for the Golden-backed Honeyeater. The Project is not expected to have a significant impact on this species given that this species is highly mobile, the vast majority of suitable habitat will be retained on the Project, and suitable habitat occurs in abundance throughout the broader region.

Clearing and disturbance may result in top soil exposure and reduced slope or bank stability leading to soil erosion. Soil erosion can lead to increased sediment loads and vegetation smothering in watercourses downstream of the disturbance.

Project disturbance is likely to cause edge effects in adjoining areas of retained vegetation. Construction and operational activities may increase the risk of weed introduction and spread on the Project site. Earth moving activities and vehicle movement can spread weed seeds into and around the Project site. This has the potential to cause degradation of vegetation communities remaining on site.

The Project development phase will involve the construction of roads, tracks, water storages and waste disposal areas. Anthropogenic activities on the Project site will introduce additional food sources for fauna such as food scraps. These actions will increase the suitability of the Project site to feral animals, and may lead to an increase in their numbers. Increased pest numbers will lead to increased predation upon and competition with native fauna, which may lead to further reductions in native populations.

The Project will introduce new ignition sources and combustible materials onto the Project site. This may lead to an increased risk of fire on the Project site. This risk will be minimal due to the provision of firefighting equipment and site emergency response personnel.

The Project will require various hydrocarbons and a small number of other chemicals to be stored and used on site. Ore processing will be conducted off-site eliminating the need for bulk chemical storage on the Project site. Inappropriate use, handling and storage of such substances present the potential for contaminants to enter soil and surface water.

7.3 MITIGATION AND MANAGEMENT STRATEGIES

7.3.1 Flora Management

Project infrastructure has been located to avoid and minimise the area of vegetation clearing, particularly in the River Red Gum riparian woodland community, which has a Biodiversity Status of Endangered. To minimise the disturbance footprint all infrastructure has been positioned in the south-east corner of the Project site. The majority of the Project site will be undisturbed with the exception of existing tracks.

The removal of vegetation should be restricted to those areas required to establish the mine pit and infrastructure areas. Areas to be cleared must be clearly demarcated and clearing shall not commence until approval has been provided by the relevant supervisor. Erosion controls shall be installed prior to commencement and maintained during of vegetation clearing to minimise erosion potential. Top soil removed from site should be retained and stockpiled for used in site rehabilitation works. Top soil stockpiles should be surrounded by appropriate erosion control measures to prevent soil loss and sedimentation further downstream.

All disturbed areas shall be rehabilitated at the completion of the Project. Where possible, disturbed areas shall undergo progressive rehabilitation works. The suite of flora species used in rehabilitation works should be selected from the relevant vegetation communities present on the Project site prior to clearing (refer to Section 6.3 and Appendix C). No introduced flora species are to be used in site rehabilitation works.

7.3.2 Fauna Management

Vegetation clearing works have the potential to cause injury and mortality to fauna in the clearance zone. Clearing shall be conducted in a staged manner, to give fauna the opportunity to move away from the clearing front. An appropriately qualified and experienced fauna spotter/catcher shall be present prior to and during all vegetation clearing works to inspect for fauna and relocate animals where required. In the event that any fauna are sighted, clearing works must cease until the animal moves on or is relocated by the spotter/catcher. All tree hollows must be inspected for fauna prior to removal and hollow-bearing trees should be lowered gently to the ground with the hollows facing upward.

Vehicles on site access roads also pose a risk to local fauna. Site speed limits should be restricted to reduce the risk of wildlife-vehicle collisions. Injured and orphaned animals should be removed from site and taken to the relevant wildlife caring group or local veterinarian for treatment.

A Bushfire Management Plan should be developed to minimise the risk of uncontrolled fires on the Project site. High intensity fires are likely to have an adverse impact on both flora and fauna species. If planned burning operations are to be implemented, they should mimic the natural fire regime of the region and be limited to small areas to avoid complete removal of habitat.

7.3.3 Threatened Species Management

The Project will result in the removal of potential foraging habitat for the Golden-backed Honeyeater. The Project will also result in the removal of 4 ha of potential shelter habitat and associated foraging habitat for the Purple-necked Rock-wallaby. Impacts on threatened species should be minimised by:

- Reinstating suitable habitat by replanting feed and shelter species (i.e. spinifex, Turpentine, Cloncurry Box, Northern Swamp Box, other native grasses and forbs) at Project completion;
- Inspecting Cloncurry Box woodlands for Golden-backed Honeyeater nests prior to clearing. Active nests should not be disturbed;
- Inspecting potential PNRW shelter areas for resident rock-wallabies. Their habitat shall not be disturbed until such time as they have been relocated;
- All impacts on PNRW shelter and associated forage habitat shall be offset in accordance with the Queensland Environmental Offsets Policy;
- Preventing fires on the Project site to minimise further habitat loss or degradation;
- Implementing a Weed and Pest Management Plan to minimise predation and habitat degradation;
- Implement reduced speed limits on site, particularly in the vicinity of PNRW habitat areas; and
- Training all site personnel and contractors in the risk of wildlife-vehicle collisions and the importance of following site speed limits and slowing down for fauna.

7.3.4 Weed and Pest Management

Development and disturbance of the Project site has the potential to introduce additional weed species onto the site through increased vehicle movements across the site. Clearing of vegetation and the introduction of additional food and water sources creates favourable conditions for both weed and pest species.

7.3.4.1 Weed Management

Six introduced flora species or weeds were identified on the Project site. No weeds occurring on the Project are declared weed species or WoNS. While land managers are only required to control declared weeds, other weeds should be managed and prevented from spreading throughout the Project site and surrounding lands. A Weed Management Plan should be developed to guide the control and prevention of weeds on the Project.

The Weed Management Plan should address the following areas:

- Vehicle washdown requirements - Vehicles should be washed down prior to entering the Project site to avoid the introduction of new weed species;
- Staff training - Staff should be made aware of major weed species in the locality and required to report any weed infestations to their supervisor;
- Weed control program – Introduced grasses and herbaceous weeds should be sprayed prior to commencement of Project construction and annually in the dry season to minimise weed

prevalence and opportunity for dispersal. Woody weeds should be controlled in accordance with the methods relevant to the species as recommended by the Department of Agriculture, Fisheries and Forestry; and

- Ongoing weed monitoring by site environmental officers.

7.3.4.2 Pest Management

Of the five pest species known to occur on the Project site, two (Dingo/Wild Dog and Feral Pig) are declared under the LP Act as Class 2 pest animals. Pest control actions are required for the two declared pests, and are also recommended for the non-declared Cane Toad. Dingoes/Wild Dogs and Feral Pigs are predators and present a threat to native wildlife. Significant impacts of Feral Pig habitation also include weed dispersal, degradation of waterbodies, soil erosion and potentially dispersal of diseases.

A Pest Management Plan should be prepared and implemented as part of the Project. The implementation of pest controls will reduce predation pressure on native fauna, reduce pressures on riparian ecosystems and minimise the risk of injuries and disease spread to site personnel, native wildlife and cattle grazing in the area. 1080 (sodium monofluroacetate) baiting programs are an effective control method for Wild dog and Feral Pig control and should be undertaken across the Project site.

While not a declared pest species, the Cane toad remains one of the greatest threats to Australia's ecosystems. Mechanical collection measures can aid in reducing the local population of Cane Toads. Nocturnal Cane Toad collection programs should be implemented on a regular basis. Cane Toads are to be placed in a freezer immediately following collection. An important component of Cane Toad control is the removal of any eggs from temporary or more permanent waterbodies throughout the Project. Troughs, dams and other permanent or semi-permanent water holding structures should be regularly inspected for Cane Toads and their eggs. Artificial ponding areas provide potential breeding sites and should be eliminated.

It is recommended that potential food and water sources are appropriately managed to reduce pest abundance. Pests may be excluded from waste receptacles and artificial water sources by sealing and/or fencing these structures, where possible.

7.3.4.3 Emission Management

Construction and operation of the Project will result in increased noise, dust, vibration and lighting of the Project site. The impacts of these emissions or disturbances on flora and fauna species will vary from species to species. Appropriate control measures should be implemented to minimise emission levels across the Project and surrounding areas. Suitable emissions controls may include the following:

- Dust suppression - covering loads, installing pollution control equipment (e.g. bag filters or a cyclone) to dust generating equipment, applying suitable work practices to minimise dust generation, and spraying water on roads and tracks as required, creating or leaving wind breaks or screens to prevent the spread of dust.

- Noise suppression - providing and maintaining low noise equipment, implementing noise barriers or reduction measures in sensitive areas, limiting the hours of operation or at least timing of high impact activities (e.g. blasting) to minimise disturbance to nocturnal fauna.

- Lighting controls – provide directional lighting to minimise the area of disturbance and the impact on nocturnal fauna.

All chemicals are to be stored as directed by the Material Data Safety Sheet and applicable Australian Standards, in sealed and bunded areas to minimise the risk of soil and water contamination. Spill response equipment must be provided at chemical storage areas and any spills that enter waterways must be reported to EHP. All staff must be trained in spill response procedures.

Clean water should be diverted around disturbed areas to minimise water pollution and sedimentation.

7.3.4.4 Training and awareness

All staff and contractors will receive environmental awareness training as a component of the site induction. This training will include, but may not be limited to:

- The appearance of the threatened fauna species known to occur on the Project site:
- The appearance and impacts of pest and weed species known to occur on the Project site;
- Reporting procedures for sightings of threatened fauna, weeds and pests;
- Vegetation clearing rules;
- The importance of correct waste disposal and not feeding wildlife or pests;
- The risk of wildlife-vehicle collisions and the importance of following designated site speed limits;
- Designated strategies for weed and pest control;
- Fire management; and
- Spill response procedures.

7.4 ENVIRONMENTAL OFFSET ASSESSMENT

The terrestrial flora and fauna assessment identified two Matters of State Environmental Significance on the Project site including, protected wildlife habitat and regional ecosystems on watercourses. The Project will impact on protected wildlife habitat for one species listed Special Least Concern, the Echidna and one vulnerable species, the PNRW. Impacts on MSES are demonstrated in Figure 13. Environmental offsetting is required where there will be an unavoidable significant residual impact on a State significant environmental value. An assessment of the offset requirements for the Project is presented in Table 18.

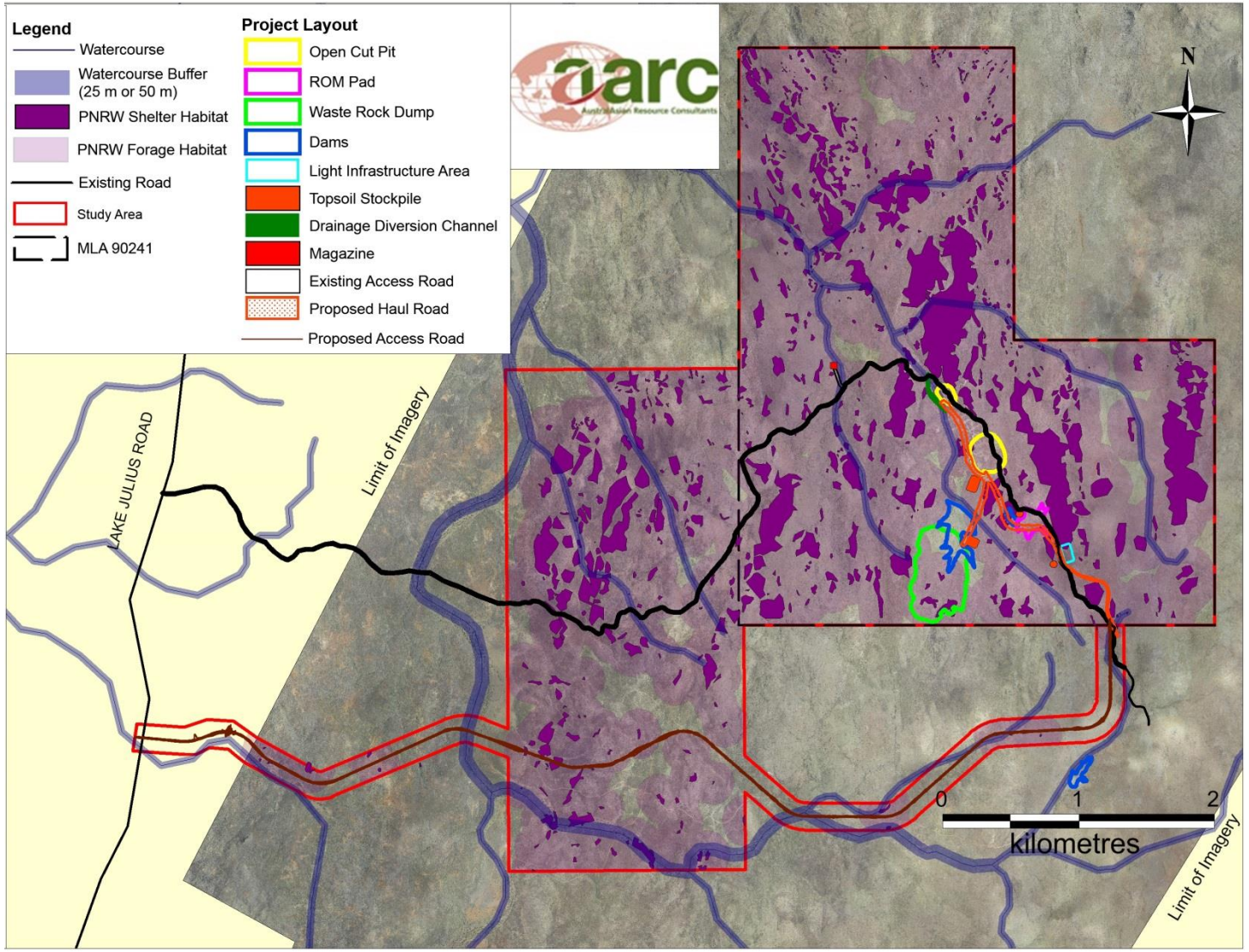


Figure 13 Potential Impacts on Watercourses and PNRW Habitat

Table 18 Summary of Environmental Offset Requirements

Matter of State Environmental Significance	Impact Assessment	Nature of Impact	Offset Requirement
Echidna (*Tachyglossus aculeatus*) The Echidna is listed as *Special Least Concern* under the *Nature Conservation (Wildlife) Regulation 2006.* This species is not listed at the Commonwealth level.	Residual impact – the Project will remove an area of suitable habitat for this species. Considering the Echidna occurs commonly throughout the region and the surrounding landscape provides vast areas of suitable habitat, the extent proposed to be removed is unlikely to have a significant impact on the local population.	Residual	Not Required.
Purple-necked Rock-wallaby (*Petrogale purpureicollis*) The Purple-necked Rock-wallaby is listed as ***Vulnerable*** under the *Nature Conservation (Wildlife) Regulation 2006.* This species is not listed at the Commonwealth level.	Significant Residual impact – the PNRW has been recorded in several locations across the Project site (Figure 10). Construction of the Project and proposed access road will impact on approximately 3.5 ha of shelter habitat within the MLA and approximately 1.3 ha of shelter habitat within the remaining study area and associated foraging areas. Project disturbance areas have been restricted to the south-east portion of the Project site where minimal PNRW habitat exists. A far greater abundance of PNRW habitat occurs in undisturbed portions of site and suitable habitat is well-represented throughout the bioregion.	Significant Residual	Offsetting Required

Matter of State Environmental Significance	Impact Assessment	Nature of Impact	Offset Requirement
Mapped Watercourses The Project site contains several watercourses that are identified on the vegetation management watercourse map and are vegetated with remnant vegetation. Clearing of remnant riparian vegetation potentially triggers offsetting requirements.	Residual impact –In total the Project and associated activities have the potential to remove 6.5 ha of remnant vegetation on watercourses. The Project and proposed access road will remove 4.7 ha of regional ecosystems within 25 m of the defining banks of mapped stream order 1 and 2 watercourses. Project disturbance is largely limited to ephemeral drainage lines in the south-east corner of the Project site leaving the majority of the existing watercourses and riparian habitats on the Project unharmed. In total, the Study Area contains approximately 75 ha of Regional Ecosystem 1.3.7b (River Red Gum riparian woodland). Of which, 1.8 ha occurring within 50 m of the defining banks of a stream order 3 watercourse may be impacted by the construction of the proposed access road and upgrading of the existing access road. Vegetation clearing in RE 1.3.7b will be limited to narrow corridors and is not expected to have a significant impact on the habitat or corridor values.	Residual	Potential offsetting required (refer to Aquatic Ecology Report)

REFERENCES

AustralAsian Resource Consultants (AARC) (2012) *Mount Remarkable Project: Terrestrial Flora and Fauna Assessment – prepared for Syndicated Metals Limited.* AustralAsian Resource Consultants, Brisbane.

AustralAsian Resource Consultants (AARC) (2014) *Barbara Copper Project: Aquatic Ecology Report.* AustralAsian Resource Consultants, Brisbane.

Churchill, S. (2010). *Australian Bats,* Reed New Holland, Sydney.

Cogger, H.G. (2000). *Reptiles and Amphibians of Australia.* Reed New Holland, Sydney.

Commonwealth of Australia (2011). *The Bureau of Meteorology,* Queensland. http://www.bom.gov.au.

Curtis, L.K., Dennis, A.J., McDonald, K.R., Kyne, P.M and Debus, S.J.S. (2012). *Queensland's Threatened Animals*. CSIRO Publishing, Collingwood.

Department of Agriculture, Fisheries and Forestry (DAFF) (2014), *Pest Animals by Common Name*. Department of Agriculture, Fisheries and Forestry, Queensland Government. Available at: http://www.daff.qld.gov.au/plants/weeds-pest-animals-ants/pest-animals/a-z-listing-of-pest-animals/pest-animals-by-common-name

Department of the Environment (2014a). *Species Profile and Threats Database, Department of the Environment, Canberra*. http://www.environment.gov.au/sprat.

Department of the Environment (2014b). *Environment Protection and Biodiversity Conservation Act 1999: Protected Matters Search Tool*. http://www.environment.gov.au/topics/about-us/legislation/environment-protection-and-biodiversity-conservation-act-1999/protected

Duncan, A., Baker, G.B. and Montgomery, N. (1999). *The Action Plan for Australian Bats*. Environment Australia, Canberra.

EcoSmart Ecology (2011) *Mount Remarkable Project: Interim Terrestrial Flora and Fauna Report,* EcoSmart Ecology, Everton Park.

Department of Environment and Heritage Protection (EHP) (2014) *Queensland Environmental Offsets Policy (Version 1.0),* Biodiversity Integration and Offsets, Ecosystem Outcomes, Department of Environment and Heritage Protection, Brisbane. http://www.qld.gov.au/environment/assets/documents/pollution/management/offsets/offsets-policy.pdf

Department of Environment and Heritage Protection (EHP) (2013) *Wetland*Maps - *Interactive Maps and Wetlands Data in Queensland*, WetlandInfo, Department of Environment and Heritage Protection, Queensland, viewed 24 July 2014, <http://wetlandinfo.ehp.qld.gov.au/wetlands/facts-maps/get-mapping-help/wetland-maps/>

Environmental Protection and Biodiversity Conservation Act 1999. Department of the Environment, Australian Government

Garnett. S., Szabo, J. and Dutson, G. (2010) *The Action Plan for Australian Birds 2010*. CSIRO Publishing, Canberra.

Geoscience Australia (2012). *Geoscience Portal.* http://www.geoscience.gov.au/

*Land Protection (Pest and Stock Route Management) Act 2002.*Queensland Government

Marchant, S. and Higgins, P. J. (eds) (1993). *Handbook of Australian, New Zealand and Antarctic Birds*. Oxford University Press, Melbourne.

Menkhorst, P. and Knight, F (2011). *A Field Guide to the Mammals of Australia*, Oxford University Press.

Nature Conservation Act 1992. Queensland Government

Nature Conservation (Wildlife) Regulation 2006. Queensland Government

Neldner, V.J., Wilson, B.A., Thompson, E.J. and Dillewaard, H.A. (2012). *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland*. Version 3.2. Updated August 2012. Queensland Herbarium, Queensland Department of Science, Information Technology, Innovation and the Arts, Brisbane.

Pizzey, G. and Knight, F (2007). *The Field Guide to the Birds of Australia*, HarperCollins Publishers, Pty, Ltd.

Queensland Herbarium (2014) Regional Ecosystem Description Database (REDD). Version 8.1 (April 2014) (DSITIA: Brisbane).

The State of Queensland Department of Environment and Heritage Protection (2010). *Southern Gulf Natural Resource Management Region Back on Track Actions for Biodiversity*, Department of Environment and Heritage Protection, Brisbane.

The State of Queensland Department of Science, Information Technology, Innovation and the Arts (2012). *Terrestrial Vertebrate Fauna Survey Guidelines for Queensland*.

The State of Queensland Environmental Protection Agency (2002). *Biodiversity Assessment and Mapping Methodology*. Environmental Protection Agency. Biodiversity Planning Unit, Biodiversity Branch. Version 2.1 July 2002.

Van Dyck, S. & Strahan, R. (2008). *The Mammals of Australia*. Third edition. Reed New Holland, Sydney.

Vegetation Management Act 1999. Queensland Government

Wannan, B. (2009). *Guidelines for Flora Survey & Assessment in Northern Queensland.* Department of Environment and Resource Management, Cairns.

Wilson, S. (2005). *A Field Guide to Reptiles of Queensland*, New Holland Publishers, Sydney.

Wilson, S. and Swan, G. (2003). *A Complete Guide to Reptiles of Australia*, Reed.

Appendix A Database Search Results

Australian Government

Department of the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

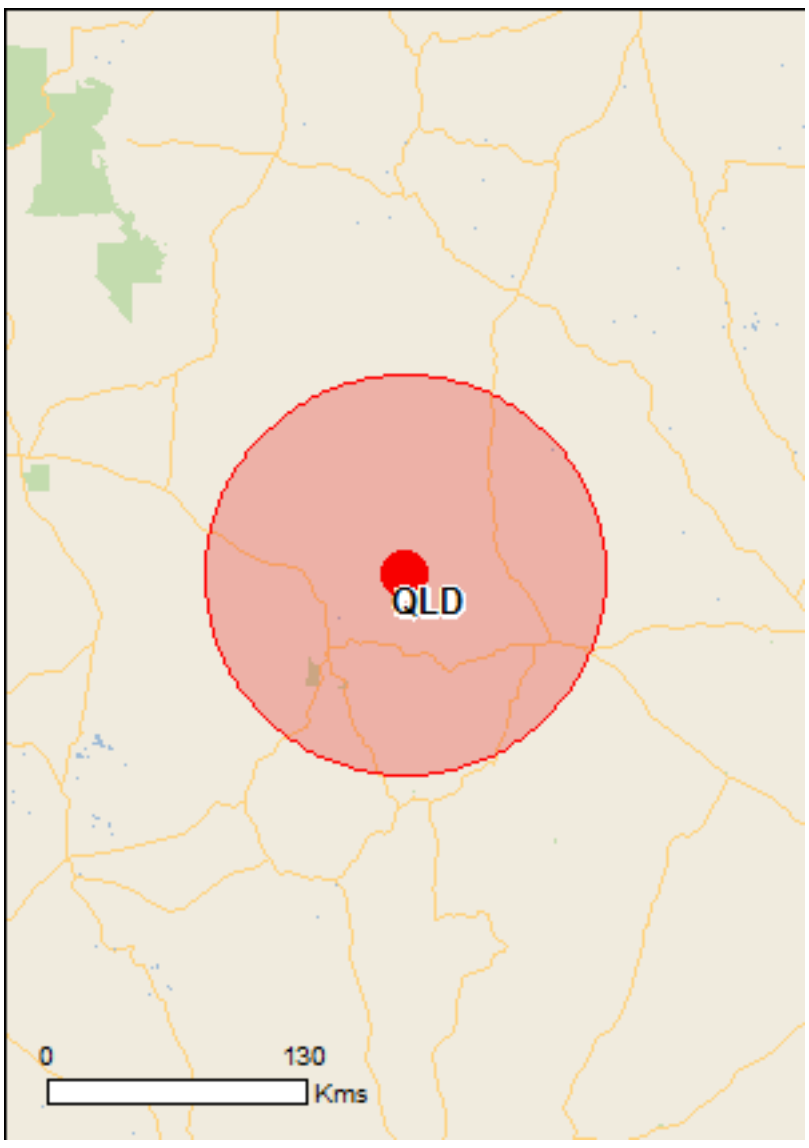
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 17/06/14 15:49:26

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

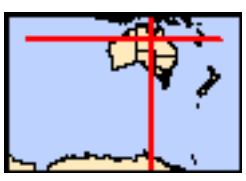
Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 100.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	10
Listed Migratory Species:	19

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	26
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	11
State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	27
Nationally Important Wetlands:	2
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat may occur within area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat known to occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Mammals		
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat likely to occur within area
Pseudantechinus mimulus Carpentarian Antechinus [59283]	Vulnerable	Species or species habitat known to occur within area
Sminthopsis douglasi Julia Creek Dunnart [305]	Endangered	Species or species habitat may occur within area
Reptiles		
Acanthophis hawkei Plains Death Adder [83821]	Vulnerable	Species or species habitat known to occur within area
Elseya lavarackorum Gulf Snapping Turtle [67197]	Endangered	Species or species habitat known to occur

Name	Status	Type of Presence within area
Sharks		
Pristis pristis Largetooth Sawfish, Freshwater Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]		Species or species habitat known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat known to occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Species or species habitat known to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Defence - MT ISA TRAINING DEPOT

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]		Species or species habitat known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat known to occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Himantopus himantopus Black-winged Stilt [870]		Species or species habitat known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Species or species habitat known to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Stiltia isabella Australian Pratincole [818]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area
Reptiles		
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	State	Status
Natural		
Fountain Range	QLD	Registered
Indigenous		
Battle Mountain	QLD	Indicative Place
Frank Creek Site	QLD	Indicative Place
Little Brumby Creek Site	QLD	Indicative Place
Bower Bird Area	QLD	Registered
Lake Moondarra Quarry 1 Area	QLD	Registered
The Granites Area	QLD	Registered
Historic		
Casa Grande	QLD	Indicative Place
Mount Isa Underground Hospital	QLD	Indicative Place
Cloncurry Courthouse	QLD	Registered
Tent House	QLD	Registered

State and Territory Reserves [Resource Information]

Name	State
Bullen Bullen	QLD

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia		
Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus		
House Sparrow [405]		Species or species habitat likely to occur within area
Frogs		
Bufo marinus		
Cane Toad [1772]		Species or species habitat likely to occur within area
Rhinella marina		
Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		

Name	Status	Type of Presence
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica Prickly Acacia [6196]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Cylindropuntia spp. Prickly Pears [85131]		Species or species habitat likely to occur within area
Eichhornia crassipes Water Hyacinth, Water Orchid, Nile Lily [13466]		Species or species habitat likely to occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Prosopis spp.		
Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Salvinia molesta		
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Tamarix aphylla		
Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Vachellia nilotica		
Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus		
Asian House Gecko [1708]		Species or species habitat likely to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Lake Julius	QLD
Lake Moondarra	QLD

Coordinates

-20.4224 139.83871

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

© Commonwealth of Australia
Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Defined Area
Species: All
Type: All
Status: All
Records: All
Date: All
Latitude: 19.7941 to 20.4224
Longitude: 140.4997 to 139.8386
Email: hdick@aarc.net.au
Date submitted: Tuesday 17 Jun 2014 16:13:00
Date extracted: Tuesday 17 Jun 2014 16:20:03

The number of records retrieved = 435

Disclaimer

As the DSITIA is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

The State of Queensland does not invite reliance upon, nor accept responsibility for this information. Persons should satisfy themselves through independent means as to the accuracy and completeness of this information.

No statements, representations or warranties are made about the accuracy or completeness of this information. The State of Queensland disclaims all responsibility for this information and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

Feedback about Wildlife Online should be emailed to wildlife.online@science.dsitia.qld.gov.au

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	amphibians	Bufonidae	*Rhinella marina*	cane toad	Y			2
animals	amphibians	Hylidae	*Litoria inermis*	bumpy rocketfrog		C		3
animals	amphibians	Hylidae	*Litoria pallida*	pallid rocketfrog		C		3
animals	amphibians	Hylidae	*Litoria caerulea*	common green treefrog		C		6
animals	amphibians	Hylidae	*Cyclorana australis*	northern snapping frog		C		7
animals	amphibians	Hylidae	*Litoria rothii*	northern laughing treefrog		C		2
animals	amphibians	Hylidae	*Litoria rubella*	ruddy treefrog		C		6
animals	amphibians	Limnodynastidae	*Platyplectrum ornatum*	ornate burrowing frog		C		3
animals	birds	Acanthizidae	*Acanthiza chrysorrhoa*	yellow-rumped thornbill		C		5
animals	birds	Acanthizidae	*Gerygone fusca*	western gerygone		C		3
animals	birds	Acanthizidae	*Smicrornis brevirostris*	weebill		C		87
animals	birds	Accipitridae	*Aquila audax*	wedge-tailed eagle		C		10
animals	birds	Accipitridae	*Circus assimilis*	spotted harrier		C		3
animals	birds	Accipitridae	*Hamirostra melanosternon*	black-breasted buzzard		C		7
animals	birds	Accipitridae	*Accipiter cirrocephalus*	collared sparrowhawk		C		6
animals	birds	Accipitridae	*Milvus migrans*	black kite		C		37
animals	birds	Accipitridae	*Accipiter fasciatus*	brown goshawk		C		9
animals	birds	Accipitridae	*Haliastur sphenurus*	whistling kite		C		27
animals	birds	Accipitridae	*Haliaeetus leucogaster*	white-bellied sea-eagle		SL		4
animals	birds	Aegothelidae	*Aegotheles cristatus*	Australian owlet-nightjar		C		11
animals	birds	Alaudidae	*Mirafra javanica*	Horsfield's bushlark		C		1
animals	birds	Alcedinidae	*Ceyx azureus*	azure kingfisher		C		2
animals	birds	Anatidae	*Malacorhynchus membranaceus*	pink-eared duck		C		3
animals	birds	Anatidae	*Dendrocygna eytoni*	plumed whistling-duck		C		4
animals	birds	Anatidae	*Anas superciliosa*	Pacific black duck		C		3
animals	birds	Anatidae	*Aythya australis*	hardhead		C		3
animals	birds	Anatidae	*Anas gracilis*	grey teal		C		3
animals	birds	Anatidae	*Nettapus coromandelianus*	cotton pygmy-goose		NT		1
animals	birds	Anhingidae	*Anhinga novaehollandiae*	Australasian darter		C		14
animals	birds	Ardeidae	*Egretta novaehollandiae*	white-faced heron		C		15
animals	birds	Ardeidae	*Nycticorax caledonicus*	Nankeen night-heron		C		7
animals	birds	Ardeidae	*Ixobrychus flavicollis*	black bittern		C		5
animals	birds	Ardeidae	*Egretta garzetta*	little egret		C		2
animals	birds	Ardeidae	*Ardea intermedia*	intermediate egret		C		3
animals	birds	Ardeidae	*Ardea pacifica*	white-necked heron		C		16
animals	birds	Ardeidae	*Ardea modesta*	eastern great egret		SL		10
animals	birds	Artamidae	*Cracticus nigrogularis*	pied butcherbird		C		29
animals	birds	Artamidae	*Artamus superciliosus*	white-browed woodswallow		C		2
animals	birds	Artamidae	*Artamus leucorynchus*	white-breasted woodswallow		C		8
animals	birds	Artamidae	*Cracticus torquatus*	grey butcherbird		C		1
animals	birds	Artamidae	*Artamus personatus*	masked woodswallow		C		4
animals	birds	Artamidae	*Cracticus tibicen*	Australian magpie		C		12
animals	birds	Artamidae	*Artamus cinereus*	black-faced woodswallow		C		33
animals	birds	Artamidae	*Artamus minor*	little woodswallow		C		15
animals	birds	Burhinidae	*Burhinus grallarius*	bush stone-curlew		C		10
animals	birds	Cacatuidae	*Calyptorhynchus banksii*	red-tailed black-cockatoo		C		3

Queensland Government Wildlife Online - Extract Date 17/06/2014 at 16:20:03

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Cacatuidae	*Eolophus roseicapillus*	galah		C		24
animals	birds	Cacatuidae	*Nymphicus hollandicus*	cockatiel		C		31
animals	birds	Cacatuidae	*Cacatua galerita*	sulphur-crested cockatoo		C		25
animals	birds	Cacatuidae	*Cacatua sanguinea*	little corella		C		8
animals	birds	Campephagidae	*Coracina novaehollandiae*	black-faced cuckoo-shrike		C		23
animals	birds	Campephagidae	*Coracina papuensis*	white-bellied cuckoo-shrike		C		5
animals	birds	Campephagidae	*Lalage sueurii*	white-winged triller		C		11
animals	birds	Campephagidae	*Coracina maxima*	ground cuckoo-shrike		C		2
animals	birds	Casuariidae	*Dromaius novaehollandiae*	emu		C		2
animals	birds	Charadriidae	*Elseyornis melanops*	black-fronted dotterel		C		19
animals	birds	Charadriidae	*Vanellus miles*	masked lapwing		C		4
animals	birds	Charadriidae	*Vanellus miles miles*	masked lapwing (northern subspecies)		C		7
animals	birds	Ciconiidae	*Ephippiorhynchus asiaticus*	black-necked stork		NT		5
animals	birds	Climacteridae	*Climacteris melanura*	black-tailed treecreeper		C		16
animals	birds	Columbidae	*Geophaps plumifera*	spinifex pigeon		C		22
animals	birds	Columbidae	*Geopelia humeralis*	bar-shouldered dove		C		9
animals	birds	Columbidae	*Phaps chalcoptera*	common bronzewing		C		16
animals	birds	Columbidae	*Ocyphaps lophotes*	crested pigeon		C		20
animals	birds	Columbidae	*Geopelia striata*	peaceful dove		C		45
animals	birds	Columbidae	*Geopelia cuneata*	diamond dove		C		22
animals	birds	Coraciidae	*Eurystomus orientalis*	dollarbird		C		6
animals	birds	Corcoracidae	*Struthidea cinerea*	apostlebird		C		24
animals	birds	Corvidae	*Corvus orru*	Torresian crow		C		10
animals	birds	Corvidae	*Corvus coronoides*	Australian raven		C		34
animals	birds	Corvidae	*Corvus sp.*					12
animals	birds	Cuculidae	*Cacomantis variolosus*	brush cuckoo		C		3
animals	birds	Cuculidae	*Eudynamys orientalis*	eastern koel		C		4
animals	birds	Cuculidae	*Centropus phasianinus*	pheasant coucal		C		2
animals	birds	Cuculidae	*Scythrops novaehollandiae*	channel-billed cuckoo		C		3
animals	birds	Cuculidae	*Chalcites basalis*	Horsfield's bronze-cuckoo		C		2
animals	birds	Cuculidae	*Cacomantis pallidus*	pallid cuckoo		C		1
animals	birds	Cuculidae	*Chalcites osculans*	black-eared cuckoo		C		1
animals	birds	Estrildidae	*Poephila acuticauda*	long-tailed finch		C		16
animals	birds	Estrildidae	*Emblema pictum*	painted finch		C		2
animals	birds	Estrildidae	*Taeniopygia bichenovii*	double-barred finch		C		18
animals	birds	Estrildidae	*Taeniopygia guttata*	zebra finch		C		47
animals	birds	Estrildidae	*Heteromunia pectoralis*	pictorella mannikin		NT		2
animals	birds	Eurostopodidae	*Eurostopodus argus*	spotted nightjar		C		8/1
animals	birds	Falconidae	*Falco hypoleucos*	grey falcon		NT		1
animals	birds	Falconidae	*Falco cenchroides*	Nankeen kestrel		C		8
animals	birds	Falconidae	*Falco subniger*	black falcon		C		1
animals	birds	Falconidae	*Falco berigora*	brown falcon		C		9
animals	birds	Falconidae	*Falco longipennis*	Australian hobby		C		8
animals	birds	Gruidae	*Grus rubicunda*	brolga		C		10
animals	birds	Halcyonidae	*Dacelo leachii*	blue-winged kookaburra		C		28
animals	birds	Halcyonidae	*Todiramphus sanctus*	sacred kingfisher		C		8

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Halcyonidae	*Todiramphus pyrrhopygius*	red-backed kingfisher		C		8
animals	birds	Hirundinidae	*Petrochelidon ariel*	fairy martin		C		9
animals	birds	Laridae	*Chlidonias hybrida*	whiskered tern		C		1
animals	birds	Maluridae	*Malurus lamberti*	variegated fairy-wren		C		27/1
animals	birds	Maluridae	*Amytornis ballarae*	Kalkadoon grasswren		C		8
animals	birds	Maluridae	*Malurus coronatus*	purple-crowned fairy-wren		V		2/2
animals	birds	Maluridae	*Malurus melanocephalus*	red-backed fairy-wren		C		8/1
animals	birds	Megaluridae	*Cincloramphus mathewsi*	rufous songlark		C		6
animals	birds	Megaluridae	*Cincloramphus cruralis*	brown songlark		C		2
animals	birds	Megaluridae	*Eremiornis carteri*	spinifexbird		C		4
animals	birds	Meliphagidae	*Philemon citreogularis*	little friarbird		C		31
animals	birds	Meliphagidae	*Ptilotula penicillatus*	white-plumed honeyeater		C		42/1
animals	birds	Meliphagidae	*Conopophila rufogularis*	rufous-throated honeyeater		C		25
animals	birds	Meliphagidae	*Acanthagenys rufogularis*	spiny-cheeked honeyeater		C		3
animals	birds	Meliphagidae	*Melithreptus brevirostris*	brown-headed honeyeater		C		1
animals	birds	Meliphagidae	*Melithreptus gularis laetior*	golden-backed honeyeater		NT		1
animals	birds	Meliphagidae	*Sugomel niger*	black honeyeater		C		1
animals	birds	Meliphagidae	*Entomyzon cyanotis*	blue-faced honeyeater		C		1
animals	birds	Meliphagidae	*Manorina flavigula*	yellow-throated miner		C		35
animals	birds	Meliphagidae	*Phylidonyris niger*	white-cheeked honeyeater		C		1
animals	birds	Meliphagidae	*Ptilotula plumulus*	grey-fronted honeyeater		C		26
animals	birds	Meliphagidae	*Epthianura tricolor*	crimson chat		C		5
animals	birds	Meliphagidae	*Gavicalis virescens*	singing honeyeater		C		6
animals	birds	Meliphagidae	*Stomiopera unicolor*	white-gaped honeyeater		C		6/2
animals	birds	Meliphagidae	*Cissomela pectoralis*	banded honeyeater		C		3
animals	birds	Meliphagidae	*Lichmera indistincta*	brown honeyeater		C		32
animals	birds	Meliphagidae	*Melithreptus gularis*	black-chinned honeyeater		NT		4
animals	birds	Meliphagidae	*Philemon argenticeps*	silver-crowned friarbird		C		1
animals	birds	Meliphagidae	*Ptilotula flavescens*	yellow-tinted honeyeater		C		13
animals	birds	Meliphagidae	*Ptilotula keartlandi*	grey-headed honeyeater		C		38
animals	birds	Meropidae	*Merops ornatus*	rainbow bee-eater		SL		22
animals	birds	Monarchidae	*Myiagra inquieta*	restless flycatcher		C		14
animals	birds	Monarchidae	*Grallina cyanoleuca*	magpie-lark		C		41
animals	birds	Motacillidae	*Anthus novaeseelandiae*	Australasian pipit		C		1
animals	birds	Nectariniidae	*Dicaeum hirundinaceum*	mistletoebird		C		13
animals	birds	Neosittidae	*Daphoenositta chrysoptera*	varied sittella		C		3
animals	birds	Oriolidae	*Oriolus sagittatus*	olive-backed oriole		C		10
animals	birds	Otididae	*Ardeotis australis*	Australian bustard		C		7
animals	birds	Pachycephalidae	*Colluricincla harmonica*	grey shrike-thrush		C		28/2
animals	birds	Pachycephalidae	*Pachycephala rufiventris*	rufous whistler		C		29
animals	birds	Pachycephalidae	*Colluricincla megarhyncha*	little shrike-thrush		C		1
animals	birds	Pachycephalidae	*Oreoica gutturalis*	crested bellbird		C		8
animals	birds	Pardalotidae	*Pardalotus rubricatus*	red-browed pardalote		C		14
animals	birds	Pardalotidae	*Pardalotus striatus*	striated pardalote		C		32
animals	birds	Passeridae	*Passer domesticus*	house sparrow	Y			1
animals	birds	Pelecanidae	*Pelecanus conspicillatus*	Australian pelican		C		3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Petroicidae	*Petroica goodenovii*	red-capped robin		C		1
animals	birds	Petroicidae	*Melanodryas cucullata*	hooded robin		C		4
animals	birds	Petroicidae	*Microeca fascinans*	jacky winter		C		10
animals	birds	Phalacrocoracidae	*Phalacrocorax sulcirostris*	little black cormorant		C		4
animals	birds	Phalacrocoracidae	*Phalacrocorax carbo*	great cormorant		C		1
animals	birds	Phalacrocoracidae	*Microcarbo melanoleucos*	little pied cormorant		C		4
animals	birds	Phalacrocoracidae	*Phalacrocorax varius*	pied cormorant		C		3
animals	birds	Phasianidae	*Coturnix ypsilophora*	brown quail		C		3
animals	birds	Podargidae	*Podargus strigoides*	tawny frogmouth		C		5
animals	birds	Podicipedidae	*Poliocephalus poliocephalus*	hoary-headed grebe		C		1
animals	birds	Podicipedidae	*Tachybaptus novaehollandiae*	Australasian grebe		C		1
animals	birds	Pomatostomidae	*Pomatostomus temporalis*	grey-crowned babbler		C		33/1
animals	birds	Psittacidae	*Trichoglossus haematodus moluccanus*	rainbow lorikeet		C		1
animals	birds	Psittacidae	*Barnardius zonarius macgillivrayi*	Cloncurry parrot		C		10/1
animals	birds	Psittacidae	*Aprosmictus erythropterus*	red-winged parrot		C		26
animals	birds	Psittacidae	*Psitteuteles versicolor*	varied lorikeet		C		31
animals	birds	Psittacidae	*Melopsittacus undulatus*	budgerigar		C		36
animals	birds	Psittacidae	*Barnardius zonarius*	Australian ringneck		C		14
animals	birds	Ptilonorhynchidae	*Ptilonorhynchus nuchalis*	great bowerbird		C		10
animals	birds	Ptilonorhynchidae	*Ptilonorhynchus maculatus*	spotted bowerbird		C		10/1
animals	birds	Rallidae	*Porzana fluminea*	Australian spotted crake		C		1
animals	birds	Rallidae	*Tribonyx ventralis*	black-tailed native-hen		C		1
animals	birds	Rallidae	*Fulica atra*	Eurasian coot		C		2
animals	birds	Recurvirostridae	*Himantopus himantopus*	black-winged stilt		C		2
animals	birds	Recurvirostridae	*Recurvirostra novaehollandiae*	red-necked avocet		C		1
animals	birds	Rhipiduridae	*Rhipidura leucophrys*	willie wagtail		C		59
animals	birds	Rhipiduridae	*Rhipidura albiscapa*	grey fantail		C		4
animals	birds	Scolopacidae	*Calidris acuminata*	sharp-tailed sandpiper		SL		1
animals	birds	Strigidae	*Ninox connivens*	barking owl		C		3
animals	birds	Strigidae	*Ninox boobook*	southern boobook		C		7
animals	birds	Threskiornithidae	*Threskiornis molucca*	Australian white ibis		C		1
animals	birds	Threskiornithidae	*Plegadis falcinellus*	glossy ibis		SL		1
animals	birds	Threskiornithidae	*Platalea regia*	royal spoonbill		C		3
animals	birds	Threskiornithidae	*Threskiornis spinicollis*	straw-necked ibis		C		3
animals	birds	Turnicidae	*Turnix velox*	little button-quail		C		1
animals	birds	Tytonidae	*Tyto javanica*	eastern barn owl		C		2
animals	insects	Nymphalidae	*Euploea core corinna*	common crow				2
animals	insects	Nymphalidae	*Danaus chrysippus petilia*	lesser wanderer				2
animals	insects	Nymphalidae	*Hypolimnas bolina nerina*	varied eggfly				5
animals	insects	Nymphalidae	*Junonia villida calybe*	meadow argus				1
animals	insects	Papilionidae	*Papilio demoleus sthenelus*	chequered swallowtail				3
animals	insects	Pieridae	*Catopsilia pyranthe crokera*	white migrant				1
animals	insects	Pieridae	*Catopsilia pomona pomona*	lemon migrant				1
animals	insects	Pieridae	*Belenois java teutonia*	caper white				1
animals	insects	Pieridae	*Eurema smilax*	small grass-yellow				1
animals	mammals	Emballonuridae	*Taphozous sp.*					2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	mammals	Macropodidae	*Petrogale purpureicollis*	purple-necked rock-wallaby		V		4
animals	mammals	Macropodidae	*Onychogalea unguifera*	northern nailtail wallaby		C		3
animals	mammals	Macropodidae	*Macropus rufus*	red kangaroo		C		5
animals	mammals	Macropodidae	*Macropus agilis*	agile wallaby		C		1
animals	mammals	Macropodidae	*Macropus robustus*	common wallaroo		C		3
animals	mammals	Molossidae	*Chaerephon jobensis*	northern freetail bat		C		1
animals	mammals	Molossidae	*Mormopterus beccarii*	Beccari's freetail bat		C		1
animals	mammals	Muridae	*Hydromys chrysogaster*	water rat		C		1
animals	mammals	Muridae	*Pseudomys desertor*	desert mouse		C		1
animals	mammals	Muridae	*Pseudomys johnsoni*			C		2
animals	mammals	Pteropodidae	*Pteropus scapulatus*	little red flying-fox		C		1
animals	mammals	Tachyglossidae	*Tachyglossus aculeatus*	short-beaked echidna		SL		1
animals	mammals	Vespertilionidae	*Chalinolobus nigrogriseus*	hoary wattled bat		C		1
animals	mammals	Vespertilionidae	*Vespadelus sp.*					1/1
animals	mammals	Vespertilionidae	*Scotorepens greyii*	little broad-nosed bat		C		14/2
animals	mammals	Vespertilionidae	*Chalinolobus gouldii*	Gould's wattled bat		C		3
animals	mammals	Vespertilionidae	*Scotorepens balstoni*	inland broad-nosed bat		C		4/3
animals	mammals	Vespertilionidae	*Vespadelus finlaysoni*	Finlayson's cave bat		C		1
animals	ray-finned fishes	Ambassidae	*Ambassis species*	northwest glassfish				1
animals	ray-finned fishes	Clupeidae	*Nematalosa erebi*	bony bream				2
animals	ray-finned fishes	Melanotaeniidae	*Melanotaenia splendida splendida*	eastern rainbowfish				1
animals	ray-finned fishes	Terapontidae	*Amniataba percoides*	barred grunter				1
animals	ray-finned fishes	Terapontidae	*Leiopotherapon unicolor*	spangled perch				3
animals	reptiles	Agamidae	*Ctenophorus caudicinctus*	ring-tailed dragon		C		1
animals	reptiles	Agamidae	*Amphibolurus temporalis*	swamplands lashtail		C		2
animals	reptiles	Agamidae	*Diporiphora bilineata*	two-lined dragon		C		1
animals	reptiles	Agamidae	*Chlamydosaurus kingii*	frilled lizard		C		1
animals	reptiles	Agamidae	*Amphibolurus gilberti*	Gilbert's dragon		C		7
animals	reptiles	Agamidae	*Diporiphora magna*			C		3
animals	reptiles	Agamidae	*Pogona vitticeps*			C		3/1
animals	reptiles	Boidae	*Aspidites melanocephalus*	black-headed python		C		2
animals	reptiles	Crocodylidae	*Crocodylus johnstoni*	Australian freshwater crocodile		C		1
animals	reptiles	Diplodactylidae	*Diplodactylus conspicillatus*	fat-tailed diplodactylus		C		3
animals	reptiles	Diplodactylidae	*Lucasium stenodactylum*	crowned gecko		C		4
animals	reptiles	Diplodactylidae	*Lucasium immaculatum*			C		2
animals	reptiles	Diplodactylidae	*Rhynchoedura ornata sensu lato*	beaked gecko		C		1/1
animals	reptiles	Elapidae	*Furina ornata*	orange-naped snake		C		1
animals	reptiles	Elapidae	*Suta suta*	myall snake		C		1
animals	reptiles	Elapidae	*Vermicella annulata*	bandy-bandy		C		1
animals	reptiles	Elapidae	*Pseudonaja textilis*	eastern brown snake		C		1
animals	reptiles	Gekkonidae	*Gehyra sp.*					1
animals	reptiles	Gekkonidae	*Gehyra nana*			C		1
animals	reptiles	Gekkonidae	*Gehyra dubia*			C		2
animals	reptiles	Gekkonidae	*Gehyra robusta*			C		2
animals	reptiles	Gekkonidae	*Heteronotia binoei*	Bynoe's gecko		C		4/1
animals	reptiles	Gekkonidae	*Gehyra versicolor*			C		3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	reptiles	Pygopodidae	*Delma nasuta*	sharp-snouted legless lizard		C		1
animals	reptiles	Pygopodidae	*Lialis burtonis*	Burton's legless lizard		C		1
animals	reptiles	Scincidae	*Ctenotus hebetior*			C		1
animals	reptiles	Scincidae	*Ctenotus lateralis*			C		8
animals	reptiles	Scincidae	*Ctenotus decaneurus*			C		1
animals	reptiles	Scincidae	*Ctenotus pulchellus*			C		2/2
animals	reptiles	Scincidae	*Ctenotus pantherinus*			C		6
animals	reptiles	Scincidae	*Ctenotus striaticeps*			C		2
animals	reptiles	Scincidae	*Tiliqua multifasciata*	Centralian blue-tongued lizard		C		1
animals	reptiles	Scincidae	*Cryptoblepharus zoticus*	agile snake-eyed skink		C		1
animals	reptiles	Scincidae	*Cryptoblepharus pannosus*	ragged snake-eyed skink		C		1
animals	reptiles	Scincidae	*Cryptoblepharus plagiocephalus sensu lato*			C		1
animals	reptiles	Scincidae	*Egernia hosmeri*	Hosmer's skink		C		2
animals	reptiles	Scincidae	*Carlia amax*			C		2
animals	reptiles	Scincidae	*Menetia maini*			C		1
animals	reptiles	Typhlopidae	*Ramphotyphlops diversus*			C		2
animals	reptiles	Varanidae	*Varanus acanthurus*	ridge-tailed monitor		C		3/1
animals	reptiles	Varanidae	*Varanus mertensi*	Mertens' water monitor		C		5
animals	reptiles	Varanidae	*Varanus panoptes*	yellow-spotted monitor		C		2
fungi	sac fungi	Lecideaceae	*Lecidea*			C		1/1
fungi	sac fungi	Teloschistaceae	*Caloplaca*			C		1/1
plants	ferns	Lindsaeaceae	*Lindsaea ensifolia subsp. ensifolia*			C		1/1
plants	ferns	Nephrolepidaceae	*Nephrolepis brownii*			C		1/1
plants	higher dicots	Amaranthaceae	*Ptilotus macrocephalus*	green pussytails		C		1/1
plants	higher dicots	Amaranthaceae	*Alternanthera denticulata*	lesser joyweed		C		1/1
plants	higher dicots	Amaranthaceae	*Gomphrena breviflora*			C		1/1
plants	higher dicots	Amaranthaceae	*Gomphrena leptophylla*			C		2/2
plants	higher dicots	Amaranthaceae	*Amaranthus interruptus*			C		1/1
plants	higher dicots	Amaranthaceae	*Gomphrena lanata*			C		3/3
plants	higher dicots	Apocynaceae	*Calotropis gigantea*		Y			2/2
plants	higher dicots	Apocynaceae	*Calotropis procera*		Y			4/4
plants	higher dicots	Asteraceae	*Pluchea dentex*	bowl daisy		C		1/1
plants	higher dicots	Asteraceae	*Pluchea rubelliflora*			C		1/1
plants	higher dicots	Asteraceae	*Streptoglossa decurrens*			C		1/1
plants	higher dicots	Asteraceae	*Pterocaulon serrulatum var. velutinum*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium haesum*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium tanythrix*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium tenuifolium*			C		2/2
plants	higher dicots	Boraginaceae	*Heliotropium cunninghamii*			C		1/1
plants	higher dicots	Boraginaceae	*Trichodesma zeylanicum var. zeylanicum*			C		2/2
plants	higher dicots	Byttneriaceae	*Waltheria indica*			C		2/2
plants	higher dicots	Caesalpiniaceae	*Senna artemisioides subsp. oligophylla*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Senna notabilis*			C		2/2
plants	higher dicots	Caryophyllaceae	*Polycarpaea spirostylis subsp. spirostylis*			C		1/1
plants	higher dicots	Caryophyllaceae	*Polycarpaea corymbosa var. corymbosa*			C		1/1
plants	higher dicots	Caryophyllaceae	*Polycarpaea breviflora*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Caryophyllaceae	*Polycarpaea spirostylis subsp. glabra*			C		1/1
plants	higher dicots	Celastraceae	*Denhamia cunninghamii*			C		1/1
plants	higher dicots	Chenopodiaceae	*Maireana georgei*			C		1/1
plants	higher dicots	Cleomaceae	*Cleome gynandra*		Y			1/1
plants	higher dicots	Cleomaceae	*Cleome viscosa*	tick-weed		C		2/2
plants	higher dicots	Combretaceae	*Terminalia aridicola subsp. aridicola*			C		2/2
plants	higher dicots	Convolvulaceae	*Ipomoea plebeia*	bellvine		C		1/1
plants	higher dicots	Convolvulaceae	*Polymeria ambigua*			C		1/1
plants	higher dicots	Convolvulaceae	*Jacquemontia browniana*			C		1/1
plants	higher dicots	Convolvulaceae	*Bonamia pannosa*			C		3/3
plants	higher dicots	Cucurbitaceae	*Cucumis melo*			C		2/2
plants	higher dicots	Cucurbitaceae	*Cucumis argenteus*			C		2/2
plants	higher dicots	Euphorbiaceae	*Euphorbia australis var. subtomentosa*			C		1/1
plants	higher dicots	Euphorbiaceae	*Euphorbia hirta*		Y			1/1
plants	higher dicots	Fabaceae	*Vigna*			C		1/1
plants	higher dicots	Fabaceae	*Cullen cinereum*			C		1/1
plants	higher dicots	Fabaceae	*Swainsona burkei*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia virens*			C		6/6
plants	higher dicots	Fabaceae	*Cullen balsamicum*			C		1/1
plants	higher dicots	Fabaceae	*Cullen leucanthum*			C		1/1
plants	higher dicots	Fabaceae	*Indigofera colutea*	sticky indigo		C		1/1
plants	higher dicots	Fabaceae	*Indigofera linnaei*	Birdsville indigo		C		1/1
plants	higher dicots	Fabaceae	*Cajanus acutifolius*			C		2/2
plants	higher dicots	Fabaceae	*Cajanus lanuginosus*			C		1/1
plants	higher dicots	Fabaceae	*Indigofera linifolia*			C		2/2
plants	higher dicots	Fabaceae	*Indigofera pratensis*			C		1/1
plants	higher dicots	Fabaceae	*Sesbania benthamiana*			C		3/3
plants	higher dicots	Fabaceae	*Tephrosia leptoclada*			C		2/2
plants	higher dicots	Fabaceae	*Crotalaria medicaginea*	trefoil rattlepod		C		1/1
plants	higher dicots	Fabaceae	*Tephrosia lasiochlaena*			C		2/2
plants	higher dicots	Fabaceae	*Indigastrum parviflorum*			C		1/1
plants	higher dicots	Fabaceae	*Macroptilium atropurpureum*	siratro	Y			1/1
plants	higher dicots	Fabaceae	*Tephrosia rosea var. rosea*			C		4/4
plants	higher dicots	Fabaceae	*Zornia prostrata var. prostrata*			C		1/1
plants	higher dicots	Fabaceae	*Sesbania cannabina var. cannabina*			C		1/1
plants	higher dicots	Fabaceae	*Zornia muriculata subsp. angustata*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia brachyodon var. longifolia*			C		3/3
plants	higher dicots	Fabaceae	*Tephrosia sp. (Mt Isa P.L.Harris 277)*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia brachyodon var. cloncurrensis*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia sp. (Magazine Hill P.Jones 365)*			C		4/4
plants	higher dicots	Fabaceae	*Crotalaria novae-hollandiae subsp. novae-hollandiae*			C		3/3
plants	higher dicots	Fabaceae	*Tephrosia phaeosperma var. (Westmoreland S.Melville 967)*			C		1/1
plants	higher dicots	Goodeniaceae	*Scaevola ovalifolia*			C		1/1
plants	higher dicots	Goodeniaceae	*Goodenia vilmoriniae*			C		4/4
plants	higher dicots	Goodeniaceae	*Goodenia fascicularis*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Goodeniaceae	*Scaevola*			C		3/3
plants	higher dicots	Lamiaceae	*Vitex benthamiana*			C		1/1
plants	higher dicots	Lamiaceae	*Mesosphaerum suaveolens*		Y			2/2
plants	higher dicots	Lamiaceae	*Ocimum caryophyllinum*			C		1/1
plants	higher dicots	Loranthaceae	*Diplatia grandibractea*			C		1/1
plants	higher dicots	Malvaceae	*Hibiscus sturtii var. grandiflorus*			C		1/1
plants	higher dicots	Malvaceae	*Abutilon hannii*			C		1/1
plants	higher dicots	Malvaceae	*Abutilon arenarium*			C		1/1
plants	higher dicots	Malvaceae	*Gossypium australe*			C		1/1
plants	higher dicots	Malvaceae	*Hibiscus meraukensis*	Merauke hibiscus		C		1/1
plants	higher dicots	Malvaceae	*Sida rohlenae subsp. rohlenae*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia victoriae subsp. fasciaria*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia sp. (Coolullah M.Lazarides 3988)*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia retivenea subsp. retivenea*			C		3/3
plants	higher dicots	Mimosaceae	*Vachellia farnesiana*		Y			2/2
plants	higher dicots	Mimosaceae	*Acacia holosericea*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia tenuissima*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia melleodora*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia elachantha*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia chisholmii*			C		3/3
plants	higher dicots	Mimosaceae	*Acacia gonoclada*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia galioides*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia laccata*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia cambagei*	gidgee		C		2/2
plants	higher dicots	Mimosaceae	*Acacia acradenia*			C		5/5
plants	higher dicots	Moraceae	*Ficus racemosa var. racemosa*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus camaldulensis subsp. obtusa*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus leucophylla x E.pruinosa*			C		3/3
plants	higher dicots	Myrtaceae	*Eucalyptus leucophloia subsp. euroa*			C		3/3
plants	higher dicots	Myrtaceae	*Lophostemon grandiflorus*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus leucophylla*			C		2/2
plants	higher dicots	Myrtaceae	*Melaleuca fluviatilis*			C		1/1
plants	higher dicots	Myrtaceae	*Corymbia capricornia*			C		1/1
plants	higher dicots	Myrtaceae	*Melaleuca argentea*	silver tea-tree		C		2/2
plants	higher dicots	Myrtaceae	*Melaleuca viridiflora var. viridiflora*			C		1/1
plants	higher dicots	Myrtaceae	*Melaleuca trichostachya*			C		1/1
plants	higher dicots	Nyctaginaceae	*Boerhavia burbidgeana*			C		1/1
plants	higher dicots	Nyctaginaceae	*Boerhavia pubescens*			C		1/1
plants	higher dicots	Orobanchaceae	*Buchnera ramosissima*			C		1/1
plants	higher dicots	Plantaginaceae	*Stemodia viscosa*			C		2/2
plants	higher dicots	Polygalaceae	*Polygala barklyensis*			C		2/2
plants	higher dicots	Portulacaceae	*Sedopsis armitii*			C		1/1
plants	higher dicots	Portulacaceae	*Portulaca*			C		1/1
plants	higher dicots	Portulacaceae	*Portulaca australis*			C		1/1
plants	higher dicots	Proteaceae	*Hakea lorea subsp. lorea*			C		1/1
plants	higher dicots	Proteaceae	*Grevillea dryandri subsp. dryandri*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Rubiaceae	*Psydrax oleifolia*			C		1/1
plants	higher dicots	Rubiaceae	*Oldenlandia mitrasacmoides subsp. mitrasacmoides*			C		1/1
plants	higher dicots	Rubiaceae	*Kohautia australiensis*			C		1/1
plants	higher dicots	Rubiaceae	*Spermacoce auriculata*			C		1/1
plants	higher dicots	Sapindaceae	*Dodonaea stenophylla*			C		1/1
plants	higher dicots	Scrophulariaceae	*Eremophila latrobei subsp. latrobei*			C		1/1
plants	higher dicots	Solanaceae	*Solanum quadriloculatum*			C		5/5
plants	higher dicots	Solanaceae	*Solanum echinatum*			C		2/2
plants	higher dicots	Solanaceae	*Solanum succosum*			C		4/4
plants	higher dicots	Solanaceae	*Solanum esuriale*	quena		C		1/1
plants	higher dicots	Solanaceae	*Datura inoxia*		Y			3/3
plants	higher dicots	Sparrmanniaceae	*Corchorus sidoides subsp. vermicularis*			C		2/2
plants	higher dicots	Sparrmanniaceae	*Corchorus sericeus subsp. densiflorus*			C		2/2
plants	higher dicots	Sparrmanniaceae	*Triumfetta marsupiata*			C		2/2
plants	higher dicots	Sparrmanniaceae	*Triumfetta johnstonii*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Triumfetta rupestris*			C		4/4
plants	higher dicots	Sparrmanniaceae	*Triumfetta plumigera*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Corchorus pumilio*			C		2/2
plants	higher dicots	Sparrmanniaceae	*Corchorus tridens*			C		2/2
plants	higher dicots	Violaceae	*Hybanthus enneaspermus*			C		3/3
plants	lower dicots	Papaveraceae	*Argemone ochroleuca subsp. ochroleuca*	Mexican poppy	Y			1/1
plants	monocots	Arecaceae	*Livistona rigida*			C		2/2
plants	monocots	Cyperaceae	*Lipocarpha microcephala*			C		1/1
plants	monocots	Cyperaceae	*Bulbostylis barbata*			C		3/3
plants	monocots	Cyperaceae	*Cyperus squarrosus*	bearded flatsedge		C		1/1
plants	monocots	Cyperaceae	*Cyperus dactylotes*			C		1/1
plants	monocots	Cyperaceae	*Cyperus vaginatus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus javanicus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus carinatus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus iria*			C		2/2
plants	monocots	Cyperaceae	*Fimbristylis sp. (Thargomindah D.E.Boyland 3094)*			C		1/1
plants	monocots	Cyperaceae	*Cyperus microcephalus subsp. microcephalus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus cunninghamii subsp. cheradicus*			C		2/2
plants	monocots	Cyperaceae	*Fimbristylis corynocarya*			C		1/1
plants	monocots	Cyperaceae	*Fimbristylis microcarya*			C		2/2
plants	monocots	Cyperaceae	*Fimbristylis littoralis*			C		1/1
plants	monocots	Poaceae	*Urochloa piligera*			C		2/2
plants	monocots	Poaceae	*Aristida latifolia*	feathertop wiregrass		C		1/1
plants	monocots	Poaceae	*Echinochloa colona*	awnless barnyard grass	Y			1/1
plants	monocots	Poaceae	*Eragrostis cumingii*			C		1/1
plants	monocots	Poaceae	*Oxychloris scariosa*	winged chloris		C		1/1
plants	monocots	Poaceae	*Tragus australianus*	small burr grass		C		1/1
plants	monocots	Poaceae	*Bothriochloa pertusa*		Y			1/1
plants	monocots	Poaceae	*Dichanthium fecundum*	curly bluegrass		C		1/1
plants	monocots	Poaceae	*Enneapogon asperatus*			C		1/1
plants	monocots	Poaceae	*Aristida hygrometrica*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	monocots	Poaceae	*Dichanthium annulatum*	sheda grass	Y			1/1
plants	monocots	Poaceae	*Aristida inaequiglumis*			C		1/1
plants	monocots	Poaceae	*Brachyachne convergens*	common native couch		C		2/2
plants	monocots	Poaceae	*Enneapogon polyphyllus*	leafy nineawn		C		2/2
plants	monocots	Poaceae	*Cenchrus pennisetiformis*		Y			1/1
plants	monocots	Poaceae	*Sporobolus australasicus*			C		1/1
plants	monocots	Poaceae	*Paspalidium rarum*			C		1/1
plants	monocots	Poaceae	*Mnesithea formosa*			C		1/1
plants	monocots	Poaceae	*Chloris pectinata*	comb chloris		C		1/1
plants	monocots	Poaceae	*Aristida contorta*	bunched kerosene grass		C		1/1
plants	monocots	Poaceae	*Themeda triandra*	kangaroo grass		C		1/1
plants	monocots	Poaceae	*Eriachne ciliata*			C		1/1
plants	monocots	Poaceae	*Eragrostis minor*	smaller stinkgrass	Y			1/1
plants	monocots	Poaceae	*Sehima nervosum*			C		1/1
plants	monocots	Poaceae	*Eriachne obtusa*			C		1/1
plants	monocots	Poaceae	*Eriachne mucronata forma (Alpha C.E.Hubbard 7882)*			C		1/1
plants	monocots	Poaceae	*Eriachne sp. (Dugald River B.K.Simon+ 3007)*			C		1/1
plants	monocots	Poaceae	*Yakirra australiensis var. australiensis*			C		1/1
plants	monocots	Poaceae	*Bothriochloa bladhii subsp. bladhii*			C		1/1
plants	monocots	Poaceae	*Cynodon dactylon var. dactylon*		Y			1/1
plants	monocots	Poaceae	*Aristida holathera var. holathera*			C		2/2
plants	monocots	Poaceae	*Eriachne pulchella subsp. dominii*			C		1/1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Defined Area
Species: All
Type: All
Status: All
Records: All
Date: All
Latitude: 20.4224 to 21.0475
Longitude: 139.8386 to 139.1728
Email: hdick@aarc.net.au
Date submitted: Tuesday 17 Jun 2014 16:21:01
Date extracted: Tuesday 17 Jun 2014 16:30:03

The number of records retrieved = 993

Disclaimer

As the DSITIA is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

The State of Queensland does not invite reliance upon, nor accept responsibility for this information. Persons should satisfy themselves through independent means as to the accuracy and completeness of this information.

No statements, representations or warranties are made about the accuracy or completeness of this information. The State of Queensland disclaims all responsibility for this information and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

Feedback about Wildlife Online should be emailed to wildlife.online@science.dsitia.qld.gov.au

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	amphibians	Bufonidae	*Rhinella marina*	cane toad	Y			14/7
animals	amphibians	Hylidae	*Litoria pallida*	pallid rocketfrog		C		1
animals	amphibians	Hylidae	*Litoria inermis*	bumpy rocketfrog		C		10/9
animals	amphibians	Hylidae	*Cyclorana novaehollandiae*	eastern snapping frog		C		3
animals	amphibians	Hylidae	*Litoria rubella*	ruddy treefrog		C		9/7
animals	amphibians	Hylidae	*Litoria caerulea*	common green treefrog		C		6/4
animals	amphibians	Hylidae	*Cyclorana australis*	northern snapping frog		C		18/18
animals	amphibians	Limnodynastidae	*Platyplectrum ornatum*	ornate burrowing frog		C		2/1
animals	birds	Acanthizidae	*Smicrornis brevirostris*	weebill		C		274
animals	birds	Acanthizidae	*Acanthiza chrysorrhoa*	yellow-rumped thornbill		C		40/1
animals	birds	Acanthizidae	*Acanthiza apicalis*	inland thornbill		C		3
animals	birds	Acanthizidae	*Gerygone fusca*	western gerygone		C		2
animals	birds	Accipitridae	*Elanus axillaris*	black-shouldered kite		C		15
animals	birds	Accipitridae	*Aquila audax*	wedge-tailed eagle		C		48
animals	birds	Accipitridae	*Erythrotriorchis radiatus*	red goshawk		E	V	1
animals	birds	Accipitridae	*Hamirostra melanosternon*	black-breasted buzzard		C		5
animals	birds	Accipitridae	*Accipiter cirrocephalus*	collared sparrowhawk		C		24
animals	birds	Accipitridae	*Hieraaetus morphnoides*	little eagle		C		15
animals	birds	Accipitridae	*Haliaeetus leucogaster*	white-bellied sea-eagle		SL		25
animals	birds	Accipitridae	*Haliastur sphenurus*	whistling kite		C		198
animals	birds	Accipitridae	*Aviceda subcristata*	Pacific baza		C		1
animals	birds	Accipitridae	*Accipiter fasciatus*	brown goshawk		C		24
animals	birds	Accipitridae	*Lophoictinia isura*	square-tailed kite		NT		1
animals	birds	Accipitridae	*Circus approximans*	swamp harrier		C		1
animals	birds	Accipitridae	*Pandion cristatus*	eastern osprey		SL		9
animals	birds	Accipitridae	*Milvus migrans*	black kite		C		281
animals	birds	Accipitridae	*Circus assimilis*	spotted harrier		C		3
animals	birds	Acrocephalidae	*Acrocephalus australis*	Australian reed-warbler		SL		129/1
animals	birds	Aegothelidae	*Aegotheles cristatus*	Australian owlet-nightjar		C		8
animals	birds	Alaudidae	*Mirafra javanica*	Horsfield's bushlark		C		2
animals	birds	Alcedinidae	*Ceyx azureus*	azure kingfisher		C		4
animals	birds	Anatidae	*Anas gracilis*	grey teal		C		155
animals	birds	Anatidae	*Anas castanea*	chestnut teal		C		1
animals	birds	Anatidae	*Anas sp.*					1
animals	birds	Anatidae	*Cygnus atratus*	black swan		C		52
animals	birds	Anatidae	*Anas superciliosa*	Pacific black duck		C		192
animals	birds	Anatidae	*Chenonetta jubata*	Australian wood duck		C		67
animals	birds	Anatidae	*Anas platyrhynchos*	northern mallard	Y			1
animals	birds	Anatidae	*Dendrocygna eytoni*	plumed whistling-duck		C		52
animals	birds	Anatidae	*Dendrocygna arcuata*	wandering whistling-duck		C		16
animals	birds	Anatidae	*Nettapus pulchellus*	green pygmy-goose		C		47
animals	birds	Anatidae	*Stictonetta naevosa*	freckled duck		NT		4
animals	birds	Anatidae	*Tadorna tadornoides*	Australian shelduck		C		1
animals	birds	Anatidae	*Nettapus coromandelianus*	cotton pygmy-goose		NT		4
animals	birds	Anatidae	*Malacorhynchus membranaceus*	pink-eared duck		C		89
animals	birds	Anatidae	*Biziura lobata*	musk duck		C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Anatidae	*Aythya australis*	hardhead		C		184
animals	birds	Anatidae	*Anas rhynchotis*	Australasian shoveler		C		2
animals	birds	Anhingidae	*Anhinga novaehollandiae*	Australasian darter		C		169
animals	birds	Anseranatidae	*Anseranas semipalmata*	magpie goose		C		1
animals	birds	Ardeidae	*Ardea intermedia*	intermediate egret		C		132
animals	birds	Ardeidae	*Ardea ibis*	cattle egret		SL		52
animals	birds	Ardeidae	*Ardea modesta*	eastern great egret		SL		147
animals	birds	Ardeidae	*Ardea pacifica*	white-necked heron		C		123
animals	birds	Ardeidae	*Egretta garzetta*	little egret		C		46
animals	birds	Ardeidae	*Nycticorax caledonicus*	Nankeen night-heron		C		38
animals	birds	Ardeidae	*Ixobrychus flavicollis*	black bittern		C		1
animals	birds	Ardeidae	*Egretta novaehollandiae*	white-faced heron		C		130
animals	birds	Artamidae	*Artamus superciliosus*	white-browed woodswallow		C		18
animals	birds	Artamidae	*Artamus leucorynchus*	white-breasted woodswallow		C		51
animals	birds	Artamidae	*Artamus cyanopterus*	dusky woodswallow		C		1
animals	birds	Artamidae	*Strepera graculina*	pied currawong		C		2
animals	birds	Artamidae	*Artamus minor*	little woodswallow		C		30
animals	birds	Artamidae	*Cracticus tibicen*	Australian magpie		C		128/1
animals	birds	Artamidae	*Artamus cinereus*	black-faced woodswallow		C		176
animals	birds	Artamidae	*Cracticus nigrogularis*	pied butcherbird		C		187
animals	birds	Artamidae	*Artamus personatus*	masked woodswallow		C		22
animals	birds	Burhinidae	*Burhinus grallarius*	bush stone-curlew		C		6
animals	birds	Cacatuidae	*Eolophus roseicapillus*	galah		C		130
animals	birds	Cacatuidae	*Cacatua sanguinea*	little corella		C		100/3
animals	birds	Cacatuidae	*Nymphicus hollandicus*	cockatiel		C		85
animals	birds	Cacatuidae	*Calyptorhynchus banksii*	red-tailed black-cockatoo		C		1
animals	birds	Cacatuidae	*Cacatua galerita*	sulphur-crested cockatoo		C		84
animals	birds	Campephagidae	*Coracina novaehollandiae*	black-faced cuckoo-shrike		C		195
animals	birds	Campephagidae	*Lalage sueurii*	white-winged triller		C		101/2
animals	birds	Campephagidae	*Coracina maxima*	ground cuckoo-shrike		C		7
animals	birds	Campephagidae	*Coracina papuensis*	white-bellied cuckoo-shrike		C		10
animals	birds	Casuariidae	*Dromaius novaehollandiae*	emu		C		5
animals	birds	Charadriidae	*Erythrogonys cinctus*	red-kneed dotterel		C		49
animals	birds	Charadriidae	*Charadrius australis*	inland dotterel		C		1/1
animals	birds	Charadriidae	*Elseyornis melanops*	black-fronted dotterel		C		161
animals	birds	Charadriidae	*Charadrius veredus*	oriental plover		SL		8
animals	birds	Charadriidae	*Vanellus tricolor*	banded lapwing		C		3
animals	birds	Charadriidae	*Pluvialis fulva*	Pacific golden plover		SL		4
animals	birds	Charadriidae	*Vanellus miles*	masked lapwing		C		99
animals	birds	Charadriidae	*Vanellus miles miles*	masked lapwing (northern subspecies)		C		58
animals	birds	Charadriidae	*Charadrius ruficapillus*	red-capped plover		C		66
animals	birds	Charadriidae	*Charadrius mongolus*	lesser sand plover		SL		1
animals	birds	Ciconiidae	*Ephippiorhynchus asiaticus*	black-necked stork		NT		40
animals	birds	Cisticolidae	*Cisticola exilis*	golden-headed cisticola		C		8
animals	birds	Climacteridae	*Climacteris melanura*	black-tailed treecreeper		C		76/1
animals	birds	Columbidae	*Geopelia striata*	peaceful dove		C		217/8

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Columbidae	*Geopelia cuneata*	diamond dove		C		126/24
animals	birds	Columbidae	*Geophaps plumifera*	spinifex pigeon		C		134/36
animals	birds	Columbidae	*Ocyphaps lophotes*	crested pigeon		C		211/4
animals	birds	Columbidae	*Phaps chalcoptera*	common bronzewing		C		48/5
animals	birds	Columbidae	*Phaps histrionica*	flock bronzewing		C		1/1
animals	birds	Columbidae	*Columba livia*	rock dove	Y			31
animals	birds	Columbidae	*Streptopelia chinensis*	spotted dove	Y			1
animals	birds	Coraciidae	*Eurystomus orientalis*	dollarbird		C		15
animals	birds	Corcoracidae	*Struthidea cinerea*	apostlebird		C		43
animals	birds	Corvidae	*Corvus sp.*					11
animals	birds	Corvidae	*Corvus orru*	Torresian crow		C		20
animals	birds	Corvidae	*Corvus bennetti*	little crow		C		3
animals	birds	Corvidae	*Corvus coronoides*	Australian raven		C		231/1
animals	birds	Cuculidae	*Chalcites osculans*	black-eared cuckoo		C		3/1
animals	birds	Cuculidae	*Scythrops novaehollandiae*	channel-billed cuckoo		C		10
animals	birds	Cuculidae	*Cuculus optatus*	oriental cuckoo		SL		1
animals	birds	Cuculidae	*Cacomantis pallidus*	pallid cuckoo		C		16
animals	birds	Cuculidae	*Eudynamys orientalis*	eastern koel		C		15
animals	birds	Cuculidae	*Cacomantis variolosus*	brush cuckoo		C		1
animals	birds	Cuculidae	*Centropus phasianinus*	pheasant coucal		C		25
animals	birds	Cuculidae	*Chalcites basalis*	Horsfield's bronze-cuckoo		C		16/1
animals	birds	Estrildidae	*Poephila acuticauda*	long-tailed finch		C		29
animals	birds	Estrildidae	*Emblema pictum*	painted finch		C		82/4
animals	birds	Estrildidae	*Erythrura gouldiae*	Gouldian finch		E	E	1
animals	birds	Estrildidae	*Neochmia ruficauda*	star finch		C		1
animals	birds	Estrildidae	*Lonchura castaneothorax*	chestnut-breasted mannikin		C		19
animals	birds	Estrildidae	*Taeniopygia guttata*	zebra finch		C		233
animals	birds	Estrildidae	*Heteromunia pectoralis*	pictorella mannikin		NT		37
animals	birds	Estrildidae	*Poephila cincta cincta*	black-throated finch (white-rumped subspecies)		E	E	1
animals	birds	Estrildidae	*Taeniopygia bichenovii*	double-barred finch		C		68
animals	birds	Eurostopodidae	*Eurostopodus argus*	spotted nightjar		C		16/1
animals	birds	Falconidae	*Falco berigora*	brown falcon		C		41
animals	birds	Falconidae	*Falco subniger*	black falcon		C		6
animals	birds	Falconidae	*Falco longipennis*	Australian hobby		C		25
animals	birds	Falconidae	*Falco peregrinus*	peregrine falcon		C		1
animals	birds	Falconidae	*Falco cenchroides*	Nankeen kestrel		C		29
animals	birds	Falconidae	*Falco hypoleucos*	grey falcon		NT		1
animals	birds	Glareolidae	*Stiltia isabella*	Australian pratincole		C		46
animals	birds	Glareolidae	*Glareola maldivarum*	oriental pratincole		SL		3/2
animals	birds	Gruidae	*Grus rubicunda*	brolga		C		31
animals	birds	Halcyonidae	*Todiramphus sanctus*	sacred kingfisher		C		71
animals	birds	Halcyonidae	*Dacelo leachii*	blue-winged kookaburra		C		113
animals	birds	Halcyonidae	*Todiramphus pyrrhopygius*	red-backed kingfisher		C		74
animals	birds	Hirundinidae	*Petrochelidon ariel*	fairy martin		C		84
animals	birds	Hirundinidae	*Hirundo rustica*	barn swallow		SL		3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Hirundinidae	*Hirundo neoxena*	welcome swallow		C		34
animals	birds	Hirundinidae	*Petrochelidon nigricans*	tree martin		C		33
animals	birds	Jacanidae	*Irediparra gallinacea*	comb-crested jacana		C		98
animals	birds	Laridae	*Chlidonias hybrida*	whiskered tern		C		42
animals	birds	Laridae	*Hydroprogne caspia*	Caspian tern		SL		942
animals	birds	Laridae	*Chroicocephalus novaehollandiae*	silver gull		C		75
animals	birds	Laridae	*Chlidonias leucopterus*	white-winged black tern		SL		5
animals	birds	Laridae	*Gelochelidon nilotica*	gull-billed tern		C		28
animals	birds	Maluridae	*Amytornis sp.*					2
animals	birds	Maluridae	*Malurus lamberti*	variegated fairy-wren		C		137/2
animals	birds	Maluridae	*Amytornis ballarae*	Kalkadoon grasswren		C		77/8
animals	birds	Maluridae	*Amytornis dorotheae*	Carpentarian grasswren		NT		1
animals	birds	Maluridae	*Malurus leucopterus*	white-winged fairy-wren		C		12
animals	birds	Maluridae	*Malurus melanocephalus*	red-backed fairy-wren		C		36
animals	birds	Megaluridae	*Eremiornis carteri*	spinifexbird		C		60/2
animals	birds	Megaluridae	*Megalurus gramineus*	little grassbird		C		17
animals	birds	Megaluridae	*Cincloramphus cruralis*	brown songlark		C		4
animals	birds	Megaluridae	*Cincloramphus mathewsi*	rufous songlark		C		29
animals	birds	Meliphagidae	*Epthianura crocea crocea*	yellow chat (gulf)		V		3
animals	birds	Meliphagidae	*Melithreptus albogularis*	white-throated honeyeater		C		2
animals	birds	Meliphagidae	*Melithreptus gularis laetior*	golden-backed honeyeater		NT		4
animals	birds	Meliphagidae	*Sugomel niger*	black honeyeater		C		4
animals	birds	Meliphagidae	*Grantiella picta*	painted honeyeater		V		2
animals	birds	Meliphagidae	*Myzomela obscura*	dusky honeyeater		C		1
animals	birds	Meliphagidae	*Epthianura crocea*	yellow chat		V		2
animals	birds	Meliphagidae	*Entomyzon cyanotis*	blue-faced honeyeater		C		2
animals	birds	Meliphagidae	*Manorina flavigula*	yellow-throated miner		C		300/1
animals	birds	Meliphagidae	*Ptilotula plumulus*	grey-fronted honeyeater		C		188/6
animals	birds	Meliphagidae	*Epthianura tricolor*	crimson chat		C		44
animals	birds	Meliphagidae	*Gavicalis virescens*	singing honeyeater		C		54
animals	birds	Meliphagidae	*Philemon buceroides*	helmeted friarbird		C		1
animals	birds	Meliphagidae	*Stomiopera unicolor*	white-gaped honeyeater		C		5
animals	birds	Meliphagidae	*Cissomela pectoralis*	banded honeyeater		C		7
animals	birds	Meliphagidae	*Epthianura aurifrons*	orange chat		C		15
animals	birds	Meliphagidae	*Lichmera indistincta*	brown honeyeater		C		214
animals	birds	Meliphagidae	*Melithreptus gularis*	black-chinned honeyeater		NT		45
animals	birds	Meliphagidae	*Philemon argenticeps*	silver-crowned friarbird		C		44
animals	birds	Meliphagidae	*Ptilotula flavescens*	yellow-tinted honeyeater		C		24
animals	birds	Meliphagidae	*Ptilotula keartlandi*	grey-headed honeyeater		C		127/5
animals	birds	Meliphagidae	*Certhionyx variegatus*	pied honeyeater		C		1
animals	birds	Meliphagidae	*Philemon citreogularis*	little friarbird		C		135
animals	birds	Meliphagidae	*Ptilotula penicillatus*	white-plumed honeyeater		C		318/3
animals	birds	Meliphagidae	*Conopophila rufogularis*	rufous-throated honeyeater		C		69/1
animals	birds	Meliphagidae	*Acanthagenys rufogularis*	spiny-cheeked honeyeater		C		53/1
animals	birds	Meropidae	*Merops ornatus*	rainbow bee-eater		SL		210
animals	birds	Monarchidae	*Grallina cyanoleuca*	magpie-lark		C		339

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Monarchidae	*Myiagra inquieta*	restless flycatcher		C		85
animals	birds	Motacillidae	*Anthus novaeseelandiae*	Australasian pipit		C		48
animals	birds	Nectariniidae	*Dicaeum hirundinaceum*	mistletoebird		C		179
animals	birds	Neosittidae	*Daphoenositta chrysoptera*	varied sittella		C		5
animals	birds	Oriolidae	*Oriolus sagittatus*	olive-backed oriole		C		57
animals	birds	Oriolidae	*Sphecotheres vieilloti*	Australasian figbird		C		1
animals	birds	Otididae	*Ardeotis australis*	Australian bustard		C		29
animals	birds	Pachycephalidae	*Oreoica gutturalis*	crested bellbird		C		17/1
animals	birds	Pachycephalidae	*Colluricincla harmonica*	grey shrike-thrush		C		91/1
animals	birds	Pachycephalidae	*Pachycephala rufiventris*	rufous whistler		C		105/1
animals	birds	Pardalotidae	*Pardalotus rubricatus*	red-browed pardalote		C		53
animals	birds	Pardalotidae	*Pardalotus striatus*	striated pardalote		C		120/2
animals	birds	Passeridae	*Passer domesticus*	house sparrow	Y			49
animals	birds	Pelecanidae	*Pelecanus conspicillatus*	Australian pelican		C		143
animals	birds	Petroicidae	*Petroica goodenovii*	red-capped robin		C		8
animals	birds	Petroicidae	*Melanodryas cucullata*	hooded robin		C		22/2
animals	birds	Petroicidae	*Microeca fascinans*	jacky winter		C		80/1
animals	birds	Phalacrocoracidae	*Phalacrocorax carbo*	great cormorant		C		52
animals	birds	Phalacrocoracidae	*Phalacrocorax varius*	pied cormorant		C		36
animals	birds	Phalacrocoracidae	*Microcarbo melanoleucos*	little pied cormorant		C		127
animals	birds	Phalacrocoracidae	*Phalacrocorax sulcirostris*	little black cormorant		C		164
animals	birds	Phasianidae	*Pavo cristatus*	Indian peafowl	Y			5
animals	birds	Phasianidae	*Coturnix pectoralis*	stubble quail		C		3
animals	birds	Phasianidae	*Coturnix ypsilophora*	brown quail		C		20
animals	birds	Podargidae	*Podargus strigoides*	tawny frogmouth		C		21/1
animals	birds	Podicipedidae	*Tachybaptus novaehollandiae*	Australasian grebe		C		205
animals	birds	Podicipedidae	*Poliocephalus poliocephalus*	hoary-headed grebe		C		48
animals	birds	Podicipedidae	*Podiceps cristatus*	great crested grebe		C		56
animals	birds	Pomatostomidae	*Pomatostomus temporalis*	grey-crowned babbler		C		213
animals	birds	Psittacidae	*Barnardius zonarius*	Australian ringneck		C		76
animals	birds	Psittacidae	*Trichoglossus haematodus moluccanus*	rainbow lorikeet		C		10
animals	birds	Psittacidae	*Platycercus adscitus*	pale-headed rosella		C		1
animals	birds	Psittacidae	*Barnardius zonarius macgillivrayi*	Cloncurry parrot		C		16/8
animals	birds	Psittacidae	*Trichoglossus chlorolepidotus*	scaly-breasted lorikeet		C		1
animals	birds	Psittacidae	*Melopsittacus undulatus*	budgerigar		C		248
animals	birds	Psittacidae	*Psitteuteles versicolor*	varied lorikeet		C		125/1
animals	birds	Psittacidae	*Aprosmictus erythropterus*	red-winged parrot		C		160
animals	birds	Ptilonorhynchidae	*Ptilonorhynchus nuchalis*	great bowerbird		C		24
animals	birds	Ptilonorhynchidae	*Ptilonorhynchus maculatus*	spotted bowerbird		C		160/4
animals	birds	Rallidae	*Porzana fluminea*	Australian spotted crake		C		6
animals	birds	Rallidae	*Porzana pusilla*	Baillon's crake		C		10
animals	birds	Rallidae	*Fulica atra*	Eurasian coot		C		110
animals	birds	Rallidae	*Porzana tabuensis*	spotless crake		C		3
animals	birds	Rallidae	*Amaurornis cinerea*	white-browed crake		C		1
animals	birds	Rallidae	*Tribonyx ventralis*	black-tailed native-hen		C		15
animals	birds	Rallidae	*Gallinula tenebrosa*	dusky moorhen		C		90

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Rallidae	*Porphyrio porphyrio*	purple swamphen		C		75
animals	birds	Rallidae	*Gallirallus philippensis*	buff-banded rail		C		9
animals	birds	Recurvirostridae	*Himantopus himantopus*	black-winged stilt		C		197
animals	birds	Recurvirostridae	*Recurvirostra novaehollandiae*	red-necked avocet		C		23
animals	birds	Rhipiduridae	*Rhipidura albiscapa*	grey fantail		C		27
animals	birds	Rhipiduridae	*Rhipidura leucophrys*	willie wagtail		C		330
animals	birds	Rostratulidae	*Rostratula australis*	Australian painted snipe		V	E	7
animals	birds	Scolopacidae	*Numenius madagascariensis*	eastern curlew		NT		1
animals	birds	Scolopacidae	*Gallinago hardwickii*	Latham's snipe		SL		6
animals	birds	Scolopacidae	*Calidris ruficollis*	red-necked stint		SL		15
animals	birds	Scolopacidae	*Calidris ferruginea*	curlew sandpiper		SL		12
animals	birds	Scolopacidae	*Tringa stagnatilis*	marsh sandpiper		SL		33
animals	birds	Scolopacidae	*Phalaropus lobatus*	red-necked phalarope		SL		1
animals	birds	Scolopacidae	*Calidris subminuta*	long-toed stint		SL		6
animals	birds	Scolopacidae	*Calidris acuminata*	sharp-tailed sandpiper		SL		251
animals	birds	Scolopacidae	*Arenaria interpres*	ruddy turnstone		SL		2
animals	birds	Scolopacidae	*Actitis hypoleucos*	common sandpiper		SL		15/1
animals	birds	Scolopacidae	*Tringa nebularia*	common greenshank		SL		18
animals	birds	Scolopacidae	*Numenius minutus*	little curlew		SL		5
animals	birds	Scolopacidae	*Heteroscelus sp.*					2
animals	birds	Scolopacidae	*Tringa glareola*	wood sandpiper		SL		16
animals	birds	Scolopacidae	*Xenus cinereus*	terek sandpiper		SL		1
animals	birds	Scolopacidae	*Limosa limosa*	black-tailed godwit		SL		8
animals	birds	Scolopacidae	*Gallinago megala*	Swinhoe's snipe		SL		10
animals	birds	Strigidae	*Ninox boobook*	southern boobook		C		19
animals	birds	Strigidae	*Ninox connivens*	barking owl		C		2
animals	birds	Threskiornithidae	*Platalea regia*	royal spoonbill		C		36
animals	birds	Threskiornithidae	*Threskiornis molucca*	Australian white ibis		C		39
animals	birds	Threskiornithidae	*Threskiornis spinicollis*	straw-necked ibis		C		119
animals	birds	Threskiornithidae	*Platalea flavipes*	yellow-billed spoonbill		C		10
animals	birds	Threskiornithidae	*Plegadis falcinellus*	glossy ibis		SL		115
animals	birds	Turnicidae	*Turnix velox*	little button-quail		C		5
animals	birds	Tytonidae	*Tyto javanica*	eastern barn owl		C		2
animals	mammals	Bovidae	*Bos sp.*	cattle	Y			1
animals	mammals	Bovidae	*Bos taurus*	European cattle	Y			1
animals	mammals	Camelidae	*Camelus dromedarius*	one-humped camel	Y			2
animals	mammals	Dasyuridae	*Pseudantechinus mimulus*	Carpentarian antechinus		C	V	3/3
animals	mammals	Emballonuridae	*Taphozous troughtoni*	Troughton's sheathtail bat		C		4/3
animals	mammals	Emballonuridae	*Saccolaimus flaviventris*	yellow-bellied sheathtail bat		C		1
animals	mammals	Emballonuridae	*Taphozous georgianus*	common sheathtail bat		C		5/5
animals	mammals	Equidae	*Equus caballus*	horse	Y			2
animals	mammals	Hipposideridae	*Hipposideros stenotis*	northern leaf-nosed bat		V		1
animals	mammals	Macropodidae	*Macropus robustus*	common wallaroo		C		7/2
animals	mammals	Macropodidae	*Macropus rufus*	red kangaroo		C		2
animals	mammals	Macropodidae	*Lagorchestes conspicillatus*	spectacled hare-wallaby		C		1
animals	mammals	Macropodidae	*Petrogale purpureicollis*	purple-necked rock-wallaby		V		4/3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	mammals	Molossidae	*Chaerephon jobensis*	northern freetail bat		C		1/1
animals	mammals	Molossidae	*Mormopterus beccarii*	Beccari's freetail bat		C		6/6
animals	mammals	Molossidae	*Mormopterus loriae ridei*	little north-eastern freetail bat		C		1/1
animals	mammals	Muridae	*Rattus sordidus*	canefield rat		C		1
animals	mammals	Muridae	*Pseudomys johnsoni*			C		5
animals	mammals	Muridae	*Zyzomys argurus*	common rock-rat		C		2/2
animals	mammals	Pteropodidae	*Pteropus scapulatus*	little red flying-fox		C		3
animals	mammals	Vespertilionidae	*Scotorepens greyii*	little broad-nosed bat		C		9/4
animals	mammals	Vespertilionidae	*Vespadelus finlaysoni*	Finlayson's cave bat		C		3/3
animals	mammals	Vespertilionidae	*Vespadelus sp.*					2/1
animals	mammals	Vespertilionidae	*Chalinolobus gouldii*	Gould's wattled bat		C		4/3
animals	mammals	Vespertilionidae	*Nyctophilus geoffroyi*	lesser long-eared bat		C		4/4
animals	mammals	Vespertilionidae	*Vespadelus baverstocki*	inland forest bat		C		1
animals	ray-finned fishes	Ambassidae	*Ambassis macleayi*	Macleay's glassfish				146
animals	ray-finned fishes	Ambassidae	*Ambassis species*	northwest glassfish				62
animals	ray-finned fishes	Ambassidae	*Ambassis sp.*					2
animals	ray-finned fishes	Ariidae	*Neoarius graeffei*	blue catfish				5
animals	ray-finned fishes	Ariidae	*Neoarius leptaspis*	boofhead catfish				1
animals	ray-finned fishes	Belonidae	*Strongylura krefftii*	freshwater longtom				105
animals	ray-finned fishes	Centropomidae	*Lates calcarifer*	barramundi				169
animals	ray-finned fishes	Clupeidae	*Nematalosa erebi*	bony bream				939
animals	ray-finned fishes	Eleotridae	*Oxyeleotris selheimi*	blackbanded gudgeon				117
animals	ray-finned fishes	Eleotridae	*Oxyeleotris lineolata*	sleepy cod				109
animals	ray-finned fishes	Gobiidae	*Awaous acritosus*	roman-nose goby				1
animals	ray-finned fishes	Gobiidae	*Glossogobius giuris*	tank goby				4
animals	ray-finned fishes	Gobiidae	*Glossogobius aureus*	golden flathead goby				3
animals	ray-finned fishes	Melanotaeniidae	*Melanotaenia splendida inornata*	checkered rainbowfish				263
animals	ray-finned fishes	Melanotaeniidae	*Melanotaenia splendida splendida*	eastern rainbowfish				2
animals	ray-finned fishes	Plotosidae	*Porochilus rendahli*	Rendahl's catfish				1
animals	ray-finned fishes	Plotosidae	*Neosilurus hyrtlii*	Hyrtl's catfish				10
animals	ray-finned fishes	Plotosidae	*Neosilurus ater*	black catfish				1
animals	ray-finned fishes	Plotosidae	*Anodontiglanis dahli*	toothless catfish				1
animals	ray-finned fishes	Terapontidae	*Leiopotherapon unicolor*	spangled perch				111
animals	ray-finned fishes	Terapontidae	*Amniataba percoides*	barred grunter				680
animals	ray-finned fishes	Terapontidae	*Hephaestus fuliginosus*	sooty grunter				82
animals	ray-finned fishes	Toxotidae	*Toxotes chatareus*	sevenspot archerfish				41
animals	reptiles	Agamidae	*Tympanocryptis cephalus*			C		1/1
animals	reptiles	Agamidae	*Ctenophorus caudicinctus*	ring-tailed dragon		C		9/6
animals	reptiles	Agamidae	*Diporiphora bilineata*	two-lined dragon		C		2/1
animals	reptiles	Agamidae	*Amphibolurus gilberti*	Gilbert's dragon		C		7/1
animals	reptiles	Agamidae	*Pogona vitticeps*			C		2
animals	reptiles	Agamidae	*Moloch horridus*	thorny devil		C		1
animals	reptiles	Agamidae	*Diporiphora sp.*					1/1
animals	reptiles	Boidae	*Aspidites melanocephalus*	black-headed python		C		3/1
animals	reptiles	Boidae	*Liasis olivaceus*	olive python		C		2
animals	reptiles	Boidae	*Antaresia childreni*	children's python		C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	reptiles	Chelidae	*Emydura subglobosa worrelli*	diamond head turtle		NT		3
animals	reptiles	Crocodylidae	*Crocodylus johnstoni*	Australian freshwater crocodile		C		3
animals	reptiles	Diplodactylidae	*Lucasium immaculatum*			C		2/2
animals	reptiles	Diplodactylidae	*Strophurus ciliaris*	spiny-tailed gecko		C		10/3
animals	reptiles	Diplodactylidae	*Strophurus taeniatus*	white-striped gecko		C		1/1
animals	reptiles	Diplodactylidae	*Oedura marmorata*	marbled velvet gecko		C		1/1
animals	reptiles	Diplodactylidae	*Amalosia rhombifer*	zig-zag gecko		C		2/2
animals	reptiles	Elapidae	*Brachyurophis incinctus*			C		1
animals	reptiles	Elapidae	*Furina ornata*	orange-naped snake		C		1
animals	reptiles	Elapidae	*Pseudonaja modesta*	ringed brown snake		C		4/4
animals	reptiles	Elapidae	*Demansia olivacea sensu lato*	marble-headed whip snake		C		1
animals	reptiles	Elapidae	*Suta punctata*	little spotted snake		C		1/1
animals	reptiles	Gekkonidae	*Gehyra robusta*			C		22/19
animals	reptiles	Gekkonidae	*Gehyra versicolor*			C		8/8
animals	reptiles	Gekkonidae	*Heteronotia binoei*	Bynoe's gecko		C		4/2
animals	reptiles	Gekkonidae	*Gehyra dubia*			C		1
animals	reptiles	Pygopodidae	*Lialis burtonis*	Burton's legless lizard		C		2
animals	reptiles	Pygopodidae	*Delma borea*			C		1/1
animals	reptiles	Scincidae	*Tiliqua multifasciata*	Centralian blue-tongued lizard		C		2/2
animals	reptiles	Scincidae	*Ctenotus striaticeps*			C		1
animals	reptiles	Scincidae	*Ctenotus pantherinus*			C		2
animals	reptiles	Scincidae	*Ctenotus pulchellus*			C		2/2
animals	reptiles	Scincidae	*Ctenotus lateralis*			C		6/4
animals	reptiles	Scincidae	*Ctenotus inornatus*			C		1
animals	reptiles	Scincidae	*Egernia hosmeri*	Hosmer's skink		C		3/2
animals	reptiles	Scincidae	*Ctenotus hebetior*			C		1
animals	reptiles	Scincidae	*Carlia amax*			C		1
animals	reptiles	Varanidae	*Varanus mertensi*	Mertens' water monitor		C		3
animals	reptiles	Varanidae	*Varanus tristis*	black-tailed monitor		C		2/1
animals	reptiles	Varanidae	*Varanus acanthurus*	ridge-tailed monitor		C		7/4
animals	reptiles	Varanidae	*Varanus glebopalma*	long-tailed rock monitor		C		1
fungi	uncertain	Fungus	*Fungus*			C		1/1
plants	ferns	Adiantaceae	*Cheilanthes brownii*			C		4/4
plants	ferns	Adiantaceae	*Cheilanthes nudiuscula*			C		2/2
plants	ferns	Adiantaceae	*Cheilanthes sieberi subsp. sieberi*			C		1/1
plants	ferns	Adiantaceae	*Cheilanthes sieberi subsp. pseudovellea*			C		1/1
plants	ferns	Marsileaceae	*Marsilea costulifera*	narrow-leaved nardoo		C		1/1
plants	ferns	Salviniaceae	*Salvinia molesta*	salvinia	Y			1/1
plants	higher dicots	Acanthaceae	*Nelsonia campestris*			C		2/2
plants	higher dicots	Acanthaceae	*Rostellularia adscendens*			C		1/1
plants	higher dicots	Acanthaceae	*Rostellularia adscendens var. clementii*			C		1/1
plants	higher dicots	Aizoaceae	*Trianthema triquetra*	red spinach		C		1/1
plants	higher dicots	Aizoaceae	*Trianthema portulacastrum*	black pigweed	Y			1/1
plants	higher dicots	Amaranthaceae	*Aerva javanica*		Y			5/5
plants	higher dicots	Amaranthaceae	*Ptilotus nobilis subsp. nobilis*			C		4/4
plants	higher dicots	Amaranthaceae	*Ptilotus sessilifolius*			C		7/7

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Amaranthaceae	*Ptilotus macrocephalus*	green pussytails		C		1/1
plants	higher dicots	Amaranthaceae	*Amaranthus interruptus*			C		2/2
plants	higher dicots	Amaranthaceae	*Gomphrena leptophylla*			C		2/2
plants	higher dicots	Amaranthaceae	*Alternanthera pungens*	khaki weed	Y			2/2
plants	higher dicots	Amaranthaceae	*Ptilotus maconochiei*			NT		9/9
plants	higher dicots	Amaranthaceae	*Amaranthus undulatus*			C		4/4
plants	higher dicots	Amaranthaceae	*Alternanthera sp. (Mt Isa R.L.Specht+ 49)*			C		4/4
plants	higher dicots	Amaranthaceae	*Gomphrena arida*			C		3/3
plants	higher dicots	Amaranthaceae	*Gomphrena lanata*			C		3/3
plants	higher dicots	Amaranthaceae	*Ptilotus incanus*			C		4/4
plants	higher dicots	Amaranthaceae	*Ptilotus obovatus*			C		6/6
plants	higher dicots	Amaranthaceae	*Ptilotus spicatus*			C		1/1
plants	higher dicots	Amaranthaceae	*Achyranthes aspera*			C		1/1
plants	higher dicots	Amaranthaceae	*Alternanthera nana*	hairy joyweed		C		1/1
plants	higher dicots	Amaranthaceae	*Amaranthus viridis*	green amaranth	Y			1/1
plants	higher dicots	Amaranthaceae	*Ptilotus clementii*			C		5/5
plants	higher dicots	Amaranthaceae	*Ptilotus decipiens*			C		1/1
plants	higher dicots	Amaranthaceae	*Ptilotus fusiformis*			C		4/4
plants	higher dicots	Amaranthaceae	*Ptilotus schwartzii*			C		3/3
plants	higher dicots	Apocynaceae	*Marsdenia viridiflora subsp. tropica*			C		5/5
plants	higher dicots	Apocynaceae	*Sarcostemma brevipedicellatum*			C		1/1
plants	higher dicots	Apocynaceae	*Gymnanthera cunninghamii*			C		1/1
plants	higher dicots	Apocynaceae	*Tylophora cinerascens*			C		1/1
plants	higher dicots	Apocynaceae	*Calotropis procera*		Y			1/1
plants	higher dicots	Apocynaceae	*Calotropis gigantea*		Y			1/1
plants	higher dicots	Apocynaceae	*Cascabela thevetia*	yellow oleander	Y			1/1
plants	higher dicots	Apocynaceae	*Carissa lanceolata*			C		2/2
plants	higher dicots	Apocynaceae	*Cynanchum floribundum*			C		1/1
plants	higher dicots	Asteraceae	*Blumea mollis*			C		3/3
plants	higher dicots	Asteraceae	*Blumea tenella*			C		1/1
plants	higher dicots	Asteraceae	*Pluchea dentex*	bowl daisy		C		7/7
plants	higher dicots	Asteraceae	*Soliva sessilis*		Y			1/1
plants	higher dicots	Asteraceae	*Bidens bipinnata*	bipinnate beggar's ticks	Y			3/3
plants	higher dicots	Asteraceae	*Eclipta prostrata*	white eclipta		C		2/2
plants	higher dicots	Asteraceae	*Tridax procumbens*	tridax daisy	Y			1/1
plants	higher dicots	Asteraceae	*Flaveria trinervia*		Y			1/1
plants	higher dicots	Asteraceae	*Olearia subspicata*			C		1/1
plants	higher dicots	Asteraceae	*Peripleura obovata*			C		2/2
plants	higher dicots	Asteraceae	*Peripleura virgata*			C		4/4
plants	higher dicots	Asteraceae	*Glossocardia bidens*	native cobbler's pegs		C		1/1
plants	higher dicots	Asteraceae	*Streptoglossa odora*			C		3/3
plants	higher dicots	Asteraceae	*Pluchea rubelliflora*			C		4/4
plants	higher dicots	Asteraceae	*Pterocaulon redolens*			C		1/1
plants	higher dicots	Asteraceae	*Xanthium occidentale*		Y			1/1
plants	higher dicots	Asteraceae	*Calotis xanthosioidea*			C		1/1
plants	higher dicots	Asteraceae	*Cyanthillium cinereum*			C		3/3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Asteraceae	*Streptoglossa bubakii*			C		1/1
plants	higher dicots	Asteraceae	*Acanthospermum hispidum*	star burr	Y			3/3
plants	higher dicots	Asteraceae	*Pterocaulon sphacelatum*	applebush		C		1/1
plants	higher dicots	Asteraceae	*Streptoglossa decurrens*			C		8/8
plants	higher dicots	Asteraceae	*Sphaeromorphaea littoralis*			C		1/1
plants	higher dicots	Asteraceae	*Chrysocephalum pterochaetum*	perennial sunray		C		1/1
plants	higher dicots	Asteraceae	*Pluchea ferdinandi-muelleri*			C		5/5
plants	higher dicots	Asteraceae	*Centipeda minima subsp. minima*			C		1/1
plants	higher dicots	Asteraceae	*Lactuca serriola forma serriola*		Y			1/1
plants	higher dicots	Asteraceae	*Peripleura hispidula var. setosa*			C		1/1
plants	higher dicots	Asteraceae	*Brachyscome ciliaris var. lanuginosa*			C		1/1
plants	higher dicots	Asteraceae	*Pterocaulon serrulatum var. velutinum*			C		3/3
plants	higher dicots	Asteraceae	*Rutidosis helichrysoides subsp. acutiglumis*			C		1/1
plants	higher dicots	Boraginaceae	*Ehretia saligna*			C		1/1
plants	higher dicots	Boraginaceae	*Coldenia procumbens*			C		1/1
plants	higher dicots	Boraginaceae	*Trichodesma zeylanicum var. latisepalum*			C		1/1
plants	higher dicots	Boraginaceae	*Trichodesma zeylanicum var. zeylanicum*			C		2/2
plants	higher dicots	Boraginaceae	*Heliotropium ballii*			C		16/16
plants	higher dicots	Boraginaceae	*Heliotropium haesum*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium aequoreum*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium tanythrix*			C		1/1
plants	higher dicots	Boraginaceae	*Trichodesma zeylanicum*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium frohlichii*			C		2/2
plants	higher dicots	Boraginaceae	*Heliotropium ovalifolium*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium tenuifolium*			C		4/4
plants	higher dicots	Boraginaceae	*Heliotropium cunninghamii*			C		4/4
plants	higher dicots	Boraginaceae	*Heliotropium curassavicum*	smooth heliotrope	Y			2/2
plants	higher dicots	Boraginaceae	*Heliotropium fasciculatum*			C		1/1
plants	higher dicots	Brassicaceae	*Lepidium strongylophyllum*			C		3/3
plants	higher dicots	Byblidaceae	*Byblis liniflora*			C		2/2
plants	higher dicots	Byttneriaceae	*Keraudrenia nephrosperma*			C		1/1
plants	higher dicots	Cactaceae	*Cylindropuntia fulgida var. mamillata*		Y			2/2
plants	higher dicots	Caesalpiniaceae	*Senna glutinosa subsp. pruinosa*			C		3/3
plants	higher dicots	Caesalpiniaceae	*Senna glutinosa subsp. glutinosa*			C		2/2
plants	higher dicots	Caesalpiniaceae	*Senna*			C		3/3
plants	higher dicots	Caesalpiniaceae	*Senna venusta*			C		3/3
plants	higher dicots	Caesalpiniaceae	*Senna notabilis*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Lysiphyllum gilvum*	bauhinia		C		1/1
plants	higher dicots	Caesalpiniaceae	*Senna occidentalis*	coffee senna	Y			1/1
plants	higher dicots	Caesalpiniaceae	*Senna planitiicola*			C		2/2
plants	higher dicots	Caesalpiniaceae	*Senna artemisioides*			C		2/2
plants	higher dicots	Caesalpiniaceae	*Chamaecrista deserti*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Parkinsonia aculeata*	parkinsonia	Y			1/1
plants	higher dicots	Caesalpiniaceae	*Petalostylis cassioides*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Chamaecrista exigua var. exigua*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Senna artemisioides subsp. oligophylla*			C		2/2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Caesalpiniaceae	*Senna artemisioides subsp. sturtii*			C		1/1
plants	higher dicots	Campanulaceae	*Wahlenbergia gracilis*	sprawling bluebell		C		2/2
plants	higher dicots	Campanulaceae	*Wahlenbergia tumidifructa*			C		2/2
plants	higher dicots	Campanulaceae	*Wahlenbergia communis*	tufted bluebell		C		2/2
plants	higher dicots	Campanulaceae	*Isotoma petraea*	rock isotome		C		1/1
plants	higher dicots	Capparaceae	*Capparis umbonata*			C		2/2
plants	higher dicots	Capparaceae	*Capparis mitchellii*			C		1/1
plants	higher dicots	Capparaceae	*Capparis loranthifolia var. loranthifolia*			C		1/1
plants	higher dicots	Caryophyllaceae	*Polycarpaea breviflora*			C		2/2
plants	higher dicots	Caryophyllaceae	*Polycarpaea spirostylis*			C		1/1
plants	higher dicots	Caryophyllaceae	*Polycarpaea spirostylis subsp. glabra*			C		3/3
plants	higher dicots	Caryophyllaceae	*Polycarpaea corymbosa*			C		1/1
plants	higher dicots	Celastraceae	*Denhamia cunninghamii*			C		4/4
plants	higher dicots	Chenopodiaceae	*Maireana georgei*			C		6/6
plants	higher dicots	Chenopodiaceae	*Dysphania rhadinostachya subsp. rhadinostachya*			C		2/2
plants	higher dicots	Chenopodiaceae	*Maireana triptera*	three-wing bluebush		C		4/4
plants	higher dicots	Chenopodiaceae	*Salsola australis*			C		2/2
plants	higher dicots	Chenopodiaceae	*Sclerolaena glabra*			C		1/1
plants	higher dicots	Chenopodiaceae	*Sclerolaena minuta*			C		2/2
plants	higher dicots	Chenopodiaceae	*Sclerolaena cuneata*	tangled copperburr		C		2/2
plants	higher dicots	Chenopodiaceae	*Enchylaena tomentosa*			C		1/1
plants	higher dicots	Chenopodiaceae	*Maireana campanulata*			C		2/2
plants	higher dicots	Chenopodiaceae	*Sclerolaena bicornis*			C		1/1
plants	higher dicots	Chenopodiaceae	*Sclerolaena eriacantha*			C		2/2
plants	higher dicots	Chenopodiaceae	*Sclerolaena lanicuspis*			C		7/7
plants	higher dicots	Chenopodiaceae	*Sclerolaena cornishiana*			C		3/3
plants	higher dicots	Chenopodiaceae	*Einadia nutans subsp. nutans*			C		1/1
plants	higher dicots	Chenopodiaceae	*Einadia nutans subsp. eremaea*			C		1/1
plants	higher dicots	Chenopodiaceae	*Sclerolaena bicornis var. horrida*			C		1/1
plants	higher dicots	Chenopodiaceae	*Tecticornia indica subsp. leiostachya*			C		1/1
plants	higher dicots	Chenopodiaceae	*Maireana villosa*			C		6/6
plants	higher dicots	Cleomaceae	*Cleome viscosa*	tick-weed		C		3/3
plants	higher dicots	Combretaceae	*Terminalia aridicola subsp. aridicola*			C		2/2
plants	higher dicots	Combretaceae	*Terminalia aridicola*			C		1/1
plants	higher dicots	Combretaceae	*Terminalia aridicola subsp. chillagoensis*			C		1/1
plants	higher dicots	Convolvulaceae	*Ipomoea muelleri*	poison morning-glory		C		2/2
plants	higher dicots	Convolvulaceae	*Polymeria ambigua*			C		3/3
plants	higher dicots	Convolvulaceae	*Ipomoea polymorpha*			C		1/1
plants	higher dicots	Convolvulaceae	*Ipomoea racemigera*			C		1/1
plants	higher dicots	Convolvulaceae	*Xenostegia tridentata*			C		7/7
plants	higher dicots	Convolvulaceae	*Jacquemontia browniana*			C		1/1
plants	higher dicots	Convolvulaceae	*Operculina aequisepala*			C		1/1
plants	higher dicots	Convolvulaceae	*Jacquemontia paniculata*			C		2/2
plants	higher dicots	Convolvulaceae	*Bonamia media var. villosa*			C		1/1
plants	higher dicots	Convolvulaceae	*Evolvulus alsinoides var. decumbens*			C		3/3
plants	higher dicots	Convolvulaceae	*Jacquemontia paniculata var. tomentosa*			C		3/3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Convolvulaceae	*Ipomoea plebeia*	bellvine		C		2/2
plants	higher dicots	Convolvulaceae	*Bonamia pannosa*			C		3/3
plants	higher dicots	Convolvulaceae	*Ipomoea nil*		Y			2/2
plants	higher dicots	Convolvulaceae	*Bonamia media*			C		3/3
plants	higher dicots	Cucurbitaceae	*Citrullus colocynthis*	colocynth	Y			2/2
plants	higher dicots	Cucurbitaceae	*Cucumis melo*			C		2/2
plants	higher dicots	Cucurbitaceae	*Citrullus lanatus*		Y			1/1
plants	higher dicots	Cucurbitaceae	*Cucumis argenteus*			C		3/3
plants	higher dicots	Cucurbitaceae	*Momordica balsamina*	balsam apple	Y			1/1
plants	higher dicots	Droseraceae	*Drosera burmanni*			C		1/1
plants	higher dicots	Droseraceae	*Drosera indica*			C		2/2
plants	higher dicots	Euphorbiaceae	*Euphorbia trigonosperma*			C		10/10
plants	higher dicots	Euphorbiaceae	*Euphorbia schultzii var. comans*			C		1/1
plants	higher dicots	Euphorbiaceae	*Euphorbia australis var. subtomentosa*			C		6/6
plants	higher dicots	Euphorbiaceae	*Euphorbia tannensis subsp. eremophila*			C		3/3
plants	higher dicots	Euphorbiaceae	*Euphorbia*			C		1/1
plants	higher dicots	Euphorbiaceae	*Euphorbia operta*			C		4/4
plants	higher dicots	Euphorbiaceae	*Microstachys chamaelea*			C		3/3
plants	higher dicots	Euphorbiaceae	*Euphorbia accedens*			C		1/1
plants	higher dicots	Euphorbiaceae	*Euphorbia biconvexa*			C		2/2
plants	higher dicots	Euphorbiaceae	*Euphorbia drummondii*			C		1/1
plants	higher dicots	Euphorbiaceae	*Euphorbia heterophylla*		Y			2/2
plants	higher dicots	Euphorbiaceae	*Jatropha gossypiifolia*	bellyache bush	Y			1/1
plants	higher dicots	Euphorbiaceae	*Ricinus communis*	castor oil bush	Y			2/2
plants	higher dicots	Fabaceae	*Sesbania benthamiana*			C		3/3
plants	higher dicots	Fabaceae	*Jacksonia lateritica*			C		3/3
plants	higher dicots	Fabaceae	*Stylosanthes viscosa*		Y			1/1
plants	higher dicots	Fabaceae	*Tephrosia delestangii*			C		3/3
plants	higher dicots	Fabaceae	*Tephrosia flagellaris*			C		3/3
plants	higher dicots	Fabaceae	*Indigofera haplophylla*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia lasiochlaena*			C		4/4
plants	higher dicots	Fabaceae	*Indigofera queenslandica*			C		1/1
plants	higher dicots	Fabaceae	*Gastrolobium grandiflorum*			C		1/1
plants	higher dicots	Fabaceae	*Macroptilium atropurpureum*	siratro	Y			2/2
plants	higher dicots	Fabaceae	*Crotalaria novae-hollandiae*			C		1/1
plants	higher dicots	Fabaceae	*Galactia tenuiflora var. lucida*			C		2/2
plants	higher dicots	Fabaceae	*Vigna lanceolata var. latifolia*			C		2/2
plants	higher dicots	Fabaceae	*Rhynchosia minima var. australis*			C		1/1
plants	higher dicots	Fabaceae	*Rhynchosia minima var. tomentosa*			C		1/1
plants	higher dicots	Fabaceae	*Vigna lanceolata var. lanceolata*			C		3/3
plants	higher dicots	Fabaceae	*Galactia tenuiflora forma sericea*			C		2/2
plants	higher dicots	Fabaceae	*Sesbania cannabina var. cannabina*			C		3/3
plants	higher dicots	Fabaceae	*Zornia muriculata subsp. angustata*			C		5/5
plants	higher dicots	Fabaceae	*Crotalaria medicaginea var. neglecta*			C		2/2
plants	higher dicots	Fabaceae	*Tephrosia brachyodon var. longifolia*			C		7/7
plants	higher dicots	Fabaceae	*Tephrosia sp. (Mt Isa P.L.Harris 277)*			C		9/9

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Fabaceae	*Tephrosia brachyodon var. cloncurrensis*			C		2/2
plants	higher dicots	Fabaceae	*Tephrosia sp. (Magazine Hill P.Jones 365)*			C		6/6
plants	higher dicots	Fabaceae	*Tephrosia sp. (Pannikan Springs A.R.Bean+ 5612)*			C		1/1
plants	higher dicots	Fabaceae	*Crotalaria novae-hollandiae subsp. novae-hollandiae*			C		2/2
plants	higher dicots	Fabaceae	*Tephrosia phaeosperma var. (Westmoreland S.Melville 967)*			C		2/2
plants	higher dicots	Fabaceae	*Glycine*			C		1/1
plants	higher dicots	Fabaceae	*Galactia*			C		2/2
plants	higher dicots	Fabaceae	*Cullen pallidum*			C		1/1
plants	higher dicots	Fabaceae	*Indigofera trita*			C		4/4
plants	higher dicots	Fabaceae	*Tephrosia supina*			C		5/5
plants	higher dicots	Fabaceae	*Tephrosia virens*			C		5/5
plants	higher dicots	Fabaceae	*Clitoria ternatea*	butterfly pea	Y			1/1
plants	higher dicots	Fabaceae	*Cullen balsamicum*			C		4/4
plants	higher dicots	Fabaceae	*Rhynchosia minima*			C		1/1
plants	higher dicots	Fabaceae	*Glycine tomentella*	woolly glycine		C		1/1
plants	higher dicots	Fabaceae	*Indigofera colutea*	sticky indigo		C		2/2
plants	higher dicots	Fabaceae	*Indigofera hirsuta*	hairy indigo		C		2/2
plants	higher dicots	Fabaceae	*Indigofera linnaei*	Birdsville indigo		C		3/3
plants	higher dicots	Fabaceae	*Aeschynomene indica*	budda pea		C		2/2
plants	higher dicots	Fabaceae	*Cajanus acutifolius*			C		4/4
plants	higher dicots	Fabaceae	*Cajanus lanuginosus*			C		2/2
plants	higher dicots	Fabaceae	*Galactia tenuiflora*			C		2/2
plants	higher dicots	Fabaceae	*Medicago polymorpha*	burr medic	Y			1/1
plants	higher dicots	Fabaceae	*Stylosanthes hamata*		Y			2/2
plants	higher dicots	Fabaceae	*Templetonia hookeri*			C		2/2
plants	higher dicots	Fabaceae	*Tephrosia eriocarpa*			C		1/1
plants	higher dicots	Fabaceae	*Alysicarpus muelleri*			C		1/1
plants	higher dicots	Fabaceae	*Cullen australasicum*			C		2/2
plants	higher dicots	Fabaceae	*Indigofera linifolia*			C		3/3
plants	higher dicots	Fabaceae	*Indigofera pratensis*			C		3/3
plants	higher dicots	Fabaceae	*Indigofera scabrella*			C		1/1
plants	higher dicots	Frankeniaceae	*Frankenia serpyllifolia*			C		1/1
plants	higher dicots	Goodeniaceae	*Scaevola*			C		3/3
plants	higher dicots	Goodeniaceae	*Goodenia lunata*			C		1/1
plants	higher dicots	Goodeniaceae	*Goodenia ramelii*			C		4/4
plants	higher dicots	Goodeniaceae	*Goodenia armitiana*			C		2/2
plants	higher dicots	Goodeniaceae	*Scaevola sp. (Mt Isa P.L.Harris 699)*			C		1/1
plants	higher dicots	Goodeniaceae	*Goodenia vilmoriniae*			C		5/5
plants	higher dicots	Goodeniaceae	*Goodenia triodiophila*			C		4/4
plants	higher dicots	Goodeniaceae	*Scaevola browniana subsp. browniana*			C		1/1
plants	higher dicots	Goodeniaceae	*Goodenia grandiflora*			C		3/3
plants	higher dicots	Lamiaceae	*Mesosphaerum suaveolens*		Y			1/1
plants	higher dicots	Lamiaceae	*Clerodendrum tomentosum*			C		1/1
plants	higher dicots	Lamiaceae	*Ocimum caryophyllinum*			C		2/2
plants	higher dicots	Lamiaceae	*Anisomeles malabarica*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Lamiaceae	*Ocimum x citriodorum*			C		1/1
plants	higher dicots	Lamiaceae	*Clerodendrum floribundum*			C		3/3
plants	higher dicots	Loganiaceae	*Mitrasacme micrantha*			C		1/1
plants	higher dicots	Loganiaceae	*Mitrasacme nudicaulis var. nudicaulis*			C		1/1
plants	higher dicots	Loganiaceae	*Mitrasacme pygmaea*			C		1/1
plants	higher dicots	Loranthaceae	*Lysiana exocarpi subsp. exocarpi*			C		1/1
plants	higher dicots	Loranthaceae	*Lysiana subfalcata*			C		3/3
plants	higher dicots	Loranthaceae	*Amyema sanguinea var. sanguinea*			C		4/4
plants	higher dicots	Loranthaceae	*Lysiana spathulata subsp. spathulata*			C		6/6
plants	higher dicots	Loranthaceae	*Diplatia grandibractea*			C		1/1
plants	higher dicots	Loranthaceae	*Amyema villiflora subsp. villiflora*			C		1/1
plants	higher dicots	Loranthaceae	*Amyema quandang var. quandang*			C		2/2
plants	higher dicots	Loranthaceae	*Dendrophthoe odontocalyx*			C		1/1
plants	higher dicots	Lythraceae	*Rotala occultiflora*			C		1/1
plants	higher dicots	Lythraceae	*Ammannia multiflora*	jerry-jerry		C		2/2
plants	higher dicots	Lythraceae	*Rotala mexicana*			C		1/1
plants	higher dicots	Malvaceae	*Sida*			C		1/1
plants	higher dicots	Malvaceae	*Hibiscus*			C		3/3
plants	higher dicots	Malvaceae	*Sida sp. (Doomadgee F.W.Whitehouse AQ116275)*			C		1/1
plants	higher dicots	Malvaceae	*Sida sp. (Musselbrook M.B.Thomas+ MRS437)*			C		7/7
plants	higher dicots	Malvaceae	*Sida arenicola*			C		1/1
plants	higher dicots	Malvaceae	*Abutilon hannii*			C		3/3
plants	higher dicots	Malvaceae	*Abutilon macrum*			C		1/1
plants	higher dicots	Malvaceae	*Sida cordifolia*		Y			2/2
plants	higher dicots	Malvaceae	*Sida fibulifera*			C		7/7
plants	higher dicots	Malvaceae	*Sida goniocarpa*			C		1/1
plants	higher dicots	Malvaceae	*Sida nematopoda*			C		2/2
plants	higher dicots	Malvaceae	*Sida platycalyx*	lifesaver burr		C		1/1
plants	higher dicots	Malvaceae	*Abutilon lepidum*			C		8/8
plants	higher dicots	Malvaceae	*Hibiscus sturtii*			C		3/3
plants	higher dicots	Malvaceae	*Malva parviflora*	small-flowered mallow	Y			1/1
plants	higher dicots	Malvaceae	*Sida cleisocalyx*			C		2/2
plants	higher dicots	Malvaceae	*Sida hackettiana*			C		4/4
plants	higher dicots	Malvaceae	*Hibiscus burtonii*			C		2/2
plants	higher dicots	Malvaceae	*Abutilon arenarium*			C		4/4
plants	higher dicots	Malvaceae	*Abutilon otocarpum*			C		2/2
plants	higher dicots	Malvaceae	*Gossypium australe*			C		9/9
plants	higher dicots	Malvaceae	*Gossypium nelsonii*			C		3/3
plants	higher dicots	Malvaceae	*Herissantia crispa*			C		1/1
plants	higher dicots	Malvaceae	*Gossypium sturtianum*			C		3/3
plants	higher dicots	Malvaceae	*Hibiscus leptocladus*			C		1/1
plants	higher dicots	Malvaceae	*Hibiscus meraukensis*	Merauke hibiscus		C		2/2
plants	higher dicots	Malvaceae	*Hibiscus verdcourtii*			C		1/1
plants	higher dicots	Malvaceae	*Abutilon leucopetalum*			C		1/1
plants	higher dicots	Malvaceae	*Hibiscus pentaphyllus*			C		1/1
plants	higher dicots	Malvaceae	*Hibiscus brachychlaenus*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Malvaceae	*Hibiscus brachysiphonius*			C		1/1
plants	higher dicots	Malvaceae	*Hibiscus sturtii var. sturtii*			C		1/1
plants	higher dicots	Malvaceae	*Sida rohlenae subsp. rohlenae*			C		1/1
plants	higher dicots	Malvaceae	*Abutilon fraseri subsp. fraseri*			C		3/3
plants	higher dicots	Malvaceae	*Hibiscus sturtii var. platychlamys*			C		1/1
plants	higher dicots	Malvaceae	*Hibiscus sturtii var. campylochlamys*			C		4/4
plants	higher dicots	Malvaceae	*Malvastrum americanum var. americanum*		Y			2/2
plants	higher dicots	Malvaceae	*Sida sp. (Jericho E.J.Thompson+ JER117)*			C		5/5
plants	higher dicots	Meliaceae	*Azadirachta indica*		Y			1/1
plants	higher dicots	Meliaceae	*Khaya senegalensis*		Y			1/1
plants	higher dicots	Menyanthaceae	*Nymphoides indica*	water snowflake		C		1/1
plants	higher dicots	Mimosaceae	*Acacia bivenosa*			C		4/4
plants	higher dicots	Mimosaceae	*Acacia cowleana*			C		7/7
plants	higher dicots	Mimosaceae	*Acacia hemsleyi*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia ligulata*			C		2/2
plants	higher dicots	Mimosaceae	*Albizia lebbeck*	Indian siris		C		2/2
plants	higher dicots	Mimosaceae	*Acacia acradenia*			C		4/4
plants	higher dicots	Mimosaceae	*Acacia adsurgens*			C		3/3
plants	higher dicots	Mimosaceae	*Acacia galioides*			C		4/4
plants	higher dicots	Mimosaceae	*Acacia gonoclada*			C		4/4
plants	higher dicots	Mimosaceae	*Acacia hammondii*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia monticola*			C		9/9
plants	higher dicots	Mimosaceae	*Acacia thomsonii*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia victoriae*			C		2/2
plants	higher dicots	Mimosaceae	*Prosopis pallida*		Y			2/2
plants	higher dicots	Mimosaceae	*Acacia chisholmii*			C		6/6
plants	higher dicots	Mimosaceae	*Acacia elachantha*			C		5/5
plants	higher dicots	Mimosaceae	*Acacia hemignosta*			C		3/3
plants	higher dicots	Mimosaceae	*Acacia lysiphloia*			C		3/3
plants	higher dicots	Mimosaceae	*Acacia megalantha*			C		4/4
plants	higher dicots	Mimosaceae	*Acacia melleodora*			C		7/7
plants	higher dicots	Mimosaceae	*Acacia orthocarpa*			C		4/4
plants	higher dicots	Mimosaceae	*Acacia tenuissima*			C		3/3
plants	higher dicots	Mimosaceae	*Acacia asperulacea*			C		6/6
plants	higher dicots	Mimosaceae	*Acacia holosericea*			C		3/3
plants	higher dicots	Mimosaceae	*Acacia phlebocarpa*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia chippendalei*			C		12/12
plants	higher dicots	Mimosaceae	*Acacia sericophylla*			C		4/4
plants	higher dicots	Mimosaceae	*Vachellia bidwillii*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia ancistrocarpa*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia estrophiolata*			C		1/1
plants	higher dicots	Mimosaceae	*Vachellia farnesiana*		Y			2/2
plants	higher dicots	Mimosaceae	*Neptunia dimorphantha*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia aneura var. aneura*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia excelsa subsp. angusta*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia retivenea subsp. retivenea*			C		4/4

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Mimosaceae	*Acacia sp. (Coolullah M.Lazarides 3988)*			C		8/8
plants	higher dicots	Mimosaceae	*Leucaena leucocephala subsp. leucocephala*		Y			3/3
plants	higher dicots	Mimosaceae	*Acacia colei*			C		3/3
plants	higher dicots	Mimosaceae	*Acacia laccata*			C		2/2
plants	higher dicots	Molluginaceae	*Glinus oppositifolius*			C		1/1
plants	higher dicots	Moraceae	*Ficus brachypoda*			C		1/1
plants	higher dicots	Moraceae	*Ficus opposita*			C		1/1
plants	higher dicots	Moraceae	*Ficus cerasicarpa*			C		4/4
plants	higher dicots	Myrtaceae	*Corymbia aparrerinja*			C		2/2
plants	higher dicots	Myrtaceae	*Corymbia capricornia*			C		2/2
plants	higher dicots	Myrtaceae	*Corymbia leichhardtii*	rustyjacket		C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus melanophloia x E.normantonensis*			C		1/1
plants	higher dicots	Myrtaceae	*Melaleuca leucadendra*	broad-leaved tea-tree		C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus leucophylla*			C		7/7
plants	higher dicots	Myrtaceae	*Melaleuca dissitiflora*			C		1/1
plants	higher dicots	Myrtaceae	*Lophostemon grandiflorus*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus normantonensis*	Normanton box		C		10/10
plants	higher dicots	Myrtaceae	*Eucalyptus leucophloia subsp. euroa*			C		3/3
plants	higher dicots	Myrtaceae	*Eucalyptus melanophloia subsp. nana*			C		12/12
plants	higher dicots	Myrtaceae	*Eucalyptus camaldulensis subsp. obtusa*			C		3/3
plants	higher dicots	Myrtaceae	*Melaleuca viridiflora var. viridiflora*			C		1/1
plants	higher dicots	Myrtaceae	*Lophostemon grandiflorus subsp. riparius*			C		2/2
plants	higher dicots	Myrtaceae	*Melaleuca bracteata*			C		4/4
plants	higher dicots	Myrtaceae	*Corymbia terminalis*			C		1/1
plants	higher dicots	Myrtaceae	*Calytrix brownii*			C		1/1
plants	higher dicots	Myrtaceae	*Corymbia aspera*			C		7/7
plants	higher dicots	Myrtaceae	*Eucalyptus nudicaulis*			C		9/9
plants	higher dicots	Nyctaginaceae	*Boerhavia repleta*			C		3/3
plants	higher dicots	Nyctaginaceae	*Boerhavia pubescens*			C		5/5
plants	higher dicots	Nyctaginaceae	*Boerhavia paludosa*			C		3/3
plants	higher dicots	Oleaceae	*Jasminum calcareum*			C		1/1
plants	higher dicots	Oleaceae	*Jasminum didymum subsp. lineare*			C		2/2
plants	higher dicots	Onagraceae	*Ludwigia*			C		1/1
plants	higher dicots	Onagraceae	*Ludwigia perennis*			C		1/1
plants	higher dicots	Onagraceae	*Ludwigia peploides subsp. montevidensis*			C		1/1
plants	higher dicots	Onagraceae	*Ludwigia octovalvis*	willow primrose		C		1/1
plants	higher dicots	Orobanchaceae	*Buchnera linearis*			C		3/3
plants	higher dicots	Orobanchaceae	*Striga squamigera*			C		2/2
plants	higher dicots	Passifloraceae	*Passiflora foetida*		Y			3/3
plants	higher dicots	Pentapetaceae	*Melhania ovata*			C		3/3
plants	higher dicots	Pentapetaceae	*Melhania oblongifolia*			C		1/1
plants	higher dicots	Phyllanthaceae	*Breynia oblongifolia*			C		1/1
plants	higher dicots	Phyllanthaceae	*Flueggea leucopyrus*			C		2/2
plants	higher dicots	Phyllanthaceae	*Phyllanthus hebecarpus*			C		1/1
plants	higher dicots	Phyllanthaceae	*Sauropus trachyspermus*			C		2/2
plants	higher dicots	Phyllanthaceae	*Phyllanthus exilis*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Phyllanthaceae	*Phyllanthus carpentariae*			C		1/1
plants	higher dicots	Phyllanthaceae	*Phyllanthus*			C		2/2
plants	higher dicots	Phyllanthaceae	*Sauropus*			C		1/1
plants	higher dicots	Phyllanthaceae	*Flueggea virosa subsp. melanthesoides*			C		2/2
plants	higher dicots	Phyllanthaceae	*Phyllanthus maderaspatensis*			C		3/3
plants	higher dicots	Pittosporaceae	*Pittosporum angustifolium*			C		2/2
plants	higher dicots	Plantaginaceae	*Scoparia dulcis*	Scoparia	Y			1/1
plants	higher dicots	Plantaginaceae	*Mecardonia procumbens*		Y			2/2
plants	higher dicots	Plantaginaceae	*Stemodia*			C		1/1
plants	higher dicots	Plantaginaceae	*Bacopa monnieri*			C		2/2
plants	higher dicots	Plantaginaceae	*Stemodia lythrifolia*			C		5/5
plants	higher dicots	Plantaginaceae	*Stemodia viscosa*			C		4/4
plants	higher dicots	Plantaginaceae	*Stemodia glabella*			C		1/1
plants	higher dicots	Polygonaceae	*Persicaria attenuata*			C		2/2
plants	higher dicots	Polygonaceae	*Polygonum plebeium*	small knotweed		C		1/1
plants	higher dicots	Portulacaceae	*Calandrinia ptychosperma*			C		1/1
plants	higher dicots	Portulacaceae	*Portulaca intraterranea*			C		1/1
plants	higher dicots	Portulacaceae	*Portulaca oligosperma*			C		1/1
plants	higher dicots	Portulacaceae	*Grahamia australiana*			C		1/1
plants	higher dicots	Portulacaceae	*Portulaca filifolia*			C		1/1
plants	higher dicots	Portulacaceae	*Calandrinia pumila*			C		1/1
plants	higher dicots	Portulacaceae	*Portulaca sp. (Blackall G.Le Gros AQ101965)*			C		1/1
plants	higher dicots	Proteaceae	*Grevillea striata*	beefwood		C		1/1
plants	higher dicots	Proteaceae	*Hakea arborescens*			C		1/1
plants	higher dicots	Proteaceae	*Hakea chordophylla*			C		2/2
plants	higher dicots	Proteaceae	*Grevillea mimosoides*			C		2/2
plants	higher dicots	Proteaceae	*Hakea lorea subsp. lorea*			C		3/3
plants	higher dicots	Proteaceae	*Grevillea wickhamii subsp. aprica*			C		8/8
plants	higher dicots	Proteaceae	*Grevillea dryandri subsp. dryandri*			C		2/2
plants	higher dicots	Rhamnaceae	*Alphitonia excelsa*	soap tree		C		4/4
plants	higher dicots	Rubiaceae	*Dentella repens*	dentella		C		1/1
plants	higher dicots	Rubiaceae	*Pavetta rupicola*			C		5/5
plants	higher dicots	Rubiaceae	*Psydrax oleifolia*			C		3/3
plants	higher dicots	Rubiaceae	*Oldenlandia galioides*			C		3/3
plants	higher dicots	Rubiaceae	*Spermacoce auriculata*			C		5/5
plants	higher dicots	Rubiaceae	*Kohautia australiensis*			C		2/2
plants	higher dicots	Rubiaceae	*Spermacoce brachystema*			C		5/5
plants	higher dicots	Rubiaceae	*Synaptantha tillaeacea var. tillaeacea*			C		3/3
plants	higher dicots	Rubiaceae	*Oldenlandia mitrasacmoides subsp. mitrasacmoides*			C		2/2
plants	higher dicots	Santalaceae	*Anthobolus leptomerioides*			C		2/2
plants	higher dicots	Santalaceae	*Santalum lanceolatum*			C		4/4
plants	higher dicots	Sapindaceae	*Dodonaea lanceolata var. lanceolata*			C		3/3
plants	higher dicots	Sapindaceae	*Dodonaea viscosa subsp. mucronata*			C		3/3
plants	higher dicots	Sapindaceae	*Dodonaea stenophylla*			C		3/3
plants	higher dicots	Sapindaceae	*Dodonaea barklyana*			C		2/2
plants	higher dicots	Sapindaceae	*Alectryon oleifolius subsp. elongatus*			C		2/2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Sapindaceae	*Dodonaea viscosa subsp. angustissima*			C		1/1
plants	higher dicots	Scrophulariaceae	*Eremophila latrobei*			C		2/2
plants	higher dicots	Scrophulariaceae	*Eremophila macgillivrayi*			C		1/1
plants	higher dicots	Scrophulariaceae	*Eremophila mitchellii*			C		3/3
plants	higher dicots	Scrophulariaceae	*Eremophila longifolia*	berrigan		C		4/4
plants	higher dicots	Solanaceae	*Nicotiana glauca*	tree tobacco	Y			1/1
plants	higher dicots	Solanaceae	*Solanum torvum*	devil's fig	Y			1/1
plants	higher dicots	Solanaceae	*Datura inoxia*		Y			4/4
plants	higher dicots	Solanaceae	*Solanum succosum*			C		5/5
plants	higher dicots	Solanaceae	*Physalis angulata*		Y			2/2
plants	higher dicots	Solanaceae	*Nicotiana megalosiphon*			C		1/1
plants	higher dicots	Solanaceae	*Nicotiana megalosiphon subsp. sessilifolia*			C		2/2
plants	higher dicots	Solanaceae	*Solanum ferocissimum*			C		3/3
plants	higher dicots	Solanaceae	*Solanum quadriloculatum*			C		7/7
plants	higher dicots	Solanaceae	*Solanum senticosum*			C		7/7
plants	higher dicots	Solanaceae	*Nicotiana benthamiana*			C		2/2
plants	higher dicots	Solanaceae	*Solanum echinatum*			C		5/5
plants	higher dicots	Sparrmanniaceae	*Triumfetta*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Corchorus pumilio*			C		5/5
plants	higher dicots	Sparrmanniaceae	*Corchorus sidoides subsp. vermicularis*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Corchorus sericeus subsp. densiflorus*			C		18/18
plants	higher dicots	Sparrmanniaceae	*Corchorus sidoides subsp. sidoides*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Corchorus sericeus subsp. sericeus*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Triumfetta marsupiata*			C		4/4
plants	higher dicots	Sparrmanniaceae	*Triumfetta johnstonii*			C		5/5
plants	higher dicots	Sparrmanniaceae	*Corchorus tridens*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Triumfetta plumigera*			C		5/5
plants	higher dicots	Sparrmanniaceae	*Triumfetta rupestris*			C		3/3
plants	higher dicots	Sparrmanniaceae	*Corchorus sericeus*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Grewia retusifolia*			C		2/2
plants	higher dicots	Sparrmanniaceae	*Triumfetta triandra*			C		1/1
plants	higher dicots	Sterculiaceae	*Brachychiton collinus*			C		2/2
plants	higher dicots	Stylidiaceae	*Stylidium desertorum*			C		1/1
plants	higher dicots	Stylidiaceae	*Stylidium floribundum*			C		1/1
plants	higher dicots	Tamaricaceae	*Tamarix aphylla*	athel pine	Y			4/4
plants	higher dicots	Ulmaceae	*Trema tomentosa*			C		2/2
plants	higher dicots	Ulmaceae	*Trema tomentosa var. tomentosa*			C		2/2
plants	higher dicots	Verbenaceae	*Phyla nodiflora*	carpetweed		C		1/1
plants	higher dicots	Violaceae	*Hybanthus enneaspermus*			C		3/3
plants	higher dicots	Violaceae	*Hybanthus aurantiacus*			C		6/6
plants	higher dicots	Zygophyllaceae	*Tribulus cistoides*	bulls head vine		C		1/1
plants	higher dicots	Zygophyllaceae	*Tribulopis angustifolia*			C		3/3
plants	higher dicots	Zygophyllaceae	*Tribulus terrestris*	caltrop		C		3/3
plants	higher dicots	Zygophyllaceae	*Tribulopis pentandra*			C		3/3
plants	higher dicots	Zygophyllaceae	*Tribulus astrocarpus*			C		1/1
plants	higher dicots	Zygophyllaceae	*Tribulus*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	liverworts	Liverwort	*Liverwort*			C		1/1
plants	lower dicots	Lauraceae	*Cassytha glabella forma glabella*			C		1/1
plants	lower dicots	Menispermaceae	*Tinospora smilacina*	snakevine		C		3/3
plants	monocots	Araceae	*Spirodela oligorrhiza*			C		3/3
plants	monocots	Colchicaceae	*Iphigenia indica*			C		1/1
plants	monocots	Commelinaceae	*Commelina ensifolia*	scurvy grass		C		1/1
plants	monocots	Cyperaceae	*Cyperus cunninghamii subsp. cunninghamii*			C		4/4
plants	monocots	Cyperaceae	*Cyperus microcephalus subsp. microcephalus*			C		5/5
plants	monocots	Cyperaceae	*Fimbristylis aestivalis var. aestivalis*			C		1/1
plants	monocots	Cyperaceae	*Cyperus cunninghamii subsp. cheradicus*			C		2/2
plants	monocots	Cyperaceae	*Cyperus iria*			C		6/6
plants	monocots	Cyperaceae	*Cyperus exaltatus*	tall flatsedge		C		2/2
plants	monocots	Cyperaceae	*Cyperus betchei subsp. commiscens*			C		3/3
plants	monocots	Cyperaceae	*Schoenoplectus lateriflorus*			C		1/1
plants	monocots	Cyperaceae	*Fimbristylis bisumbellata*			C		1/1
plants	monocots	Cyperaceae	*Schoenoplectus subulatus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus bifax*	western nutgrass		C		1/1
plants	monocots	Cyperaceae	*Cyperus fulvus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus conicus*			C		2/2
plants	monocots	Cyperaceae	*Fuirena ciliaris*			C		1/1
plants	monocots	Cyperaceae	*Cyperus carinatus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus difformis*	rice sedge		C		2/2
plants	monocots	Cyperaceae	*Cyperus microcephalus subsp. saxicola*			C		1/1
plants	monocots	Cyperaceae	*Cyperus vaginatus*			C		2/2
plants	monocots	Cyperaceae	*Fimbristylis nuda*			C		1/1
plants	monocots	Cyperaceae	*Cyperus dactylotes*			C		6/6
plants	monocots	Cyperaceae	*Cyperus ixiocarpus*			C		4/4
plants	monocots	Cyperaceae	*Cyperus nervulosus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus pulchellus*			C		2/2
plants	monocots	Cyperaceae	*Cyperus squarrosus*	bearded flatsedge		C		3/3
plants	monocots	Cyperaceae	*Bulbostylis barbata*			C		13/13
plants	monocots	Cyperaceae	*Fimbristylis dichotoma*	common fringe-rush		C		1/1
plants	monocots	Cyperaceae	*Eleocharis atropurpurea*			C		1/1
plants	monocots	Cyperaceae	*Fimbristylis aestivalis*			C		2/2
plants	monocots	Cyperaceae	*Fimbristylis littoralis*			C		1/1
plants	monocots	Cyperaceae	*Fimbristylis microcarya*			C		3/3
plants	monocots	Cyperaceae	*Lipocarpha microcephala*			C		4/4
plants	monocots	Cyperaceae	*Bolboschoenus caldwellii*			C		1/1
plants	monocots	Hydrocharitaceae	*Hydrilla verticillata*	hydrilla		C		1/1
plants	monocots	Hydrocharitaceae	*Vallisneria nana*			C		1/1
plants	monocots	Juncaceae	*Juncus aridicola*	tussock rush		C		1/1
plants	monocots	Juncaceae	*Juncus continuus*			C		1/1
plants	monocots	Najadaceae	*Najas marina*			C		2/2
plants	monocots	Poaceae	*Eragrostis tenuifolia*	elastic grass	Y			1/1
plants	monocots	Poaceae	*Aristida*			C		1/1
plants	monocots	Poaceae	*Perotis rara*	comet grass		C		3/3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	monocots	Poaceae	*Eulalia aurea*	silky browntop		C		4/4
plants	monocots	Poaceae	*Aristida acuta*			C		2/2
plants	monocots	Poaceae	*Melinis repens*	red natal grass	Y			4/4
plants	monocots	Poaceae	*Panicum buncei*			C		2/2
plants	monocots	Poaceae	*Sarga plumosum*			C		4/4
plants	monocots	Poaceae	*Chloris inflata*	purpletop chloris	Y			3/3
plants	monocots	Poaceae	*Chloris pumilio*			C		1/1
plants	monocots	Poaceae	*Chloris virgata*	feathertop rhodes grass	Y			1/1
plants	monocots	Poaceae	*Eriachne obtusa*			C		3/3
plants	monocots	Poaceae	*Panicum effusum*			C		5/5
plants	monocots	Poaceae	*Sarga timorense*			C		1/1
plants	monocots	Poaceae	*Sehima nervosum*			C		2/2
plants	monocots	Poaceae	*Setaria surgens*			C		1/1
plants	monocots	Poaceae	*Triodia molesta*			C		5/5
plants	monocots	Poaceae	*Triodia pungens*			C		13/13
plants	monocots	Poaceae	*Eragrostis minor*	smaller stinkgrass	Y			3/3
plants	monocots	Poaceae	*Eragrostis olida*			C		2/2
plants	monocots	Poaceae	*Polytrias indica*		Y			1/1
plants	monocots	Poaceae	*Themeda triandra*	kangaroo grass		C		5/5
plants	monocots	Poaceae	*Triraphis mollis*	purple plumegrass		C		1/1
plants	monocots	Poaceae	*Acrachne racemosa*			C		2/2
plants	monocots	Poaceae	*Aristida contorta*	bunched kerosene grass		C		3/3
plants	monocots	Poaceae	*Aristida pruinosa*			C		3/3
plants	monocots	Poaceae	*Cenchrus robustus*			C		1/1
plants	monocots	Poaceae	*Chloris pectinata*	comb chloris		C		1/1
plants	monocots	Poaceae	*Digitaria brownii*			C		5/5
plants	monocots	Poaceae	*Digitaria gibbosa*			C		3/3
plants	monocots	Poaceae	*Mnesithea formosa*			C		7/7
plants	monocots	Poaceae	*Paspalidium rarum*			C		2/2
plants	monocots	Poaceae	*Setaria apiculata*			C		1/1
plants	monocots	Poaceae	*Paspalidium constrictum*			C		1/1
plants	monocots	Poaceae	*Pseudoraphis spinescens*	spiny mudgrass		C		2/2
plants	monocots	Poaceae	*Schizachyrium perplexum*			C		3/3
plants	monocots	Poaceae	*Sporobolus actinocladus*	katoora grass		C		2/2
plants	monocots	Poaceae	*Cenchrus pennisetiformis*		Y			7/7
plants	monocots	Poaceae	*Enneapogon robustissimus*			C		4/4
plants	monocots	Poaceae	*Sporobolus australasicus*			C		3/3
plants	monocots	Poaceae	*Diplachne fusca var. fusca*			C		2/2
plants	monocots	Poaceae	*Eriochloa pseudoacrotricha*			C		1/1
plants	monocots	Poaceae	*Urochloa gilesii var. gilesii*			C		3/3
plants	monocots	Poaceae	*Cynodon dactylon var. dactylon*		Y			2/2
plants	monocots	Poaceae	*Megathyrsus maximus var. maximus*		Y			1/1
plants	monocots	Poaceae	*Aristida holathera var. holathera*			C		5/5
plants	monocots	Poaceae	*Eriachne pulchella subsp. dominii*			C		4/4
plants	monocots	Poaceae	*Bothriochloa bladhii subsp. bladhii*			C		4/4
plants	monocots	Poaceae	*Eriachne pulchella subsp. pulchella*			C		2/2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	monocots	Poaceae	*Megathyrsus maximus var. pubiglumis*		Y			1/1
plants	monocots	Poaceae	*Cynodon nlemfuensis var. nlemfuensis*		Y			3/3
plants	monocots	Poaceae	*Urochloa holosericea subsp. velutina*			C		1/1
plants	monocots	Poaceae	*Yakirra australiensis var. intermedia*			C		1/1
plants	monocots	Poaceae	*Panicum decompositum var. decompositum*			C		1/1
plants	monocots	Poaceae	*Yakirra australiensis var. australiensis*			C		1/1
plants	monocots	Poaceae	*Eriachne sp. (Dugald River B.K.Simon+ 3007)*			C		6/6
plants	monocots	Poaceae	*Eriachne mucronata forma (Alpha C.E.Hubbard 7882)*			C		6/6
plants	monocots	Poaceae	*Eriachne mucronata forma (Burnham R.W.Purdie 1370)*			C		8/8
plants	monocots	Poaceae	*Aristida polyclados*			C		2/2
plants	monocots	Poaceae	*Cymbopogon ambiguus*	lemon grass		C		3/3
plants	monocots	Poaceae	*Cymbopogon obtectus*			C		2/2
plants	monocots	Poaceae	*Digitaria ctenantha*			C		1/1
plants	monocots	Poaceae	*Enteropogon ramosus*			C		5/5
plants	monocots	Poaceae	*Eragrostis cumingii*			C		2/2
plants	monocots	Poaceae	*Eragrostis elongata*			C		7/7
plants	monocots	Poaceae	*Eragrostis speciosa*			C		5/5
plants	monocots	Poaceae	*Leptochloa digitata*			C		1/1
plants	monocots	Poaceae	*Oxychloris scariosa*	winged chloris		C		4/4
plants	monocots	Poaceae	*Panicum larcomianum*			C		1/1
plants	monocots	Poaceae	*Tragus australianus*	small burr grass		C		3/3
plants	monocots	Poaceae	*Triodia burbidgeana*			C		3/3
plants	monocots	Poaceae	*Aristida longicollis*			C		3/3
plants	monocots	Poaceae	*Bothriochloa pertusa*		Y			1/1
plants	monocots	Poaceae	*Brachyachne ciliaris*	hairy native couch		C		1/1
plants	monocots	Poaceae	*Dichanthium fecundum*	curly bluegrass		C		3/3
plants	monocots	Poaceae	*Enneapogon asperatus*			C		2/2
plants	monocots	Poaceae	*Enneapogon avenaceus*			C		1/1
plants	monocots	Poaceae	*Eragrostis tenellula*	delicate lovegrass		C		4/4
plants	monocots	Poaceae	*Eragrostis xerophila*			C		1/1
plants	monocots	Poaceae	*Sorghum arundinaceum*	Rhodesian Sudan grass	Y			1/1
plants	monocots	Poaceae	*Tripogon loliiformis*	five minute grass		C		1/1
plants	monocots	Poaceae	*Aristida biglandulosa*			C		3/3
plants	monocots	Poaceae	*Chrysopogon elongatus*			C		1/1
plants	monocots	Poaceae	*Cymbopogon bombycinus*	silky oilgrass		C		3/3
plants	monocots	Poaceae	*Dichanthium annulatum*	sheda grass	Y			1/1
plants	monocots	Poaceae	*Eragrostis desertorum*	woollybutt		C		3/3
plants	monocots	Poaceae	*Eragrostis lanicaulis*			C		1/1
plants	monocots	Poaceae	*Eragrostis leptocarpa*	drooping lovegrass		C		3/3
plants	monocots	Poaceae	*Sporobolus caroli*	fairy grass		C		1/1
plants	monocots	Poaceae	*Triodia basedowii*			C		1/1
plants	monocots	Poaceae	*Triodia bitextura*			C		6/6
plants	monocots	Poaceae	*Triodia brizoides*			C		10/10
plants	monocots	Poaceae	*Triodia longiceps*	giant grey spinifex		C		5/5
plants	monocots	Poaceae	*Urochloa piligera*			C		1/1
plants	monocots	Poaceae	*Xerochloa barbata*			C		4/4

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	monocots	Poaceae	*Aristida latifolia*	feathertop wiregrass		C		1/1
plants	monocots	Poaceae	*Aristida leptopoda*	white speargrass		C		1/1
plants	monocots	Poaceae	*Chrysopogon fallax*			C		1/1
plants	monocots	Poaceae	*Digitaria bicornis*			C		1/1
plants	monocots	Poaceae	*Echinochloa colona*	awnless barnyard grass	Y			1/1
plants	monocots	Poaceae	*Eriachne pulchella*			C		1/1
plants	monocots	Poaceae	*Paspalum distichum*	water couch		C		1/1
plants	monocots	Poaceae	*Setaria sphacelata*		Y			1/1
plants	monocots	Poaceae	*Triodia mitchellii*	buck spinifex		C		6/6
plants	monocots	Poaceae	*Yakirra pauciflora*			C		1/1
plants	monocots	Poaceae	*Heteropogon contortus*	black speargrass		C		2/2
plants	monocots	Poaceae	*Iseilema vaginiflorum*	red flinders grass		C		1/1
plants	monocots	Poaceae	*Schizachyrium fragile*	firegrass		C		2/2
plants	monocots	Poaceae	*Aristida inaequiglumis*			C		4/4
plants	monocots	Poaceae	*Bothriochloa ewartiana*	desert bluegrass		C		3/3
plants	monocots	Poaceae	*Enneapogon lindleyanus*			C		1/1
plants	monocots	Poaceae	*Enneapogon polyphyllus*	leafy nineawn		C		4/4
plants	monocots	Poaceae	*Eragrostis trichophora*		Y			1/1
plants	monocots	Poaceae	*Paraneurachne muelleri*			C		2/2
plants	monocots	Poaceae	*Paspalidium basicladum*			C		3/3
plants	monocots	Poaceae	*Urochloa mosambicensis*	sabi grass	Y			1/1
plants	monocots	Poaceae	*Urochloa subquadripara*		Y			1/1
plants	monocots	Poaceae	*Dactyloctenium radulans*	button grass		C		1/1
plants	monocots	Pontederiaceae	*Monochoria cyanea*			C		1/1
plants	monocots	Pontederiaceae	*Eichhornia crassipes*	water hyacinth	Y			1/1
plants	monocots	Potamogetonaceae	*Potamogeton tricarinatus*	floating pondweed		C		1/1
plants	monocots	Typhaceae	*Typha domingensis*			C		1/1
plants		Phrymaceae	*Glossostigma diandrum*			C		1/1
plants		Streptophyceae	*Chara vulgaris*			C		1/1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Defined Area
Species: All
Type: All
Status: All
Records: All
Date: All
Latitude: 20.4236 to 21.0048
Longitude: 140.5269 to 139.8569
Email: hdick@aarc.net.au
Date submitted: Tuesday 17 Jun 2014 16:44:59
Date extracted: Tuesday 17 Jun 2014 16:50:03

The number of records retrieved = 533

Disclaimer

As the DSITIA is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

The State of Queensland does not invite reliance upon, nor accept responsibility for this information. Persons should satisfy themselves through independent means as to the accuracy and completeness of this information.

No statements, representations or warranties are made about the accuracy or completeness of this information. The State of Queensland disclaims all responsibility for this information and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

Feedback about Wildlife Online should be emailed to wildlife.online@science.dsitia.qld.gov.au

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	amphibians	Bufonidae	*Rhinella marina*	cane toad	Y			2
animals	amphibians	Hylidae	*Litoria rubella*	ruddy treefrog		C		1
animals	amphibians	Hylidae	*Litoria caerulea*	common green treefrog		C		1
animals	amphibians	Hylidae	*Litoria electrica*	buzzing treefrog		C		1
animals	amphibians	Hylidae	*Cyclorana australis*	northern snapping frog		C		1
animals	amphibians	Hylidae	*Cyclorana cultripes*	grassland collared frog		C		1
animals	amphibians	Hylidae	*Litoria inermis*	bumpy rocketfrog		C		1
animals	amphibians	Hylidae	*Cyclorana brevipes*	superb collared frog		C		2/1
animals	amphibians	Myobatrachidae	*Uperoleia trachyderma*	orange shouldered gungan		C		1
animals	birds	Acanthizidae	*Smicrornis brevirostris*	weebill		C		71
animals	birds	Acanthizidae	*Gerygone fusca*	western gerygone		C		1
animals	birds	Acanthizidae	*Acanthiza chrysorrhoa*	yellow-rumped thornbill		C		23
animals	birds	Accipitridae	*Pandion cristatus*	eastern osprey		SL		1
animals	birds	Accipitridae	*Aquila audax*	wedge-tailed eagle		C		28
animals	birds	Accipitridae	*Milvus migrans*	black kite		C		113
animals	birds	Accipitridae	*Elanus axillaris*	black-shouldered kite		C		2
animals	birds	Accipitridae	*Hamirostra melanosternon*	black-breasted buzzard		C		2
animals	birds	Accipitridae	*Circus approximans*	swamp harrier		C		1
animals	birds	Accipitridae	*Accipiter fasciatus*	brown goshawk		C		12
animals	birds	Accipitridae	*Haliastur sphenurus*	whistling kite		C		95
animals	birds	Accipitridae	*Haliaeetus leucogaster*	white-bellied sea-eagle		SL		14
animals	birds	Accipitridae	*Hieraaetus morphnoides*	little eagle		C		2
animals	birds	Accipitridae	*Accipiter cirrocephalus*	collared sparrowhawk		C		7
animals	birds	Acrocephalidae	*Acrocephalus australis*	Australian reed-warbler		SL		6
animals	birds	Aegothelidae	*Aegotheles cristatus*	Australian owlet-nightjar		C		8/1
animals	birds	Alaudidae	*Mirafra javanica*	Horsfield's bushlark		C		2
animals	birds	Anatidae	*Anas rhynchotis*	Australasian shoveler		C		1
animals	birds	Anatidae	*Aythya australis*	hardhead		C		60
animals	birds	Anatidae	*Anas superciliosa*	Pacific black duck		C		64
animals	birds	Anatidae	*Dendrocygna eytoni*	plumed whistling-duck		C		4
animals	birds	Anatidae	*Nettapus pulchellus*	green pygmy-goose		C		1
animals	birds	Anatidae	*Malacorhynchus membranaceus*	pink-eared duck		C		20
animals	birds	Anatidae	*Anas gracilis*	grey teal		C		51
animals	birds	Anatidae	*Cygnus atratus*	black swan		C		1
animals	birds	Anatidae	*Chenonetta jubata*	Australian wood duck		C		6
animals	birds	Anhingidae	*Anhinga novaehollandiae*	Australasian darter		C		75
animals	birds	Apodidae	*Apus pacificus*	fork-tailed swift		SL		1
animals	birds	Ardeidae	*Ardea modesta*	eastern great egret		SL		58
animals	birds	Ardeidae	*Egretta garzetta*	little egret		C		12
animals	birds	Ardeidae	*Ixobrychus flavicollis*	black bittern		C		2
animals	birds	Ardeidae	*Nycticorax caledonicus*	Nankeen night-heron		C		21
animals	birds	Ardeidae	*Egretta novaehollandiae*	white-faced heron		C		60
animals	birds	Ardeidae	*Ardea ibis*	cattle egret		SL		3
animals	birds	Ardeidae	*Ardea pacifica*	white-necked heron		C		57
animals	birds	Ardeidae	*Ardea intermedia*	intermediate egret		C		36
animals	birds	Artamidae	*Cracticus tibicen*	Australian magpie		C		55

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Artamidae	*Artamus personatus*	masked woodswallow		C		3
animals	birds	Artamidae	*Strepera graculina*	pied currawong		C		1
animals	birds	Artamidae	*Artamus cyanopterus*	dusky woodswallow		C		1
animals	birds	Artamidae	*Artamus cinereus*	black-faced woodswallow		C		63
animals	birds	Artamidae	*Artamus leucorynchus*	white-breasted woodswallow		C		22
animals	birds	Artamidae	*Artamus superciliosus*	white-browed woodswallow		C		5
animals	birds	Artamidae	*Cracticus nigrogularis*	pied butcherbird		C		65
animals	birds	Artamidae	*Artamus minor*	little woodswallow		C		29
animals	birds	Artamidae	*Cracticus torquatus*	grey butcherbird		C		2
animals	birds	Burhinidae	*Burhinus grallarius*	bush stone-curlew		C		1
animals	birds	Cacatuidae	*Cacatua galerita*	sulphur-crested cockatoo		C		46
animals	birds	Cacatuidae	*Cacatua sanguinea*	little corella		C		36/1
animals	birds	Cacatuidae	*Nymphicus hollandicus*	cockatiel		C		44
animals	birds	Cacatuidae	*Eolophus roseicapillus*	galah		C		72
animals	birds	Campephagidae	*Lalage sueurii*	white-winged triller		C		33
animals	birds	Campephagidae	*Coracina novaehollandiae*	black-faced cuckoo-shrike		C		66
animals	birds	Campephagidae	*Coracina papuensis*	white-bellied cuckoo-shrike		C		3
animals	birds	Campephagidae	*Coracina maxima*	ground cuckoo-shrike		C		4
animals	birds	Casuariidae	*Dromaius novaehollandiae*	emu		C		7
animals	birds	Charadriidae	*Vanellus miles*	masked lapwing		C		40
animals	birds	Charadriidae	*Elseyornis melanops*	black-fronted dotterel		C		48
animals	birds	Charadriidae	*Erythrogonys cinctus*	red-kneed dotterel		C		8
animals	birds	Charadriidae	*Vanellus miles miles*	masked lapwing (northern subspecies)		C		18
animals	birds	Charadriidae	*Charadrius ruficapillus*	red-capped plover		C		1
animals	birds	Ciconiidae	*Ephippiorhynchus asiaticus*	black-necked stork		NT		13
animals	birds	Cisticolidae	*Cisticola exilis*	golden-headed cisticola		C		1
animals	birds	Climacteridae	*Climacteris melanura*	black-tailed treecreeper		C		41/2
animals	birds	Columbidae	*Geophaps plumifera*	spinifex pigeon		C		34/1
animals	birds	Columbidae	*Geopelia striata*	peaceful dove		C		96
animals	birds	Columbidae	*Phaps histrionica*	flock bronzewing		C		1/1
animals	birds	Columbidae	*Phaps chalcoptera*	common bronzewing		C		25
animals	birds	Columbidae	*Ocyphaps lophotes*	crested pigeon		C		46
animals	birds	Columbidae	*Geopelia humeralis*	bar-shouldered dove		C		2
animals	birds	Columbidae	*Geopelia cuneata*	diamond dove		C		50
animals	birds	Columbidae	*Columba livia*	rock dove	Y			5
animals	birds	Coraciidae	*Eurystomus orientalis*	dollarbird		C		3
animals	birds	Corcoracidae	*Struthidea cinerea*	apostlebird		C		18
animals	birds	Corvidae	*Corvus orru*	Torresian crow		C		18
animals	birds	Corvidae	*Corvus bennetti*	little crow		C		4
animals	birds	Corvidae	*Corvus coronoides*	Australian raven		C		83/1
animals	birds	Corvidae	*Corvus sp.*					13
animals	birds	Cuculidae	*Eudynamys orientalis*	eastern koel		C		2
animals	birds	Cuculidae	*Cacomantis variolosus*	brush cuckoo		C		1
animals	birds	Cuculidae	*Centropus phasianinus*	pheasant coucal		C		9
animals	birds	Cuculidae	*Scythrops novaehollandiae*	channel-billed cuckoo		C		1
animals	birds	Cuculidae	*Chalcites basalis*	Horsfield's bronze-cuckoo		C		4

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Cuculidae	*Chalcites osculans*	black-eared cuckoo		C		1
animals	birds	Cuculidae	*Cacomantis pallidus*	pallid cuckoo		C		3
animals	birds	Estrildidae	*Taeniopygia guttata*	zebra finch		C		78
animals	birds	Estrildidae	*Poephila acuticauda*	long-tailed finch		C		13
animals	birds	Estrildidae	*Emblema pictum*	painted finch		C		25
animals	birds	Estrildidae	*Taeniopygia bichenovii*	double-barred finch		C		53
animals	birds	Estrildidae	*Neochmia ruficauda*	star finch		C		2
animals	birds	Estrildidae	*Heteromunia pectoralis*	pictorella mannikin		NT		4
animals	birds	Estrildidae	*Lonchura castaneothorax*	chestnut-breasted mannikin		C		2
animals	birds	Estrildidae	*Erythrura gouldiae*	Gouldian finch		E	E	1
animals	birds	Eurostopodidae	*Eurostopodus argus*	spotted nightjar		C		3
animals	birds	Falconidae	*Falco subniger*	black falcon		C		2
animals	birds	Falconidae	*Falco hypoleucos*	grey falcon		NT		2
animals	birds	Falconidae	*Falco berigora*	brown falcon		C		24/1
animals	birds	Falconidae	*Falco peregrinus*	peregrine falcon		C		1
animals	birds	Falconidae	*Falco cenchroides*	Nankeen kestrel		C		14
animals	birds	Falconidae	*Falco longipennis*	Australian hobby		C		8
animals	birds	Glareolidae	*Stiltia isabella*	Australian pratincole		C		5
animals	birds	Gruidae	*Grus rubicunda*	brolga		C		28
animals	birds	Halcyonidae	*Todiramphus sanctus*	sacred kingfisher		C		24
animals	birds	Halcyonidae	*Dacelo leachii*	blue-winged kookaburra		C		35
animals	birds	Halcyonidae	*Todiramphus pyrrhopygius*	red-backed kingfisher		C		14
animals	birds	Hirundinidae	*Hirundo neoxena*	welcome swallow		C		7
animals	birds	Hirundinidae	*Hirundo sp.*					5
animals	birds	Hirundinidae	*Petrochelidon ariel*	fairy martin		C		32
animals	birds	Hirundinidae	*Petrochelidon nigricans*	tree martin		C		10
animals	birds	Hirundinidae	*Cheramoeca leucosterna*	white-backed swallow		C		2
animals	birds	Jacanidae	*Irediparra gallinacea*	comb-crested jacana		C		5
animals	birds	Laridae	*Gelochelidon nilotica*	gull-billed tern		C		2
animals	birds	Laridae	*Chlidonias hybrida*	whiskered tern		C		4
animals	birds	Laridae	*Hydroprogne caspia*	Caspian tern		SL		39
animals	birds	Laridae	*Chroicocephalus novaehollandiae*	silver gull		C		19
animals	birds	Maluridae	*Malurus melanocephalus*	red-backed fairy-wren		C		7
animals	birds	Maluridae	*Malurus leucopterus*	white-winged fairy-wren		C		2
animals	birds	Maluridae	*Amytornis ballarae*	Kalkadoon grasswren		C		13
animals	birds	Maluridae	*Malurus lamberti*	variegated fairy-wren		C		29
animals	birds	Megaluridae	*Eremiornis carteri*	spinifexbird		C		4
animals	birds	Megaluridae	*Megalurus gramineus*	little grassbird		C		1
animals	birds	Megaluridae	*Cincloramphus cruralis*	brown songlark		C		4
animals	birds	Megaluridae	*Cincloramphus mathewsi*	rufous songlark		C		10
animals	birds	Meliphagidae	*Certhionyx variegatus*	pied honeyeater		C		1
animals	birds	Meliphagidae	*Philemon citreogularis*	little friarbird		C		37
animals	birds	Meliphagidae	*Ptilotula penicillatus*	white-plumed honeyeater		C		125/1
animals	birds	Meliphagidae	*Conopophila rufogularis*	rufous-throated honeyeater		C		20
animals	birds	Meliphagidae	*Acanthagenys rufogularis*	spiny-cheeked honeyeater		C		7
animals	birds	Meliphagidae	*Melithreptus albogularis*	white-throated honeyeater		C		4

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Meliphagidae	*Melithreptus gularis laetior*	golden-backed honeyeater		NT		1
animals	birds	Meliphagidae	*Epthianura aurifrons*	orange chat		C		11
animals	birds	Meliphagidae	*Cissomela pectoralis*	banded honeyeater		C		3
animals	birds	Meliphagidae	*Gavicalis virescens*	singing honeyeater		C		19
animals	birds	Meliphagidae	*Epthianura tricolor*	crimson chat		C		20
animals	birds	Meliphagidae	*Ptilotula plumulus*	grey-fronted honeyeater		C		21
animals	birds	Meliphagidae	*Manorina flavigula*	yellow-throated miner		C		76
animals	birds	Meliphagidae	*Grantiella picta*	painted honeyeater		V		5
animals	birds	Meliphagidae	*Sugomel niger*	black honeyeater		C		4
animals	birds	Meliphagidae	*Ptilotula keartlandi*	grey-headed honeyeater		C		38
animals	birds	Meliphagidae	*Ptilotula flavescens*	yellow-tinted honeyeater		C		6
animals	birds	Meliphagidae	*Lichmera indistincta*	brown honeyeater		C		92
animals	birds	Meliphagidae	*Melithreptus gularis*	black-chinned honeyeater		NT		7
animals	birds	Meliphagidae	*Philemon argenticeps*	silver-crowned friarbird		C		10
animals	birds	Meropidae	*Merops ornatus*	rainbow bee-eater		SL		76
animals	birds	Monarchidae	*Myiagra inquieta*	restless flycatcher		C		40
animals	birds	Monarchidae	*Grallina cyanoleuca*	magpie-lark		C		139
animals	birds	Motacillidae	*Anthus novaeseelandiae*	Australasian pipit		C		14
animals	birds	Nectariniidae	*Dicaeum hirundinaceum*	mistletoebird		C		42
animals	birds	Neosittidae	*Daphoenositta chrysoptera*	varied sittella		C		3
animals	birds	Oriolidae	*Oriolus sagittatus*	olive-backed oriole		C		18
animals	birds	Otididae	*Ardeotis australis*	Australian bustard		C		7
animals	birds	Pachycephalidae	*Colluricincla harmonica*	grey shrike-thrush		C		44
animals	birds	Pachycephalidae	*Oreoica gutturalis*	crested bellbird		C		9
animals	birds	Pachycephalidae	*Pachycephala rufiventris*	rufous whistler		C		54
animals	birds	Pardalotidae	*Pardalotus rubricatus*	red-browed pardalote		C		24
animals	birds	Pardalotidae	*Pardalotus striatus*	striated pardalote		C		74
animals	birds	Passeridae	*Passer domesticus*	house sparrow	Y			14
animals	birds	Pelecanidae	*Pelecanus conspicillatus*	Australian pelican		C		54
animals	birds	Petroicidae	*Petroica goodenovii*	red-capped robin		C		6/1
animals	birds	Petroicidae	*Melanodryas cucullata*	hooded robin		C		4
animals	birds	Petroicidae	*Microeca fascinans*	jacky winter		C		42
animals	birds	Phalacrocoracidae	*Phalacrocorax sulcirostris*	little black cormorant		C		48
animals	birds	Phalacrocoracidae	*Microcarbo melanoleucos*	little pied cormorant		C		57
animals	birds	Phalacrocoracidae	*Phalacrocorax varius*	pied cormorant		C		14
animals	birds	Phalacrocoracidae	*Phalacrocorax carbo*	great cormorant		C		25
animals	birds	Phasianidae	*Coturnix ypsilophora*	brown quail		C		5
animals	birds	Podargidae	*Podargus strigoides*	tawny frogmouth		C		6
animals	birds	Podicipedidae	*Podiceps cristatus*	great crested grebe		C		42
animals	birds	Podicipedidae	*Poliocephalus poliocephalus*	hoary-headed grebe		C		6
animals	birds	Podicipedidae	*Tachybaptus novaehollandiae*	Australasian grebe		C		76
animals	birds	Pomatostomidae	*Pomatostomus temporalis*	grey-crowned babbler		C		83
animals	birds	Psittacidae	*Polytelis alexandrae*	princess parrot		C	V	1
animals	birds	Psittacidae	*Melopsittacus undulatus*	budgerigar		C		40
animals	birds	Psittacidae	*Psitteuteles versicolor*	varied lorikeet		C		67
animals	birds	Psittacidae	*Barnardius zonarius*	Australian ringneck		C		36

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Psittacidae	*Barnardius zonarius macgillivrayi*	Cloncurry parrot		C		24/14
animals	birds	Psittacidae	*Aprosmictus erythropterus*	red-winged parrot		C		59/3
animals	birds	Ptilonorhynchidae	*Ptilonorhynchus maculatus*	spotted bowerbird		C		64
animals	birds	Ptilonorhynchidae	*Ptilonorhynchus nuchalis*	great bowerbird		C		8
animals	birds	Rallidae	*Porphyrio porphyrio*	purple swamphen		C		2
animals	birds	Rallidae	*Tribonyx ventralis*	black-tailed native-hen		C		1
animals	birds	Rallidae	*Gallinula tenebrosa*	dusky moorhen		C		11
animals	birds	Rallidae	*Fulica atra*	Eurasian coot		C		18
animals	birds	Recurvirostridae	*Himantopus himantopus*	black-winged stilt		C		52
animals	birds	Recurvirostridae	*Recurvirostra novaehollandiae*	red-necked avocet		C		2
animals	birds	Rhipiduridae	*Rhipidura leucophrys*	willie wagtail		C		149
animals	birds	Rhipiduridae	*Rhipidura albiscapa*	grey fantail		C		4
animals	birds	Scolopacidae	*Tringa nebularia*	common greenshank		SL		1
animals	birds	Scolopacidae	*Tringa stagnatilis*	marsh sandpiper		SL		1
animals	birds	Strigidae	*Ninox boobook*	southern boobook		C		6
animals	birds	Threskiornithidae	*Platalea regia*	royal spoonbill		C		5
animals	birds	Threskiornithidae	*Threskiornis molucca*	Australian white ibis		C		15
animals	birds	Threskiornithidae	*Platalea flavipes*	yellow-billed spoonbill		C		1
animals	birds	Threskiornithidae	*Threskiornis spinicollis*	straw-necked ibis		C		33
animals	birds	Threskiornithidae	*Plegadis falcinellus*	glossy ibis		SL		6
animals	birds	Turnicidae	*Turnix velox*	little button-quail		C		2
animals	insects	Lycaenidae	*Theclinesthes miskini miskini*	wattle blue (Australian subspecies)				1
animals	insects	Nymphalidae	*Euploea core corinna*	common crow				1
animals	insects	Nymphalidae	*Junonia villida calybe*	meadow argus				1
animals	insects	Nymphalidae	*Hypolimnas bolina nerina*	varied eggfly				1
animals	insects	Papilionidae	*Papilio aegeus aegeus*	orchard swallowtail (Australian subspecies)				1
animals	insects	Papilionidae	*Papilio demoleus sthenelus*	chequered swallowtail				1
animals	malacostracans	Parastacidae	*Cherax quadricarinatus*	redclaw				1
animals	mammals	Bovidae	*Bos sp.*	cattle	Y			1
animals	mammals	Emballonuridae	*Taphozous georgianus*	common sheathtail bat		C		1
animals	mammals	Emballonuridae	*Taphozous troughtoni*	Troughton's sheathtail bat		C		1/1
animals	mammals	Macropodidae	*Lagorchestes conspicillatus*	spectacled hare-wallaby		C		2
animals	mammals	Macropodidae	*Petrogale purpureicollis*	purple-necked rock-wallaby		V		9/1
animals	mammals	Macropodidae	*Macropus robustus*	common wallaroo		C		4
animals	mammals	Macropodidae	*Macropus rufus*	red kangaroo		C		1
animals	mammals	Macropodidae	*Macropus agilis*	agile wallaby		C		2
animals	mammals	Muridae	*Pseudomys johnsoni*			C		9
animals	mammals	Muridae	*Zyzomys argurus*	common rock-rat		C		3
animals	mammals	Pteropodidae	*Pteropus scapulatus*	little red flying-fox		C		1
animals	mammals	Tachyglossidae	*Tachyglossus aculeatus*	short-beaked echidna		SL		1
animals	mammals	Vespertilionidae	*Chalinolobus gouldii*	Gould's wattled bat		C		1
animals	mammals	Vespertilionidae	*Vespadelus finlaysoni*	Finlayson's cave bat		C		1/1
animals	ray-finned fishes	Ambassidae	*Ambassis macleayi*	Macleay's glassfish				14
animals	ray-finned fishes	Ambassidae	*Ambassis species*	northwest glassfish				27
animals	ray-finned fishes	Ambassidae	*Parambassis gulliveri*	giant glassfish				5

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	ray-finned fishes	Ambassidae	*Ambassis sp.*					31
animals	ray-finned fishes	Ariidae	*Neoarius leptaspis*	boofhead catfish				2
animals	ray-finned fishes	Centropomidae	*Lates calcarifer*	barramundi				23
animals	ray-finned fishes	Clupeidae	*Nematalosa erebi*	bony bream				706
animals	ray-finned fishes	Eleotridae	*Oxyeleotris selheimi*	blackbanded gudgeon				186
animals	ray-finned fishes	Eleotridae	*Oxyeleotris lineolata*	sleepy cod				22
animals	ray-finned fishes	Gobiidae	*Glossogobius aureus*	golden flathead goby				6
animals	ray-finned fishes	Gobiidae	*Glossogobius giuris*	tank goby				1
animals	ray-finned fishes	Melanotaeniidae	*Melanotaenia splendida inornata*	checkered rainbowfish				456
animals	ray-finned fishes	Plotosidae	*Anodontiglanis dahli*	toothless catfish				1
animals	ray-finned fishes	Terapontidae	*Leiopotherapon unicolor*	spangled perch				137
animals	ray-finned fishes	Terapontidae	*Hephaestus fuliginosus*	sooty grunter				21
animals	ray-finned fishes	Terapontidae	*Amniataba percoides*	barred grunter				202
animals	ray-finned fishes	Terapontidae	*Scortum ogilbyi*	Gulf grunter				1
animals	reptiles	Agamidae	*Ctenophorus caudicinctus*	ring-tailed dragon		C		1
animals	reptiles	Agamidae	*Pogona vitticeps*			C		3/1
animals	reptiles	Agamidae	*Amphibolurus gilberti*	Gilbert's dragon		C		3/2
animals	reptiles	Agamidae	*Tympanocryptis lineata*	lined earless dragon		C		1
animals	reptiles	Boidae	*Antaresia stimsoni*	Stimson's python		C		1
animals	reptiles	Boidae	*Aspidites melanocephalus*	black-headed python		C		1
animals	reptiles	Diplodactylidae	*Strophurus ciliaris*	spiny-tailed gecko		C		1/1
animals	reptiles	Elapidae	*Suta suta*	myall snake		C		1/1
animals	reptiles	Elapidae	*Pseudonaja nuchalis sensu lato*	western brown snake		C		1
animals	reptiles	Gekkonidae	*Heteronotia binoei*	Bynoe's gecko		C		2/1
animals	reptiles	Gekkonidae	*Gehyra versicolor*			C		2/2
animals	reptiles	Gekkonidae	*Gehyra robusta*			C		1
animals	reptiles	Pygopodidae	*Lialis burtonis*	Burton's legless lizard		C		2
animals	reptiles	Pygopodidae	*Delma nasuta*	sharp-snouted legless lizard		C		2
animals	reptiles	Pygopodidae	*Delma borea*			C		1
animals	reptiles	Pygopodidae	*Pygopus steelescotti*	northern hooded scaly-foot		C		1/1
animals	reptiles	Scincidae	*Cryptoblepharus plagiocephalus sensu lato*			C		1/1
animals	reptiles	Scincidae	*Tiliqua multifasciata*	Centralian blue-tongued lizard		C		3/2
animals	reptiles	Scincidae	*Tiliqua scincoides*	eastern blue-tongued lizard		C		1/1
animals	reptiles	Scincidae	*Ctenotus lateralis*			C		1
animals	reptiles	Scincidae	*Ctenotus hebetior*			C		1/1
animals	reptiles	Scincidae	*Egernia hosmeri*	Hosmer's skink		C		3/2
animals	reptiles	Varanidae	*Varanus mertensi*	Mertens' water monitor		C		1
animals	uncertain	Indeterminate	*Indeterminate*	Unknown or Code Pending		C		1
fungi	club fungi	Basidiomycota	*Polyporus*			C		1/1
fungi	sac fungi	Physciaceae	*Dirinaria confluens*			C		1/1
plants	ferns	Adiantaceae	*Cheilanthes brownii*			C		1/1
plants	ferns	Adiantaceae	*Cheilanthes nudiuscula*			C		1/1
plants	ferns	Adiantaceae	*Cheilanthes sieberi subsp. pseudovellea*			C		1/1
plants	ferns	Salviniaceae	*Salvinia molesta*	salvinia	Y			1/1
plants	higher dicots	Aizoaceae	*Trianthema triquetra*	red spinach		C		1/1
plants	higher dicots	Amaranthaceae	*Alternanthera denticulata*	lesser joyweed		C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Amaranthaceae	*Aerva javanica*		Y			9/9
plants	higher dicots	Amaranthaceae	*Gomphrena arida*			C		2/2
plants	higher dicots	Amaranthaceae	*Gomphrena lanata*			C		1/1
plants	higher dicots	Amaranthaceae	*Ptilotus incanus*			C		2/2
plants	higher dicots	Amaranthaceae	*Ptilotus obovatus*			C		2/2
plants	higher dicots	Amaranthaceae	*Ptilotus spicatus*			C		1/1
plants	higher dicots	Amaranthaceae	*Achyranthes aspera*			C		1/1
plants	higher dicots	Amaranthaceae	*Alternanthera nana*	hairy joyweed		C		1/1
plants	higher dicots	Amaranthaceae	*Ptilotus leucocoma*			C		1/1
plants	higher dicots	Amaranthaceae	*Ptilotus fusiformis*			C		2/2
plants	higher dicots	Amaranthaceae	*Ptilotus schwartzii*			C		1/1
plants	higher dicots	Amaranthaceae	*Amaranthus undulatus*			C		2/2
plants	higher dicots	Amaranthaceae	*Ptilotus maconochiei*			NT		1/1
plants	higher dicots	Amaranthaceae	*Gomphrena celosioides*	gomphrena weed	Y			1/1
plants	higher dicots	Amaranthaceae	*Ptilotus sessilifolius*			C		1/1
plants	higher dicots	Amaranthaceae	*Alternanthera angustifolia*			C		1/1
plants	higher dicots	Apocynaceae	*Cryptostegia grandiflora*	rubber vine	Y			1/1
plants	higher dicots	Apocynaceae	*Sarcostemma brevipedicellatum*			C		1/1
plants	higher dicots	Apocynaceae	*Carissa lanceolata*			C		2/2
plants	higher dicots	Apocynaceae	*Calotropis procera*		Y			3/3
plants	higher dicots	Asteraceae	*Rhodanthe microglossa*	clustered sunray		C		1/1
plants	higher dicots	Asteraceae	*Streptoglossa bubakii*			C		1/1
plants	higher dicots	Asteraceae	*Acanthospermum hispidum*	star burr	Y			1/1
plants	higher dicots	Asteraceae	*Pterocaulon sphacelatum*	applebush		C		1/1
plants	higher dicots	Asteraceae	*Streptoglossa decurrens*			C		3/3
plants	higher dicots	Asteraceae	*Apowollastonia cylindrica*			C		1/1
plants	higher dicots	Asteraceae	*Blumea tenella*			C		1/1
plants	higher dicots	Asteraceae	*Pterocaulon serrulatum var. velutinum*			C		1/1
plants	higher dicots	Asteraceae	*Pterocaulon serrulatum var. serrulatum*			C		2/2
plants	higher dicots	Asteraceae	*Rutidosis helichrysoides subsp. acutiglumis*			C		1/1
plants	higher dicots	Asteraceae	*Peripleura obovata*			C		1/1
plants	higher dicots	Asteraceae	*Eclipta prostrata*	white eclipta		C		1/1
plants	higher dicots	Asteraceae	*Glossocardia*			C		1/1
plants	higher dicots	Asteraceae	*Pseudognaphalium luteoalbum*	Jersey cudweed		C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium haesum*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium conocarpum*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium styotrichum*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium cunninghamii*			C		4/4
plants	higher dicots	Boraginaceae	*Trichodesma zeylanicum var. zeylanicum*			C		2/2
plants	higher dicots	Boraginaceae	*Heliotropium ballii*			C		2/2
plants	higher dicots	Byttneriaceae	*Melochia pyramidata*		Y			1/1
plants	higher dicots	Cactaceae	*Cylindropuntia fulgida var. mamillata*		Y			1/1
plants	higher dicots	Caesalpiniaceae	*Lysiphyllum cunninghamii*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Petalostylis cassioides*			C		4/4
plants	higher dicots	Caesalpiniaceae	*Senna planitiicola*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Senna notabilis*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Caesalpiniaceae	*Senna venusta*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Senna glutinosa subsp. pruinosa*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Senna artemisioides subsp. helmsii*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Senna artemisioides subsp. sturtii*			C		1/1
plants	higher dicots	Campanulaceae	*Lobelia arnhemiaca*			C		1/1
plants	higher dicots	Caryophyllaceae	*Polycarpaea breviflora*			C		1/1
plants	higher dicots	Caryophyllaceae	*Polycarpaea spirostylis subsp. glabra*			C		2/2
plants	higher dicots	Chenopodiaceae	*Salsola australis*			C		1/1
plants	higher dicots	Chenopodiaceae	*Einadia nutans*			C		2/2
plants	higher dicots	Chenopodiaceae	*Dysphania rhadinostachya subsp. rhadinostachya*			C		2/2
plants	higher dicots	Cleomaceae	*Cleome viscosa*	tick-weed		C		2/2
plants	higher dicots	Combretaceae	*Terminalia aridicola subsp. aridicola*			C		1/1
plants	higher dicots	Convolvulaceae	*Ipomoea muelleri*	poison morning-glory		C		2/2
plants	higher dicots	Convolvulaceae	*Ipomoea coptica*			C		1/1
plants	higher dicots	Convolvulaceae	*Polymeria longifolia*	polymeria		C		1/1
plants	higher dicots	Convolvulaceae	*Operculina aequisepala*			C		2/2
plants	higher dicots	Convolvulaceae	*Bonamia media var. media*			C		1/1
plants	higher dicots	Convolvulaceae	*Evolvulus alsinoides var. decumbens*			C		1/1
plants	higher dicots	Convolvulaceae	*Ipomoea nil*		Y			1/1
plants	higher dicots	Convolvulaceae	*Bonamia media*			C		1/1
plants	higher dicots	Cucurbitaceae	*Momordica balsamina*	balsam apple	Y			3/3
plants	higher dicots	Ebenaceae	*Diospyros humilis*	small-leaved ebony		C		1/1
plants	higher dicots	Elatinaceae	*Bergia trimera*			C		1/1
plants	higher dicots	Euphorbiaceae	*Euphorbia tannensis subsp. eremophila*			C		1/1
plants	higher dicots	Euphorbiaceae	*Euphorbia biconvexa*			C		1/1
plants	higher dicots	Euphorbiaceae	*Jatropha gossypiifolia*	bellyache bush	Y			2/2
plants	higher dicots	Euphorbiaceae	*Euphorbia australis var. subtomentosa*			C		2/2
plants	higher dicots	Fabaceae	*Indigofera hirsuta*	hairy indigo		C		1/1
plants	higher dicots	Fabaceae	*Cullen pustulatum*			C		1/1
plants	higher dicots	Fabaceae	*Cullen balsamicum*			C		5/5
plants	higher dicots	Fabaceae	*Cajanus pubescens*			C		2/2
plants	higher dicots	Fabaceae	*Vigna lanceolata*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia virens*			C		1/1
plants	higher dicots	Fabaceae	*Swainsona burkei*			C		2/2
plants	higher dicots	Fabaceae	*Glycine falcata*			C		2/2
plants	higher dicots	Fabaceae	*Indigofera linnaei*	Birdsville indigo		C		2/2
plants	higher dicots	Fabaceae	*Cajanus acutifolius*			C		2/2
plants	higher dicots	Fabaceae	*Cajanus lanuginosus*			C		3/3
plants	higher dicots	Fabaceae	*Alysicarpus muelleri*			C		1/1
plants	higher dicots	Fabaceae	*Crotalaria verrucosa*			C		1/1
plants	higher dicots	Fabaceae	*Indigofera pratensis*			C		4/4
plants	higher dicots	Fabaceae	*Galactia*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia lasiochlaena*			C		1/1
plants	higher dicots	Fabaceae	*Crotalaria novae-hollandiae subsp. novae-hollandiae*			C		2/2
plants	higher dicots	Fabaceae	*Tephrosia sp. (Musselbrook M.B.Thomas+ MRS472)*			C		3/3
plants	higher dicots	Fabaceae	*Tephrosia sp. (Adels Grove A.de Lestang 359)*			C		2/2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Fabaceae	*Tephrosia sp. (Magazine Hill P.Jones 365)*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia brachyodon var. longifolia*			C		4/4
plants	higher dicots	Fabaceae	*Crotalaria aridicola subsp. glabrata*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia rosea var. rosea*			C		1/1
plants	higher dicots	Fabaceae	*Rhynchosia minima var. australis*			C		1/1
plants	higher dicots	Fabaceae	*Vigna lanceolata var. lanceolata*			C		4/4
plants	higher dicots	Goodeniaceae	*Scaevola*			C		3/3
plants	higher dicots	Goodeniaceae	*Goodenia grandiflora*			C		1/1
plants	higher dicots	Goodeniaceae	*Goodenia fascicularis*			C		1/1
plants	higher dicots	Haloragaceae	*Myriophyllum verrucosum*	water milfoil		C		2/1
plants	higher dicots	Lamiaceae	*Clerodendrum floribundum*			C		1/1
plants	higher dicots	Lamiaceae	*Vitex benthamiana*			C		11/11
plants	higher dicots	Lamiaceae	*Mesosphaerum suaveolens*		Y			1/1
plants	higher dicots	Loranthaceae	*Lysiana subfalcata*			C		1/1
plants	higher dicots	Loranthaceae	*Decaisnina brittenii subsp. brittenii*			C		1/1
plants	higher dicots	Loranthaceae	*Lysiana spathulata subsp. spathulata*			C		3/3
plants	higher dicots	Loranthaceae	*Lysiana spathulata subsp. parvifolia*			C		1/1
plants	higher dicots	Loranthaceae	*Amyema sanguinea var. sanguinea*			C		1/1
plants	higher dicots	Lythraceae	*Ammannia multiflora*	jerry-jerry		C		2/1
plants	higher dicots	Malvaceae	*Abelmoschus ficulneus*	native rosella		C		1/1
plants	higher dicots	Malvaceae	*Hibiscus brachychlaenus*			C		1/1
plants	higher dicots	Malvaceae	*Hibiscus sturtii var. campylochlamys*			C		1/1
plants	higher dicots	Malvaceae	*Hibiscus meraukensis*	Merauke hibiscus		C		2/2
plants	higher dicots	Malvaceae	*Gossypium nelsonii*			C		1/1
plants	higher dicots	Malvaceae	*Gossypium australe*			C		2/2
plants	higher dicots	Malvaceae	*Hibiscus coatesii*			C		1/1
plants	higher dicots	Malvaceae	*Abutilon hannii*			C		2/2
plants	higher dicots	Malvaceae	*Sida fibulifera*			C		3/3
plants	higher dicots	Malvaceae	*Sida goniocarpa*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia hemsleyi*			C		3/3
plants	higher dicots	Mimosaceae	*Acacia tropica*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia acradenia*			C		4/4
plants	higher dicots	Mimosaceae	*Acacia monticola*			C		2/2
plants	higher dicots	Mimosaceae	*Prosopis pallida*		Y			1/1
plants	higher dicots	Mimosaceae	*Acacia chisholmii*			C		9/9
plants	higher dicots	Mimosaceae	*Acacia melleodora*			C		5/5
plants	higher dicots	Mimosaceae	*Acacia orthocarpa*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia tenuissima*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia phlebocarpa*			C		4/4
plants	higher dicots	Mimosaceae	*Acacia chippendalei*			C		1/1
plants	higher dicots	Mimosaceae	*Vachellia bidwillii*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia ancistrocarpa*			C		2/2
plants	higher dicots	Mimosaceae	*Neptunia dimorphantha*			C		1/1
plants	higher dicots	Mimosaceae	*Vachellia sutherlandii*			C		1/1
plants	higher dicots	Mimosaceae	*Neptunia gracilis forma gracilis*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia retivenea subsp. retivenea*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Mimosaceae	*Acacia victoriae subsp. fasciaria*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia limbata*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia salicina*	doolan		C		1/1
plants	higher dicots	Moraceae	*Ficus rubiginosa forma rubiginosa*			C		1/1
plants	higher dicots	Moraceae	*Ficus aculeata var. aculeata*			C		1/1
plants	higher dicots	Myrtaceae	*Lophostemon grandiflorus subsp. riparius*			C		2/2
plants	higher dicots	Myrtaceae	*Eucalyptus melanophloia subsp. nana*			C		2/2
plants	higher dicots	Myrtaceae	*Corymbia bella*			C		2/2
plants	higher dicots	Myrtaceae	*Corymbia aspera*			C		2/2
plants	higher dicots	Myrtaceae	*Melaleuca nervosa*			C		1/1
plants	higher dicots	Myrtaceae	*Corymbia terminalis*			C		3/3
plants	higher dicots	Myrtaceae	*Melaleuca bracteata*			C		3/2
plants	higher dicots	Myrtaceae	*Eucalyptus nudicaulis*			C		3/3
plants	higher dicots	Myrtaceae	*Melaleuca fluviatilis*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus leucophylla*			C		5/5
plants	higher dicots	Myrtaceae	*Melaleuca dissitiflora*			C		2/2
plants	higher dicots	Myrtaceae	*Melaleuca trichostachya*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus camaldulensis*			C		1
plants	higher dicots	Myrtaceae	*Lophostemon grandiflorus*			C		1
plants	higher dicots	Myrtaceae	*Eucalyptus pruinosa subsp. pruinosa*			C		1/1
plants	higher dicots	Nyctaginaceae	*Boerhavia schomburgkiana*			C		1/1
plants	higher dicots	Nyctaginaceae	*Boerhavia pubescens*			C		2/2
plants	higher dicots	Nyctaginaceae	*Boerhavia sp. (St George A.Hill AQ399299)*			C		1/1
plants	higher dicots	Pedaliaceae	*Josephinia eugeniae*	josephinia burr		C		1/1
plants	higher dicots	Pentapetaceae	*Melhania ovata*			C		1/1
plants	higher dicots	Phyllanthaceae	*Phyllanthus fuernrohrii*			C		1/1
plants	higher dicots	Phyllanthaceae	*Breynia oblongifolia*			C		1/1
plants	higher dicots	Phyllanthaceae	*Phyllanthus carpentariae*			C		1/1
plants	higher dicots	Phyllanthaceae	*Phyllanthus maderaspatensis*			C		1/1
plants	higher dicots	Plantaginaceae	*Stemodia viscosa*			C		3/3
plants	higher dicots	Polygonaceae	*Persicaria barbata*			C		2/1
plants	higher dicots	Portulacaceae	*Portulaca oligosperma*			C		1/1
plants	higher dicots	Portulacaceae	*Portulaca oleracea*	pigweed	Y			1/1
plants	higher dicots	Proteaceae	*Grevillea mimosoides*			C		1/1
plants	higher dicots	Proteaceae	*Hakea arborescens*			C		2/2
plants	higher dicots	Proteaceae	*Hakea lorea subsp. lorea*			C		4/4
plants	higher dicots	Rhamnaceae	*Alphitonia excelsa*	soap tree		C		1/1
plants	higher dicots	Rubiaceae	*Pavetta rupicola*			C		2/2
plants	higher dicots	Rubiaceae	*Kohautia australiensis*			C		1/1
plants	higher dicots	Rubiaceae	*Spermacoce auriculata*			C		1/1
plants	higher dicots	Santalaceae	*Santalum lanceolatum*			C		2/2
plants	higher dicots	Sapindaceae	*Dodonaea lanceolata var. lanceolata*			C		1/1
plants	higher dicots	Sapindaceae	*Dodonaea viscosa subsp. mucronata*			C		1/1
plants	higher dicots	Sapindaceae	*Dodonaea stenophylla*			C		1/1
plants	higher dicots	Scrophulariaceae	*Eremophila longifolia*	berrigan		C		1/1
plants	higher dicots	Scrophulariaceae	*Eremophila oppositifolia subsp. rubra*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Scrophulariaceae	*Eremophila latrobei subsp. latrobei*			C		3/3
plants	higher dicots	Solanaceae	*Solanum succosum*			C		2/2
plants	higher dicots	Solanaceae	*Solanum quadriloculatum*			C		4/4
plants	higher dicots	Solanaceae	*Solanum echinatum*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Triumfetta rupestris*			C		2/2
plants	higher dicots	Sparrmanniaceae	*Corchorus pumilio*			C		2/2
plants	higher dicots	Sparrmanniaceae	*Corchorus sericeus subsp. densiflorus*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Triumfetta marsupiata*			C		2/2
plants	higher dicots	Sterculiaceae	*Brachychiton collinus*			C		2/2
plants	higher dicots	Ulmaceae	*Trema tomentosa var. tomentosa*			C		1/1
plants	higher dicots	Ulmaceae	*Trema tomentosa*			C		1/1
plants	higher dicots	Verbenaceae	*Phyla nodiflora*	carpetweed		C		1/1
plants	higher dicots	Zygophyllaceae	*Tribulus cistoides*	bulls head vine		C		2/2
plants	higher dicots	Zygophyllaceae	*Tribulus terrestris*	caltrop		C		1/1
plants	higher dicots	Zygophyllaceae	*Tribulopis pentandra*			C		1/1
plants	lower dicots	Lauraceae	*Cassytha capillaris*			C		1/1
plants	monocots	Cyperaceae	*Cyperus brevifolius*	Mullumbimby couch	Y			1
plants	monocots	Cyperaceae	*Cyperus pulchellus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus vaginatus*			C		5/4
plants	monocots	Cyperaceae	*Cyperus difformis*	rice sedge		C		1/1
plants	monocots	Cyperaceae	*Cyperus rotundus*	nutgrass	Y			1/1
plants	monocots	Cyperaceae	*Cyperus iria*			C		1/1
plants	monocots	Cyperaceae	*Fimbristylis aestivalis*			C		1/1
plants	monocots	Najadaceae	*Najas tenuifolia*	water nymph		C		1/1
plants	monocots	Poaceae	*Themeda avenacea*			C		1/1
plants	monocots	Poaceae	*Themeda triandra*	kangaroo grass		C		2/2
plants	monocots	Poaceae	*Aristida pruinosa*			C		2/2
plants	monocots	Poaceae	*Digitaria brownii*			C		1/1
plants	monocots	Poaceae	*Mnesithea formosa*			C		1/1
plants	monocots	Poaceae	*Paspalidium rarum*			C		1/1
plants	monocots	Poaceae	*Triodia brizoides*			C		1/1
plants	monocots	Poaceae	*Triodia longiceps*	giant grey spinifex		C		1/1
plants	monocots	Poaceae	*Aristida latifolia*	feathertop wiregrass		C		1/1
plants	monocots	Poaceae	*Cenchrus setigerus*		Y			1/1
plants	monocots	Poaceae	*Chrysopogon fallax*			C		1/1
plants	monocots	Poaceae	*Echinochloa colona*	awnless barnyard grass	Y			2/1
plants	monocots	Poaceae	*Triodia mitchellii*	buck spinifex		C		1/1
plants	monocots	Poaceae	*Digitaria ctenantha*			C		2/2
plants	monocots	Poaceae	*Aristida longicollis*			C		2/2
plants	monocots	Poaceae	*Dichanthium fecundum*	curly bluegrass		C		4/4
plants	monocots	Poaceae	*Enneapogon asperatus*			C		3/3
plants	monocots	Poaceae	*Enneapogon nigricans*	niggerheads		C		1/1
plants	monocots	Poaceae	*Eragrostis basedowii*			C		1/1
plants	monocots	Poaceae	*Tripogon loliiformis*	five minute grass		C		1/1
plants	monocots	Poaceae	*Urochloa praetervisa*			C		1/1
plants	monocots	Poaceae	*Cymbopogon bombycinus*	silky oilgrass		C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	monocots	Poaceae	*Eragrostis leptocarpa*	drooping lovegrass		C		1/1
plants	monocots	Poaceae	*Heteropogon contortus*	black speargrass		C		2/2
plants	monocots	Poaceae	*Iseilema vaginiflorum*	red flinders grass		C		1/1
plants	monocots	Poaceae	*Bothriochloa ewartiana*	desert bluegrass		C		2/2
plants	monocots	Poaceae	*Enneapogon cylindricus*	jointed nineawn		C		1/1
plants	monocots	Poaceae	*Enneapogon eremophilus*			C		1/1
plants	monocots	Poaceae	*Enneapogon lindleyanus*			C		4/4
plants	monocots	Poaceae	*Enneapogon polyphyllus*	leafy nineawn		C		5/5
plants	monocots	Poaceae	*Paspalidium constrictum*			C		1/1
plants	monocots	Poaceae	*Pseudoraphis spinescens*	spiny mudgrass		C		1/1
plants	monocots	Poaceae	*Eriochloa pseudoacrotricha*			C		1/1
plants	monocots	Poaceae	*Urochloa gilesii var. gilesii*			C		1/1
plants	monocots	Poaceae	*Cynodon dactylon var. dactylon*		Y			1/1
plants	monocots	Poaceae	*Aristida holathera var. holathera*			C		1/1
plants	monocots	Poaceae	*Eriachne pulchella subsp. dominii*			C		1/1
plants	monocots	Poaceae	*Panicum decompositum var. tenuius*			C		1/1
plants	monocots	Poaceae	*Eriachne pulchella subsp. pulchella*			C		1/1
plants	monocots	Poaceae	*Eriachne mucronata forma (Alpha C.E.Hubbard 7882)*			C		2/2
plants	monocots	Poaceae	*Iseilema fragile*			C		1/1
plants	monocots	Poaceae	*Eragrostis olida*			C		1/1
plants	monocots	Poaceae	*Cynodon dactylon*		Y			1
plants	monocots	Poaceae	*Aristida exserta*			C		1/1
plants	monocots	Poaceae	*Triodia pungens*			C		3/3
plants	monocots	Poaceae	*Triodia molesta*			C		1/1
plants	monocots	Poaceae	*Sehima nervosum*			C		2/2
plants	monocots	Poaceae	*Eriachne obtusa*			C		1/1
plants	monocots	Poaceae	*Eulalia aurea*	silky browntop		C		2/2
plants	mosses	Bryophyte	*Bryophyte*			C		1/1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Queensland Government

Wildlife Online Extract

Search Criteria: Species List for a Defined Area
Species: All
Type: All
Status: All
Records: All
Date: All
Latitude: 19.7534 to 20.422
Longitude: 139.8376 to 139.2124
Email: hdick@aarc.net.au
Date submitted: Tuesday 17 Jun 2014 16:59:23
Date extracted: Tuesday 17 Jun 2014 17:00:15

The number of records retrieved = 475

Disclaimer

As the DSITIA is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

The State of Queensland does not invite reliance upon, nor accept responsibility for this information. Persons should satisfy themselves through independent means as to the accuracy and completeness of this information.

No statements, representations or warranties are made about the accuracy or completeness of this information. The State of Queensland disclaims all responsibility for this information and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

Feedback about Wildlife Online should be emailed to wildlife.online@science.dsitia.qld.gov.au

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	amphibians	Bufonidae	*Rhinella marina*	cane toad	Y			1/1
animals	amphibians	Myobatrachidae	*Uperoleia trachyderma*	orange shouldered gungan		C		1/1
animals	birds	Acanthizidae	*Smicrornis brevirostris*	weebill		C		89
animals	birds	Acanthizidae	*Acanthiza chrysorrhoa*	yellow-rumped thornbill		C		4
animals	birds	Acanthizidae	*Gerygone fusca*	western gerygone		C		1
animals	birds	Accipitridae	*Milvus migrans*	black kite		C		8
animals	birds	Accipitridae	*Accipiter cirrocephalus*	collared sparrowhawk		C		3
animals	birds	Accipitridae	*Accipiter novaehollandiae*	grey goshawk		NT		1
animals	birds	Accipitridae	*Aquila audax*	wedge-tailed eagle		C		8
animals	birds	Accipitridae	*Haliaeetus leucogaster*	white-bellied sea-eagle		SL		2
animals	birds	Accipitridae	*Accipiter fasciatus*	brown goshawk		C		2
animals	birds	Accipitridae	*Haliastur sphenurus*	whistling kite		C		20
animals	birds	Acrocephalidae	*Acrocephalus australis*	Australian reed-warbler		SL		2
animals	birds	Aegothelidae	*Aegotheles cristatus*	Australian owlet-nightjar		C		2
animals	birds	Alcedinidae	*Ceyx azureus*	azure kingfisher		C		3
animals	birds	Anatidae	*Malacorhynchus membranaceus*	pink-eared duck		C		1
animals	birds	Anatidae	*Nettapus coromandelianus*	cotton pygmy-goose		NT		1
animals	birds	Anatidae	*Nettapus pulchellus*	green pygmy-goose		C		2
animals	birds	Anatidae	*Dendrocygna arcuata*	wandering whistling-duck		C		1
animals	birds	Anatidae	*Dendrocygna eytoni*	plumed whistling-duck		C		2
animals	birds	Anatidae	*Chenonetta jubata*	Australian wood duck		C		4
animals	birds	Anatidae	*Anas superciliosa*	Pacific black duck		C		5
animals	birds	Anatidae	*Aythya australis*	hardhead		C		3
animals	birds	Anatidae	*Anas gracilis*	grey teal		C		2
animals	birds	Anatidae	*Cygnus atratus*	black swan		C		1
animals	birds	Anhingidae	*Anhinga novaehollandiae*	Australasian darter		C		13
animals	birds	Ardeidae	*Nycticorax caledonicus*	Nankeen night-heron		C		3
animals	birds	Ardeidae	*Ardea modesta*	eastern great egret		SL		4
animals	birds	Ardeidae	*Ardea pacifica*	white-necked heron		C		8
animals	birds	Ardeidae	*Ardea intermedia*	intermediate egret		C		5
animals	birds	Ardeidae	*Egretta garzetta*	little egret		C		1
animals	birds	Ardeidae	*Egretta novaehollandiae*	white-faced heron		C		4
animals	birds	Ardeidae	*Ixobrychus flavicollis*	black bittern		C		2
animals	birds	Artamidae	*Cracticus nigrogularis*	pied butcherbird		C		16
animals	birds	Artamidae	*Artamus minor*	little woodswallow		C		5
animals	birds	Artamidae	*Artamus cinereus*	black-faced woodswallow		C		33
animals	birds	Artamidae	*Cracticus tibicen*	Australian magpie		C		11
animals	birds	Artamidae	*Artamus leucorynchus*	white-breasted woodswallow		C		9
animals	birds	Cacatuidae	*Nymphicus hollandicus*	cockatiel		C		12
animals	birds	Cacatuidae	*Cacatua sanguinea*	little corella		C		5
animals	birds	Cacatuidae	*Cacatua galerita*	sulphur-crested cockatoo		C		12
animals	birds	Cacatuidae	*Eolophus roseicapillus*	galah		C		13
animals	birds	Campephagidae	*Coracina papuensis*	white-bellied cuckoo-shrike		C		4
animals	birds	Campephagidae	*Lalage sueurii*	white-winged triller		C		9
animals	birds	Campephagidae	*Coracina novaehollandiae*	black-faced cuckoo-shrike		C		16
animals	birds	Casuariidae	*Dromaius novaehollandiae*	emu		C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Charadriidae	*Vanellus miles miles*	masked lapwing (northern subspecies)		C		4
animals	birds	Charadriidae	*Vanellus miles*	masked lapwing		C		3
animals	birds	Charadriidae	*Elseyornis melanops*	black-fronted dotterel		C		14
animals	birds	Ciconiidae	*Ephippiorhynchus asiaticus*	black-necked stork		NT		5
animals	birds	Climacteridae	*Climacteris melanura*	black-tailed treecreeper		C		45
animals	birds	Columbidae	*Geopelia cuneata*	diamond dove		C		10
animals	birds	Columbidae	*Geophaps plumifera*	spinifex pigeon		C		7
animals	birds	Columbidae	*Geopelia humeralis*	bar-shouldered dove		C		1
animals	birds	Columbidae	*Phaps chalcoptera*	common bronzewing		C		12
animals	birds	Columbidae	*Ocyphaps lophotes*	crested pigeon		C		10
animals	birds	Columbidae	*Geopelia striata*	peaceful dove		C		32
animals	birds	Columbidae	*Columba livia*	rock dove	Y			1
animals	birds	Coraciidae	*Eurystomus orientalis*	dollarbird		C		4
animals	birds	Corcoracidae	*Struthidea cinerea*	apostlebird		C		6
animals	birds	Corvidae	*Corvus sp.*					1
animals	birds	Corvidae	*Corvus bennetti*	little crow		C		1
animals	birds	Corvidae	*Corvus coronoides*	Australian raven		C		39
animals	birds	Corvidae	*Corvus orru*	Torresian crow		C		2
animals	birds	Cuculidae	*Cacomantis pallidus*	pallid cuckoo		C		1
animals	birds	Cuculidae	*Chalcites basalis*	Horsfield's bronze-cuckoo		C		3
animals	birds	Cuculidae	*Scythrops novaehollandiae*	channel-billed cuckoo		C		1
animals	birds	Cuculidae	*Centropus phasianinus*	pheasant coucal		C		1
animals	birds	Cuculidae	*Eudynamys orientalis*	eastern koel		C		2
animals	birds	Estrildidae	*Taeniopygia guttata*	zebra finch		C		19
animals	birds	Estrildidae	*Emblema pictum*	painted finch		C		2
animals	birds	Estrildidae	*Neochmia ruficauda*	star finch		C		1
animals	birds	Estrildidae	*Poephila acuticauda*	long-tailed finch		C		10
animals	birds	Estrildidae	*Lonchura castaneothorax*	chestnut-breasted mannikin		C		1
animals	birds	Estrildidae	*Heteromunia pectoralis*	pictorella mannikin		NT		4
animals	birds	Estrildidae	*Poephila cincta cincta*	black-throated finch (white-rumped subspecies)		E	E	1
animals	birds	Estrildidae	*Taeniopygia bichenovii*	double-barred finch		C		24
animals	birds	Eurostopodidae	*Eurostopodus argus*	spotted nightjar		C		2
animals	birds	Falconidae	*Falco berigora*	brown falcon		C		4
animals	birds	Falconidae	*Falco longipennis*	Australian hobby		C		2
animals	birds	Falconidae	*Falco cenchroides*	Nankeen kestrel		C		2
animals	birds	Gruidae	*Grus rubicunda*	brolga		C		2
animals	birds	Halcyonidae	*Todiramphus pyrrhopygius*	red-backed kingfisher		C		4
animals	birds	Halcyonidae	*Todiramphus sanctus*	sacred kingfisher		C		5
animals	birds	Halcyonidae	*Dacelo leachii*	blue-winged kookaburra		C		11
animals	birds	Hirundinidae	*Petrochelidon nigricans*	tree martin		C		1
animals	birds	Hirundinidae	*Petrochelidon ariel*	fairy martin		C		5
animals	birds	Jacanidae	*Irediparra gallinacea*	comb-crested jacana		C		4
animals	birds	Laridae	*Gelochelidon nilotica*	gull-billed tern		C		1
animals	birds	Laridae	*Hydroprogne caspia*	Caspian tern		SL		1
animals	birds	Maluridae	*Malurus melanocephalus*	red-backed fairy-wren		C		8

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Maluridae	*Amytornis dorotheae*	Carpentarian grasswren		NT		2
animals	birds	Maluridae	*Malurus lamberti*	variegated fairy-wren		C		38
animals	birds	Maluridae	*Amytornis ballarae*	Kalkadoon grasswren		C		19
animals	birds	Megaluridae	*Cincloramphus mathewsi*	rufous songlark		C		4
animals	birds	Megaluridae	*Eremiornis carteri*	spinifexbird		C		7
animals	birds	Meliphagidae	*Philemon citreogularis*	little friarbird		C		17
animals	birds	Meliphagidae	*Certhionyx variegatus*	pied honeyeater		C		1
animals	birds	Meliphagidae	*Acanthagenys rufogularis*	spiny-cheeked honeyeater		C		2
animals	birds	Meliphagidae	*Ptilotula penicillatus*	white-plumed honeyeater		C		27
animals	birds	Meliphagidae	*Conopophila rufogularis*	rufous-throated honeyeater		C		10
animals	birds	Meliphagidae	*Cissomela pectoralis*	banded honeyeater		C		1
animals	birds	Meliphagidae	*Ptilotula flavescens*	yellow-tinted honeyeater		C		11
animals	birds	Meliphagidae	*Philemon argenticeps*	silver-crowned friarbird		C		9
animals	birds	Meliphagidae	*Lichmera indistincta*	brown honeyeater		C		15
animals	birds	Meliphagidae	*Melithreptus gularis*	black-chinned honeyeater		NT		5
animals	birds	Meliphagidae	*Manorina flavigula*	yellow-throated miner		C		29
animals	birds	Meliphagidae	*Ptilotula plumulus*	grey-fronted honeyeater		C		78
animals	birds	Meliphagidae	*Gavicalis virescens*	singing honeyeater		C		15
animals	birds	Meliphagidae	*Stomiopera unicolor*	white-gaped honeyeater		C		6
animals	birds	Meliphagidae	*Ptilotula keartlandi*	grey-headed honeyeater		C		21
animals	birds	Meropidae	*Merops ornatus*	rainbow bee-eater		SL		23
animals	birds	Monarchidae	*Myiagra inquieta*	restless flycatcher		C		19
animals	birds	Monarchidae	*Grallina cyanoleuca*	magpie-lark		C		37
animals	birds	Motacillidae	*Anthus novaeseelandiae*	Australasian pipit		C		2
animals	birds	Nectariniidae	*Dicaeum hirundinaceum*	mistletoebird		C		12
animals	birds	Neosittidae	*Daphoenositta chrysoptera*	varied sittella		C		3
animals	birds	Oriolidae	*Oriolus sagittatus*	olive-backed oriole		C		7
animals	birds	Otididae	*Ardeotis australis*	Australian bustard		C		1
animals	birds	Pachycephalidae	*Colluricincla harmonica*	grey shrike-thrush		C		22
animals	birds	Pachycephalidae	*Oreoica gutturalis*	crested bellbird		C		3
animals	birds	Pachycephalidae	*Pachycephala rufiventris*	rufous whistler		C		25
animals	birds	Pardalotidae	*Pardalotus rubricatus*	red-browed pardalote		C		9
animals	birds	Pardalotidae	*Pardalotus striatus*	striated pardalote		C		27
animals	birds	Passeridae	*Passer domesticus*	house sparrow	Y			2
animals	birds	Pelecanidae	*Pelecanus conspicillatus*	Australian pelican		C		6
animals	birds	Petroicidae	*Melanodryas cucullata*	hooded robin		C		2
animals	birds	Petroicidae	*Microeca fascinans*	jacky winter		C		12
animals	birds	Phalacrocoracidae	*Phalacrocorax carbo*	great cormorant		C		1
animals	birds	Phalacrocoracidae	*Phalacrocorax sulcirostris*	little black cormorant		C		7
animals	birds	Phalacrocoracidae	*Microcarbo melanoleucos*	little pied cormorant		C		7
animals	birds	Phalacrocoracidae	*Phalacrocorax varius*	pied cormorant		C		1
animals	birds	Phasianidae	*Coturnix ypsilophora*	brown quail		C		4
animals	birds	Podargidae	*Podargus strigoides*	tawny frogmouth		C		2
animals	birds	Podicipedidae	*Tachybaptus novaehollandiae*	Australasian grebe		C		4
animals	birds	Pomatostomidae	*Pomatostomus temporalis*	grey-crowned babbler		C		29
animals	birds	Psittacidae	*Melopsittacus undulatus*	budgerigar		C		8

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Psittacidae	*Barnardius zonarius*	Australian ringneck		C		8
animals	birds	Psittacidae	*Psitteuteles versicolor*	varied lorikeet		C		11
animals	birds	Psittacidae	*Trichoglossus haematodus moluccanus*	rainbow lorikeet		C		1
animals	birds	Psittacidae	*Aprosmictus erythropterus*	red-winged parrot		C		20
animals	birds	Ptilonorhynchidae	*Ptilonorhynchus nuchalis*	great bowerbird		C		5
animals	birds	Ptilonorhynchidae	*Ptilonorhynchus maculatus*	spotted bowerbird		C		8
animals	birds	Rallidae	*Fulica atra*	Eurasian coot		C		1
animals	birds	Rallidae	*Porzana pusilla*	Baillon's crake		C		1
animals	birds	Rallidae	*Gallinula tenebrosa*	dusky moorhen		C		1
animals	birds	Recurvirostridae	*Himantopus himantopus*	black-winged stilt		C		2
animals	birds	Rhipiduridae	*Rhipidura leucophrys*	willie wagtail		C		42
animals	birds	Rhipiduridae	*Rhipidura albiscapa*	grey fantail		C		1
animals	birds	Scolopacidae	*Tringa glareola*	wood sandpiper		SL		1
animals	birds	Strigidae	*Ninox connivens*	barking owl		C		1
animals	birds	Threskiornithidae	*Platalea regia*	royal spoonbill		C		3
animals	birds	Threskiornithidae	*Threskiornis spinicollis*	straw-necked ibis		C		4
animals	birds	Threskiornithidae	*Plegadis falcinellus*	glossy ibis		SL		1
animals	mammals	Canidae	*Canis lupus dingo*	dingo				1
animals	mammals	Macropodidae	*Macropus rufus*	red kangaroo		C		3
animals	mammals	Macropodidae	*Lagorchestes conspicillatus*	spectacled hare-wallaby		C		3
animals	mammals	Vespertilionidae	*Chalinolobus gouldii*	Gould's wattled bat		C		9/9
animals	ray-finned fishes	Ambassidae	*Ambassis species*	northwest glassfish				56
animals	ray-finned fishes	Ambassidae	*Ambassis macleayi*	Macleay's glassfish				250
animals	ray-finned fishes	Apogonidae	*Glossamia aprion*	mouth almighty				52
animals	ray-finned fishes	Ariidae	*Neoarius graeffei*	blue catfish				27
animals	ray-finned fishes	Belonidae	*Strongylura krefftii*	freshwater longtom				68
animals	ray-finned fishes	Centropomidae	*Lates calcarifer*	barramundi				8
animals	ray-finned fishes	Clupeidae	*Nematalosa erebi*	bony bream				351
animals	ray-finned fishes	Eleotridae	*Oxyeleotris selheimi*	blackbanded gudgeon				31
animals	ray-finned fishes	Eleotridae	*Oxyeleotris lineolata*	sleepy cod				97
animals	ray-finned fishes	Gobiidae	*Glossogobius aureus*	golden flathead goby				2
animals	ray-finned fishes	Melanotaeniidae	*Melanotaenia splendida inornata*	checkered rainbowfish				86
animals	ray-finned fishes	Terapontidae	*Hephaestus fuliginosus*	sooty grunter				29
animals	ray-finned fishes	Terapontidae	*Leiopotherapon unicolor*	spangled perch				10
animals	ray-finned fishes	Terapontidae	*Amniataba percoides*	barred grunter				178
animals	ray-finned fishes	Toxotidae	*Toxotes chatareus*	sevenspot archerfish				34
animals	reptiles	Agamidae	*Amphibolurus gilberti*	Gilbert's dragon		C		2/2
animals	reptiles	Agamidae	*Ctenophorus caudicinctus*	ring-tailed dragon		C		1/1
animals	reptiles	Crocodylidae	*Crocodylus johnstoni*	Australian freshwater crocodile		C		1
animals	reptiles	Elapidae	*Demansia flagellatio*			C		1
animals	reptiles	Elapidae	*Suta suta*	myall snake		C		1
animals	reptiles	Gekkonidae	*Gehyra robusta*			C		1/1
animals	reptiles	Scincidae	*Ctenotus pulchellus*			C		3/3
animals	reptiles	Scincidae	*Ctenotus striaticeps*			C		2/2
animals	reptiles	Scincidae	*Ctenotus lateralis*			C		1/1
plants	ferns	Adiantaceae	*Cheilanthes brownii*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Acanthaceae	*Nelsonia campestris*			C		2/2
plants	higher dicots	Amaranthaceae	*Ptilotus fusiformis*			C		1/1
plants	higher dicots	Amaranthaceae	*Ptilotus schwartzii*			C		1/1
plants	higher dicots	Amaranthaceae	*Ptilotus maconochiei*			NT		1/1
plants	higher dicots	Amaranthaceae	*Alternanthera pungens*	khaki weed	Y			1/1
plants	higher dicots	Amaranthaceae	*Alternanthera sp. (Mt Isa R.L.Specht+ 49)*			C		1/1
plants	higher dicots	Amaranthaceae	*Alternanthera angustifolia*			C		1/1
plants	higher dicots	Amaranthaceae	*Amaranthus interruptus*			C		1/1
plants	higher dicots	Amaranthaceae	*Ptilotus spicatus*			C		1/1
plants	higher dicots	Amaranthaceae	*Gomphrena lanata*			C		1/1
plants	higher dicots	Amaranthaceae	*Alternanthera denticulata*	lesser joyweed		C		1/1
plants	higher dicots	Amaranthaceae	*Amaranthus cochleitepalus*			C		1/1
plants	higher dicots	Apocynaceae	*Marsdenia viridiflora subsp. tropica*			C		1/1
plants	higher dicots	Apocynaceae	*Sarcostemma brevipedicellatum*			C		1/1
plants	higher dicots	Apocynaceae	*Carissa lanceolata*			C		1/1
plants	higher dicots	Asteraceae	*Pterocaulon serrulatum var. velutinum*			C		2/2
plants	higher dicots	Asteraceae	*Centipeda minima subsp. minima*			C		1/1
plants	higher dicots	Asteraceae	*Streptoglossa decurrens*			C		1/1
plants	higher dicots	Asteraceae	*Pterocaulon ciliosum*			C		2/2
plants	higher dicots	Asteraceae	*Tridax procumbens*	tridax daisy	Y			1/1
plants	higher dicots	Asteraceae	*Bidens bipinnata*	bipinnate beggar's ticks	Y			2/2
plants	higher dicots	Asteraceae	*Blumea saxatilis*			C		1/1
plants	higher dicots	Boraginaceae	*Trichodesma zeylanicum var. latisepalum*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium cunninghamii*			C		2/2
plants	higher dicots	Boraginaceae	*Heliotropium tenuifolium*			C		3/3
plants	higher dicots	Boraginaceae	*Heliotropium tanythrix*			C		2/2
plants	higher dicots	Boraginaceae	*Heliotropium haesum*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium ballii*			C		1/1
plants	higher dicots	Byttneriaceae	*Waltheria indica*			C		1/1
plants	higher dicots	Byttneriaceae	*Melochia pyramidata*		Y			1/1
plants	higher dicots	Caesalpiniaceae	*Senna glutinosa subsp. glutinosa*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Senna notabilis*			C		3/3
plants	higher dicots	Caesalpiniaceae	*Senna venusta*			C		1/1
plants	higher dicots	Caryophyllaceae	*Polycarpaea corymbosa var. corymbosa*			C		2/2
plants	higher dicots	Chenopodiaceae	*Maireana villosa*			C		1/1
plants	higher dicots	Cleomaceae	*Cleome cleomoides*			C		1/1
plants	higher dicots	Cleomaceae	*Cleome viscosa*	tick-weed		C		1/1
plants	higher dicots	Combretaceae	*Terminalia canescens*			C		1/1
plants	higher dicots	Convolvulaceae	*Ipomoea polymorpha*			C		1/1
plants	higher dicots	Convolvulaceae	*Jacquemontia sp. (Fairview R.W.Johnson 4026)*			C		1/1
plants	higher dicots	Convolvulaceae	*Bonamia sp. (Musselbrook M.B.Thomas+ MRS639)*			C		1/1
plants	higher dicots	Convolvulaceae	*Jacquemontia paniculata var. tomentosa*			C		1/1
plants	higher dicots	Convolvulaceae	*Evolvulus alsinoides var. villosicalyx*			C		1/1
plants	higher dicots	Convolvulaceae	*Evolvulus alsinoides var. decumbens*			C		1/1
plants	higher dicots	Convolvulaceae	*Ipomoea antonschmidii*			NT		6/6
plants	higher dicots	Convolvulaceae	*Ipomoea lonchophylla*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Convolvulaceae	*Ipomoea muelleri*	poison morning-glory		C		2/2
plants	higher dicots	Convolvulaceae	*Ipomoea costata*			C		1/1
plants	higher dicots	Convolvulaceae	*Bonamia media*			C		3/3
plants	higher dicots	Cucurbitaceae	*Citrullus lanatus*		Y			1/1
plants	higher dicots	Cucurbitaceae	*Momordica balsamina*	balsam apple	Y			2/2
plants	higher dicots	Euphorbiaceae	*Microstachys chamaelea*			C		2/2
plants	higher dicots	Euphorbiaceae	*Euphorbia hassallii*			C		2/2
plants	higher dicots	Euphorbiaceae	*Euphorbia australis var. subtomentosa*			C		3/3
plants	higher dicots	Euphorbiaceae	*Euphorbia papillata var. papillata*			C		1/1
plants	higher dicots	Euphorbiaceae	*Euphorbia trigonosperma*			C		1/1
plants	higher dicots	Euphorbiaceae	*Euphorbia hirta*		Y			2/2
plants	higher dicots	Euphorbiaceae	*Euphorbia coghlanii*			C		2/2
plants	higher dicots	Euphorbiaceae	*Ricinus communis*	castor oil bush	Y			1/1
plants	higher dicots	Fabaceae	*Tephrosia sp. (Magazine Hill P.Jones 365)*			C		2/2
plants	higher dicots	Fabaceae	*Tephrosia phaeosperma var. (Westmoreland S.Melville 967)*			C		3/3
plants	higher dicots	Fabaceae	*Cullen cinereum*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia virens*			C		3/3
plants	higher dicots	Fabaceae	*Rhynchosia minima*			C		1/1
plants	higher dicots	Fabaceae	*Desmodium muelleri*			C		1/1
plants	higher dicots	Fabaceae	*Indigofera colutea*	sticky indigo		C		1/1
plants	higher dicots	Fabaceae	*Indigofera hirsuta*	hairy indigo		C		1/1
plants	higher dicots	Fabaceae	*Indigofera linnaei*	Birdsville indigo		C		1/1
plants	higher dicots	Fabaceae	*Aeschynomene indica*	budda pea		C		2/2
plants	higher dicots	Fabaceae	*Galactia tenuiflora*			C		1/1
plants	higher dicots	Fabaceae	*Alysicarpus muelleri*			C		1/1
plants	higher dicots	Fabaceae	*Crotalaria verrucosa*			C		3/3
plants	higher dicots	Fabaceae	*Indigofera brevidens*			C		1/1
plants	higher dicots	Fabaceae	*Indigofera linifolia*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia delestangii*			C		4/4
plants	higher dicots	Fabaceae	*Tephrosia remotiflora*			C		1/1
plants	higher dicots	Fabaceae	*Aphyllodium biarticulatum*			C		1/1
plants	higher dicots	Fabaceae	*Galactia tenuiflora var. lucida*			C		1/1
plants	higher dicots	Fabaceae	*Galactia tenuiflora forma sericea*			C		1/1
plants	higher dicots	Fabaceae	*Sesbania cannabina var. cannabina*			C		1/1
plants	higher dicots	Fabaceae	*Galactia tenuiflora var. macrantha*			C		1/1
plants	higher dicots	Fabaceae	*Zornia muriculata subsp. angustata*			C		3/3
plants	higher dicots	Fabaceae	*Crotalaria aridicola subsp. glabrata*			C		1/1
plants	higher dicots	Fabaceae	*Crotalaria medicaginea var. neglecta*			C		2/2
plants	higher dicots	Fabaceae	*Tephrosia brachyodon var. longifolia*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia*			C		1/1
plants	higher dicots	Fabaceae	*Indigofera*			C		1/1
plants	higher dicots	Fabaceae	*Crotalaria dissitiflora subsp. rugosa*			C		1/1
plants	higher dicots	Goodeniaceae	*Goodenia strangfordii*			C		1/1
plants	higher dicots	Goodeniaceae	*Scaevola sp. (Mt Isa P.L.Harris 699)*			C		2/2
plants	higher dicots	Goodeniaceae	*Scaevola amblyanthera*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Goodeniaceae	*Goodenia ramelii*			C		2/2
plants	higher dicots	Haloragaceae	*Myriophyllum verrucosum*	water milfoil		C		1/1
plants	higher dicots	Lamiaceae	*Mesosphaerum suaveolens*		Y			1/1
plants	higher dicots	Lamiaceae	*Ocimum caryophyllinum*			C		1/1
plants	higher dicots	Lamiaceae	*Vitex benthamiana*			C		1/1
plants	higher dicots	Loganiaceae	*Mitrasacme connata*			C		1/1
plants	higher dicots	Loranthaceae	*Amyema sanguinea var. sanguinea*			C		1/1
plants	higher dicots	Loranthaceae	*Decaisnina brittenii subsp. brittenii*			C		1/1
plants	higher dicots	Loranthaceae	*Amyema quandang var. bancroftii*	broad-leaved grey mistletoe		C		1/1
plants	higher dicots	Loranthaceae	*Lysiana spathulata subsp. spathulata*			C		2/2
plants	higher dicots	Lythraceae	*Rotala mexicana*			C		1/1
plants	higher dicots	Malvaceae	*Sida*			C		1/1
plants	higher dicots	Malvaceae	*Hibiscus*			C		4/4
plants	higher dicots	Malvaceae	*Sida spinosa*	spiny sida	Y			1/1
plants	higher dicots	Malvaceae	*Abutilon hannii*			C		3/3
plants	higher dicots	Malvaceae	*Abutilon macrum*			C		1/1
plants	higher dicots	Malvaceae	*Sida cleisocalyx*			C		1/1
plants	higher dicots	Malvaceae	*Sida hackettiana*			C		1/1
plants	higher dicots	Malvaceae	*Abutilon arenarium*			C		1/1
plants	higher dicots	Malvaceae	*Abutilon otocarpum*			C		1/1
plants	higher dicots	Malvaceae	*Abutilon malvifolium*	bastard marshmallow		C		1/1
plants	higher dicots	Malvaceae	*Hibiscus meraukensis*	Merauke hibiscus		C		1/1
plants	higher dicots	Malvaceae	*Hibiscus verdcourtii*			C		1/1
plants	higher dicots	Malvaceae	*Abutilon leucopetalum*			C		1/1
plants	higher dicots	Malvaceae	*Hibiscus pentaphyllus*			C		1/1
plants	higher dicots	Malvaceae	*Sida rohlenae subsp. rohlenae*			C		3/3
plants	higher dicots	Malvaceae	*Hibiscus sturtii var. campylochlamys*			C		2/2
plants	higher dicots	Malvaceae	*Sida sp. (Aramac E.J.Thompson+ JER192)*			C		1/1
plants	higher dicots	Malvaceae	*Sida sp. (Jericho E.J.Thompson+ JER117)*			C		1/1
plants	higher dicots	Malvaceae	*Sida sp. (Musselbrook M.B.Thomas+ MRS437)*			C		7/7
plants	higher dicots	Mimosaceae	*Acacia limbata*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia bivenosa*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia cambagei*	gidgee		C		1/1
plants	higher dicots	Mimosaceae	*Acacia shirleyi*	lancewood		C		2/2
plants	higher dicots	Mimosaceae	*Acacia acradenia*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia calligera*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia galioides*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia gonoclada*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia monticola*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia umbellata*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia chisholmii*			C		5/5
plants	higher dicots	Mimosaceae	*Acacia elachantha*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia hemignosta*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia lysiphloia*			C		8/8
plants	higher dicots	Mimosaceae	*Acacia megalantha*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia orthocarpa*			C		3/3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Mimosaceae	*Acacia tenuissima*			C		3/3
plants	higher dicots	Mimosaceae	*Acacia asperulacea*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia holosericea*			C		4/4
plants	higher dicots	Mimosaceae	*Acacia phlebocarpa*			C		3/3
plants	higher dicots	Mimosaceae	*Acacia stenophylla*	belalie		C		1/1
plants	higher dicots	Mimosaceae	*Acacia chippendalei*			C		1/1
plants	higher dicots	Mimosaceae	*Dichrostachys spicata*			C		1/1
plants	higher dicots	Mimosaceae	*Neptunia dimorphantha*			C		1/1
plants	higher dicots	Mimosaceae	*Vachellia sutherlandii*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia monticola x A.phlebocarpa*			C		3/3
plants	higher dicots	Mimosaceae	*Neptunia gracilis forma gracilis*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia victoriae subsp. fasciaria*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia sp. (Urandangi L.Pedley 2025)*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia drepanocarpa subsp. drepanocarpa*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia sp. (Coolullah M.Lazarides 3988)*			C		6/6
plants	higher dicots	Moraceae	*Ficus aculeata var. aculeata*			C		1/1
plants	higher dicots	Myrtaceae	*Melaleuca argentea*	silver tea-tree		C		2/2
plants	higher dicots	Myrtaceae	*Corymbia terminalis*			C		3/3
plants	higher dicots	Myrtaceae	*Corymbia capricornia*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus herbertiana*	kalumburu gum		C		3/3
plants	higher dicots	Myrtaceae	*Melaleuca trichostachya*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus normantonensis*	Normanton box		C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus leucophylla x E.pruinosa*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus pruinosa subsp. pruinosa*			C		2/2
plants	higher dicots	Myrtaceae	*Eucalyptus camaldulensis subsp. obtusa*			C		1/1
plants	higher dicots	Myrtaceae	*Corymbia grandifolia subsp. grandifolia*			C		1/1
plants	higher dicots	Myrtaceae	*Lophostemon grandiflorus subsp. riparius*			C		2/2
plants	higher dicots	Myrtaceae	*Corymbia*			C		1/1
plants	higher dicots	Myrtaceae	*Corymbia aspera*			C		1/1
plants	higher dicots	Myrtaceae	*Calytrix brownii*			C		2/2
plants	higher dicots	Myrtaceae	*Corymbia polycarpa*	long-fruited bloodwood		C		1/1
plants	higher dicots	Onagraceae	*Ludwigia perennis*			C		1/1
plants	higher dicots	Pentapetaceae	*Melhania ovata*			C		1/1
plants	higher dicots	Phyllanthaceae	*Phyllanthus maderaspatensis*			C		2/2
plants	higher dicots	Phyllanthaceae	*Phyllanthus lacunarius*			C		1/1
plants	higher dicots	Phyllanthaceae	*Breynia oblongifolia*			C		1/1
plants	higher dicots	Picrodendraceae	*Petalostigma quadriloculare*			C		1/1
plants	higher dicots	Plantaginaceae	*Stemodia glabella*			C		2/2
plants	higher dicots	Plantaginaceae	*Stemodia lythrifolia*			C		1/1
plants	higher dicots	Plumbaginaceae	*Plumbago zeylanica*	native plumbago		C		2/2
plants	higher dicots	Polygalaceae	*Polygala pterocarpa*			C		1/1
plants	higher dicots	Polygalaceae	*Polygala*			C		1/1
plants	higher dicots	Proteaceae	*Grevillea dryandri subsp. dryandri*			C		1/1
plants	higher dicots	Proteaceae	*Grevillea wickhamii subsp. aprica*			C		4/4
plants	higher dicots	Proteaceae	*Hakea chordophylla*			C		1/1
plants	higher dicots	Proteaceae	*Hakea arborescens*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Proteaceae	*Grevillea heliosperma*			C		2/2
plants	higher dicots	Rubiaceae	*Oldenlandia mitrasacmoides subsp. mitrasacmoides*			C		1/1
plants	higher dicots	Rubiaceae	*Oldenlandia argillacea*			C		1/1
plants	higher dicots	Rubiaceae	*Spermacoce auriculata*			C		2/2
plants	higher dicots	Rubiaceae	*Oldenlandia galioides*			C		1/1
plants	higher dicots	Rubiaceae	*Spermacoce argillacea*			C		1/1
plants	higher dicots	Sapindaceae	*Dodonaea lanceolata var. lanceolata*			C		1/1
plants	higher dicots	Scrophulariaceae	*Eremophila acrida*			C		1/1
plants	higher dicots	Solanaceae	*Solanum quadriloculatum*			C		2/2
plants	higher dicots	Solanaceae	*Solanum echinatum*			C		2/2
plants	higher dicots	Solanaceae	*Solanum succosum*			C		6/6
plants	higher dicots	Sparrmanniaceae	*Corchorus sericeus subsp. densiflorus*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Triumfetta marsupiata*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Triumfetta rupestris*			C		2/2
plants	higher dicots	Sparrmanniaceae	*Triumfetta plumigera*			C		3/3
plants	higher dicots	Sparrmanniaceae	*Corchorus olitorius*	jute		C		1/1
plants	higher dicots	Sterculiaceae	*Brachychiton collinus*			C		1/1
plants	higher dicots	Violaceae	*Hybanthus enneaspermus*			C		2/2
plants	higher dicots	Violaceae	*Hybanthus aurantiacus*			C		1/1
plants	higher dicots	Zygophyllaceae	*Tribulopis pentandra*			C		2/2
plants	higher dicots	Zygophyllaceae	*Tribulopis solandri*			C		2/2
plants	lower dicots	Lauraceae	*Cassytha filiformis*	dodder laurel		C		1/1
plants	lower dicots	Papaveraceae	*Argemone ochroleuca subsp. ochroleuca*	Mexican poppy	Y			1/1
plants	monocots	Arecaceae	*Livistona rigida*			C		2/2
plants	monocots	Commelinaceae	*Commelina ensifolia*	scurvy grass		C		2/2
plants	monocots	Cyperaceae	*Cyperus bifax*	western nutgrass		C		2/2
plants	monocots	Cyperaceae	*Cyperus fulvus*			C		5/5
plants	monocots	Cyperaceae	*Scleria brownii*			C		2/2
plants	monocots	Cyperaceae	*Cyperus carinatus*			C		7/7
plants	monocots	Cyperaceae	*Cyperus difformis*	rice sedge		C		1/1
plants	monocots	Cyperaceae	*Cyperus vaginatus*			C		3/3
plants	monocots	Cyperaceae	*Cyperus nervulosus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus pulchellus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus squarrosus*	bearded flatsedge		C		1/1
plants	monocots	Cyperaceae	*Fimbristylis elegans*			C		1/1
plants	monocots	Cyperaceae	*Fimbristylis macrantha*			C		2/2
plants	monocots	Cyperaceae	*Fimbristylis littoralis*			C		2/2
plants	monocots	Cyperaceae	*Fimbristylis microcarya*			C		1/1
plants	monocots	Cyperaceae	*Lipocarpha microcephala*			C		2/2
plants	monocots	Cyperaceae	*Fimbristylis depauperata*			C		1/1
plants	monocots	Cyperaceae	*Cyperus conicus var. conicus*			C		3/3
plants	monocots	Cyperaceae	*Cyperus betchei subsp. betchei*			C		1/1
plants	monocots	Cyperaceae	*Cyperus betchei subsp. commiscens*			C		4/4
plants	monocots	Cyperaceae	*Cyperus cunninghamii subsp. cheradicus*			C		3/3
plants	monocots	Cyperaceae	*Cyperus microcephalus subsp. microcephalus*			C		2/2
plants	monocots	Cyperaceae	*Cyperus iria*			C		2/2

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	monocots	Poaceae	*Aristida*			C		1/1
plants	monocots	Poaceae	*Eriachne mucronata forma (Burnham R.W.Purdie 1370)*			C		2/2
plants	monocots	Poaceae	*Eulalia aurea*	silky browntop		C		1/1
plants	monocots	Poaceae	*Sarga plumosum*			C		2/2
plants	monocots	Poaceae	*Eriachne obtusa*			C		1/1
plants	monocots	Poaceae	*Panicum effusum*			C		2/2
plants	monocots	Poaceae	*Sarga timorense*			C		1/1
plants	monocots	Poaceae	*Setaria surgens*			C		1/1
plants	monocots	Poaceae	*Triodia molesta*			C		1/1
plants	monocots	Poaceae	*Triodia pungens*			C		1/1
plants	monocots	Poaceae	*Aristida exserta*			C		3/3
plants	monocots	Poaceae	*Aristida ingrata*			C		1/1
plants	monocots	Poaceae	*Digitaria minima*			C		1/1
plants	monocots	Poaceae	*Eragrostis minor*	smaller stinkgrass	Y			1/1
plants	monocots	Poaceae	*Eriachne ciliata*			C		1/1
plants	monocots	Poaceae	*Iseilema fragile*			C		1/1
plants	monocots	Poaceae	*Aristida nitidula*			C		1/1
plants	monocots	Poaceae	*Aristida pruinosa*			C		1/1
plants	monocots	Poaceae	*Digitaria brownii*			C		2/2
plants	monocots	Poaceae	*Eragrostis fallax*			C		1/1
plants	monocots	Poaceae	*Mnesithea formosa*			C		1/1
plants	monocots	Poaceae	*Paspalidium rarum*			C		2/2
plants	monocots	Poaceae	*Triodia bitextura*			C		3/3
plants	monocots	Poaceae	*Triodia brizoides*			C		2/2
plants	monocots	Poaceae	*Urochloa piligera*			C		1/1
plants	monocots	Poaceae	*Arundinella setosa*			C		3/3
plants	monocots	Poaceae	*Digitaria ciliaris*	summer grass	Y			2/2
plants	monocots	Poaceae	*Echinochloa colona*	awnless barnyard grass	Y			2/2
plants	monocots	Poaceae	*Eriachne mucronata*			C		2/2
plants	monocots	Poaceae	*Eriachne pulchella*			C		1/1
plants	monocots	Poaceae	*Triodia mitchellii*	buck spinifex		C		1/1
plants	monocots	Poaceae	*Eragrostis cumingii*			C		2/2
plants	monocots	Poaceae	*Eragrostis speciosa*			C		1/1
plants	monocots	Poaceae	*Tragus australianus*	small burr grass		C		1/1
plants	monocots	Poaceae	*Bothriochloa pertusa*		Y			1/1
plants	monocots	Poaceae	*Dichanthium fecundum*	curly bluegrass		C		2/2
plants	monocots	Poaceae	*Enneapogon asperatus*			C		1/1
plants	monocots	Poaceae	*Enneapogon nigricans*	niggerheads		C		1/1
plants	monocots	Poaceae	*Eragrostis basedowii*			C		1/1
plants	monocots	Poaceae	*Eragrostis laniflora*			C		1/1
plants	monocots	Poaceae	*Eragrostis stagnalis*			C		1/1
plants	monocots	Poaceae	*Eragrostis tenellula*	delicate lovegrass		C		1/1
plants	monocots	Poaceae	*Iseilema macratherum*			C		1/1
plants	monocots	Poaceae	*Tripogon loliiformis*	five minute grass		C		1/1
plants	monocots	Poaceae	*Cymbopogon bombycinus*	silky oilgrass		C		2/2
plants	monocots	Poaceae	*Eragrostis desertorum*	woollybutt		C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	monocots	Poaceae	*Paspalidium clementii*			C		1/1
plants	monocots	Poaceae	*Schizachyrium fragile*	firegrass		C		1/1
plants	monocots	Poaceae	*Aristida inaequiglumis*			C		1/1
plants	monocots	Poaceae	*Bothriochloa ewartiana*	desert bluegrass		C		1/1
plants	monocots	Poaceae	*Enneapogon lindleyanus*			C		2/2
plants	monocots	Poaceae	*Enneapogon polyphyllus*	leafy nineawn		C		2/2
plants	monocots	Poaceae	*Dactyloctenium radulans*	button grass		C		1/1
plants	monocots	Poaceae	*Digitaria nematostachya*			C		1/1
plants	monocots	Poaceae	*Pseudoraphis spinescens*	spiny mudgrass		C		1/1
plants	monocots	Poaceae	*Sporobolus actinocladus*	katoora grass		C		1/1
plants	monocots	Poaceae	*Sporobolus australasicus*			C		1/1
plants	monocots	Poaceae	*Eriachne pulchella subsp. dominii*			C		1/1
plants	monocots	Poaceae	*Eriachne pulchella subsp. pulchella*			C		1/1
plants	monocots	Poaceae	*Dichanthium sericeum subsp. sericeum*			C		1/1
plants	monocots	Poaceae	*Eriachne sp. (Dugald River B.K.Simon+ 3007)*			C		1/1
plants	monocots	Poaceae	*Eriachne mucronata forma (Alpha C.E.Hubbard 7882)*			C		1/1
plants	monocots	Potamogetonaceae	*Potamogeton crispus*	curly pondweed		C		1/1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Recovery Actions Database

Title: Species list for 'Back on Track' priority species in Southern Gulf

Extracted: 18/06/2014 10:34:48

Search Criteria: [Back on Track Rank (NRM Back on Track Rank), NRM Region (Southern Gulf)]

NRM Region of Occurrence	Kingdom	Plant/Animal Type	Species Scientific Name	Species Common Name	NRM BoT Rank	State BoT Rank	NCA Status	EPBC Status
Southern Gulf	*Animals*	*Arachnids*	*Selenocosmia crassipes*		High	Critical	Least concern	
Southern Gulf	*Animals*	*Arachnids*	*Selenotypus plumipes*		High	Critical	Least concern	
Southern Gulf	*Animals*	*Birds*	*Amytornis ballarae*	Kalkadoon grasswren	High	High	Least concern	
Southern Gulf	*Animals*	*Birds*	*Amytornis dorotheae*	Carpentarian grasswren	High	High	Near threatened	
Southern Gulf	*Animals*	*Birds*	*Erythrotriorchis radiatus*	red goshawk	High	High	Endangered	Vulnerable
Southern Gulf	*Animals*	*Birds*	*Esacus magnirostris*	beach stone-curlew	High	High	Vulnerable	
Southern Gulf	*Animals*	*Birds*	*Grantiella picta*	painted honeyeater	High	High	Vulnerable	
Southern Gulf	*Animals*	*Birds*	*Lophochroa leadbeateri*	Major Mitchell's cockatoo	High	High	Vulnerable	
Southern Gulf	*Animals*	*Birds*	*Malurus coronatus*	purple-crowned fairy-wren	High	High	Vulnerable	
Southern Gulf	*Animals*	*Birds*	*Neochmia ruficauda clarescens*	star finch (northern subspecies)	High	High	Least concern	
Southern Gulf	*Animals*	*Birds*	*Rostratula australis*	Australian painted snipe	High	Medium	Vulnerable	Endangered
Southern Gulf	*Animals*	*Birds*	*Sternula albifrons*	little tern	High	High	Endangered	
Southern Gulf	*Animals*	*Fish*	*Dasyatis fluviorum*	estuary stingray	High	High	Not Protected	
Southern Gulf	*Animals*	*Fish*	*Glyphis glyphis*	Bizant River shark	Critical	Critical	Not Protected	Critically Endangered
Southern Gulf	*Animals*	*Fish*	*Pristis clavata*	dwarf sawfish	High	High	Not Protected	Vulnerable
Southern Gulf	*Animals*	*Fish*	*Pristis pristis*	freshwater sawfish	High	High	Not Protected	Vulnerable
Southern Gulf	*Animals*	*Fish*	*Pristis zijsron*	green sawfish	High	High	Not Protected	Vulnerable
Southern Gulf	*Animals*	*Mammals*	*Dugong dugon*	dugong	Critical	Critical	Vulnerable	
Southern Gulf	*Animals*	*Mammals*	*Macroderma gigas*	ghost bat	Critical	Critical	Vulnerable	
Southern Gulf	*Animals*	*Mammals*	*Orcaella heinsohni*	Australian snubfin dolphin	Critical	Critical	Near threatened	
Southern Gulf	*Animals*	*Mammals*	*Sminthopsis douglasi*	Julia Creek dunnart	Critical	Critical	Endangered	Endangered
Southern Gulf	*Animals*	*Mammals*	*Sousa chinensis*	Indo-Pacific humpback dolphin	Critical	Critical	Near threatened	
Southern Gulf	*Animals*	*Reptiles*	*Acanthophis antarcticus*	common death adder	High	Medium	Near threatened	
Southern Gulf	*Animals*	*Reptiles*	*Caretta caretta*	loggerhead turtle	Critical	Critical	Endangered	Endangered

Southern Gulf	*Animals*	*Reptiles*	*Chelonia mydas*	green turtle	Critical	Critical	Vulnerable	Vulnerable
Southern Gulf	*Animals*	*Reptiles*	*Elseya lavarackorum*	Gulf snapping turtle	High	High	Vulnerable	Endangered
Southern Gulf	*Animals*	*Reptiles*	*Eretmochelys imbricata*	hawksbill turtle	Critical	Critical	Vulnerable	Vulnerable
Southern Gulf	*Animals*	*Reptiles*	*Lepidochelys olivacea*	olive ridley turtle	Critical	Critical	Endangered	Endangered
Southern Gulf	*Animals*	*Reptiles*	*Natator depressus*	flatback turtle	High	Critical	Vulnerable	Vulnerable
Southern Gulf	*Plants*	*Cycads*	*Cycas couttsiana*		High	Critical	Near threatened	
Southern Gulf	*Plants*	*Herbs*	*Eriocaulon carsonii*		Critical	High	Endangered	Endangered
Southern Gulf	*Plants*	*Trees*	*Pandanus aquaticus*		High	Medium	Least concern	
Southern Gulf	*Plants*	*Water plants*	*Aponogeton queenslandicus*		High	Medium	Least concern	

Appendix B Fauna Study Sites

2011 Study Sites

Terrestrial fauna study sites sampled during the 2011 surveys are described and illustrated below.

DSFS1 was located in a dry watercourse in the north-west corner of the Project site. Photo Plate 14 provides graphic representation of the study site centred around the pitfall trapping line.

Photo Plate 14 Pitfall Line at DSFS1

DSFS2 was positioned in a dry waterway, adjacent to steep rocky hills in the centre of the site. Photographic representation of the pitfall trapping line and typical habitat at DSFS2 is shown in Photo Plate 15.

Photo Plate 15 Pitfall Line at DSFS2

DSFS3 was located in on the pediment slope of a Snappy Gum dominated hillside. A photograph of the fauna site and the associated pitfall trapping line is shown in Photo Plate 16.

Photo Plate 16 Pitfall Line at Study Site DSFS3

DSFS4 was located in a dry watercourse dominated by *Melaleuca bracteata*. A photograph of the pitfall trapping line at DSFS4 is shown in Photo Plate 17.

Photo Plate 17 Pitfall Line at DSFS4

DSFS5 was located on top of a stony hillside dominated by *Acacia phlebocarpa.* The pitfall trapping line at DSFS5 is shown in Photo Plate 18.

Photo Plate 18 Pitfall Line at DSFS5

TR01 was located in the south-western corner of the Project site among Cloncurry Box hills. Photo Plate 19 provides graphic representation of the study site centred around the pitfall trapping line.

Photo Plate 19 Pitfall Line at TR01

TR02 was located in the east of the Project site on undulating Snappy Gum hills. The fauna site and pitfall trapping line in particular are shown in Photo Plate 20.

Photo Plate 20 Pitfall Line at TR02

TR03 was located in the centre of the Project site among Snappy Gum hills. Photo Plate 21 provides graphic representation of the study site centred around the pitfall trapping line.

Photo Plate 21 Pitfall Line at TR03

TR04 was located on the creek flats of a mapped watercourse in the centre of the Project site. The pitfall trapping line established within fauna site TR04 is shown in Photo Plate 22.

Photo Plate 22 Pitfall Line at TR04

TR05 was located on the lower slopes of a hillside dominated by Snappy Gum. The pitfall line and typical habitat at fauna site TR05 is shown in Photo Plate 23.

Photo Plate 23 Pitfall Line at TR05

TR06 was located on a stony hillside in the south-east of the Project site. Fauna site TR06 is shown in Photo Plate 24 along with the pitfall trapping line established at the time of the survey.

Photo Plate 24 Pitfall Line at TR06

TR07 was positioned in close proximity to the DSFS5 on an undulating hill dominated by Snappy Gum and Bloodwoods. The pitfall line established at TR07 is shown in Photo Plate 25 which also provides graphical presentation of the study site.

Photo Plate 25 Pitfall Line at TR07

TR08 was located toward the centre of the Project site on the creek flats of a mapped watercourse. The fauna site and pitfall trapping line as established at the time of the survey are shown in Photo Plate 26.

Photo Plate 26 Pitfall Line at TR08

2014 Fauna Study Sites

FA1 was positioned in a Cloncurry Box drainage line in the south-west portion of the Project site. The low vegetation canopy was dominated by Cloncurry Box and associated with a dense understorey of *Melaleuca bracteata* and a sparse ground layer on sandy clay soils. The ground layer was dominated by Buffel and cattle tracks were prominent throughout the habitat area. The shallow creek channels were dry at the time of the survey with minor erosion in some areas. Photo Plate 27 provides graphic representation of the study site centred around the pitfall trapping line.

Photo Plate 27 Pitfall Line at FA1

FA2 was located in River Red Gum Riparian woodland on the major creek that passes through the south-west corner of the site. The vegetation canopy is dominated by River Red Gum while the understorey is dominated by Arid Peach and Turpentine. The ground layer is sparse due to grazing cattle movements on the creek embankments and the rocky nature of the high bank. The habitat area contains moderate cover of leaf litter, a few logs and many hollows within the River Red Gum trees. The fauna site runs along a major creek which was dry at the time of the survey. A photograph of the fauna site, centred around the pitfall trapping line is shown in Photo Plate 28.

Photo Plate 28 Pitfall Line at FA2

FA3 was located in the mid-western portion of the Project site on an outcropping rocky hilltop. This outcropping hill occurs as part of a series of rocky ranges that form the dominant landform in this area of the Project. The vegetation community consists of low open woodland of Snappy Gum with the occasional Hill Kurrajong, an understorey of Arid Peach and Turpentine and a Soft Spinifex (*Triodia pungens*) dominant ground layer. The rocky outcrop landform provides an abundance of habitat for reptiles and rock-wallabies. A few hollow-bearing trees occur at the rear of the outcrop. The rocky outcrop that forms the focus of the FA3 is shown in Photo Plate 29.

Photo Plate 29 Rocky outcrop habitat at FA3

FA4 was centred around low open woodlands of Cloncurry Box on an ephemeral drainage line and valley flat located in the west of the Project site. Either side of the valley flat features low relief rocky hills that are dominated by Snappy Gum and Turpentine. This fauna site featured good habitat variety with plenty of leaf litter, grassy tussocks, fallen timber and cracking bark. Combined these features were found to support an abundance of retiles. A photograph of the fauna site and the pitfall trapping line, in particular, is shown in Photo Plate 30.

Photo Plate 30 Pitfall Line at FA4

FA5 was located in Cloncurry Box woodlands on a small dry drainage line in the central-western portion of the site. The Cloncurry Box dominant canopy is accompanied by the occasional Northern Swamp Box, while the understorey contains a mix of Turpentine, Arid Peach, Conkerberry and Whitewood. Buffel and Soft Spinifex co-dominate the ground layer. The fauna site was surrounded by Snappy Gum dominant hills. Habitat features include small hollows, rocks, leaf litter and grassy tussocks. A photograph of the pitfall trapping line at FA5 is shown in Photo Plate 31.

Photo Plate 31 Pitfall Line at FA5

FA6 was located in low open Snappy Gum woodlands on a rocky hill in the south-east of the Project site. The Snappy Gum dominant vegetation community consists of the occasional bloodwood in the canopy, Arid Peach and Tabletop Wattle in the understorey and a ground layer of Kangaroo Grass, Soft Spinifex and Mountain Wanderrie Grass. The site featured good habitat variety with many grass tussocks, low shrubs, outcropping rock habitat, some leaf litter and fallen timber. A broad landscape photographic view of FA6 is shown in Photo Plate 32.

Photo Plate 32 Low Open Snappy Gum Woodland on Hillsides at FA6

FA7 was located in low open Snappy Gum woodland on a rocky outcrop and hillslope in the east of the Project site. The vegetation canopy was dominated by Snappy Gum with associated Arid Peach and a shrub layer of Tabletop Wattle, Soap Bush and Turpentine. The ground layer was dominated by Soft Spinifex, Common Fringe-sedge and *Paspalidium distans*. The site contained moderate habitat variety with plenty of outcropping rocks, crevices and grass tussocks but little leaf litter, fallen timber or tree hollows. A portion of the hilltop rocky outcrop at FA7 is shown in Photo Plate 33.

Photo Plate 33 Rocky outcrop habitat at FA7

FA8 was located along a River Red Gum creek in the north of the Project site. The riparian canopy was typically dominated by River Red Gum while Northern Swamp Box forms a dense understorey in the upstream reach of the fauna transect. The creek consisted of a sandy to rocky, cobble bed with boulder outcrops occurring sporadically. There was a good cover of leaf litter and an abundance of tree hollows. The upstream section of the creek at FA8 is shown in Photo Plate 34.

Photo Plate 34 Harp trap in River Red Gum / Northern Swamp Box Creek at FA8

Appendix C Flora Species Inventory

Scientific Name	Common Name	Conservation Status		2011 Records	Flora Survey Transect										
		NC Act/LP Act	EPBC Act		FT1	FT2	FT3	FT4	FT5	FT6	FT7	FT8	FT9	FT10	OPPS
Abildgaardia vaginata		LC	NL	X											
Abutilon hannii		LC	NL	X											
Acacia chisholmii	Turpentine	LC	NL	X	X			X	X	X					
Acacia coriacea		LC	NL	X											
Acacia gonoclada		LC	NL	X											
Acacia hemsleyi		LC	NL			X	X								
Acacia hemignosta		LC	NL	X											X
Acacia holosericea	Soapbush	LC	NL	X			X		X			X	X	X	
Acacia melleodora		LC	NL	X								X	X		X
Acacia monticola	Red Wattle	LC	NL								X			X	
Acacia orthocarpa		LC	NL	X											X
Acacia phlebocarpa	Tabletop Wattle	LC	NL	X							X	X	X	X	
Acacia retivenea	Net-vein Wattle	LC	NL	X											X
Achyranthes aspera		LC	NL	X											
Aerva javanica		I	NL	X											
Alphitonia excelsa	Red Ash	LC	NL	X											
Anisomeles malabarica		LC	NL	X											
Aristida holathera		LC	NL	X											
Aristida latifolia		LC	NL	X											
Aristida longicollis		LC	NL		X	X		X							
Aristida pruinosa		LC	NL			X	X								X
Aristida sp.		LC	NL									X			

Scientific Name	Common Name	Conservation Status		2011 Records	Flora Survey Transect										
		NC Act/LP Act	EPBC Act		FT1	FT2	FT3	FT4	FT5	FT6	FT7	FT8	FT9	FT10	OPPS
Atalaya hemiglauca	Whitewood	LC	NL	X	X	X		X	X	X					X
Bidens bipinnata	Bipinnate Beggar's Ticks	I	NL	X											
Bonamia media		LC	NL	X										X	
Boerhavia sp.		LC	NL			X	X	X	X		X		X		
Bothriochloa ewartiana	Forest Bluegrass	LC	NL	X									X		
Brachyachne convergens		LC	NL	X											X
Brachychiton collinus	Hill Kurrajong	LC	NL	X											X
Bulbostylis barbata		LC	NL	X											X
Cajanus sp.		LC	NL			X									
Carissa lanceolata	Conkerberry	LC	NL	X					X			X	X		X
Cenchrus ciliaris	Buffel Grass	I	NL	X	X	X	X	X		X					
Chamaecrista absus		LC	NL	X											
Chamaecrista concinna		LC	NL	X											
Chamaesyce hirta	Asthma Plant	I	NL												X
Cheilanthes brownii	Woolly Cloak Fern	LC	NL					X		X	X	X			
Cheilanthes sieberi		LC	NL	X											
Chloris pectinata	Comb Chloris	LC	NL	X											
Chrysopogon elongatus		LC	NL	X											
Chrysopogon fallax		LC	NL	X											
Cleome viscosa	Tickweed	LC	NL	X		X	X	X	X	X	X				X

Scientific Name	Common Name	Conservation Status		2011 Records	Flora Survey Transect										
		NC Act/LP Act	EPBC Act		FT1	FT2	FT3	FT4	FT5	FT6	FT7	FT8	FT9	FT10	OPPS
Corchorus aestuans		LC	NL	X											
Corchorus sericeus	Grey Jute	LC	NL	X					X		X	X		X	
Corchorus sidoides	Flannel Jute	LC	NL		X			X							
Corymbia aparrerinja	Ghost Gum	LC	NL	X						X			X		X
Corymbia capricornia		LC	NL	X										X	
Corymbia polycarpa	Long-fruited Bloodwood	LC	NL	X											
Corymbia terminalis	Northern Bloodwood	LC	NL	X	X					X			X	X	X
Crotalaria novae-hollandiae subsp. novae-hollandiae	New Holland Rattlepod	LC	NL	X											X
Cryptandra propinqua		LC	NL	X											
Cucumis maderaspatanus		LC	NL	X											
Cucumis melo		LC	NL	X										X	
Cymbopogon bombycinus	Lemon-scented Grass	LC	NL	X				X	X	X	X	X	X		
Cyperus cunninghamii		LC	NL				X								
Cyperus microcephalus subsp. microcephalus		LC	NL			X									
Dactyloctenium radulans	Button Grass	LC	NL	X											X

Scientific Name	Common Name	Conservation Status		2011 Records	Flora Survey Transect										
		NC Act/LP Act	EPBC Act		FT1	FT2	FT3	FT4	FT5	FT6	FT7	FT8	FT9	FT10	OPPS
Digitaria gibbosa		LC	NL	X											
Dodonaea lanceolata var. lanceolata		LC	NL	X											
Enneapogon avenaceus	Common Bottlewashers	LC	NL				X	X	X	X	X				
Enneapogon lindleyanus		LC	NL		X					X		X		X	X
Enneapogon polyphyllus	Leafy Nineawn	LC	NL	X									X		X
Enteropogon ramosus	Twirly Windmill Grass	LC	NL						X						X
Eragrostis sp.		LC	NL			X									
Eragrostis tenellula	Delicate Lovegrass	LC	NL	X											X
Eremophila latrobei		LC	NL											X	X
Eremophila longifolia	Berrigan	LC	NL	X	X			X	X						
Eriachne ciliata		LC	NL	X											
Eriachne mucronata	Mountain Wanderrie Grass	LC	NL	X								X	X	X	
Eriachne mucronata forma (Alpha C.E. Hubbard 7882)		LC	NL						X		X				
Eucalyptus camaldulensis	River Red Gum	LC	NL	X		X	X								X

Scientific Name	Common Name	Conservation Status		2011 Records	Flora Survey Transect										
		NC Act/LP Act	EPBC Act		FT1	FT2	FT3	FT4	FT5	FT6	FT7	FT8	FT9	FT10	OPPS
Eucalyptus leucophloia	Snappy Gum	LC	NL					X			X	X	X	X	X
Eucalyptus leucophylla	Cloncurry Box	LC	NL	X	X			X	X	X			X		X
Eulalia aurea	Silky Browntop	LC	NL	X				X						X	X
Euphorbia biconvexa		LC	NL		X				X	X			X		
Euphorbia drummondii		LC	NL	X											
Euphorbia tannensis subsp. tannensis		LC	NL								X	X			
Evolvulus alsinoides	Tropical Speedwell	LC	NL	X								X			X
Fimbristylis dichotoma	Common Fringe-sedge	LC	NL	X	X			X			X	X	X		X
Flueggea leucopyrus	Bushweed	LC	NL												X
Flueggea virosa subsp. melanthesoides	White Currant Bush	LC	NL	X	X	X	X		X						X
Galactia tenuiflora	Galactia	LC	NL	X		X	X	X	X						X
Glycine sp.		LC	NL						X						
Goodenia ramelii		LC	NL												X
Goodenia vilmoriniae		LC	NL												X
Gomphrena canescens subsp. canescens		LC	NL	X											
Gossypium australe	Native Cotton	LC	NL	X	X			X	X	X				X	
Grevillea mimosoides	Caustic Bush	LC	NL	X											X
Grevillea wickhamii	Holly-leaved Grevillea	LC	NL	X											X

Scientific Name	Common Name	Conservation Status		2011 Records	Flora Survey Transect										
		NC Act/LP Act	EPBC Act		FT1	FT2	FT3	FT4	FT5	FT6	FT7	FT8	FT9	FT10	OPPS
Hakea arborescens		LC	NL	X											
Hakea chordophylla	Bootlace Oak	LC	NL		X					X			X		X
Hakea lorea		LC	NL	X											
Heliotropium ballii		LC	NL											X	X
Heliotropium conocarpum		LC	NL	X											
Heliotropium cunninghamii		LC	NL				X	X	X		X	X	X		
Heteropogon contortus	Black Speargrass	LC	NL	X					X	X					X
Hibiscus meraukensis	Merauke hibiscus	LC	NL	X											
Hibiscus sturtii		LC	NL	X										X	X
Hybanthus aurantiacus		LC	NL	X											
Hybanthus enneaspermus		LC	NL	X										X	
Hyptis suaveolens	Hyptis	LC	NL			X									
Indigofera colutea	Sticky Indigo	LC	NL	X											X
Indigofera hirsuta	Hairy Indigo	LC	NL	X											X
Indigofera linifolia		LC	NL	X										X	X
Indigofera linnaei	Birdsville Indigo	LC	NL	X											
Indigofera pratensis	Forest Indigo	LC	NL	X								X			X
Indigofera sp.		LC	NL						X				X		
Indigofera trita		LC	NL	X											

Scientific Name	Common Name	Conservation Status		2011 Records	Flora Survey Transect										
		NC Act/LP Act	EPBC Act		FT1	FT2	FT3	FT4	FT5	FT6	FT7	FT8	FT9	FT10	OPPS
Lophostemon grandiflorus	Northern Swamp Mahogany	LC	NL	X		X	X		X						X
Ludwigia octovalvis	Willow Primrose	LC	NL	X											
Lysiphyllum cunninghamii		LC	NL	X											X
Maytenus cunninghamii	Yellow Berry Bush	LC	NL	X					X						X
Melaleuca bracteata	Black Tea-tree	LC	NL	X	X										X
Melhania oblongifolia	Velvet Hibiscus	LC	NL	X										X	X
Melinis repens	Red Natal Grass	I	NL	X											
Mnesithea formosa	Silkytop Grass	LC	NL	X							X				X
Neptunia dimorphantha	Sensitive Plant	LC	NL										X		
Neptunia gracilis		LC	NL	X											
Ocimum tenuiflorum		LC	NL	X											
Panicum decompositum		LC	NL	X											
Paspalidium constrictum		LC	NL										X	X	X
Paspalidium distans		LC	NL				X								
Paspalidium rarum	Rare Paspalidium	LC	NL								X	X			X
Peripleura hispidula var. hispidula	Fuzzweed	LC	NL												X
Perotis rara	Comet Grass	LC	NL	X											

Scientific Name	Common Name	Conservation Status		2011 Records	Flora Survey Transect										
		NC Act/LP Act	EPBC Act		FT1	FT2	FT3	FT4	FT5	FT6	FT7	FT8	FT9	FT10	OPPS
Phyllanthus maderaspatensis		LC	NL						X					X	X
Ptilotus obovatus		LC	NL												X
Santalum lanceolatum	Sandalwood	LC	NL												X
Sarcostemma brevipedicellatum	Caustic Bush	LC	NL												X
Senna artemisioides subsp. helmsii	Crinkle Leaf Cassia	LC	NL											X	X
Senna planitiicola		LC	NL												X
Senna venusta	Graceful Cassia	LC	NL												X
Sida fibulifera	Pin Sida	LC	NL									X	X		X
Sida sp.		LC	NL							X					
Sida subspicata	Spiked Sida	LC	NL											X	X
Solanum ellipticum	Potato Bush	LC	NL		X									X	X
Solanum esuriale	Quena	LC	NL												X
Solanum quadriloculatum		LC	NL							X					X
Spermacoce auriculata		LC	NL	X											
Sporobolus actinocladus	Katoora Grass	LC	NL	X											X
Sporobolus australasicus	Australian Dropseed	LC	NL	X											X
Stackhousia viminea	Slender	LC	NL	X											

Scientific Name	Common Name	Conservation Status		2011 Records	Flora Survey Transect										
		NC Act/LP Act	EPBC Act		FT1	FT2	FT3	FT4	FT5	FT6	FT7	FT8	FT9	FT10	OPPS
	Stackhousia														
Streptoglossa bubakii		LC	NL	X											
Streptoglossa decurrens		LC	NL	X											
Swainsona burkei	Hairy Darling Pea	LC	NL								X				
Tephrosia brachyodon var longifolia	Narrow-leaved Tephrosia	LC	NL			X						X			X
Tephrosia rosea		LC	NL	X										X	X
Tephrosia sp.		LC	NL					X							
Tephrosia virens		LC	NL	X											
Terminalia aridicola	Arid Peach	LC	NL	X				X	X			X	X	X	X
Themeda triandra	Kangaroo Grass	LC	NL	X					X	X	X	X	X	X	X
Tinospora smilacina	Snake Vine	LC	NL	X	X					X					X
Trema tomentosa		LC	NL	X											
Trianthema triquetra	Red Spinach	LC	NL				X								
Tribulopsis pentandra		LC	NL					X	X	X	X	X	X		
Trichodesma zeylanicum	Camel Bush	LC	NL	X							X	X			X
Triodia bitextura		LC	NL	X											X
Triodia pungens	Soft Spinifex	LC	NL	X	X		X	X		X	X	X	X	X	X
Triodia longiceps	Giant Grey Spinifex	LC	NL	X											X
Triumfetta plumigera		LC	NL	X											
Triumfetta microcantha		LC	NL								X				X

Scientific Name	Common Name	Conservation Status		2011 Records	Flora Survey Transect										
		NC Act/LP Act	EPBC Act		FT1	FT2	FT3	FT4	FT5	FT6	FT7	FT8	FT9	FT10	OPPS
Urochloa sp.		LC	NL								X				
Vachellia bidwillii	Corkwood Wattle	LC	NL	X											X
Vachellia farnesiana	Mimosa Bush	I	NL			X	X								X
Vigna radiata		I	NL	X											
Waltheria indica		LC	NL	X											
Zornia muriculata		LC	NL	X											

Key:

LC – This species is classified as Least Concern under the NC Act

I – Introduced species

NL – This species is not listed under the EPBC Act as a species of conservation significance

Appendix D Fauna Species Inventory

Family	*Scientific Name*	Common Name	Conservation Status		Wet season Survey								Dry Season Survey							
			NC Act / LP Act	EPBC Act	OPPS	FA1	FA2	FA3	FA4	FA5	FA6	FA7	OPPS	FA1	FA2	FA4	FA5	FA6	FA7	FA8
Reptiles																				
Agamidae	*Amphibolurus gilberti*	Gilberts Dragon	LC	NL										X	X					
Boidae	*Antaresia childreni*	Children's Python	LC	NL							X									
Boidae	*Liasis olivaceus*	Olive Python	LC	NL			X				X									
Elapidae	*Suta suta*	Curl Snake	LC	NL														X		
Gekkonidae	*Strophurus ciliaris*	Northern Spiny-tailed Gecko	LC	NL						X										
Gekkonidae	*Gehyra robusta*	Robust Dtella	LC	NL		X		X			X	X			X	X				X
Gekkonidae	*Gehyra variegata*	Tree Dtella	LC	NL					X					X						
Gekkonidae	*Heteronotia binoei*	Bynoe's Gecko	LC	NL											X					
Pygopodidae	*Lialis burtonis*	Burton's Legless Lizard	LC	NL									X							
Pygopodidae	*Pygopus steelescotti*	Northern Hooded Scaly-foot	LC	NL		X														
Scincidae	*Carlia amax*	Two-spined Rainbow-skink	LC	NL			X					X								
Scincidae	*Carlia munda*	Shaded-litter Rainbow-skink	LC	NL									X						X	X
Scincidae	*Cryptoblepharus metallicus*	Metallic Snake-eyed Skink	LC	NL					X											
Scincidae	*Cryptoblepharus zoticus*	Agile Snake-eyed Skink	LC	NL								X								
Scincidae	*Ctenotus lateralis*	Gravelly-soil Ctenotus	LC	NL					X						X					
Scincidae	*Ctenotus saxatilis*	Rock Ctenotus	LC	NL			X		X											
Scincidae	*Ctenotus striaticeps*	Carpentarian Ctenotus	LC	NL					X											
Scincidae	*Egernia hosmeri*	Hosmer's Skink	LC	NL							X							X		
Scincidae	*Proablepharus tenuis*	Northern Soil-crevice Skink	LC	NL							X									
Typhlopidae	*Ramphotyphlops diversus*	Northern Blind Snake	LC	NL		X	X		X	X										
Typhlopidae	*Ramphotyphlops ligatus*	Robust Blind Snake	LC	NL					X	X										
Varanidae	*Varanus acanthurus*	Ridge-tailed Monitor	LC	NL		X														
Amphibians																				
Hylidae	*Cyclorana longipes*	Long-footed Frog	LC	NL					X											
Hylidae	*Litoria caerulea*	Common Green Treefrog	LC	NL	X	X	X		X			X								
Hylidae	*Litoria rubella*	Ruddy Treefrog	LC	NL	X		X					X								
Birds																				
Acanthizidae	*Smicrornis brevirostris*	Weebill	LC	NL	X	X	X		X	X		X	X		X				X	X
Accipitridae	*Accipiter cirrocephalus*	Collared Sparrowhawk	LC	NL							X		X							
Accipitridae	*Aquila audax*	Wedge-tailed Eagle	LC	NL									X							
Accipitridae	*Elanus axillaris*	Black-shouldered Kite	LC	NL	X				X											
Accipitridae	*Haliastur sphenurus*	Whistling Kite	LC	NL									X	X						
Aegothelidae	*Aegotheles cristatus*	Australian Owlet-nightjar	LC	NL				X												
Artamidae	*Artamus cinereus melanops*	Black-faced Woodswallow	LC	NL	X			X			X	X	X							
Artamidae	*Artamus personatus*	Masked Woodswallow	LC	NL	X								X							
Artamidae	*Cracticus nigrogularis*	Pied Butcherbird	LC	NL	X			X	X	X										
Artamidae	*Cracticus tibicen*	Australian Magpie	LC	NL	X								X							
Cacatuidae	*Nymphicus hollandicus*	Cockatiel	LC	NL															X	
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	LC	NL	X	X	X	X					X						X	
Campephagidae	*Lalage sueurii*	White-winged Triller	LC	NL	X						X	X								
Climacteridae	*Climacteris melanura*	Black-tailed Treecreeper	LC	NL									X							
Columbidae	*Geopelia cuneata*	Diamond Dove	LC	NL	X			X					X		X	X				X
Columbidae	*Geopelia striata*	Peaceful Dove	LC	NL	X	X	X			X	X		X		X					X
Columbidae	*Geophaps plumifera*	Spinifex Pigeon	LC	NL	X															
Columbidae	*Ocyphaps lophotes*	Crested Pigeon	LC	NL										X						
Columbidae	*Phaps chalcoptera*	Common Bronzewing	LC	NL	X			X		X	X		X					X		X
Corcoracidae	*Eurystomus orientalis*	Dollarbird	LC	NL	X															
Corcoracidae	*Struthidea cinerea*	Apostlebird	LC	NL	X				X											
Corvidae	*Corvus coronoides*	Australian Raven	LC	NL											X					
Corvidae	*Corvus orru*	Torresian Crow	LC	NL		X	X							X	X					
Cuculidae	*Cacomantis variolosus*	Brush Cuckoo	LC	NL							X	X								

Family	*Scientific Name*	Common Name	Conservation Status		Wet season Survey								Dry Season Survey							
			NC Act / LP Act	EPBC Act	OPPS	FA1	FA2	FA3	FA4	FA5	FA6	FA7	OPPS	FA1	FA2	FA4	FA5	FA6	FA7	FA8
Cuculidae	*Eudynamys orientalis*	Eastern Koel	LC	NL	X						X									
Estrildidae	*Taeniopygia bichenovii*	Double-barred Finch	LC	NL	X	X	X		X		X	X	X		X					X
Estrildidae	*Taeniopygia guttata*	Zebra Finch	LC	NL	X			X		X	X		X	X	X					
Eurostopodidae	*Eurostopodus argus*	Spotted Nightjar	LC	NL	X															
Falconidae	*Falco berigora*	Brown Falcon	LC	NL	X								X							
Halcyonidae	*Dacelo leachii*	Blue-winged Kookaburra	LC	NL	X		X													X
Halcyonidae	*Todiramphus pyrrhopygius*	Red-backed Kingfisher	LC	NL	X															
Halcyonidae	*Todiramphus sanctus*	Sacred Kingfisher	LC	NL	X		X													
Maluridae	*Malurus lamberti*	Variegated Fairy-wren	LC	NL	X	X		X		X			X			X				X
Maluridae	*Malurus leucopterus*	White-winged Fairy-wren	LC	NL	X				X	X										
Maluridae	*Malurus melanocephalus*	Red-backed Fairy-wren	LC	NL	X								X							
Megaluridae	*Cincloramphus mathewsi*	Rufous Songlark	LC	NL	X						X									
Meliphagidae	*Lichmera indistincta*	Brown Honeyeater	LC	NL	X														X	
Meliphagidae	*Ptilotula keartlandi*	Grey-headed Honeyeater	LC	NL						X			X	X						
Meliphagidae	*Philemon citreogularis*	Little Friarbird	LC	NL		X		X		X	X	X								
Meliphagidae	*Melithreptus gularis laetior*	Golden-backed Honeyeater	NT	NL									X						X	
Meropidae	*Merops ornatus*	Rainbow Bee-eater	LC	Mi	X		X				X	X	X							
Monarchidae	*Grallina cyanoleuca*	Magpie-lark	LC	NL	X		X		X				X				X			
Monarchidae	*Myiagra inquieta*	Restless Flycatcher	LC	NL	X	X	X			X		X		X	X	X				X
Otididae	*Ardeotis australis*	Australian Bustard	LC	NL	X															
Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-thrush	LC	NL	X					X			X							
Pachycephalidae	*Pachycephala rufiventris*	Rufous Whistler	LC	NL	X	X	X			X		X	X	X	X				X	X
Pardalotidae	*Pardalotus striatus*	Striated Pardalote	LC	NL									X		x					X
Petroicidae	*Microeca fascinans*	Jacky Winter	LC	NL	X															
Phasianidae	*Coturnix pectoralis*	Stubble Quail	LC	NL	X															
Pomatostomidae	*Pomatostomus temporalis rubeculus*	Grey-crowned Babbler (north-western)	LC	NL	X	X	X	X	X					X			X			
Psittacidae	*Aprosmictus erythropterus*	Red-winged Parrot	LC	NL						X										
Psittacidae	*Melopsittacus undulatus*	Budgerigar	LC	NL									X	X	X			X	X	X
Psittacidae	*Psitteuteles versicolor*	Varied Lorikeet	LC	NL		X	X													
Ptilonorhynchidae	*Ptilonorhynchus maculatus*	Spotted Bowerbird	LC	NL									X							
Rhipiduridae	*Rhipidura leucophrys*	Willie Wagtail	LC	NL	X				X				X	X						
Mammals																				
Bovidae	*Bos taurus*	Cow	I	NL		X	X		X	X										
Canidae	*Canis familiaris*	Wild Dog	C2	NL									*							
Dasyuridae	*Planigale maculata*	Common Planigale	LC	NL													X			
Dasyuridae	*Sminthopsis macroura*	Stripe-faced Dunnart	LC	NL							#									
Macropodidae	*Lagorchestes conspicillatus*	Spectacled Hare-wallaby	LC	NL				X		X										
Macropodidae	*Macropus robustus*	Common Wallaroo	LC	NL	X						X		X						X	
Macropodidae	*Petrogale purpureicollis*	Purple-necked Rock-wallaby	V	NL	X			X										*	X	X
Hipposideridae	*Hipposideros ater*	Eastern Dusky Leaf-nosed Bat	LC	NL		X	X													
Suidae	*Sus scrofa*	Pig	C2	NL											X	*	*			
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat	LC	NL		X	X	X	X	X	X			^	^				^	^
Vespertilionidae	*Chalinolobus nigrogriseus*	Hoary Wattled Bat	LC	NL		X	X	X	X		X								^	^
Vespertilionidae	*Nyctophilus sp.*					X	X		X											
Vespertilionidae	*Scotorepens balstoni*	Inland Broad-nosed Bat	LC	NL		X	X	X	X	X				^	^				^	^
Vespertilionidae	*Scotorepens greyii*	Little Broad-nosed Bat	LC	NL		X	X	X	X	X	X								^	^
Vespertilionidae	*Vespadelus baverstocki*	Inland Forest Bat	LC	NL															^	^
Vespertilionidae	*Vespadelus finlaysoni*	Finlayson's Cave Bat	LC	NL																^
Molossidae	*Chaerephon jobensis*	Northern Freetail Bat	LC	NL		X	X	X	X	X	X								X	X
Molossidae	*Mormopterus beccarii*	Beccari's Freetail Bat	LC	NL		X	X	*	X		X									
Molossidae	*Mormopterus sp.*					X	*	*	*											
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail Bat	LC	NL		X	X	X	X		X									

Family	*Scientific Name*	Common Name	Conservation Status		Wet season Survey								Dry Season Survey							
			NC Act / LP Act	EPBC Act	OPPS	FA1	FA2	FA3	FA4	FA5	FA6	FA7	OPPS	FA1	FA2	FA4	FA5	FA6	FA7	FA8
Emballonuridae	*Taphozous georgianus*	Common Sheathtail Bat	LC	NL		X	X	X	X		X				X					
Emballonuridae	*Taphozous troughtoni*	Troughton's Sheathtail Bat	LC	NL		X	X		X		X									

Key:

LC – This species is classified as Least Concern under the NC Act

V – This species is classified as Vulnerable under either the EPBC Act and/or NC Act

I – Introduced species

C2 – Declared Class 2 pest species as classified under the LP Act

NL – This species is not listed under the EPBC Act as a species of conservation significance

- Probable identification of species from hair samples

* - Species identified from tracks, scats or other traces

^ - Probable species identification from bat calls

Appendix E Bat Call Analysis Results

Anabat echolocation data interpretation summary

Client: AARC (Mark Sanders via Paul Jackson) **Balance Job no.:** AARC1103

Project name/location: Mt Remarkable, NW of Cloncurry (March 2011)

Data summary tables

Numbers in columns indicate number of calls attributed to species/group for given night

Date:	28-Mar	29-Mar	30-Mar	31-Mar	1-Apr	Total Calls
No. sequence files recorded:	286	884	48	2	3	
Species positively identified (i.e. species definitely present)						
Chalinolobus gouldii	8	12	1			21
Nyctophilus species	18					18
Scotorepens balstoni	19	27	10			56
Vespadelus baverstocki	48	9	1			58
Vespadelus caurinus / V. finlaysoni	14	1				15
Mormopterus beccarii	2	1	1			4
Saccolaimus flaviventris	35	54	20			109
Taphozous georgianus	1					1
Total calls positively identified	145	104	33	0	0	282
Calls NOT positively identified *						
Chalinolobus gouldii / Scotorepens balstoni	1	56	7			64
C. gouldii / S. balstoni / Mormopterus species	32	22	1			55
Scotorepens greyii / Vespadelus baverstocki	32	11				43
Scotorepens greyii / Chalinolobus nigrogriseus	40	115				155
Chaerephon jobensis / Saccolaimus flaviventris	3	1				4
Mormopterus beccarii / Saccolaimus flaviventris		1	1			2
Mormopterus beccarii / Taphozous troughtoni	1					1
Unknown bat - linear w. 45° knee Fc42-45kHz	43	5				48
Unidentified bat calls	9	58				67
Total calls not positively identified	161	269	9	0	0	439
Total calls for site/night	**306**	**373**	**42**	**0**	**0**	**721**

***** A species listed in the bottom section of the table that is not also listed in the top section should be considered as possibly present. Likelihood of occurrence and call identification issues for these species are discussed in the 'Reliability of species ID' section on the following pages.

Species nomenclature:

Species names used in this summary follow Churchill (2008), except for the free-tailed bats (Molossidae), which follow van Dyck & Strahan (2008) and Adams *et al.* (1988).

Call identification & reporting standard:

No bat call identification guide or key exists for the region from which these data were collected.

Call identification was based on published call descriptions (Milne 2001; Reinhold *et al* 2001; and Pennay *et al.* 2004); and on reference calls collected from various locations in Queensland, New South Wales & the Northern Territory.

Determination of species' identification was further refined by considering probability of occurrence based on distributional information presented in Churchill (2008) and van Dyck & Strahan (2008).

The format and content of this report complies with nationally accepted standards for the interpretation and reporting of Anabat data (Reardon 2003); latest version available from the Australasian Bat Society on-line at http://www.ausbats.org.au/.

Anabat echolocation data interpretation summary

Client: AARC (Mark Sanders via Paul Jackson) **Balance Job no.:** AARC1103

Project name/location: Mt Remarkable, NW of Cloncurry (March 2011)

Reliability of species ID

***Nyctophilus* species**

Nyctophilus bats generally produce distinctive calls, but the species cannot be reliably differentiated from call data. The species most likey to be present in the study area is *N. geoffroyi* . Three other species (*N. arnhemensis* , *N. daedelus* and *N. walkeri*) also occur in the far north-west of Queensland but are primarily restricted to moist habitats such as watercourses lined with pandanus and paperbark.

Vespadelus caurinus / V. finlaysoni

These species produce distinctive calls with hooked pulses at higher frequency (>50kHz) than any other species (with similar pulse shape) that would occur in the area. Most calls attributed to this species pair were in the range 57-58kHz, with a couple of sequences having slightly lower frequency (*ca.* 55kHz). The higher frequency is most likely to represent *V. caurinus* and the lower frequency *V. finlaysoni* ; however, the full range of both species is poorly known, so all calls were attributed to the pair rather than attempting an unreliable species split.

***Chalinolobus gouldii / Scotorepens balstoni / Mormopterus* species**

C. gouldii (28-34kHz) has steep and curved pulses that usually alternate in frequency by 2-3kHz. *S. balstoni* (30-36kHz) pulses are also steep and curved but do not alternate in frequency. *Mormopterus* sp (30-34kHz) pulses are generally much flatter; however, pulses sometimes steepen when flying close to vegetation and brief calls may be confused with calls from the other two spp. Similarly, *C. gouldii* and *S. balstoni* pulses sometimes lack steep initial broad-band frequency sweeps when flying in open space and these calls can appear similar to those of *Mormopterus* .

A number of steep-pulsed calls at 30-34kHz were listed as either *C. gouldii* or *S. balstoni* because they were brief and/or weak and/or showed inconclusive evidence of frequency alternation and could not be reliably distinguished. *C* alls with similarly low quality but obviously less steep pulses could have been from any of these three species. If from *Mormopterus* sp., these calls probably represent one of the un-named species in the *M. 'loriae'* complex, presumably *M.* 'species 5' (Adams et al. 1988).

Scotorepens greyii / Chalinolobus nigrogriseus

Signficant frequency overlap occurs in the range 36-39kHz, but pulse shape is sometimes diagnostic. Some *C. nigrogriseus* have flatter body of longer duration (2/3 of total pulse duration) compared with cup-shaped body of shorter duration in *S. greyii* . Most calls (and all from this survey), however, exhibit pulses with intermediate features or a mixture of pulse types and cannot be reliably differentiated.

Scotorepens greyii / Vespadelus baverstocki

S. greyii (35-40kHz) calls overlap in frequency with and have very similar pulse shapes to *V. baverstocki* (39-46kHz). A number of calls within the frequency overlap zone (39-40kHz) could have been from either of these species.

Cherephon jobensis / Saccolaimus flaviventris / Taphozous georgianus / T. troughtoni / Mormopterus beccarii

Frequency overlap occurs between these spp across a range of about 12kHz: *C. jobensis* (15-21kHz); *S. flaviventris* (17-22kHz); *T. georgianus* (21-23kHz); *T. troughtoni* (23-25kHz); *M. beccarii* (21-27kHz). Where good quality signals are recorded (i.e. long duration call sequence with numerous clearly defined pulses) species identity is usually discernible due to the shape and uniformity of pulses within the sequence. Most of the calls from this survey were of sufficient quality to be reliably attributed to one or other of these species. A few calls in this frequency range, however, were too brief and/or weak and/or noisy to be reliably identified.

Unknown bat - linear w. 45° knee Fc42-45kHz

A number of calls recorded in this survey exhibit distinctive pulse shape and frequency characteristics that cannot be readily attributed to any known species that would occur in the study area. The broad initial frequency sweep is steep with a distinct "knee" in the lower third and a straight, downward-sloping body at about 45° to the initial slope. The body lies between about 42-47kHz, with characteristic frequency (Fc) ranging from 42-44kHz.

The calls are superficially similar to those of *Miniopterus orianae oceanensis* , which is not known to occur west of Cape York. Given the frequency range of these calls and the presence of call sequences attributed to *Vespadelus baverstocki* during the same periods as these unknown calls were recorded, it is probable that they represent an unusual variant of that species, rather than another unknown species.

Unidentified bat calls

Many calls were too brief and/or weak and/or contained too much interference to enable reliable identification to species. All such calls were within frequency ranges of one or more species otherwise identified from the data and do not represent additional species.

Anabat echolocation data interpretation summary

Client: AARC (Mark Sanders via Paul Jackson) **Balance Job no.:** AARC1103

Project name/location: Mt Remarkable, NW of Cloncurry (March 2011)

References:

Adams, M., Reardon, T., Baverstock, P.R. and Watts, C.H.S. (1988). Electrophoretic resolution of species boundaries in Australian Microchiroptera. IV. The Molossidae (Chiroptera). *Australian Journal of Biological Sciences* **41**, 315-326.

Churchill, S. (2008). *Australian Bats* . Jacana Books, Allen & Unwin; Sydney.

Milne, D.J. (2002). *Key to the Bat Calls of the Top End of the Northern Territory.* Technical Report No. 71, Parks and Wildlife Commission of the Northern Territory, Darwin.

Pennay, M., Law, B. and Reinhold, L. (2004). *Bat Calls of New South Wales.* Department of Environment and Conservation, Hurstville.

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**, 41-43.

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales.* Department of Natural Resources and Mines, Brisbane.

van Dyck, S. and Strahan, R. (ed.) (2008). *The Mammals of Australia* (Third Edition); New Holland; Sydney.

Anabat Data Analysis Summary

Client: AARC (Mark Sanders via Paul Jackson)

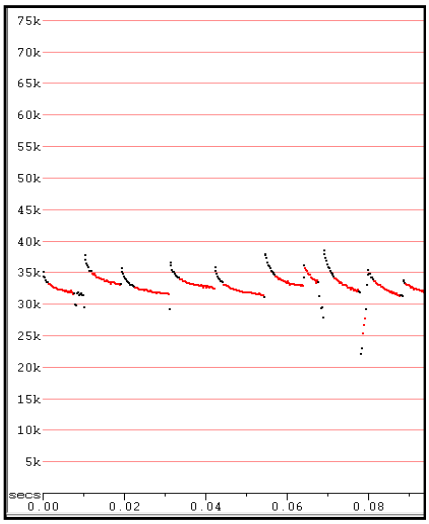
Balance Job no.: AARC1103

Project name/location: Mt Remarkable, NW of Cloncurry (March 2011)

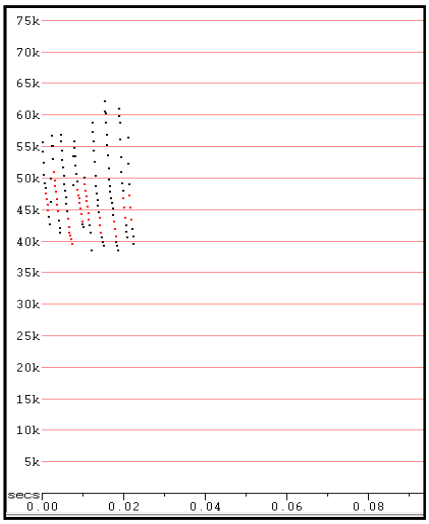
Sample calls extracted from the survey data.

Scale: 10 msec per tick; time between pulses removed (AnalookW F7 compressed mode)

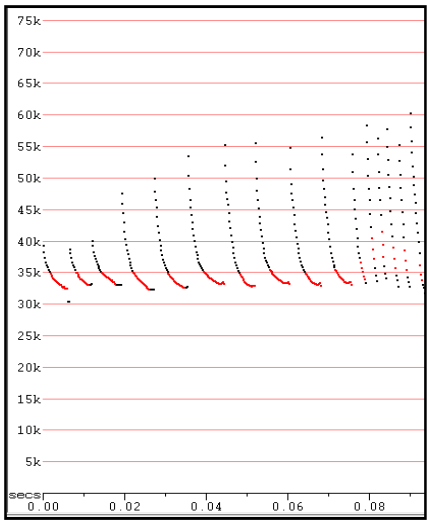
Species positively identified



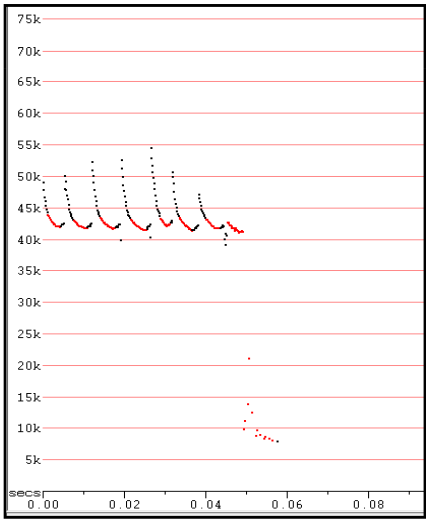
Chalinolobus gouldii



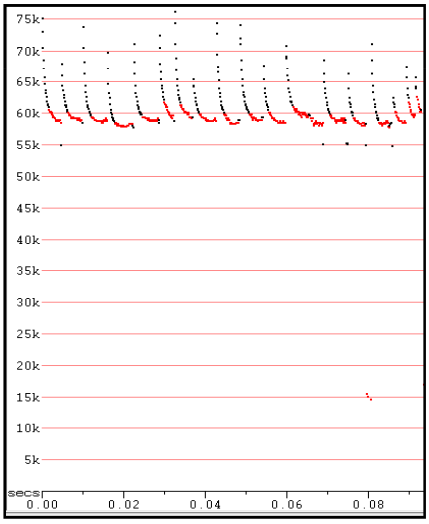
Nyctophilus species



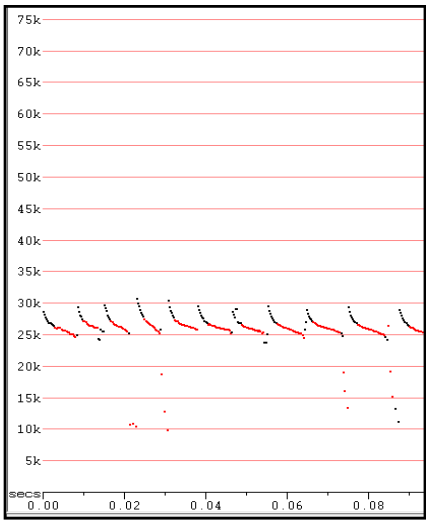
Scotorepens balstoni



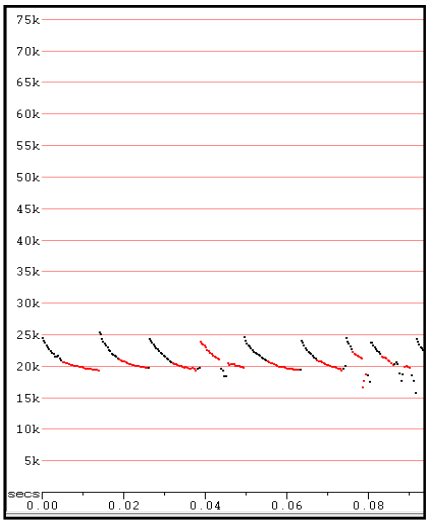
Vespadelus baverstocki



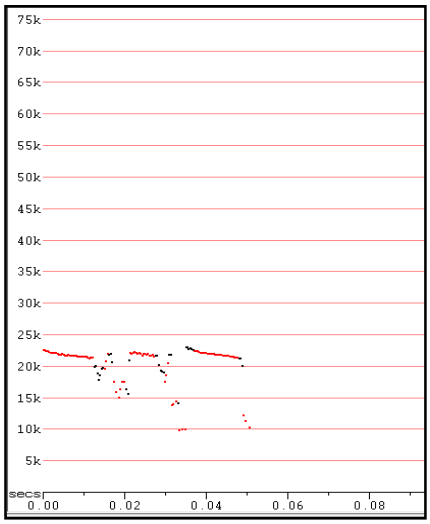
Vespadelus caurinus / V. finlaysoni



Mormopterus beccarii



Saccolaimus flaviventris



Taphozous georgianus

Anabat Data Analysis Summary

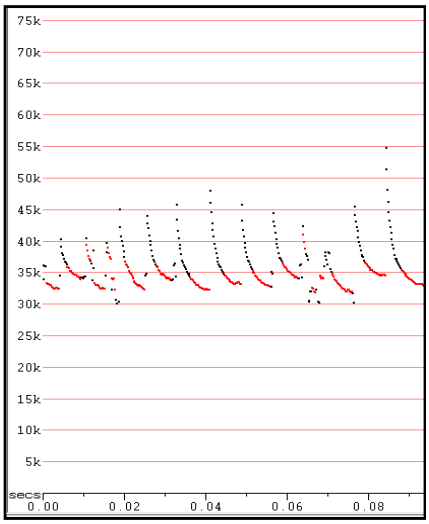
Client: AARC (Mark Sanders via Paul Jackson) **Balance Job no.:** AARC1103

Project name/location: Mt Remarkable, NW of Cloncurry (March 2011)

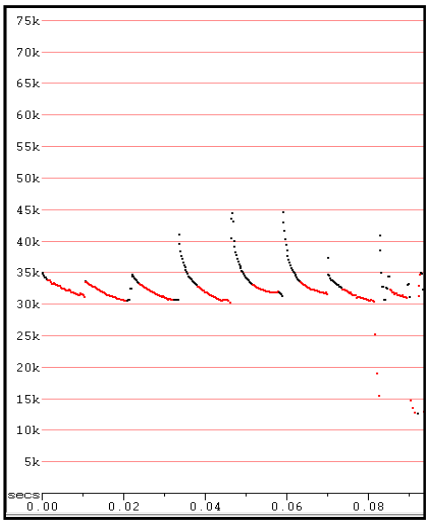
Sample calls extracted from the survey data.

Scale: 10 msec per tick; time between pulses removed (AnalookW F7 compressed mode)

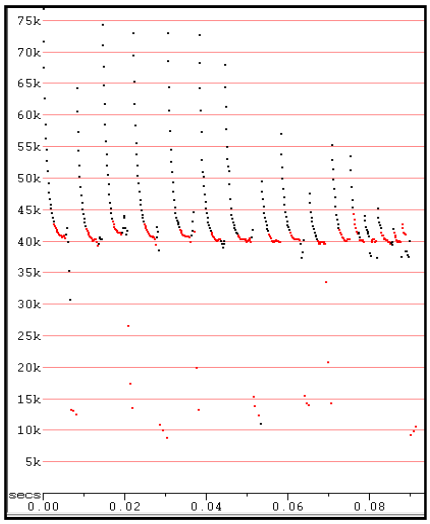
Calls NOT positively identified



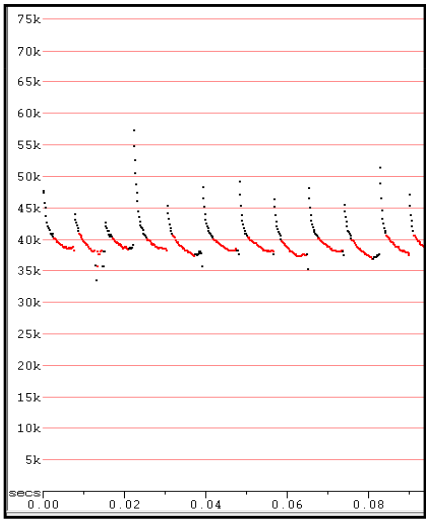
C. gouldii / S. balstoni



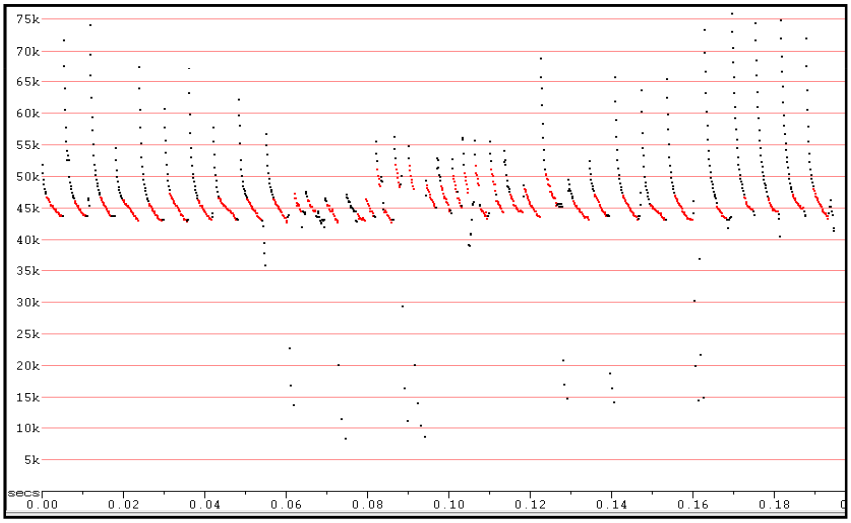
C. gouldii / S. balstoni / Mormopterus sp



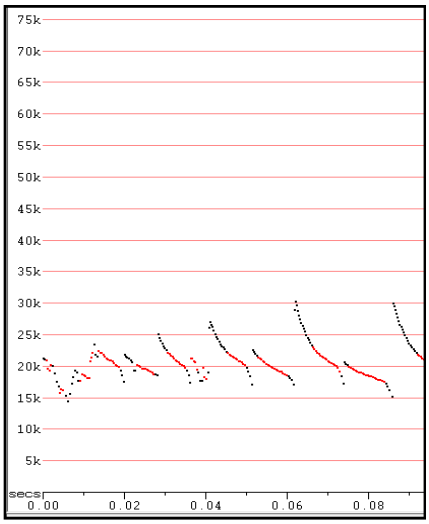
S. greyii / V. baverstocki



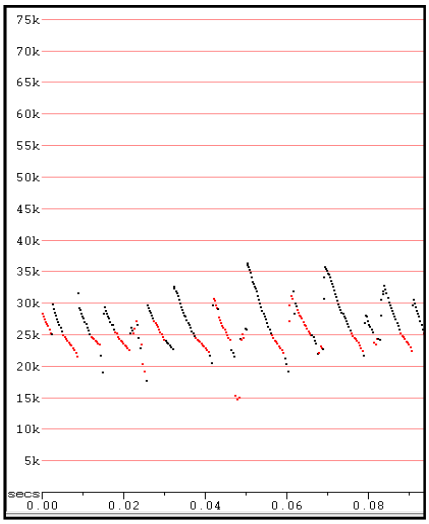
S. greyii / C. nigrogriseus



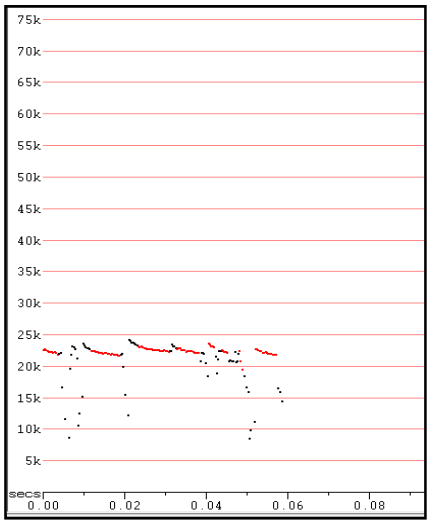
Unknown bat - linear w. 45 ° knee Fc42-45kHz



C. jobensis / S. flaviventris



M. beccarii / S. flaviventris



M. beccarii / T. troughtoni

Anabat echolocation data interpretation summary

Client: AARC (Mitch Gregory) **Balance Job no.:** AARC1113

Project name/location: East of Mount Isa, 10-26 October 2011

Data summary table

Numbers in columns refer to number of calls attributed to a species for a given night/site. Please note that these ***numbers do not imply relative abundance*** of the various species recorded. They may, however, be construed to represent relative differences in activity levels between the species.

Date:	10-Oct	11-Oct	12-Oct	13-Oct	23-Oct	24-Oct	25-Oct
No. sequence files recorded:	43	11	182	27	169	422	139
Species positively identified (i.e. species definitely present)							
Chalinolobus gouldii	1		44	2	6	258	3
Scotorepens balstoni			2	1	1	3	
Scotorepens greyii	1		6	4	6	5	2
Vespadelus baverstocki	1		34		1	2	
Vespadelus finlaysoni		3	4			14	
Chaerephon jobensis	2					1	
Mormopterus beccarii					1	3	1
Saccolaimus flaviventris			6		18	3	
Total calls positively identified	5	3	96	7	33	289	6
Calls NOT positively identified *							
Chalinolobus gouldii or Scotorepens balstoni		1			2	3	
S. greyii or *Chalinolobus nigrogriseus*	2	1	3	2	3	13	
Nyctophilus species							1
Mormopterus species or *C. gouldii*	1			1	9	13	61
C. jobensis or *S. flaviventris*	2		1		1	1	5
S. flaviventris or *Mormopterus beccarii*						8	3
M. beccarii or *Taphozous georgianus*	1				2		
Unidentified bat calls			11		1	75	13
Total calls NOT positively identified	6	2	15	3	18	113	83
Total calls for site/night	**11**	**5**	**111**	**10**	**51**	**402**	**89**

***** A species listed in the bottom section of the table that is not also listed in the top section should be considered as possibly present. Likelihood of occurrence and call identification issues for these species are discussed in the 'Reliability of species ID' section on the following pages.

Species nomenclature:

Species names used in this summary follow Churchill (2008).

Call identification & reporting standard:

Call identification was based on published call descriptions for Qld (Reinhold *et al* 2001), NSW (Pennay *et al.* 2004) and the Northern Territory (Milne 2001); and on reference calls collected from various localities in Queensland.

Determination of species' identification was further refined by considering probability of occurrence based on distributional information presented in Churchill (2008) and van Dyck & Strahan (2008).

The format and content of this report complies with nationally accepted standards for the interpretation and reporting of Anabat data (Reardon 2003); latest version available from the Australasian Bat Society on-line at http://www.ausbats.org.au/.

Anabat echolocation data interpretation summary

Client: AARC (Mitch Gregory) **Balance Job no.:** AARC1113

Project name/location: East of Mount Isa, 10-26 October 2011

Reliability of species ID:

Chalinolobus gouldii* or *Scotorepens balstoni

C. gouldii (Fc=28-34kHz) has steep and curved pulses that usually alternate in frequency by 2-3kHz. *S. balstoni* produces pulses of similar shape that overlap in frequency (Fc=30-35kHz), but which lack frequency alternation. Numerous calls were positively attributable to both species based on these criteria; however, a few brief or poor quality calls in the range could have been from either species.

S. greyii or Chalinolobus nigrogriseus

These species' calls overlap in frequency and often have similar pulse shapes; however, they can sometimes be differentiated on subtle differences in pulse shape (*S. greyii* pulses are more curved and have upward-sloping tail *cf.* no tail or down-sloping tail in *C. nigrogriseus*). A number of calls were reliably attributable to *S. greyii* based on this characteristics, but some calls had intermediate pulse shape features and could have been from either of these species.
Mormopterus eleryi (=*Mormopterus* 'species 6') is also known to produce calls similar to those of *S. greyii* (Reardon *et al* 2008) and may hae been responsible for some of these calls.

***Nyctophilus* species**

Nyctophilus bats generally produce distinctive calls, but the species within the genus cannot be reliably differentiated from call data. Just one call was attributed to this group - it had the typical linear pulse shape of the genus, but the sequence was weak and very noisy. The species most likely to be present in the study area is *N. geoffroyi* although it is possible that both *N. daedelus* and *N. arnhemsis* also occur at this locality.

Mormopterus* species or *C. gouldii

Several *Mormopterus* species produce calls around 30-34kHz, which overlap in frequency with those of *C. gouldii* ; however, differentiation is often possible due to the flatter pulse shape in *Mormopterus* and lack of frequency alternation that is common in *C. gouldii* . Most calls in the frequency range were reliably attributable to *C. gouldii* ; however, a number of calls appeared to have consistently flat pulses andcould havebeen from *Mormopterus* sp.
The distribution and taxonomy of the *Mormopterus* species that use this call type is somewhat confusing; and it is difficult to know which species may occur in the study area. Potential candidates for this call type include: inland free-tailed bat (*M. '*species 3') and little northern free-tailed bat (*M.* 'species 5'/*M. loriae*). The hairy-nosed free-tailed bat (*M. eleryi* /*M.* 'species 6') also occurs in this region, but has calls more like those of *S. greyii* (see above).

C. jobensis or S. flaviventris

C. jobensis (15-21kHz) calls generally have uneven or erratic pulse shapes and frequency within a given call sequence, compared with mostly uniform pulse shape and regular frequency in *S. flaviventris* (17-22kHz). Most of the calls within the relevant frequency range were reliably attributed to one or other of these species; however, a few calls were too brief and/or weak and/or noisy to be reliably attributed to either species.

S. flaviventris or Mormopterus beccarii

These species are generally distinguishable on frequency differential (*S. flaviventris* <22kHz; *M. beccarii* >23kHz) and pulse shape (steeper curves in *M. beccarii*). Numerous calls were attributed to *S. flaviventris* on this basis, and a few also to *M. beccarii* . Several brief calls, however, had intermediate pulse shapes with frequency around 22-23kHz and could have been from either species.

M. beccarii or Taphozous georgianus

T. georgianus calls (23-25kHz) overlap completely in frequency with those of *M. beccarii* (21-27kHz). Where good quality signals are recorded (i.e. long duration call sequence with numerous clearly defined pulses) *T. georgianus* calls generally have more consistent pulse shape and frequency within the sequence. Several calls were attributed to *M. beccarrii* based on the steeper and somewhat more erratic pulse shape; however, a few calls had flatter, more even pulses and could have been from either species.

Unidentified bat calls

Many calls were brief and/or weak and/or lacked conclusive evidence of identifiable characteristics, thus precluding reliable identification to species level. All such calls were within frequency ranges of one or more species otherwise identified from the data and do not represent additional species.

Anabat echolocation data interpretation summary

Client: AARC (Mitch Gregory) **Balance Job no.:** AARC1113

Project name/location: East of Mount Isa, 10-26 October 2011

References:

Churchill, S. (2008). *Australian Bats* . Jacana Books, Allen & Unwin; Sydney.

Milne, D.J. (2002). *Key to the Bat Calls of the Top End of the Northern Territory.* Technical Report No. 71, Parks and Wildlife Commission of the Northern Territory, Darwin.

Pennay, M., Law, B. and Reinhold, L. (2004). *Bat Calls of New South Wales.* Department of Environment and Conservation, Hurstville.

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**, 41-43.

Reardon, T., Adams, M., McKenzie, N. and Jenkins, P. (2008). A new species of Australian freetail bat *Mormopterus eleryi* sp. nov. (Chiroptera: Molossidae) and a taxonomic reappraisal of *M. norfolkensis* (Gray). *Zootaxa* **1875:** 1-31.

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales.* Department of Natural Resources and Mines, Brisbane.

van Dyck, S. and Strahan, R. (ed.) (2008). *The Mammals of Australia* (Third Edition); New Holland; Sydney.

Anabat Data Analysis Summary

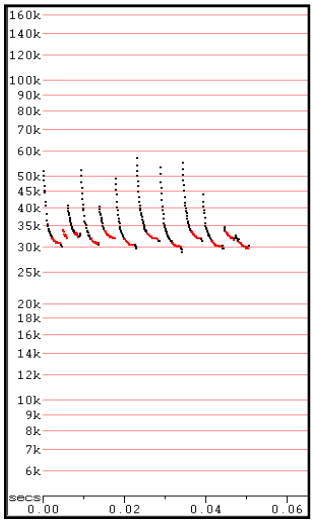
Client: AARC (Mitch Gregory) **Balance Job no.:** AARC1113

Project name/location: East of Mount Isa, 10-26 October 2011

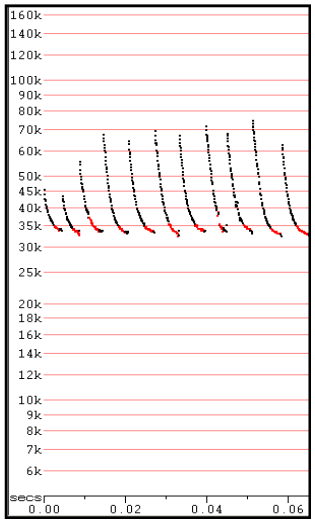
Sample calls extracted from the survey data.

Scale: 10 msec per tick; time between pulses removed (AnalookW F7 compressed mode)

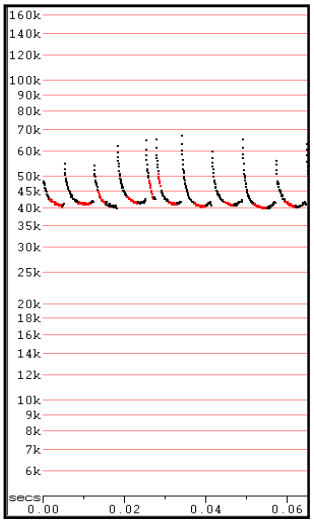
Species positively identified



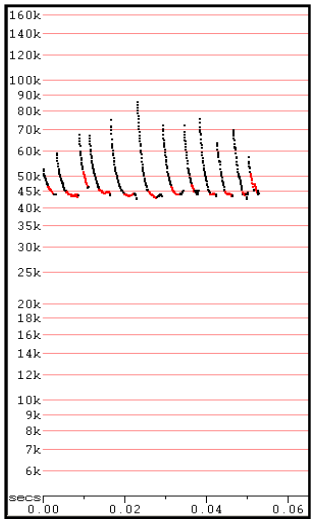
Chalinolobus gouldii



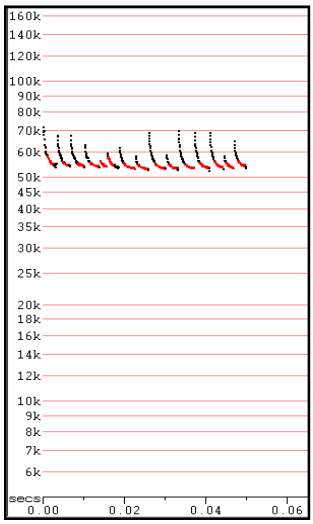
Scotorepens balstoni



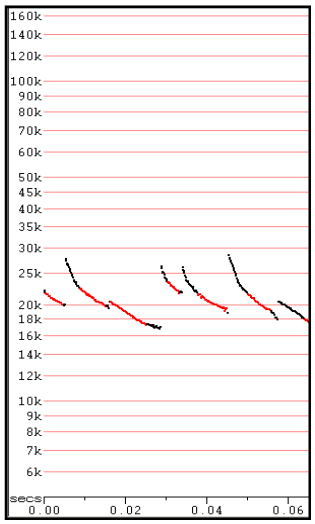
Scotorepens greyii



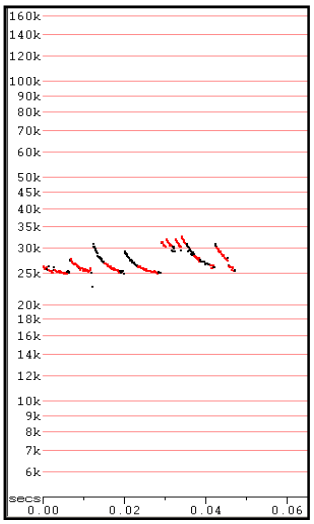
Vespadelus baverstocki



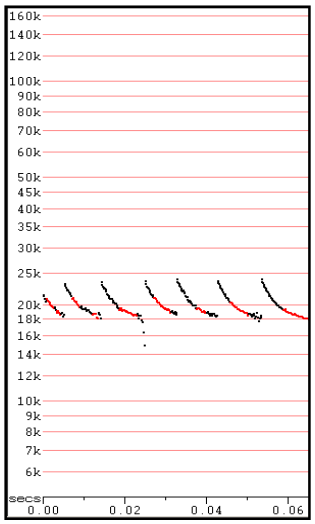
Vespadelus finlaysoni



Chaerephon jobensis



Mormopterus beccarii



Saccolaimus flaviventris

Anabat Data Analysis Summary

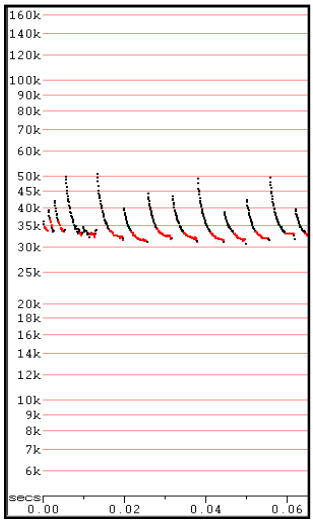
Client: AARC (Mitch Gregory) **Balance Job no.:** AARC1113

Project name/location: East of Mount Isa, 10-26 October 2011

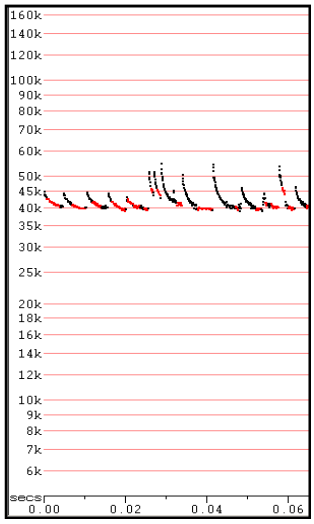
Sample calls extracted from the survey data.

Scale: 10 msec per tick; time between pulses removed (AnalookW F7 compressed mode)

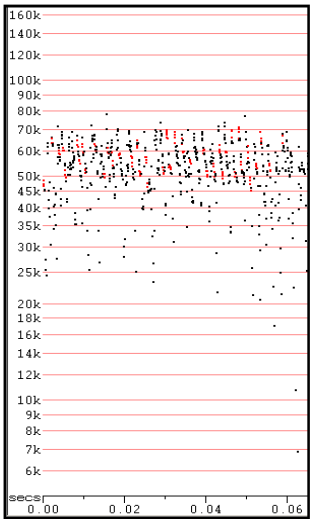
Calls NOT positively identified



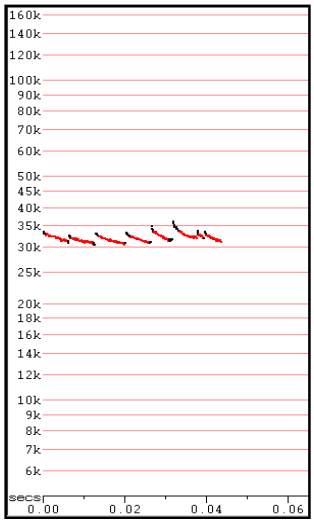
C. gouldii or S. balstoni



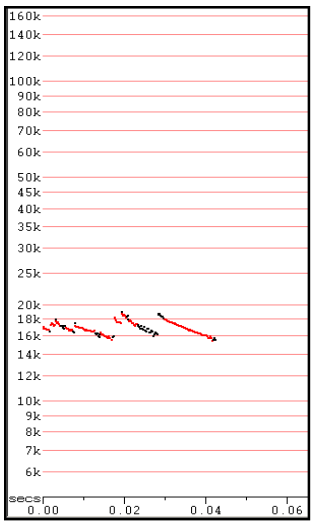
S. greyii or *C. nigrogriseus*



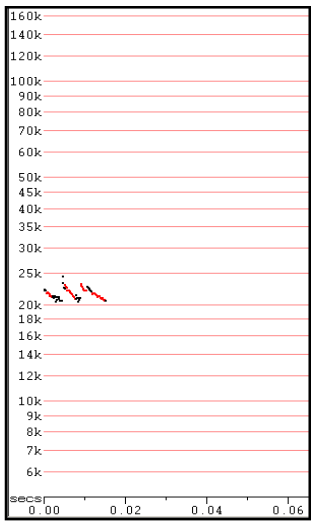
Nyctophilus species



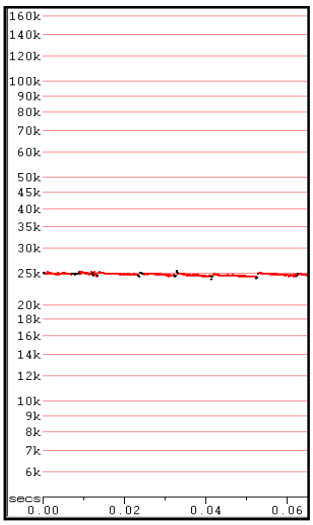
Mormopterus sp. or *C. gouldii*



C. jobensis or *S. flaviventris*



S. flaviventris or *M. beccarii*



M. beccarii or *T. georgianus*

Microbat Call Identification Report

Prepared for ("Client"):	AustralAsian Resource Consultants
Survey location/project name:	Barbara (Mt Isa)
Survey dates:	January-February 2014
Client project reference:	
Job no.:	AARC1402
Report date:	26 May 2014

DISCLAIMER:

© Copyright – Balance! Environmental, ABN 75 795 804 356. This document and its content are copyright and may not be copied, reproduced or distributed (in whole or part) without the prior written permission of Balance! Environmental other than by the Client for the purposes authorised by Balance! Environmental ("Intended Purpose"). To the extent that the Intended Purpose requires the disclosure of this document and/or its content to a third party, the Client must procure such agreements, acknowledgements and undertakings as may be necessary to ensure that the third party does not copy, reproduce, or distribute this document and its content other than for the Intended Purpose. This disclaimer does not limit any rights Balance! Environmental may have under the Copyright Act 1968 (Cwlth).

The Client acknowledges that the Final Report is intended for the sole use of the Client, and only to be used for the Intended Purpose. Any representation or recommendation contained in the Final Report is made only to the Client. Balance! Environmental will not be liable for any loss or damage whatsoever arising from the use and/or reliance on the Final Report by any third party.

Methods

Data receipt and processing

Bat call data were recorded using Anabat (Titley Scientific, Brisbane) and Song Meter SM2 detectors (Wildlife Acoustics, USA), with the Anabat recordings saved in Anabat raw data format and the SM2 recordings saved as compressed audio files (WAC format).

Two data sets were received for analysis, with the accompanying field data sheets indicating the following expected contents:

Data set	Detector name	Recording dates	Site
1	Anabat	Nights of 4/2/14 - 6/2/14	FA6
	Song Meter 2	Nights of 30/1/14 - 1/2/14	FA1
		Nights of 2/2/14 - 4/2/14	FA4
		Nights of 5/2/14 - 6/2/14	FA5
	Song Meter 6	Nights of 30/1/14 - 1/2/14	FA2
		Nights of 2/2/14 - 4/2/14	FA3
		Nights of 5/2/14 - 6/2/14	FA7
2	Song Meter 8	Nights of 25/2/14 - 26/2/14	AQ1
		Nights of 27/2/14 - 28/2/14	AQ4

All received data files were converted to Anabat sequence file format (zero-crossing analysis, or ZCA files) prior to call analysis. The Anabat data file from Data Set 1 was converted with the *CFCread* program (Corben 2012), yielding 180 sequence files recorded over the three nights. Wildlife Acoustics' *Kaleidoscope* software was used to convert the SM2 WAC files. This process yielded some 1800 files for the two SM2 detectors submitted in Data Set 1; however, no bat call data could be extracted from the WAC files received in Data Set 2.

Relatively few sequence files were recorded from Site FA5 compared with the other sites where SM2 was deployed; and no data were recorded by SM6 at Site FA7. This lack of data from the final two nights of survey by each detector suggests that the batteries may have failed rather than reflecting a true absence of bat activity at those sites.

Bat call identification

All sequence files were analysed using *AnalookW* (Corben 2013) and a subset of 623 files containing representative samples of all call types recorded at each site were selected for identification. Species identification was achieved manually by comparing the *AnalookW* call sonograms with those of regionally-relevant reference calls and with published call descriptions (e.g. Reinhold *et al.* 2001; Milne 2002; Pennay *et al*. 2004).

Species' identification was also guided by considering their probability of occurrence based on general distribution information (Churchill 2008; van Dyck *et al.* 2013) and/or database records obtained from Wildlife Online (http://www.ehp.qld.gov.au/wildlife/wildlife-online/index.html) and/or the Atlas of Living Australia (http://www.ala.org.au).

Reporting standard

The format and content of this report follows Australasian Bat Society standards for the interpretation and reporting of bat call data (Reardon 2003), available on-line at http://www.ausbats.org.au/.

Species nomenclature follows van Dyck *et al.* (2013).

Results & Discussion

Some 800 individual bat calls were selected for identification.

Ten call types were identified positively to individual species, with two others attributable to genus level but not further differentiated. These unresolved calls included:

- near-vertical, linear FM pulses with characteristic frequency (Fc) of 40-50 kHz, from a *Nyctophilus* species bat (*N. arnhemensis, N. bifax* and *N. geoffroyi* all potentially occur in the study area); and
- relatively flat FM-qCF pulses with Fc=30-32 kHz, probably representative of a small *Mormopterus* species (similar to calls produced by *M.* 'species 3').

Table 1 Insectivorous bats recorded during the Barbara (Mt Isa) surveys, January-February 2014.

♦ denotes species positively identified from call data.
□ denotes species possibly present, but not reliably identified.

Site:	FA1	FA2	FA3	FA4	FA5	FA6	FA7
Hipposideros ater	♦	♦					
Chalinolobus gouldii	♦	♦	♦	♦	♦	♦	
Chalinolobus nigrogriseus	♦	♦	♦	♦		♦	
Nyctophilus species	♦	♦		♦			
Scotorepens balstoni	♦	♦	♦	♦	♦		
Scotorepens greyii	♦	♦	♦	♦	♦	♦	
Chaerephon jobensis	♦	♦	♦	♦	♦	♦	
Mormopterus beccarii	♦	♦	□	♦		♦	
Mormopterus species	♦	□	□	□			
Saccolaimus flaviventris	♦	♦	♦	♦		♦	
Taphozous georgianus	♦	♦	♦	♦		♦	
Taphozous troughtoni	♦	♦		♦		♦	

References

Churchill, S. (2008). *Australian Bats*. Jacana Books, Allen & Unwin; Sydney.

Corben, C. (2012). *CFCread Storage ZCAIM interface.* Version 4.4n; 04 November 2012.

Corben, C. (2013). *AnalookW for bat call analysis using ZCA*. Version 3.9f; 22 March 2013.

Milne, D.J. (2002). *Key to the Bat Calls of the Top End of the Northern Territory.* Technical Report No. 71, Parks and Wildlife Commission of the Northern Territory, Darwin.

Pennay, M., Law, B. and Reinhold, L. (2004). *Bat Calls of New South Wales*. Department of Environment and Conservation, Hurstville.

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**, 41-43.

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales*. Department of Natural Resources and Mines, Brisbane.

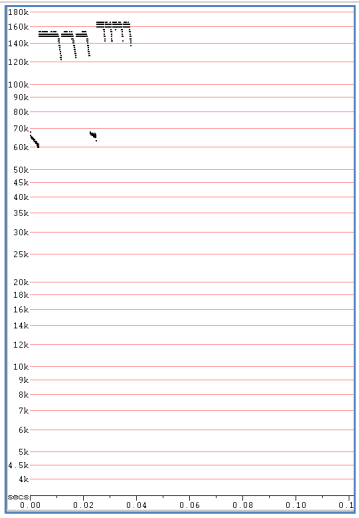
van Dyck, S., Gynther, I. and Baker, A. (eds.) (2013). *Field Companion to The Mammals of Australia*. New Holland; Sydney.

Glossary

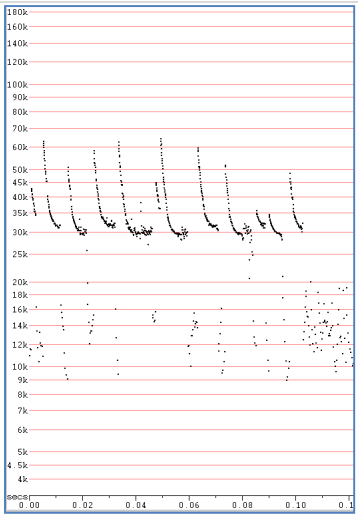
Technical terms used in this report are described in the following table.

Approach phase	The part of a bat *call* emitted as the bat starts to home in on a detected prey item; a transitional series of *pulses* between the *search phase* and *feeding buzz*, that become progressively steeper and shorter in duration.
Call	Refers to a single bat call, made up of a series of individual sound *pulses* in one or more *phases* (*search, approach, feeding buzz*).
CF (=Constant Frequency)	A type of *pulse* in which the dominant component consists of a more-or-less 'pure tone' of sound at a Constant Frequency; with *shape* appearing flat on the sonogram. Often also contains a brief *FM* component at the beginning and/or end of the CF component (*viz.* FM-CF-FM).
Characteristic frequency (Fc)	The frequency of the flattest part of a *pulse*; usually the lowest frequency reached in the *qCF* component of a pulse. This is often the primary diagnostic feature for species identification.
Duration	The time period from the beginning of a *pulse* to the end of the pulse.
Feeding buzz	The terminal part of a *call*, following the *approach phase*, emitted as the bat catches a prey item; a distinctive, rapid series of very steep, very short-duration pulses.
FM (=Frequency Modulated)	A type of *pulse* in which there is substantial change in frequency from beginning to end; *shape* ranges from almost vertical and linear through varying degrees of curvature.
FC range	Refers to the range of frequencies occupied by the *characteristic frequency* section of *pulses* within a call or set of calls.
Frequency sweep or "band-width"	The range of frequencies through which a *pulse* sweeps from beginning to end; Maximum frequency (Fmax) – minimum frequency (Fmin).
Knee	The transitional part of a *pulse* between the initial (usually steeper) frequency sweep and the *characteristic frequency* section (usually flatter); time to knee (Tk) and frequency of knee (Fk) can be diagnostic for some species.
Pulse	An individual pulse of sound within a bat *call*; the *shape*, *duration* and *characteristic frequency* of a pulse are the key diagnostic features used to differentiate species.
Pulse body	The part of the *pulse* between the *knee* and *tail* and containing the *characteristic frequency* section.
Pulse shape	The general appearance of a *pulse* on the sonogram, described using relative terms related to features such as slope and degree of curvature. See also *CF, qCF* and *FM*.
qCF (=quasi Constant Frequency)	A type of *pulse* in which there is very little change in frequency from beginning to end; *shape* appears to be almost flat. Some pulses also contain an *FM* component at the beginning and/or end of the qCF component (*viz.* FM-qCF).
Search phase	The part of a bat *call* generally required for reliable species diagnosis. A consistent series of *pulses* emitted by a bat that is searching for prey or and/or navigating through its habitat. Search phase pulses generally have longer duration, flatter slope and more consistent shape than *approach phase* and *feeding buzz* pulses.
Sequence	Literally, a sequence of *pulses* that may be from one or more bats; but generally refers to a *call* or part (e.g. *phase*) of a call.
Tail	The final component of a *pulse*, following the *characteristic frequency* section; may consist of a short or long sweep of frequencies either upward or downward from the Fc; or may be absent.

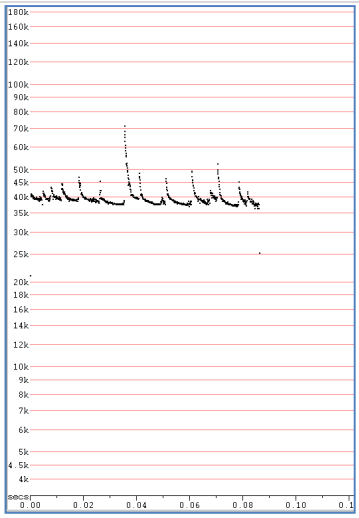
Appendix 1 Representative call sequences recorded at 'Barbara', January-February 2014. x-axis:10msec per tick; time between pulses removed. y-axis: $\log_{10}$ frequency (kHz)



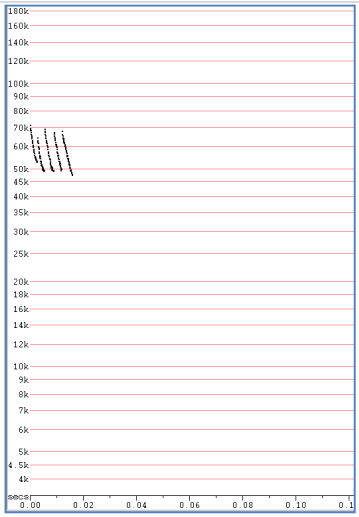
Hipposideros ater



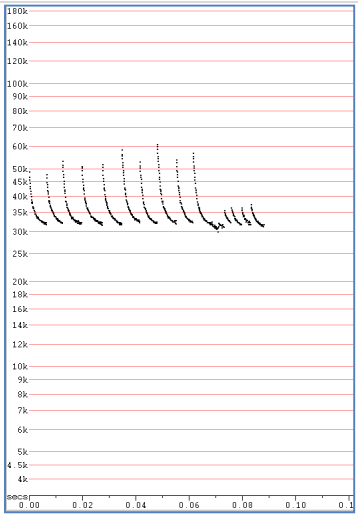
Chalinolobus gouldii



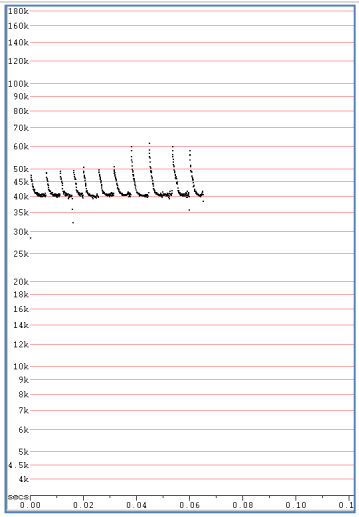
Chalinolobus nigrogriseus



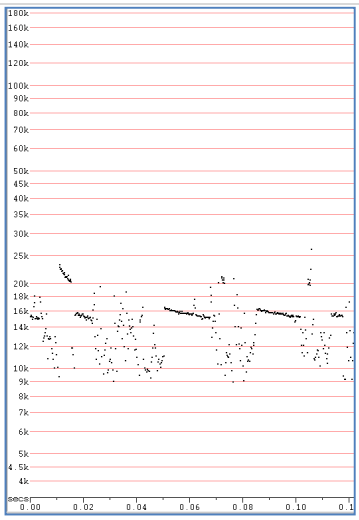
Nyctophilus species



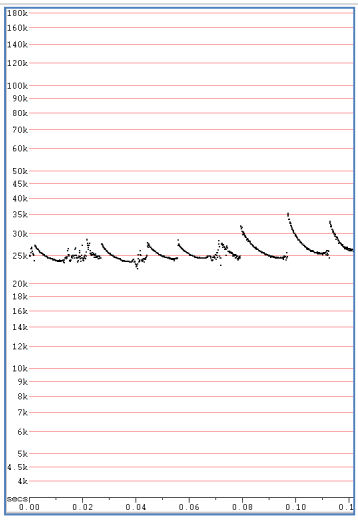
Scotorepens balstoni



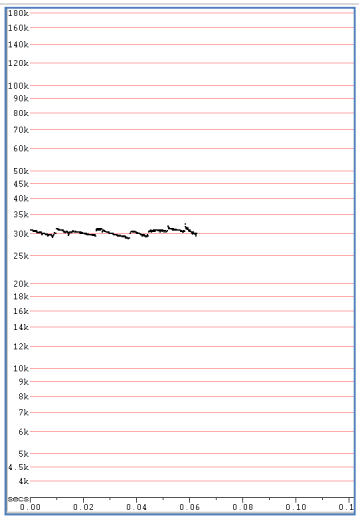
Scotorepens greyii



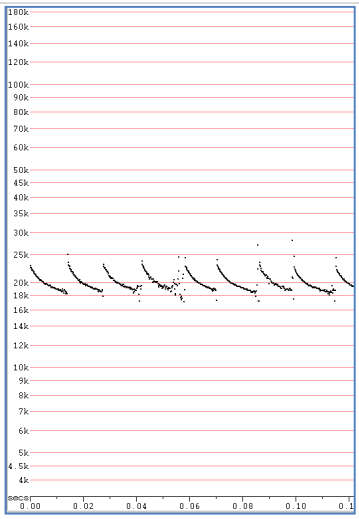
Chaerephon jobensis



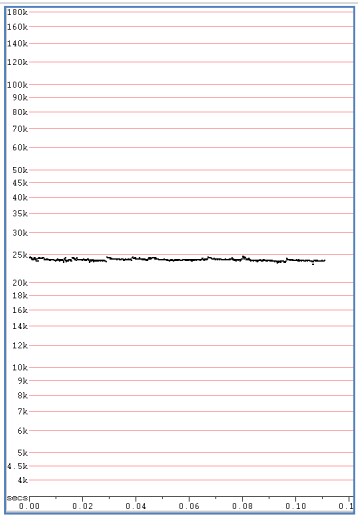
Mormopterus beccarii



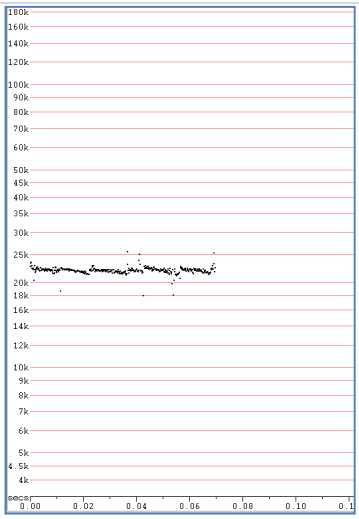
Mormopterus sp 3/sp5



Saccolaimus flaviventris



Taphozous georgianus



Taphozous troughtoni

Microbat Call Identification Report

Prepared for ("Client"):	AustralAsian Resource Consultants
Survey location/project name:	Barbara Terrestrial Fauna Survey
Survey dates:	Dry Season, August 2014
Client project reference:	
Job no.:	AARC1405
Report date:	18 August 2014

DISCLAIMER:

© Copyright – Balance! Environmental, ABN 75 795 804 356. This document and its content are copyright and may not be copied, reproduced or distributed (in whole or part) without the prior written permission of Balance! Environmental other than by the Client for the purposes authorised by Balance! Environmental ("Intended Purpose"). To the extent that the Intended Purpose requires the disclosure of this document and/or its content to a third party, the Client must procure such agreements, acknowledgements and undertakings as may be necessary to ensure that the third party does not copy, reproduce, or distribute this document and its content other than for the Intended Purpose. This disclaimer does not limit any rights Balance! Environmental may have under the Copyright Act 1968 (Cwlth).

The Client acknowledges that the Final Report is intended for the sole use of the Client, and only to be used for the Intended Purpose. Any representation or recommendation contained in the Final Report is made only to the Client. Balance! Environmental will not be liable for any loss or damage whatsoever arising from the use and/or reliance on the Final Report by any third party.

Methods

Data receipt and post-processing

Bat call data were recorded at six sites (three nights per site) using three Song Meter SM2BAT detectors (Wildlife Acoustics, USA), with an Anabat detector (Titley Scientific, Brisbane) recording over four nights at one additional site.

Data received for analysis included the following:

Detector name	Recording dates	Site	Files received
Anabat	Nights of 4/8/14 to 7/8/14	FA6	2079 Anabat zero-crossing analysis files
Song Meter 6	Nights of 2/8/14, 3/8/14 & 4/8/14	FA4	25 WAV files
	Nights of 5/8/14, 6/8/14 & 7/8/14	FA5	254 WAV files
Song Meter 8	Nights of 2/8/14, 3/8/14 & 4/8/14	FA2	55 WAV files
	Nights of 5/8/14, 6/8/14 & 7/8/14	FA8	60 WAV files
Song Meter 10	Nights of 2/8/14, 3/8/14 & 4/8/14	FA1	20 WAV files
	Nights of 5/8/14, 6/8/14 & 7/8/14	FA7	55 WAV files

All Song Meter WAV files were post-processed with Wildlife Acoustics' *Kaliedoscope Version 2.0.3* to generate call sequence files in Anabat zero-crossing analysis (ZCA) format.

Bat call identification

All ZCA sequence files were analysed using *AnalookW* (Corben 2014), with species identification achieved manually by comparing the *AnalookW* call sonograms with those of regionally-relevant reference calls and with published call descriptions (e.g. Reinhold *et al.* 2001; Milne 2002; Pennay *et al*. 2004).

Species' identification was also guided by considering their probability of occurrence based on general distribution information (Churchill 2008; van Dyck *et al.* 2013) and/or database records obtained from Wildlife Online (http://www.ehp.qld.gov.au/wildlife/wildlife-online/index.html) and/or the Atlas of Living Australia (http://www.ala.org.au).

Reporting standard

The format and content of this report follows Australasian Bat Society standards for the interpretation and reporting of bat call data (Reardon 2003), available on-line at http://www.ausbats.org.au/.

Species nomenclature follows van Dyck *et al.* (2013).

Results & Discussion

The Anabat unit failed to record any bat calls over the four-night deployment at Site FA6. All sequence files contained just background noise generated by insects and/or wind and/or other environmental disturbance.

Similarly, Song Meter 6 recorded only insect calls and other non-bat noise; consequently, there are no bat species records from this dry season survey for Sites FA4 or FA5.

The *Kaleidoscope* conversion process generated 185 ZCA sequence files for the other two Song Meter detectors; however, only 109 of those files contained recognisable bat calls.

The number of calls recorded at each site was very low (see Table 1), which possibly reflects reduced bat activity due to cool overnight temperatures and windy conditions. Furthermore, call quality was also quite low, with most calls having weak and fragmented pulse structures, which significantly reduced the reliability of species identification.

Only two species were positively identified form this data set: *Chaerephon jobensis*, recorded at FA7 and FA8; and *Taphozous georgianus*, recorded at FA2.

Up to seven other species may also have been present, with four additional call types recognised, each potentially representing two species. Poor recording quality and similarities in the call characteristics of some species that probably occur in the study area prevented reliable identification of these calls. The unidentified call types represented the following species groups:

- *Chalinolobus gouldii* and *Scotorepens balstoni*
    - FM-qCF pulses with characteristic frequency (Fc) around 30-33 kHz, but all calls with highly variable pulse shape and frequency characteristics
    - no clear inter-pulse frequency alternation that would readily differentiate *C. gouldii*
    - no calls with clearly uniform pulses that would be attributable to *S. balstoni*
    - both species probably responsible for some of the calls
- *Scotorepens greyii* and *Chalinolobus nigrogriseus*
    - FM-qCF pulses with Fc around 37-40 kHz
    - mostly quite short duration pulses so considered most likely from *S. greyii* but pulse shapes and frequencies inconsistent so cannot discount *C. nigrogriseus*
- *S. greyii* and *Vespadelus baverstocki*
    - FM-qCF pulses with Fc around 41-43 kHz
    - considered more likely to be from *V. baverstocki*, but only a few very brief and weak calls so possibly just *S. greyii* at upper limit of frequency range
- *Vespadelus caurinus* and *V. finlaysoni*
    - FM-qCF pulses with Fc=55-57 kHz
    - most likely from *V. finlaysoni* but all calls very messy and poor quality
    - nearest records for *V. caurinus* are in the Boodjamulla National Park area, so these calls more likely from *V. finlaysoni.*

Technical terms used in the above call descriptions are explained in the Glossary.

Table 1 Insectivorous bats recorded during the Barbara Terrestrial Fauna surveys, 2-8 August 2014.

Site:	FA1	FA7	FA2	FA8
No. of sequence files:	18	54	53	60
No. of calls identified:	1	47	26	35
Species positively identified				
Chaerephon jobensis		✓		✓
Taphozous georgianus			✓	
Species not positively identified				
Chalinolobus gouldii or *Scotorepens balstoni*	✓	✓	✓	✓
Scotorepens greyii or *Chalinolobus nigrogriseus*		✓		✓
Scotorepens greyii or *Vespadelus baverstocki*		✓		✓
Vespadelus finlaysoni or *Vespadelus caurinus*				✓

References

Churchill, S. (2008). *Australian Bats*. Jacana Books, Allen & Unwin; Sydney.

Corben, C. (2014). *AnalookW for bat call analysis using ZCA*. Version 4.1b 19 May 2014.

Milne, D.J. (2002). *Key to the Bat Calls of the Top End of the Northern Territory.* Technical Report No. 71, Parks and Wildlife Commission of the Northern Territory, Darwin.

Pennay, M., Law, B. and Reinhold, L. (2004). *Bat Calls of New South Wales*. Department of Environment and Conservation, Hurstville.

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**, 41-43.

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales*. Department of Natural Resources and Mines, Brisbane.

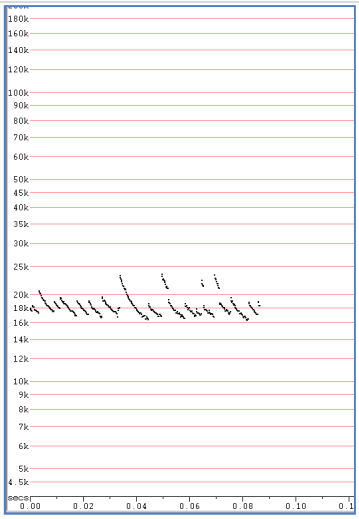
van Dyck, S., Gynther, I. and Baker, A. (eds.) (2013). *Field Companion to The Mammals of Australia*. New Holland; Sydney.

Glossary

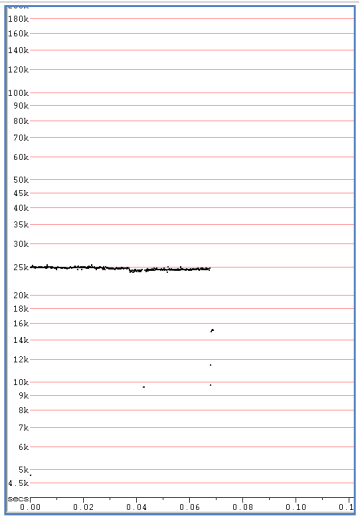
Technical terms used in this report are described in the following table.

Approach phase	The part of a bat *call* emitted as the bat starts to home in on a detected prey item; a transitional series of *pulses* between the *search phase* and *feeding buzz*, that become progressively steeper and shorter in duration.
Call	Refers to a single bat call, made up of a series of individual sound *pulses* in one or more *phases* (*search, approach, feeding buzz*).
CF (=Constant Frequency)	A type of *pulse* in which the dominant component consists of a more-or-less 'pure tone' of sound at a Constant Frequency; with *shape* appearing flat on the sonogram. Often also contains a brief *FM* component at the beginning and/or end of the CF component (*viz.* FM-CF-FM).
Characteristic frequency (Fc)	The frequency of the flattest part of a *pulse*; usually the lowest frequency reached in the *qCF* component of a pulse. This is often the primary diagnostic feature for species identification.
Duration	The time period from the beginning of a *pulse* to the end of the pulse.
Feeding buzz	The terminal part of a *call*, following the *approach phase*, emitted as the bat catches a prey item; a distinctive, rapid series of very steep, very short-duration pulses.
FM (=Frequency Modulated)	A type of *pulse* in which there is substantial change in frequency from beginning to end; *shape* ranges from almost vertical and linear through varying degrees of curvature.
FC range	Refers to the range of frequencies occupied by the *characteristic frequency* section of *pulses* within a call or set of calls.
Frequency sweep or "band-width"	The range of frequencies through which a *pulse* sweeps from beginning to end; Maximum frequency (Fmax) – minimum frequency (Fmin).
Knee	The transitional part of a *pulse* between the initial (usually steeper) frequency sweep and the *characteristic frequency* section (usually flatter); time to knee (Tk) and frequency of knee (Fk) can be diagnostic for some species.
Pulse	An individual pulse of sound within a bat *call*; the *shape*, *duration* and *characteristic frequency* of a pulse are the key diagnostic features used to differentiate species.
Pulse body	The part of the *pulse* between the *knee* and *tail* and containing the *characteristic frequency* section.
Pulse shape	The general appearance of a *pulse* on the sonogram, described using relative terms related to features such as slope and degree of curvature. See also *CF, qCF* and *FM*.
qCF (=quasi Constant Frequency)	A type of *pulse* in which there is very little change in frequency from beginning to end; *shape* appears to be almost flat. Some pulses also contain an *FM* component at the beginning and/or end of the qCF component (*viz.* FM-qCF).
Search phase	The part of a bat *call* generally required for reliable species diagnosis. A consistent series of *pulses* emitted by a bat that is searching for prey or and/or navigating through its habitat. Search phase pulses generally have longer duration, flatter slope and more consistent shape than *approach phase* and *feeding buzz* pulses.
Sequence	Literally, a sequence of *pulses* that may be from one or more bats; but generally refers to a *call* or part (e.g. *phase*) of a call.
Tail	The final component of a *pulse*, following the *characteristic frequency* section; may consist of a short or long sweep of frequencies either upward or downward from the Fc; or may be absent.

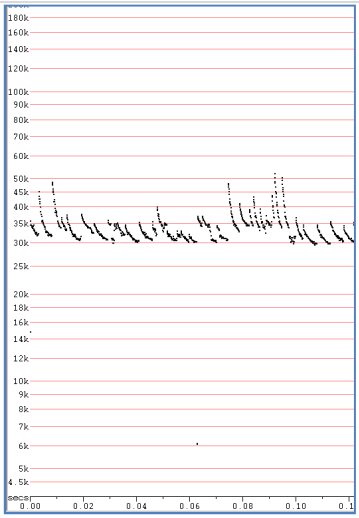
Appendix 1 Representative call sequences recorded at 'Barbara', 2-8 August 2014. x-axis:10msec per tick; time between pulses removed. y-axis: $\log_{10}$ frequency (kHz)



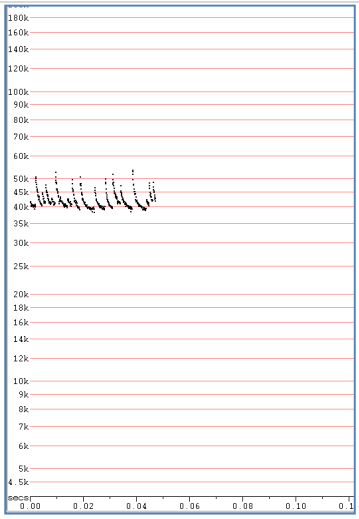
Chaerephon jobensis



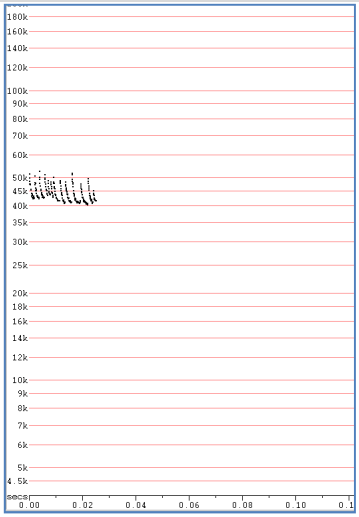
Taphozous georgianus



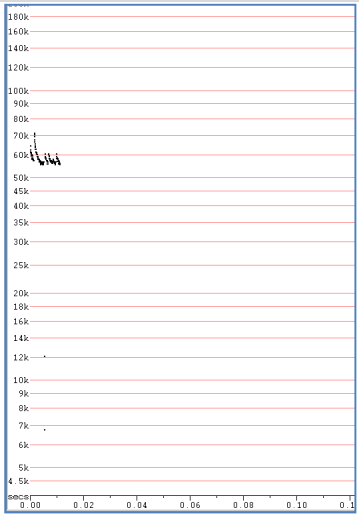
C. gouldii or *S. balstoni*



S. greyii or *C. nigrogriseus*



S. greyii or *V. baverstocki*



V. finlaysoni or *V. caurinus*

Appendix F Pest Species Fact Sheets

FERAL PIGS

Feral pigs (*Sus scrofa*) in Queensland

PEST STATUS REVIEW SERIES - LAND PROTECTION

by
C. C. McGaw
J. Mitchell

Queensland Government
Natural Resources and Mines

Acknowledgements
This assessment has drawn heavily from information contained within the Bureau of Resource Sciences publication "Managing Vertebrate Pests - Feral Pigs" (Choquenot, McIlroy and Korn 1996). Additional information and data have been included to provide the assessment with a Queensland emphasis.

Information has also been supplied by Cliff Dee (Wild Game Resources), Graham Hardwick, Barry Toms and Dr Jonathon Lee (AQIS).

Cover and contents design:
Grant Flockhart and Sonia Jordan

Photographic credits:
Natural Resources and Mines staff

ISBN 0 7242 7273 9

DNRQ980030

Published by the Department of Natural Resources and Mines, Qld.

Information in this document may be copied for personal use or published for educational purposes, provided that any extracts are fully acknowledged.

Land Protection
Department of Natural Resources and Mines
Locked Bag 40, Coorparoo Delivery Centre, Q, 4151

Contents

1.0 Summary 1

2.0 History 2

3.0 Current and Predicted Distribution 3

4.0 Estimates of Current and Potential Impact 5

4.1 Impact on Primary Production 5
4.2 Impact on the Environment 6
4.3 Disease 7
4.4 The Pig as a Resource 8
4.5 Cost:Benefit Relationship 9

5.0 Biology and Ecology 10

5.1 Habitat Requirements 10
5.2 Diet 10
5.3 Social Structure and Behaviour 10
5.4 Reproduction and Population Dynamics 11

6.0 Efficacy of Current Control Methods 12

6.1 Exclusion and Habitat Modification 12
6.2 Poisoning 12
6.3 Recreational Hunting 13
6.4 Trapping 14
6.5 Biological Control 15
6.6 Fertility Control 16
6.7 Shooting (helicopter and ground shooting) 17
6.8 Control During Exotic Disease Outbreaks 17

7.0 Animal Welfare Considerations 18

8.0 Management and Control Practices 19

8.1 Legislative Status in Queensland 19
8.2 Management Strategies in Queensland 20
8.2.1 Pastoral Zone 20
8.2.2 Wet Tropics 20
8.2.3 Agricultural Zone 20
8.2.4 Near Urban Situations 21
8.3 Property Management Strategies 21

9.0 Acknowledgments 22

10. References 23

1.0 Summary

Feral pigs are one of the most widespread and damaging pest animals in Queensland and they are difficult to control in some situations. Feral pigs are widely distributed and inflict damage on the environment, lower agricultural production and the general amenity of Queensland.

Feral pigs also pose a disease risk to humans and the native and domestic animals of the State. They are found across most of the State and are susceptible to many exotic and endemic diseases.

Benefits also accrue from feral pigs as they provide income to many professional and amateur hunters, and the revenue gained from the export of 'wild boar' products increase export income and injects money into many small rural communities.

There are few control methods available: baiting, trapping, shooting, hunting and exclusion. The control method used varies with the habitat, safety of people and animals, and the size and location of the area to be treated.

2.0 History

Feral pigs have been part of the Queensland landscape since about 1865. The theory that feral pigs, sometimes known as 'Captain Cookers' were derived from deliberate releases or escapes from Cook's time at Cooktown in north Queensland has been discounted. The only pigs landed by Cook were killed by a fire deliberately lit by Aborigines (Pullar 1953). There has also been some speculation that pigs were introduced from New Guinea by travellers to Cape York. This too has been shown to only be the case for the later part of last century (Pullar 1953), as there are no words in the local Aboriginal language for 'pig' before this time (Pullar 1950; Pavlov *et al.* 1992).

Feral pigs were derived from stock that were let loose or wandered away from where they were being kept, often under semi-feral conditions as settlement progressed across the State. To this day, pigs are still being introduced, both accidentally (escapes from piggeries or truck accidents) and deliberately (usually by recreational hunters), to many parts of the State.

These pigs were probably descendants of Berkshire and Tamworth pigs that were introduced to Australia, including pigs transported as part of the First Fleet (Choquenot *et al.* 1996). These pigs probably then crossed with various breeds from Europe and Asia that were brought into Australia by early settlers from these regions.

3.0 Current and Predicted Distribution

Feral pigs are distributed across much of the State (Fig.1). The distribution of feral pigs is related to their strict requirements of daily water and dense foliage for protection from weather extremes, particularly heat to which they have a poor tolerance. Even so, pigs have become established within a wide variety of habitat types from the Arid Zone to the Wet Tropics. In the more arid areas, the distribution of pigs is quite seasonal and their distribution is restricted to watercourses, associated floodplains and man-made water supplies.

Fig. 1. Relative distribution of feral pigs in Australia.
Commonwealth of Australia copyright reproduced by permission from *Managing Vertebrate Pest - Feral Pigs* Choquenot *et al* 1996 after Wilson *et al* 1992

Because feral pigs usually have quite definite home ranges, and only disperse during times of major disturbance or limitations on food resources, they have been slow dispersers across much of Queensland. Because of this, feral pigs are still colonising new areas. Some coastal areas and areas around Cunnamulla and within the Wet Tropics World Heritage Area, have only been colonised by feral pigs within the last 30 years. Many cases of feral pigs establishing in new areas are because of deliberate introduction by recreational hunters, particularly in State Forests and on other State lands.

It is estimated that there are some 4 to 6 million feral pigs in Queensland (Mitchell, *pers. comm*.). No detailed survey has been conducted to accurately estimate the size of the population, however some research has been conducted on densities in different habitat types. About 75% of the estimated population is thought to inhabit tropical north Queensland (J. Mitchell, pers comm).

There is great difficulty in accurately estimating the numbers of feral pigs because of their secretive behaviour and the dense vegetation that forms their preferred habitat. Pig numbers also vary quite considerably from season to season, and from habitat to habitat. Table 1 illustrates some of the different densities of feral pigs for a variety of habitats.

Table 1. Reported densities of feral pigs for various districts and habitats.

DISTRICT	HABITAT	DENSITY	REFERENCE
Goondiwindi	pasture woodland, forests and wheat crops	0.1-3.9 pigs/sq km	Wilson *et al* 1987
Aurukun	floodplain, swamp and woodland	1>20 pigs/sq km	Dexter 1990
Aurukun	floodplain, swamp and woodland	1-40 pigs/sq km	J.Mitchell, pers comm.
Lilyvale	floodplain, swamp and woodland	4.2 pigs/sq km	J.Mitchell, pers comm.
Lakefield National Park	floodplain, swamp and woodland	4 pigs/sq km	Mitchell 1998

4.0 Estimates of Current and Potential Impact

4.1 Impact on Primary Production

The impact of feral pigs on agriculture takes three forms (Choquenot *et al* 1996):

- value of the direct losses to agricultural production;
- value of the continuing expenditure on pig control; and
- value of lost opportunities to take profit from alternative investment of this expenditure.

It is difficult to accurately provide a dollar figure to the economic damage caused by pigs as some localities will suffer less damage because of naturally low pig numbers or adequate control methods that reduce their impacts. Despite these problems, some estimates have been made of the magnitude of costs of feral pigs.

The national loss to agriculture by feral pigs has been estimated to be in the order of $100 million, but this may be a conservative estimate (Choquenot *et al* 1996).

Pigs are responsible for damage to a variety of industries. They reduce the yields of grain crops (Benson 1980, Caley 1993), damage and consume pastures (Hone 1980), reduce yields of sugar cane and some tropical fruits such as bananas, mangoes, pawpaw and lychees (McIlroy 1993), damage netting fences, damage and pollute water sources (Tisdell 1982; O'Brien 1987) and prey upon newborn lambs (Plant *et al* 1978; Pavlov *et al* 1981; Hone 1983; Choquenot 1993).

Lamb predation by feral pigs is estimated to range from 18.7% to 32% for the semi arid rangelands (Pavlov *et al* 1981; Plant *et al* 1978). Estimates for losses to grain crops in Queensland are shown in Table 2.

Table 2. Estimated value of lost crop production for Queensland 1996

CROP	% REDUCTION IN YIELD*	VALUE#
Wheat	3	$ 1.9m
Sorghum	5	$ 9.1m
Barley	1	$ 0.3m
Maize	3	$ 0.6m
Total		$ 11.9m

* Based on Tisdell 1982

This figure is for the end of a severe drought and the winter crop figures are significantly lower than average, with the sorghum crop being inflated due to a breaking of the drought allowing large areas to be planted to summer crops.

In 1991 it was estimated that the cost of feral pig damage to sugar cane crops was in the vicinity of $628 000, which equated to a reduction in yield of 25510 tonnes of sugar cane (McIlroy 1993). The value of other crop losses has not been accurately assessed, but pigs are known to cause severe, but often

localised, damage to crops such as potatoes, melons, mandarins, strawberries, pumpkins and tropical fruits (bananas, mangoes, lychees, pawpaws and pineapples). One farmer in the Tully area reported losses of up to 140 bunches of bananas per month (valued at between $4,200 and $12,600) for a twenty hectare plantation, but average losses in the area are about 20 bunches ($600 - $1800) per month (Noble 1996).

The damage caused to pasture and competition with domestic stock is difficult to estimate, as there is considerable variation across pasture types and their biomass. It has been shown that pig activity reduces pasture availability and can lead to the establishment of less desirable pasture species, including weeds (Hone 1980). Most work to date on the impacts of pigs on grazing industries has been concentrated on the predation of lambs and the effects on the sheep grazing lands of semi-arid New South Wales, which is similar in some respects to the southern sheep grazing areas of Queensland.

It has been estimated that Queensland spent approximately $1.1 million in 1984 on feral pig control, which equates to about $2.2 million in today's dollar values (Choquenot *et al* 1996). This amount includes both government and private expenditure on control by various means. It does not include amounts spent by recreational hunters who also contribute to control. This estimate of expenditure is based upon estimates of landholder and government expenditure on control, and so should only be used as a guide to current control costs.

4.2 Impact on the Environment

The impacts of feral pigs on the environment takes one of two forms: damage to habitats or direct damage to animal species.

Degradation of habitats is probably the most obvious form of environmental damage caused by pigs. This damage can be because of rooting, trampling, tusking or rubbing trees and consumption of plants and soil organisms.

The rooting behaviour of pigs has been linked to areas of high soil moisture such as drainage lines and swampy areas (Hone 1988, 1995; Mitchell 1993). This rooting behaviour can severely disrupt the composition of the soil's microorganisms, and subsequently nutrient cycling. Rooting can also disrupt the regeneration of plants, change the composition of the plant community, and allow water erosion to occur in drainage areas where the soil has been severely disturbed.

Pigs can physically destroy vegetation by trampling it along their paths or in the areas where they wallow. Pigs will often have a favourite rubbing tree, but this has not been linked to territory marking. This behaviour is to remove parasites and to relieve irritations. They also tusk trees as part of their normal behaviour. Undermining and rooting during feeding can lead to trees being uprooted.

Although pigs are known to feed on most parts of a wide variety of native and exotic plants, they usually prefer the softer higher energy parts, tubers and fruits. Their negative impact on plant communities is partially balanced by the positive impact of their aiding in the spread of some plants by passing their seeds in dung. This spread of plants also includes weed species.

The feral pig has also been implicated in the transmission of plant diseases such as rootrot fungus (*Phytophthora cinnamomi*) and other plant pathogens. Introduction is usually via contaminated mud and soil carried by pigs and by the physical damage to plants that allows diseases to enter through the wounds.

Feral pigs are known to consume numerous native animals including earthworms, amphipods, centipedes, beetles and other arthropods, snails, frogs, lizards, snakes, the eggs of freshwater crocodiles (C*rocodylus johnstoni*), turtles and their eggs and small ground nesting birds and their eggs (Pullar 1950; Tisdell 1984; McIlroy 1990; Mitchell 1993; Roberts *et al* 1996).

Without definitive information on the prey eaten, rates of predation, density and status of prey and whether predation is density dependent (Choquenot *et al* 1996) it is impossible to accurately determine what effect pigs have on native fauna, apart from the observable damage to individual animals.

Competition with other animal species has not been proven, but there is some evidence that pigs may compete directly with some specialist feeders such as the Cassowary (C*asuarius casuarius*) (Choquenot *et al* 1996) and other species such as the brolga (*Grus rubicundus*) and magpie geese (*Anseranas semipalmata*) (Tisdell 1984).

4.3 Disease

The feral pig poses a serious threat to Queensland's livestock industries and human health through being a potential carrier, or amplifier, of many endemic and exotic diseases. The diseases that pose the greatest threat are listed in Table 3.

Table 3. List of endemic and exotic diseases carried by feral pigs.

ENDEMIC	**EXOTIC**
Brucellosis (*Brucella suis)*	Foot and Mouth Disease (FMD)
Tuberculosis (*Mycobacterium spp*.)	Classical Swine Fever
Porcine Parvovirus	Aujeszky's Disease
Leptospirosis (*Leptospira spp*)	Japanese Encephalitis
Melioidosis (*Pseudomonas pseudomallei*)	Swine Vesicular Disease
Sparganosis (*Spirometra erinacei*)	African Swine Fever
Murray Valley Encephalitis	Trichinosis
	Rabies
	Screw-worm Fly infestations

Of the exotic diseases, Foot and Mouth Disease (FMD) poses the greatest threat to Queensland's economy. It has been estimated that a FMD outbreak would cost more than $3 billion nationally and if it were to persist in the order of $0.3 - 4 billion annually (Wilson and Choquenot 1996). FMD could have devastating effects on the livestock industries of Queensland, particularly if it were introduced through Cape York, where early detection and eradication

would be difficult. The Department of Primary Industries and the Commonwealth have formulated a national approach to exotic disease management, the Australian Veterinary Emergency Plan (AUSVETPLAN).

4.4 The Pig as a Resource

Many people are of the opinion that the feral pig should be managed as a resource rather than eradicated as a pest. Control programs are usually conducted that do not utilise the feral pig as a resource. These control programs are conducted because of the economic and environmental damage caused by feral pigs and the legislative requirement in all mainland States except the ACT and South Australia.

The feral pig marketed as 'Wild Boar', has been harvested for export since 1980. The main markets for Australian wild boar meat are European Union countries (particularly Germany, France, Italy, Belgium/Luxembourg) and Japan and Sweden. The EU countries have traditionally consumed wild boar meat, and with high human populations and decreasing boar populations in those countries, they have increasingly become dependant on imports for much of their wild boar meats.

Australia now supplies some 20-30 percent of the wild boar consumed, and is now close to overtaking Poland as the worlds largest supplier of wild boar (Ramsay 1994). This market is very volatile, with sales and prices fluctuating from year to year. The market seems to be dependent on the length and severity of the northern winter, which effects the supply of local wild boar.

The Australian Game Meat Producers Association has prepared a Code Of Practice for Humane Shooting, Harvesting and Hygienic Handling of Game Animals. This code of practice provides guidelines to shooters and pig 'chasers' on how to harvest and handle the product so that it is suitable for the export market.

The value of wild boar exports has varied between $10 and $20 million over the last few years because of Australia's drought conditions and the variability of European supply and demand (Ramsay 1994). The number of carcasses processed in Australia is shown in Table 4.

Table 4. Number of wild boar carcasses processed in Australia 1989-1992.

YEAR	CARCASSES
1989	203 837
1990	96 962
1991	101 006
1992	271 133

It has been estimated that there are about 3000 Queensland Meat and Livestock accredited shooters in Queensland and 1200 licensed professional kangaroo shooters who take pigs opportunistically (Dee, pers. comm.). There are also numerous other shooters and hunters who do not sell carcasses. Recreational feral pig hunters across Australia make a significant impact on pig numbers, as well as injecting funds into local economies where they hunt (Tisdell 1982).

In Queensland in 1996 there were about 70 seasonal chiller boxes operating that received approximately 65 000 carcasses, which was about 60% of the national total. Based on this percentage of the national trade, Queensland harvests between $6 and 12 million worth of feral pigs per year (Ramsay 1994). These boxes are located as far north as Lakeland and Doomadgee, but the grain growing areas provided the greatest and most constant supplies of 'wild boar'. The average price paid to 'hunters' in 1996 was 90 cents/kg, but by mid 1997 averaged about 70-75 cents/kg. Preferred carcasses are between 30 and 60 kg with anything below 26 kg being rejected and carcasses over 90 kg being difficult to chill and process. In 1997 there were four export licensed processing works in Queensland, located in Longreach, Roma and two at Eagle Farm in Brisbane. The game meat processing industry in Queensland employs up to 80 people during times of peak production/harvest (Dee, pers. comm.).

4.5 Cost:Benefit Relationship

Whilst the game meat industry and recreational hunters play an important role in controlling feral pigs in some localities, there is an overall net cost to the broader community from feral pigs. The damage done to crops, pastures, fences, water facilities and livestock can be quantified ($100M), and are in excess of the value of the 'wild boar' market ($20M) even without including the costs to the environment and the potential costs from exotic disease.

5.0 Biology and Ecology

5.1 Habitat Requirements

Feral pigs are found in a wide variety of habitats, ranging from dry arid areas, to high mountainous forests and grasslands, to dense tropical rainforest. The two requirements that feral pigs have that restricts their distribution in these habitats are daily water and suitable cover.

5.2 Diet

The feral pig is considered to be an opportunistic omnivore (Choquenot *et al* 1996), and it has been known to consume the following groups of foods:

fruits and seeds: grains, fruits, rainforest fruits;
foliage and stems: grasses, sugar cane, banana trees;
rhizomes, bulbs and tubers: including tuberous crops such as potatoes;
fungi; and
animal material: carrion, earthworms, lambs, arthropods.

The foods consumed vary from region to region and the potential food sources are limited by availability rather than preference for any one food type.

Pigs have a relatively high-energy requirement, particularly during lactation, and growth of young pigs (Choquenot *et al* 1996). Sows require about 15% of their diet to be crude protein in order to successfully suckle their young. This protein requirement can be met from plant material, but is met more commonly from animal matter such as earthworms, carrion, arthropods, frogs and reptiles. Animal matter rarely exceeds 5-18% of a pigs diet (Giles 1980; Pavlov 1980).

Feral pigs will relocate in response to food availability, particularly seasonal requirements for higher protein and energy associated with reproduction and growth.

5.3 Social Structure and Behaviour

The most common groupings of feral pigs is either a few sows and their young, bachelor groups (individuals less than 18 months of age), or individual boars (usually older than 18 months). After weaning pigs will remain with their mother until the next litter, or in the case of sows, until they mate (Masters 1979; Giles 1980; Pavlov 1980).

Group size varies with age, sex, food and water availability and disturbances (such as hunting or other control measures). Group size can range from solitary boars to groups of 100 or more sharing a locally scarce resource such as a single waterhole during droughts.
Feral pigs habitually make use of trails, shelter areas, feeding and watering areas (subject to availability), rubbing and tusking trees and wallows. Even though they are habitual in their use of such areas, there is no evidence that feral pigs, of either sex, actively defend territories.

The size of a feral pig's home range depends on a number of variables, sex (males have larger home ranges than females) and resources. Food availability and quality is thought to be the main determining factor influencing home range size. Home range size varies from as little as 0.16 sq km for furrowing sows, to greater than 40 sq km for individual boars in the semi arid rangelands (Saunders 1988; Giles 1980).

Feral pigs are most active at night or during times of cooler temperatures (late afternoon, early morning, cooler weather, rainy or overcast conditions. They may become active during periods of disturbance from hunting or other human activities such as stock mustering (Pullar 1950; Giles 1980; Saunders and Kay 1991).

5.4 Reproduction and Population Dynamics

The feral pig is polyoestrus; adult sows have a 21-day oestrus cycle and a gestation period of 112-114 days. Their breeding is limited by food availability and quality (particularly the dietary requirement for about 15% protein). If food quantity and quality is available then feral pigs have the ability to produce two litters every 12-15 months (Giles 1980; Pavlov 1983; Ridpath 1991).

Sexual maturity in feral pig sows is dependent on weight (25-30 kg) rather than age, similar to domestic pigs (Masters 1979; Giles 1980; Pavlov 1980). The litter size of feral pigs generally averages between 4.9 and 6.3 piglets, but may be as high as 10 under favourable conditions (Choquenot *et al* 1996).

Juvenile mortality ranges from 10-15% under favourable conditions to 90 or 100% during periods of drought (Masters 1979; Giles 1980; Saunders 1988). Adult mortality ranges from 15 to 50% depending upon food availability and quality, predators (including hunting pressure) and disease.

The potential for pig populations to grow is estimated by their exponential rate of increase (r). The corresponding (e^r) value provides the approximate multiplication rate. Table 5 gives an indication of the potential rates of increase of a feral pig population starting at 100 (female) pigs without external influences such as harvesting, control, immigrations or emigrations.

Table 5. Potential rates of population increase for a base population of 100 feral breeding sows.

HABITAT	REFERENCE	e^r	After 1 year	After 2 years
Semi-arid rangelands	Choquenot 1994	0.97	197	388
"	Giles 1980	1.82-2.0	282-300	795-900
Tablelands	Saunders et al 1990	1.28	228	519
Wet/Dry Tropics	Caley 1993	0.78 (max)	178	316

6.0 Efficacy of Current Control Methods

6.1 Exclusion and Habitat Modification

Fencing is effective for feral pig control for small high value areas such as cropping and lambing paddocks. Fencing has not been adopted as a large scale control method for several reasons: initial high expense, high maintenance costs, low cost effectiveness for large areas and relocation of the problem rather than overcoming it.

Several trials have been conducted to determine the most effective fence design (Hone and Atkinson 1983; Plant 1980; Tilley 1973). Electrification significantly increases the effectiveness of fencing to exclude or reduce the movements of feral pigs. The most effective fence design features 8/80/15 hinge joint, steel posts at 5m intervals, two top barb wires, and an electrified outrigger wire 25 cm above ground level (Hone and Atkinson 1983). This electrified fence design costs near $2500/km to construct.

Habitat modification, e.g. clearing remnant vegetation or closing water points, is rarely used as a control technique, as it results in the destruction of habitats for native species, is poor soil conservation practice and usually only moves the problem to another location.

Changes in management practices sometimes occur when pigs are a serious economic problem. The change in management usually revolves around altering the duration of lambing, but this was shown to be ineffective by Hone (1987). A more effective change in management involves lambing in paddocks away from areas of known pig activity, or changing from sheep breeding and wool growing to wool growing alone, or even cattle production in extreme cases of pig predation. The shift in enterprise may involve potential lost income to the landholder.

6.2 Poisoning

Poisoning is the most cost effective and efficient control method currently available for feral pig control (Korn 1986). The use of poisons is restricted, with baits containing 1080 only being able to be prepared by registered operators.

1080 (Sodium monofluroacetate) poison is the one of only two products registered for use in Queensland to control feral pigs, the other being CSSP (see below). 1080 poison has many attributes that make it suitable for general usage; it is found in many native plant species, therefore native animals have a certain inbuilt tolerance to it, and it degrades readily in soil. There are several disadvantages in using 1080; it is highly toxic to dogs, it has no antidote and secondary poisoning, via animals consuming carcasses, can occur.

1080 has been widely used for feral pig control across Queensland and can be used with meat (in western and northern grazing areas), grain, pellets or vegetables, as the bait material. Prefeeding is usually conducted for a period of 2 or 3 days before poisoning to attract as many pigs as possible to the bait station.

Not all pigs within an area will take baits (depending on alternative food availability, density of baits and pigs). The success rates of baiting vary considerably, with population reductions ranging from 58% to 99.4% (Hone and Pederson 1980; Bryant and Hone 1984). The success of baiting also varies with operator experience and incidence of vomiting. Pigs are known to vomit following 1080 ingestion, and males are known to vomit more than females independent of amount of poison ingested (Hone 1987). This vomiting behaviour by feral pigs will reduce the effectiveness of current baiting campaigns and may lead to bait shyness for future campaigns. Anti-emetic compounds have not been shown to reduce the amount of vomiting by feral pigs (O'Brien *et al.* 1986).

Warfarin, an anticoagulant, is another poison that has been trialed for use in feral pig control. It has not however been registered for use by the National Registration Authority for broad scale use. It has several benefits over other poisons, it has an antidote (Vitamin K), can require several doses before causing death, secondary poisoning does not occur, it does not cause vomiting and is cheaper than 1080. It does however have some disadvantages: it is not specific, requires several doses before becoming effective and can take several days before mortality occurs.

Phosphorus based poisons (Sayers Alport Phosphorus-SAP and CSSP) have been used in the past by landholders. They cause a long and painful death, and consequently are not used or recommended by the Department of Natural Resources and Mines. Because they could previously be purchased by landholders without restriction, they have been widely used and stored by landholders. The exact amount of these poisons used in pig control is unknown. These poisons also have serious impacts on non-target species as dose rates vary and there is no control over the use of stocks held by landholders.

6.3 Recreational Hunting

It has been estimated that recreational hunters kill 15-20% of the feral pig population in accessible areas annually (Tisdell 1982). The use of recreational hunters to control pig numbers is seldom effective as recreational hunters only kill a small percentage of the population, disperse pigs through regular disturbance and hunt on relatively small, easily accessible areas.

However the value of recreational hunters to the broader community must not be overlooked, recreational hunting can provide significant revenue to small communities.

Hunters have been known to introduce pigs to 'clean' areas to provide themselves with hunting opportunities in the future. Hunters have also been known not to take small pigs or sows or to castrate males or to cut the ears off pigs to make them more difficult to catch with dogs, thus insuring 'sport' in future seasons. These actions are in direct opposition to effective pig control.

The use of dogs to hunt pigs, either to flush them out of shelter, or to chase and catch them has been criticized by animal welfare groups, but is currently legal throughout Queensland. A review of the animal protection legislation by the Department of Primary Industries may alter this situation. The success of dogs capturing pigs has been studied and results show that solitary pigs are caught on 90% of the occasions when chased (Caley 1993), when groups of

pigs are encountered only one is usually caught and only about 70% of those chased are caught (Oliver *et al.* 1992). Another risk associated with using dogs is them becoming lost and their subsequently becoming 'feral', preying on stock and native animals.

6.4 Trapping

Trapping of feral pigs has gained increasing acceptance as trap designs improve, feeding behaviour is better understood and the restrictions on the use of poisoned baits increases. Trapping is relatively expensive and labour intensive and so not practical for large scale control. Trapping is environmentally friendly, relatively humane and some costs can be defrayed against the sale of pig carcasses. However, the success of trapping has been found to vary from 28% of the population (Saunders *et al* 1993), to 81% (Choquenot 1993).

Some of the other advantages of trapping over other control methods are that (Lukins 1989):

- trapping does not interfere with normal pig behaviour (unlike shooting or dogging);
- the number of pigs is known exactly, and carcasses can be removed safely;
- it is a flexible technique and can be fitted into routine property activities, making it economical in terms of labour, materials and number of operators; and
- properly designed traps can be moved or re-used as necessary. Good trapping makes use of opportunities as they arise.

Hone *et al* (1980) outlined the points that landholders and managers need to consider when trapping:

- type of trap to use;
- number of traps to use;
- where to put traps;
- number of nights each trap is used;
- type and amount of bait to use; and
- amount and duration of pre-feeding.

Several trap types are successful. The relative success and design of trap to use depends on the local environment, materials, number of pigs to be trapped and presence of non-target species such as cassowaries (Figure 2.).

Some of the other factors that may influence the decision to trap include: it is time consuming and expensive to initially build and maintain traps.

The Department of Natural Resources and Mines advises landholders to consider trapping when poisoning is impractical, or as a follow up to poisoning. The Department also advises landholders to reduce disturbance to pigs from shooting or dogs before and during the trapping period.

Hone (1984) has described the important steps in trapping:

- feeding sites should be placed where feral pigs are active, for example, water points and pop-holes in fences;
- initially, feed the pigs with bait such as grain and pellets (fermented material is often attractive), vegetables or fruit, meat or carrion;
- build the trap where feed is being taken, and leave it open and baited, but not set, for one or two nights;
- then set the trap each night;
- if the feed is being taken, continue to trap until no more pigs are caught;
- leave the trap unset and feed a different bait from that used initially;
- if feral pigs start taking the bait, set the trap for several nights; and
- once no bait is taken, start feeding elsewhere before moving the trap.

6.5 Biological Control

Pathogens and immunocontraception via a vector have been suggested as possible biological control methods for feral pigs.

These methods have not been pursued, as it would be difficult if not impossible to stop the spread of any disease or disease borne immunocontraception to domestic pigs. The feral pig industry, and the associated export and flow on revenue would also be significantly affected by any such disease.

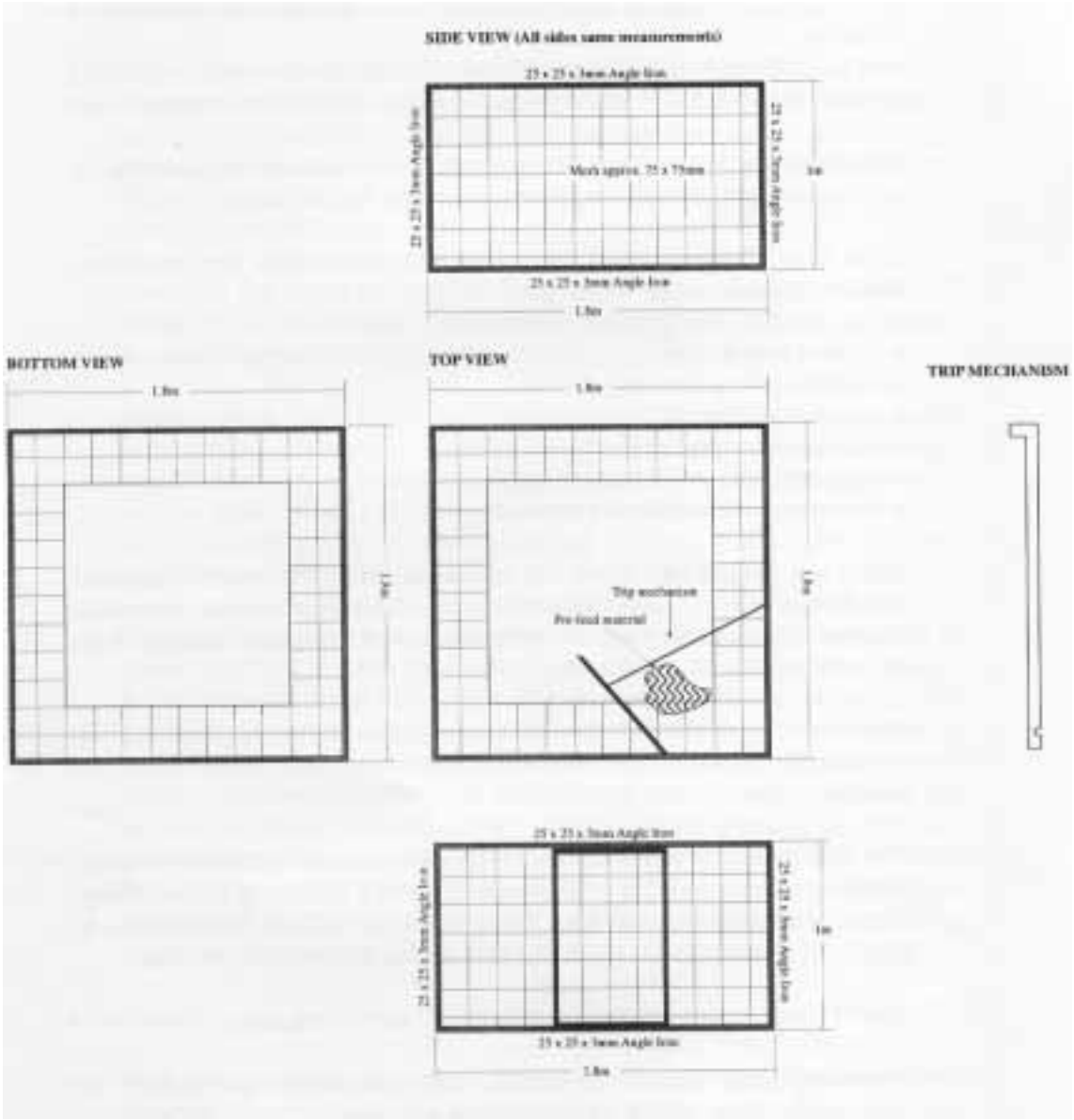


Fig.2 Cassowary Safe Feral Pig - Box Trap (Mitchell and Dorrington)

6.6 Fertility Control

Currently there is no work being carried out on producing an immunocontraceptive bait for feral pigs. There is research being conducted on finding an immunocontraceptive for control of rabbits, foxes and rodents. As with these other species, there are problems involved in possibly developing such a control method (Bomford 1990):

- lack of long-acting contraceptive compounds (making repeat dosing necessary);
- high costs of delivery by baits (particularly when repeat dosing is needed);
- less effect on population size than when an equivalent number of pigs are killed, due to repeat dosing requirements; and
- potential effects on non-target species.

Because delivery methods are the same it would be far more efficient to provide a poisoned bait than an immunocontraceptive bait.

6.7 Shooting (helicopter and ground shooting)

Shooting has been used as a control method ever since feral pigs first became a problem in Queensland. Shooting, particularly from the ground is a very labour and resource intensive method, and cannot be used to control pigs over large areas, particularly when pigs are at low densities. Shooting, both ground and air, can cause pigs to disperse and requires a great deal of skill for it to be cost effective.

The use of helicopters in recent times has made shooting a more economic option, particularly in inaccessible areas. Helicopter shooting still has some shortcomings. Some habitat types can conceal pigs from the air making them difficult to shoot and shooting cannot be used as a stand alone control measure, as it will only reduce the population by a limited amount.

It has been proposed to use 'Judas' pigs in a similar way as 'Judas' goats are used in feral goat control. This method involves the use of a radio collared individual to locate other animals after it is released and rejoins a group. Because pigs are not as gregarious as goats, this method has limited application and is seldom used.

6.8 Control During Exotic Disease Outbreaks

In the event of an exotic disease outbreak, financial and legal control constraints take on less importance and the amount of control required is increased. The procedure for an exotic disease outbreak, as set out in the AUSVETPLAN, requires that containment of the disease within a geographic area occurs first, and secondly that vector population reduction is carried out as quickly as possible. Monitoring of the adjoining vector population for disease incidence must also be carried out to assess the rate of spread of the disease.

To successfully plan an eradication campaign for containment of an outbreak of exotic disease within a feral pig population several factors, including the delay in first detecting infected animals, the prevalence of infection and the size and location of the area to be decontaminated must be determined (Pech and McIlroy 1990). In order to eradicate an exotic disease, it is necessary to reduce the vector population to the threshold at which the disease will not spread. This varies for different areas but has been estimated to be in the order of 95%. However, in simulated exercises reductions in the order of 40-80% have been achieved. This result indicates that current planning and control measures for pigs will need to be modified to achieve successful reduction of populations to required levels.

7.0 Animal Welfare Considerations

In Queensland the *Animals Protection Act* 1925, gives no protection to any feral animal but does provide, in broad terms, that procedures to destroy declared animals must not constitute 'unreasonable, unnecessary or unjustifiable ill-treatment'. Ill-treat is defined as : ill-treat, wound, mutilate, overdrive, override, overwork, abuse, worry, torment, torture and cause any animal unnecessary pain or suffering; also overload or overdrive when loaded, and overcrowd, and unreasonably beat or kick.

This legislation is currently being reviewed. Once the legislation review is complete, a new Act is expected to be tabled in 1998. This new legislation will be prepared by the Department of Primary Industries in consultation with animal welfare groups, the pet industry, environmental groups, primary producers and the Department of Natural Resources and Mines and will have broad community input.

As mentioned above, the use of dogs in chasing and capturing pigs has been condemned by animal welfare groups, but remains legal in Queensland. There have been suggestions that the practice has been withdrawn from the recommended methods list in NSW, and penalties of up to $10 000 being applicable for using this method of pest control.

8.0 Management and Control Practices

8.1 Legislative Status in Queensland

The feral pig is a declared animal under Section 69 of the *Rural Lands Protection Act* 1985. It is categorized as an A1, A2 and A6 animal for the whole State, which means that:

> *A1 in respect of an area if the introduction of those animals into that area should, in the opinion of the Governor in Council be prohibited;*
>
> *A2 in respect of an area if those animals-*
> *(i) are not vertebrate animals native to that area; and*
> *(ii) should, in the opinion of the Governor in Council, be destroyed in that area;*
>
> *A6 in respect of an area if the keeping and selling of those animals in that area should, in the opinion of the Governor in Council, be subject to prescribed conditions and restrictions.*

Penalties applicable to landholders for noncompliance with the provisions of the Act, are shown in Table 6.

Table 6. Offences and penalties applicable to feral pigs in Queensland.

OFFENCE	MAX. FIRST OFFENCE	MAX. SECOND OFFENCE
Failure to control	$375	$1,500
Failure to comply with direction	$1,500	$3,750
Introduction of Category A1 animals	$7,500	
Restrictions on keeping and selling A6 animals	$3,750	
Liberating declared animals	$7,500	

Section 80 of the *Rural Lands Protection Act 1985* places the responsibility for control of declared animals with the landholder, and there is a penalty of $375 for failure to control. As can be seen from the list of penalties, people releasing feral pigs into areas for hunting purposes are liable to a $7,500 fine, and persons who keep feral pigs are liable to fines up to $3,750.

The Department of Natural Resources and Mines policy is to 'reduce the impact of feral pigs through coordinated and sustained control programs in strategic areas of Queensland where feral pigs constitute a high risk to agricultural production and/or the environment.'

The policy states that A2 animals shall be subject to 'sustained control in strategic areas in concert with commercial utilisation where appropriate for established pests.' This has been further explained by defining:

Sustained control as ' the implementation of control on a regular basis to keep population at or below a threshold density at which the benefit of control is equal to or greater than the cost of control. Sustained control requires the development of pest animal management plans that include regular and integrated control options. (Integrated control is the use and combination of multiple control techniques).'

Commercial utilisation (harvesting and hunting) as ' utilising animal pests as a resource is particularly appropriate for some species such as the feral horse, feral pig, feral goat and rabbit. Commercial utilisation can be integrated with other control methods to regulate pest animal numbers and should be incorporated in management plans.'

8.2 Management Strategies in Queensland

8.2.1 Pastoral Zone

In the pastoral zone, the main management strategy is baiting, including aerial bait dispersal. This strategy is used because any program needs to cover large areas, but should be concentrated around areas where pig activity is greatest such as around, but not too close to, drainage lines and watering points. The actual impact of feral pigs in these extensive grazing areas, particularly the cattle grazing areas, is limited. Commercial utilisation by professional and recreational hunters also forms part of the overall control strategy, as it is control at a low cost to the landholder. Because this zone takes in arid and semi arid regions, feral pig numbers are subject to wide variations due to climatic extremes that lead to food and water shortages, but also occasional large numbers.

8.2.2 Wet Tropics

The Wet Tropics presents unique problems due to the inaccessible nature of the terrain, high conservation value, plentiful food and water, and proximity to urban settlement. Control is mainly by using traps (cassowary and wallaby safe) with limited baiting in some areas. Trapping is conducted at accessible sites that border or are in close proximity to agricultural enterprises and urban settlement. Broadscale baiting is not possible because of the presence of endangered fauna and tourists. A project to determine the impacts of feral pigs on the natural environment in this region, and a successful community based trapping program has been running in this area for several years. Shooting and 'dogging' are considered to be ineffective control methods because of the thick vegetation and the potential for dogs to escape or become lost, and become problems themselves.

8.2.3 Agricultural Zone

Feral pigs cause a great deal of damage to agricultural crops, particularly grain crops (as shown in Table 2) and considerable resources are allocated to control in this zone. The main means of control is capturing either with dogs or in traps, or hunting. The feral pig or 'wild boar' industry provides a significant input into local economies, and also controls a significant number of pigs. Baiting is carried out to a lesser extent depending on landholder

perceptions of hunting, the extent of the problem, proximity to chiller boxes, prices paid for carcasses and availability of alternate food sources.

8.2.4 Near Urban Situations

Feral pigs are reasonably common in these situations, and are sometimes found in surprising numbers: approximately 100 feral pigs were found along a creek line in the Redland Bay area, south of Brisbane in 1996. Feral pigs in these situations cause damage to parklands, for example Mt Glorious National Park, and to gardens and hobby farms. Control options in these situations are limited. Baiting can only be used in areas where it is considered to be safe by the local Land Protection Officer. Trapping is considered to be the safest and most effective control option. Hunting is of limited value because of firearms restrictions and the problems of using dogs. Exclusion fencing is practiced and is effective for high value areas.

8.3 Property Management Strategies

The Bureau of Resource Sciences (BRS) (Choquenot *et al.* 1996) has outlined four stages of a strategic management program at both the local and regional level:

Problem definition - The problem, if it is real or perceived, needs to be defined. This process will compare the dollar or conservation value of the damage caused by feral pigs, with the benefits received from controlling them. The estimation of environmental costs and benefits is difficult and requires the costing of intangible factors.

Developing a management plan - The main components of developing a management plan is to establish: a set of objectives (interim and long-term goals), a time frame to achieve goals, and indicators for measuring performance. There are several options for the level of control, these range from local eradication, strategic management, commercial management, crisis management or no management, depending on the particular situation. Strategic management offers the most flexible option, as it allows for changes in economic, environmental and pest circumstances. Control techniques need to be included in the preparation of the plan.

Implementing the plan - In order to effectively implement the plan, it is essential to gain broad support for the plan. Stakeholders should be identified and their involvement and 'ownership' of the plan should be encouraged.

Monitoring and evaluating progress - Monitoring of both the operational (cost effectiveness) and performance (effectiveness of the management plan) components of the plan is essential if changes are to be made, and mistakes rectified.

This approach to preparing an effective management plan will allow for the preparation of a dynamic plan that can be adapted for a variety of situations and changing circumstances.

9.0 Acknowledgments

This assessment has drawn heavily from information contained within the Bureau of Resource Sciences publication “Managing Vertebrate Pests - Feral Pigs” (Choquenot, McIlroy and Korn 1996). Additional information and data has been include so as to give the assessment a Queensland emphasis.

Information has also been supplied by Cliff Dee (Wild Game Resources), Graham Hardwick, Barry Toms and Jonathon Lee.

10. References

Benson, R. 1980 Evaluating Feral Pig Damage and Cost of Control in Western New South Wales. Research Workpaper Series, Division of Marketing and Economics, Department of Agriculture, New South Wales.

Bomford, M. 1990 A Role for Fertility Control in Wildlife Management? Bureau of Rural Resources Bulletin 7. Australian Government Publishing Service, Canberra.

Bryant, H and Hone, J. 1984 Field evaluations of poisoning programmes for feral pig control in north-west New South Wales. Advisory Note No. 19/84. Agdex 673, New South Wales Agriculture.

Caley, P. 1993 The ecology and management of feral pigs in the wet-dry tropics of the Northern Territory. Unpublished M.App.Sc. thesis, University of Canberra.

Choquenot, D. 1993 Optimising feral pig management in relation to climatic and pasture conditions. Unpublished report to the International Wool Secretariat.

Choquenot, D., McIlroy, J. and Korn, T. 1996 Managing Vertebrate Pests: Feral Pigs. Bureau of Resource Sciences, Australian Government Publishing Service, Canberra.

Dexter, N. 1990 Population Density and Management of Feral Pigs at Aurukun, North Queensland. Bureau of Resource Sciences, Report R/11/90, Canberra.

Giles, J.R. 1980 The ecology of the feral pig in western New South Wales. Unpublished Ph.D. thesis, University of Sydney.

Hone, J. 1980 Effect of feral pig rooting on introduced and native pasture in north-eastern New South Wales. Journal of the Australian Institute of Agricultural Science **46**: 130-132.

Hone, J. 1983 Agricultural damage by feral pigs and studies of control methods. Australian Meat Research Committee. Final Report, Department of Agriculture, New South Wales.

Hone, J. 1984 Controlling feral pigs. Agfact A9.0.9 Agdex 673, Department of Agriculture, New South Wales.

Hone, J. 1987 Theoretical and practical aspects of feral pig control. Unpublished Ph.D. thesis, Australian National University, Canberra.

Hone, J. 1988 Feral pig rooting in a mountain forest and woodland: distribution, abundance and relationships with environmental variables. Australian Journal of Ecology **13**: 393-400.

Hone, J. 1995 Spatial and temporal aspects of vertebrate pest damage with emphasis on feral pigs. Journal of Applied Ecology **32**: 311-319.

Hone, J. and Atkinson, B. 1983 Evaluation of fencing to control feral pig movement. Australian Wildlife Research **10**: 499-505.

Hone, J. and Pederson, H. 1980 Changes in a feral pig population after poisoning. J.P. Clark, (ed)., Vertebrate Pest Conference **9**: 176-182. University of California, Davis.

Hone, J, O'Grady, J. and Pederson, H. 1980 Decisions in the control of feral pig damage. AG Bulletin 5, Department of Agriculture, New South Wales.

Korn, T.J. 1986 The use of helicopters for feral pig control in New South Wales. 10th National Conference of Noxious Plants and Animals. Port Stephens, New South Wales.

Lukins, B. 1989 Feral pigs: Trapping in New South Wales. Agfact A9.0.15, 1st edition, New South Wales Agriculture.

Masters, K. 1979 Feral pigs in the south-west of Western Australia. Final Report to Feral Pig Committee. Agricultural Protection Board and Department of Conservation and Land Management, Western Australia.

McIlroy, J.C. 1990 Feral Pig. Pp 358-371 in: C.M. King, (ed)., The Handbook of New Zealand Mammals. Oxford University Press, Auckland, New Zealand.

McIlroy, J.C. 1993 Feral pig management problems in the wet tropics of Queensland World Heritage Area. Final consultancy report on control of feral pigs (*Sus scrofa*) associated with the wet tropics Queensland World Heritage Area, to Wet Tropics Management Authority, Cairns.

Mitchell, J. 1993 Systematic assessment of feral pig damage and recommended pig control methods in the wet tropics World Heritage Area. Final Report to the Wet Tropics Management agency, Department of Lands, Charters Towers, Queensland.

Mitchell, J. 1998 Effectiveness of aerial baiting for feral pigs (*Sus scrofa*) in north Queensland. Wildlife Research. In press.

Noble, K. 1996 Sustainable Best Practice Feral Pig Management in the Queensland Wet Tropics. Final Report to the Vertebrate Pest Program. Department of Natural Resources and Mines, Townsville.

O'Brien, P.H. (1987) Socio-economic and biological impact of feral pig in New South Wales: an overview and alternative management plan. Australian Rangeland Journal **9**:96-101.

O'Brien, P.H., Kleba, R.E., Beck, J.A. and Baker, P.J. 1986 Vomiting by feral pigs after 1080 intoxication, non-target hazard and influence of anti-emetics. Wildlife Society Bulletin **14**:425-432.

Oliver, A.J., Marsack, P.R., Mawson, P.R., Coyle, P.H., Spencer, R.D., and Dean, K.R. 1992 Species management plan for feral pigs. Agricultural Protection Board, Perth, Western Australia.

Pavlov, P.M. 1980 The diet and general ecology of the feral pig in the Girilambone district of New South Wales. Unpublished M.Sc. thesis, Monash University, Melbourne.

Pavlov, P.M. 1983 Feral pigs. Pp 494-495 in: R. Strahan. (ed). The Australian Museum Complete Book of Australian Mammals. Angus and Robertson, Sydney.

Pavlov, P.M., Hone, J. and Moore, L.A. 1992 Feral Pigs, rainforest conservation and exotic disease in north Queensland. Wildlife Research **19**:179-193.

Pavlov, P.M., Kilgour, R.J., and Pederson, H. 1981 Predation by feral pigs on merino lambs at Nyngan, New South Wales. Australian Journal of Experimental Agriculture and Animal Husbandry **21**:570-574.

Pech, R.P. and McIlroy, J.C. 1990 A model of the velocity of advance of foot-and-mouth disease in feral pigs. Journal of Applied Ecology **27**:635-650.

Plant, J.W., Marchant R., Mitchell T.D. and Giles, J.R. 1978 Neonatal lamb losses due to feral pig predation. Australian Veterinary Journal **54**: 426-429.

Plant, J.W. 1980 Electric fences will give feral pigs a shock. Agricultural Gazette New South Wales **91**: 38-40.

Pullar, E.M. 1950 The wild (feral) pigs of Australia and their role in the spread of exotic diseases in Australia. Australian Veterinary Journal **26**:99-109.

Pullar, E.M. 1953 The wild (feral) pigs of Australia: their origin, distribution and economic importance. Memoirs of the National Museum, Melbourne **18**:7-23.

Ramsay, B.J. 1994 Commercial Use of Wild Animals in Australia. Bureau of Resource Sciences, Australian Government Publishing Service, Canberra.

Ridpath, M.G. 1991 Feral mammals and their environment. Pp 169-191 in: C.D. Haynes, M.G. Ridpath, M.A.J. Williams and A.A. Balkema (eds), Monsoonal Australia: Landscape, Ecology and Man in the Northern Lowlands. Rotterdam, Netherlands.

Rural Lands Protection Act 1985 Queensland Government Printer.

Roberts, A., Klomp, N. and Birkhead, J. 1996 Monitoring marine and terrestrial hunting in an Aboriginal community in north Queensland. Pp 152-164 in : M. Bomford and J. Caughley. (eds), Sustainable Use of Wildlife by Aboriginal Peoples and Torres Strait Islanders. Bureau of Resource Sciences, Australian Government Printing Service, Canberra.

Saunders, G. 1988 The ecology and management of feral pigs in New South Wales. Unpublished M.Sc. thesis. Macquarie University, Sydney.

Saunders, G. and Kay. B, 1991 Movements of feral pigs (*Sus scrofa*) at Sunny Corner, New South Wales. Wildlife Research **18**:49-61.

Saunders, G., Kay, B. and Nicol, H. 1993 Factors effecting bait uptake and trapping success for feral pigs (*Sus scrofa*) in Kosciusko National Park. Wildlife Research **20**: 653-665.

Tilley, L.G.W. 1973 Pig fencing in Mossman. Cane Grower Queensland Bulletin. **36**: 132-133.

Tisdell, C.A. 1982 Wild Pigs: Environmental Pest or Economic Resource? Pergamon Press, Sydney.

Tisdell, C.A. 1984 Feral pigs threaten native wildlife in Australia. Tigerpaper **11**: 13-17.

Wilson, G.R. and Choquenot, D. 1996 Review of feral pigs and exotic disease preparedness. Report to Bureau of Resource Sciences, Canberra.

Wilson, G., Dexter, N., O'Brien, P. and Bomford, M. 1992 *Pest animals in Australia - a Survey of Introduced Wild Mammals.* Kangaroo Press and Bureau of Rural Resources, Canberra.

Wilson, G.R., Hill, J.E. and Barnes, A. 1987 An aerial survey of feral pigs and emus in south-eastern Queensland. Australian Wildlife Research **14**: 515-520.

Pest Status Reviews

Others in the series:

Prickly acacia in Queensland

Rubber vine in Queensland

Mesquite in Queensland

Cabomba in Queensland

Sicklepod in Queensland

Veterbrate Pests of Built-up areas

House mouse in Queensland

Bellyache bush in Queensland

Hymenachne in Queensland

Feral Goat in Queensland

For further information contact:

C.S. Walton,
Land Protection,
Natural Resources and Mines.
Phone: (07) 3406 2879.

HOUSE MOUSE

House mouse

(*Mus domesticus*)

in Queensland

PEST STATUS REVIEW SERIES - LAND PROTECTION

by
J.A.Caughley

Queensland Government
Natural Resources and Mines

Acknowledgements
The author wishes to thank the many people who provided information for this assessment. In
particular the Bureau of Resouce Sciences, Grains Research and Development Corporation, Mary Bomford, Bob Parker, Ron Sinclair, John Griffths and Dana Kelly who supported or produced the B RS Managing Vertebrate Pests – Rodents publication from which much of this information is derived

Cover and contents design:
Grant Flockhart and Sonia Jordan

Photographic credits:
Natural Resources and Mines staff

ISBN 0 7242 7258 5
Published by the Department of Natural Resources and Mines, Qld.

Information in this document may be copied for personal use or published for educational purposes, provided that any extracts are fully acknowledged.

Land Protection
Department of Natural Resources and Mines
Locked Bag 40, Coorparoo Delivery Centre, Q, 4151

Contents

1.0 Summary 1
2.0 History 2
3.0 Current and Predicted Distribution 3
3.1 Monitoring Methods 4
3.1.1 Trap Lines 4
3.1.2 Bait Cards 4
3.1.3 Visible Sightings 4
3.1.4 Rate of Bait Removal 5
3.1.5 Crop Damage 5
4.0 Estimates of Current and Potential Impact 6
4.1 Impact on Primary Production 6
4.1.1 Impact on grain growers 6
4.1.2 Impact on sheep and cattle graziers 7
4.1.3 Impact on horticulturalists 8
4.1.4 Impact on intensive livestock producers 8
4.1.5 Off-farm impact 8
4.2 Impact on the Environment 10
5.0 Biology and Ecology 12
5.1 Diet 12
5.2 Gnawing behaviour 12
5.3 Reproductive Capacity and Population Dynamics 12
5.4 Other Behavioural Characteristics 13
5.4.1 Feeding behaviour 14
5.4.2 Sensory capabilities 14
6.0 Efficacy of Current Control Methods 15
6.1 Poisoning 15
6.1.1 In crops 15
Value of baiting during mouse plagues 15
6.1.2 Around buildings 16
6.2 Trapping 16
6.3 Exclusion 17
6.4 Habitat Modification 17
6.5 Other Control Measures 17
6.5.1 Use of raptor perches 17
6.5.2 Chemical repellents 17
6.5.3 Ultrasonic devices 17
6.5.4 Biological Control 17
7.0 Human and Animal Welfare Considerations 19
7.1 Disease 19
7.2 Other health risks 19
7.2.1 Risk of poisoning 19
7.2.2 Risk of fire 19
7.3 Animal Welfare Issues 20
7.3.1 Impact of mice on livestock 20
7.3.2 Humane control of mice 20
8.0 Legislation and Policy 21
8.1 Legislative Status of Mice in Queensland 21
8.2 Queensland Department of Natural Resources and Mines' Policy on Mice 21
9.0 Recommended Management and Control Practices 22
9.1 Managing Mice around Buildings 22
9.2 Managing Mice on Farms 22
10. References 24

Appendix 1. A Summary of the Biology and Ecology of the House Mouse 27
Appendix 2: Rodenticides that are registered for use in Qld 28

1.0 Summary

Mice cause serious damage to Queensland grain crops during mouse plagues. The problem is most severe on the Darling Downs where plagues are more frequent but major crop damage has also occurred in recent years in the Dawson and Callide catchments and around Goondiwindi. Mice are a problem in other crops as well, especially vegetable crops, and on pig and poultry farms within these regions.

Mice are also a serious nuisance in homes and buildings during a plague. They contaminate foodstuffs, destroy paper and cloth goods, and gnaw on electrical equipment and other possessions. Because they can transmit *Salmonella* (which causes food poisoning), they constitute a potential health hazard if they are in food preparation areas.

Control of mice is usually achieved by trapping and poisoning. Trapping is effective in buildings that can largely be made 'mouse-proof' by blocking all holes and placing sealing strips on doors. The few mice that enter are easily removed by trapping. Where buildings cannot be rodent-proofed (e.g. sheds), a number of rodenticides are available for use.

No rodenticide is currently registered for broadacre use, although zinc phosphide bait is presently under consideration by the National Registration Authority for Agricultural and Veterinary Chemicals (NRA). If it receives registration, strategic baiting will then be an option available to farmers. At present, their management options are restricted to habitat manipulation, except during major plagues, when the NRA provides temporary registration of a rodenticide for in-crop control.

Plagues vary in timing and location within a district according to the degree to which on-farm environmental factors are conducive to a build up in mouse numbers. For this reason each farmer needs to monitor mouse numbers on their farm at regular intervals so they can take appropriate management actions to control mice when their numbers are building up and thus restrict the amount of crop damage. Tracking mouse numbers through time can provide an advance warning of a plague.

Regular broadscale monitoring is undertaken on the Darling Downs each year (in June, September, October and November) by the Department of Natural Resources and Mines. A one per cent trap success or greater (that is, 9 or more mice caught in 940 traps) in spring is considered the commencement of the increase phase. Conversely, a plague is not expected if the September trap return is lower than one per cent.

Mice are not a declared pest under the *Rural Lands Protection Act 1985* so there is no legal requirement that they be controlled. The Queensland Department of Natural Resources and Mines' policy on mice includes provision for the department to monitor rodent populations on the Central Darling Downs and provide short and long term predictions on the potential for plague development.

2.0 History

House mice (*Mus domesticus*) are introduced pests probably arriving in Australia at the time of European settlement (Singleton and Redhead 1989). They are now distributed throughout the continent and are ubiquitous in agricultural areas where they are usually found in areas of long grass (e.g. along fencelines), within crops and stubble, and around sheds and houses. At most times, their numbers are low but when seasonal conditions are favourable, their numbers can increase to such a level that they become a serious pest, causing damage to crops, stored products and equipment. These events are called mouse plagues.

The earliest reported plague of mice in Queensland was in 1917 on the Darling Downs. From then until 1980, plagues occurred on average once every 10 years, but since 1980 the incidence of plagues has increased (Singleton and Brown 1998). Between 1980 and 1995, a plague has occurred on the Darling Downs on average every three years. This increase in frequency of plagues has been attributed to the progressive adoption in recent years of conservation farming practices such as stubble retention that provides undisturbed habitat for mice for long periods of the year (Singleton and Brown 1998).

The trigger for a mouse plague is considered to be above-average autumn rainfall—particularly if the rain follows one or two years of drought. Saunders and Giles (1977) suggested that this relationship arises because populations of mice and their natural predators, pathogens and parasites decline during a drought, and then when conditions again become favourable, mouse populations reach plague proportions before these normal agents of mortality are re-established. However Redhead *et al.* (1985) proposed that drought-breaking rain, rather than drought *per se,* was the important factor, as it ensured a good growth of grasses in the following spring when the breeding season of mice begins. If conditions continue to be favourable, breeding continues through summer and, by autumn, mice can be in plague proportions (Redhead and Singleton 1988; Singleton 1989).

3.0 Current and Predicted Distribution

Although mice are found throughout Queensland, plagues of mice occur primarily in the grain-growing areas (Fig. 1). It appears from a questionnaire sent to members of the Queensland Grain Growers Association in 1997 that the frequency of plagues varies between grain-growing areas. For example, the questionnaire returns indicated that four plagues had occurred on the Darling Downs between 1992 and 1997. In contrast only one plague occurred in Goondiwindi and South West Queensland (in 1995), and one in the Dawson and Callide Valley regions (in 1997). Very few problems were experienced with mice in the Lockyer, Burnett and Emerald regions over the five years.

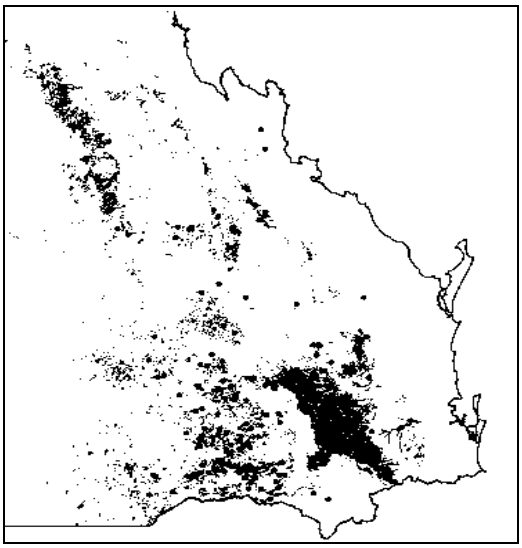


Figure 1. Map of grain-growing areas in Queensland The extent and frequency of plagues also varied between farms within each region. Although the Darling Downs had experienced four plagues between 1992 and 1997, the majority of farmers experienced only one plague within this time interval (Table 1).

Table 1. Number of plagues experienced between 1992 and 1997 by Darling Downs respondents (*n*=204) to a questionnaire (from Donkin and Caughley 1998).

No. of plagues experienced	% of respondents
0	22
1	53
2	23
3	2

These results show how spatially and temporally variable plagues can be. A farmer will experience a mouse plague according to the degree to which on-farm environmental factors are conducive to a build up in mouse numbers. For this reason farmers need to monitor mouse numbers on their farms at regular intervals to detect the onset of a plague. They will then be able to take appropriate management actions to control mice at that time and thus restrict the amount of crop damage.

Regular broadscale monitoring can track mouse numbers through time to provide an advance warning of a plague. Such monitoring is undertaken by the Department of

Natural Resources and Mines on the Darling Downs and the data collected are entered into a model that predicts the probability of a plague at least six months in advance.

3.1 Monitoring Methods

3.1.1 Trap Lines

The monitoring on the central Darling Downs by the Department of Natural Resources and Mines is undertaken each year in June, September, October and November. Forty-seven trap lines with 20 break-back traps in each (total of 940 traps) are set for one night. The number of mice caught is entered into a model developed by the Queensland University of Technology that predicts the probability of plague the following autumn. For example, a one per cent trap success or greater (that is, 9 or more mice caught in 940 traps) in September is considered the commencement of an increase phase that will lead to a plague the following autumn. Conversely, a plague is not expected if the September trap return is lower than one per cent.

Lines of break-back traps in different habitats could also be used by farmers for on-farm monitoring. The method gives a good indication of abundance and provides a cheap, simple and effective means of keeping track of mouse numbers over time.

3.1.2 Bait Cards

Bait cards have been introduced recently as a technique for estimating the likely effectiveness of crop baiting. Bait cards are 10cm x 10cm square pieces of white paper that are soaked in canola oil and pegged out overnight in a crop or other habitat. To obtain a reasonable estimate, at least five cards should be placed 5-10 metres apart at each site.

The bait card technique is a less reliable indicator of mouse numbers. The amount of a card eaten is largely a reflection of the numbers of mice and the availability of food for the mice rather than the numbers of mice present *per se*. When food is plentiful, the cards may be largely untouched even when mouse numbers are high. However, if bait card take is greater than 10%, it indicates (i) that mouse numbers are high and (ii) the mice will readily take the bait and cost-effective control will be achieved.

3.1.3 Visible Sightings

There are a number of visual sighting techniques available to farmers. The presence of burrows or of worn paths between cracks on the cracking clay soils of the Darling Downs are good indicators that mice are present. The number of burrow entrances counted per unit area in crops, contour banks and along grass verges and fencelines gives an indication of mouse activity. Freshly dug soil at the entrance to a burrow indicates that the burrow is active.

Counting numbers of mice seen on a road regularly travelled at night can provide an indicator of mouse abundance. Another visual method can be the number of mice seen in a one minute period after switching on a light in a shed.

3.1.4 Rate of Bait Removal

The rate of removal of baits placed in sheds and around grain stores is a good indicator of whether mouse numbers are increasing or decreasing.

3.1.5 Crop Damage

Crop damage from mice is not a good indicator of mouse numbers as it is often unnoticed until it is severe. Signs of high mouse activity include chewed stems or damage to seed heads. Debris such as seed husks at the base of plants suggests the damage to seed heads has been caused by mice rather than insects or birds.

4.0 Estimates of Current and Potential Impact

The impact of mice on various primary industries and on rural communities has been quantified for other states. Few hard data exist for the Queensland situation but some of the data from other states can be used to gain an appreciation of the scale of the impact mice have on all of these areas.

4.1 Impact on Primary Production

Mice can have a serious economic impact on a range of farming enterprises. The principal enterprise affected is grain growing, but vegetable growers, orchardists, graziers and intensive livestock producers can also suffer significant losses during a plague. In addition to production losses, farmers incur damage to machinery and vehicles, insulation in ceilings and walls of buildings, electrical equipment and fittings, and to household items and personal possessions.

The impact varies considerably between enterprises and between years. In most years mouse numbers are low and the damage they cause is unnoticeable, but when their numbers irrupt to plague densities in grain-growing areas, the damage on farms in the affected areas and in adjacent rural townships is measured in millions of dollars (Caughley *et al.* 1994).

4.1.1 Impact on grain growers

Mice can damage grain crops at all stages of growth (Redhead and Singleton 1988). Generally, plagues irrupt in autumn at the end of a protracted breeding season and thus in Queensland the potential for damage is greatest to maturing summer crops. Mouse numbers usually decline over winter but the timing of the decline varies. If survival is high early in winter, mice can also cause severe damage to winter crops through attacking the embryonic seed heads within the tillers.

Following the 1997 Central Queensland mouse plague and baiting program a questionnaire was sent to graingrowers involved in the baiting program Caughley *et al* (1998b). For the landholders who responded, the winter crop losses prior to baiting were between 0-$100,000+; they estimated that baiting prevented further crop losses of between $1,000-$100,000+. If the estimates of the landholders who responded were typical for all landholders who baited, the total crop losses prior to baiting would have been in the order of $2.8 million, and baiting would have prevented a further $4.8 million of damage.[1] The average cost of baiting per landholder was $2,800, which provides an average cost benefit ratio of 12:1 (range 2:1 to 48:1).

In 1995, a major mouse plague was experienced on the Darling Downs and around Goondiwindi. As in 1997, a questionnaire was sent to farmers at the end of the plague. From the responses, the estimated damage to crops prior to the baiting campaign (in this case the poison used was strychnine) was in the order of $18 million; the damage prevented was estimated to be in the order of $45 million (Miller 1996). The average loss per respondent was $27,000 (range $0–$400,000), and the damage prevented $65,000 (range $0–$1,125,000). The average cost of baiting to the farmer was $1,750. No estimates of other on-farm losses and costs were made in either 1995 or 1997.

[1] The total figures are estimates for all landholders who baited, and do not include other landholders who may have suffered damage but did not bait.

The economic impact of a plague in Victoria in 1993 was evaluated by Caughley *et al.* (1994) from data gathered from 257 farmers who responded to a phone-in. In this plague, the average crop loss of the respondents was $51,100 (Table 2). Other economic losses were experienced from damage to machinery, stores, and household goods but these were small by comparison with the loss in crop production (Table 2).

Table 2. Average amount lost per grain-grower, based on information provided by those who responded to the phone-in during the 1993 mouse plague in Victoria (from Caughley *et al.* 1994).

Estimated losses in crop production	$51,000
Resowing costs	$ 2,900
Baiting costs	$ 760
Damage to sheds, machinery, household goods	$ 1,360
Total	**$56,120**

The total loss reported by the respondents was $14.4 million. The response came from 7% of the farmers in the affected shires in Victoria, but how many more farmers experienced damage in the region is unknown. In South Australia, damage from mice was also widespread in 1993. The Department of Primary Industries, South Australia estimated the losses to grain-growers in that State was in the vicinity of $46 million (Caughley *et al.* 1994).

Various estimates of crop losses have been made in other plagues. Saunders (1987) reported that a plague in 1969–70 cost grain growers in southern New South Wales, Victoria and South Australia in the order of $14 million (NPV $117 million). In 1979–80, losses in Victoria were in the order of $15–20 million (NPV $46–61 million) (Redhead 1988). In 1984, surveys conducted by Government agencies in South Australia, Victoria and New South Wales placed losses in excess of $13 million (NPV $22 million).

Damage is recorded in localised areas in years between major plagues. For example, a plague in the Murrumbidgee Irrigation Area in 1994 caused an estimated $8 million of damage (Croft and Caughley 1995). Over the past 30 years, the average *annual* impact of mice on the Australian grain-growing industry was conservatively placed at $8 million by Caughley *et al*. (1994). Not surprisingly, the increasing incidence of mouse plagues (Singleton and Brown 1998) is deemed a matter of considerable concern both in Queensland and nationally.

4.1.2 Impact on sheep and cattle graziers

No value has been placed on losses experienced by graziers during mouse plagues. In Victoria in 1993, farmers reported severe depletion of medic pastures and a resultant loss in stock condition, especially in ewes and lambs (Caughley *et al.* 1994). Other losses experienced by graziers were damage to stored hay and wool bales. As with all other farmers in affected regions, graziers would have also suffered losses from damage to sheds, equipment and household goods, to which needs to be added the cost of bait to control the numbers of mice.

4.1.3 Impact on horticulturalists

Mice cause damage to a range of horticultural crops during plagues. Vegetable growers report losses in broccoli, tomatoes, capsicum, chilli, garlic, pumpkins and melons. Grapes, apples and other soft fruit are also damaged and serious losses can occur in almond and pistachio orchards. In the 1984 plague, losses to vegetable growers were placed at $100,000 (NPV $162,000) in Victoria (Redhead 1988). No estimates are available for other areas or plagues but losses are likely to be significant.

4.1.4 Impact on intensive livestock producers

Pig and poultry farmers in plague-affected areas can sustain major losses in livestock production, arising from stress (pigs in particular are highly stress-labile) and from direct physical attacks by mice upon the animals themselves (Table 3). Feed costs also increase. During the 1993 plague in Victoria, producers reported feed costs rose by up to 50%. Mice also block feed lines, gnaw on electrical wiring in air conditioners and waste disposal units, and cause damage to sheds (particularly the insulation in the walls). The losses experienced by intensive livestock producers during the 1993 plague were in the order of $530,000 in the worst affected area in north-western Victoria (Caughley *et al.* 1994).

Table 3. Losses experienced by pig and poultry producers in Victoria during the 1993 plague (from Caughley *et al.* 1994).

Pigs		Poultry	
Sows		**Layers**	
Conception rate		Weight	Down 30-50%
Litter size	Down 20-50%	Mortality	Up 15%
Litter mortality	Down 20-30%		
Baconers	Up	**Eggs**	
Growth rate		Number	Down 20%
Mortality	Down 20%	Size and quality	Down
Carcase quality	Up		
	Down 10%		

4.1.5 Off-farm impact

During plagues, mice often cause damage in rural townships. The types of off-farm impacts on rural businesses include:

- Damage to plant and equipment (particularly electrical appliances);
- Spoiling and consumption of perishables intended for sale;
- Lost business opportunity from not stocking, and therefore not selling, products considered at risk (e.g. packet foods); and
- Cost of redirected time and effort spent trapping and cleaning to protect goods and maintain health and hygiene standards.

Businesses where there are few food resources for mice (e.g. banks, machinery sales or fuel distributors) are not affected to the same extent as those that stock perishable goods. However, in all businesses, electrical and electronic equipment is at risk.

Only one detailed assessment of the off-farm economic cost of a mouse plague to townspeople has been conducted. During the 1993 plague, rural townspeople were interviewed across a broad spectrum of retail businesses and community services in South Australia[2] (Caughley *et al.* 1994). Everyone interviewed indicated that their most significant cost was the time required to mouse-proof, bait, trap, clean, and search for and dispose of carcasses; in many instances, these costs were incurred every day for the duration of the plague (in this case, for four months). For the purposes of their assessment, Caughley *et al.* (1994) costed all such time at $10 per hour.

Apart from time, the losses incurred were principally from damage to goods and electrical equipment. Three factors determined the extent of damage experienced: type of business, its location and type of construction. Retail outlets with large quantities of feed or foodstuffs, such as rural suppliers, grocers, supermarkets and bakeries, suffered more than other businesses. Secondly, those situated on the edges of town had more problems than similar businesses located centrally. Thirdly, the age and construction of the business premises determined how easy it was to exclude mice. Rural suppliers recorded the highest losses (Table 4). Their businesses were usually located on the edges of towns, their stock included large amounts of produce palatable to mice (e.g. grain and seed supplies, organic fertilisers and pet foods), and their premises were often open sheds that were impossible to mouse-proof. Food retailers, hotels and motels also experienced high costs. Goods and equipment were damaged and high labour costs were incurred in cleaning premises to the standard required by council health regulations. Schools and hospitals incurred similar costs in maintaining standards of hygiene.

Table 4. Average costs to retailers, community services and residents interviewed in plague-affected regions of South Australia, 1993, and some extrapolated estimates for the region (data from Caughley *et al.* 1994).

Service or business	No. sampled	Average cost	No. in plague area	Estimated total (South Aust.)
Retailers				
Rural suppliers	9	$7,451	45	$335,295
Food retailers	33	$2,304	100	$230,400
Hotels and motels	13	$2,496	82	$204,672
Other (e.g. finance)	72	$ 778		
Community services				
Schools	9	$2,734	24	$65,616
Hospitals	7	$2,107	36	$75,852
Councils, postal and emergency services	14	$ 814		
Households*	48	$ 280		

* Household costs do not include a costed labour component.

Telephone communications can be vulnerable to damage during mouse plagues. Not surprisingly, automatic exchanges in plague-prone areas are constructed to be mouse-proof and they are regularly checked by technicians who lay rodenticide baits as an extra precaution. Despite this state of preparedness, mice gained access to

[2]Note: the estimates were of costs incurred up to the time of the survey. No flow-on costs beyond the duration of the plague nor costs incurred prior to the plague (for example, construction costs in making buildings mouse-proof) were included. Some of the costs identified by a business or individual would have come from the sale of goods or services by another, but no method was available to balance the ledger.

one exchange in South Australia during the 1993 plague. It cost $30,000 to replace the damaged equipment; after parts were replaced, mouse-proofing the building cost a further $600.

Another enterprise that is highly vulnerable during mouse plagues is grain handling. Losses to grain stored in vertical silos are small since the structures are essentially mouse-proof. However, some grain is still stored in horizontal sheds on the Eyre Peninsula in South Australia and during the 1993 plague, mice caused considerable, though uncosted, losses in these sheds. In Victoria, in addition to silos, grain is stored in horizontal sheds and covered bunkers. With the onset of the plague in 1993, the Victorian grain-handling authorities instituted specific measures to limit losses; these included increased vigilance (bunker covers were checked weekly for holes or other signs of mouse infestation); the removal of grain from districts where the plague was severe; and the increased use of rodenticides around horizontal storage sheds. Between April and October, $12,000 was spent on bait. South Australian grain handling authorities spent $25,000 on bait over the same period. No estimates of losses to stored grain have been made in Queensland where grain is stored in similar ways to other states.

Many other off-farm costs of mouse plagues are intangible. For example, redirection of State Government staff to managing mouse plagues is usually uncosted. The one exception is for the 1995 plague on the Darling Downs where Fisher (1996) estimated that the cost to Queensland Government Departments of the strychnine baiting campaign was $311,000.

4.2 Impact on the Environment

The impact of mice on the environment has not been researched. Potential impacts could be:

- Competition with native fauna for food resources;
- Depletion of seed banks in pastures and native vegetation;
- Increased risk of soil erosion through the consequent reduction of ground cover;
- Increased predator pressure on native species at the end of a plague if predator numbers have increased in response to availability of mice during the plague; and
- Transmission of disease to other fauna.

Another important potential environmental impact is non-target mortalities arising from poisons used to control mice. Several rodenticides may legally be used around sheds and buildings, the most commonly used products being the anticoagulants brodifacoum (Talon™) and bromadiolone (Bromakil™). These baits take several days to kill and, as a consequence, can indirectly kill predators that feed on mice that have consumed poisoned bait. Carcasses of Australian kestrels (*Falco cenchroides*) are not infrequently seen around grain handling facilities.

Non-target mortality also occurs during broadacre baiting campaigns. Monitoring during the strychnine baiting campaign in Queensland in 1995 found approximately 120 birds that were considered to have died from strychnine poisoning (Lundie-Jenkins and Brown, 1996). After the same baiting campaign, landholders reported over 300 bird carcasses of a variety of species found after the baiting campaign, but the cause of death could not be confidently attributed to the strychnine baiting (Miller 1996). Strychnine was detected in carcasses of the following species: apostle bird, cockatiel, crested pigeon, feral pigeon, galah, sulphur crested cockatoo, Australian kestrel, black-shouldered kite, letter-wing kite, crow, emu, magpie and magpie lark. The greatest proportion of the bird deaths came from a single site where the bait had

been distributed 10 m beyond a fenceline into bordering woodland. By comparison, the effect of the baiting campaign on populations of non-target species had been minimal when bait had been distributed according to the established protocols.

Monitoring during the strychnine baiting campaign in 1993 in South Australia found 665 birds believed to have been killed by strychnine (Bird 1995). Most were granivores (67% of species and 98% of individuals found) and the commonest species killed were crested pigeons and feral pigeons.

In contrast, non-target mortalities recorded during the zinc phosphide baiting campaign in Central Queensland in 1997 were very few (Caughley *et al*.1998). The only species whose carcasses were found and tested positive for phosphine were Torresian crow (*n=4*) and Australian magpie (*n=1*). Similar low non-target mortality has been reported with zinc phosphide baits in the United States (Ramey and Sterner 1995; Parker and Hannan-Jones 1996). However, native rodents may have been poisoned if they were present in the areas baited. None were found dead during monitoring but they are known to occur at very low densities in crops and grassy habitats in Central Queensland.

The environmental fate of poisons not consumed has received some attention. Strychnine is gradually adsorbed onto soil particles where, in soils with high clay content, it breaks down within 45 days (Kookana *et al.* 1997). No evidence of crop uptake or of movement into water bodies has been recorded. Studies in the United States have also shown that zinc phosphide breaks down rapidly and its use does not lead to contamination of soils or water bodies (Parker and Hannan-Jones 1996).

5.0 Biology and Ecology

Three salient aspects of the biology of mice explain their pest status. The first is their diet, the second their propensity for gnawing, and the third is their reproductive capacity.

5.1 Diet

Mice are highly opportunistic feeders. They predominantly feed on grass seeds but also eat invertebrates and other plant material. They are cannibalistic during plagues.

In the laboratory, a mouse consumes 3–4 grams of food per day. Saunders (1987) calculated that during a plague in a sunflower crop mice were eating around 12 kg of sunflower seeds per hectare per day. If numbers remained high up to harvest, more than half a tonne would have been consumed per hectare, reducing the yield by some 29%. However, mice often eat only part of a seed so calculations such as these can underestimate the true level of damage.

5.2 Gnawing behaviour

The upper and lower incisors of all rodents grow continuously and are constantly ground down by grinding or by gnawing. Mice frequently gnaw on any hard surface. They are notorious for the damage they cause by gnawing on plastic. Telephone cables and electrical wiring are particularly susceptible. In addition to the direct damage, the gnawing on wiring can cause fires, set off alarms and disrupt telecommunications.

5.3 Reproductive Capacity and Population Dynamics

Mice living in buildings may breed throughout the year but in the field breeding is mostly in spring and early summer. The start of breeding is usually triggered by the increase in seed and insect availability in spring (Bomford 1987; Tann *et al.* 1991). The proportion of females breeding at any time is a function of the quality of the food as well as the quantity (Bomford and Redhead 1987), both of which are largely determined by rainfall. If the summer is hot and dry, reproduction ceases, but if conditions are favourable, mice will continue to breed through into autumn.

Mice are highly fecund (Table 5). The young grow rapidly and reach sexual maturity early. They are also good dispersers and quickly colonise new areas when conditions are favourable. Conversely, mortality is often high and the life span short.

Table 5. Reproductive potential of the house mouse (*Mus domesticus*) (from Caughley *et al*. 1998b).

Breeding season	From spring to autumn, depending on seasonal conditions (can breed throughout the year)
Mean litter size	6 (range 1-10; nipples 10)
Post partum oestrus	Yes
Gestation	19-20 days (although delayed implantation of up to two weeks has been reported)
Weaned at	18-21 days
Age at 1st breeding	5 weeks

Female mice can produce a litter each month during the breeding season. If the breeding season extends well into summer and the number of females participating remains high, then the doubling time for a population can be as short as three to four weeks and a plague may develop. In Fig. 2, the solid line shows the growth of a mouse population leading to a plague. Plotted on the same graph is population growth (the dotted line) that does not result in a plague. The principal differences between the two curves are: (i) starting density (i.e. number of mice at the start of the breeding season and (ii) the length of the breeding season. Quite small differences in population dynamics can produce large differences in abundance.

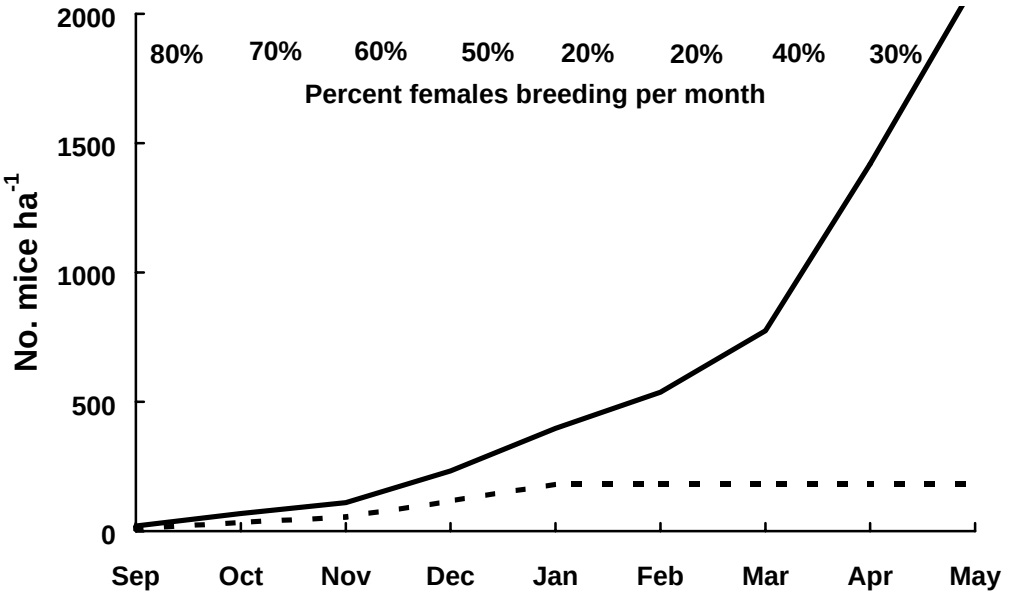


Figure 2. **Mouse Population Trends** The solid line represents the growth of a hypothetical mouse population where the starting density is 20 mice per hectare and breeding extends over eight months of the year, the proportion of females breeding each month between September and April as shown. The dotted line presents for comparison the trend in numbers of a population where the starting density is 10 mice per hectare, the breeding season is only four months long (September to December), and 80%, 70%, 60% and 40% of females participate in breeding in each of these months respectively.
Note: In both curves, litter size is set at six young per female, the sex ratio at birth at 1:1 and the age at first breeding in females at 2 months. No mortality is factored in.

This graph clearly indicates the potential for mouse populations to increase from very low numbers to large numbers in a relatively short period ie 8-9 months. The graph also shows (dotted line) that if only half the original population is present and if the breeding season is reduced then the population will not increase as dramatically.

5.4 Other Behavioural Characteristics

Mice are primarily nocturnal although they are often seen during the day when numbers are high. Mostly they spend the day in nests they have created in natural cavities or in shallow burrows e.g. in cracked soils. They tend to live in small colonies that are probably groups of related individuals. Burrows used by each group are clumped and distinct runways may be visible between their entrances. When populations are high, these runways become more obvious from their frequent use.

5.4.1 Feeding behaviour

Laboratory studies show that mice may feed from up to 20-30 different sites each night, eating only a little at each location. Consequently, the optimal baiting strategy recommended for mice is to offer a small amount of bait at a large number of sites (MacDonald and Fenn 1994).

5.4.2 Sensory capabilities

Mice have poor sight but very acute senses of smell, hearing, touch and taste. Odours are produced by specific glands and are present in urine and faeces (MacDonald and Fenn 1994). All mice mark extensively with urine, creating a network of odours on every object in their environment. They recognise other members of the group and negotiate in total darkness by these odours.

Because mice have an acute sense of smell, a number of chemical repellents have been tested as a means for excluding mice. None of the repellents has been successful for more than a short time (Smith 1994). Ultrasonic devices similarly repel for little more than a day or two (Kaukeinen 1994).

6.0 Efficacy of Current Control Methods

Management of mouse plagues at the farm level has largely been directed towards reducing mouse numbers after farmers notice damage to their crops. The reduction is usually attempted by the use of poisons.

6.1 Poisoning

6.1.1 In crops

In the past, a multitude of chemicals has been used in and around the perimeter of crops during mouse plagues. For example, during the 1970 plague in New South Wales, the chemicals[3] used included strychnine, arsenic, phosphorus, 1080, the organochlorines DDT, Dieldrin and Endrin, the organophosphates Parathion, Phosdrin and Lucijet, the fungicide Thiram and the anticoagulants Ratsak and Racumin (Ryan and Jones 1972).

Because of its effectiveness, strychnine has been the most widely used chemical but its availability has been progressively restricted since the 1980's because of its toxicity. Nonetheless, during the 1993–94 plague, it was given temporary registration by the National Registration Authority for Agricultural and Veterinary Chemicals (NRA) for broadacre distribution in South Australia and Victoria, and again during the mouse plague in southern Queensland and northern New South Wales in 1995.

However, the use of strychnine as an in-crop rodenticide was finally banned in 1997, not because of its dangers but because of Australia's need to meet international residue standards for exported products. No maximum permissible residue level (MRL) has been assigned for strychnine by the International Codex Committees on Pesticide Residues and Residues of Veterinary Drugs in Food. When no MRL is assigned, it is by default set at zero. It is impossible to prove zero residues because all assay techniques have a lower limit of detection.

Consequently, when mouse plagues irrupted in several areas of Australia in 1997, temporary registration was given by NRA to a bait formulation containing zinc phosphide. Zinc phosphide baits are widely used overseas as in-crop rodenticides and an MRL exists for the bait's breakdown product, phosphine. Good results were achieved with the bait, and the Victorian manufacturing company has applied to the NRA for registration of its product. In the interim, a minor off label permit has been issued by the NRA to allow use of the bait where and when necessary, which is valid until 30 June 1999.

Value of baiting during mouse plagues

Several studies have attempted to estimate the cost/benefits of baiting mice in crops. The first study was during a plague in the Murrumbidgee Irrigation Area in 1979–80 when Saunders (1986) baited a sunflower crop with strychnine and achieved a 90% reduction in mouse numbers. He calculated that, had the mice not been killed, they would have eaten 3.4g per mouse per day over the seven weeks remaining to harvest, equivalent to 29% of the yield. The cost of baiting (excluding labour) was $8/ha; the value of the crop was $640/ha. Baiting may thus have prevented a loss of $130/ha, giving a benefit/cost ratio of 16:1. The calculation presumes neither re-

[3] Most of these chemicals are now banned or are not registered for use on rodents.

invasion of the baited crop by mice from unbaited areas nearby, nor the possibility of a natural decline in mouse numbers over the time between baiting and harvest.

A study by Singleton *et al.* (1991) evaluated the cost/benefit of baiting with bromadiolone in summer soybean crops in the Namoi Valley using responses to a questionnaire sent to farmers. At baiting costs[4] of $45/ha and a crop value $400/ha, they estimated that the break-even point would have been when crop damage was around 11%. The extent of crop damage varied considerably between farms and between areas but on average, the damage exceeded 11%. Therefore, for more than half the respondents, the benefit of baiting would have exceeded the cost.

Mutze (1993) conducted an economic assessment of strychnine baiting in a wheat crop at the time of flowering in 1987. The baiting reduced mouse numbers by 46%. Although by the time of harvest two months later, densities were similar to pre-baiting levels, Mutze found baiting had reduced the level of damage to the grain heads by 81%. Mouse numbers were only around 50 per ha at the time of the study so the actual tonnage lost was small, approximating a 2% reduction in yield. Mutze concluded that even at those relatively low densities the cost of baiting was close to the gain in yield.

No studies have been conducted on the effectiveness of perimeter baiting but Kay *et al.* (1994a) evaluated the effect of baiting refuge habitats around irrigated soybeans with bromadiolone. They found that baiting significantly reduced the number of mice inhabiting the refuge habitat and reduced the rate at which mice invaded and colonised the adjacent crops. No significant reductions in crop damage were detected because mouse numbers overall were low.

6.1.2 Around buildings

Poisons are also widely used to control mice around buildings. Several rodenticides are registered for use in and around buildings (see Appendix B).

6.2 Trapping

Break-back traps are commonly used around houses and sheds. Trapping is preferable to baiting in these areas since:

- There is no danger of accidental poisoning of children and pets; and
- Mice do not die (and smell) in wall cavities and other inaccessible nooks and crannies.

During plagues, farmers also often use water traps where a greased bottle with a food attractant in the neck is balanced over a bucket of water. Mice fall into the water when trying to reach the food. There are numerous variations on trap designs used by farmers. If a record of the number of mice caught is kept, all of these trapping methods can provide an index of mouse numbers and allow a farmer to judge the size of the mouse problem at any given time.

Trapping is also used for monitoring mouse numbers over time in fields. For example, multiple catch traps are used in broccoli crops by the landholder on ‘Wando’ on the Darling Downs, and break-back traps are used by the Queensland

[4]Comprising cost of bait and grain ($4.20); cost of bait stations ($20) (which could be re-used) and cost of labour ($21) (1989$ values) (Singleton *et al.* 1991).

Department of Natural Resources and Mines personnel to follow trends in mouse numbers over transects in grain-growing areas.

6.3 Exclusion

Exclusion is a highly successful way of reducing the damage caused by mice in buildings. Houses and storages are made rodent-proof by sealing all holes, keeping doors closed, fitting traps to drains, screening all vents, etc. Barrier fencing in doorways is successfully used to exclude mice in some businesses in Queensland (e.g. seed merchants, peanut processors). Two major types of barriers are used: electric pads and counter-levered fences made of steel that allow access of machinery but prevent the entry of mice.

6.4 Habitat Modification

Undisturbed areas such as roadside verges and fencelines can act as refuge habitat for mice (Mutze 1991; Chambers *et al.* 1996). Other refuge habitats are areas where weeds or rubbish is allowed to accumulate (Singleton 1989). Reducing mice by habitat modification involves removing weeds and debris around crops, buildings and storages and controlling growth of grasses and weeds along fencelines and roads by ploughing, burning, grazing or applying herbicides. These methods are used variously by farmers throughout plague-prone areas. Other forms of habitat modification widely used are slashing and working stubble. Some of these methods may however conflict with soil conservation principles and practices, and so need to be carefully considered as part of a holistic approach to on-farm management.

6.5 Other Control Measures

6.5.1 Use of raptor perches

An option that has been researched both in Australia and overseas is the placement of raptor perches in or at the margins of crops to increase the level of predation (Howard *et al*. 1985; Kay *et al*. 1994b). While it is recognised that birds of prey cannot eat enough mice to prevent a plague (Sinclair *et al*. 1990), they can slow the rate of plague formation by several weeks.

6.5.2 Chemical repellents

Because mice have an acute sense of smell, chemical repellents have been tested as a means of control. However, as noted earlier, research has shown that the repellent effect tends to be short-lived.

6.5.3 Ultrasonic devices

Similarly, studies have shown that ultrasonic devices are unsuccessful as a practical means of rodent control (Meehan 1984; Howard and Marsh 1985). Although the animals initially withdraw from a loud new ultrasonic noise, they start to ignore it within a few days. As Smith (1994) commented, ‘behavioural modification is only effective if the animal can choose a more attractive alternative. If food or harbourage is short, or population density is high, methods that do not exclude absolutely may be overcome because the animal perceives that the alternatives are worse’.

6.5.4 Biological Control

The potential for a parasitic nematode, *Capillaria hepatica*, to control mouse populations was investigated in Australia by Singleton and his co-workers (Singleton and McCallum 1990). If mice infected with the parasite have less frequent litters,

population growth rate would be slowed and plagues would be prevented. Field trials on the Darling Downs and in the Mallee in Victoria, however, failed to demonstrate any decline in breeding by mouse populations that were experimentally infected with *C. hepatica* (Singleton *et al*. 1995; Singleton and Chambers 1996) and the research has been discontinued.

Singleton and his co-workers at the Cooperative Research Centre for Biological Control have now directed their research towards immunocontraception using a mouse-specific virus[5] that is present in nearly all Australian mouse populations (Chambers *et al*. 1997). Laboratory trials to date have shown that the virus will carry foreign material and that the modified virus will replicate in mice. The next step in the research is to identify an appropriate fertility blocking protein to attach to the virus and to study the behaviour and epidemiology of this modified virus.

[5] Murine Cytomegalovirus (MCMV)

7.0 Human and Animal Welfare Considerations

7.1 Disease

Rodents are vectors of a number of diseases that affect humans and livestock. In Australia, most of these pathogens are absent or rare but there are a few that cause problems. Perhaps the commonest are *Salmonella* bacteria that can be spread by a range of animal species (including humans). The bacteria are usually transmitted to people through food contaminated with infected urine or droppings, and can cause acute gastroenteritis (Stevenson and Hughes 1988).

Another known pathogen in mice in Australia is *Streptobacillus moniliformis* that causes rat bite fever in people and other animals (Taylor *et al.* 1994). During plagues, mice are caught occasionally with polyarthritis or abscesses ('lumpy tail') that are caused by the pathogen. Although no transmission to humans from infected mice has been recorded, one person in Australia has died from the pathogen following a bite from a wild rat (Taylor *et al*. 1994).

The best means of limiting the risk to humans from these pathogens is to exclude mice from foodstuffs and to maintain high standards of cleanliness in food preparation and eating areas. Protection of feed storages and good shed hygiene are likewise important in intensive livestock operations.

For livestock, the most serious disease that mice may transmit is swine encephalo-myocarditis that led to substantial pig mortalities on some properties in New South Wales during the mouse plagues of 1970 and 1984 (Acland and Littlejohns 1975; Seaman *et al.* 1986). Intensive livestock farmers also reported an increase in the incidence of other infectious diseases during mouse plagues. Scouring is a frequent problem in pig herds during plagues with mice aiding the transfer of bacteria between pens. During the 1984 NSW and 1993 SA plagues, infection with *Erysipelas* was reported in some herds.

7.2 Other health risks

7.2.1 Risk of poisoning

During a mouse outbreak, people take risks with poisons, using them in ways that they would not normally countenance. No poisoning of humans has been attributed to rodent baits during mouse plagues in Australia but accidental poisoning of domestic pets occurs quite frequently. During the 1993 mouse plague in South Australia, one veterinarian treated 40 dogs that according to their owners had eaten rodent bait (Caughley *et al.* 1994).

As a part of any education program prior to mouse plagues, town residents must be alerted to the dangers to pets of accidental poisoning and offered advice on how to prepare baits in bait stations or to lay them in places inaccessible to dogs.

7.2.2 Risk of fire

Mice gnawing on electrical wiring can cause fires in homes and other buildings. For intensive livestock farmers, the risk is magnified if their sheds are lined with

polyurtheane insulation since it gives off cyanide gases when it burns which is lethal to both livestock and firefighters.

7.3 Animal Welfare Issues

7.3.1 Impact of mice on livestock

During the 1993 SA plague, mice caused considerable damage to penned animals (Caughley *et al.* 1994). Poultry had their feet gnawed and, as a direct result of stress and stress-related injuries, the birds lost condition, egg production declined and mortality increased. In piggeries, breeding sows and piglets were the most seriously affected and badly gnawed animals had to be destroyed to end their suffering.

Destocking is one option available to intensive livestock producers during a mouse plague but the costs of destocking and restocking are high. Farmers usually choose to persist with baiting and the constant care of their animals.

7.3.2 Humane control of mice

With regard to mice, the primary animal welfare issue is that the control methods selected are those that cause the minimal pain, distress and discomfort to the animals being controlled. Measurements of the humaneness of rodenticides are largely subjective, but in animal welfare terms, a poison, which acts quickly to kill or leave an animal unconscious, is better than one that takes a considerable time to act.

8.0 Legislation and Policy

8.1 Legislative Status of Mice in Queensland

Mice are not a declared pest under the *Rural Lands Protection Act 1985* so there is no legal requirement that they be controlled. As the house mouse is not a native species there are no laws governing their control other than the *Animals Protection Act 1925* and *via* health regulations[6].

The use of chemical poisons is constrained by Government regulations in Queensland. A number of rodenticide poisons are registered (see Appendix B) and may be used in and around buildings, animals sheds and storage facilities. No rodenticide is registered for use in grain crops although temporary registration has been given for the broadacre distribution of strychnine and zinc phosphide during the 1995 and 1997 mouse plagues respectively.

8.2 Queensland Department of Natural Resources and Mines' Policy on Mice

The Queensland Department of Natural Resources and Mines' does not have any legislative responsibility to control or enforce the control of the house mouse but has assumed a coordination role for non-urban situations. The departments' exact role is outlined in the policy on rodents that states.

"The Department of Natural Resources and Mines will:

(a) Monitor rodent populations on the Central Darling Downs and provide short and long term predictions on the potential for plague development;
(b) Provide graingrowers with technical advice on available mouse control strategies;
(c) Undertake research to support the registration of a rodenticide suitable for incrop baiting of mice;
(d) Undertake research into integrated long term management strategies for the control of mice in farming areas;
(e) Accept responsibility for coordinating large scale emergency mouse control operations;
(f) Collaborate with industry (eg GrainGrowers Association), State Departments (Primary Industries, Environment and Health), interstate counterparts and research and development organisations, including CSIRO, as necessary to satisfy Queensland's requirements for mouse control consistent with national standards;
(g) Cooperate with industry and other organisations in the development of control options for other rodent species, subject to availability of funding.

The Department of Natural Resources and Mines will not:

(a) Declare any rodent species."

[6] An authorised health officer may give 'reasonable directions' to the owner or occupier of premises to destroy any rats and mice on those premises or to rectify conditions that are conducive to their breeding.

9.0 Recommended Management and Control Practices

The Queensland Department of Natural Resources and Mines and Mines advocates the following management and control practices.

9.1 Managing Mice around Buildings

Controlling mice in and around buildings is important for all people living in plague-prone areas. In homes, trapping is recommended, rather than the use of poisons, to avoid accidental poisoning of children or pets and to prevent the unpleasant smell of decaying mice if they die in wall cavities and inaccessible areas.

Good hygiene is very important. Because mice can carry a number of diseases, washing hands with soap and water after handling dead mice, and washing food preparation surfaces, plates, utensils, etc. before use, are strongly recommended.

If possible, houses should be made 'mouse-proof' by locating the routes mice are using to enter the house, blocking holes with steel wool, and placing sealing strips on doors. Foodstuffs and precious items should be stored in mouse-proof containers.

In sheds, a combination of trapping, baiting and storing goods in rodent-proof containers or on rodent-proof stands is recommended measures. Baits should be used according to directions on the manufacturer's label. Bait blocks and pellets should be laid in bait stations to prevent mice from scattering the bait and to guard against the accidental poisoning of children and pets. The simplest design is a small plastic container with a lid, with small holes cut in the sides to give mice access to the bait.

Grassy areas around sheds and homes should be kept mown, building materials stored upright and piles of rubble or other material removed.

9.2 Managing Mice on Farms

A number of agronomic practices are available to broadacre farmers to limit the impact of mice. The best forms of defence are methods that reduce the amount of shelter and food available to mice. General farm hygiene is important - that is, cleaning up piles of rubbish and any spilt grain, and keeping grass down by slashing or spraying along roads and around verges, haystacks, etc. Minimising grain spill at harvest is also very important.

Slashing, working or burning stubble reduces both the availability of food and shelter for mice, but stubble retention is an important method for controlling soil erosion and retaining soil moisture. Controlling mice by stubble management needs to be balanced against the benefits of its retention. To optimise stubble management practices, farmers should assess the number of mice in the stubble and make their decision accordingly.

Monitoring

Regular monitoring of mouse numbers enables farmers to undertake management actions to control mice before they begin to damage crops. In order to prevent mouse damage to crops, the most important times to check mouse numbers are prior to flowering for each winter and summer crop, checking both within crops and within adjacent stubble on each occasion.

There are two principal means of monitoring. The first is break-back traps which can be set out overnight in crops, stubbles and other habitats in a line of 20 or so traps. These traps are a cheap, simple and effective means of keeping track of mouse numbers over time.

The second method is to use bait cards that are 10cm x 10cm square pieces of white paper that are soaked in canola oil and pegged out overnight in crops and in other habitats. The amount of card eaten serves as an index of mouse numbers. To obtain a reasonable estimate, at least five cards should be placed 5-10 metres apart in each habitat.

The bait card technique is a less reliable indicator of mouse numbers than break-back traps, since the amount of a card eaten is largely a reflection of the paucity of food available for the mice rather than the numbers of mice present. When food is plentiful, the cards may be relatively untouched even when mouse numbers are high. However, if bait card take is greater than 10%, it indicates (i) that mouse numbers are high and (ii) the mice will readily take the bait and cost-effective control will be achieved.

Baiting

At present, no rodenticide is registered for in-crop mouse control although an application for the registration of zinc phosphide bait is currently before the National Registration Authority for Agricultural and Veterinary Chemicals. If it receives approval, baiting crop and stubble areas will be an option available to farmers. Research has shown that the best results will be achieved by baiting when alternative food is scarce (for example, in crops before flowering commences and in stubble about one month after harvest). Recommended strategies for use of bait will be published by the Department when the product receives registration.

10. References

Acland, H.M. and Littlejohns, I.R. 1975. Encephalomyocarditis virus infection of pigs. I. An outbreak in New South Wales. *Australian Veterinary Journal* 51: 409–415.

Bird, P. 1995. Off-target mortalities due to strychnine baiting during the 1993 mouse plague in South Australia. *Proceedings of the 10th Australian Vertebrate Pest Control Conference*, pp. 188–191.

Bomford, M. 1987. Food and reproduction of wild house mice. I. Diet and breeding seasons in various habitats on irrigated cereal farms in New South Wales. *Australian Wildlife Research* 14: 183–196.

Bomford, M. and Redhead, T. 1987. A field experiment to examine the effects of food quality and population density on reproduction of wild house mice. *Oikos* 48: 304–311.

Caughley, J., Monamy, V. and Heiden, K. 1994. Impact of the 1993 mouse plague. *Occasional Paper Series No. 7*. Grains Research and Development Corporation, Canberra.

Caughley, J., Strong, K. and Donkin, C. 1998a. Managing mouse plagues in rural Australia. *Proceedings 18th Vertebrate Pest Conference*, 2–5 March 1998, Costa Mesa, California (in press).

Caughley, J., Strong, K. and Hinchcliffe, P. 1998b. Report on the Zinc Phosphide Baiting Program to Control Mice in Central Queensland in 1997. Queensland Department of Natural Resources and Mines, Brisbane.

Caughley, J., Bomford, M., Parker, R. , Sinclair, R., Griffiths, J. and Kelly, D. 1998b. *Managing Vertebrate Pests: Rodents*. Bureau of Resource Sciences and Grains Research and Development Corporation, Canberra.

Chambers, L.K., Singleton, G.R. and van Wensveen, M. 1996. Spatial heterogeneity in wild populations of house mice (*Mus domesticus*) on the Darling Downs, south-eastern Queensland. *Wildlife Research* 23: 23–38.

Chambers, L. K., Singleton, G. R., and Hood, G. M. 1997. Immunocontraception as a potential control method of wild rodent populations. *Belgian Journal of Zoology* 127 (Suppl. 1): 145–156.

Croft, D. and Caughley, J. 1995. A survey of the MIA mouse plague — at what cost? *Farmers' Newsletter* 145: 40–41.

Donkin, C., and Caughley, J. 1998. Are mouse plagues increasing in frequency in Queensland? *Proceedings of the 11th Australian Vertebrate Pest Conference*, Bunbury, May 1998.

Fisher. G. 1996. Resourcing the operation. Pp. 25–28 in: V. Eldershaw (ed.) *Report on Aerial Baiting with Strychnine during the 1995 Mouse Plague in the Dalby-Goondiwindi Area, Queensland*. Queensland Department of Natural Resources and Mines, Brisbane.

Howard, W.E. and Marsh, R.E. 1985. Ultrasonics and electromagnetic control of rodents. *Acta Zoologica Fennica* 173: 187–189.

Howard, W.E., Marsh, R.E. and Corbett, C.W. 1985. Raptor perches: their influence on crop protection. *Acta Zoologica Fennica* 173: 191–192.

Kaukeinen, D. 1994. Rodent control in practice: householders, pest control authorities and municipal authorities. Pp. 249–271 in: A.P. Buckle and R.H. Smith (eds) *Rodent Pests and their Control.* CAB International, Wallingford, Oxford.

Kay, B.J., Twigg, L.E. and Nicol, H.I. 1994a. The strategic use of rodenticides against house mice (*Mus domesticus*) prior to crop invasion. *Wildlife Research* 21: 11–19.

Kay, B.J., Twigg, L.E., Korn, T.J. and Nicol, H.I. 1994b. The use of artificial perches to increase predation on house mice (*Mus domesticus*) by raptors. *Wildlife Research* 21: 95–106.

Kookana, R.S., Rogers, S.L. and Oliver, D.P. 1997. Sorption and desorption behaviour of strychnine rodenticide in soils. *Australian Journal of Soil Research* 35:491–502.

Lundie-Jenkins, G. and Brown, P. 1996. Monitoring of non-target species. Pp. 160–164 in: V. Eldershaw (ed.) *Report on Aerial Baiting with Strychnine during the 1995 Mouse Plague in the Dalby-Goondiwindi Area, Queensland*. Queensland Department of Natural Resources and Mines, Brisbane.

Macdonald, D.W. and Fenn, M.G.P. 1994. The natural history of rodents: preadaptations to pestilence. Pp. 1–21 in: A.P. Buckle and R.H. Smith (eds) *Rodent Pests and their Control*. CAB International, Wallingford.

Meehan, A.P. 1984. *Rats and Mice: their Biology and Control*. Rentokil, East Grinstead, United Kingdom.

Miller, E. 1996. Landholder survey after mouse plague. Pp. 29–48 in: V. Eldershaw (ed.) *Report on Aerial Baiting with Strychnine during the 1995 Mouse Plague in the Dalby-Goondiwindi Area, Queensland*. Queensland Department of Natural Resources and Mines, Brisbane.

Mutze, G. 1991. Mouse plagues in South Australian cereal-growing areas. III. Changes in mouse abundance during plague and non-plague years, and the role of refugia. *Wildlife Research* 18: 593–604.

Mutze, G.J. 1993. Cost-effectiveness of poison bait trails for control of house mice in Mallee cereal crops. *Wildlife Research* 20: 445–456.

Parker, R. and Hannan-Jones, M. 1996. The Potential of Zinc Phosphide for Mouse Plague Control in Australia. Queensland Department of Natural Resources and Mines, Brisbane.

Ramey, C.A. and Sterner, R.T. 1995. Mortality of gallinaceous birds associated with 2% zinc phosphide baits for control of voles in alfalfa. *International Biodeterioration and Degradation* 1995: 51–64.

Redhead, T.D. 1988. Prevention of plagues of house mice in rural Australia. Pp. 191–205 in: I. Prakash (ed.) *Rodent Pest Management*. CRC Press, Baton Rouge.

Redhead, T. and Singleton, G. 1988. An examination of the PICA strategy for the prevention of losses caused by plagues of house mice *Mus domesticus* in rural Australia. Pp. 18–37 in: G.A. Norton and R.P. Pech (eds) *Vertebrate Pest Management in Australia: A Decision Analysis/Systems Analysis Approach*. Project Report No. 5, CSIRO Division of Wildlife and Ecology, Melbourne.

Redhead, T.D., Enright, N. and Newsome, A.E. 1985. Causes and predictions of outbreaks of *Mus musculus* in irrigated and non-irrigated cereal farms. *Acta Zoologica Fennica* 173: 123–127.

Ryan, G.E. and Jones, E.L. 1972. A report on the mouse plague in the Murrumbidgee and Coleambally Irrigation Areas, 1970. New South Wales Agriculture, Orange.

Saunders, G. 1986. Research into the ecology and control of the house mouse and other rodents. Agdex 672. Miscellaneous Bulletin 15. New South Wales Agriculture, Orange.

Saunders, G.R. and Giles, J.R. 1977. A relationship between plagues of the house mouse, *Mus musculus* (Rodentia: Muridae) and prolonged periods of dry weather in south-eastern Australia. *Australian Wildlife Research* 4: 241–247.

Seaman, J.T., Boulton, J.G. and Carrigan, M.J. 1986. Encephalomyocarditis virus disease of pigs associated with a plague of rodents. *Australian Veterinary Journal* 63: 292–294.

Sinclair, A.R.E., Olsen, P.D. and Redhead, T.D. 1990. Can predators regulate small mammal populations? Evidence from house mouse outbreaks in Australia. *Oikos* 59: 382–392.

Singleton, G.R. 1989. Population dynamics of an outbreak of house mice (*Mus domesticus*) in the Mallee wheatlands of Australia—hypothesis of plague formation. *London Journal of Zoology* 219: 495–515.

Singleton, G. and Brown, P. 1998. Management of mouse plagues in Australia: integration of population ecology, bio-control and best farm practice. In: D.P. Cowan and C.J. Feare (eds) *Advances in Vertebrate Pest Management.* Zoological Library Vol. 7 (in press).

Singleton, G.R. and Chambers, L.K. 1996. A large scale manipulative field study of the effect of *Capillaria hepatica* on wild mouse populations in southern Australia. *International Journal for Parasitology* 26: 383–398.

Singleton, G.R. and McCallum, H.I. 1990. The potential of *Capillaria hepatica* to control mouse plagues. *Parasitology Today* 6: 190–193.

Singleton, G.R. and Redhead, T.D. 1989. House mouse plagues. Pp. 418–433 in: J.C. Noble and R.A. Bradstock (eds) *Mediterranean Landscapes in Australia. Mallee Ecosystems and their Management*. CSIRO, Melbourne.

Singleton, G.R., Chambers, L.K. and Spratt, D.M. 1995. An experimental field study to examine whether *Capillaria hepatica* (Nematoda) can limit house mouse populations in eastern Australia. *Wildlife Research* 22: 31–53.

Singleton, G.R., Twigg, L.E., Weaver, K.E. and Kay, B.J. 1991. Evaluation of bromadiolone against house mouse (*Mus domesticus*) populations in irrigated soybean crops. II. Economics. *Wildlife Research* 18: 275–283.

Smith, R.H. 1994. Control methods: non-chemical and non-lethal chemical. Pp. 109–125 in: A.P. Buckle and R.H. Smith (eds) *Rodent Pests and their Control*. CAB International, Wallingford, Oxford.

Stevenson, W.J. and Hughes, K.L. 1988. *Synopsis of Zoonoses in Australia* (2nd edition). Australian Government Publishing Service, Canberra.

Tann, C.R., Singleton, G.R. and Coman, B.J. 1991. Diet of the house mouse*, Mus domesticus*, in the Mallee wheatlands of North-western Victoria. *Wildlife Research* 18: 1–12.

Taylor, J.D., Stephens, C.P., Duncan, R.G. and Singleton, G.R. 1994. Polyarthritis in wild mice (*Mus musculus*) caused by *Streptobacillus moniliformis*. *Australian Veterinary Journal* 71: 143–145.

Appendix 1. A Summary of the Biology and Ecology of the House Mouse

Scientific name: *Mus domesticus*
Common name: House mouse (*also* Field mouse)

Size

- Head/body length 55-100 mm
- Tail length 75-100 mm
- Weight 10-25 g

Description

- Brown, grey or black above; white, pale yellow or grey below. Fur soft, short. Distinguished from similar species by notched upper incisors and musty smell.

Reproductive characteristics

Breeding season	Mostly between spring and autumn, but can breed throughout the year
Mean litter size	6 (range 1-10; nipples 10)
Post partum oestrus	Yes
Gestation	19-20 days (although delayed implantation of up to two weeks has been reported)
Weaned at	18-21 days
Age at 1st breeding	5 weeks

Diet

- Principally seeds but omnivorous and highly opportunistic.

Behaviour

- Predominantly nocturnal except when population density is high.
- Social, living in small groups of related individuals, usually with in a home range that appears to be defended at certain times or at certain population densities. Most young disperse on reaching adulthood.
- Burrows are often complex with interconnecting tunnels. Usually shallow (less than 20 cm below the surface) but in light soils can be 100 cm or more deep. Stores of seed can sometimes be found in burrows. Also nests in natural cavities, e.g. in wood piles, back of stoves, between walls.

Appendix 2: Rodenticides that are registered for use in Qld

Department of Natural Resources and Mines

RODENTICIDES REGISTERED FOR USE IN QUEENSLAND

Product Name	Active Ingredient	Pack Sizes	Registered Usage Area
Ditrac All Weather Blox Rodenticide	Brodifacoum	1.8 kg, 4 kg, 8 kg, 10 kg	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings
Ditrac Rodenticide	Brodifacoum	2 kg, 5 kg, 10 kg	Unspecified Perimeter baiting adjacent to crops
Farmoz Rodex B Rat Blocks	Brodifacoum	2 kg, 5 kg	Commercial/Industrial Buildings Domestic Buildings Public Services
Farmoz Rodex B Rodenticide Pellets	Brodifacoum	300 g, 5 kg	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings Public Services Perimeter baiting adjacent to crops
Hortico Ratsack 1 Shot Rat and Mouse Bait	Brodifacoum	150 g (2 x 75g)	Unspecified
Klerat Rodenticide Wax Blocks	Brodifacoum	10 kg	Sugarcane
Mortein Rat Kill, Rat & Mouse Killer	Brodifacoum	150 g (4 x 37.5g), 450 g (12 x 37.5g)	Unspecified
Oztec Ratal Rodenticide Pellets	Brodifacoum	200 g, 1 kg, 10 kg, 140 kg	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings Public Services Perimeter baiting adjacent to crops
Talon Rodenticide All Weather Rodenticide Wax Blocks	Brodifacoum	75 g, 1 kg, 2.4 kg, 10 kg	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings Public Services
Talon Rodenticide Pellets	Brodifacoum	50 g, 200 g, 1 kg, 10 kg	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings Public Services Perimeter baiting adjacent to crops
Bromakil Super Rat Bait	Bromadiolone	500 g, 2 kg, 5 kg, 15 kg	Commercial/Industrial Buildings Domestic Buildings Public Services Perimeter baiting adjacent to crops
Bromakil Super Rat Blocks	Bromadiolone	1.4 kg	Commercial/Industrial Buildings Domestic Buildings Public Services
Bromakil Super Rat Drink Concentrate	Bromadiolone	500 mL	Commercial/Industrial Buildings Domestic Buildings Public Services
Contrac Blox	Bromadiolone	1.8 kg, 8 kg, 9 kg	Commercial/Industrial Buildings Domestic Buildings Public Services
Contrac Rat and Mouse Bait	Bromadiolone	5 kg (100 x	Commercial/Industrial Buildings

		50g), 10 kg	Domestic Buildings Public Services Perimeter baiting adjacent to crops
Contrac Rodenticide	Bromadiolone	5 kg, 10 kg	Commercial/Industrial Buildings Domestic Buildings Public Services Perimeter baiting adjacent to crops
Country Di-O-Lone Super Rat Grain Bait	Bromadiolone	500 g, 1 kg, 2 kg, 5 kg, 10 kg, 20 kg	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings Perimeter baiting adjacent to crops
Rattex Bromablock	Bromadiolone	5 kg	Buildings Sewers/Drains
Rattex Grain Bait	Bromadiolone	5 kg	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings Perimeter baiting adjacent to crops
Rentokil Bromakil Bait for Rats and Mice	Bromadiolone	200 g	Domestic Buildings
Rentokil Bromakil Mouse Mix	Bromadiolone	750 g, 3 kg, 10 kg	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings Public Services Perimeter baiting adjacent to crops
Rentokil Bromakil Rodenticide Concentrate	Bromadiolone	1 L, 5 L, 20 L	Commercial/Industrial Buildings Domestic Buildings Public Services
Rentokil Bromakil Super Rat Bait Sachets	Bromadiolone	2.5 kg (100 x 25 g)	Domestic Buildings
Rentokil Bromakil Super Rat Blocks	Bromadiolone	500 g, 2 kg, 5 kg, 10 kg	Commercial/Industrial Buildings Domestic Buildings Public Services
Rentokil Bromakil Super Rat Drink	Bromadiolone	500 mL	Commercial/Industrial Buildings Domestic Buildings Public Services
Rentokil Bromakil Super Rat Grain Bait	Bromadiolone	2 kg, 4 kg, 15 kg	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings Perimeter baiting adjacent to crops
Rentokil Bromakil Super Rodent Blocks Rodenticide	Bromadiolone	140 g	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings
Rentokil Bromakil-P Rodenticide Pellets	Bromadiolone	200 g, 1 kg, 10 kg	Commercial/Industrial Buildings Domestic Buildings Perimeter baiting adjacent to crops
Tomcat All-Weather Blox	Bromadiolone	112 g, 224 g, 784 g, 900 g, 1.8 kg, 4 kg, 8 kg, 9 kg	Commercial/Industrial Buildings Domestic Buildings Public Services
Tomcat Rat and Mouse Bait	Bromadiolone	50 g, 200 g, 300 g, 500 g, 1.75 kg, 2.5 kg, 3.5 kg, 5 kg, 10 kg	Commercial/Industrial Buildings Domestic Buildings Public Services Perimeter baiting adjacent to crops
Yates Mouser One Shot Mouse Bait	Bromadiolone	33 g	Domestic Buildings
Yates Rat Attack One Shot Rodenticide	Bromadiolone	200 g (4 x 50 g)	Commercial/Industrial Buildings Domestic Buildings
* Rampage Rat and Mouse Bait	Cholecalciferol	1 kg, 1.5 kg	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings
Barmac Racupak Ready to use Rodenticide	Coumatetralyl	100 g	Industrial Sites/Factories
Racumin 8 Bayer Rat and	Coumatetralyl	1 kg, 10 kg	Commercial/Industrial Buildings

Mouse Rodenticide Bait Concentrate and Tracking Powder			Domestic Buildings Farm/Agricultural Buildings Meatworks (non-product areas) Wharves
Racumin Domestic Mouse and Rat Bait	Coumatetralyl	150 g	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings Meatworks (non-product areas) Wharves
Racumin Mouse and Rat Blocks Ready to use Bait Blocks	Coumatetralyl	1440 g	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings Meatworks (non-product areas) Wharves
Racumin Mouse and Rat Bait Pelleted Bait - ready to use	Coumatetralyl	1.5 kg, 15 kg	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings Meatworks (non-product areas) Wharves
Ratex Mouse and Rat Bait	Coumatetralyl	1 kg, 5 kg, 15 kg	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings Meatworks (non-product areas) Wharves
Hortico Double Strength Ratsak Ready to use Rat Bait	Warfarin	250 g, 350 g, 1 kg, 2.5 kg	Unspecified
* Rattex Gel	Warfarin	500 g	Commercial/Industrial Buildings
* Rattex Tracking Powder	Warfarin	5 kg	Commercial/Industrial Buildings Domestic Buildings
RCI Ratblitz Bait	Warfarin	3 kg, 13 kg	Unspecified
Terminator Mouse and Rat Bait	Warfarin	300 g, 1.5 kg, 8 kg	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings
Storm Wax Block Rodenticide	Flocoumafen	500 g, 3 kg, 10 kg	Commercial/Industrial Buildings Domestic Buildings Farm/Agricultural Buildings

* Supply/use restricted to licensed Pest Control Operators

Prepared by Officers of - Land Protection
Department of Natural Resources and Mines and Mines

Chemical Services
Department of Primary Industries

4 June 1998

Pest Status Reviews

Others in the series:

Prickly acacia in Queensland

Rubber vine in Queensland

Mesquite in Queensland

Cabomba in Queensland

Sicklepod in Queensland

Veterbrate Pests of Built-up areas

Hymenachne in Queensland

Bellyache bush in Queensland

Feral pigs in Queensland

Feral Goat in Queensland

For further information contact:

C.S. Walton,
Land Protection,
Natural Resources and Mines.
Phone: (07) 3406 2879.

Department of Agriculture, Fisheries and Forestry
Biosecurity Queensland

Fact sheet
PEST ANIMAL
PA21 December 2013

Cane toad

Bufo marinus

The cane toad is not a declared pest in Queensland, so there is no legal requirement to control them.

Their original introduction in 1935 was to control agricultural pests, but they proved ineffective.

For the past 60 years, cane toads have been expanding their territory in Australia, and are capable of colonising at least four of the mainland Australian states.

As the toad's geographical range continues to expand, concern has increased about their detrimental environmental effects, particularly on the wetlands of the Northern Territory.

Studies into the feasibility of biological control have commenced.

History of introduction and spread

The cane toad or giant toad is an amphibian, native to Central and South America. Cane toads have been introduced throughout the world as a biological control for insect pests of agriculture, most notably sugarcane.

A consignment of cane toads from Hawaii was released into Queensland cane fields in 1935. The introduction was surrounded by controversy as to the potential costs and benefits to Australia.

It was hoped that the toad would control Frenchi and greyback beetles—pests of economic importance to the sugarcane industry.

By 1941, however, it had become evident that the cane toad was exerting only limited control over its intended prey. There were two main reasons for this:

- Greyback beetles are only rarely in contact with the ground and Frenchi beetles invade cane fields at a time when the toads are absent due to a lack of protective cover.
- The cane toad has a wide-ranging and indiscriminate diet, and it was not solely dependant upon its intended prey.

The unlimited food source, suitable environment and low rates of predation allowed dynamic reproduction and spread. Toads were recorded in Brisbane only 10 years after release. The toad continues to thrive and has now invaded the Northern Territory and New South Wales (see Map 1).

Map 1. Distribution of the cane toad in Australia

The cane toad's advance is only limited by environmental factors, such as the availability of water for breeding, tolerable temperatures, suitable shelter and availability of food.

Toads at the frontier of their range of expansion may be larger than those in established populations. This is most probably due to greater food supply, combined with a lower incidence of disease.

Description and general information

In comparison with native frog and toad species, adult cane toads have a distinctive head and face, and are large and heavily built creatures (adults may grow to 20 cm).

Following their aquatic larval stages (eggs and tadpoles), cane toads are generally encountered at night near any source of light. Cane toads are ground-dwelling—they are poor climbers and unable to jump very high.

A definite visor or awning extends over each eye and a high angular bony ridge extends from the eyes to the nose.

The parotid glands (see Figure 1) are perhaps the most characteristic feature of the adult cane toad. These glands are large, protuberant, and are situated on the head behind each ear. These glands carry a toxin.

Map 2. Distribution of the cane toad in Queensland

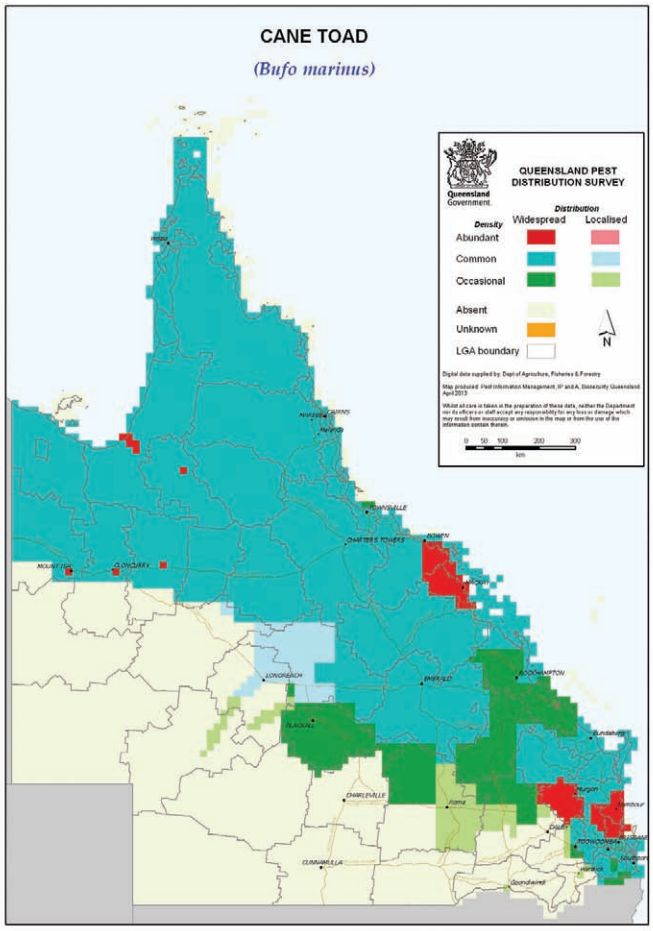
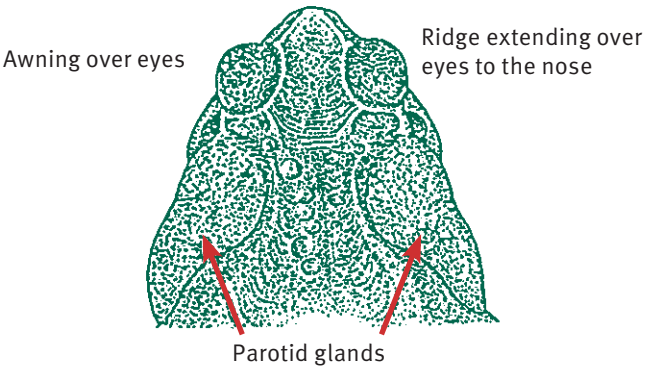


Figure 1. Distinguishing features of the cane toad



The cane toad's hands and feet are relatively small and lack discs at the tips of the digits. Webbing is absent between the fingers but is distinct and leathery between the toes.

Colouring on the dorsal (upper) surface may be brown, olive-brown or reddish-brown. The ventral (under) surface varies from white to yellow and is usually mottled with brown.

Warts are present on all cane toads; however, males possess more than females. Warts are dark brown at the caps.

Mating

Mating can occur at any time of the year and depends only on available food and permanent water. The mating call is a continuous purring trill that sounds like a running motor.

In situations where females are scarce or absent, male cane toads may have the ability to undergo a sex change to become fertile females; however, this has not been proved.

Eggs

Both cane toads and native frogs spawn in slow-moving or still water, but their eggs can be easily distinguished.

Cane toad eggs are laid in long, gelatinous 'strings' with the developing tadpoles appearing as a row of small black dots along the length. The strings are unique to cane toads, generally appearing as blobs of jelly attached to water plants or debris. Native frogs generally produce egg clusters as mounds of foam floating on the water surface.

Compared with native species, cane toad egg production is dynamic and a single clutch can contain up to 35 000 eggs. Remove any cane toad eggs found in the water and allow to dry out.

Figure 2. Drawing of toad spawn from *Wildlife of greater Brisbane*

Tadpoles

The cane toad is the only species in Australia that has a pure black tadpole. Native frogs have lighter-coloured undersides with a great range of colours and markings—cane toad tadpoles may turn paler colours to almost transparent at night.

Cane toad tadpoles are small and usually congregate in vast, slow-moving shoals. This 'shoaling' behaviour is uncharacteristic of most native species.

Unlike cane toad tadpoles, native species develop lungs at an early stage and periodically rise to the surface in order to exchange their lung gasses. Large groupings of tadpoles that do not break the water surface for air indicate cane toads.

Young toads

Following emergence from the water, the young toadlets usually congregate around the moist perimeter of the water body for about a week before they eventually disperse.

Young toads are very difficult to distinguish from the native *Uperoleiea* species, which also have parotid glands, but all *Uperolelea* species have bright red patches in the groin area.

Under ideal conditions toadlets may reach adult size within a year.

Toxicity

Bufo marinus produce venom in glands occurring in most of the skin on their upper surface. The venom is concentrated in the parotid glands as a creamy-white solution, which is released when the animal experiences extreme provocation or direct localised pressure (e.g. grasped by the mouth of a predator).

The parotid solution is highly toxic and when ingested it produces drastic acceleration of the heartbeat, shortness of breath, salivation and prostration. It is extremely painful if accidentally rubbed into the eye.

Ingestion of toads by domestic and most native animals can result in death. In some recorded cases, death has occurred within 15 minutes.

Field observations suggest that some predatory Australian species have learned how to feed safely on cane toads.

Birds have been observed flipping toads over to avoid the parotid glands. Predatory reptiles may have more trouble adapting, being unable to remove a toad from the mouth once they start feeding.

Effects on wildlife

The cane toad is poisonous at all stages of its life cycle and most native frog larvae and many aquatic invertebrates are dramatically affected by their presence.

Cane toads are voracious feeders that consume a wide variety of insects, frogs, small reptiles, mammals and even birds. Perhaps the only limiting factor to the prey taken is the width of the cane toad's mouth.

It has been suggested that cane toad competition for food and breeding grounds has been responsible for reducing the populations of some native frogs. However, many native frogs are arboreal (tree-dwelling) and occupy different niches. Cane toads don't have the native frogs' ability to 'shut down' during dry seasons when resources are limited.

Pressure from cane toads may displace native animals (frogs and other species) where they are already suffering due to manipulation of their habitat by humans and grazing animals. Animals that use waterholes as retreat sites during the dry season are especially vulnerable—toads will congregate here in large numbers.

Public health

Cane toads readily eat animal and human faecal material and, in areas of poor hygiene, they have been known to transmit disease such as salmonella.

Control

Control of cane toads is not enforced as there is currently no available effective broad scale control. Individuals and community groups have carried out removal campaigns to decrease numbers and slow the invasion front.

Fencing is recommended to keep toads out of ponds intended for native fish and frogs; a height of 50 cm is sufficient. Bird wire with 1 cm holes may keep toads out of an area.

Research indicates that spread can be delayed in semi-arid areas by blocking access to water holes.

Individual toads may be killed relatively humanely using a commercial spray available from hardware stores or may be stunned and decapitated (only by experienced operators). The removal of eggs from small water bodies such as frog ponds can be effective

Researchers have successfully mitigated impacts in recently colonised areas by 'training' predators however, large scale application of this technique is difficult.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at www.biosecurity.qld.gov.au).

This fact sheet is developed with funding support from the Land Protection Fund.

Fact sheets are available from Department of Agriculture, Fisheries and Forestry (DAFF) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DAFF does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

© The State of Queensland, Department of Agriculture, Fisheries and Forestry, 2013

Department of Agriculture, Fisheries and Forestry
Biosecurity Queensland

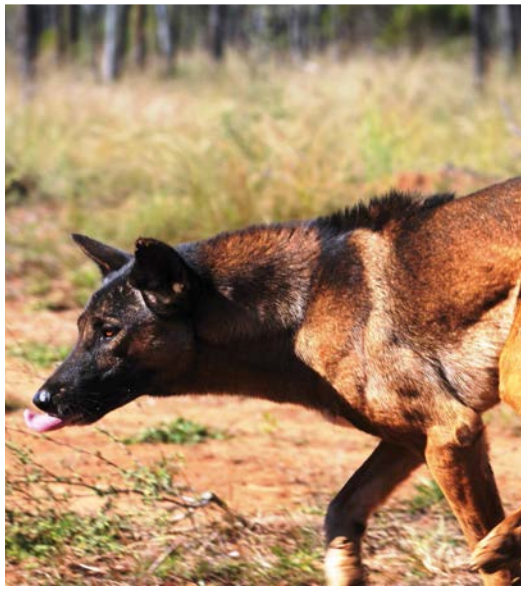
Fact sheet

DECLARED CLASS 2 PEST ANIMAL

July 2014

Wild dog control

Canis familiaris



The term wild dog refers collectively to purebred dingoes, dingo hybrids and domestic dogs that have escaped or been deliberately released.

Wild dog control methods include baiting, trapping, shooting, fencing, and the use of guardian animals to protect stock. A planned strategy using a combination of these methods that also considers wild dog behavior will enable effective management.

Declaration details

Wild dogs are a declared Class 2 pest animal under Queensland legislation. As such, all landholders in Queensland are required to reduce the number of wild dogs on their properties.

Management strategies

To increase wild dog control effectiveness, it is essential that control programs are coordinated among adjoining properties.

Queensland research has shown that in some situations wild dogs can quickly re-colonise baited areas due to a number of factors including inconsistent bait programs which do not provide comprehensive wild dog control across the landscape. Such programs may alter the dynamics of wild dog populations in the area. To prevent livestock attacks and enhance wild dog management, it is important for producers to work together using a variety of control methods.

Wild dog ecology and seasonal variations can also influence the likelihood of wild dogs coming into contact with a control tool. The timing of control should consider seasonal variations and the availability of water (where water is restricted) and then target watering points. Many land owners bait using 1080 twice a year to target wild dogs during peaks in activity associated with breeding (March/May) and then again in September/November to target pups and juveniles. However, baiting and trapping is recommended at all times when wild dogs are active.

Control

Baiting

Poison baits are the most economic, efficient and effective method of controlling wild dogs, especially in inaccessible or extensive areas. Baits can be laid quickly by hand, from vehicles and from aircraft.

Currently there are two poisons legally available for wild dog control. These are 1080 (sodium fluoroacetate) and strychnine.

Subject to restrictions, 1080 baits, either manufactured or prepared from fresh meat can be obtained through people approved under the Health (Drugs & Poisons) Regulation 1996. A permit from the Queensland Department of Health is required for land owners to purchase strychnine. Strychnine can be used both in baits and on traps. The use of both 1080 and strychnine require adherence to the associated conditions of supply.

The use of poison baits will control some but not all wild dogs. Baits should be used in conjunction with all other control tools and not be relied on as a total control method.

Meat baits are attractive both to wild dogs and a range of non-target species. When using meat baits, they can be strategically positioned as wild dogs' keen sense of smell enables them to find baits intentionally buried in sand or otherwise hidden under bushes or in hollow logs. Meat baits may also be tied to prevent their loss to non-target species.

These meat bait placement techniques help to:

- reduce the risk of poisoning non-target species
- increase wild dog contact, hence receiving a lethal dose
- minimise bait removal by non-target scavengers
- deter ants (ant-covered baits are believed to be less attractive to wild dogs).

Heavy rain within two weeks of baiting can leach 1080 from baits, but baits may still remain toxic for a considerable time.

Trapping

A key success to trapping wild dogs (using foot-hold traps) depends on the skill of the operator. Visit www.feral.org.au to watch a PestSmart video on best practice techniques for wild dog trapping.

For humane reasons and to prevent escape, poisoning traps with strychnine is recommended to quickly kill captured wild dogs. A properly poisoned trap becomes a lethal device rather than a holding device.

A mixture of dog faeces and urine is a popular lure used by trappers. Attractiveness of lures varies with seasons and locations. No single lure has yet been found that is consistently attractive to all wild dogs and repeated use of one lure can lead to aversion amongst remaining dogs.

Traps are best placed in areas of high wild dog activity (known as leads). Here the wild dog is most likely to find and investigate the decoy/odour.

A wild dog scent post (an area where urine or faeces have been deposited) can be found by walking with a domestic dog on a lead along a known pad. Trap placement in relation to the scent post can be optimised by observing the domestic dog's behaviour as it approaches. Factors to consider are:

- where on the bush it smells
- placement of feet while urinating/defecating/sniffing
- how it approaches and where it scratches in relation to the pad and scent post.

Padded, laminated or offset foot-hold traps, in a well tuned and functioning state are recommended.

Shooting

Shooting is an opportunistic method, mostly used for control of small populations or individual problem animals.

Fencing

Property fencing suitable to exclude wild dogs is expensive to build and requires continual maintenance to repair damage caused by fallen timber, fire, floods, feral and domestic animals, as well as vegetation regrowth. However, a properly maintained fence can restrict movement into an area where wild dogs have been controlled.

Electric fences suitable for wild dogs have been developed. Electrifying a fence creates a fear of the fence itself and deters wild dogs from approaching.

For property fencing to be successful, the fence must be maintained in good order and ongoing wild dog control conducted within the protected area to limit livestock impacts.

Fencing is the most effective method of protecting livestock and pets from wild dog attack on small acreage blocks.

A fence can also be a good area to place baits and traps when wild dogs are active.

Livestock guardian animals

Livestock guardian animals have been used to protect livestock from predators in Europe, Asia and America. Some producers in Queensland have decreased predation on sheep and goats using this method. The use of trapping and poisoning in conjunction with guardian animals must be well planned and managed to ensure guardian animal safety.

Further information

Further information is available from your local government office, or by contacting Biosecurity Queensland (call 13 25 23 or visit our website at www.biosecurity.qld.gov.au).

This fact sheet is developed with funding support from the Land Protection Fund.
Fact sheets are available from Department of Agriculture, Fisheries and Forestry (DAFF) service centres and our Customer Service Centre (telephone 13 25 23). Check our website at www.biosecurity.qld.gov.au to ensure you have the latest version of this fact sheet. The control methods referred to in this fact sheet should be used in accordance with the restrictions (federal and state legislation, and local government laws) directly or indirectly related to each control method. These restrictions may prevent the use of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, DAFF does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.

© The State of Queensland, Department of Agriculture, Fisheries and Forestry, 2014.

This page is intentionally blank.

Appendix F

Memorandum: Supporting Technical Information for Potential Impacts from Change in Blasting Practices

Memo

To:	Gemma Brown (Principal Environment & Mine Closure Planning)
Cc:	-
From:	Tim Brettell (Principal Mining Engineer)
Subject:	Barbara Project – EA amendment Supporting technical information for potential impacts from change in blasting practices
Date:	14 May 2024

Context

As part of the current EA amendment process initiated due to the proposed underground mine development at the Barbara Project, DESI (Queensland Department of Environment, Science & Innovation) have queried potential impacts from underground blasting practices.

Q1. Will the blast charge be the same as Mt Colin?

Q2. Do blast times need to be amended?
Note: Include detail about blast, charge, frequency and timing
Note: The application needs to include detail about blasting and its potential impact on EVs

Purpose

The purpose of this memo is to provide the supporting technical information on blasting for compliance with standard blasting conditions for underground mining and demonstrate negligible impacts on Environmental Values (EVs).

Summary conclusions

The two most common physical environmental impacts from blasting are ground vibration and airblast overpressure (noise). The potential impacts from vibration and airblast have been predicted via a desktop assessment using typical industry methods and relevant blasting parameters based on Mt Colin Operations as detailed in the next sections.

The ground vibration and airblast overpressure at the nearest sensitive receiver, 23km away, is not expected to exceed the current EA conditions, nor the DESI Guideline for noise and vibration from blasting.

Blast sizes, frequency and timing

- Blast sizes, both development and production (stoping) would be similar to Mt Colin because the proposed development drive sizes and stope mining method and orebody geometry is analogous to Barbara.
    - Indicative typical blast sizes are:
      Development – 0.5t ANFO or equivalent per 4m round
      Stoping: 5-10t ANFO or equivalent per blast. Individual stope extraction will generally comprise multiple blasts spread over a number of days

- Blast frequency
    - Development blasting (multiple cuts/headings) would generally occur at end of day shift and the end of night shift, i.e. twice per day.
    - Production/stope blasting will commence once sufficient work areas have been accessed via the development mining activities (several months after commencement). Production blasting would occur less frequently than daily but likely to be several times per week.
    - To support these comments, the table below was sourced from the Mt Colin NPI reporting. The number of blasts per year peaked at 1,340 when the mine was in the development and production (stoping) phase. This is equivalent to around 4 blasts per day.

INFORMATION	FURTHER DETAILS	AMOUNT REPORTED IN 1/7/2018-30/6/2019	AMOUNT REPORTED IN 1/7/2019-30/6/2020	AMOUNT REPORTED IN 1/7/2020-30/6/2021	MOST RECENT AMOUNT 1/7/2021-30/6/2022	MOST RECENT AMOUNT 1/7/2022-30/6/2023
Explosives	Provide details of explosive types (ANFO, etc)	20 tonnes	22 tonnes	370 tonnes	518 tonnes	394 tonnes
Number of blasts		1,200 blasts	1,340 blasts	1,300 blasts	920 blasts	338 blasts

- Blast timing
    - Typically, underground mines carry out blasting at defined periods (approximately 1 hour window) at the end of both day shift and night shift (6am and 6pm). This would be the case for both development and production/stope blasts.

Ground vibration & airblast overpressure (sound level) criteria

The table below contains the current blasting limits imposed by the existing Barbara EA.

Airblast overpressure nuisance

D2 The holder of this environmental authority must ensure that blasting does not cause the limits for peak particle velocity and air blast overpressure in *Table D2* to be exceeded at a sensitive place or commercial place.

Table D2 – Blasting noise limits ('Table D2')

Blasting noise limits	Sensitive or commercial blasting noise limits place limits	
	7am to 6pm	6pm to 7am
Airblast overpressure	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB (Linear) Peak at any time	No blasting
Ground vibration peak particle velocity	5mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time	No blasting

The table below is from the DESI guideline for noise and vibration from blasting (DESI 2022). These limits would apply to any change in blasting practices and times associated with underground mining.

Guideline
Noise and vibration from blasting

For mining industry

Blasting limits Surface mining	Sensitive or commercial place criteria	
	7am to 6pm	6pm to 7am
Airblast overpressure	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB (Linear) Peak at any time	<insert either no blasting or limits justified by proponent not less stringent than 7am – 6pm>
Ground vibration peak particle velocity (vector sum)	5 mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time	<insert either no blasting or limits justified by proponent not less stringent than 7am – 6pm>
Blasting limits Underground mining	**Sensitive or commercial blasting noise limits place limits**	
	7am to 6pm	**6pm to 7am**
Airblast overpressure	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB (Linear) Peak at any time	115 dB (Linear) Peak
Ground vibration peak particle velocity (vector sum)	5 mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time	2 mm/second peak

Blasting outside of these times should be only conducted where:

a) blasting during the preferred times is demonstrably impracticable (in such situations blasts should be limited in number and stricter airblast overpressure and ground vibration limits should apply) or

b) there is no likelihood of persons in a noise-sensitive place being affected by the blasting due to the remoteness of the blast site from that place.

Ground vibration prediction

Previous assessment during open pit operations

ASK completed an assessment of vibration for the Barbara open pit operations and found that, for a maximum instantaneous charge of 90kg, vibrations levels less than 5 mm/s peak particle velocity criterion would be achieved at distances greater than 0.2 km from the blast and levels less than 2 mm/s would be achieved at 0.6 km from the blast. ASK advised that the vibration levels are predicted to be acceptable at the nearest residence, 23 km away. (ASK 2014)

Prediction method

Best Practice for blasting operations is defined within the AS2187.2 (1993) Explosives - storage, transport and use.

AS2187.2 Appendix J provides the following prediction equation.

Ground Vibration Prediction (ppv)

When an explosive is detonated in a blast hole, a pressure wave is generated in the surrounding rock. As this pressure wave moves from the blast hole it forms seismic waves by displacing particles. The particle movement is measured to determine the magnitude of the blast vibration.
Maximum particle vibration can be estimated using the following formula.

$$V = K \left| \frac{R}{Q^{0.5}} \right|^{B}$$

V	peak particle velocity (mm/s)
K	site and rock factor constant
Q	maximum instantaneous charge (kg)
B	constant related to the rock and site (usually -1.6)
R	distance from charge (m)

Typical K factors

Free face - hard or highly structured rock	500
Free face - average rock	1140
Heavily confined	5000

Recommended maximum ppv quoted AS2187.2 - 1993

10mm/s	Housing and low rise residential buildings, Commercial buildings not included below
25mm/s	Commercial and industrial buildings or structures of reinforced concrete or steel construction
5mm/s	For high rise, hospitals, long floor spans, dams or historic buildings where no specified limit exists

Expected Damage

13 mm/s	Lower limit for damage to plaster walls
19 mm/s	Lower limit for dry wall structures
70 mm/s	Minor damage
140 mm/s	>50% chance of minor damage to structures
190 mm/s	50% chance of major damage

Input parameters (assumptions)

Many site-based factors including rock type, structure, topography, explosive type, blast design and geometry determine the vibration level that will be transmitted to a particular location remote from the blast location. Consequently, the most accurate prediction of ground vibration by calculation will be that generated from vibration measurements taken at the site. However, in the absence of such site data, AS2187.2 recommends the following values for the K factor:

- K factor = 500
  For hard or highly structured rock – i.e. when blasting is to be carried out to a free face in open cut mines and hard or highly structured rock quarries.
- K factor = 1,140
  For average rock – i.e. when blasting is to be carried out to a free face in average field conditions.
- K factor = 5,000
  For heavily confined blasting, nearfield – i.e. when blasting is to be carried out in heavily confined areas (e.g. opening holes in a heading, presplitting and similar, where no free face exists, or the overburden is large) or in moist ground conditions.

AS2187.2 also states that, where no data from previous blasting is available, K=1,140 and b=-1.6 are applicable to prediction of mean ppv (i.e. 50% Confidence Limit). The use of a higher K factor, e.g. 5,000, would generally provide a higher percentile probability for the predictions but may also overestimate, in other words, utilising this assumption for the K factor represents a worst case scenario.

The B factor value of -1.6 is usually applied.

For the desktop assessment, the predictions were undertaken using the range of values for K and B recommended in AS2187.2. It is worth noting that ASK assumed K factors of 800 and 1,600 based on similar mining projects and estimated a B factor of -1.6 for their assessment of Barbara open cut blasting impacts (ASK 2014).

Ground vibration depends on the maximum charge weight per delay, or maximum instantaneous charge (MIC or Q in the equation), and not the total charge weight, provided the delay interval is significant (more than 8 ms). Several MIC sizes were defined based on blast designs from Mt Colin and other comparable blasts within the industry. The predictions used the following MIC assumptions:

- 150kg (typical underground development blast)
- 250kg (typical stope blast – based on an actual Mt Colin stope charge plan)
- 750kg (conservative assumption for a specialised stope blast - based on an actual Mt Colin stope charge plan + 25%)

The range of distances from the blast assessed were 1,000m, 10,000m and 23,000m (23km, distance to nearest sensitive receiver).

The full set of combinations of input parameters, i.e. K factor, B factor, MIC and distance from charge used in the vibration predictions calculations are shown on the following page.

BARBARA PROJECT
Blast vibration
Input parameters & predictions matrix

Exceeds night guideline 2mm/s

NOTE: Day time guideline is 5mm/s

GROUND VIBRATION PREDICTION					
Case #	*K Factor*	*B constant*	*Q MIC (kg)*	*R Distance from charge (m)*	*Estimated PPV (mm/s)*
V-1	500	-1.6	150	1,000	0.4
V-2	500	-1.6	250	1,000	0.7
V-3	500	-1.6	750	1,000	1.6
V-4	500	-1.6	150	10,000	0.0
V-5	500	-1.6	250	10,000	0.0
V-6	500	-1.6	750	10,000	0.0
V-7	500	-1.6	150	23,000	0.0
V-8	500	-1.6	250	23,000	0.0
V-9	500	-1.6	750	23,000	0.0
V-10	1,140	-1.6	150	1,000	1.0
V-11	1,140	-1.6	250	1,000	1.5
V-12	1,140	-1.6	750	1,000	3.6
V-13	1,140	-1.6	150	10,000	0.0
V-14	1,140	-1.6	250	10,000	0.0
V-15	1,140	-1.6	750	10,000	0.1
V-16	1,140	-1.6	150	23,000	0.0
V-17	1,140	-1.6	250	23,000	0.0
V-18	1,140	-1.6	750	23,000	0.0
V-19	5,000	-1.6	150	1,000	4.4
V-20	5,000	-1.6	250	1,000	6.6
V-21	5,000	-1.6	750	1,000	15.8
V-22	5,000	-1.6	150	10,000	0.1
V-23	5,000	-1.6	250	10,000	0.2
V-24	5,000	-1.6	750	10,000	0.4
V-25	5,000	-1.6	150	23,000	0.0
V-26	5,000	-1.6	250	23,000	0.0
V-27	5,000	-1.6	750	23,000	0.1

Ground vibration prediction outputs & conclusions

The charts on the next page depict the outputs from the ground vibration predictions.

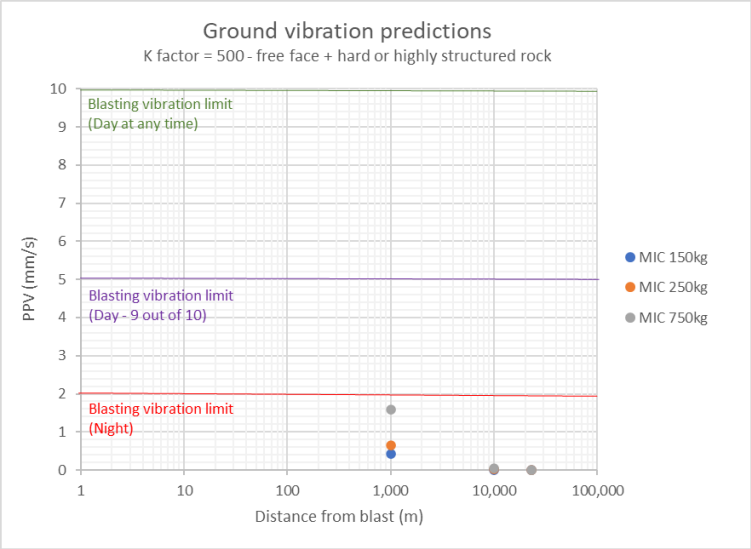
The results indicate that underground blasting will likely meet the strictest DESI criteria (night time, 2mm/s) at 1km for "average site conditions" (K factor assumption of 1,140 as per AS2187.2) for both typical development and stope blasting. The vibration at 1km for a "specialised" stope blast is predicted to exceed the night time criteria but below the day time limit of 5mm/s.

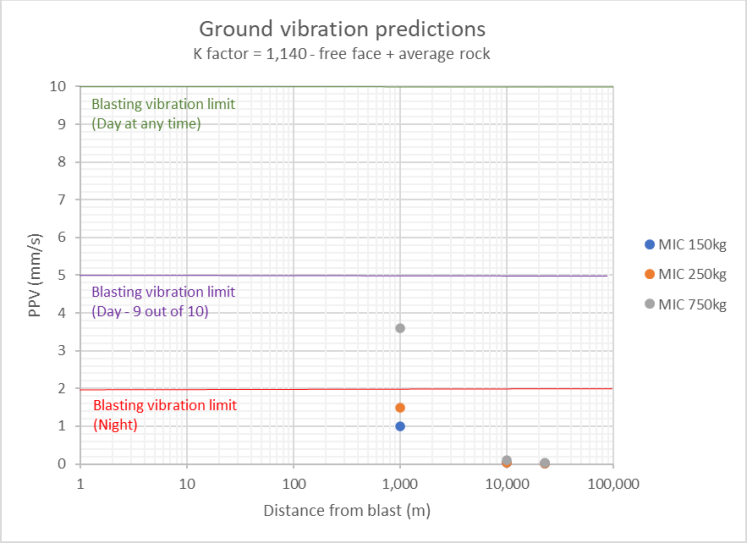
Importantly, at the closest sensitive receiver, 23km from the blast site, none of the predictions, across all the combinations of input parameter ranges exceed the DESI limits.

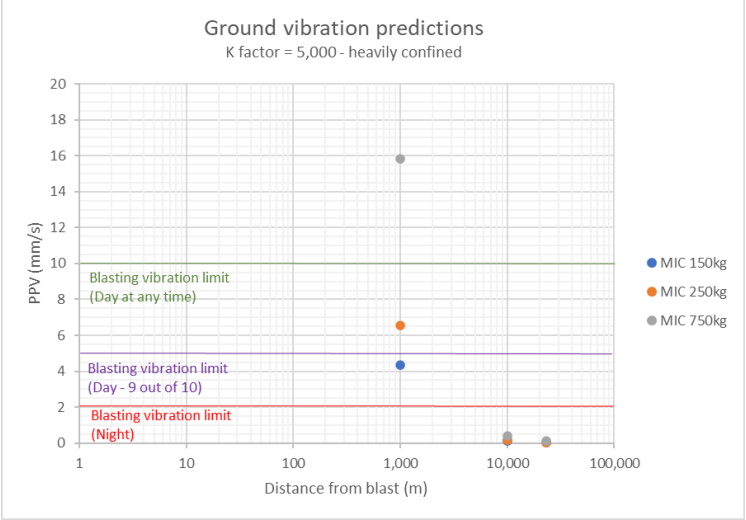
The table below shows the minimum distances from the blast location, for all input assumption combinations, at which the strictest ground vibration limit (2mm/s) is met. For example, using the **most conservative assumptions** for both K factor and MIC (750kg), the distance to the minimum vibration limit of 2mm/s is predicted to be 3.6km.

MINIMUM DISTANCES FROM BLAST FOR VIBRATION BELOW STRICTEST DESI LIMIT (2mm/s)

Case #	*K Factor*	*B constant*	*Q MIC (kg)*	*R Distance from charge (m)*	*Estimated PPV (mm/s)*
V-GS1	500	-1.6	150	386	2.0
V-GS2	500	-1.6	250	500	2.0
V-GS3	500	-1.6	750	866	2.0
V-GS4	1,140	-1.6	150	648	2.0
V-GS5	1,140	-1.6	250	837	2.0
V-GS6	1,140	-1.6	750	1,450	2.0
V-GS7	5,000	-1.6	150	1,634	2.0
V-GS8	5,000	-1.6	250	2,109	2.0
V-GS9	5,000	-1.6	750	3,653	2.0


Ground vibration predictions
K factor = 500 - free face + hard or highly structured rock
Blasting vibration limit
(Day at any time)
Blasting vibration limit
(Day - 9 out of 10)
Blasting vibration limit
(Night)
MIC 150kg
MIC 250kg
MIC 750kg
PPV (mm/s)
Distance from blast (m)


Ground vibration predictions
K factor = 1,140 - free face + average rock
Blasting vibration limit
(Day at any time)
Blasting vibration limit
(Day - 9 out of 10)
Blasting vibration limit
(Night)
MIC 150kg
MIC 250kg
MIC 750kg
PPV (mm/s)
Distance from blast (m)


Ground vibration predictions
K factor = 5,000 - heavily confined
Blasting vibration limit
(Day at any time)
Blasting vibration limit
(Day - 9 out of 10)
Blasting vibration limit
(Night)
MIC 150kg
MIC 250kg
MIC 750kg
PPV (mm/s)
Distance from blast (m)

Airblast overpressure prediction

Previous assessment during open pit operations

ASK completed an assessment of airblast for the Barbara open pit operations and found that, for a maximum instantaneous charge of 90kg, the distance beyond which the 115 dB (Lin) airblast criteria could be achieved is approximately 0.4km. ASK advised that the airblast levels are predicted to be acceptable at the nearest residence, 23 km away (ASK 2014).

Prediction method

Most of the energy released in blasting is consumed in fracturing and shifting the rock, however, some of this energy can result in airblast overpressure (noise). Best practice blasting processes generally do not produce significant airblast because the explosives are properly confined in blast holes and the burdens are spacing are appropriate (Olson & Fletcher, 1971). Airblast may become significant in cases of unconfined blasting at surface.

Typically, the equation below is used to predict airblast overpressure/sound levels. This equation was developed for surface blasting.

A literature review revealed that the industry lacks a specific equation for prediction of airblast levels on surface due to underground blasting (Rouse & Petrie, 2014). This is in part because potential impacts associated with airblast overpressure on surface from blasting conducted underground are generally considered negligible. Nonetheless, the equation below has been used for this desktop assessment with the selection of the K factor most relevant to simulate underground blasting.

Airblast Prediction

An airblast is an airborne shockwave that results from the detonation of explosives. The severity of the airblast is dependent on explosive charge, distance, and especially the explosives confinement

$$P = K \left(\frac{R}{Q^{0.33}} \right)^{-1.2}$$

P	Pressure (kPa)
K	State of confinement
Q	maximum instantaneous charge (kg)
R	distance from charge (m)

Typical K factors

Unconfined	185
Fully confined	3.3

Expected Damage

0.3 kPa	Windows rattle
0.7 kPa	1% of windows break
7 kPa	Most windows break, plaster cracks

Sound Level Calculation

$$Lp = 20 \log \left(\frac{P}{20 \times 10^{-9}} \right)$$

Lp	Sound level (dB)
P	Pressure (kPa)

Minimum levels quoted AS2187.2 - 1993

120 dB (lin)	Human discomfort
130 dB (lin)	Onset of structure damage or historic buildings where no specific limit exists

Input parameters (assumptions)

The K factor is determined mainly by the level of confinement of the explosives and atmospheric conditions. The publication, ICI – Handbook of Blasting Tables, suggests that for fully confined blasthole charges in average atmospheric conditions, a K factor of 3.3 is appropriate, while for unconfined charges, a K factor of 185 may be used.

It is worth noting that the ICI Handbook recommends a value of -1.2 for the site exponent for both confined and unconfined blasthole charges. This assumption is already accounted for in the equation above.

For the desktop assessment, because the level of confinement for typical underground blasts is high combined with the fact that the prediction equation was not specifically developed for predicting the airblast impacts on surface from underground blasting, a K factor of 3.3 has been used.

The maximum instantaneous charge (MIC or Q in the formulas) assumptions are the same as those employed for the vibration predictions.

- 150kg (typical underground development blast)
- 250kg (typical stope blast – based on an actual Mt Colin stope charge plan)
- 750kg (conservative assumption for a specialised stope blast - based on an actual Mt Colin stope charge plan + 25%)

The range of distances from the blast assessed were 1,000m, 10,000m and 23,000m (23km, distance to nearest sensitive receiver).

The full set of combinations of input parameters, i.e. K factor, MIC and distance from charge used in the calculations is shown below.

BARBARA PROJECT
Airblast overpressure/Sound Level
Input parameters & predictions matrix

Exceeds day/night guideline 115dB (Linear) Peak

AIRBLAST OVERPRESSURE/SOUND LEVEL PREDICTION					
Case #	*K Factor*	*Q MIC (kg)*	*R Distance from charge (m)*	*Pressure (kPa)*	*Lp Sound level (db)*
AB-1	3.3	150	1,000	0.01	110
AB-2	3.3	250	1,000	0.01	111
AB-3	3.3	750	1,000	0.01	115
AB-4	3.3	150	10,000	0.00	86
AB-5	3.3	250	10,000	0.00	87
AB-6	3.3	750	10,000	0.00	91
AB-7	3.3	150	23,000	0.00	77
AB-8	3.3	250	23,000	0.00	79
AB-9	3.3	750	23,000	0.00	82

Airblast overpressure/sound level predictions, analysis & conclusions

The chart on the next page depicts the outputs from the airblast overpressure predictions.

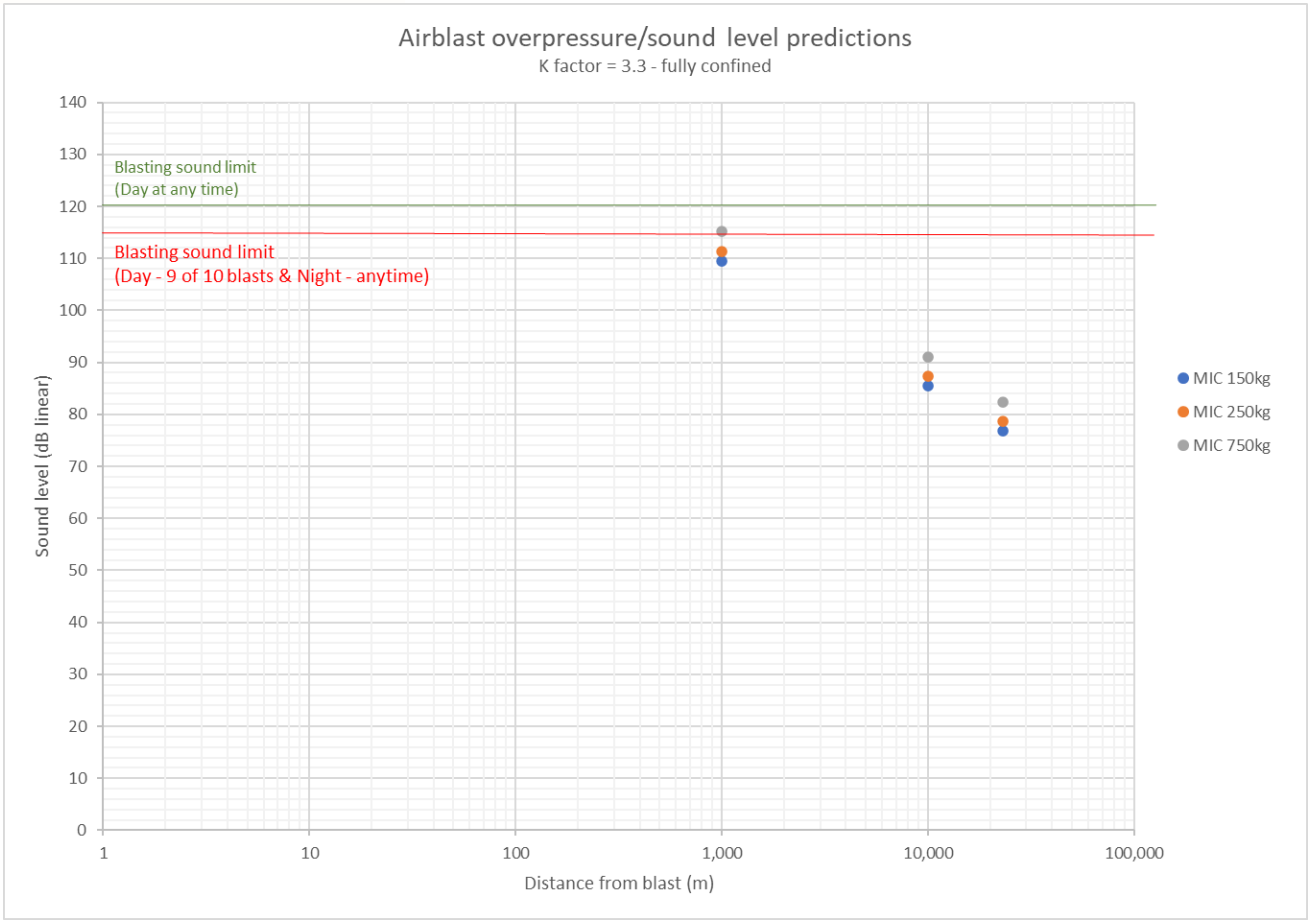
The results indicate that underground blasting will meet the strictest DESI criteria (night time, 115dB) for distances from the blast of 1km or more for typical development and stope blasting. The airblast prediction for the **most conservative MIC assumption** (750kg) for a specialised stope blast marginally exceeds the DESI criteria at 1km distance.

Importantly, for a receiver 23km from the blast site, the predictions across all the combinations of input parameter ranges are well below the DESI limits.

The table below shows the minimum distances from the blast location, for all input assumption combinations, at which the strictest airblast limit (115db) is met. However, to re-iterate, the equation was not specifically developed for predicting the airblast impacts on surface from underground blasting and, it is generally accepted that underground blasting does not cause airblast overpressure impacts on surface, therefore, these distances are considered **very conservative**.

MINIMUM DISTANCES FROM BLAST FOR AIRBLAST OVERPRESSURE BELOW STRICTEST DESI LIMIT (115dB)

Case #	*K Factor*	*Q MIC (kg)*	*R Distance from charge (m)*	*Pressure (kPa)*	*Lp Sound level (db)*
AB-GS1	3.3	150	601	0.01	115
AB-GS2	3.3	250	711	0.01	115
AB-GS3	3.3	750	1,012	0.01	115


Airblast overpressure/sound level predictions
K factor = 3.3 - fully confined
Blasting sound limit
(Day at any time)
Blasting sound limit
(Day - 9 of 10 blasts & Night - anytime)
Sound level (dB linear)
Distance from blast (m)
MIC 150kg
MIC 250kg
MIC 750kg
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1,000
10,000
100,000

References

1. Guideline – Noise & vibration from blasting (2022), QLD Department of Environment, Science and Innovation https://www.des.qld.gov.au/policies?a=272936:policy_registry/eis-gl-noise-vibration-blasting.pdf

2. AS2187.2 Explosives – Storage, transport and use – Use of explosives (1993), Standards Australia

3. Barbara Copper Project – Noise impact assessment, (2014), ASK Consulting Engineers Pty Ltd

4. ICI Handbook of Blasting Tables, (1971), Imperial Chemical Industries of Australia and New Zealand, Explosives Division

5. Blasting principles – airblast, Orica website https://www.orica.com/products-services/resources/blasting-principles#:~:text=Airblast%20%28Overpressure%29%20Pressure%20pulses%20in%20air%20%28often%20not,confined%20blastholes%20do%20not%20generate%20excessive%20airblast%20overpressures

6. Rouse, N.T., Petri, B.S., (2014) "Air Overpressure Monitoring for Underground Production Blasting Operation in Limestone", Blasting and Fragmentation, Vol. 8, No. 2, 2014, International Society of Explosives Engineers

7. Olson, J.J., Fletcher, L.R., "Report of Investigations 7574, Airblast-Overpressure Levels From Confined Underground Production Blasts", (1971), Twin Cities Mining Research Center, Minneapolis, Minnesota, US Deparment of the Interior – Bureau of Mines

This page is intentionally blank.

Appendix G
Groundwater Technical Report

WMV environmental
Contaminated Land | Hydrogeology | Environment
PO Box 597
Cannon Hill QLD 4170
T +61 (0)408 598 137

Barbara Copper Project UG EA Amendment

Groundwater Technical Report

Prepared for Aeris Resources Limited | 14 March 2024

Barbara Copper Project UG EA Amendment

Groundwater Technical Report

Client:	Aeris Resources Limited
ABN:	30 147 131 977

Author	Willy Van Vaerenbergh
Position	Principal Hydrogeologist
Signature	
Date	14/03/2024

WMV Environmental Pty Ltd has prepared this document for the sole use of the Client and for a specific purpose, each as expressly stated in the document. No other party, except for the Department of Environment, Science and Innovation, should rely on this document without the prior written consent of WMV Environmental Pty Ltd. WMV Environmental Pty Ltd undertakes no duty, nor accepts any responsibility, to any third party who may rely upon or use this document. This document has been prepared based on the Client's description of its requirements and WMV Environmental Pty Ltd's experience, having regard to assumptions that WMV Environmental Pty Ltd can reasonably be expected to make in accordance with sound professional principles. WMV Environmental Pty Ltd may also have relied upon information provided by the Client and other third parties to prepare this document, some of which may not have been verified. Subject to the above conditions, this document may be transmitted, reproduced or disseminated only in its entirety.

© (WMV Environmental Pty Ltd). All rights reserved. Reproduction of this report for educational or other non-commercial purposes is authorised without prior written permission from WMV Environmental Pty Ltd provided the source is fully acknowledged. Reproduction of this report for resale or other commercial purposes is prohibited without WMV Environmental Pty Ltd's prior written permission.

Quality Information

Project Number	J23011
Document	P:\J23011 - BCP Underground EA (Aeris)\4. Reports\4.2 Final Reports\4.2.01 BCP UG EA Groundwater Report\J23011-RP01 - BCP UG EA Groundwater Technical Report (Final v2.00 - 2024_03_14).docx
Version	2.0
Reference	J23011-RP01
Status	Final Report
Date	14 March 2024

Table of Contents

1 Introduction 1
1.1 Introduction 1
1.2 Scope of work 1
1.3 Regulatory requirements for UG EA amendment 3
2 Environmental Authority EPML02840015 4
2.1 Authorised activities 4
2.2 EA groundwater-related conditions 4
2.3 EA groundwater monitoring program 6
3 BCP proposed underground mining 11
4 Environmental settings 16
4.1 Climate 16
4.2 Topography 22
4.3 Geomorphology and landforms 22
4.4 Vegetation 22
4.5 Surface water and hydrology 24
4.5.1 Drainage basins and catchments 24
4.5.2 Watercourses and water bodies 25
4.5.3 Surface water Environmental Values and Water Quality Objectives 25
4.5.4 Surface water quality characteristics 26
4.6 Soils 26
5 Geology 28
5.1 Local geology 28
5.2 Geochemistry 28
6 Hydrogeological settings 29
6.1 Water resource planning areas 29
6.2 Registered groundwater bores 29
6.3 Groundwater Dependent Ecosystems (GDE) 32
6.4 Groundwater beneficial use and environmental values 32
6.5 Stygofauna 33
6.6 Local aquifers 33
6.7 Aquifer hydraulic properties 34
6.8 Groundwater seeps/spring 39
7 Surface water monitoring results 42
7.1 Surface water monitoring network and events 42
7.2 2014 surface water monitoring (AARC, November 2014) 45
7.3 2022 REMP monitoring results 45

7.4 REMP and EA surface water quality results 46
7.4.1 Hydrogeochemistry 47
7.4.2 REMP and EA surface water quality results 48
7.5 Mine site surface water monitoring results 57
7.5.1 Hydrogeochemistry 57
7.5.2 Mine site surface water quality results 59
7.5.3 Assessment of water levels at BCP Spring locations and in the sump 65
8 Groundwater monitoring results 69
8.1 Groundwater monitoring network 69
8.2 Groundwater levels and flow 72
8.2.1 Groundwater levels in mineral exploration bores (2013) 72
8.2.2 Groundwater levels in monitoring bores (2014) 73
8.2.3 Groundwater levels in monitoring bores (2018-2024) 74
8.2.4 Assessment of water levels in seepage monitoring wells 83
8.3 Groundwater hydrogeochemistry and water types 91
8.4 Groundwater quality 97
8.4.1 Groundwater monitoring bores 97
8.4.2 Seepage monitoring bores 105
9 Hydrogeological conceptual site model 112
10 Groundwater impact assessment 116
10.1 Introduction 116
10.2 Extent and level of drawdown around open pits and underground workings 116
10.3 Impacts on groundwater/surface water interaction 120
10.4 Groundwater inflows into open pits and underground works 120
10.4.1 Introduction 120
10.4.2 Marinelli and Niccoli method for inflow into mine pits 121
10.4.3 Steady-state groundwater inflow into open pits 122
10.4.4 Steady-state groundwater inflow into underground works 125
10.4.5 BCP water balance model results 126
10.5 North Pit, South Pit and WRD Sediment Dam final void water quality 130
10.5.1 Development of Water Quality Models 131
10.5.2 WRD Sediment Dam final void water quality 131
10.5.3 North Pit water quality 132
10.5.4 South Pit water quality 132
10.5.5 Summary 132
10.6 Underground workings final void water quality 133
10.6.1 Methodology 133
10.6.2 Summary of water balance model volumes 133
10.6.3 Modelled final void water quality 134
10.7 Potential AMD impact on final void water quality 141
10.7.1 Summary of AMD investigations 141

10.7.2 Potential AMD impacts on final void water quality in open pits 145
10.7.3 Potential AMD impacts on underground final void water quality..... 149
10.8 Preliminary assessment of final void stratification 153
10.8.1 Introduction..... 153
10.8.2 Depth/area ratio assessment..... 154
10.8.3 One-dimension GLM model..... 154
11 Conclusions 160
11.1 Groundwater impact assessment..... 160
11.2 Proposed EA amendment..... 161
12 References..... 162
13 Limitations 164

Appendices

Appendix A EA EPML02840015
Appendix B Bore construction logs
Appendix C Registered bore reports
Appendix D Google Earth images of BCP Spring
Appendix E REMP and EA surface water monitoring data
Appendix F Mine site surface water monitoring data
Appendix G Groundwater monitoring data
Appendix H Seepage monitoring bore results
Appendix I Inflow calculations for open pits and underground works
Appendix J WQM results for open pits and WRD sediment dam
Appendix K WQM results for underground workings
Appendix L Summary of AMD Investigations

Figures

Figure 1 Location of the Barbara Copper Project
Figure 2 Location of BCP groundwater monitoring wells (regional scale)
Figure 3 Location of BCP groundwater monitoring wells (local scale)
Figure 4 Pre-mining 2014 topography
Figure 5 2021 topography
Figure 6 Mapped pre-clear regional ecosystems
Figure 7 Watercourses near the Project site

Figure 8 Surface water monitoring locations (regional scale)
Figure 9 Surface water monitoring locations (local scale)
Figure 10 Regional geology at BCP
Figure 11 Registered water bores within 5 km of BCP
Figure 12 Registered water bores within ML90241
Figure 13 BOM groundwater dependent ecosystems
Figure 14 Contour map of June 2014 groundwater levels
Figure 15 Contour map of June 2018 groundwater levels
Figure 16 Contour map of April 2022 groundwater levels
Figure 17 Contour map of April 2023 groundwater levels
Figure 18 Location of hydrogeological cross-section

Plates

Plate 1 BCP project layout 2
Plate 2 Proposed BCP underground mining schedule 12
Plate 3 Cumulative underground void volumes 13
Plate 4 Underground voids after mining 13
Plate 5 BCP UG mining – cumulative waste/backfill tonnage 14
Plate 6 BCP UG mining – PAF/NAF temporary storage requirements 15
Plate 7 Daily Rainfall (mm) from Mount Isa Aero weather station 029127 19
Plate 8 Average monthly rainfall (mm) and pan evaporation (mm) from SILO data 20
Plate 9 Cumulative Rainfall Distribution for BCP 21
Plate 10 Pre-mining vegetation communities at BCP 24
Plate 11 Distribution of soil management units within the Project area 27
Plate 12 Airlift Yield from Mineral Exploration Bores (RLA, 2014) 37
Plate 13 Drawdown and recovery water levels in BAWB07 38
Plate 14 Google Earth images for October 2015 and March 2020 40
Plate 15 Monthly rainfall (2002-2022) and Cumulative Rainfall Departure 41
Plate 16 Water elevation (mAHD) at BCP Spring (N), BCP Spring (S) and the sump 67
Plate 17 Water level changes (m) at BCP Spring (N), BCP Spring (S) and the sump 68
Plate 18 Depth to water (mbRL) in groundwater monitoring bores 77
Plate 19 Groundwater levels (mAHD) in groundwater monitoring bores 78
Plate 20 Depth to water (mbRL) in EA seepage monitoring bores 79
Plate 21 Groundwater levels (mAHD) in EA seepage monitoring bores 80
Plate 22 Depth to water (mbRL) in additional seepage monitoring bores 81
Plate 23 Groundwater levels (mAHD) in additional seepage monitoring bores 82
Plate 24 Data logger based groundwater levels (mAHD) versus manually obtained groundwater levels (mAHD) 87
Plate 25 Groundwater levels (mAHD) in seepage monitoring bores 1a, 2a, 3a, 5b, 6b, 8a and 9a versus rainfall 88

Plate 26 Groundwater level changes (m) in seepage bores 1a, 2a, 3a, 5b, 6b, 8a and 9a versus rainfall 89
Plate 27 Groundwater levels (mAHD) in selected seepage monitoring bores and BCP spring locations versus rainfall 90
Plate 28 Hydrogeological cross-section (A-A') with June 2018 groundwater levels 114
Plate 29 Hydrogeological cross-section (A-A') with April 2022 groundwater levels 115
Plate 30 North Pit radius of influence/drawdown 117
Plate 31 South Pit radius of influence/drawdown 118
Plate 32 Underground workings radius of influence/drawdown 119
Plate 33 Mine pit inflow conceptual model (Marinelli & Niccoli, 2000) 121
Plate 34 Calculated steady-state North Pit groundwater inflows 124
Plate 35 Calculated steady-state South Pit groundwater inflows 124
Plate 36 Calculated steady-state underground works groundwater inflows 126
Plate 37 Schematic BCP water balance model (ATC Williams, 2024) 127
Plate 38 South Pit accumulated groundwater inflows 128
Plate 39 Underground workings accumulated groundwater inflows 129
Plate 40 North Pit accumulated groundwater inflows 130
Plate 41 AMD plot for waste rock and ROM oxide and AMD classification (EGi, 2020) 143
Plate 42 North Pit waste rock cross-sections (AECOM 2014) 147
Plate 43 South Pit waste rock cross-sections (AECOM 2014) 147
Plate 44 Summary of EC values for all rock units within Barbara drill core samples (EGi, 2014) 148
Plate 45 North Pit GLM model results – temperature (°C) distribution 156
Plate 46 North Pit GLM model results – density distribution 156
Plate 47 North Pit GLM model results – salinity (g/L) distribution 157
Plate 48 South Pit GLM model results – temperature (°C) distribution 158
Plate 49 South Pit GLM model results – density distribution 159
Plate 50 North Pit GLM model results – salinity (g/L) distribution 159

Tables

Table 1 Pre-lodgement meeting critical matters 3
Table 2 BCP environmentally relevant activity and location details (EA EPML02840015) 4
Table 3 EA Table E5 - Groundwater monitoring locations and frequency 7
Table 4 EA Table E6 - Groundwater quality objectives 8
Table 5 BCP seepage monitoring bores 9
Table 6 Underground void volumes after mining 11
Table 7 Monthly climate statistics for Mount Isa Airport station (BOM station 029127) 18
Table 8 Site preclear regional ecosystems 22
Table 9 Pre-mining vegetation communities at BCP 23
Table 10 Registered water bores within 10 km of the Project site 30
Table 11 Terrestrial GDEs within 5km of Project Site (BOM GDE Atlas) 32

Table 12 Mineral Exploration Bore Airlift Yield Test Results (RLA, 2014) 35
Table 13 Calculated hydraulic conductivity of aquifer sequences at BCP (RLA, 2014) 39
Table 14 Historical presence of BCP Spring on Google Earth images 40
Table 15 BCP surface water monitoring locations 43
Table 16 Water-type classification of REMP and EA surface water sampling locations 47
Table 17 Range of analysis results above the LOR at the REMP/EA surface water monitoring locations 50
Table 18 REMP and EA surface water exceedances of EA receiving water quality trigger levels 52
Table 19 REMP and EA surface water exceedances of EA receiving water WQOs 54
Table 20 REMP and EA surface water exceedances of ANZG aquatic ecosystem (slightly to moderately disturbed) protection DGVs 56
Table 21 Water-type classification of mine site surface water sampling locations 57
Table 22 Range of analysis results above the LOR at the mine site surface water monitoring locations 61
Table 23 Mine site surface water exceedances of ANZECC Livestock Water Quality Guidelines 63
Table 24 Mine site surface water exceedances of ANZG aquatic ecosystem (slightly to moderately disturbed) WQOs 64
Table 25 Datalogger periods at surface water monitoring locations 65
Table 26 BCP groundwater monitoring well details 70
Table 27 Exploration Drill Hole Groundwater Levels – October 2013 (RLA, 2014) 72
Table 28 Depth to Groundwater in BCP Groundwater Monitoring Bores (RLA, 2014) 73
Table 29 Datalogger periods at seepage monitoring bore locations 83
Table 30 Water-type classification of groundwater monitoring bores 91
Table 31 Water-type classification of seepage monitoring bores 93
Table 32 Range of analysis results above the LOR in the groundwater monitoring bores 99
Table 33 Groundwater monitoring bore exceedances of EA Limit A 101
Table 34 Groundwater monitoring bore exceedances of EA Limit B 102
Table 35 Groundwater monitoring bore exceedances of ANZG Livestock Water Quality guidelines 103
Table 36 Groundwater monitoring bore exceedances of ANZG aquatic ecosystem (slightly to moderately disturbed) WQOs 104
Table 37 Range of analysis results above the LOR in the EA seepage monitoring bores 107
Table 38 Range of analysis results above the LOR in the additional seepage monitoring bores 109
Table 39 Seepage monitoring bore exceedances of ANZG Livestock Water Quality guidelines 111
Table 40 Seepage monitoring bore exceedances of ANZG aquatic ecosystem (slightly to moderately disturbed) WQOs 111
Table 41 BCP hydrogeological conceptual model 112
Table 42 Groundwater inflow into mine pit equations and assumptions 121
Table 43 Assumptions and variables for open pit groundwater inflow calculations 122

Table 44 Assumptions and variables for underground works groundwater inflow calculations 125
Table 45 Initial concentrations of relevant solutes/parameters for UG WQM 135
Table 46 Modelled UG workings final void water quality concentrations (mg/L) 139
Table 47 BCP AMD classification (EGi, 2014) 141
Table 48 Acid rock drainage samples - acid generation lag time (EGi, 2014) 141
Table 49 Descriptions of Barbara waste rock and ROM oxide samples (EGi, 2020) 142
Table 50 Summary of leachate analysis from week 4 to 52 (EGi, 2020) 144
Table 51 Input water quality and water volumes for UG PAF disposal WQM 150
Table 52 End-point UG water quality (mg/L) with PAF/NAF disposal 152
Table 53 "*Relative Depth*" of open pits and sediment dam 154

1 Introduction

1.1 Introduction

Aeris Resources Limited ('Aeris') engaged WMV Environmental Pty Ltd ('WMV Environmental') to prepare a "*Groundwater Technical Report*" in support of a submission for an Environmental Authority (EA) amendment for underground mining at Aeris' Barbara Copper Project (BCP).

BCP is located within Mining Lease (ML) ML90241 (Figure 1 in the Figures Section at the end of the main text) and is authorised under Environmental Authority (EA) EPML02840015 for resource activities relevant to mining metals (copper, lead, silver, zinc, gold and iron ore). The Project is an open-cut copper mine that has extracted approximately 772,000 tonnes of ore. The mine operated from June 2019 until March 2021 and was placed in care and maintenance in April 2021.

Aeris intends to expand the BCP operations to include underground mining. The existing and proposed mine features are presented in Plate 1.

1.2 Scope of work

The scope of work includes the preparation of a groundwater impact assessment, including:

- a detailed assessment of current groundwater resources, including geological and geochemical characteristics
- hydrogeological assessments, including groundwater flow characteristics, storability, hydraulic conductivity and permeability in zones that may be impacted by mining
- a description of how seepage between deep and shallow groundwater will be detected and managed
- a description of groundwater/surface water interactions
- an impact assessment that includes numeric groundwater monitoring and describes how mining may affect groundwater quality, flow regimes and drawdown, existing uses and potential future uses
- an assessment of groundwater lowering / reduction in hydraulic head and associated impacts, if relevant
- an assessment of cones of depression and their associated impacts, if relevant
- an assessment of potential contaminants and associated impacts on environmental values.

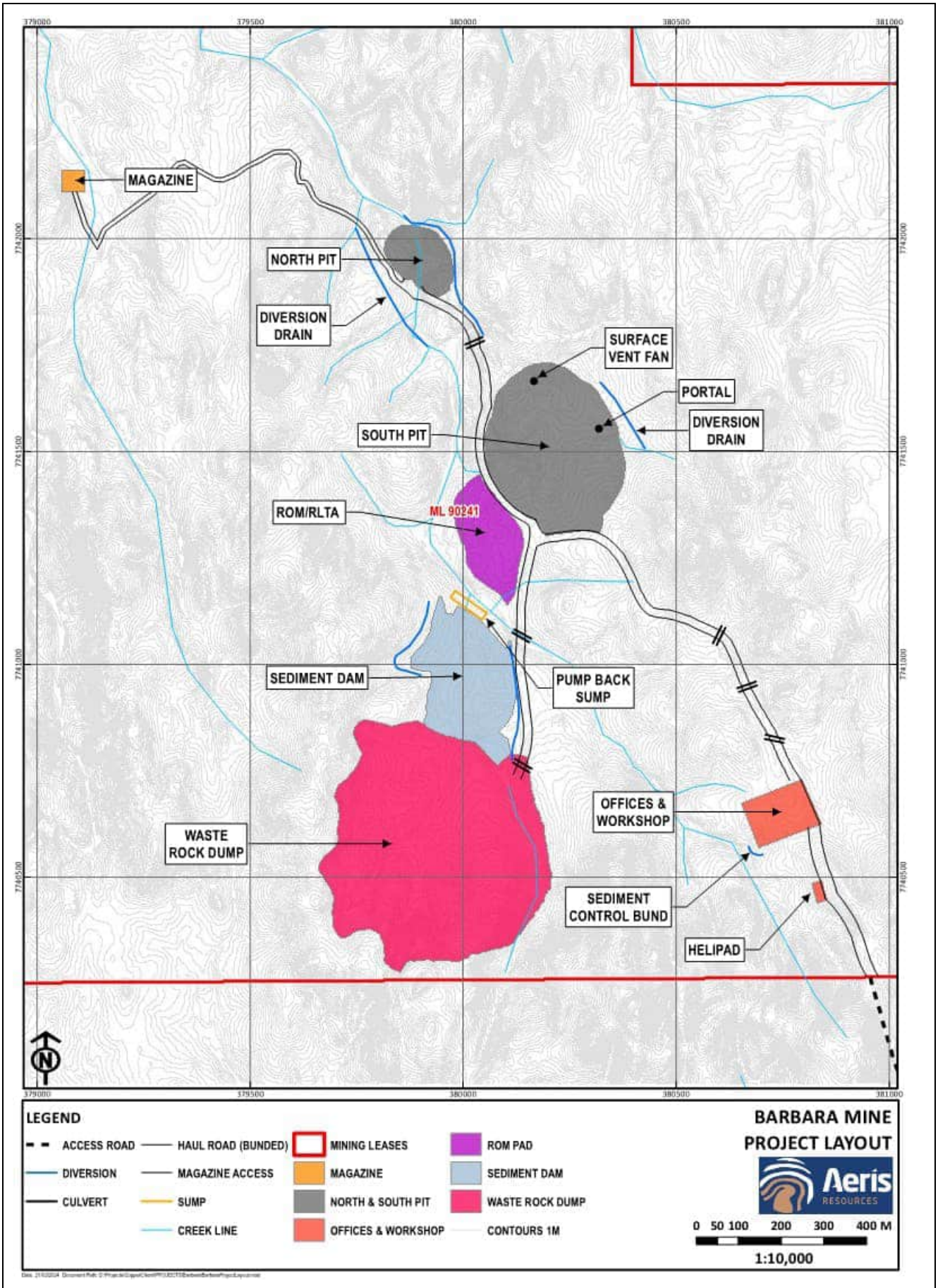


Plate 1 BCP project layout

1.3 Regulatory requirements for UG EA amendment

A pre-lodgement to discuss commencing underground operations at Barbara Copper was conducted between Aeris (as the EA holder) and the Department of Environment, Science and Innovation (DESI) on 10 November 2023.

DESI emphasised throughout the pre-lodgement that groundwater interactions and a comprehensive assessment of the groundwater network throughout the project site and surrounding areas should be provided with the EA Amendment application.

In the *Record of pre-lodgement*, issued by DESI on 10 November 2023, DESI identified the critical matters presented in Table 1.

Table 1 Pre-lodgement meeting critical matters

High risk/ concerning areas	Relevant reference documents that may assist you in addressing the critical matters	Report section(s) relevant to item
Groundwater	As discussed throughout the pre-lodgement, extensive groundwater studies and modelling should be provided with the application to demonstrate groundwater interactions and networks throughout the site and surrounds. An assessment of the implications on these networks as a result of underground mining and the proposed backfill with potentially acid forming (PAF) material and water should also be provided. The modelling should include the interactions with Design Storage Allowance (DSA) requirements, backfilling operations and the time periods associated with these. An assessment of any impacts between the PAF material returned as backfill and the water disposed of underground should be provided, with sufficient supporting information.	Section 7 Section 8 Section 9 Section 10
Surface water	An assessment of the current groundwater and surface water interactions and how these may be affected by the amendment should be provided with the application. As discussed throughout the pre-lodgement, extensive water balance models and assessments of such models, should be provided with the application.	
EA Conditions	The applicant should clearly identify any EA conditions to be amended and state what amendments to these conditions are required. Where there are existing limits imposed by the EA and no EA amendments proposed for these, the application should contain sufficient justification that the change to operations can occur within the existing limits.	Section 11

2 Environmental Authority EPML02840015

2.1 Authorised activities

BCP is located within Mining Lease (ML) ML90241 and is authorised under Environmental Authority (EA) EPML02840015, effective from 30 September 2022, (Appendix A) for resource activities relevant to mining metals (Table 2).

Table 2 BCP environmentally relevant activity and location details (EA EPML02840015)

Activity	Location
Ancillary 08 - Chemical Storage 3 - Storing more than 500 cubic metres of chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous goods class 3 under subsection (1)(c)	ML90241: MOUNT ISA CITY
Ancillary 15 - Fuel burning Using fuel burning equipment that is capable of burning at least 500kg of fuel in an hour	ML90241: MOUNT ISA CITY
Ancillary 33 - Crushing, milling, grinding or screening Crushing, grinding, milling or screening more than 5000t of material in a year	ML90241: MOUNT ISA CITY
Ancillary 63 - Sewage Treatment 1(a-i) - Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of 21 to 100EP - if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme	ML90241: MOUNT ISA CITY
Schedule 3 17 - Mining copper ore	ML90241: MOUNT ISA CITY
Schedule 3 16 - Mining gold ore	ML90241: MOUNT ISA CITY
Schedule 3 14 - Mining iron ore	ML90241: MOUNT ISA CITY
Schedule 3 19 - Mining metal ore, other than a metal ore mentioned in items 11, 12, 14, 15, 16,17 or 18	ML90241: MOUNT ISA CITY
Schedule 3 18 - Mining lead, silver or zinc separately or in any combination	ML90241: MOUNT ISA CITY

2.2 EA groundwater-related conditions

Conditions relating to groundwater are defined in Schedule E of the EA, as attached in Appendix A and provided below.

Groundwater

E8 *The holder of this environmental authority must not release contaminants to groundwater.*

E9 *The extraction of groundwater must not cause environmental harm to any groundwater dependent ecosystems.*

E10 *Groundwater quality and levels must be monitored:*

a) at the locations specified in Table E5 (Groundwater monitoring bore locations); and

b) at the frequencies specified in Table E5 (Groundwater monitoring bore locations); and

c) for the quality characteristics identified in Table E6 (Groundwater Quality Objectives).

E11 Groundwater measured from any compliance bore specified in Table E5 must not exceed the corresponding Limit A specified in Table E6 on any five consecutive sampling occasions.

E12 Groundwater measured from any compliance bore specified in Table E5 must not exceed the corresponding Limit B specified in Table E6 on any three consecutive sampling occasions.

E13 If groundwater measured from any compliance bore specified in Table E5 exceeds the corresponding Limit B specified in Table E6 on any one sampling occasion the environmental authority holder must resample the groundwater within the compliance bore for all exceeding parameters within ten business days of receipt of results.

Bore construction and maintenance and decommissioning

E14 The construction, maintenance and decommissioning of groundwater monitoring bores must be undertaken in a manner that:

a) prevents contaminants entering the groundwater; and

b) ensures the integrity of the bores to obtain representative groundwater samples from the target aquifer; and

c) maintains the hydrogeological environment within the aquifer.

E15 A bore drill log must be kept for each reference, compliance and observation groundwater monitoring bore which includes:

a) bore identification reference and geographic coordinate location;

b) specific construction information including but not limited to depth of bore, depth and length of casing, depth and length of screening and bore sealing details;

c) standing groundwater level and water quality parameters including physical parameters and results of laboratory analysis for the possible trigger parameters;

d) lithological data and stratigraphic interpretation by an appropriately qualified person to identify important features associated with groundwater monitoring; and

e) target aquifer formation of the bore.

Groundwater Management Program

E16 A Groundwater Management Program must be developed, documented and implemented by appropriately qualified persons.

E17 The Groundwater Management Program required by Condition E16 must:

a) identify potential sources of contamination to groundwater from the activity; and

b) ensure that all potential groundwater impacts due to the activity are identified, monitored and mitigated; and

c) document sampling and monitoring methodology; and

d) ensure that adequate groundwater monitoring and data analysis is undertaken to achieve the following objectives:

i. detect any impacts to groundwater levels due to the activity;

ii. detect any impacts to groundwater quality due to the activity;

iii. determine compliance with condition E11 and E12; and

iv. determine trends in groundwater quality; and

e) include an appropriate quality assurance and quality control program; and

f) include a conceptual groundwater model; and

g) include a review process to identify improvements to the program that includes addresses any comments provided by the administering authority.

E18 The Groundwater Management Program must be reviewed on an annual basis by an appropriately qualified person to determine if it continues to meet the requirements stated in condition E17.

E19 Monitoring and sampling must be carried out in accordance with written procedures and must address the requirements of the latest version of the following documents unless otherwise approved by the administering authority:

a) for waters and aquatic environments, the Queensland Government's Monitoring and Sampling Manual – Environmental Protection (Water) Policy;
b) for groundwater, Groundwater Sampling and Analysis - A Field Guide (2009:27 GeoCat#6890.1) and Australian Standard AS/NZS 5667.11:1998 Water Quality - Sampling - Guidance on sampling of groundwaters;
c) for subterranean aquatic fauna, the Guideline for the Environmental Assessment of Subterranean Aquatic Fauna.

2.3 EA groundwater monitoring program

Table 3 shows the details of the EA monitoring bores, with locations shown in Figure 2 and Figure 3. Table 4 shows the EA groundwater quality objectives. Appendix B provides the available bore construction logs.

Table 3 EA Table E5 - Groundwater monitoring locations and frequency

Monitoring Point	Location (GDA94 – Zone 54)		Surface RL (m)[1]	Total Depth (mbgl)[2]	Screened interval (mbgl)	Monitoring Frequency	
	Easting	Northing				Standing water level	Groundwater quality
Compliance bores							
BAWB05	380948	7740252	377.32	102	35-102	Monthly	Three monthly
Bore E	380022	7738827	334.23	85	28-83		
BAWB01	380432	7742097	352.68	104	20-101	Monthly	Three monthly
BAWB02	379480	7742395	310.59	104	96-102		
BAWB03	379834	7741692	329.50	104	50-102		
BAWB04	380043	7742054	329.14	100	94-100		
BAWB07	379849	7741936	328.74	127	18-146		
BAWBR1	380292	7740939	334.49	14	5-6		
BAWBR2	379912	7741279	322.98	14	2-3		
BAWBR3	379991	7741485	326.02	14	3-4		
Seepage monitoring bores							
Seepage Bore 1a	380084	7741046	336.819	6	1-5	Monthly	Three monthly
Seepage Bore 1b	380084	7741048	336.487	16	5-15		
Seepage Bore 2a	380025	7741117	331.218	6	1-5		
Seepage Bore 2b	380023	7741116	331.342	16	5-15		
Seepage Bore 3a	379985	7741133	332.189	6	1-5		
Seepage Bore 3b	379986	7741135	331.962	16	5-15		
Seepage Bore 4a	380711	7740798	355.061	6	1-5		
Seepage Bore 4b	380711	7740800	355.111	16	5-15		

Notes:

1. RL must be measured to the nearest 5cm from the top of the bore casing.
2. Metres below ground level

Table 4 EA Table E6 - Groundwater quality objectives

Contaminant[1]	Units	Limit type	Bore(s)	Limit A[3]	Limit B[4]
pH	pH	Range	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	7.0-8.5
Electrical conductivity (EC)	µS/cm	Maximum	BAWB01, BAWB02, BAWB07	1260	1365
			BAWB03, BAWB04, BAWB05, BAWBR1, BAWBR2, BAWBR3, Bore E	950	1010
Sulfate	mg/L	Maximum	BAWB01, BAWB03, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	65	73
			BAWB02	190	200
			BAWB04	16	21
Fluoride	mg/L	Maximum	BAWB02, BAWB03, BAWB04, BAWB05, BAWBR1, BAWBR2, BAWBR3	0.8	0.9
			BAWB01, BAWB07, Bore E	1.6	1.7
Arsenic	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	0.013[2]
Barium	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	0.140	0.170
			BAWB04	0.400	0.420
			BAWB05	0.2	0.3
Bismuth	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	0.0007[5]
Cobalt	mg/L	Maximum	BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	0.0014[5]
			BAWB01	-	0.0028
Chromium	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	0.001[2]
Copper	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	0.003	0.008
Molybdenum	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	0.034[2]
Nickel	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	0.011[2]

Contaminant[1]	Units	Limit type	Bore(s)	Limit A[3]	Limit B[4]
Selenium	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	0.011[2]
Uranium	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	0.006	0.007
Major cations			BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	For interpretation only	
Major anions			BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	For interpretation only	
Total Hardness			BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	For interpretation only	

Notes:

1. All metals and metalloids must be measured as 'dissolved' (from analysis of a field filtered sample)
2. Contaminant limit based on ANZECC (2000), Table 3.4.1, 95% aquatic species protection level for slightly to moderately disturbed ecosystem.
3. Derived from site-specific values, based off dissolved concentration of metals (80th percentiles).
4. Derived from site-specific values, based off dissolved concentration of metals (95th percentiles).
5. Based off ANZECC (2000) low reliability metals and metalloids, Section 8.3.7.1

Aeris installed additional seepage monitoring bores adjacent to the WRD Dam end-2022 as part of the BCP Spring/Seepage assessment. Seepage monitoring bores have been installed as paired bores at some locations, i.e. adjacent shallow (6 metres deep) and deep (16 metres deep) bores. Table 5 presents the details of all seepage monitoring bores, with locations shown in Figure 3.

Table 5 BCP seepage monitoring bores

Monitoring Point		Location (GDA94 – Zone 54)		Surface RL (m)	Total Depth (mbgl)	Screened interval (mbgl)	Date Installed
		Easting	Northing				
EA seepage monitoring bores							
1	Seepage Bore 1a	380084	7741046	336.819	6	1 - 5	Jun 2019
	Seepage Bore 1b	380084	7741048	336.487	16	5 - 15	Jun 2019
2	Seepage Bore 2a	380025	7741117	331.218	6	1 - 5	Jun 2019
	Seepage Bore 2b	380023	7741116	331.342	16	5 - 15	Jun 2019
3	Seepage Bore 3a	379985	7741133	332.189	6	1 - 5	Jun 2019
	Seepage Bore 3b	379986	7741135	331.962	16	5 - 15	Jun 2019
4	Seepage Bore 4a	380711	7740798	355.061	6	1 - 5	Jun 2019
	Seepage Bore 4b	380711	7740800	355.111	16	5 - 15	Jun 2019

Monitoring Point		Location (GDA94 – Zone 54)		Surface RL (m)	Total Depth (mbgl)	Screened interval (mbgl)	Date Installed
		Easting	Northing				
Additional seepage monitoring bores							
6	Seepage Bore 5a	379978	7740810	338.46	10	6 – 10	Dec-2022
	Seepage Bore 5b	379979	7740810	341.95	15	11 – 15	Dec-2022
7	Seepage Bore 6a	379913	7740838	337.96	10	6 – 10	Dec-2022
	Seepage Bore 6b	379912	7740840	339.66	15	11 - 15	Dec-2022
7	Seepage Bore 7a	379929	7741239	328.95	6	3.5 – 6	Dec-2022
8	Seepage Bore 8a	380021	7741146	329.45	6	3.5 – 6	Dec-2022
9	Seepage Bore 9a	380058	7741122	331.45	6	3.5 – 6	Dec-2022

3 BCP proposed underground mining

Underground mining schedule and volumes

Plate 2 presents the proposed underground mining schedule over 4 years' of mining. Plate 3 shows the cumulative void volumes generated during the underground mining.

Mining sequence is planned to be bottom up with rockfill utilised as the backfill medium. After a stope panel is completed, it is filled with waste rock and becomes the floor for the subsequent stopes above it. This mining method is commonly known as the Modified Avoca method and is utilised at other Aeris mines, including Mt Colin.

The backfill method planned for Barbara UG is development waste rock placed into completed stope voids. The waste will be temporarily moved to surface during development mining operations and will be returned UG once stoping commences. The waste balance shows that all waste generated during the Barbara underground operations will be able to be utilised as backfill. NAF material generated from the UG mining may be able to be utilised as cover material for the existing waste rock dump (WRD).

An excess of water currently exists at Barbara with both pits containing a significant amount of water. Water will be drawn from the South Pit and utilised for UG mining. Water will also be required for dust suppression on surface roads and UG. Mt Colin mine currently uses approximately 5ML of water each month but can use up to 8-10 ML per month when evaporating and using water for dust suppression. Water usage rates at Barbara are expected to be similar to Mt Colin.

The portal will be located on the initial section of the ramp located along the Eastern wall. The portal requires separation of the exhaust fan to prevent recirculation of air into the mine. The surface vent fan will be located within the footprint of the existing South pit.

Table 6 and Plate 4 show the void remaining in the mine after completion of underground mining activities. The table assumes all workings will be fully submerged after completion of mining.

Table 6 Underground void volumes after mining

Void	Volume	Overbreak	Void Ratio	Total Void	Units
Development	102000	5%	100%	107100	m³ (Cubic Metres)
Open Stopes	84000	15%	100%	96600	m³ (Cubic Metres)
Backfilled Stopes	225000	15%	30%	77625	m³ (Cubic Metres)
Total				281325	m³ (Cubic Metres)
				281.3	ML (Megalitres)

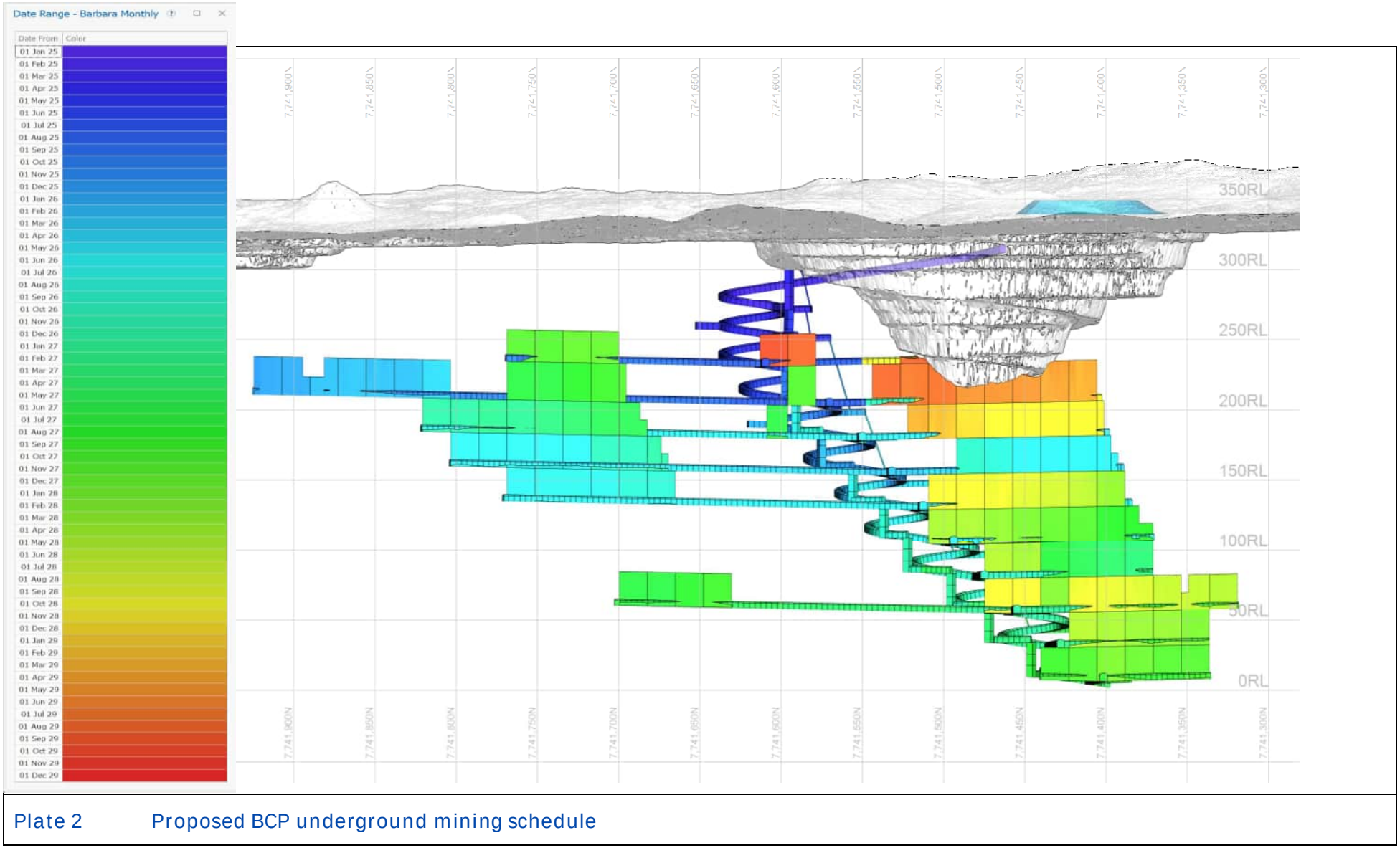


Plate 2 Proposed BCP underground mining schedule

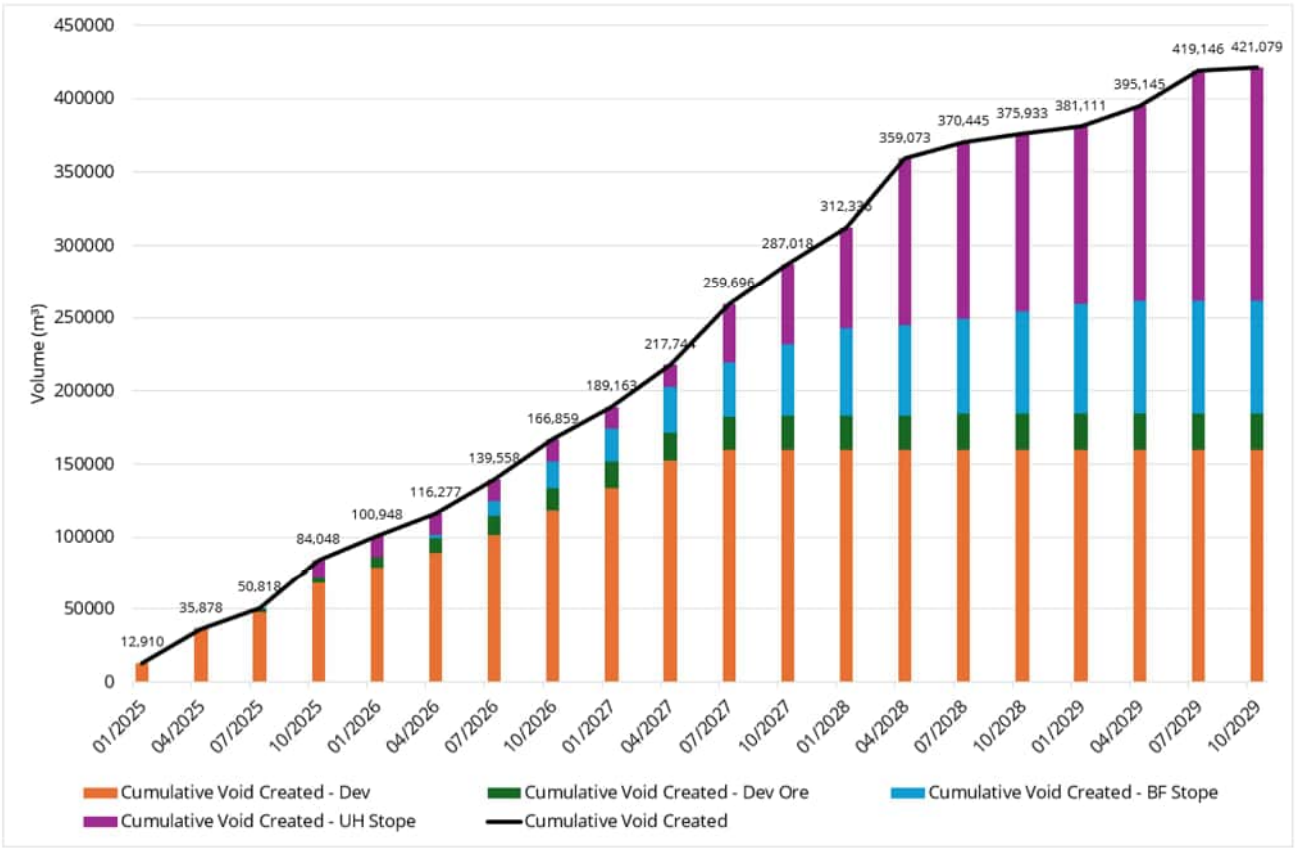


Plate 3 Cumulative underground void volumes

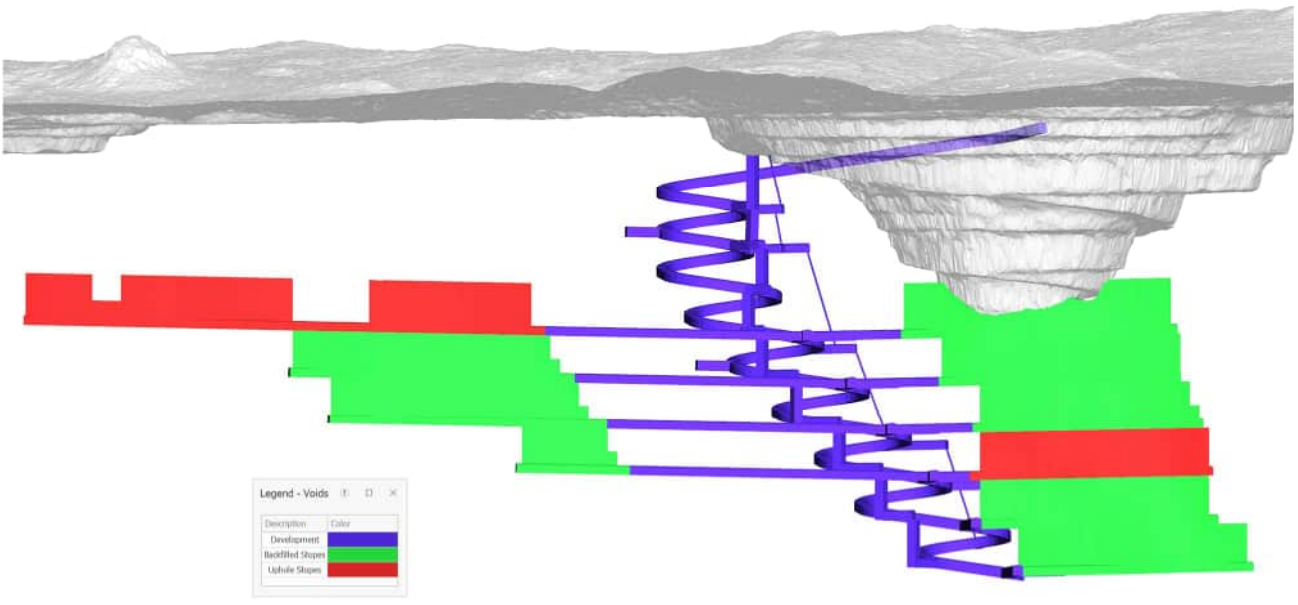


Plate 4 Underground voids after mining

Water management

The water management strategy will involve drawing down and using the South Pit water over the life of the mine with the intent to empty it to allow mining below the South Pit. The South pit requires full

dewatering to allow completion of UG mining. Methods used to reduce water levels in storage areas include:

- usage as dust suppression on roads within the mining lease
- set up of evaporation spray lines in existing water storage areas.

The North Pit can remain as water storage for the entire life of mine as the planned workings don't interact with the bottom of the pit.

Waste management

The backfill method planned for Barbara UG is development waste rock placed into completed stope voids. The waste will be temporarily moved to surface during development mining operations and will be returned UG once stoping commences.

The waste balance (Plate 5 and Plate 6) shows that all waste generated during the Barbara underground operations can be utilised as backfill. NAF material generated from the UG mining may be able to be utilised as cover material for the existing waste rock dump (WRD).

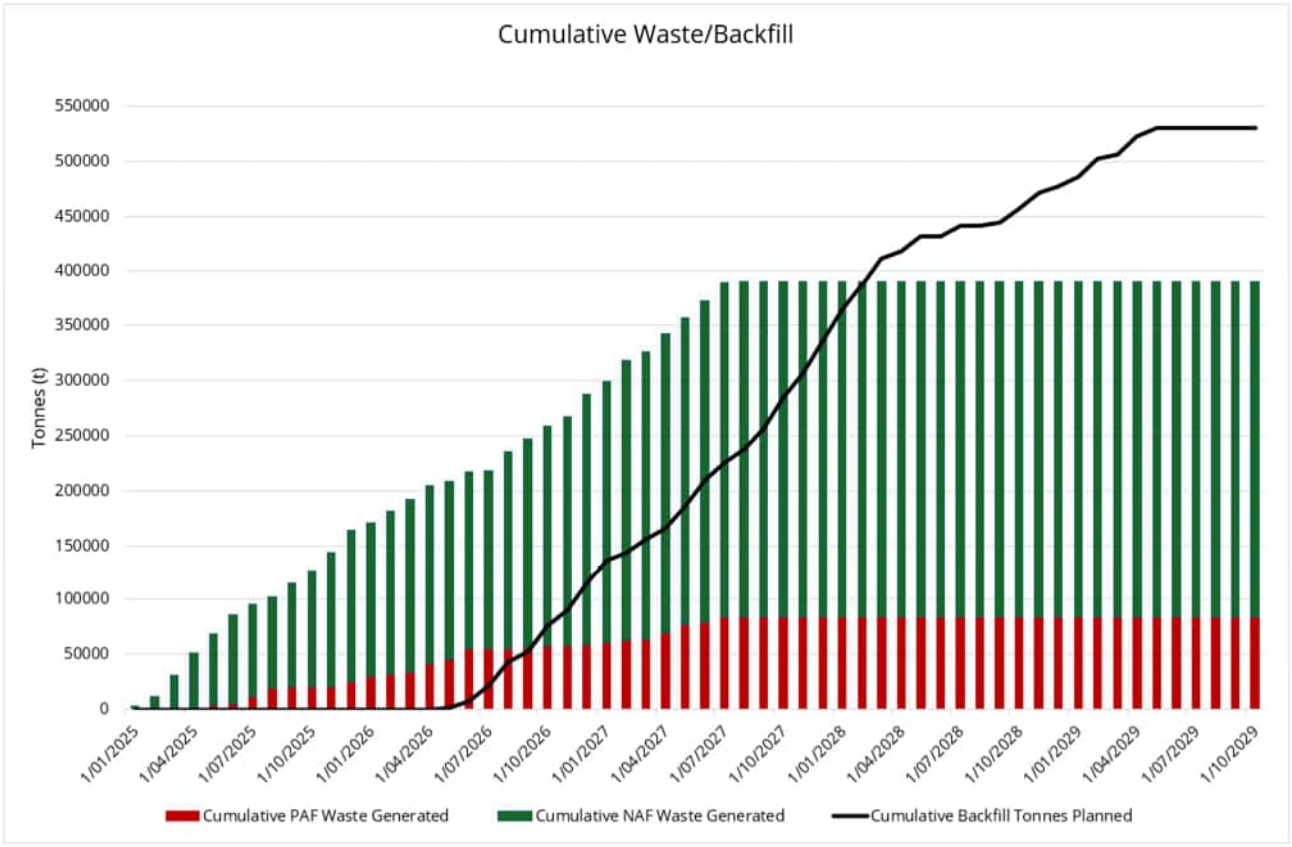


Plate 5 BCP UG mining – cumulative waste/backfill tonnage

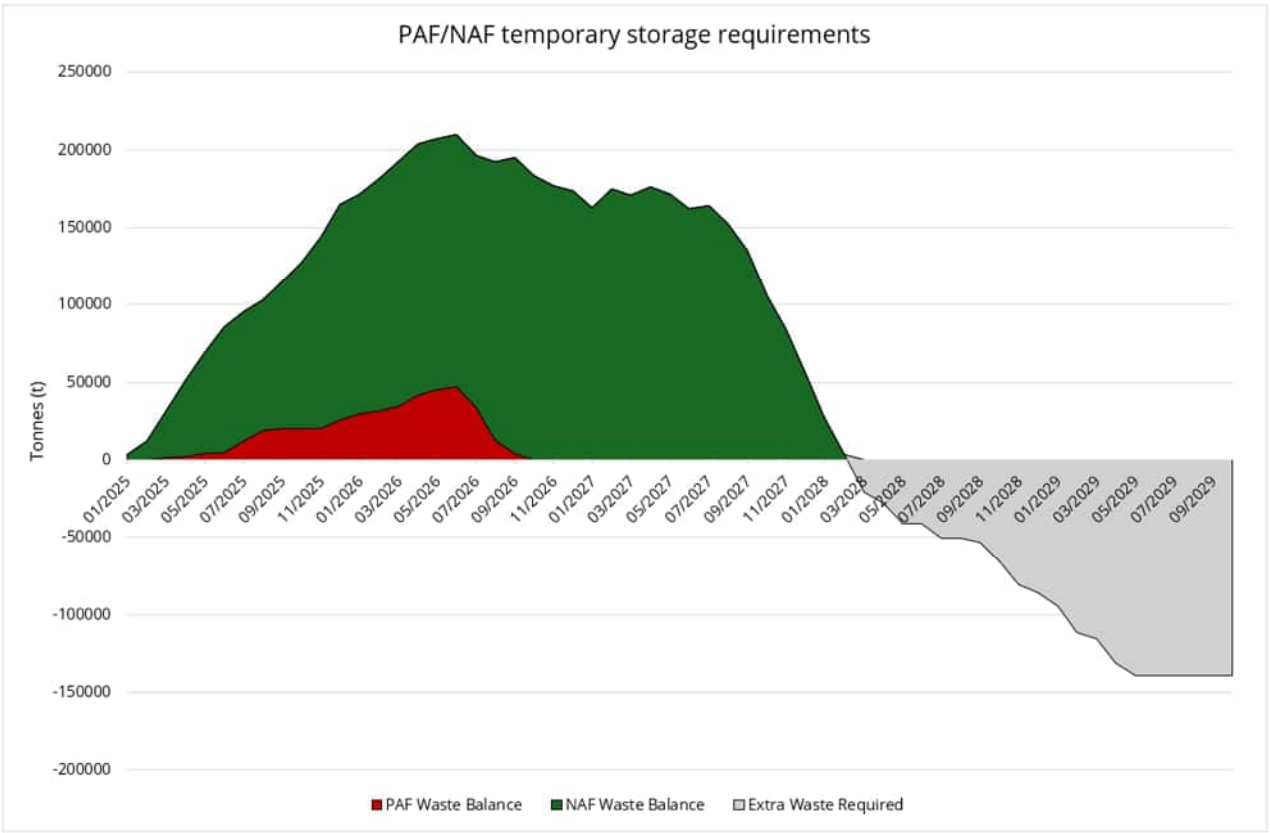


Plate 6 BCP UG mining – PAF/NAF temporary storage requirements

4 Environmental settings

4.1 Climate

Climate data for the Project site were assessed from Bureau of Meteorology (BOM) records. The nearest BOM meteorological station to the Project site is Mount Isa Airport (Station 029127). This station has data on rainfall and evaporation, key factors in assessing groundwater recharge.

Table 7 presents the station's monthly climate statistics from 1966 to 2023, with daily rainfall shown in Plate 7. The climate in Mt Isa is semi-arid to arid (Köppen Australian climate classification subtype BSh – semi-arid climate in low altitudes).

The climate of Mount Isa is governed by three main criteria: Tropical location (latitude), elevation and distance from the coast. With the Gulf of Carpentaria approximately 340km to the north and the Coral Sea 740km to the east-northeast, the climate of Mount Isa is suitably described as 'Tropical Continental' (http://www.bom.gov.au/qld/mt_isa/climate.shtml)

Three main seasons are experienced in Mount Isa:

- mild temperatures with low humidity from May to August.
- hot temperatures with low humidity from September to December.
- hot temperatures with high humidity from January to April.

Summer storms and floods dominate precipitation in the semi-arid to arid climate of Mount Isa. Evaporation is greatest in summer, with average evaporation exceeding 250 mm/month from September to April. Even in the average wettest summer months of January and February, evaporation exceeds average monthly rainfall approximately threefold. The evaporation rate is primarily temperature-related, with the highest mean monthly evaporation occurring in November and the lowest mean in June.

Climate data for BCP has been obtained from the SILO database (https://www.longpaddock.qld.gov.au/silo/point-data/) (Queensland Government, 2022). Average monthly rainfall and evaporation SILO data at BCP is presented in Plate 8.

The climate data shows the following:

- The average annual temperature is 32.1°C at Mt Isa and 33.4°C at Cloncurry. The warmest month, on average, is December, and the coolest month is June/July.
- The average annual rainfall is 459 mm at Mt Isa and 495 mm at Cloncurry.
- The highest rainfall occurs mostly in the wet summer from October/November to March.
- Monthly evaporation rates exceed rainfall every month of the year, even during the wet season. Evaporation is greatest in summer, with average evaporation exceeding 250 mm/month from September to January.

The Cumulative Rainfall Departure (CRD) from normal rainfall (Plate 9) is a concept sometimes utilised to evaluate the temporal correlation of rainfall with surface water or groundwater levels. A general analysis approach is that:

- a positive slope (upward) indicates a wetter than average period resulting in potential recharge that increases groundwater storage
- a negative slope (downward) indicates a drier-than-average period resulting in potentially limited recharge events that reduce groundwater storage. Water levels generally decline, resulting in a reduction of available drawdown and recovery rates in the boreholes.

The CRD graph in Plate 9 shows prolonged periods of below long-term average rainfall and/or negative slopes between 1920 and 1996, with an upward trend from 1996 to 2013. From 2013 onwards, the CRD trend has mainly been downwards.

Table 7 Monthly climate statistics for Mount Isa Airport station (BOM station 029127)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature													
Mean maximum temperature (°C)	36.6	35.5	34.5	32.1	28	25	24.9	27.5	31.5	34.9	36.6	37.4	32
Mean minimum temperature (°C)	23.9	23.3	21.8	18.5	13.9	10	8.7	10.2	14.2	18.6	21.5	23.1	17.3
Rainfall													
Mean rainfall (mm) for years 1966 to 2023	115.2	101.9	63.5	13.5	11.6	6.9	6.1	3.4	8.8	19.2	38.8	72	460.7
Highest rainfall (mm) for years 1966 to 2023	535.2	278.2	276.6	167.8	176.4	111.8	67.4	41.8	117	91.4	205.6	275.2	1092.4
Lowest rainfall (mm) for years 1966 to 2023	0.2	2.2	0	0	0	0	0	0	0	0	0	0	93.4
Decile 5 (median) monthly rainfall (mm) for years 1966 to 2023	75.5	85.6	39.5	1.4	1.2	0.1	0	0.4	0.3	10.4	27.3	59.2	421.2
Mean number of days of rain >= 1 mm for years 1966 to 2023	7.9	7	4.2	1.4	1.1	0.7	0.6	0.5	1	2.4	4	5.8	36.6
Mean number of days of rain >= 10 mm for years 1966 to 2023	3.2	2.9	1.7	0.4	0.4	0.3	0.2	0.1	0.2	0.6	1.3	2	13.3
Mean number of days of rain >= 25 mm for years 1966 to 2023	1.4	1.3	0.9	0.2	0.1	0.1	0.1	0	0.1	0.1	0.3	0.9	5.5
Other daily elements													
Mean daily sunshine (hours) for years 1975 to 2016	8.7	8.8	9	9.6	9.4	9.5	9.8	10.4	10.3	10	9.7	9.3	9.5
Mean number of clear days for years 1966 to 2010	6	5	10.5	13.3	16	19.8	22.3	23.1	20.1	17.9	12.1	9.3	175.4
Mean number of cloudy days for years 1966 to 2010	11.4	10.4	8	4.7	5.2	3.2	2.8	2	2.2	3.4	5.4	8.2	66.9
Evaporation													
Mean daily evaporation (mm) for years 1975 to 2016	9.6	8.9	8.9	8.3	6.4	5.3	5.5	6.9	8.9	10.5	11	10.5	8.4
9 am conditions													
Mean 9am temperature (°C) for years 1966 to 2012	28.9	27.9	27	24.5	19.8	15.9	15.2	17.8	22.6	26.8	29	29.7	23.8
Mean 9am relative humidity (%) for years 1966 to 2012	52	58	49	42	46	50	45	37	31	29	33	41	43
Mean 9am wind speed (km/h) for years 1966 to 2012	11.8	11	12	13.3	11.4	10.2	10.1	12.1	15.1	16.2	15.2	13.4	12.6
3 pm conditions													
Mean 3pm temperature (°C) for years 1966 to 2010	34.6	33.8	33.1	30.9	27	24.1	23.8	26.2	30	33.3	34.8	35.4	30.6
Mean 3pm relative humidity (%) for years 1966 to 2010	35	38	32	27	29	28	25	20	18	18	22	27	27
Mean 3pm wind speed (km/h) for years 1966 to 2010	14.3	13.9	14.3	14	12.8	13.1	13	13.8	13.4	13.8	13.8	13.6	13.6

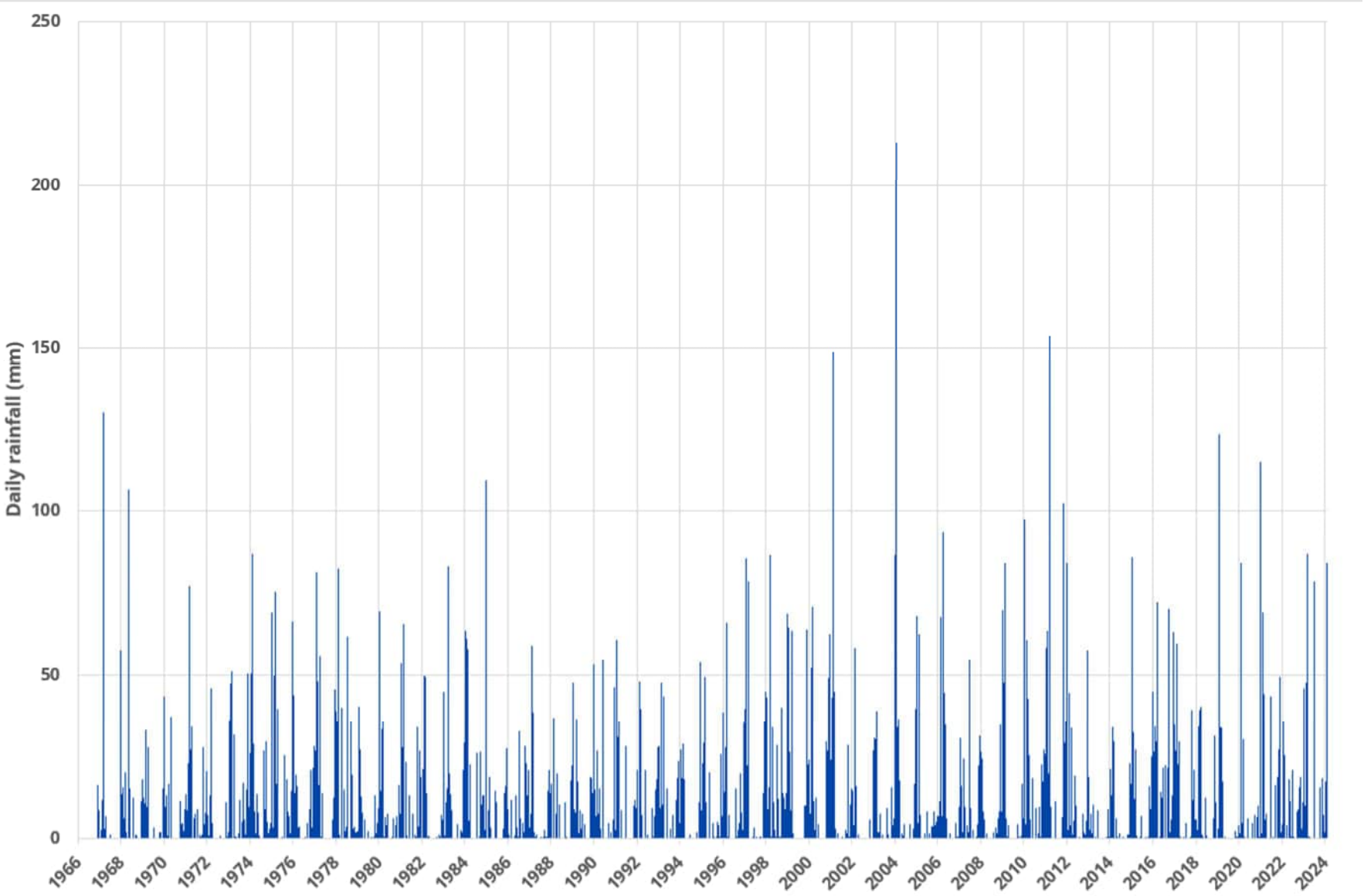


Plate 7 Daily Rainfall (mm) from Mount Isa Aero weather station 029127

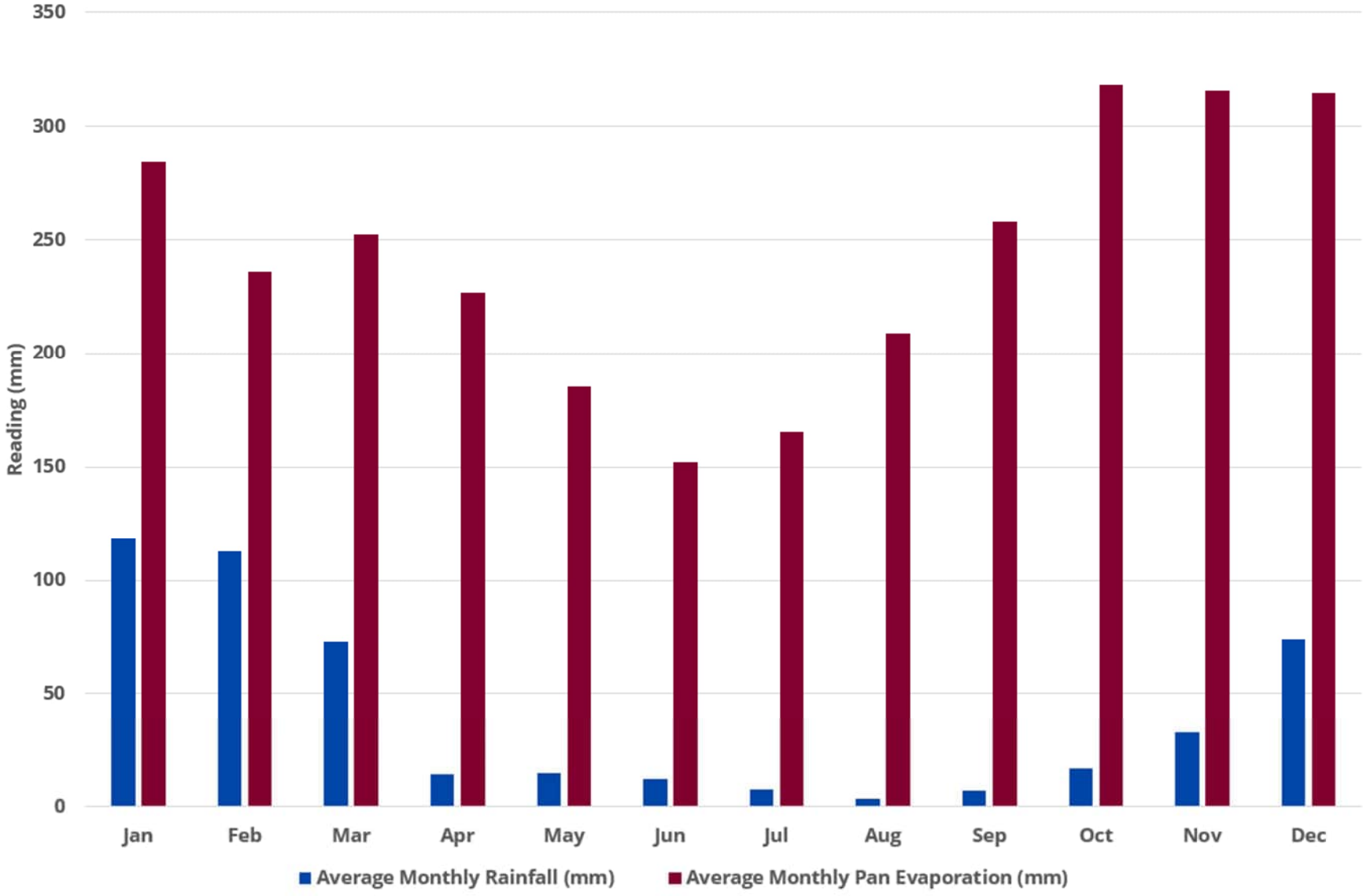


Plate 8 Average monthly rainfall (mm) and pan evaporation (mm) from SILO data

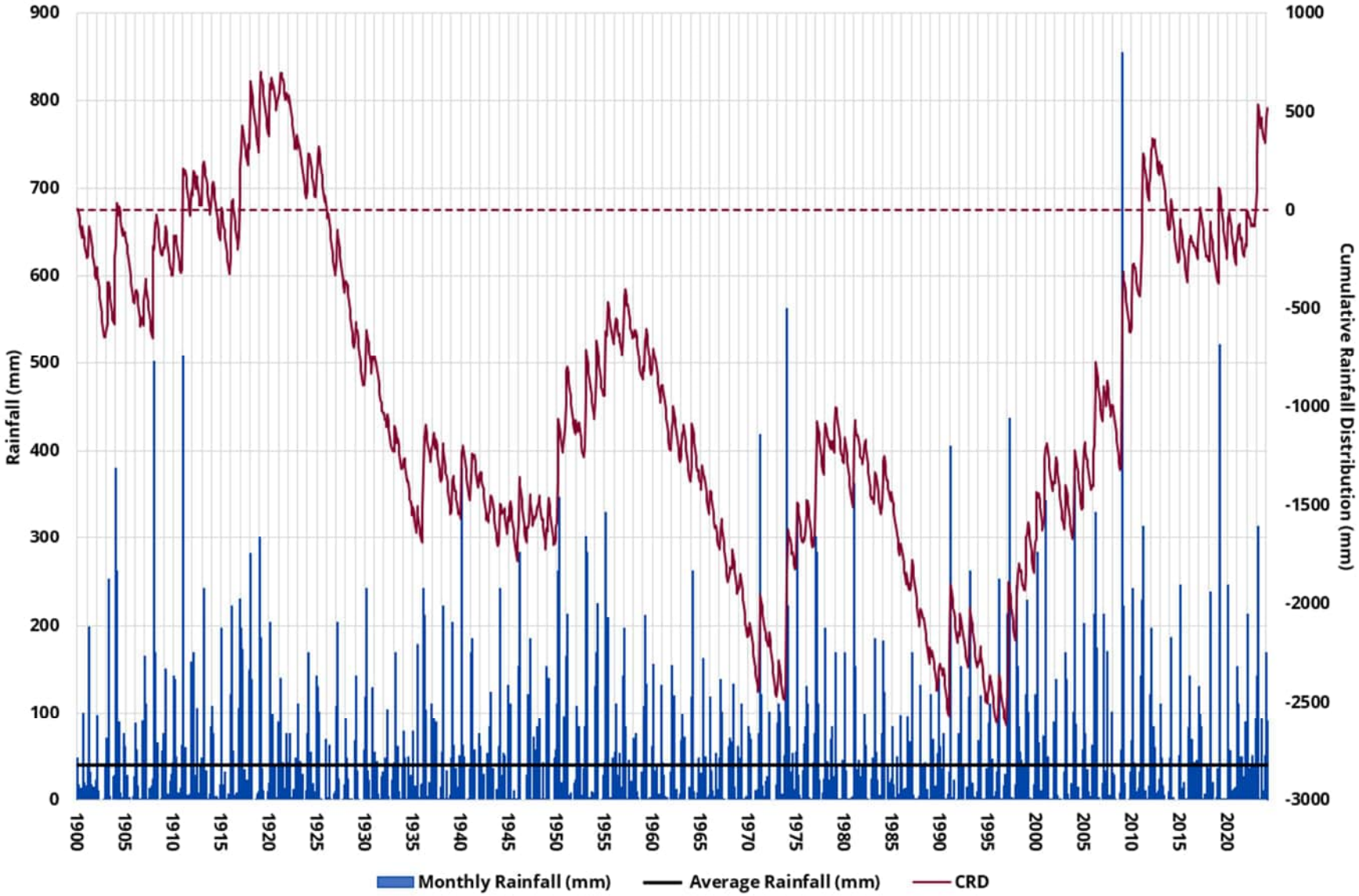


Plate 9 Cumulative Rainfall Distribution for BCP

4.2 Topography

Figure 4 shows the pre-mining 2014 topography, whilst Figure 5 shows the 2021 topography based on a LiDAR survey undertaken by ROM. Since 2021, no site operations that would significantly alter the topography have been undertaken at BCP.

The elevation at and near BCP ranges from 330 m Australian Datum Height (AHD) on the west side of the mine area to approximately 390 m (AHD) on the south side of the project area (GeoResGlobe 2022).

4.3 Geomorphology and landforms

The Project site is largely situated on rocky undulating hills and outcropping, rocky ridgelines in the Mount Isa Inlier of the northwest Highlands Bioregion (AARC, 2014b; AARC, 2014c).

Syndicated Metals Ltd (2014) describes the geomorphology and drainage characteristics at BCP as follows:

> *"There are three main landform types in the Barbara area. These are: erosional hills, ridges and plateaus, colluvial footslopes and alluvial channels. The area is dominated by exposed and subcropping Proterozoic rocks forming the hills and plateaus which dominate the landscape. Small areas of proximal colluvium are found as footslopes flanking the sides of ridges and at the base of scarps. Minimal alluvial sediments are found in immature drainage systems."*

4.4 Vegetation

Regional ecosystems

Table 8 and Figure 6 present the pre-clear regional ecosystems within BCP mapped under the *Vegetation Management Act 1999*.

Table 8 Site preclear regional ecosystems

RE	VM Act 1999 Status	Biodiversity status	RE description
12.3.10a	Endangered – Dominant vegetation	E	Eucalyptus populnea woodland on alluvial plains
12.9-10.6/ 12.9-10.2	Endangered – Dominant vegetation	E/NC	Acacia harpophylla open forest on sedimentary rocks/ Corymbia citriodora subsp. variegata +/- Eucalyptus crebra open forest on sedimentary rocks

RE: regional ecosystem

There are no identified remnant regional ecosystems at BCP.

2014 flora survey (AARC)

AARC conducted flora surveys before mining to assess vegetation communities and ecological values. Survey timing was selected per the '*Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland*' (Neldner *et al*., 2017). Seven vegetation communities were identified across the Project site, all classified as remnant vegetation. No flora species of conservation significance were found in the Investigation Area (AARC, 2014c).

A summary of the vegetation communities is provided in Table 9 and Plate 10. The following vegetation has been known to have a moderately to high dependency on groundwater:

- Eucalyptus camaldulensis
- Eucalyptus leucophloia and Eucalyptus leucophylla
- Eucalyptus persistens
- Eucalyptus normantonensis

Table 9 Pre-mining vegetation communities at BCP

Community	Description	Regional Ecosystem
1	Low Open Woodland of Snappy Gum (Eucalyptus leucophloia) on metamorphic hills	1.11.2d - Low open woodland of Eucalyptus leucophloia often with E. leucophylla, Corymbia spp., Terminalia aridicola and/or Brachychiton collinus on rock outcrops with a very sparse shrub layer of Acacia spp. and a sparse to very sparse ground layer of Triodia pungens. Occurs on steep rocky slopes and crests on metamorphosed igneous rocks.
2	Low Open Woodland of Cloncurry Box (Eucalyptus leucophylla) and Bloodwood (Corymbia terminalis) on Metamorphic hills	1.11.3 - Low open woodland of Corymbia terminalis usually with Eucalyptus leucophylla or E. leucophloia with Acacia spp. dominated shrub layer and ground layer of Triodia spp. and/or tussock grasses. Includes areas of Acacia spp. shrubland and Triodia spp. grassland. Occurs on metabasalts and dolerites; skeletal soils, some shallow loams.
3	Low Open Woodland of Cloncurry Box (E. leucophylla) on Alluvial Flats	1.3.6x1b - Floodplain (other than floodplain wetlands). Eucalyptus leucophylla woodland with a mid-dense ground layer dominated by tussock grasses. Occurs on narrow terraces.
4	River Red Gum (Eucalyptus camaldulensis) and Northern Swamp Box (Lophostemon grandiflorus) Riparian Woodland	1.3.7b - Riverine wetland or fringing riverine wetland. Fringing woodland of Eucalyptus camaldulensis, usually with Lophostemon grandiflorus and Melaleuca bracteata and/or M. dissitiflora. Occurs on recent levees and channel deposits of medium and smaller tributaries which are dry for most of the year; alluvial soils.
5	Low Open Woodland of Arid Peach (Terminalia aridicola) on Rocky Outcrops	1.11.2x4: Low open woodland of Terminalia aridicola, often with Brachychiton collinus, Alphitonia spp. and Corymbia aspera with mid-dense shrub layer of Acacia spp. and ground layer of mixed tussock grasses and Triodia spp. Occurs on rock outcrops on hills and ranges on strongly folded siliceous sedimentary and metamorphic pre-Cambrian rocks.
6	Capricornia (Corymbia Capricornia) Ridges	1.11.2x1b: Low open woodland of Eucalyptus herbertiana and/or Corymbia capricornia, mixed shrub layer and ground layer of Triodia pungens and tussock grasses. Occurs on hills on Surprise Creek Formation.
7	Low Open Woodland of Cloncurry Box (E. leucophylla) and Bloodwood (C. terminalis) on granites	1.12.1x1: Low open woodland of Eucalyptus leucophylla often with Corymbia terminalis or C. aparrerinja, shrub layer of Acacia chisholmii with hummock grass ground layer of Triodia spp. Includes areas of treeless Triodia spp. grasslands and Acacia spp. shrublands. Occurs on ranges and stony hills and rises on igneous rocks; skeletal soils and some shallow red earths.

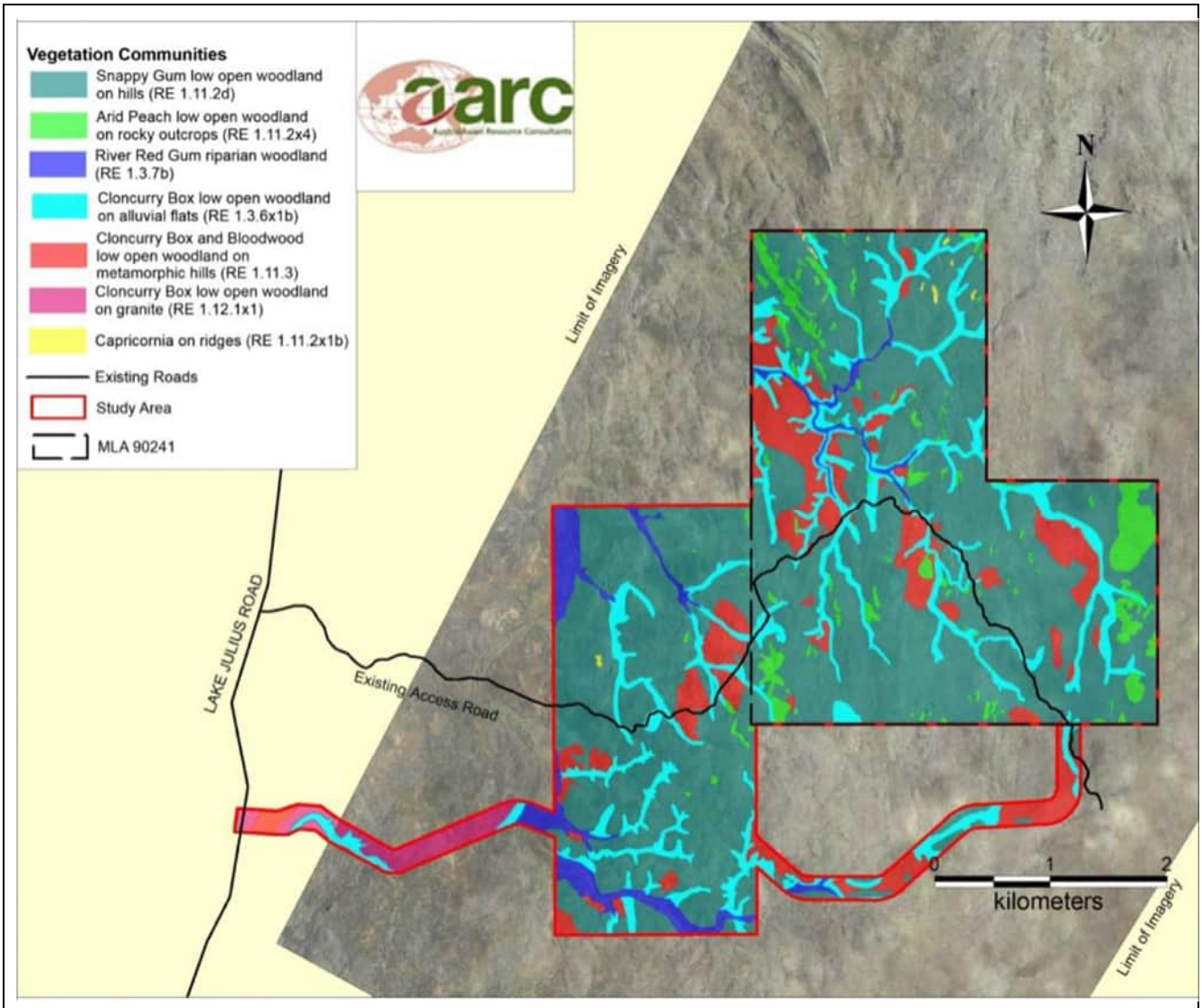


Plate 10 Pre-mining vegetation communities at BCP

4.5 Surface water and hydrology

4.5.1 Drainage basins and catchments

BCP lies within the Leichardt drainage basin, which spans an area of approximately 32,878 km^2, originating from the south of Mount Isa and draining via the Leichardt River into the Gulf of Carpentaria (AARC, 2014c).

Relevant drainage basin details are as follows:

- Drainage Division: Gulf (Division IX)
- Drainage Basin: Leichardt (Basin number 913)
- Drainage Sub-Basin: Leichardt River (sub number 9130)

Under the *Water Act 2000*, water plans are developed to sustainably manage and allocate water resources in Queensland. A water plan may apply to rivers, lakes and springs; overland flow and/or underground water.

BCP is within the *Water Plan (Gulf) 2007* water plan (State of Queensland, 2018). Relevant details are as follows:

- Water Plan Catchment: Leichardt River Catchment
- Water Plan Sub-Catchments: Upper Leichardt River sub-catchment + Lower Leichardt River sub-catchment

4.5.2 Watercourses and water bodies

Watercourses

There are no major watercourses in and near BCP. The BCP area is traversed by numerous drainage lines and ephemeral watercourses that only flow after heavy rainfall and drain into the Leichhardt River (Figure 7).

Drainages tend to drain to the northwest, down from the steeper hills in the south and through the central BCP area. Deposition of alluvium within drainage systems is minimal, and no paleochannels are present in the area.

One larger, third-order watercourse flows through the south-western and north-western areas of the BCP area. Except for one stream order 3 watercourse, all other watercourses near BCP are classified as stream orders 1 and 2. The third order watercourse passes from the east, through the south-west portion of BCP, flows west, off-site and returns through the western boundary in the north before heading off-site and draining north-west into the Leichhardt River.

All other drainage lines and tributaries at BCP drain into the third-order watercourse. The Leichhardt River eventually drains into the Gulf of Carpentaria.

Water bodies

There are no wetlands, dams, rockpools, lakes or reservoirs mapped within a 5km radius of mining lease ML90241.

Springs and groundwater seeps

In July 2021, a body of water was identified within an unnamed drainage feature at the BCP. The waterbody was approximately 450m to the north and downgradient of the waste rock dump (WRD), 100m to the north of the WRD Sediment Dam, and about 40m to the west of the run-of-mine (ROM) pad. Given the highly ephemeral nature of the watercourses within the vicinity of the project, the water body was determined to be a spring (the 'BCP Spring') at the time.

The presence of standing water downgradient of the WRD Sediment Dam was also noted at the spring location during the 2021 pre-wet season inspection conducted by the then Department of Environment and Science (DES, now DESI) on 16 August 2021. The spring was not recorded as a matter of concern during the inspection outcome letter dated 1 September 2021. DES informally requested the inclusion of the waterbody in subsequent receiving environment monitoring surveys.

Section 6.8 provides more information and discussion on the occurrence of springs/seeps within the creeks and drainage lines at and near BCP.

4.5.3 Surface water Environmental Values and Water Quality Objectives

The purpose of the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water and Wetland Biodiversity) is to achieve the object of the *Environmental Protection Act 1994* (EP Act) in relation to waters and wetlands. That is, protecting Queensland's water environment while allowing for development that is ecologically sustainable.

Environmental values (EVs) and water quality objectives (WQOs) are being progressively determined for Queensland waters. EVs define the uses of the water by aquatic ecosystems and for human uses

(e.g. drinking water, irrigation, aquaculture, recreation). WQOs define objectives for the physical, chemical and biological characteristics of the water (e.g. nitrogen content, dissolved oxygen, turbidity, toxicants, fish).

The management intent for waters is stated in section 15 of the EPP Water and Wetland Biodiversity. For waters of high ecological value, the water quality is to be maintained. For slightly disturbed waters, the water quality is to be improved where needed, to achieve the WQOs. For moderately disturbed waters, water quality is to be maintained, or improved where needed, to meet the WQOs. In highly disturbed waters, water quality is to be improved so that it achieves the WQOs.

As EVs and WQOs are established for Queensland waters in accordance with the EPP Water and Wetland Biodiversity, after approval they are included in Schedule 1. For waters not included in Schedule 1, the EVs and WQOs are respectively determined in accordance with section 6 and section 11 of the EPP Water and Wetland Biodiversity.

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) include a management framework adopted in the EPP Water and Wetland Biodiversity.

To date, no EVs or WQOs have been determined for the Leichardt River catchment.

4.5.4 Surface water quality characteristics

Section 7 provides a detailed discussions on the surface water monitoring results that are relevant for this groundwater technical report.

4.6 Soils

A Soil and Land Suitability Assessment (SLSA) was conducted by AustralAsian Resource Consultants Pty Ltd (AARC, 2014) to classify soil types, assess the suitability of topsoil material and identify potential management limitations associated with soil characteristics at the Project site.

Three broad Soil Management Units (SMU) were confirmed within the study area, dominated by moderately undulating lands with much rock outcrop and quartz gravels dominated by shallow gravel-strewn loams. Rock outcrops dominate up to 20 % of the study area, with slopes over 25% typically constituting areas of exposed rock. The SMUs are (Plate 11):

- SMU 1 - River Red Gum Sands restricted to higher-order drainage lines and ephemeral watercourses;
- SMU 2 - Cloncurry Box Drainage Terraces occurring along terraces adjacent open drainage depressions; and
- SMU 3 - Snappy Gum Slopes on steep low hills.

SMU 1 soils have a high gravel and cobble content, with abundant rounded coarse fragments and a loose surface. Finer soil material has often been removed via alluvial action, with occasional evidence of distinct depositional horizons associated with stream flow and regular and prolonged inundation. These areas are sparsely covered with surface vegetation but associated with larger river red gum and riverine species.

Soils of SMU 2 typically have lower fine gravel content but have larger (20-60+ mm) sub-rounded to rounded fragments present throughout the profile. This soil also constitutes a Tenosol classification. Within SMU 2 there is evidence of very minor areas of gully erosion associated with the ephemeral watercourses which transect SMU 2; however, soil chemistry is not strongly indicative of a predisposition to erosivity or dispersion.

SMU 3 consist of slopes of clayey sands to sandy clay loams with moderate to high gravel content (coarse fragment size: 6-20mm and 20-60mm; shape: angular) on steep low hills. These areas are

often dominated on the steeper slopes by extensive areas of rock outcrop. Slopes within the SMU vary from 0 – 20+ % with an average of 6%.

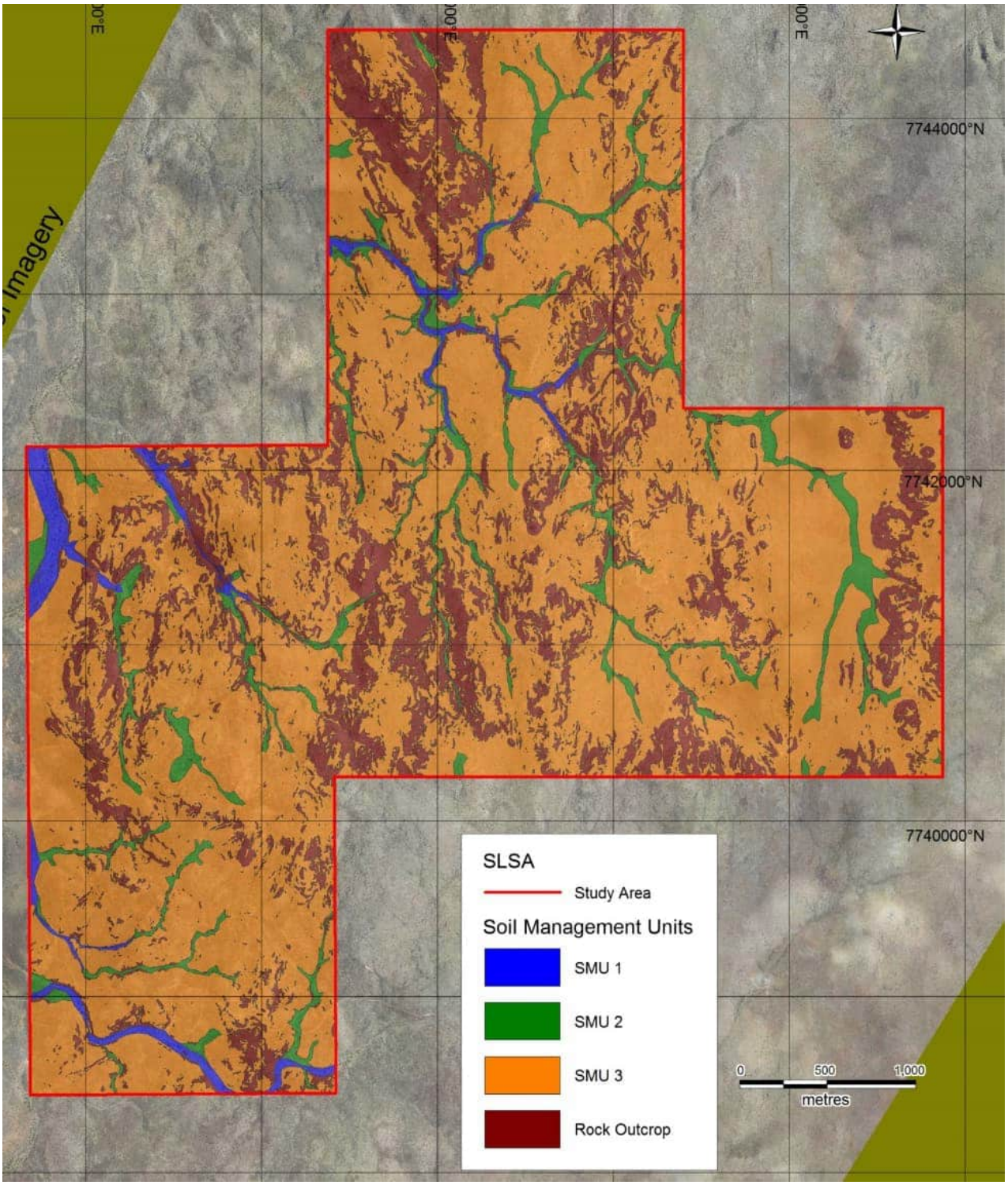


Plate 11 Distribution of soil management units within the Project area

5 Geology

5.1 Local geology

The BCP orebody at the Project site is hosted within the Leichardt Metamorphics within the Kalkadoon-Leichhardt belt of the Mt Isa Inlier. The regional geology is presented in Figure 10, which shows a segment of the *Cloncurry, Queensland 1:250,000 Geological Series map* (Department of Mines, Queensland and Bureau of Mineral Resources, Geology and Geophysics, 1983). The area is structurally complex, with structural repetition of stratigraphic units and wrench faulting common.

Syndicated Metals Ltd (August 2014) describes the local geology of the Barbara Copper Project site as follows:

> *"Bedrock geology in the area comprises Proterozoic rocks of the Mount Isa Inlier. Rock types at Barbara include felsic volcanics (forming the hills), dolerite/amphibolite (in the drainages/valleys) and basalt (forming plateaus). The felsic volcanics are the dominant rock type in the project area. The felsic and mafic volcanics dip at 60 degrees towards the northeast and the dolerites are sub-vertical within the project area. These three rock types are resistant to weathering and extensive outcrop occurs throughout the area."*

The orebody is located within what is informally termed as the Barbara Shear Zone, which is a shear-hosted deposit within the acid volcanics. The NW striking lode dips at approximately 60° to the southwest and varies from 2m to 30m true thickness.

5.2 Geochemistry

The Barbara deposit lies within the Mount Isa Inlier. The copper-gold-silver-cobalt mineralisation is structurally controlled by the Barbara Shear Zone and occurs as a series of sulfide lodes hosted within a package of felsic volcanic rocks intruded by dolerite dykes.

Sulfide mineralisation comprises semi-massive pyrrhotite/pyrite with chalcopyrite and chalcopyrite stringer veins. Two phases of mineralisation occur with a low-grade copper-cobalt phase overprinted with a later coarse-grained, chalcopyrite-gold-silver phase, forming both hangingwall and footwall zones of higher-grade mineralisation.

The copper sulphide in the area can occur close to the surface with a maximum thickness of 45 m and consists of massive sulphide through to stringer veins within an alteration zone of biotite, tourmaline and quartz. The weathering profile averages around 15 m deep.

An assessment of geochemical characteristics of waste rock and ore material at Barbara was conducted by the Environmental Geochemistry International Pty Ltd (EGI). A total of 121 drill core samples from 14 locations were analysed. Most samples representing waste had low sulphur contents and were non-acid forming (NAF) but there were some waste samples from close to mineralised zones that had elevated sulphur contents and were potentially acid-forming (PAF). Ore samples had high sulphide contents and approximately half of the ore samples tested were PAF.

The Australian Standard Leaching Procedure testing on waste rock samples showed that all of the freshly mined waste rock is expected to be alkaline, with pH values ranging between 8.6 -9.0.

On average, sulphate concentrations for PAF waste were slightly higher than for NAF waste. Other differences were relatively minor. Most extracts had trace concentrations of aluminium (median 0.19 mg/L). Still, the concentrations of copper and other environmentally important elements were low, and in most cases, the concentrations were close to, or below, the analytical detection limits. The Australian Standard Leaching Procedure testing on ore material recorded that all samples were slightly alkaline and that the concentrations of environmentally important elements were low, with the possible exception of manganese which for the ore samples exhibited a median concentration of 0.16 mg/L compared to 0.001 mg/L for the waste samples (EGI, 2014).

6 Hydrogeological settings

6.1 Water resource planning areas

The Project site is located within the *Water Plan (Gulf) 2007* (State of Queensland, 2018). The water plan applies to "underground water" that is not water to which the *Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017* (State of Queensland, 2017) applies.

The Project site is not within any groundwater management area defined within either water plan.

6.2 Registered groundwater bores

A search for registered water bores within a 5km radius of the project site was undertaken in June 2022 through the Queensland Globe. Thirty (30) registered bores were identified, with locations shown in Figure 11 and Figure 12 and relevant details in Table 10. Bore cards are attached in Appendix C. Most registered bores were mine monitoring bores, with only four bores designated as having a "water supply" role. Three "water supply" bores located within the ML are bores drilled and installed by the mining company owning the mining lease. None of these bores are currently operational for water supply pruposes nor are intended to be in the future.

Table 10 Registered water bores within 10 km of the Project site

Registered Number	Date Drilled	Original Name	Status	Latitude	Longitude	Roles	Comments
Inside ML90241							
146948	26-Jan-14	BAWB03	Existing	-20.4103073	139.848289	Mine monitoring	MT BARBARA
146949	30-Jan-14	BAWB04	Existing	-20.4160841	139.850251	Mine monitoring	MT BARBARA
146950	31-Jan-14	BAWB01	Existing	-20.424750	139.853915	Mine monitoring	MT BARBARA
146951	1-Feb-14	BAWB05	Existing	-20.4324213	139.858801	Mine monitoring	MT BARBARA
146952	2-Feb-14	BAWB02	Existing	-20.4129705	139.844879	Mine monitoring	MT BARBARA
146953	4-Feb-14	BARC071	Existing	-20.4171471	139.848477	Water supply	
146954	5-Feb-14	BARC065	Existing	-20.4191827	139.850315	Water supply	
163352	4-Oct-14	BOWBR1	Existing	-20.4261718	139.85256	Mine monitoring	SYNDICATED METALS LTD
163353	25-Sep-14	-	Abandoned and Destroyed	-20.4156453	139.842863	Mine monitoring	SYNDICATED METALS LTD
163359	4-Oct-14	BAWBR 3	Abandoned and Destroyed	-20.42122	139.849712	Mine monitoring	SYNDICATED METALS PTY LTD
163360	4-Oct-14	BAWBR 2	Abandoned and Destroyed	-20.4230761	139.848941	Mine monitoring	SYDICATED METALS PTY LTD
163369	29-Sep-14	WB ""B""	Abandoned and Destroyed	-20.4272295	139.855607	Mine monitoring	SYNDICATED METALS PTY LTD
184264	15-Jul-19	SB3A	Existing	-20.4244177	139.849621	Mine monitoring	BARBARA COPPER PROJECT
184265	15-Jul-19	SB3B	Existing	-20.4244177	139.849621	Mine monitoring	BARBARA COPPER PROJECT
184266	16-Jul-19	SB2A	Existing	-20.4245647	139.849984	Mine monitoring	BARBARA COPPER PROJECT
184267	16-Jul-19	SB2B	Existing	-20.4245647	139.849984	Mine monitoring	BARBARA COPPER PROJECT
184268	16-Jul-19	SB1A	Existing	-20.425183	139.850583	Mine monitoring	BARBARA COPPER PROJECT
184269	16-Jul-19	SB1B	Existing	-20.425183	139.850583	Mine monitoring	BARBARA COPPER PROJECT
184270	26-Jul-19	SB4A	Existing	-20.4279796	139.856802	Mine monitoring	BARBARA COPPER PROJECT
184271	26-Jul-19	SB4B	Existing	-20.4279796	139.856802	Mine monitoring	BARBARA COPPER PROJECT
184272	28-Jul-19	-	Existing	-20.4160442	139.848344	Water supply	
Outside ML90241							
37655	18-Oct-71	GOANNA HOLE	Abandoned and Destroyed	-20.4068254	139.813691	-	
163354	26-Sep-14	WBE	Existing	-20.4451634	139.849869	Mine monitoring	SYNDICATED METALS LTD
163355	27-Sep-14	WBF	Abandoned and Destroyed	-20.4469011	139.850326	Mine monitoring	SYDICATED METALS LTD

Registered Number	Date Drilled	Original Name	Status	Latitude	Longitude	Roles	Comments
163356	28-Sep-14	WBO	Abandoned and Destroyed	-20.4433479	139.859554	Mine monitoring	SYNDICATED METALS LTD
163358	3-Oct-14	-	Abandoned and Destroyed	-20.4285718	139.811664	Mine monitoring	SYNDICATED METALS PTY LTD
163368	28-Sep-14	WB ""C""	Abandoned and Destroyed	-20.4433574	139.859395	Mine monitoring	SYNDICATED METALS LTD
163370	1-Oct-14	WB ""G""	Existing	-20.3908895	139.8197	Mine monitoring	SYNDICATED METALS PTY LTD
163371	2-Oct-14	STOCK YARDS	Abandoned and Destroyed	-20.3815216	139.806405	Mine monitoring	SYNDICATED METALS PTY LTD
184209	11-Apr-14	-	Existing	-20.3627075	139.80284	Water supply	

6.3 Groundwater Dependent Ecosystems (GDE)

Information relating to groundwater-dependent ecosystems (GDEs) within and surrounding the Project site was obtained from the following sources:

- The Queensland Globe (State of Queensland, 2022) (https://qldglobe.information.qld.gov.au/).
- BOM Groundwater Dependent Ecosystem Atlas (GDE Atlas) (Commonwealth of Australia, 2022) (http://www.bom.gov.au/water/groundwater/gde/map.shtml).

The search results indicate the following:

- No GDEs were identified through the Queensland Globe within a 5km radius of the project site.
- No aquatic or subterranean GDEs were identified through the BOM GDE Atlas within a 5km radius of the Project site.
- Terrestrial GDEs identified through the BOM GDE Atlas within the 5km radius (Figure 13) are presented in Table 11. Only the low-potential terrestrial GDEs are present within ML90241.

Table 11 Terrestrial GDEs within 5km of Project Site (BOM GDE Atlas)

GDE Potential	Vegetation Type
High potential GDE - from national assessment	Eucalyptus spp. dominated open-forest and woodlands drainage lines and alluvial plains.
Moderate potential GDE - from national assessment	Eucalyptus spp. (E. leucophloia, E. leucophylla, E. persistens, E. normantonensis) low open-woodlands often with Triodia spp. dominated ground layer.
Low potential GDE - from national assessment	Eucalyptus spp. (E. leucophloia, E. leucophylla, E. persistens, E. normantonensis) low open-woodlands often with Triodia spp. dominated ground layer.

6.4 Groundwater beneficial use and environmental values

A search of groundwater bores on Queensland Globe (Section 6.2) indicates there are 30 registered bores within 10 km of the Project site, as follows:

- Twenty-five (25) of these bores are mine monitoring bores, several of which have been abandoned and destroyed.
- Five (5) bores are privately owned. However, one has been abandoned and destroyed, and two have been drilled for the Barbara Copper Project. Only two bores (RN184209 and RN184272) are genuinely private and exist.

Concerning potential beneficial use of the groundwater:

- No homesteads within the immediate vicinity of the Project area would rely on groundwater for drinking water or domestic use. However, the two private, existing bores could potentially be used for farm water supply (e.g. livestock watering or irrigation).
- The Project site is not situated near any township, and the surrounding landscape is not likely to be utilised by the public for recreational purposes.
- No aquaculture practices or industrial activities are occurring in the surrounding landscape.
- Terrestrial GDEs have been identified within 5km of the Project site.

Based on the above, groundwater environmental values applicable to the Project under the EPP Water and Wetland Biodiversity (DES, 2019) would include the following:

- Aquatic ecosystems – slightly to moderately disturbed waters – the biological integrity of high ecological value waters with slightly modified physical or chemical indicators but effectively unmodified biological indicators.
- Stock watering – suitability of water supply for the production of healthy livestock.
- Cultural and spiritual values – custodial, spiritual, cultural and traditional heritage, hunting, gathering and ritual responsibilities.

6.5 Stygofauna

Stygofauna are small aquatic invertebrates that spend their entire lives below the surface in groundwater. A pilot survey for stygofauna was conducted at the BCP and consisted of two field sampling events, sampling 10 bores in January and 9 bores in April 2014 (AARC, 2014b). Survey design and sampling were conducted in accordance with the Western Australian (WA) Environmental Protection Authority's *Environmental Assessment Guideline No. 12: Consideration of Subterranean Fauna in Environmental Impact Assessment in WA* (WA EPA 2013) and *Draft Guidance Statement 54a Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia* (WA EPA 2007).

Sampling was conducted to ascertain the presence (or absence) of stygofauna and the significance of stygofaunal communities within the zone of impact (groundwater dewatering).

The stygofauna identified during the pilot study included:

- two individuals of the Diptera taxa (stygoxenes)
- three insect species (Collembola, Coleoptera and Thysanura), although these are classified as troglobites, not stygofauna
- twelve Tubificida individuals
- two Parabathynellidae individuals.

Results indicate that the BCP site yielded a comparatively low abundance and diversity of taxa compared with other Stygofauna sampling sites across Australia. Although not represented in the area beyond the BCP site, these taxa are expected to be identified in groundwater associated with similar geological attributes likely.

6.6 Local aquifers

During the drilling of monitoring bores BAWB01 to BAWB05 and BARC07 in early 2014, the following observations were made (RLA, 2014):

- Shearing in Barbara Shear Zone is almost vertical and pervasive to several hundred metres.
- The most productive aquifer intervals are either in the orebody itself or where a combination of shearing and quartz veining occurs.
- Quartz veining is suspected to be generally massive (Michael Martin, Syndicated Metals, pers. comm.).
- Shearing is not constrained to any particular lithology because it is a shear zone.
- There is no predictable depth pattern for the occurrence of aquifer intervals. This is typical of sheared fractured rock terrain.
- Airlift yields are highly variable. This is typical of fractured rock aquifers.
- BAWB01 and BARC071 were the most productive in terms of airlift yield.
- Drilling and construction logs show no groundwater at all at depths of less than 19m below the ground surface.

- Three of the groundwater monitoring bores encountered no free groundwater at all during drilling. Two of these bores (BAWB02 and BAWB04) subsequently slowly 'made' water.

Based on the historical investigations undertaken for Syndicated Metals Ltd, the occurrence of aquifer/groundwater bearing systems can be described as follows:

- The primary aquifer occurs within the Leichardt Metamorphics, generally at the base of the weathered zone.
- Syndicated Metals (2014) has extensively investigated the regolith and has concluded that there is almost no potential for the development of regolith aquifers. There is little regolith at the Project site and no regolith aquifers are identifiable.
- Syndicated Metals (2014) reports that deposition of alluvium within drainage systems is minimal, and there are no paleochannels in the area. There is little or no potential for the development of alluvial aquifers at the Project site.

6.7 Aquifer hydraulic properties

Airlift yield testing in ore body

Five of the RC mineral exploration drill holes in the ore body were selected for airlift yield (ALY) testing (RLA, 2014). Details of the results of the airlift yield testing program are shown in Table 12, and graphs of the airlift yields against time are shown in Plate 12.

The airlift yield testing program illustrated that groundwater yield from the orebody inevitably declined as airlifting continued over two hours. The airlift yield testing program results suggest groundwater depletion of the orebody under continuous extraction (either by pumping or groundwater inflow to open pits).

Table 12 Mineral Exploration Bore Airlift Yield Test Results (RLA, 2014)

	BARC057		BARC042		BARC039		BARC065		BARC025	
Hole Depth (m)	144		162		70		126		62	
Water Level (mbgl)	20		11		9		27		2	
Time (mins)	Height above V-Notch (mm)	Flow rate (L/s)	Height above V-Notch (mm)	Flow rate (L/s)	Height above V-Notch (mm)	Flow rate (L/s)	Height above V-Notch (mm)	Flow rate (L/s)	Height above V-Notch (mm)	Flow rate (L/s)
5	66	1.6	27	0.2	40	0.5	65	1.5	30	0.2
10	65	1.5	24	0.1	39	0.4	60	1.2	26	0.2
15	65	1.5	23	0.1	39	0.4	59.5	1.2	26	0.2
20	63	1.4	22	0.1	38	0.4	59	1.2	25	0.1
25	62.5	1.4	22	0.1	38	0.4	59	1.2	24	0.1
30	62	1.3	22	0.1	37	0.4	58	1.1	23.5	0.1
35	61	1.3			37	0.4	57.5	1.1	23	0.1
40	61	1.3			35	0.3	57	1.1	23	0.1
45	60	1.2			35	0.3	56	1.0	22.5	0.1
50	60	1.2			35	0.3	55	1.0	22.5	0.1
55	59.5	1.2			34.5	0.3	54	1.0	22	0.1
60	59	1.2			34	0.3	53	0.9	22	0.1
65	58	1.1			34	0.3	53	0.9		
70	58	1.1			34	0.3	52.5	0.9		
75	56.5	1.1			34	0.3	52	0.9		
80	56	1.0			33.5	0.3	52	0.9		
85	56	1.0			33.5	0.3	51.5	0.8		
90	56	1.0			33	0.3	51	0.8		
95	55	1.0			32.5	0.3	50.5	0.8		
100	55	1.0			32.5	0.3	50	0.8		
105	54.5	1.0			32.5	0.3	49.5	0.8		
110	54	1.0			33	0.3	49	0.7		
115	54	1.0			33	0.3	48.5	0.7		
120	54	1.0			33	0.3	48.5	0.7		

	BARC057		BARC042		BARC039		BARC065		BARC025	
Hole Depth (m)	144		162		70		126		62	
Water Level (mbgl)	20		11		9		27		2	
125	54	1.0								
130	54	1.0								

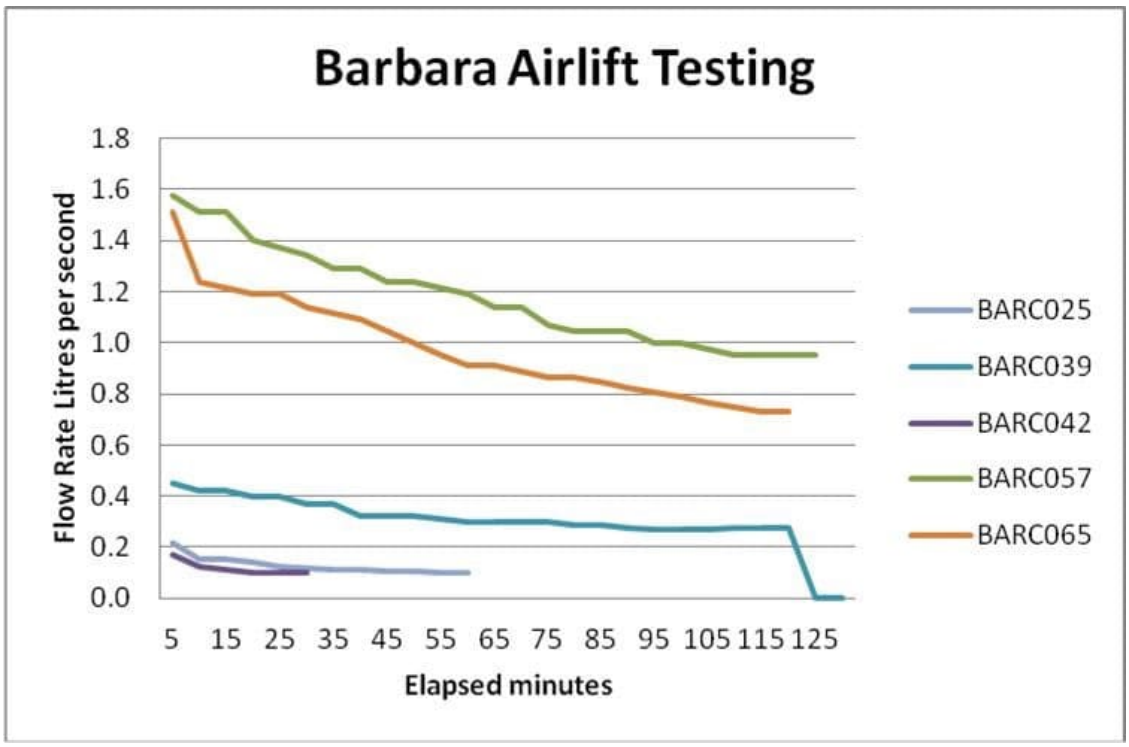


Plate 12 Airlift Yield from Mineral Exploration Bores (RLA, 2014)

Pumping Test

A pumping test was conducted on a temporary production bore installed for drilling water supply. This bore was subsequently designated BAWB07 and incorporated into the BCP's groundwater monitoring network.

Before the pumping test, the standing water level in BAWB07 was 28.79m below the top of the casing. BAWB07 was pumped at a discharge rate of 1.62 L/s. Plate 13 shows the drawdown and recovery water levels plotted against the logarithm of time for this pumping test.

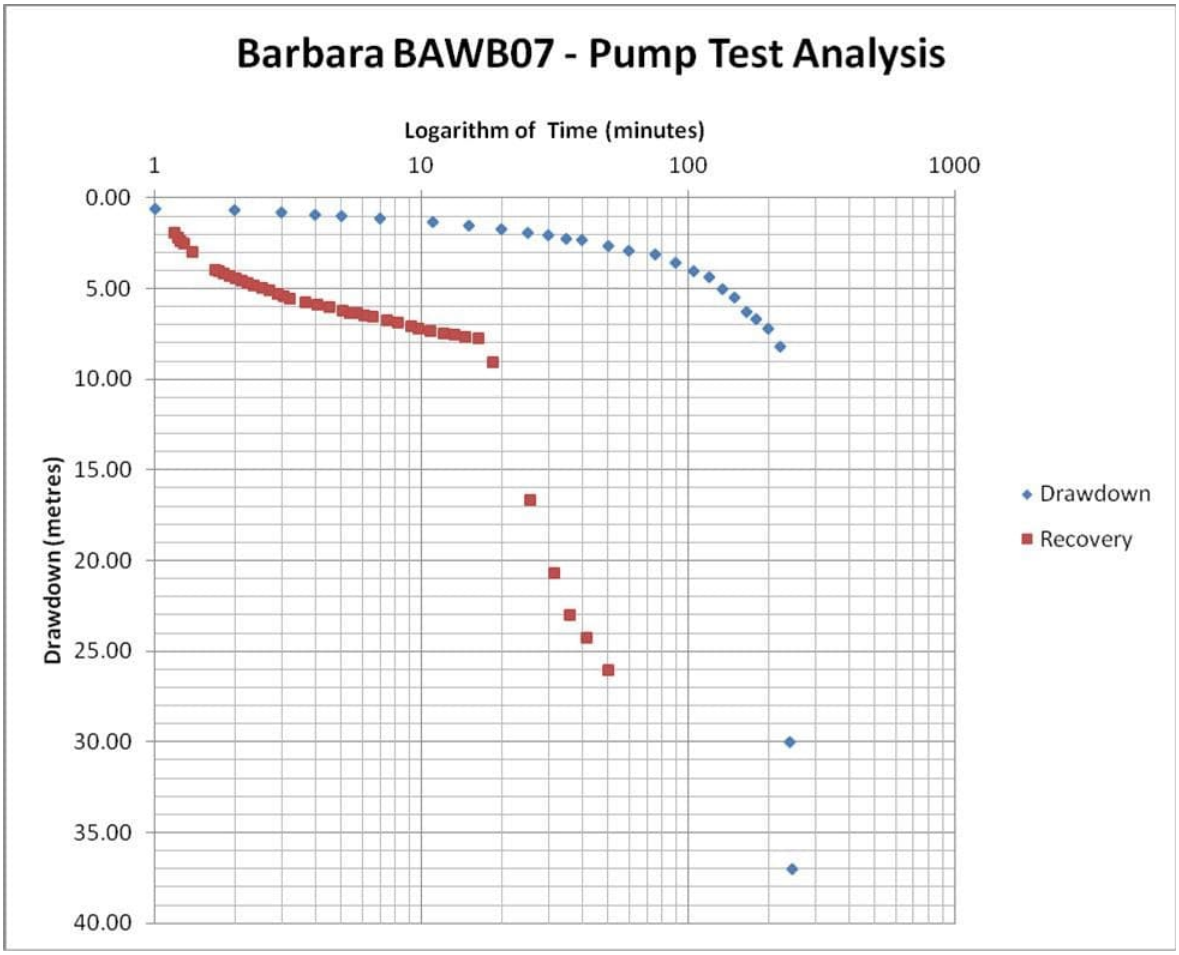


Plate 13 Drawdown and recovery water levels in BAWB07

The drawdown and recovery curves indicate that:

- A hydraulic discharge barrier was reached after a pumping time of 75 minutes. This hydraulic discharge barrier is at a depth of 31.92m in the bore.
- A second hydraulic discharge barrier was reached after a pumping time of 221 minutes when the drawdown became so great that the bore pump would have broken suction at 250 minutes. Pumping was discontinued at 245 minutes. This hydraulic discharge barrier is at a depth of 36.99m in the bore.
- Recovery from a drawdown of 37m to a drawdown of 7.75m was relatively rapid (about 10 minutes).
- Recovery from a residual drawdown of 7.75m to the original standing water level in the bore took almost 22 hours.

The results of the pumping test indicate that:

- the prime aquifer interval in BAWB07 resides in the depth interval from 28 to 37m
- once the groundwater from this aquifer interval was exhausted by pumping, there was little or no groundwater contribution from the strata at a depth of greater than 37m
- the groundwater that resided within the orebody would have been depleted once open-pit mine development commenced
- natural recharge will be slow.

Falling head permeability tests

RLA (2014) references falling head permeability tests undertaken on bores BAWB01, BAWB02, BAWB04 and BAWB05. Table 13 shows the calculated hydraulic conductivity (a term used synonymously with permeability) of the aquifer sequences in the Barbara Copper Project bores that could be tested (RLA, 2014).

Table 13 Calculated hydraulic conductivity of aquifer sequences at BCP (RLA, 2014)

Bore	k m/s	k m/d	k m/d	Qualitative description
BAWB01	9.26E-03	8.00E+02	800.00	Locally high
BAWB02	2.23E-10	1.93E-05	0.00002	Extremely low
BAWB04	2.29E-08	1.98E-03	0.00198	Very low
BAWB05	7.94E-09	6.86E-04	0.00069	Very low

6.8 Groundwater seeps/spring

In July 2021, a body of water was identified within an unnamed drainage feature at the BCP. The waterbody was approximately 450m to the north and downgradient of the waste rock dump (WRD), 100m to the north of the WRD Sediment Dam, and about 40m to the west of the run-of-mine (ROM) pad. Given the highly ephemeral nature of the watercourses within the vicinity of the project, the water body was determined to be a spring (the 'BCP Spring') at the time.

The presence of standing water downgradient of the WRD Sediment Dam was also noted at the spring location during the 2021 pre-wet season inspection conducted by the then Department of Environment and Science (DES, now DESI) on 16 August 2021. The spring was not recorded as a matter of concern during the inspection outcome letter dated 1 September 2021. DES informally requested the inclusion of the waterbody in subsequent receiving environment monitoring surveys.

Round Oak Minerals Limited ('Round Oak'), the EA holder who owned the BCP in 2021 and now is a subsidiary of Aeris Resources, initiated ongoing investigations into the BCP Spring, including sampling the spring, the WRD Sediment Dam, the Sump between the dam and the spring and the existing seepage monitoring bores.

Sample collection was undertaken to investigate:

- the quality of the water compared to that of other sampling locations in the vicinity
- the source of the BCP Spring waterbody
- the pathway(s) by which the water is transported and expressed
- any potential impacts on downstream water quality and the receiving environment,

Sampling of the BCP Spring commenced on 22 August 2021 during the 2021 dry season REMP survey. It continued in subsequent sampling events to determine the water quality characteristics of the BCP Spring and to enable comparison with groundwater and surface waters in the project vicinity. The results of the investigations were presented in Round Oak's report "*Barbara Copper Project. Initial Investigation, Spring Water Quality*", dated May 2022.

Anecdotal information and visual observations indicate that the BCP Spring waterbody exhibits a novel, non-historical habitat. However, a review of Google Earth images indicates that surface water has been present at the location of the BCP Spring before any mine development. Appendix D presents Google Earth images for different dates and an orthomosaic aerial obtained in 2021. Plate 14 shows Google Earth images for October 2015 (with surface water present at the BCP Spring) and March 2020 (with no surface water present).

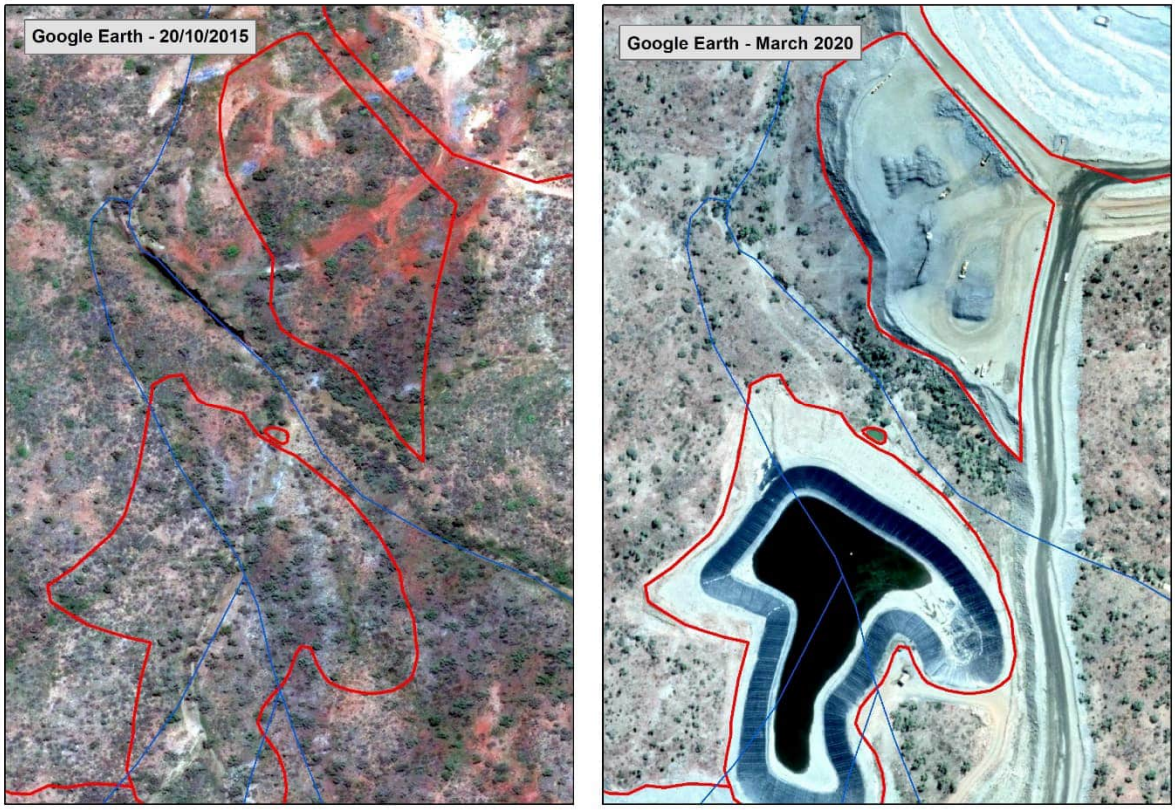


Plate 14 Google Earth images for October 2015 and March 2020

The presence of surface water in the unnamed creek at locations north of the WRD Sediment Dam on the aerials in Appendix D is presented in Table 14.

Table 14 Historical presence of BCP Spring on Google Earth images

Source	Date	Water visible?
Google Earth	31/01/2003	Yes
Google Earth	04/07/2005	No
Google Earth	09/08/2005	No
Google Earth	22/09/2006	No
Google Earth	06/12/2011	Yes
Google Earth	04/01/2013	Yes
Google Earth	03/10/2013	No
Google Earth	20/10/2015	No
Google Earth	07/03/2020	Yes
Google Earth	15/05/2020	No
Orthomosaic	01/05/2021	Yes
Google Earth	01/04/2023	Yes

Plate 15 shows the monthly rainfall measured at the Mt Isa Aero weather station from 2002 to 2022, together with the Cumulative Rainfall Departure curve and markers for the historical imagery.

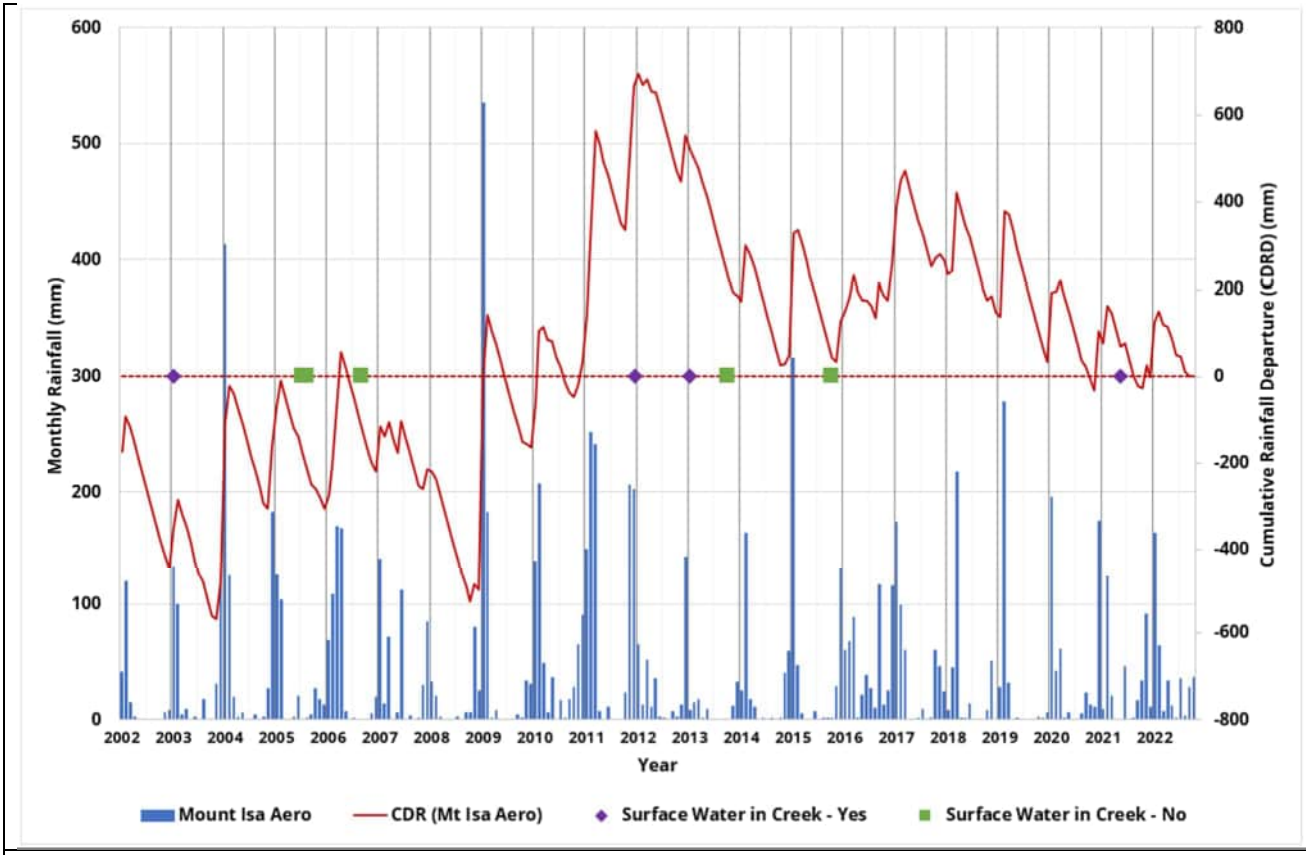


Plate 15 Monthly rainfall (2002-2022) and Cumulative Rainfall Departure

The Cumulative Rainfall Departure (CRD) from normal rainfall is a concept sometimes utilised to evaluate the temporal correlation of rainfall with surface water or groundwater levels. A general analysis approach is that:

- a positive slope (upward) indicates a wetter than average period resulting in potential recharge that increases groundwater storage
- a negative slope (downward) indicates a drier-than-average period, resulting in a potentially limited recharge event that reduces groundwater storage. Water levels generally decline, resulting in reduced available drawdown and recovery rates in the boreholes.

The overlay of the aerial imagery from Table 14 on the monthly rainfall and CRD graph in Plate 15 indicates that the presence of water within the unnamed creek at the BCP Spring generally correlates with wet weather periods and/or a positive slope in the CRD curve.

Round Oak/Aeris developed an action plan to assess the occurrence and water quality of the BCP spring. The results of this assessment are summarised in Section 7.5.

7 Surface water monitoring results

7.1 Surface water monitoring network and events

Surface water sampling and monitoring have been undertaken at BCP since 2014 as part of the following investigations or sampling events:

- In 2014, as part of the submission by Syndicated Metals Ltd and CopperChem Ltd of a site-specific application for an Environmental Authority for the Mining Lease Application (MLA) 90241. Results are provided in the report "*Barbara Copper Project. Assessment of Environmental Impacts (Site Specific EA Application) (Document reference: AEI; Version 1 dated 10/12/2014*" (Syndicated Metal & CopperChem, 2014). Sampling and monitoring were undertaken at up to 12 aquatic survey locations (AQ1 to AQ12).
- Between 2018 and 2024, as part of the receiving environment monitoring program (REMP) implemented by ROM at the Project to monitor surface water quality during wet and dry seasons over time. REMP monitoring was undertaken at up to 11 locations (B1 to B9, B1US, BCP Spring).
- Sampling at receiving water reference sites (BASW09, BASW05) and compliance monitoring sites (BASW01, BASW04, BASW08, BASW11) in accordance with the conditions of EA EPPML02840015.
- Surface water sampling by ROM as part of the BCP Spring investigations at several locations within the mine site.

Figure 8 and Table 15 show the surface water sampling locations.

Table 15 BCP surface water monitoring locations

Location ID	Type/Purpose	Location Description	Easting (GDA94 Z54)	Northing (GDA94 Z54)
Receiving environment				
B1	REMP surface water	Previously furthest upstream site prior to current infrastructure development and establishment of B1US. Adjacent to historical disturbance.	380436	7740728
B1.1US	REMP surface water	Located on a small drainage line upstream of site B1 and a confluence with the drainage feature where B1US is situated. Adjacent to historical disturbance.	380519	7740563
B1US	REMP surface water	Furthest upstream site on the main watercourse. Upstream of historical activities.	380677	7740482
B2	REMP surface water	Approximately 1.8km downstream from B1 on the main watercourse. Downstream of historical disturbance.	379678	7742242
B3	REMP surface water	Eastern tributary of the main watercourse. Upstream of historical disturbance.	379897	7742670
B4	REMP surface water	On the main watercourse, below the confluence of the eastern tributary. Approximately 370m downstream of B2. Downstream of historical disturbance.	379398	7742448
B5	REMP surface water	Southern tributary of the main watercourse. Upstream of historical disturbance.	379136	7741925
B6	REMP surface water	Eastern tributary of the main watercourse. Upstream of historical disturbance.	379089	7743128
B7	REMP surface water	On the main watercourse, below the confluence of all tributaries. Approximately 1.3km downstream of B4. Downstream of historical disturbance.	378660	7743261
B8	REMP surface water	Previously furthest downstream site prior to establishment of B9. Approximately 1.6km downstream of B7. Downstream of historical disturbance.	377326	7743786
B9	REMP surface water	Furthest downstream site on the main watercourse, positioned approximately 500m east of Lake Julius Road and 3.1km downstream of B8. Downstream of historical disturbance.	374831	7744106
EA EPML02840015				
BASW09	EA receiving waters reference site	Drainage feature outside and northeast of disturbance footprint catchment	377540	7738673
BASW05	EA receiving waters reference site	Drainage feature southwest and outside of disturbance footprint catchment	380736	7742273

Location ID	Type/Purpose	Location Description	Easting (GDA94 Z54)	Northing (GDA94 Z54)
BASW01	EA receiving waters compliance site	Watercourse at Mining Lease west boundary	378513	7743286
BASW04	EA receiving waters compliance site	Watercourse downstream of North Pit	379491	7742440
BASW08	EA receiving waters compliance site	Drainage feature at the top of the catchment (Mining Lease entry)	380776	7740396
BASW11	EA receiving waters compliance site	Drainage feature upstream of the junction with watercourse	379884	7742685
Mine site monitoring				
BCP North Pit	Open Pit	Barbara North Pit	379907	7741954
BCP South Pit	Open Pit	Barbara South Pit	380222	7741506
BCP Spring	Spring	Additional site added per DES request. Located ~730m downstream of B1. Site is adjacent to the current mining infrastructure and disturbance.	379947	7741249
BCP Spring (N)	Spring	-	379954	7741241
BCP Spring (S)	Spring	-	380085	7741125
Pooled water S of sediment dam	Pooled water S of sediment dam	-		
Sediment Dam	Sediment Dam	-	380005	7741050
Seepage	Seepage	-		
Sump	Sump	-	380014	7741134

As EVs and WQOs have not yet been determined under the EPP Water and Wetland Biodiversity, the surface water quality data has been assessed against one or more of the following guidelines (depending on the time and purpose of the sampling):

- Australian and New Zealand Environmental Conservation Council (ANZECC & ARMCANZ, 2000) tropical Australia upland streams guideline values were used for pH, turbidity, and dissolved oxygen (DO)
- QWQG (EHP, 2009) regional guideline values for the Gulf Rivers – upland streams – Gulf salinity zone for electrical conductivity (EC)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) default guideline values (DGV's) for heavy metals (recognised as toxicants in ANZG) for the protection of slightly to moderately disturbed systems (95% protection for aquatic organisms) for total and dissolved metals.
- The receiving water trigger levels and water quality objectives, as shown in EA EPML02840015.

7.2 2014 surface water monitoring (AARC, November 2014)

Physicochemical water quality was moderately poor. pH values were slightly alkaline and above the ANZECC aquatic ecosystems guideline range at several sites (AQ1 in the wet season, AQ4, AQ7, AQ8, AQ11). Conductivity levels were high in the dry season, with all sites exceeding the ANZECC guideline. Site AQ4 recorded conductivity levels above the ANZECC guideline in the wet season. Dissolved oxygen levels were low and below the ANZECC guideline range at most sites (AQ1 in the dry season, AQ2, AQ4, AQ6, AQ7, AQ11, AQ12). The high pH and conductivity values and the low DO levels recorded are typical of stagnant, ephemeral waterbodies.

Nutrient levels (i.e. total nitrogen and total phosphorus) exceeded the ANZECC guidelines at all sites in both surveys. These high results are likely attributable to natural factors, as no artificial nutrient sources (such as fertilisers and sewage) are present in the Investigation Area. Nitrogen sources include decaying organic matter and animal waste. Phosphorus is found in rocks and soil and is released into water through weathering and erosion. Animal and plant wastes are also a source of phosphorus. Nutrient levels tend to be high in ephemeral waterbodies, due to concentration from evaporation.

Metals levels in water were generally below the ANZECC guideline limits, with a few exceptions. In the wet season, total and dissolved silver (at AQ4, AQ6 and AQ7), total and dissolved copper (at all sites), total zinc (AQ8), total and dissolved aluminium (at AQ4, AQ7 and AQ8) and dissolved aluminium at AQ1 were above ANZECC aquatic ecosystems guidelines. Metal results were similar in the dry season, with total and dissolved copper (at AQ1, AQ8 and AQ11), total copper (AQ12), total and dissolved manganese (AQ12), total aluminium (AQ11 and AQ12) and total zinc (AQ11 and AQ12) exceeding the ANZECC guidelines. Copper, zinc and aluminium are naturally abundant elements, and their elevated levels are likely to be the result of mineralisation in the Project region. High silver levels are also likely to be attributable to local geology. High manganese levels were detected only at site AQ12. Manganese is an abundant metal in soil, and it is possible that trampling of the soft, sandy bed at AQ12 by cattle increased manganese levels at this site. No breaches of the Livestock Drinking Water guidelines were detected.

7.3 2022 REMP monitoring results

REMP surface water monitoring results are provided in the annual REMP reports submitted to DESI by Aeris Resources. The results of the 2022 REMP monitoring can be summarised as follows (SLR Consulting, 2022):

- In terms of surface water and stream sediment quality, REMP sites were generally in a good condition (with few parameters exceeding the GVs) over both the 2022 wet and dry season surveys; however, copper concentrations in both surface water and stream sediment samples were elevated above the published guideline values at some of the upstream and downstream sites.
- Comparisons of temporal downstream surface water data suggest that total and dissolved copper concentrations have fluctuated since the commencement of the REMP. A large increase in total copper concentrations was observed in water samples from site B8 during the 2022 dry season survey. Due to the ephemeral nature of watercourses within the BCP receiving environment, upstream and downstream surface water data has been infrequently collected. The confounding factors of historical mining activities, a naturally mineralised local landscape and current mining infrastructure make interpretation of downstream data in regard to mining related influences difficult. It is unknown if the Barbara project has contributed to the metal concentrations recorded at downstream sites.
- Stream sediment results from upstream site B1US should be interpreted with caution as the site is dominated by topsoil (rather than stream sediments) and may not be representative or comparable to other REMP sites. Whole and fine sediment fraction copper and nickel concentrations at upstream and downstream sites during the 2022 wet and dry season surveys are generally elevated above the ANZG guideline values. Fine fraction copper concentrations at downstream sites B2 and B4 were elevated above the ANZG GV-High during the 2022 survey(s) and higher compared to reference sites (excluding B1US). Exceedances of fine and/or whole fraction nickel concentrations were recorded at both upstream and downstream sites. Overall, elevated metal concentrations are likely caused by natural mineralisation in the local area; however, downstream site B2 may be influenced by confounding factors of historical mining, natural mineralisation and current mining activities. It is unknown to what degree each factor attributes to the high concentrations recorded at B2 and further investigation may be warranted.
- Macroinvertebrate indices at REMP sites have varied over time and generally improved at both upstream and downstream sites, with microhabitat quality and macroinvertebrate diversity likely being the biggest drivers for this variation. The high concentrations of total copper in surface water samples, and copper and nickel in the fine sediment fraction at REMP sites (which are more bioavailable than whole fraction sediment concentrations or total metal concentrations in water) do not appear to be having a detrimental effect on macroinvertebrate communities at these sites. It is recommended that macroinvertebrate sampling continue to be conducted, with the intention of establishing a robust dataset to enable more informed spatiotemporal comparisons of the BCP receiving environment.

In addition to the REMP monitoring, Aeris Resources also undertakes surface water sampling at the EA receiving waters reference and compliance monitoring sites in accordance with the requirements of EA EPML02840015.

7.4 REMP and EA surface water quality results

Appendix E provides relevant data, charts and plots, with:

- Appendix E.1: data tables
- Appendix E.2: time series of selected parameters
- Appendix E.3: box & whisker plots
- Appendix E.4: hydrogeochemistry plots

7.4.1 Hydrogeochemistry

Surface water samples were analysed for major ions and alkalinity to allow for hydrogeochemical analysis. Piper, Durov, Chadha and Gibbs diagrams for the REMP and EA surface water sample locations are presented in Appendix E.

Based on the ionic composition of the water samples and interpretation of the diagrams, the surface water at these sites can be classified as per Table 16.

Table 16 Water-type classification of REMP and EA surface water sampling locations

Location	Piper diagram water type	Durov diagram classification
B3	• Mixed Ca-Na-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.
B4	• Mixed Ca-Na-HCO3	• 6: SO4 and Na are dominant. Water type is not frequently encountered and indicates probable mixing or uncommon dissolution influences.
B6	• Mixed Ca-Na-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.
B7	• Mixed Ca-Na-HCO3	• 3: HCO3 and Na are dominant, indicates ion exchange water.
B8	• Ca-Mg-HCO3 • Mixed Ca-Na-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed. • 3: HCO3 and Na are dominant, indicates ion exchange water.
B9	• Ca-Mg-HCO3 • Mixed Ca-Na-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.
BASW01	• Ca-Mg-HCO3 • Mixed Ca-Na-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed. • 3: HCO3 and Na are dominant, indicates ion exchange water. • 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing.
BASW04	• Ca-Mg-HCO3 • Mixed Ca-Na-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.
BASW05	• Ca-Mg-HCO3 • Mixed Ca-Na-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.

Location	Piper diagram water type	Durov diagram classification
		• 1: HCO3 and Ca dominant; frequently indicates recharging waters in limestone, sandstone and many other aquifers.
BASW09	• Ca-Mg-HCO3 • Mixed Ca-Na-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed. • 3: HCO3 and Na are dominant, indicates ion exchange water.
BASW11	• Ca-Mg-HCO3 • Mixed Ca-Na-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed. • 3: HCO3 and Na are dominant, indicates ion exchange water.

The ionic composition of the surface water samples obtained from the REMP and EA surface water monitoring locations indicates the following:

- Water type is predominantly mixed calcium-sodium-bicarbonate and/or calcium-magnesium-bicarbonate.
- Ion exchange processes predominantly define ionic composition.
- Ionic composition is influenced mainly by rainfall events and interaction between surface water and underlying, mineralised geology, as demonstrated by the Gibbs diagrams in Appendix E. Water types are generally consistent at all sampled locations, with no apparent difference between background (BASW09 and BASW05) and downstream (e.g. BASW04, B7) locations.
- There is no evidence that external factors (e.g. water runoff from the mine site) have affected the ionic composition at the sampled locations.

7.4.2 REMP and EA surface water quality results

Table 17 presents the range of analysis results above the LOR for selected analytes/parameters at the sampling locations. A summary of exceedances of the EA receiving water trigger levels and WQOs and the ANZG 2018 DGVs for protecting aquatic (slightly to moderately disturbed) ecosystems is presented in Table 18, Table 19 and Table 20, respectively.

The data and information indicate the following:

- Exceedances of the EQ receiving water trigger levels and WQOs and the ANZG aquatic ecosystem (slightly to moderately disturbed) protection DGVs have occurred before, during and after the open-cut mining. Generally, where an exceedance for a given analyte was identified post-mining, exceedances for the same analyte existed pre-mining or during mining.
- The time series graphs indicate that there is generally no increasing trend in analyte concentration with time, from before to during to post-mining. There may be some seasonal variations related to seasonal rainfall/storm events.
- The box & whisker plots show the natural variability of analyte concentrations at a given monitoring location.

The data and information provide no evidence that the mining operations have adversely impacted the water quality at these monitoring locations.

Table 17 Range of analysis results above the LOR at the REMP/EA surface water monitoring locations

Parameter	B3	B4	B6	B7	B8	B9	BASW01	BASW04	BASW05	BASW08	BASW09	BASW11
Alkalinity												
Bicarbonate Alkalinity as CaCO3 (mg/L)	74 - 200	460 - 460	130 - 220	130 - 560	100 - 740	160 - 300	24 - 242	40 - 499	23 - 295		17 - 824	27 - 407
Total Alkalinity as CaCO3 (mg/L)	74 - 200	460 - 460	130 - 220	150 - 560	100 - 740	160 - 300	24 - 242	40 - 531	23 - 295		17 - 824	27 - 407
Field Measurements												
Dissolved Oxygen (field) (% sat)							0 - 53.4	4.8 - 179.6	0 - 72.6	48.4 - 48.4	0 - 163	0 - 122.3
Electrical Conductivity (field) (µS/cm)							60 - 1293	126 - 1293	79 - 1027	1305 - 1305	49 - 1723	54 - 994
ORP (field) (mV)							22.2 - 185.8	1.8 - 168.4	-133.6 - 231.7	-21.1 - -21.1	-45.8 - 170	-16.2 - 216.1
pH (field)							5.87 - 8.61	6.78 - 8.89	5.34 - 8.63	9.09 - 9.09	6.6 - 9.52	5.95 - 9.09
Salinity (field) (PSU)							0.03 - 0.65	0.06 - 0.65	0.04 - 0.51	0.65 - 0.65	0.02 - 0.87	0.02 - 0.49
TDS (field) (ppm)							30 - 647	63 - 647	40 - 514	653 - 653	0.07 - 861	27 - 497
Temperature (field) (°C)							15 - 34.13	22.09 - 35.99	15.31 - 28.99	20.94 - 20.94	20.77 - 34.84	16.2 - 34.22
Turbidity (field) (FNU)							12.8 - 54.8	4 - 170	0 - 272	97 - 97	7.3 - 147	9.5 - 170
Hardness												
Total Hardness (mg CaCO3/L)	26 - 110	270 - 270	55 - 110	62 - 240	57 - 310	82 - 190	16 - 126	30 - 312	18 - 165		9 - 402	18 - 226
Major Ions												
Calcium (mg/L)	6 - 19	40 - 40	12 - 26	15 - 38	15 - 73	19 - 36	3 - 19	7 - 66	4 - 37		2 - 44	4 - 36
Chloride (mg/L)	7 - 34	110 - 110	10 - 28	12 - 97	7 - 60	7 - 76	2 - 30	4 - 86	2 - 27		1 - 111	3 - 70
Fluoride (mg/L)	0.1 - 0.3	0.5 - 0.5	0.1 - 0.1	0.2 - 0.4	0.1 - 0.4	0.1 - 0.1	0.1 - 0.3	0.1 - 1.6	0.1 - 0.2		0.1 - 0.5	0.1 - 0.6
Magnesium (mg/L)	2.7 - 14	42 - 42	5.7 - 13	6.1 - 34	4.9 - 30	8.5 - 25	2 - 19	3 - 49	2 - 21		1 - 76	2 - 33
Potassium (mg/L)	3.6 - 12	9 - 9	4.1 - 5.5	5.6 - 9.9	7 - 160	8.7 - 13	2 - 21	4 - 20	2 - 60		3 - 70	2 - 32
Sodium (mg/L)	15 - 66	270 - 270	22 - 56	32 - 230	17 - 140	19 - 98	4 - 93	4 - 212	2 - 57		1 - 234	3 - 145
Sulfate (as SO4)	1.9 - 12	230 - 230	1.2 - 3.8	8.9 - 66	2.6 - 37	2 - 34	4 - 44	1 - 55	1 - 6		2 - 30	1 - 27
Metals (dissolved)												
Aluminium - dissolved (mg/L)	0.007 - 0.03		0.011 - 0.02	0.013 - 0.013	0.006 - 0.29							
Arsenic - dissolved (mg/L)			0.002 - 0.002	0.002 - 0.002	0.004 - 0.004		0.001 - 0.001	0.001 - 0.004	0.001 - 0.003		0.001 - 0.003	0.001 - 0.003
Barium - dissolved (mg/L)	0.015 - 0.047	0.08 - 0.08	0.026 - 0.047	0.031 - 0.072	0.032 - 0.29	0.035 - 0.07	0.009 - 0.07	0.019 - 0.419	0.015 - 0.176		0.005 - 0.18	0.01 - 0.127
Chromium - dissolved (mg/L)							0.002 - 0.002				0.001 - 0.001	
Cobalt - dissolved (mg/L)					0.005 - 0.005		0.001 - 0.003	0.001 - 0.005	0.001 - 0.004		0.001 - 0.002	0.002 - 0.003
Copper - dissolved (mg/L)	0.001 - 0.004	0.005 - 0.005	0.002 - 0.002	0.002 - 0.012	0.001 - 0.004	0.002 - 0.003	0.002 - 0.039	0.004 - 0.208	0.001 - 0.018		0.001 - 0.005	0.001 - 0.018
Molybdenum - dissolved (mg/L)	0.0007 - 0.0007	0.002 - 0.002	0.0006 - 0.0006	0.001 - 0.003	0.0009 - 0.002	0.0007 - 0.0007	0.001 - 0.002	0.001 - 0.003	0.002 - 0.002		0.001 - 0.003	0.001 - 0.003
Nickel - dissolved (mg/L)					0.003 - 0.003		0.002 - 0.008	0.001 - 0.007	0.001 - 0.002		0.001 - 0.001	0.001 - 0.004
Selenium - dissolved (mg/L)												
Uranium - dissolved (mg/L)	0.001 - 0.001	0.005 - 0.005	0.0005 - 0.0005	0.0009 - 0.012	0.0018 - 0.0029	0.0018 - 0.0018	0.001 - 0.001	0.002 - 0.004	0.001 - 0.001		0.002 - 0.005	0.001 - 0.002
Zinc - dissolved (mg/L)												
Metals (total)												
Aluminium - total (mg/L)	0.067 - 0.55	0.066 - 0.066	0.02 - 0.028	0.03 - 0.75	0.035 - 4.9	0.07 - 0.26						
Arsenic - total (mg/L)			0.002 - 0.002	0.002 - 0.002	0.006 - 0.006		0.001 - 0.002	0.001 - 0.005	0.001 - 0.004		0.001 - 0.004	0.001 - 0.003
Barium - total (mg/L)	0.02 - 0.068	0.085 - 0.085	0.026 - 0.052	0.033 - 0.075	0.036 - 0.38	0.039 - 0.075	0.017 - 0.074	0.02 - 0.376	0.026 - 0.215		0.012 - 0.316	0.013 - 0.16
Chromium - total (mg/L)					0.0036 - 0.0036		0.001 - 0.003	0.002 - 0.002	0.004 - 0.016		0.002 - 0.002	
Cobalt - total (mg/L)	0.001 - 0.001	0.001 - 0.001	0.002 - 0.002	0.001 - 0.001	0.011 - 0.011		0.001 - 0.003	0.001 - 0.006	0.003 - 0.007		0.001 - 0.005	0.001 - 0.003
Copper - total (mg/L)	0.002 - 0.006	0.006 - 0.006	0.001 - 0.002	0.003 - 0.014	0.002 - 0.033	0.004 - 0.004	0.002 - 0.046	0.003 - 0.311	0.002 - 0.039		0.001 - 0.009	0.002 - 0.024
Molybdenum - total (mg/L)		0.002 - 0.002	0.0006 - 0.0006	0.001 - 0.003	0 - 0.001	0.0007 - 0.0007	0.001 - 0.002	0.001 - 0.004	0.001 - 0.002		0.002 - 0.004	0.001 - 0.002
Nickel - total (mg/L)	0.001 - 0.001			0.001 - 0.001	0.007 - 0.007		0.002 - 0.004	0.001 - 0.004	0.001 - 0.009		0.001 - 0.003	0.001 - 0.002
Selenium - total (mg/L)												
Uranium - total (mg/L)	0.0011 - 0.0011	0.0051 - 0.0051	0.0005 - 0.0005	0.001 - 0.012	0.002 - 0.0029	0.0019 - 0.0019	0.001 - 0.001	0.002 - 0.004	0.001 - 0.001		0.002 - 0.006	0.001 - 0.002
Nutrients												

Parameter	B3	B4	B6	B7	B8	B9	BASW01	BASW04	BASW05	BASW08	BASW09	BASW11
Nitrite + Nitrate as N (mg/L)												
Total Kjeldahl Nitrogen as N (mg/L)								0.9 - 0.9				
Total Nitrogen as N (mg/L)								0.9 - 0.9				
Total Phosphorus as P (mg/L)								0.07 - 0.07				
Physico-Chemical Parameters												
Electrical Conductivity (µS/cm)	130 - 500	1600 - 1600	230 - 460	280 - 1400	200 - 930	260 - 840	57 - 573	120 - 1260	58 - 666		39 - 1710	57 - 963
pH (lab)	7.3 - 8.4		7.8 - 8	8 - 8.4	7.4 - 7.8	7.8 - 7.8	6.48 - 8.43	7.17 - 8.58	6.47 - 8.21		6.8 - 8.97	6.68 - 8.69
Turbidity (NTU)	6.6 - 6.6		3 - 3	4 - 4	5.7 - 5.7	12 - 12	1.7 - 137	2.9 - 130	4.2 - 205		1.1 - 129	1.6 - 58.3

Table 18 REMP and EA surface water exceedances of EA receiving water quality trigger levels

Parameter/Period	B3	B4	B6	B7	B8	B9	BASW01	BASW04	BASW05	BASW08	BASW09	BASW11
Aluminium - dissolved (mg/L)												
3. Post-open cut mining					✓							
Aluminium - total (mg/L)												
2. Open cut mining	✓				✓	✓						
3. Post-open cut mining	✓	✓		✓	✓	✓						
Chromium - dissolved (mg/L)												
3. Post-open cut mining							✓					
Chromium - total (mg/L)												
1. Pre-open cut mining								✓				
2. Open cut mining									✓		✓	
3. Post-open cut mining					✓		✓	✓	✓			
Cobalt - dissolved (mg/L)												
1. Pre-open cut mining								✓	✓			
2. Open cut mining							✓	✓	✓			✓
Copper - dissolved (mg/L)												
1. Pre-open cut mining							✓	✓	✓		✓	✓
2. Open cut mining	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓
3. Post-open cut mining	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓
Copper - total (mg/L)												
1. Pre-open cut mining							✓	✓	✓		✓	✓
2. Open cut mining	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓
3. Post-open cut mining	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓
Electrical Conductivity (µS/cm)												
1. Pre-open cut mining							✓	✓	✓		✓	✓
2. Open cut mining											✓	✓
Electrical Conductivity (field) (µS/cm)												
1. Pre-open cut mining							✓	✓	✓		✓	✓
2. Open cut mining							✓	✓	✓	✓	✓	✓
Fluoride (mg/L)												

Parameter/Period	B3	B4	B6	B7	B8	B9	BASW01	BASW04	BASW05	BASW08	BASW09	BASW11
1. Pre-open cut mining pH (field)								✓				
1. Pre-open cut mining							✓	✓	✓		✓	✓
2. Open cut mining							✓	✓	✓	✓	✓	✓
3. Post-open cut mining pH (lab)							✓	✓	✓		✓	✓
1. Pre-open cut mining							✓	✓	✓		✓	✓
2. Open cut mining							✓	✓			✓	✓
3. Post-open cut mining Uranium - dissolved (mg/L)							✓	✓	✓		✓	✓
3. Post-open cut mining Uranium - total (mg/L)				✓								
3. Post-open cut mining				✓								

✓ Exceedance observed

Table 19 REMP and EA surface water exceedances of EA receiving water WQOs

Parameter	B3	B4	B6	B7	B8	B9	BASW01	BASW04	BASW05	BASW08	BASW09	BASW11
Aluminium - dissolved (mg/L)												
3. Post-open cut mining					✓							
Aluminium - total (mg/L)												
2. Open cut mining	✓				✓	✓						
3. Post-open cut mining	✓	✓		✓	✓	✓						
Chromium - dissolved (mg/L)												
3. Post-open cut mining							✓					
Chromium - total (mg/L)												
1. Pre-open cut mining								✓				
2. Open cut mining									✓		✓	
3. Post-open cut mining					✓		✓	✓	✓			
Cobalt - dissolved (mg/L)												
1. Pre-open cut mining								✓	✓			
2. Open cut mining							✓	✓	✓			✓
Copper - dissolved (mg/L)												
1. Pre-open cut mining							✓	✓	✓		✓	✓
2. Open cut mining	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓
3. Post-open cut mining	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓
Copper - total (mg/L)												
1. Pre-open cut mining							✓	✓	✓		✓	✓
2. Open cut mining	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓
3. Post-open cut mining	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓
Electrical Conductivity (µS/cm)												
1. Pre-open cut mining							✓	✓	✓		✓	✓
2. Open cut mining											✓	✓
Electrical Conductivity (field) (µS/cm)												
1. Pre-open cut mining							✓	✓	✓		✓	✓
2. Open cut mining							✓	✓	✓	✓	✓	✓
Fluoride (mg/L)												

Parameter	B3	B4	B6	B7	B8	B9	BASW01	BASW04	BASW05	BASW08	BASW09	BASW11
1. Pre-open cut mining pH (field)								✓				
1. Pre-open cut mining							✓	✓	✓		✓	✓
2. Open cut mining							✓	✓	✓	✓	✓	✓
3. Post-open cut mining pH (lab)							✓	✓	✓		✓	✓
1. Pre-open cut mining							✓	✓	✓		✓	✓
2. Open cut mining							✓	✓			✓	✓
3. Post-open cut mining Uranium - dissolved (mg/L)							✓	✓	✓		✓	✓
3. Post-open cut mining Uranium - total (mg/L)				✓								
3. Post-open cut mining				✓								

✓ Exceedance observed

Table 20 REMP and EA surface water exceedances of ANZG aquatic ecosystem (slightly to moderately disturbed) protection DGVs

Parameter	B3	B4	B6	B7	B8	B9	BASW01	BASW04	BASW05	BASW08	BASW09	BASW11
Aluminium - dissolved (mg/L)												
3. Post-open cut mining					✓							
Aluminium - total (mg/L)												
2. Open cut mining	✓				✓	✓						
3. Post-open cut mining	✓	✓		✓	✓	✓						
Chromium - dissolved (mg/L)												
3. Post-open cut mining							✓					
Chromium - total (mg/L)												
1. Pre-open cut mining								✓				
2. Open cut mining									✓		✓	
3. Post-open cut mining					✓		✓	✓	✓			
Copper - dissolved (mg/L)												
1. Pre-open cut mining							✓	✓	✓		✓	✓
2. Open cut mining	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓
3. Post-open cut mining	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓
Copper - total (mg/L)												
1. Pre-open cut mining							✓	✓	✓		✓	✓
2. Open cut mining	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓
3. Post-open cut mining	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓

✓ Exceedance observed

7.5 Mine site surface water monitoring results

Aeris has undertaken regular surface water monitoring and sampling at several locations within ML90241 as part of routine monitoring and investigations related to the occurrence of the BCP Spring(s). The locations included the following:

- BCP North Pit: Barbara North open pit
- BCP South Pit: Barbara South open pit
- BCP Spring: An additional site within the drainage line south of the sediment dam was where the BCP Spring was first noticed. The site was added to the REMP program as per DES request.
- BCP Spring (N): Sampling site in the immediate vicinity of the BCP Spring site.
- BCP Spring (S): Additional sampling site further south along the drainage line.
- Sediment Dam: sampling site within the Sediment Dam
- Sump: sampling site within the sump excavated south of the Sediment Dam
- Pooled water south of the sediment dam

Details of these locations are provided in Table 15, with locations shown in Figure 8. The investigations included the following:

- Sampling of surface water at the above locations.
- Installation of automated data loggers to record water levels/depths at BCP Spring (N), BCP Spring (S) and SUMP

Appendix F provides relevant data, charts and plots, with:

- Appendix F.1: data tables
- Appendix F.2: time series of selected parameters
- Appendix F.3: box & whisker plots
- Appendix F.4: hydrogeochemistry plots

7.5.1 Hydrogeochemistry

Surface water samples were analysed for major ions and alkalinity to allow for hydrogeochemical analysis. Piper, Durov, Gibbs and Chadha diagrams for the mine site surface water sample locations are presented in Appendix F.4.

Based on the ionic composition of the water samples and interpretation of the diagrams, the surface water at these sites can be classified as per Table 21.

Table 21 Water-type classification of mine site surface water sampling locations

Location	Piper diagram water type	Durov diagram classification
BCP North Pit	• Mixed Ca-Mg-Cl	• 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing.
BCP South Pit	• Ca-Mg-Cl-SO4	• 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing.
BCP Spring	• Mixed Ca-Na-HCO3	• 6: SO4 and Na are dominant. Water type is not frequently encountered and

Location	Piper diagram water type	Durov diagram classification
	• Na-K-Cl-SO4	indicates probable mixing or uncommon dissolution influences.
BCP Spring (N)	• Mixed Ca-Na-HCO3 • Na-K-Cl-SO4	• 6: SO4 and Na are dominant. Water type is not frequently encountered and indicates probable mixing or uncommon dissolution influences.
BCP Spring (S)	• Mixed Ca-Na-HCO3 • Na-K-Cl-SO4	• 6: SO4 and Na are dominant. Water type is not frequently encountered and indicates probable mixing or uncommon dissolution influences. • 3: HCO3 and Na are dominant, indicates ion exchange water.
Pooled water S of sediment dam	• Ca-Mg-Cl-SO4	• 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing.
Sediment Dam	• Mixed Ca-Mg-Cl • Ca-Mg-Cl-SO4	• 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing.
Seepage	• Mixed Ca-Na-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.
Sump	• Na-K-Cl-SO4 • Mixed Ca-Na-HCO3	• 6: SO4 and Na are dominant. Water type is not frequently encountered and indicates probable mixing or uncommon dissolution influences.

The ionic composition of the surface water samples obtained from the REMP and EA surface water monitoring locations indicates the following:

- The water type at the mine site surface water monitoring locations is different and more variable than at the REMP and EA surface water monitoring locations.
- Water types can be summarised as follows:
  - BCP North and South Pits: mixed Ca-Mg-Cl and Ca-Mg-Cl-SO4 water types, with no dominant anion or cation, indicating water exhibiting dissolution or mixing. The water types reflect the local geology and interaction between water in the open pits, evaporation and groundwater inflow. The south pit is deeper than the north pit, and the water type in the south pit is probably influenced by localised mineralisation at depth.
  - BCP Spring locations and Sump: water types at each location vary between mixed Ca-Na-HCO3 and Na-K-Cl-SO4. These water types indicate probable mixing or uncommon dissolution influences (e.g. from underlying mineralisation).
  - Sediment dam and pooled water south of the dam: water types at this location vary between mixed Ca-Mg-Cl and Ca-Mg-Cl-SO4. No dominant anion or cation is present, indicating water exhibiting dissolution or mixing.

- Ionic composition is influenced mainly by rainfall events and interaction between surface water and underlying, mineralised geology, as demonstrated by the Gibbs diagrams in Appendix E. Water types are generally consistent at all sampled locations, with no apparent difference between background (BASW09 and BASW05) and downstream (e.g. BASW04, B7) locations.

7.5.2 Mine site surface water quality results

Table 22 presents the range of analysis results above the LOR for selected analytes/parameters at the mine site sampling locations. A summary of exceedances of the ANZECC livestock water quality guidelines and ANZG 2018 DGVs for protecting aquatic (slightly to moderately disturbed) ecosystems is presented in Table 23 and Table 24, respectively.

The data and information indicate the following:

- Exceedances of the ANZECC livestock water quality guidelines and the ANZG aquatic (slightly to moderately disturbed) ecosystem protection DGVs have occurred mainly for salinity, selected metals (aluminium, arsenic, chromium, copper, molybdenum and selenium), fluoride and sulfate.
- Surface water is generally alkaline, with field pH values between 7.8 and 10.1.
- Salinity levels are lowest in the BCP North and South Pit (reflecting rainfall recharge and groundwater inflow). Elevated salinity levels are observed in the sump and at BCP Spring (N), BCP Spring (S) and BCP Spring locations.
- With respect to major ions:
  - Calcium levels in the sediment dam are higher than in other locations and appear to increase with time. Catchment runoff captured in the sediment dam is known to be alkaline due to localised soil composition.
  - Magnesium levels are lowest in the BCP North and South Pits and highest at the BCP Spring locations. Except for the pits, magnesium levels appear to increase with time.
  - Sodium levels are highest at the Sump, BCP Spring (N) and BCP Spring locations and lowest in the BCP North and South Pits. Except for the pits, sodium levels vary with time, most likely in response to rainfall events.
  - Chloride levels are highest at the Sump, BCP Spring and BCP Spring (N) locations and lowest in the BCP North and South Pits. Except for the pits, chloride levels vary with time, most likely in response to rainfall events.
  - Sulfate levels are lowest in the BCP North and South Pits and high, but within the same range, at the other locations. Except for the pits, sulfate concentrations have appeared to vary and have increased since 2020.
  - Bicarbonate alkalinity is lowest in the Sediment Dam and the BCP North and South Pits and highest at the BCP Spring locations. Except for the sediment dam and the pits, bicarbonate alkalinity appears to vary with time, most likely in response to rainfall events.
- With respect to metals:
  - Metal concentrations are generally low, except for barium, copper, molybdenum, nickel, selenium and uranium at some locations.
  - There is generally no increasing trend in metal concentrations. There may be some seasonal variations related to seasonal rainfall/storm events.
- The box & whisker plots show the natural variability of analyte concentrations at a given monitoring location.

The data and information show that a range of variable factors influences the water quality at the mine site surface water locations, as follows:

- Water quality at the BCP Spring locations and the Sump differs from the water quality in the sediment dam and the open pits. The water quality indicates probable mixing or uncommon dissolution influences (e.g. from underlying mineralisation).
- Water quality in the open pits appears to be affected by rainfall and groundwater inflow.
- Water quality in the sediment dam appears to be affected mainly by surface water runoff from the surrounding catchment, which is known to have alkaline soils.

Water quality at the mine site locations also differs from the REMP and EA surface water quality, indicating that more localised factors affect the mine site surface water quality.

Table 22 Range of analysis results above the LOR at the mine site surface water monitoring locations

Parameter	BCP North Pit	BCP South Pit	BCP Spring	BCP Spring (N)	BCP Spring (S)	Culvert Outflow	Pooled water S of sediment dam	Sediment Dam	Seepage	Sump	U/S of Culvert
Alkalinity											
Bicarbonate Alkalinity as CaCO3 (mg/L)	98 - 382	78 - 93	321 - 1700	243 - 1470	227 - 938	166 - 166	73 - 152	38 - 129	744 - 744	83 - 1300	202 - 202
Carbonate Alkalinity as CaCO3 (mg/L)			66 - 1400	93 - 490	24 - 438			10 - 28		25 - 331	
Total Alkalinity as CaCO3 (mg/L)	98 - 382	78 - 93	470 - 2950	243 - 1960	227 - 1230	166 - 166	73 - 152	50 - 129	744 - 744	83 - 1420	202 - 202
Field Measurements											
Dissolved Oxygen (field) (% sat)	0 - 196	0 - 162.8	1.2 - 311.6	23.8 - 315.9	1.2 - 127.6		94.2 - 94.2	0 - 211.4		0.4 - 186.6	145.8 - 145.8
Electrical Conductivity (field) (µS/cm)	738 - 1386	977 - 1591	2278 - 9392	968 - 5416	674 - 3324		4632 - 4632	65 - 2752		340 - 6686	530 - 530
ORP (field) (mV)	-34.1 - 237.2	-40.3 - 207.4	-31.3 - 131.5	-58.8 - 142.5	-58.6 - 2.3		-54.2 - -54.2	-22.1 - 252.9		-57.4 - 133	9.3 - 9.3
pH (field)	7.89 - 8.86	8.14 - 9.12	8.78 - 10.06	8.55 - 8.94	8.3 - 8.64		8.23 - 8.23	7.76 - 9.38		8.12 - 9.84	9.12 - 9.12
Salinity (field) (PSU)	0.3 - 0.68	0.47 - 0.8	1.15 - 5.24	0.48 - 2.71	0.33 - 1.68		2.3 - 2.3	0.03 - 1.43		0.16 - 3.64	0.25 - 0.25
TDS (field) (ppm)	369 - 693	489 - 796	1139 - 4695	484 - 2708	338 - 1662		2315 - 2315	32 - 1375		171 - 3343	265 - 265
Temperature (field) (°C)	19.82 - 32.84	22.41 - 33.96	27.42 - 32.05	22.65 - 29.33	22.62 - 28.88		21.88 - 21.88	19.72 - 33.8		24.15 - 32.25	33.35 - 33.35
Turbidity (field) (FNU)	3 - 3							2.1 - 2.1			
Hardness											
Total Hardness (mg CaCO3/L)	157 - 249		390 - 570	138 - 885	110 - 916	77 - 77	2100 - 3550	215 - 1720	450 - 450	37 - 546	74 - 74
Major Ions											
Bromide (mg/L)	0.12 - 0.12		0.88 - 2.36					0.11 - 0.21		0.086 - 1.56	
Calcium (mg/L)	38 - 128	103 - 153	12 - 39	15 - 45	15 - 93	11 - 11	430 - 754	42 - 358	50 - 58	10 - 75	10 - 10
Chloride (mg/L)	16 - 153	14 - 22	170 - 912	52 - 554	26 - 278	20 - 20	136 - 326	15 - 186	49 - 49	17 - 721	20 - 20
Fluoride (mg/L)	1 - 1.9	0.8 - 1.1	0.6 - 2.5	0.6 - 1.9	0.5 - 2.1	0.5 - 0.5	0.4 - 0.6	0.6 - 2.6	1.9 - 1.9	0.2 - 1.2	0.5 - 0.5
Iodide (mg/L)			0.62 - 0.62							0.68 - 0.68	
Magnesium (mg/L)	15 - 43	53 - 60	24 - 140	21 - 204	16 - 179	12 - 12	229 - 406	19 - 248	78 - 79	3 - 96	12 - 12
Potassium (mg/L)	9 - 33	15 - 25	7 - 42	4 - 21	4 - 8	4 - 4	21 - 34	13 - 84	6 - 7	2 - 12	4 - 4
Sodium (mg/L)	54 - 156	72 - 101	375 - 2260	174 - 1660	106 - 744	85 - 90	482 - 958	42 - 690	195 - 213	41 - 1410	90 - 94
Sulfate (as SO4)	142 - 583	481 - 713	227 - 1040	112 - 1640	55 - 767	33 - 33	1540 - 3220	168 - 2140	79 - 79	32 - 970	25 - 25
Metals (dissolved)											
Aluminium - dissolved (mg/L)			0.011 - 0.013								
Arsenic - dissolved (mg/L)	0.001 - 0.003	0.006 - 0.012	0 - 0.035	0.002 - 0.017	0.001 - 0.004	0.002 - 0.002	0.001 - 0.002	0.002 - 0.006	0.003 - 0.003	0.001 - 0.012	0.002 - 0.002
Barium - dissolved (mg/L)	0.041 - 0.093	0.037 - 0.052	0.059 - 0.118	0.046 - 0.109	0.033 - 0.176	0.034 - 0.034	0.069 - 0.12	0.06 - 0.139	0.124 - 0.124	0.021 - 0.15	0.03 - 0.03
Boron - dissolved (mg/L)			0.09 - 0.09					0.06 - 0.07		0.13 - 0.13	
Chromium - dissolved (mg/L)			0.002 - 0.002							0.002 - 0.002	
Cobalt - dissolved (mg/L)	0.001 - 0.004	0.001 - 0.012	0.001 - 0.014	0.001 - 0.001	0.001 - 0.002		0.005 - 0.007	0.001 - 0.003	0.001 - 0.001	0.001 - 0.003	
Copper - dissolved (mg/L)	0.005 - 0.054	0.011 - 0.069	0.011 - 0.196	0.014 - 0.067	0.003 - 0.012	0.012 - 0.012	0.012 - 0.03	0.004 - 0.027	0.001 - 0.001	0.008 - 0.04	0.012 - 0.012
Iron - dissolved (mg/L)			0.09 - 0.09								
Molybdenum - dissolved (mg/L)	0.006 - 0.02	0.024 - 0.043	0.005 - 0.016	0.004 - 0.012	0.002 - 0.006	0.004 - 0.004	0.009 - 0.018	0.019 - 0.146	0.014 - 0.014	0.001 - 0.008	0.003 - 0.003
Nickel - dissolved (mg/L)	0.001 - 0.018	0.007 - 0.024	0.001 - 0.006	0.001 - 0.002	0.002 - 0.002		0.001 - 0.001	0.001 - 0.027		0.001 - 0.002	
Selenium - dissolved (mg/L)	0.01 - 0.03	0.01 - 0.01	0.002 - 0.029				0.16 - 0.28	0.01 - 0.13		0.01 - 0.04	
Uranium - dissolved (mg/L)	0.002 - 0.014	0.006 - 0.008	0.015 - 0.057	0.005 - 0.033	0.002 - 0.014	0.003 - 0.003	0.003 - 0.036	0.002 - 0.021	0.011 - 0.011	0.002 - 0.076	0.003 - 0.003
Vanadium - dissolved (mg/L)			0.03 - 0.03								
Metals (total)											
Aluminium - total (mg/L)			0.11 - 0.99								
Arsenic - total (mg/L)	0.001 - 0.003	0.007 - 0.012	0.004 - 0.066	0.002 - 0.018	0.001 - 0.004	0.002 - 0.002	0.001 - 0.003	0.002 - 0.005	0.003 - 0.003	0.002 - 0.013	0.002 - 0.002
Barium - total (mg/L)	0.035 - 0.088	0.037 - 0.053	0.059 - 0.165	0.046 - 0.118	0.041 - 0.188	0.035 - 0.035	0.073 - 0.128	0.057 - 0.142	0.133 - 0.133	0.024 - 0.163	0.032 - 0.032
Boron - total (mg/L)			0.1 - 0.1					0.07 - 0.07		0.14 - 0.14	
Chromium - total (mg/L)			0.0009 - 0.005	0.001 - 0.001			0.001 - 0.002		0.001 - 0.001	0.001 - 0.004	

Parameter	BCP North Pit	BCP South Pit	BCP Spring	BCP Spring (N)	BCP Spring (S)	Culvert Outflow	Pooled water S of sediment dam	Sediment Dam	Seepage	Sump	U/S of Culvert
Cobalt - total (mg/L)	0.001 - 0.004	0.001 - 0.015	0.001 - 0.016	0.001 - 0.002	0.001 - 0.003	0.001 - 0.001	0.005 - 0.007	0.001 - 0.003	0.002 - 0.002	0.001 - 0.004	0.001 - 0.001
Copper - total (mg/L)	0.008 - 0.065	0.012 - 0.072	0.017 - 0.392	0.023 - 0.098	0.006 - 0.021	0.021 - 0.021	0.013 - 0.03	0.008 - 0.036	0.007 - 0.007	0.011 - 0.051	0.021 - 0.021
Iron - total (mg/L)			1.06 - 1.06							0.3 - 0.3	
Molybdenum - total (mg/L)	0.007 - 0.022	0.026 - 0.051	0 - 0.025	0.004 - 0.013	0.003 - 0.007	0.004 - 0.004	0.01 - 0.017	0.022 - 0.156	0.018 - 0.018	0.001 - 0.009	0.004 - 0.004
Nickel - total (mg/L)	0.002 - 0.017	0.007 - 0.025	0.001 - 0.012	0.001 - 0.004	0.001 - 0.004		0.001 - 0.002	0.001 - 0.006	0.002 - 0.002	0.001 - 0.003	
Selenium - total (mg/L)	0.02 - 0.03	0.01 - 0.01	0.002 - 0.054				0.16 - 0.28	0.01 - 0.14		0.01 - 0.04	
Uranium - total (mg/L)	0.003 - 0.016	0.007 - 0.008	0.016 - 0.091	0.005 - 0.044	0.003 - 0.018	0.003 - 0.003	0.004 - 0.038	0.004 - 0.023	0.012 - 0.012	0.002 - 0.083	0.003 - 0.003
Vanadium - total (mg/L)			0.04 - 0.04							0.01 - 0.01	
Nutrients											
Nitrate as N (mg/L)	0.09 - 0.09		0.14 - 0.14					17.3 - 34.6		0.32 - 0.32	
Nitrite + Nitrate as N (mg/L)	0.09 - 0.09		0.15 - 0.15					17.6 - 35.3		0.32 - 0.32	
Nitrite as N (mg/L)			0.01 - 0.01					0.29 - 0.65			
Physico-Chemical Parameters											
Electrical Conductivity (µS/cm)	556 - 1360	1250 - 1520	1890 - 8850	956 - 7080	619 - 3420	491 - 491	5690 - 9460	739 - 5280	1500 - 1500	279 - 6290	471 - 471
pH (lab)	7.85 - 8.26	7.92 - 8.17	8.61 - 9.3	8.27 - 9.19	7.85 - 8.54	8.09 - 8.09	7.89 - 8.04	7.51 - 8.73	7.73 - 7.73	8 - 9.14	8.28 - 8.28
Turbidity (NTU)	0.2 - 3.4	0.2 - 1	1.8 - 155	1.6 - 33.1	1.3 - 19.1	19.7 - 19.7	0.8 - 3.6	0.5 - 2.1	10.9 - 10.9	2.6 - 38.7	19.7 - 19.7

Table 23 Mine site surface water exceedances of ANZECC Livestock Water Quality Guidelines

Parameter	BCP North Pit	BCP South Pit	BCP Spring	BCP Spring (N)	BCP Spring (S)	Pooled water S of sediment dam	Sediment Dam	Seepage	Sump
Electrical Conductivity (µS/cm)									
3. Post-open cut mining			✓	✓		✓			✓
Electrical Conductivity (field) (µS/cm)									
3. Post-open cut mining			✓						✓
Fluoride (mg/L)									
2. Open cut mining							✓		
3. Post-open cut mining			✓		✓				
Molybdenum - total (mg/L)									
2. Open cut mining							✓		
Selenium - dissolved (mg/L)									
2. Open cut mining	✓								
3. Post-open cut mining			✓			✓	✓		✓
Selenium - total (mg/L)									
2. Open cut mining	✓								
3. Post-open cut mining			✓			✓	✓		✓
Sulfate (as SO4) (mg/L)									
3. Post-open cut mining			✓	✓		✓	✓		

✓ Exceedance observed

Table 24 Mine site surface water exceedances of ANZG aquatic ecosystem (slightly to moderately disturbed) WQOs

Parameter	BCP North Pit	BCP South Pit	BCP Spring	BCP Spring (N)	BCP Spring (S)	Pooled water S of sediment dam	Sediment Dam	Seepage	Sump
Aluminium - total (mg/L)									
3. Post-open cut mining			✓						
Arsenic - dissolved (mg/L)									
3. Post-open cut mining			✓	✓					
Arsenic - total (mg/L)									
3. Post-open cut mining			✓	✓					
Chromium - dissolved (mg/L)									
3. Post-open cut mining			✓						✓
Chromium - total (mg/L)									
3. Post-open cut mining			✓			✓			✓
Copper - dissolved (mg/L)									
2. Open cut mining	4						✓		
3. Post-open cut mining	✓	✓	✓	✓	✓	✓	✓		✓2
Copper - total (mg/L)									
2. Open cut mining	✓						✓	✓	
3. Post-open cut mining	✓	✓	✓	✓	✓	✓	✓		✓
Selenium - dissolved (mg/L)									
2. Open cut mining	✓						✓		
3. Post-open cut mining		✓	✓			✓	✓		✓
Selenium - total (mg/L)									
2. Open cut mining	✓						✓		
3. Post-open cut mining		✓	✓			✓	✓		✓

7.5.3 Assessment of water levels at BCP Spring locations and in the sump

To assess the water levels and response to rainfall events, Aeris installed automated data loggers at three locations, i.e. BCP Spring (N), BCP Spring (S) and SUMP. Data was downloaded on a regular basis and collected data was compensated for barometric pressure changes. Table 25 shows the timeframes/periods the dataloggers were operational.

Table 25 Datalogger periods at surface water monitoring locations

Location/Data File		Recording Period	
BCP Spring (N)		14/12/2022 06:00	29/09/2023 14:00
#S(N)1	BCP Spring (N)_2023-01-06_13-20	14/12/2022 06:00	6/01/2023 13:00
#S(N)2	BCP Spring (N)_2023-05-14_10-00	6/01/2023 18:00	5/02/2023 11:00
#S(N)3	BCP Spring (N)_2023-05-14_1 (2)	5/02/2023 14:00	14/05/2023 09:00
#S(N)4	BCP Spring (N)_2023-06-23_11-01	14/05/2023 12:00	23/06/2023 10:00
#S(N)5	BCP Spring (N)_2023-07-22_11-22	23/06/2023 13:00	22/07/2023 11:00
#S(N)6	BCP Spring (N)_2023-09-03_11-39	22/07/2023 13:00	3/09/2023 11:00
#S(N)7	BCP Spring (N)_2023-09-29_15-12	3/09/2023 13:00	29/09/2023 14:00
BCP Spring (S)		14/12/2022 06:00	29/09/2023 14:00
#S(S)1	BCP Spring (S)_Append_2023-01-0	14/12/2022 06:00	6/01/2023 13:00
#S(S)2	BCP Spring (S)_2023-05-14_10-22	6/01/2023 18:00	5/02/2023 11:00
#S(S)3	BCP Spring (S)_2023-05-14_1 (2)	5/02/2023 14:00	14/05/2023 09:00
#S(S)4	BCP Spring (S)_2023-06-23_11-15	14/05/2023 12:00	23/06/2023 10:00
#S(S)5	BCP Spring (S)_2023-07-22_11-27	23/06/2023 13:00	22/07/2023 11:00
#S(S)6	BCP Spring (S)_Append_2023-09-0	22/07/2023 13:00	3/09/2023 11:00
#S(S)7	BCP Spring (S)_2023-09-29_14-51	3/09/2023 13:00	29/09/2023 14:00
SUMP		14/12/2022 06:00	29/09/2023 14:00
#SP1	SUMP_2023-01-06_13-32-38-158-Ba	14/12/2022 06:00	6/01/2023 13:00
#SP2	SUMP_2023-05-14_10-12-58-223-Ba	6/01/2023 18:00	5/02/2023 11:00
#SP3	SUMP_2023-05-14_10-12-58-22 (2)	5/02/2023 14:00	14/05/2023 09:00
#SP4	SUMP_2023-06-23_11-13-07-584-Ba	14/05/2023 12:00	23/06/2023 10:00
#SP5	SUMP_2023-07-22_11-16-45-000-Ba	23/06/2023 13:00	22/07/2023 11:00
#SP6	SUMP_2023-09-03_11-44-33-405-Ba	22/07/2023 13:00	3/09/2023 11:00
#SP17	SUMP_2023-09-29_15-04-02-346-Ba	3/09/2023 13:00	29/09/2023 14:00

Data logger recordings were processed to calculate equivalent absolute surface water elevations (in mAHD) and plotted against rainfall. In addition, increases/decreases in water levels relative to the first reading were calculated and plotted against rainfall to assess the response of water levels to rainfall events.

Time series are provided as follows:

- Plate 16: Water elevations (mAHD) at BCP Spring (N), BCP Spring (S) and the sumps

- Plate 17: Water level changes at BCP Spring (N), BCP Spring (S) and the sumps

The datalogger recordings indicate the following:

- Water levels at the BCP Spring (N) and BCP Spring (S) locations rise almost immediately in response to significant rainfall events. For example, water levels rose approximately 65cm at the BCP spring sites in response to the rainfall events in early March 2023. It is considered that the nearly immediate rise is mainly due to “first flush” flow in the creek and not as much to localised runoff from the mine site and direct rainfall accumulation. Following the rainfall event, water levels decline (almost exponentially) due to reduced creek flow. Once the flow in the creek has reduced to a trickle or stopped, water levels at the BCP Spring (N) and BCP Spring (S) locations reach an “equilibrium” between baseflow within the creek, shallow groundwater interaction and evaporation.
- Water levels in the Sump also respond to rainfall events. However, the water from the sump is pumped back into the sediment dam regularly to prevent overflow. This pump-back operation masks the long-term impact of rainfall and evaporation on sump water levels.

The corresponding changes in shallow groundwater levels and potential correlation with surface water level changes are discussed in Section 8.2.4.

Plate 16 Water elevation (mAHD) at BCP Spring (N), BCP Spring (S) and the sump

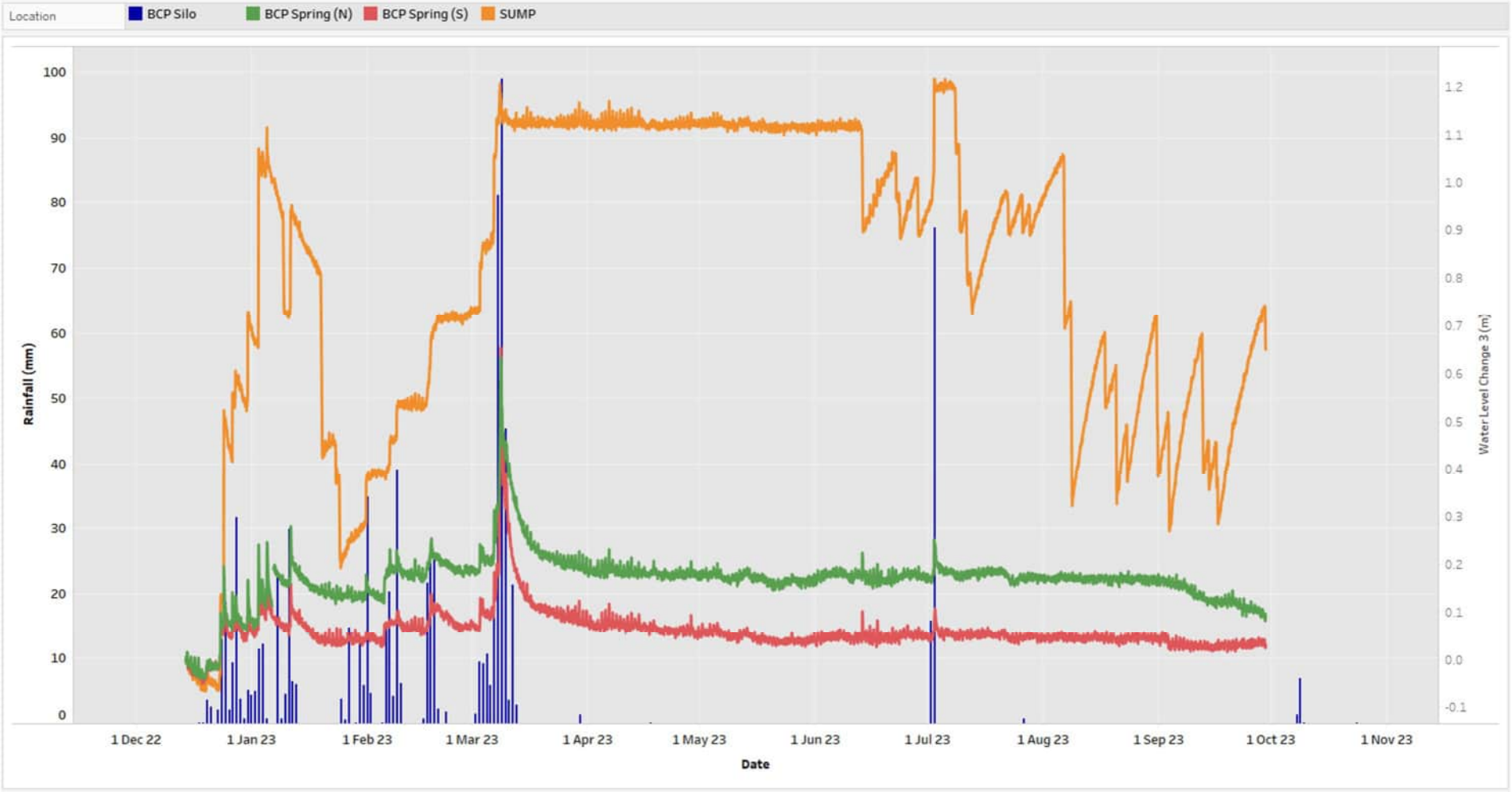


Plate 17 Water level changes (m) at BCP Spring (N), BCP Spring (S) and the sump

8 Groundwater monitoring results

8.1 Groundwater monitoring network

Groundwater monitoring and sampling have been undertaken at BCP since 2014 as part of different environmental monitoring and investigation programs. Details of the groundwater monitoring bores are provided in Table 26, with locations shown in Figure 2 and Figure 3. Available drilling logs are presented in Appendix B.

Table 26 BCP groundwater monitoring well details

Well ID	Easting	Northing	Total Depth (mbgl)	Surface RL (mAHD)	Aquifer interval (mbgl)	Screened Interval (mbgl)	Screened Formation	Purpose/comments
EA groundwater compliance bores								
Bore E	380026	7738835	85	334.23	-	28-83	Basalt/ dolerite	-
BAWB01	380432	7741097	104	352.68	22-23/34-35/43-44	20-101	Rhyolite	Groundwater level and groundwater quality along strike of the ore body to the south east
BAWB02	379480	7742395	104	310.59	No aquifer encountered	96-102	Rhyolite	Groundwater level and groundwater quality along strike of the ore body to the north west, in the Green Zone ore body.
BAWB03	379834	7741692	104	329.50	No aquifer encountered	50-102	Rhyolite	Groundwater level and groundwater quality normal to strike of the ore body to the south west
BAWB04	380043	7742054	100	329.14	No aquifer encountered	94-100	Rhyolite	Groundwater level and groundwater quality normal to strike of the ore body to the north east
BAWB05	380948	7740252	102	377.32	39-40/49-51	35-102	Rhyolite	Background bore for groundwater level and groundwater quality assessment remote from any influence of the mining operation
BAWB07	379849	7741936	127	328.74	No drilling or construction log available. Groundwater level and groundwater quality within the ore body			
BAWBR01	380292	7740939	14	334.49	-	5-6	Dolerite	-
BAWBR02	379912	7741279	14	322.98	-	2-3	Dolerite	-
BAWBR03	379991	7741485	14	326.02	-	3-4	Dolerite	-
EA seepage monitoring bores								
Seepage Bore 1a	380084	7741046	6	336.819		1-5	Rhyolite	Assess seepage from sediment dam

Well ID	Easting	Northing	Total Depth (mbgl)	Surface RL (mAHD)	Aquifer interval (mbgl)	Screened Interval (mbgl)	Screened Formation	Purpose/comments
Seepage Bore 1b	380084	7741048	16	336.487		5-15	Rhyolite	Assessment of seepage from sediment dam
Seepage Bore 2a	380025	7741117	6	331.218		1-5	Rhyolite	Assessment of seepage from sediment dam
Seepage Bore 2b	380023	7741116	16	331.342		5-15	Rhyolite	Assessment of seepage from sediment dam
Seepage Bore 3a	379985	7741133	6	332.189		1-5	Rhyolite	Assessment of seepage from sediment dam
Seepage Bore 3b	379986	7741135	16	331.962		5-15	Rhyolite	Assessment of seepage from sediment dam
Seepage Bore 4a	380711	7740798	6	355.061		1-5	Rhyolite	Assessment of seepage from sediment dam
Additional seepage monitoring bores								
Seepage Bore 5a	379978	7740810	10	338.46		6 – 10		Assessment of potential impact from WRD on shallow and deeper groundwater
Seepage Bore 5b	379979	7740810	15	341.95		11 – 15		
Seepage Bore 6a	379913	7740838	10	337.96		6 – 10		Assessment of potential impact from WRD on shallow and deeper groundwater
Seepage Bore 6b	379912	7740840	15	339.66		11 - 15		
Seepage Bore 7a	379929	7741239	6	328.95		3.5 – 6		Assessment of relationship between shallow groundwater and BCP Spring (N)
Seepage Bore 8a	380021	7741146	6	329.45		3.5 – 6		Assessment of relationship between shallow groundwater and sump
Seepage Bore 9a	380058	7741122	6	331.45		3.5 – 6		Assessment of relationship between shallow groundwater and BCP Spring (S)
Other monitoring bores								
BARC071	379656	7742085	146		19-22/108-109	18-146	Rhyolite	Groundwater level and groundwater quality within the ore body

8.2 Groundwater levels and flow

8.2.1 Groundwater levels in mineral exploration bores (2013)

Between 2008 and 2012, mineral exploration drilling programs were undertaken at and near the Project site. This included the drilling of nine (9) percussion holes, twenty-two (22) diamond drill holes (DDH), and seventy-five (75) reverse circulation (RC) drill holes for the Barbara Copper Project.

Several of the DDH and RC holes remained open for a time, which permitted the measurement of groundwater levels across the ore body. Syndicated Metals undertook a groundwater level measuring campaign in October 2013 in forty (40) exploration drill holes.

Table 27 shows the groundwater level data that were obtained from this campaign. This data shows that the median depth to groundwater in the BCP ore body is about 12m below the ground surface (which equates to a groundwater level elevation of about 302m AHD).

Table 27 Exploration Drill Hole Groundwater Levels – October 2013 (RLA, 2014)

Hole ID	Easting (MGA94)	Northing (MGA94)	Depth to groundwater (mbRL)	Surface RL (mAHD)	Groundwater Level Elevation (mAHD)
BADD002	380146.3	7741437	8.65	327.026	318.376
BADD003	380148.9	7741504	14.43	320.731	306.301
BADD004	380007.3	7741402	7	322.47	315.47
BADD005	380034.1	7741365	9.41	323.2	313.79
BADD006	379967	7741326	8.2	321.1	312.9
BADD008	380144.8	7741390	13.49	324.058	310.568
BADD009	380145	7741434	12.7	323.021	310.321
BARC006	380178.6	7741609	20.29	323.359	303.069
BARC007	380145	7741580	37.93	305.661	267.731
BARC008	380144	7741635	33.56	307.498	273.938
BARC009	380143.4	7741669	30.71	307.936	277.226
BARC010	380147.3	7741437	9.87	325.806	315.936
BARC012	380253.1	7741463	18.64	320.301	301.661
BARC015	380150.5	7741532	22	316.931	294.931
BARC016	380010.3	7741401	7.34	322.31	314.97
BARC017	380036.4	7741365	9.7	322.91	313.21
BARC018	379952.9	7741871	20.36	307.02	286.66
BARC022	379968.8	7741325	8.32	320.82	312.5
BARC023	379896.2	7741919	6.75	309.71	302.96
BARC027	379926.6	7741868	16.41	308.304	291.894
BARC030	380019.8	7741789	12.84	308.835	295.995
BARC031	380059.4	7741764	23.6	309.877	286.277
BARC032	380192.2	7741487	12.5	323.542	311.042
BARC033	380194.6	7741421	7.42	327.381	319.961
BARC038	379856.4	7741890	12.41	307.081	294.671
BARC039	379928.3	7741938	9	309.702	300.702
BARC040	379907.3	7741962	6.79	308.588	301.798
BARC043	379856	7741888	11.67	307.881	296.211
BARC044	379902.1	7741846	6.12	309.65	303.53

Hole ID	Easting (MGA94)	Northing (MGA94)	Depth to groundwater (mbRL)	Surface RL (mAHD)	Groundwater Level Elevation (mAHD)
BARC046	379922.2	7741820	10.43	310.302	299.872
BARC047	379921.9	7741818	10.4	310.315	299.915
BARC049	380110.9	7741463	11.71	318.432	306.722
BARC050	380192.4	7741422	6.52	328.371	321.851
BARC059	379923.7	7741815	11.2	309.68	298.48
BARC061	379911.2	7741761	8.82	309.733	300.913
BARC062	380134.4	7741289	15.64	323.318	307.678

8.2.2 Groundwater levels in monitoring bores (2014)

Table 28 shows the depth to groundwater measured in the dedicated groundwater monitoring bores at the Barbara Copper Project in May and July 2014. Groundwater levels generally fell slightly between May and July 2014 (RLA, 2014).

The depths to groundwater in bores BAWB07 and BARC071 differ by about 5m. These bores are close to each other and are separated topographically by about 1m. Such differing depths to groundwater are not unusual in fractured rock aquifers and illustrate the disconnect between aquifers over such short horizontal distances.

Table 28 Depth to Groundwater in BCP Groundwater Monitoring Bores (RLA, 2014)

Groundwater monitoring bore	Date of Measurement	Standing water level (m below measurement point)
BAWB01	21/05/2014	16.24
BAWB01	29/07/2014	16.33
BAWB02	21/05/2014	8.26
BAWB02	29/07/2014	9.00
BAWB04	20/05/2014	14.38
BAWB04	29/07/2014	14.46
BAWB05	21/05/2014	25.96
BAWB05	29/07/2014	25.81
BAWB07	20/05/2014	16.38
BAWB07	29/07/2014	16.93
BARC071	21/05/2014	21.55
BARC071	29/07/2014	21.70

Contours of the Australian Height Datum (AHD) elevation of the 2014 groundwater level at each of the Barbara Copper Project groundwater monitoring bores are presented in Figure 14.

The contours and potentiometric surface profile show that, provided hydraulic continuity exists throughout the Leichhardt Metamorphics, groundwater flow will be from southwest to northeast within the Barbara Shear Zone. The local depression in the potentiometric surface is due to depression by pumping within the orebody.

The groundwater gradient within the Barbara Shear Zone is 0.02 or 2%, which is relatively steep. This steep gradient reflects the low hydraulic conductivity of the aquifers within the Leichhardt Metamorphics.

8.2.3 Groundwater levels in monitoring bores (2018-2024)

Groundwater monitoring bores

The time series of measured groundwater levels in the groundwater monitoring bores are presented in Plate 18 and Plate 19. Overall, the measurements indicate the following:

- In 2018, the depth to groundwater ranged between 5 and 25 mbRL. These levels are within the range observed in October 2013 within the RC exploration drill holes (Table 27).
- In early 2019, the water levels in the bores rose in response to the significant rainfall in February 2019 and were between 5 and 10 metres shallower than in 2018.
- Since early 2019, groundwater levels in the bores have declined, reflecting recovery after the rainfall event, the open-cut mining operations and the dewatering of the aquifers due to groundwater seepage/inflow into the open pits. The decline rate has slowed down since mining started in June 2019. Groundwater levels did rise in response to rainfall events.
- Since mining finished in March 2021, groundwater levels seem to be slowly recovering to pre-mining levels.
- In early 2023, groundwater levels rose in response to the significant rainfall events in January/February 2023.

Seepage monitoring bores

Plate 20 to Plate 23 present time series of measured groundwater levels in the seepage monitoring bores. Overall, the measurements indicate the following:

- Seepage monitoring bores 4a/4b:
  - The bores are located near the offices and workshop area along the access road to the mine site. The bores were installed as background monitoring bores.
  - Between October 2019 and November 2023, groundwater levels in shallow bore 4a varied between 349.3 mAHD and 350.3 mAHD. Groundwater levels in deeper bore 4b varied between 348.3 mAHD and 349.9 mAHD.
  - Groundwater level fluctuations in response to rainfall were minor but more pronounced in deeper bore 4b than in shallow bore 4a. The vertical gradient between shallow and deep bore is minor.
- Seepage monitoring bores 1a/1b:
  - These shallow (1a) and deep (1b) bores were installed northeast of the sediment dam, between the sediment dam and the creek.
  - Between October 2019 and November 2023, groundwater levels in shallow bore 1a varied between 331.1 mAHD and 333.3 mAHD. Groundwater levels in deeper bore 1b varied between 328.1 mAHD and 333.3 mAHD.
  - Groundwater levels in the shallow and deep bore have slowly increased since installed in 2019, mainly during the open-cut mining. After the end of the open-cut mining, groundwater levels slightly fluctuate in response to rainfall.
  - Overall, there is a minor vertical gradient (< 1m) from the shallow to the deeper bore. The vertical gradient does not imply the existence of different aquifers.
- Seepage monitoring bores 2a/2b and 3a/b:

- The shallow (2a/3a) and deep (2b/3b) bores were installed adjacent to the sump between the sediment dam and the creek.
- Between October 2019 and November 2023, groundwater levels variations were as follows:
  - Shallow bore 2a: from 324.8 mAHD to 330.2 mAHD
  - Shallow bore 3a: from 329.4 mAHD to 331.0 mAHD
  - Deeper bore 2b: from 328.5 mAHD to 331.6 mAHD.
  - Deeper bore 3b: from 329.5 mAHD to 332.7 mAHD.
- Groundwater levels in the shallow and deep bores have generally increased since installation in 2019. Groundwater levels are lower during the open-cut mining, most likely due to the mine dewatering operations. Groundwater levels rise/recover quickly once the open-cut mining ends.
- Until July 2021, groundwater levels in shallow bore 2a were below the levels in deep bore 2b, indicating a vertical gradient from the deep to the shallow bore. In July 2021, water levels in the shallow bore 2a dropped and then rose in December 2021 to reach levels close to those in deep bore 2b. The sudden drop and rise are most likely associated with the sump excavation between the sediment dam and the creek, with the sump recharging the shallow water-bearing sediment. The vertical upward gradient is still present, albeit at a lower gradient. Fluctuations due to rainfall events are masked by the influence of seepage from the sump into underlying formations.
- Groundwater levels in shallow bore 3a are similar to the levels in deep bore 3b during the open-cut mining, indicating the impact of mine dewatering. After the open-cut mining, groundwater levels rise/recover, with a higher recovery in the deep bore 3b than in shallow bore 3b. The vertical gradient between deep 3b and shallow bore 3a is greater than between bore 2b and 2a. The excavation and operation of the sump have not affected the groundwater levels in shallow bore 3a to the same extent as in shallow bore 2a. Fluctuations due to rainfall events are evident.

- Seepage monitoring bores 5a/b and 6a/b:
  - These shallow (5a and 6a) and deep (5b and 6b) bores were installed between the WRD and sediment dam to assess the impact of potential seepage through the base of the WRD on groundwater.
  - Between January 2023 and November 2023, groundwater levels variations were as follows:
    - Shallow bore 5a: from 336.1 mAHD to 335.1 mAHD
    - Shallow bore 6a: from 335.6 mAHD to 335.1 mAHD
    - Deeper bore 5b: from 339.6 mAHD to 338.6 mAHD.
    - Deeper bore 6b: from 335.5 mAHD to 335.4 mAHD.
  - Large-scale groundwater level variations (as opposed to minute variations observed using data loggers and discussed in Section 8.2.4) are minor, with limited long-term responses to rainfall events.
  - Groundwater levels in deep seepage monitoring bore 5b are higher than in the shallow bore 5a. During the drilling of bore 5b, groundwater inflow was observed at depth of ±12 mbgl. The bore is located within an old drainage line that runs in a northerly direction underneath the

WRD and the sediment dam to join the unnamed creek north of the sediment dam. Groundwater levels in this bore may be affected by subflow within this drainage line or by infiltration of water through the base of the WRD.

  - Groundwater levels in shallow bore 6a and deep bore 6b are similar, with no vertical gradient.

- Seepage bore 7a, 8a and 9a:
  - Shallow bore 7a was installed near the BCP Spring (N). Between January 2023 and November 2023, groundwater levels varied from 327.3 mAHD to 326.1 mAHD.
  - Shallow bore 8a was installed between the sump and the creek. Between January 2023 and November 2023, groundwater levels varied from 328.7 mAHD to 328.5 mAHD.
  - Shallow bore 9a was installed near the BCP Spring (S). Between January 2023 and November 2023, groundwater levels varied from 331.7 mAHD to 330.1 mAHD.
  - Large-scale groundwater level variations (as opposed to minute variations observed using data loggers and discussed in Section 8.2.4) are minor, with limited long-term responses to rainfall events.
  - Since May 2023, groundwater levels have generally remained stable in bores 8a and 9a. Groundwater levels in bore 7a appear to decline towards the nearby topographical level of the creek (at ±326 mAHD)

Groundwater flow direction

Contour maps of groundwater levels are presented as follows:

- Figure 15 presents a contour map of the June 2018 groundwater levels.
- Figure 16 presents a contour map of the April 2022 groundwater levels.
- Figure 17 presents a contour map of the April 2023 groundwater levels.

Groundwater flow generally follows topography and is in a northerly direction underneath the WRD and sediment dam and in a north-westerly direction along the creek.

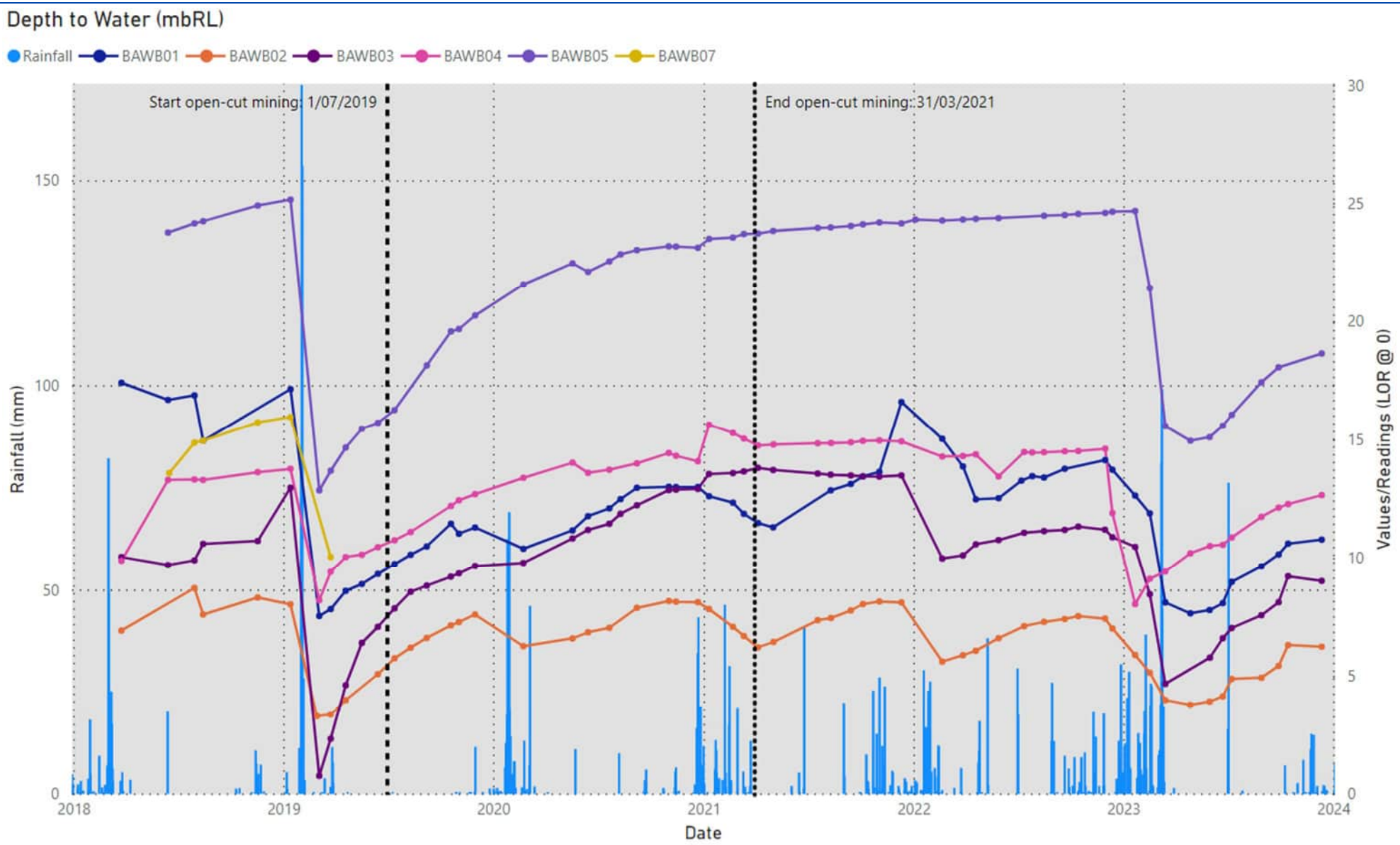


Plate 18 Depth to water (mbRL) in groundwater monitoring bores

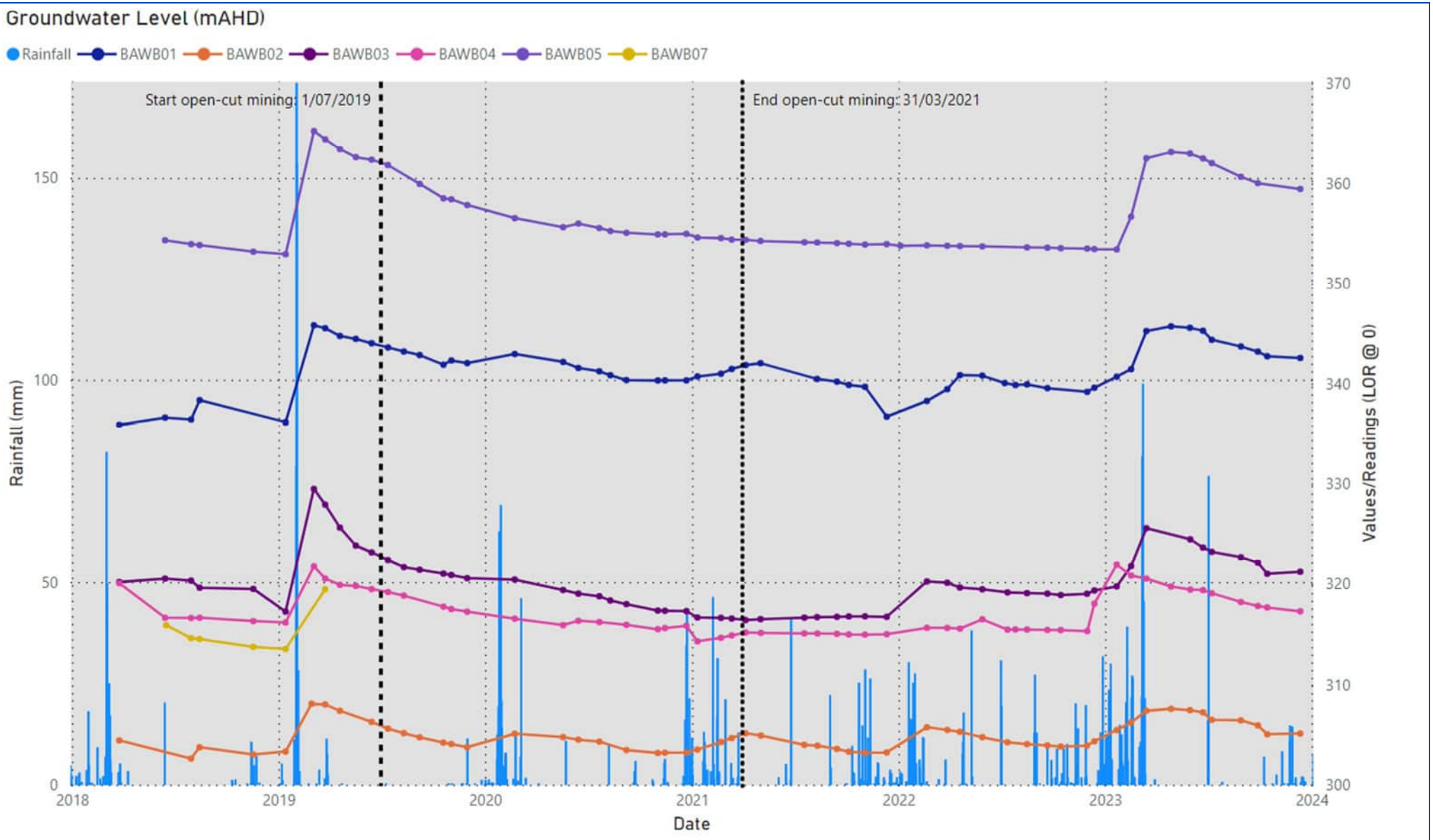


Plate 19 Groundwater levels (mAHD) in groundwater monitoring bores

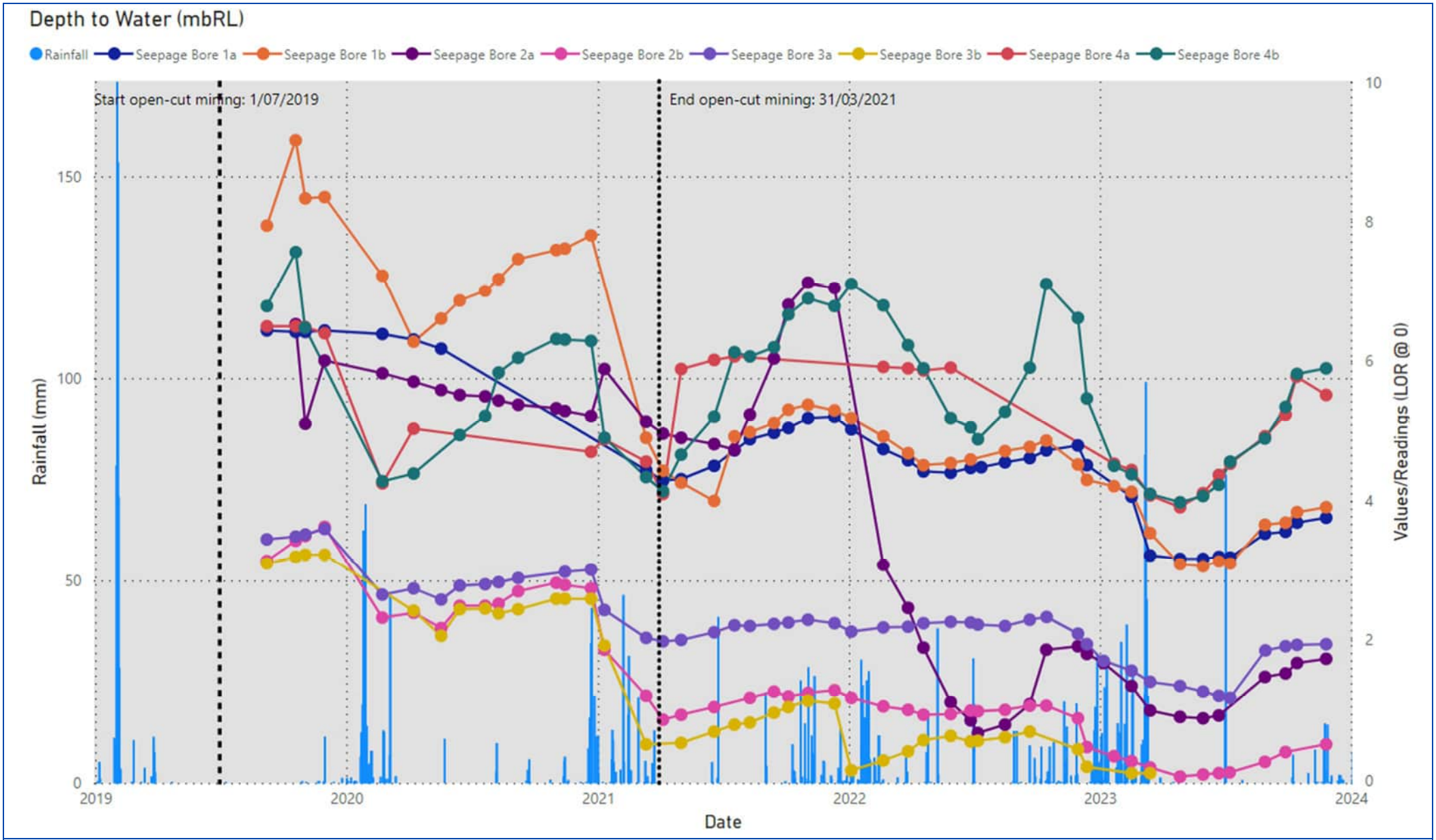


Plate 20 Depth to water (mbRL) in EA seepage monitoring bores

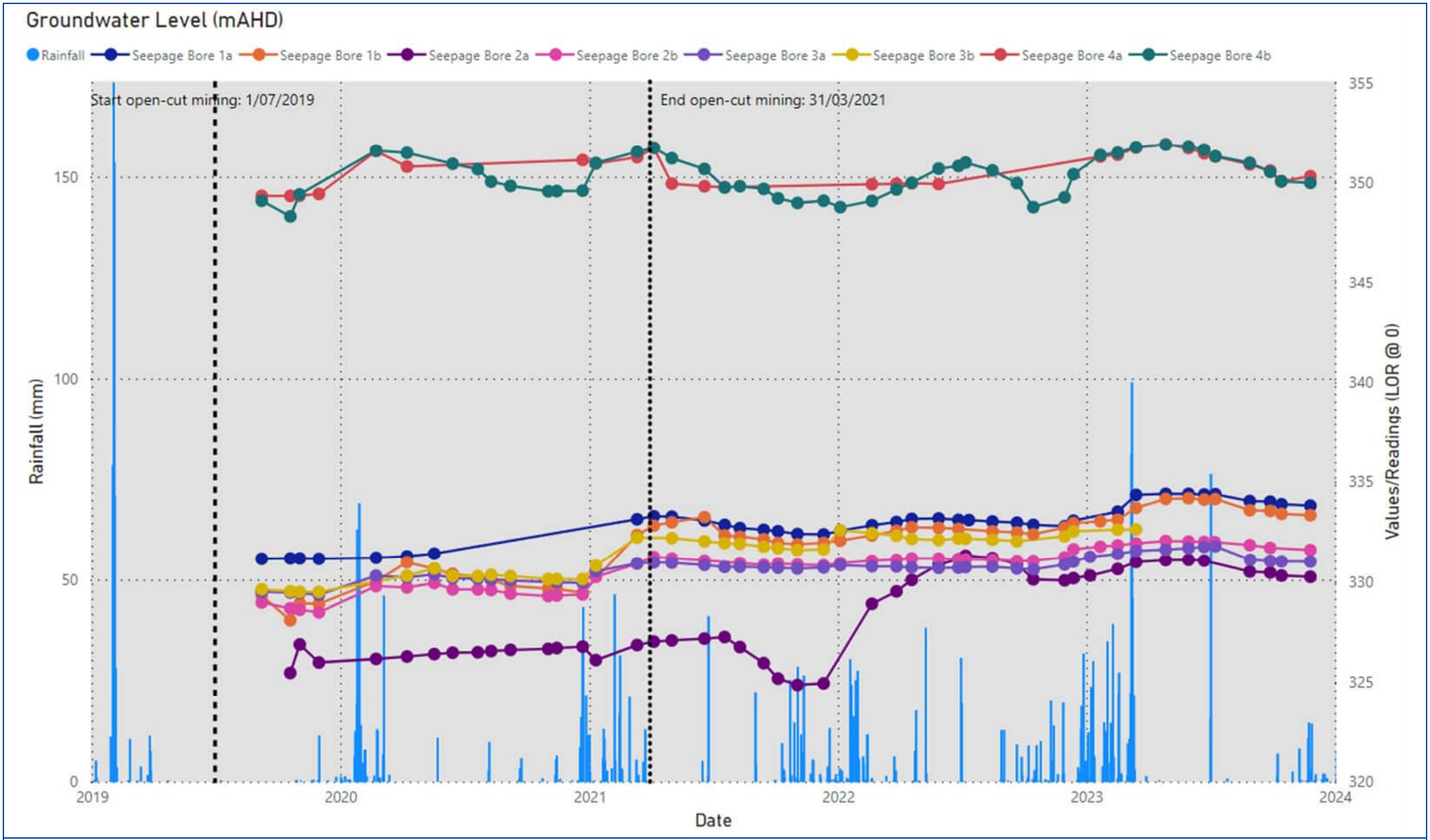


Plate 21 Groundwater levels (mAHD) in EA seepage monitoring bores

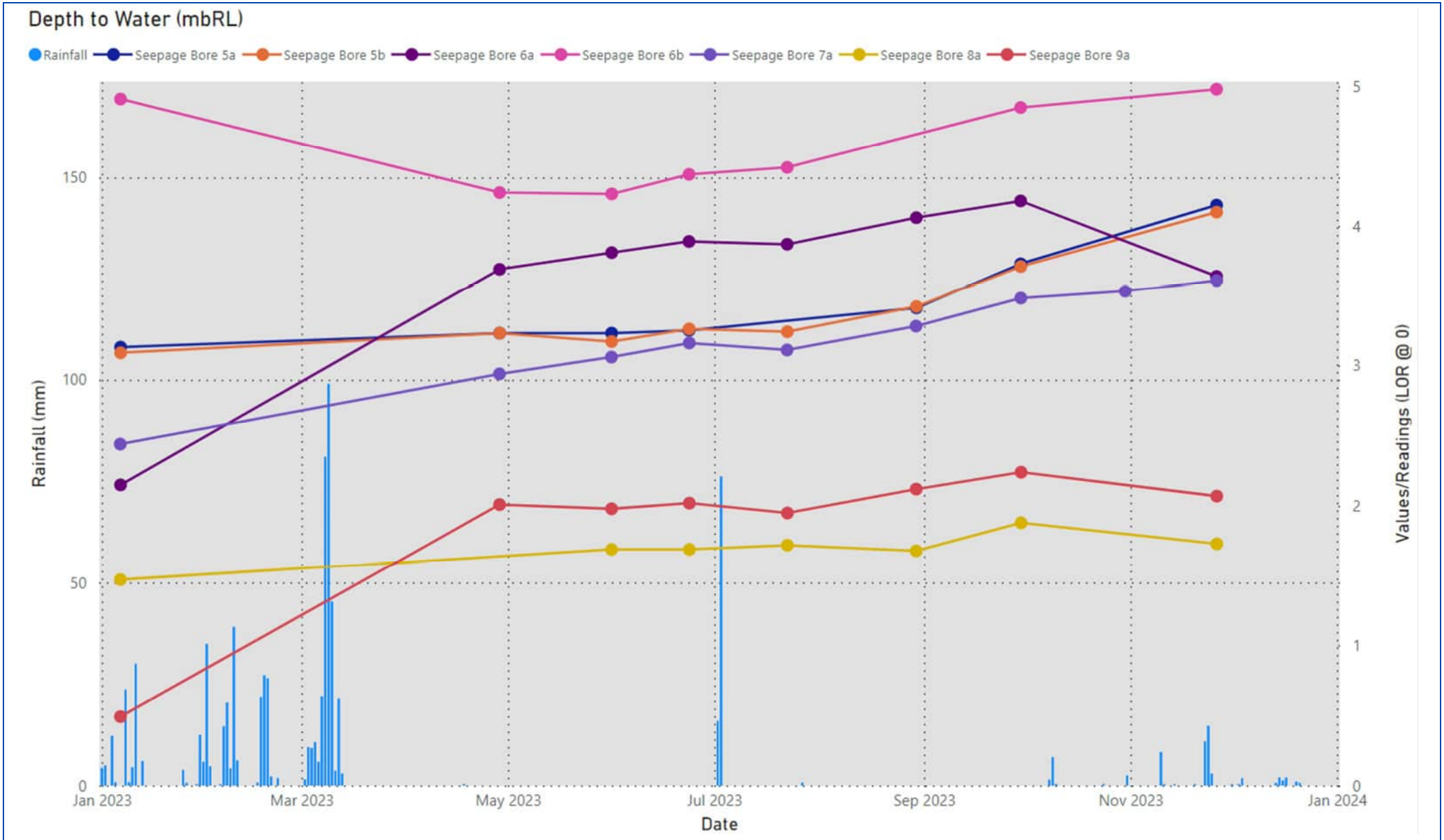


Plate 22 Depth to water (mbRL) in additional seepage monitoring bores

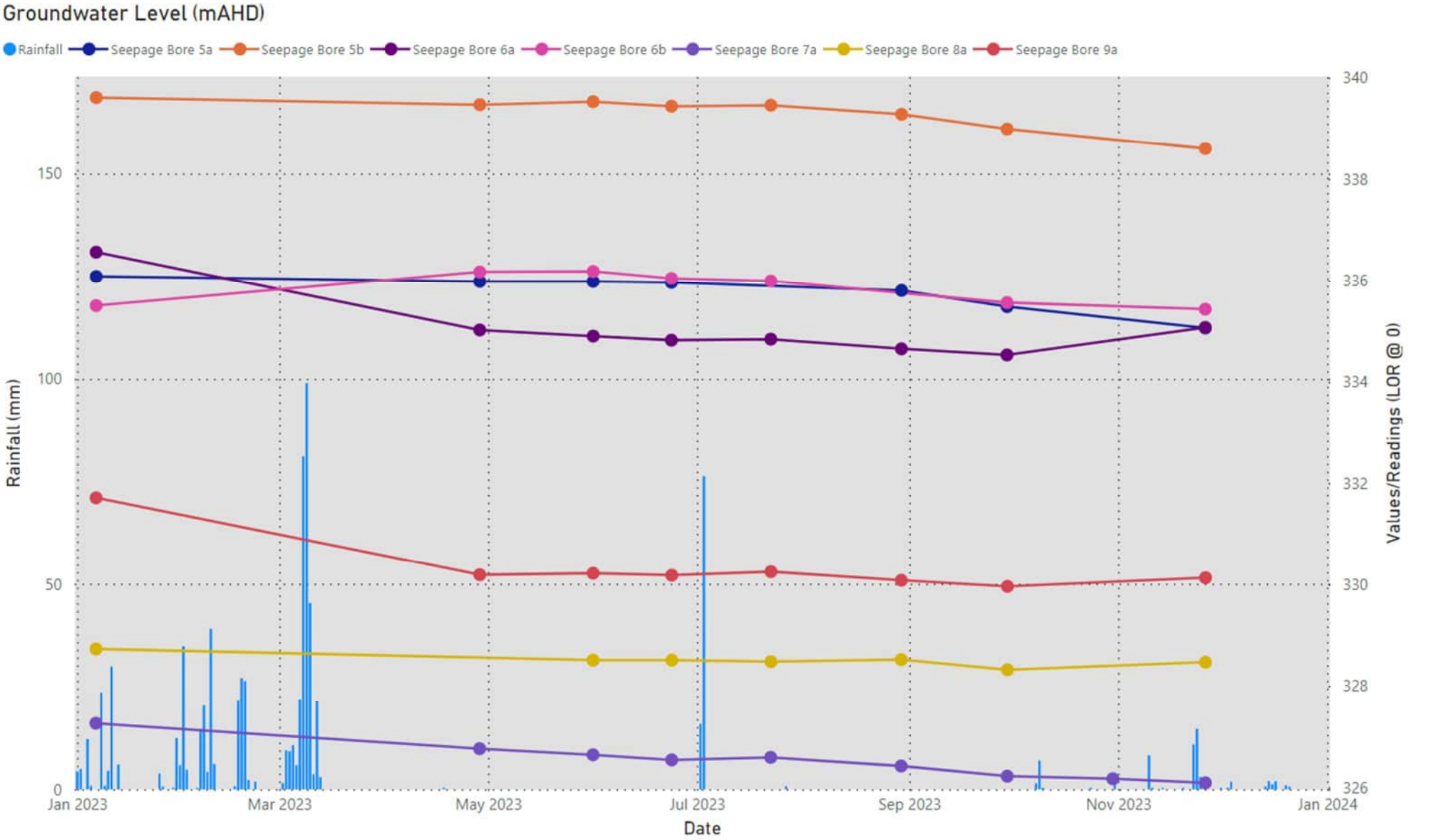


Plate 23 Groundwater levels (mAHD) in additional seepage monitoring bores

8.2.4 Assessment of water levels in seepage monitoring wells

To assess the water levels and response to rainfall events, Aeris installed automated data loggers in several seepage monitoring bores (Table 29). Data was downloaded regularly and compensated for barometric pressure changes. Table 29 shows the timeframes/periods the dataloggers were operational.

Table 29 Datalogger periods at seepage monitoring bore locations

Row Labels	Min. of Date and Time	Max. of Date and Time
Seep 1a	14/12/2022 06:00	29/09/2023 13:00
Seep 1a_2023-01-06_13-45-00-242	14/12/2022 06:00	6/01/2023 13:00
Seep 1a_Append_2023-02-05_11-18	6/01/2023 18:00	5/02/2023 11:00
Seep 1a_2023-05-14_10-25-16-833	5/02/2023 14:00	14/05/2023 09:00
Seep 1a_Append_2023-06-23_11-18	14/05/2023 12:00	23/06/2023 10:00
Seep 1a_2023-07-22_10-58-34-004	23/06/2023 13:00	22/07/2023 10:00
Seep 1a_2023-09-03_12-02-26-140	22/07/2023 13:00	3/09/2023 11:00
Seep 1a_2023-09-29_13-54-29-857	3/09/2023 13:00	29/09/2023 13:00
Seep 2a	14/12/2022 06:00	29/09/2023 14:00
Seep 2a_2023-01-06_13-28-27-350	14/12/2022 06:00	6/01/2023 13:00
Seep 2a_2023-02-05_11-12-33-098	6/01/2023 18:00	5/02/2023 11:00
Seep 2a_2023-05-14_10-10-36-649	5/02/2023 14:00	14/05/2023 09:00
Seep 2a_2023-06-23_11-07-31-909	14/05/2023 12:00	23/06/2023 10:00
Seep 2a_2023-07-22_11-02-21-664	23/06/2023 13:00	22/07/2023 11:00
Seep 2a_2023-09-03_11-48-39-821	22/07/2023 13:00	3/09/2023 11:00
Seep 2a_2023-09-29_14-02-16-472	3/09/2023 13:00	29/09/2023 14:00
Seep 3a	14/12/2022 06:00	29/09/2023 14:00
Seep 3a_2023-01-06_13-26-01-559	14/12/2022 06:00	6/01/2023 13:00
Seep 3a_2023-02-05_11-10-09-928	6/01/2023 18:00	5/02/2023 11:00
Seep 3a_2023-05-14_10-06-32-219	5/02/2023 14:00	14/05/2023 09:00
Seep 3a_2023-06-23_11-05-16-218	14/05/2023 12:00	23/06/2023 10:00
Seep 3a_2023-07-22_11-04-57-060	23/06/2023 13:00	22/07/2023 11:00
Seep 3a_2023-09-03_11-42-20-245	22/07/2023 13:00	3/09/2023 11:00
Seep 3a_2023-09-29_14-11-17-723	3/09/2023 13:00	29/09/2023 14:00
Seep 5b	14/12/2022 06:00	29/09/2023 13:00
Seep 5b_2023-01-06_13-43-11-781	14/12/2022 06:00	6/01/2023 13:00
Seep 5b_2023-02-05_11-22-56-347	6/01/2023 18:00	5/02/2023 11:00
Seep 5b_2023-05-14_10-27-44-437	5/02/2023 14:00	14/05/2023 09:00
Seep 5b_2023-06-23_11-22-49-485	14/05/2023 12:00	23/06/2023 10:00
Seep 5b_2023-07-22_11-07-26-000	23/06/2023 13:00	22/07/2023 11:00
Seep 5b_Append_2023-09-03_12-05	22/07/2023 13:00	3/09/2023 11:00
Seep 5b_2023-09-29_13-50-45-218	3/09/2023 13:00	29/09/2023 13:00
Seep 6b	14/12/2022 06:00	29/09/2023 13:00
Seep 6b_2023-01-06_13-40-50-964	14/12/2022 06:00	6/01/2023 13:00
Seep 6b_2023-02-05_11-21-22-507	6/01/2023 18:00	5/02/2023 11:00
Seep 6b_2023-05-14_10-30-36-146	5/02/2023 14:00	14/05/2023 09:00
Seep 6b_2023-06-23_11-20-44-358	14/05/2023 12:00	23/06/2023 10:00

Row Labels	Min. of Date and Time	Max. of Date and Time
Seep 6b_2023-07-22_11-10-17-524	23/06/2023 13:00	22/07/2023 11:00
Seep 6b_2023-09-03_12-10-41-784	22/07/2023 13:00	3/09/2023 11:00
Seep 6b_2023-09-29_13-41-30-879	3/09/2023 13:00	29/09/2023 13:00
Seep 8a	14/12/2022 06:00	29/09/2023 14:00
Seep 8a_2023-01-06_13-34-25-119	14/12/2022 06:00	6/01/2023 13:00
Seep 8a_2023-02-05_11-14-40-420	6/01/2023 18:00	5/02/2023 11:00
Seep 8a_2023-05-14_10-16-22-227	5/02/2023 14:00	14/05/2023 09:00
Seep 8a_2023-06-23_11-09-18-812	14/05/2023 12:00	23/06/2023 10:00
Seep 8a_2023-07-22_11-12-44-380	23/06/2023 13:00	22/07/2023 11:00
Seep 8a_2023-09-03_11-51-46-130	22/07/2023 13:00	3/09/2023 11:00
Seep 8a_2023-09-29_14-32-44-838	3/09/2023 13:00	29/09/2023 14:00
Seep 9a	14/12/2022 06:00	29/09/2023 14:00
Seep 9a_2023-01-06_13-36-18-670	14/12/2022 06:00	6/01/2023 13:00
Seep 9a_2023-02-05_11-16-14-723	6/01/2023 18:00	5/02/2023 11:00
Seep 9a_2023-05-14_10-18-54-663	5/02/2023 14:00	14/05/2023 09:00
Seep 9a_2023-06-23_11-11-16-577	14/05/2023 12:00	23/06/2023 10:00
Seep 9a_2023-07-22_11-14-50-664	23/06/2023 13:00	22/07/2023 11:00
Seep 9a_2023-09-03_11-54-49-258	22/07/2023 13:00	3/09/2023 11:00
Seep 9a_2023-09-29_14-41-00-590	3/09/2023 13:00	29/09/2023 14:00

Data logger recordings were processed to calculate equivalent absolute groundwater levels in the seepage bores. As part of the quality control, the groundwater levels calculated using the data loggers were compared against manually obtained groundwater levels to ensure that the data logger data was reliable. Plate 24 shows the calculated versus manually obtained groundwater levels, presenting an acceptable correlation between data logger and manual recordings. Therefore, the data logger recordings accurately represent the minute and short-term responses of groundwater levels to rainfall events.

Time series are provided as follows:

- Plate 25: Groundwater levels (mAHD) in seepage monitoring bores 1a, 2a, 3a, 5b, 6b, 8a and 9a versus rainfall
- Plate 26: Groundwater level changes (m) in seepage monitoring bores 1a, 2a, 3a, 5b, 6b, 8a and 9a versus rainfall

The datalogger recordings indicate the following:

- Seepage monitoring bores 1a, 2a and 3a
  - These shallow seepage monitoring bores were installed between the sediment dam and the creek, with bores 2a and 3a installed near the sump.
  - Groundwater levels in these bores rise almost immediately in response to significant rainfall events. The rise and recovery of groundwater levels is as follows:
    - The magnitude of the rise in groundwater levels following significant rainfall events is the largest in seepage monitoring bore 1a. This bore is furthest from and outside the radius of influence of the sump. Recovery of groundwater levels in bore 1a is less gradual and steeper than in bores 2a and 3a.

    - The magnitude of groundwater level rise following significant rainfall events in bore 3a is not as large as in bore 1a. Bore 3a is located near the sump; however, the influence of the sump on water levels at this location is minor. Recovery of groundwater levels in bore 3a is more gradual and less steep than in bore 1a.
    - Groundwater levels in bore 2a rise in response to rainfall, but to a lesser extent than in bores 1a and 3a. The water levels in bore 2a are most likely influenced by the water levels in the sump.

- Seepage monitoring bores 5b and 6b
  - These deep bores were installed between the WRD and sediment dam to assess the impact of potential seepage through the base of the WRD on groundwater. Bore 5b was installed at/within a drainage line that runs northwards from underneath the WRD and sediment dam and then joins the main creek downstream of the BCP Spring (N) location.
  - Groundwater levels in both bores generally respond in a similar manner (i.e. similar magnitude) to rainfall events. However, the recovery/decrease in water levels varies, with the recovery in bore 5a being steeper and quicker than in bore 6b. This is most likely due to the fact that bore 5b was installed at/near the drainage line, allowing for groundwater flow/migration along this drainage line. Infiltration of water from the WRD through its base into the underlying drainage line and/or groundwater may also affect the groundwater levels in seepage monitoring bore 5b.
- Seepage monitoring bores 8a and 9a
  - Shallow bore 8a was installed between the sump and the creek, whilst shallow bore 9a was installed near the BCP Spring (S).
  - Groundwater level rises to rainfall are larger in bore 9a than in bore 8a. Recovery of water levels is generally steeper in bore 9a than in bore 8a. Groundwater level changes at both bores appear correlated with water level changes at the BCP Spring (S) and (N) sites. However, water levels in bores 8a may also be influenced by the nearby sump.

Comparison of groundwater levels in seepage monitoring bores near the creek and water levels within the creek (Plate 27) indicates the following:

- Groundwater levels in shallow seepage monitoring bores 1a, 2a and 3a are generally above the water level at the BCP Spring (S) and BCP Spring (N) sites. These bores are located immediately downgradient of the WRD sediment dam. Groundwater levels fluctuate in response to rainfall events. The dissimilarity in fluctuations (in terms of amplitude and pattern) between groundwater levels in these bores and water levels at the spring indicates that there is limited groundwater throughflow and connectivity from immediately north of the sediment dam to the creek.
- Seepage monitoring bore 9a is located nearest to the BCP Spring (S) site. Groundwater levels in this bore are gently declining towards the water level at the BCP Spring (S) site, indicating a hydraulic connectivity between the shallow groundwater and the water body at this location. However, it is considered that the hydraulic gradient towards the water body is the result of a temporary rise in groundwater levels after the March 2023 and July 2023 rainfall events. The rainfall-event generated gradient will dissipate and disappear with time so that the shallow groundwater no longer recharges the water body, until the next significant rainfall event. The ephemeral occurrence of the water bodies along the creek supports this hypothesis.

- Seepage monitoring bore 8a is located near the creek, with groundwaters below the water level at BCP Spring (S). This indicates limited groundwater throughflow and connectivity from this location to the creek.

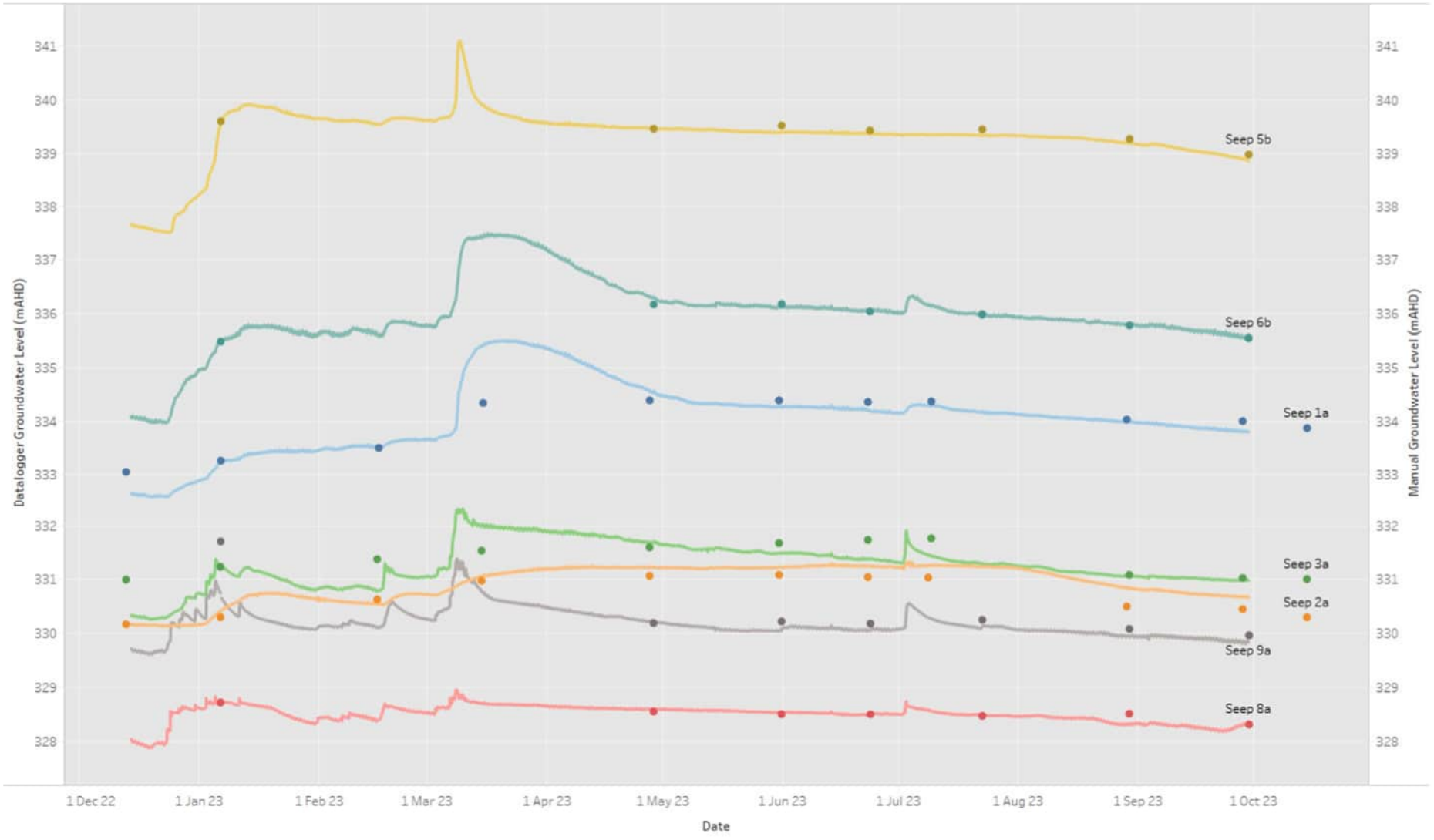


Plate 24 Data logger based groundwater levels (mAHD) versus manually obtained groundwater levels (mAHD)

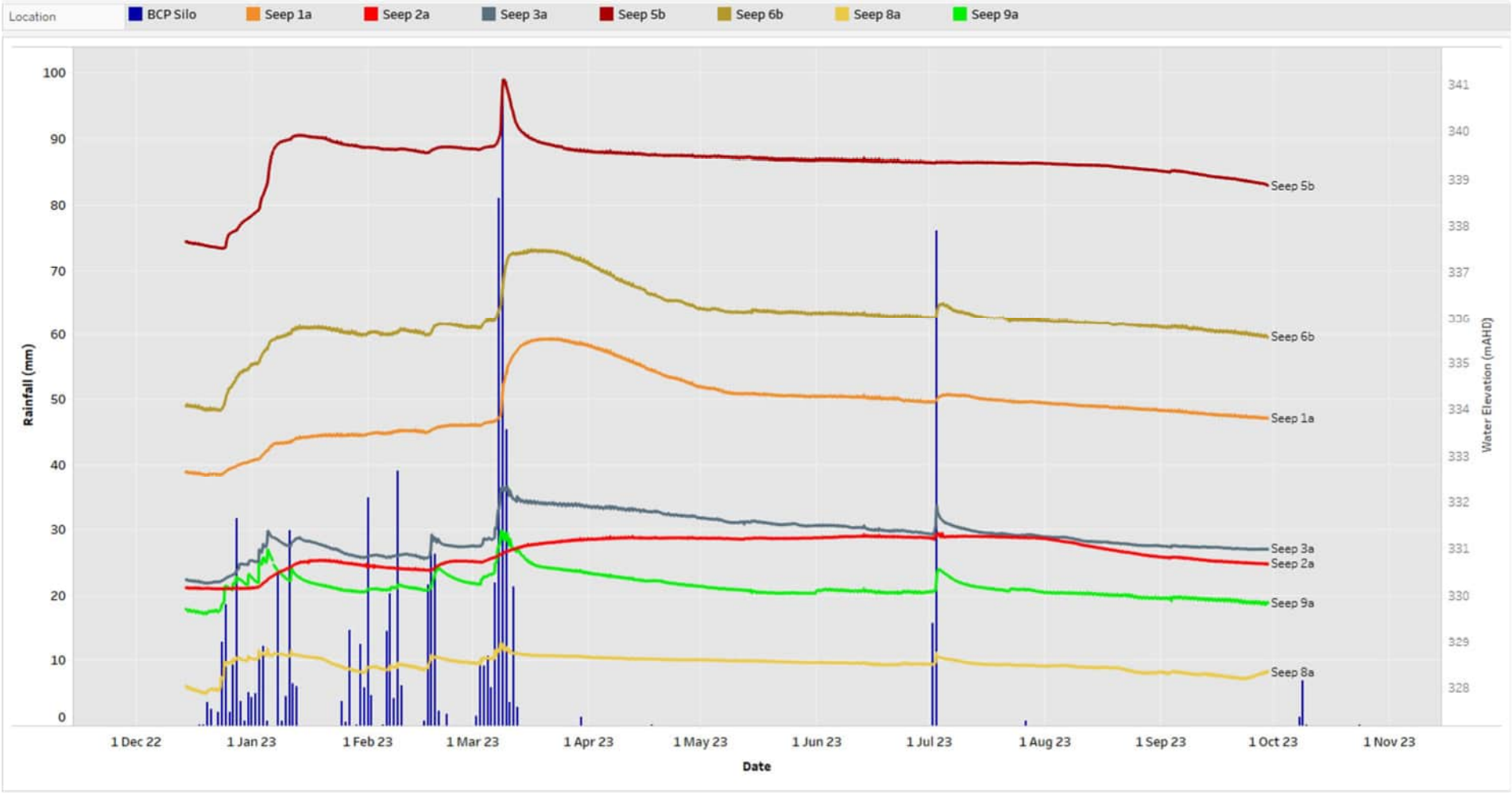


Plate 25 Groundwater levels (mAHD) in seepage monitoring bores 1a, 2a, 3a, 5b, 6b, 8a and 9a versus rainfall

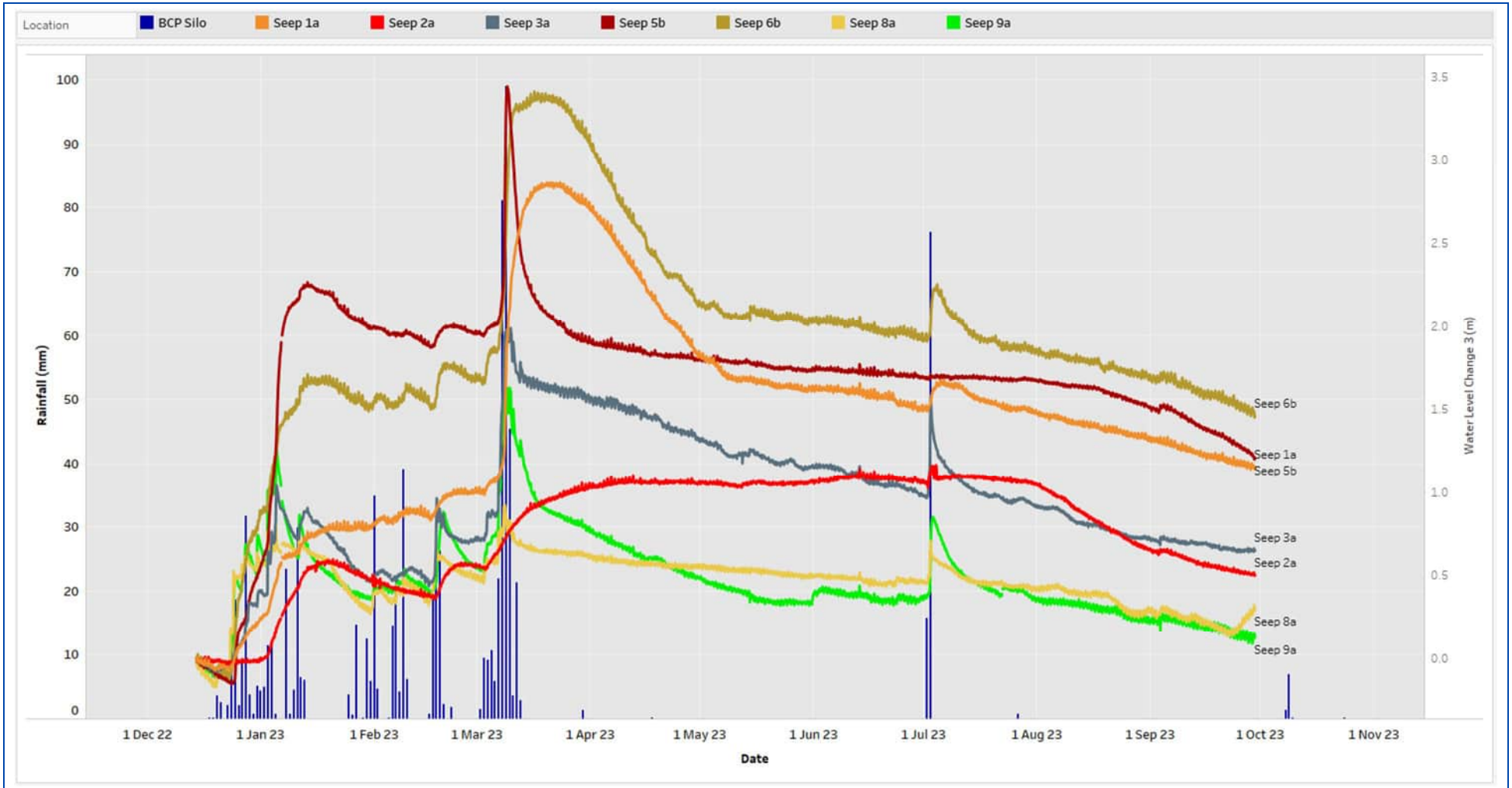


Plate 26 Groundwater level changes (m) in seepage bores 1a, 2a, 3a, 5b, 6b, 8a and 9a versus rainfall

Plate 27 Groundwater levels (mAHD) in selected seepage monitoring bores and BCP spring locations versus rainfall

8.3 Groundwater hydrogeochemistry and water types

Groundwater samples were analysed for major ions and alkalinity to allow for hydrogeochemical analysis. Piper, Durov and Chadha diagrams of the groundwater samples from the groundwater monitoring and the seepage monitoring bores are presented in Appendix G.4 and Appendix H.4, respectively.

Groundwater monitoring bores

Based on the ionic composition of the water samples, the groundwater in the monitoring wells at BCP can be classified as per Table 30.

Table 30 Water-type classification of groundwater monitoring bores

Location	Screened lithology	Piper diagram water type	Durov diagram classification
BARC071	Rhyolite	• Mixed Ca-Na-HCO3	• 3: HCO3 and Na are dominant, indicates ion exchange water.
BAWB01	Rhyolite	• Ca-Mg-HCO3 • Mixed Ca-Na-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed. • 3: HCO3 and Na are dominant, indicates ion exchange water.
BAWB02	Rhyolite	• Mixed Ca-Na-HCO3	• 3: HCO3 and Na are dominant, indicates ion exchange water. • 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.
BAWB03	Rhyolite	• Mixed Ca-Na-HCO3 • Ca-Mg-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.
BAWB04	Rhyolite	• Ca-Mg-HCO3 • Na-K-HC03	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.
BAWB05	Rhyolite	• Ca-Mg-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.
BAWB07	Ore body?	• Mixed Ca-Na-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.

Location	Screened lithology	Piper diagram water type	Durov diagram classification
			• 3: HCO3 and Na are dominant, indicates ion exchange water.
BAWBR01	Dolerite	• Na-K-Cl-SO4	• 6: SO4 and Na are dominant. Water type is not frequently encountered and indicates probable mixing or uncommon dissolution influences.
BAWBR02	Dolerite	• Mixed Ca-Na-HCO3 • Na-K-Cl-SO4	• 6: SO4 and Na are dominant. Water type is not frequently encountered and indicates probable mixing or uncommon dissolution influences. • 3: HCO3 and Na are dominant, indicates ion exchange water.
BAWBR03	Dolerite	• Na-K-Cl-SO4	• 6: SO4 and Na are dominant. Water type is not frequently encountered and indicates probable mixing or uncommon dissolution influences. • 3: HCO3 and Na are dominant, indicates ion exchange water. • 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing.
Bore E	Basalt/dolerite	• Ca-Mg-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.

The ionic composition of the water samples obtained from groundwater monitoring bores indicates the following:

- The water type of bores screened in rhyolite or orebody (BARC071 and BAWB01 to BAWB07) is different than at other bores (BAWBR01 to BAWBR03 and Bore E).
- Water types can be summarised as follows:
  - Rhyolite/ore body bores (BARC071 and BAWB01 to BAWB07): water type is mixed Ca-Na-HCO3 and/or Ca-Mg-HCO3. Groundwater quality is predominantly associated with ion exchange reactions.
  - Dolerite/basalt bores (BAWBR01 to BAWBR03, Bore E): water type is mixed Ca-Na-HCO3, Na-K-Cl-SO4 and/or Ca-Mg-HCO3. Groundwater quality is predominantly associated with mixing/dissolution and ion exchange reactions.
- Water types appear to be influenced mainly by screened lithology, as evidenced by the Gibbs diagrams. Open-cut mining operations do not appear to have changed or adversely affected the water type over time.

- There is no indication of high sulphate content in the groundwater at these locations, even in the groundwater from bore BAWB02 (located in the Green Zone orebody) or from bores BAWB07 and BARC071 (located in the BCP orebody).

Seepage monitoring bores

Based on the ionic composition of the water samples, the groundwater in the seepage monitoring wells at BCP can be classified as per Table 31.

Table 31 Water-type classification of seepage monitoring bores

Location	Screened formation	Piper diagram water type	Durov diagram classification
Seepage Bore 1a	Rhyolite	• Mixed Ca-Mg-Cl	• 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing.
Seepage Bore 1b	Rhyolite	• Variable (evolution?) • Mixed Ca-Na-HCO3 • Na-K-Cl-SO4 • Mixed Ca-Mg-Cl	• 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing (2021-2023). • 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed (2019-2020).
Seepage Bore 2a	Rhyolite	• Na-K-Cl-SO4	• 6: SO4 and Na are dominant. Water type is not frequently encountered and indicates probable mixing or uncommon dissolution influences (2020-2021). • 9: Cl and Na dominant. Frequently indicates end-point waters through dissolution (2022-2023).
Seepage Bore 2b	Rhyolite	• Mixed Ca-Na-HCO3 • Ca-Mg-HCO3	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed (2019-2023). • 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing (2023).
Seepage Bore 3a	Rhyolite	• Mixed Ca-Na-HCO3 • Ca-Mg-HCO3 • Na-K-Cl-SO4 • Mixed Ca-Mg-Cl	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed (2020-2021).

Location	Screened formation	Piper diagram water type	Durov diagram classification
			• 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing (2019, 2022-2023).
Seepage Bore 3b	Rhyolite	• Ca-Mg-HCO3 • Mixed Ca-Mg-Cl	• 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed (2020-2021). • 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing (2019, 2022-2023).
Seepage Bore 4a	Rhyolite	• Na-K-HCO3 • Mixed Ca-Na-HCO3	• 3: HCO3 and Na are dominant, indicates ion exchange water (2020-2023). • 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed (2022).
Seepage Bore 4b	Rhyolite	• Mixed Ca-Na-HCO3 • Ca-Mg-HCO3	• 3: HCO3 and Na are dominant, indicates ion exchange water (2019-2023). • 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed (2022-2023).
Seepage Bore 5a	Rhyolite	• Mixed Ca-Mg-Cl • Ca-Mg-Cl-SO4	• 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing (2023).
Seepage Bore 5b	Rhyolite	• Na-K-Cl-SO4	• 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing (2023).
Seepage Bore 6a	Rhyolite	• Mixed Ca-Mg-Cl • Ca-Mg-Cl-SO4	• 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing (2023).
Seepage Bore 6b	Rhyolite	• Mixed Ca-Na-HCO3	• 3: HCO3 and Na are dominant, indicates ion exchange water (2023). • 2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an

Location	Screened formation	Piper diagram water type	Durov diagram classification
			important ion exchange is presumed (2023).
Seepage Bore 7a	Rhyolite	• Mixed Ca-Na-HCO3	• 3: HCO3 and Na are dominant, indicates ion exchange water (2023).
Seepage Bore 8a	Rhyolite	• Na-K-Cl-SO4 • Mixed Ca-Na-HCO3	• 6: SO4 and Na are dominant. Water type is not frequently encountered and indicates probable mixing or uncommon dissolution influences (2023).
Seepage Bore 9a	Rhyolite	• Na-K-Cl-SO4 • Mixed Ca-Na-HCO3	• 6: SO4 and Na are dominant. Water type is not frequently encountered and indicates probable mixing or uncommon dissolution influences (2023). • 5: No dominant anion or cation, indicates water exhibiting dissolution or mixing (2023).

The ionic composition/water types in the seepage monitoring bores are more varied than in the groundwater monitoring bores and appear to be influenced by multiple factors, including screened lithology, depth of the bore and proximity to mine features and the creek.

The ionic composition indicates the following:

- Seepage monitoring bores 4a/4b:
  - The bores are located near the offices and workshop area along the access road to the mine site. The bores were installed as background monitoring bores.
  - Water types include Na-K-HCO3, mixed Ca-Na-HCO3 and Ca-Mg-HCO3.
  - Water types are related to ion exchange with screened lithology.
- Seepage monitoring bores 1a/1b:
  - These shallow (1a) and deep (1b) bores were installed northeast of the sediment dam, between the sediment dam and the creek.
  - Water type in the shallow bore (1a) is mixed Ca-Mg-Cl and related to dissolution or mixing. Gibbs diagram indicated rock and evaporation dominance.
  - Water type in the deep bore (1b) varies between mixed Ca-Na-HCO3, Na-K-Cl-SO4 and mixed Ca-Mg-Cl. Water types are associated with dissolution/mixing and/or ion exchange with screened lithology. Gibbs diagram indicates rock and evaporation dominance.
- Seepage monitoring bores 2a/2b
  - The bores were installed adjacent to the sump between the sediment dam and the creek.
  - Water type in the shallow bore (2a) is Na-K-Cl-SO4 and is associated with mixing or uncommon dissolution influences. Gibbs diagram indicates mainly evaporation dominance.

  - Water type in the deep bore (2b) varies between mixed Ca-Na-HCO3, Na-K-Cl-SO4 and mixed Ca-Mg-Cl. Water types are associated mainly with ion exchange and some dissolution or mixing. Gibbs diagram indicates mainly rock dominance.
- Seepage monitoring bores 3a/3b
  - The bores were installed adjacent to the sump between the sediment dam and the creek.
  - Water type in the shallow bore (3a) is variable (mixed Ca-Na-HCO3, Ca-Mg-HCO3, Na-K-Cl-SO4 and mixed Ca-Mg-Cl) and mainly associated with ion exchange. Gibbs diagram indicates mainly rock dominance, with some evaporation.
  - Water type in the deep bore (3b) varies between Ca-Mg-HCO3 and mixed Ca-Mg-Cl. Water types are associated mainly with ion exchange and some dissolution or mixing. Gibbs diagram indicates mainly rock dominance.
- Seepage monitoring bores 5a and 5b
  - These bores were installed between the WRD and sediment dam to assess the impact of potential seepage through the base of the WRD on groundwater.
  - Water type in the shallow bore (5a) is mixed Ca-Mg-Cl and Ca-Mg-Cl-SO4 and associated with dissolution or mixing. Gibbs diagram indicates mainly rock dominance.
  - Water type in the deep bore (5b) is mixed Na-K-Cl-SO4 and associated with dissolution or mixing. Gibbs diagram indicates evaporation dominance.
- Seepage monitoring bores 5a and 5b
  - These bores were installed between the WRD and sediment dam to assess the impact of potential seepage through the base of the WRD on groundwater.
  - Water type in the shallow bore (6a) is mixed Ca-Mg-Cl and Ca-Mg-Cl-SO4 and associated with dissolution or mixing. Gibbs diagram indicates evaporation and rock dominance.
  - Water type in the deep bore (6b) is mixed Ca-Na-HCO3 and associated with ion exchange. Gibbs diagram indicates evaporation dominance.
- Seepage bore 7a
  - Shallow bore 7a was installed near the BCP Spring (N).
  - Water type in this bore is mixed Ca-Na-HCO3, associated with ion exchange. Gibbs diagram indicates evaporation and rock dominance.
- Seepage bore 8a
  - Shallow bore 8a was installed between the sump and the creek.
  - Water type in this bore is Na-K-Cl-SO4 and mixed Ca-Na-HCO3 and indicates probably mixing or uncommon dissolution influences. Gibbs diagram indicates evaporation and rock dominance.
- Seepage bore 8a
  - Shallow bore 9a was installed near the BCP Spring (S).
  - Water type in this bore is Na-K-Cl-SO4 and mixed Ca-Na-HCO3 and indicates probably mixing or uncommon dissolution influences. Gibbs diagram indicates evaporation dominance.

8.4 Groundwater quality

8.4.1 Groundwater monitoring bores

Table 32 presents the range of analysis results above the LOR for selected analytes/parameters in the groundwater monitoring bores. Time series and box & whisker plots are provided in Appendix G.

Table 33 to Table 36 show the occurrence of exceedances against the EA Limit A and Limit B values, the ANZECC livestock water quality guidelines and the ANZG 2018 DGVs for protecting aquatic (slightly to moderately disturbed) ecosystems.

The data and information indicate the following:

- The box & whisker plots show the natural variability of analyte concentrations within a given bore or between bores screened within a given formation.
- Field water quality parameters:
  - pH values range from slightly acidic (±6.5) to slightly alkaline (±8.75), with pH generally increasing since the end of open-cut mining. The increase in pH is considered associated with ion exchange between the groundwater and the screened formations. Highest pH values are observed in bores BAWBR01, BAWBR02 and BAWBR03 that are screened in dolerite/basalt.
  - Based on field EC readings), groundwater quality is mainly fresh in bores BAWB01 to BAWB07 and slightly brackish in bores BAWBR01, BAWBR02 and BAWBR03. There is no discernible trend in EC values.
- Major ions
  - Concentrations of anions, cations and bicarbonate alkalinity are generally low in bores BAWB01 to BAWB07, screened in rhyolite, with no discernible trend over time.
  - Concentrations of anions, cations and bicarbonate alkalinity are generally higher in bores BAWBR01 to BAWBR03, screened in dolerite and/or basalt, with no discernible trend over time. The highest sulfate concentration is observed in bore BAWBR01.
  - Major ion concentrations reflect the natural groundwater-aquifer interactions at the monitoring locations. There is no evidence to date that the historical open-cut mining has affected major ion levels at the bores.
- Metals
  - Dissolved metal concentrations vary between bores and are influenced by the screened formation and natural groundwater-rock formation interactions.
  - Elevated metal concentrations (relative to the other bores) have been observed as follows:
    - BAWB07: arsenic
    - BAWB04: barium and manganese
    - BAWB05: molybdenum
    - BAWB02: boron
    - BAWBR01: cobalt, molybdenum and uranium
  - The absence of commonality or a pattern between the bores indicates that the elevated concentrations are associated with localised lithology/mineralisation and not due to historical mining operations.

- Exceedances of the EA Limit A and Limit B values have occurred before, during and after the open-cut mining. Generally, where an exceedance for a given analyte was identified post-mining, exceedances for the same analyte existed pre-mining or during mining.

Table 32 Range of analysis results above the LOR in the groundwater monitoring bores

Parameter	BARC071	BAWB01	BAWB02	BAWB03	BAWB04	BAWB05	BAWB07	BAWBR01	BAWBR02	BAWBR03	Bore E
Alkalinity											
Bicarbonate Alkalinity as CaCO3 (mg/L)	404 - 406	163 - 695	124 - 510	108 - 546	166 - 601	66 - 501	419 - 554	2120 - 2220	290 - 2200	255 - 662	261 - 515
Carbonate Alkalinity as CaCO3 (mg/L)			13 - 18		4 - 4	13 - 26					28 - 28
Total Alkalinity as CaCO3 (mg/L)	404 - 406	163 - 695	137 - 510	108 - 546	170 - 601	66 - 501	419 - 554	2120 - 2220	290 - 2200	255 - 662	261 - 515
Field Measurements											
Dissolved Oxygen (field) (% sat)		0 - 131.5	0 - 450.6	0 - 296.3	0 - 422.6	0 - 116.1	2.4 - 25.2	6 - 198.3	0 - 208.5	0 - 72	0 - 171.1
Electrical Conductivity (field) (µS/cm)	842 - 976	14.63 - 1529	13.9 - 1416	665 - 1221	82 - 1269	11.17 - 1142	998 - 1264	28.4 - 665	557 - 7385	665 - 1621	844 - 1226
ORP (field) (mV)		-104.5 - 184.8	-200.4 - 302.4	-154.9 - 208.9	-156.8 - 187.9	-190.1 - 158.4	-77.3 - 43.9	-118.7 - 26.7	-300.9 - 104.9	-156.8 - 43.6	-71.1 - 219.2
pH (field)	6.69 - 8.05	5.91 - 7.98	6.39 - 8.6	6.12 - 8.11	6.17 - 8.12	6.99 - 8.68	6.62 - 8.01	7.67 - 8.38	7.05 - 8.99	7.4 - 8.86	6.09 - 8.51
Salinity (field) (PSU)		0.06 - 0.76	0.36 - 0.7	0.32 - 0.6	0.19 - 0.63	0.3 - 0.56	0.5 - 0.58	0.32 - 17.79	0.26 - 4.07	0.32 - 0.81	0.41 - 0.6
TDS (field) (ppm)		563 - 765	378 - 713	352 - 610	200 - 635	312 - 571	541 - 590	14.19 - 332	279 - 3692	332 - 810	431 - 613
Temperature (field) (°C)		27 - 35.42	24.52 - 33.61	27.11 - 33.53	23.25 - 35.33	21.99 - 33.47	24.79 - 31.68	30.6 - 33.48	23.81 - 31.97	28.84 - 32.28	27.47 - 33.55
Hardness											
Total Hardness (mg CaCO3/L)		112 - 440	77 - 320	63 - 295	69 - 288	43 - 327	236 - 307	1140 - 1140	80 - 1300	114 - 517	194 - 405
Major Ions											
Calcium (mg/L)	39 - 41	22 - 55	16 - 75	15 - 77	11 - 79	9 - 58	44 - 62	125 - 142	17 - 184	26 - 118	30 - 63
Chloride (mg/L)	32 - 36	7 - 65	11 - 82	7 - 23	7 - 67	5 - 28	36 - 49	5420 - 5490	58 - 950	16 - 220	22 - 77
Fluoride (mg/L)		0.3 - 1.8	0.3 - 0.9	0.3 - 2.4	0.2 - 0.6	0.2 - 0.8	0.8 - 1.7	2 - 2.4	0.3 - 1	0.2 - 1	0.5 - 1.6
Magnesium (mg/L)	15 - 15	9 - 80	6 - 41	5 - 26	10 - 31	5 - 53	26 - 37	173 - 199	9 - 277	12 - 54	24 - 76
Potassium (mg/L)	9 - 10	4 - 9.6	1 - 16	4 - 14	2 - 11	4 - 25	5 - 10	35 - 37	2 - 20	5 - 12	6 - 14
Sodium (mg/L)	150 - 153	32 - 242	26 - 229	29 - 150	37 - 168	16 - 118	117 - 173	7790 - 8580	170 - 1570	72 - 627	70 - 137
Sulfate (as SO4)	48 - 52	17 - 104	44 - 220	14 - 56	1 - 39	13 - 84	39 - 75	7220 - 7360	80 - 1290	47 - 737	28 - 74
Metals (dissolved)											
Aluminium - dissolved (mg/L)		0.012 - 0.012	0.017 - 0.017	0.03 - 0.03	0.012 - 0.012	0.02 - 0.034					
Arsenic - dissolved (mg/L)	0.009 - 0.01	0.001 - 0.003	0.001 - 0.001	0.001 - 0.001	0.001 - 0.004	0.001 - 0.002	0.002 - 0.018	0.006 - 0.006	0.001 - 0.01	0.002 - 0.003	0.001 - 0.003
Barium - dissolved (mg/L)	0.053 - 0.06	0.03 - 0.216	0.083 - 0.179	0.057 - 0.169	0.06 - 0.493	0.071 - 0.374	0.054 - 0.152	0.091 - 0.096	0.003 - 0.162	0.031 - 0.068	0.06 - 0.474
Bismuth - dissolved (mg/L)									0.00006 - 0.00006		
Boron - dissolved (mg/L)	0.19 - 0.24	0.034 - 0.26	0.27 - 0.35	0.15 - 0.15	0.06 - 0.13	0.04 - 0.08	0.05 - 0.08			0.12 - 0.12	
Cadmium - dissolved (mg/L)			0.0001 - 0.0001		0.0002 - 0.0002	0.0005 - 0.0005					
Chromium - dissolved (mg/L)		0.001 - 0.002	0.001 - 0.004		0.001 - 0.002	0.002 - 0.002	0.001 - 0.002		0.001 - 0.007	0.001 - 0.006	
Cobalt - dissolved (mg/L)		0.001 - 0.005	0.001 - 0.002	0.001 - 0.002	0.001 - 0.004		0.001 - 0.001	0.013 - 0.015	0.002 - 0.005	0.001 - 0.001	0.001 - 0.002
Copper - dissolved (mg/L)	0.002 - 0.004	0.001 - 0.018	0.001 - 0.01	0.001 - 0.012	0.001 - 0.02	0.001 - 0.024	0.001 - 0.015	0.007 - 0.007	0.005 - 0.247	0.002 - 0.008	0.001 - 0.008
Lead - dissolved (mg/L)		0.001 - 0.001	0.003 - 0.003		0.003 - 0.003		0.001 - 0.006				
Manganese - dissolved (mg/L)	0.131 - 0.137	0.098 - 1.5	0.288 - 1.4		0.684 - 4.06	0.3 - 1.4	0.058 - 0.086			0.007 - 0.007	
Molybdenum - dissolved (mg/L)		0.002 - 0.009	0.001 - 0.007	0.001 - 0.005	0.002 - 0.005	0.005 - 0.031	0.003 - 0.005	0.209 - 0.212	0.002 - 0.018	0.003 - 0.011	0.001 - 0.008
Nickel - dissolved (mg/L)		0.001 - 0.003	0.001 - 0.016	0.001 - 0.004	0.001 - 0.004	0.001 - 0.005	0.001 - 0.004		0.002 - 0.025		0.001 - 0.007
Selenium - dissolved (mg/L)					0.003 - 0.003						
Silicon - dissolved (mg/L)		28 - 28	13 - 13	15 - 15	18 - 18	13 - 13					
Uranium - dissolved (mg/L)		0.001 - 0.007	0.002 - 0.008	0.002 - 0.008	0.001 - 0.003	0.001 - 0.006	0.004 - 0.005	0.461 - 0.496	0.003 - 0.143	0.002 - 0.096	0.001 - 0.007
Vanadium - dissolved (mg/L)		0.008 - 0.01		0.003 - 0.003		0.002 - 0.002				0.003 - 0.003	
Zinc - dissolved (mg/L)	0.012 - 0.014	0.007 - 0.02	0.005 - 0.026	0.06 - 0.06	0.007 - 0.024	0.007 - 0.015	0.005 - 0.008			0.046 - 0.046	
Metals (total)											
Aluminium - total (mg/L)		0.021 - 0.03	0.024 - 0.09	0.09 - 0.09	0.02 - 0.039	0.044 - 0.19					
Arsenic - total (mg/L)	0.011 - 0.011	0.001 - 0.003	0.001 - 0.002	0.001 - 0.001	0.001 - 0.004	0.001 - 0.005	0.002 - 0.019	0.006 - 0.007	0.001 - 0.011	0.002 - 0.003	0.001 - 0.004
Barium - total (mg/L)	0.06 - 0.064	0.027 - 0.253	0.083 - 0.197	0.058 - 0.183	0.068 - 0.529	0.088 - 0.399	0.066 - 0.105	0.076 - 0.096	0.067 - 0.182	0.031 - 0.068	0.06 - 0.258
Bismuth - total (mg/L)									0.00009 - 0.0002		

Parameter	BARC071	BAWB01	BAWB02	BAWB03	BAWB04	BAWB05	BAWB07	BAWBR01	BAWBR02	BAWBR03	Bore E
Boron - total (mg/L)	0.2 - 0.24	0.03 - 0.18	0.26 - 0.35	0.15 - 0.15	0.06 - 0.13	0.04 - 0.07	0.05 - 0.09			0.12 - 0.12	
Cadmium - total (mg/L)		0.0001 - 0.0002	0.0005 - 0.0005		0.0003 - 0.0003	0.0003 - 0.0004	0.0001 - 0.0001			0.0002 - 0.0002	
Chromium - total (mg/L)		0.001 - 0.001	0.002 - 0.011	0.001 - 0.001	0.002 - 0.006	0.001 - 0.004	0.001 - 0.001		0.001 - 0.013	0.002 - 0.006	0.001 - 0.012
Cobalt - total (mg/L)	0.002 - 0.002	0.001 - 0.007	0.001 - 0.014	0.001 - 0.002	0.002 - 0.004	0.001 - 0.002		0.013 - 0.014	0.001 - 0.009	0.002 - 0.002	0.001 - 0.002
Copper - total (mg/L)	0.006 - 0.013	0.001 - 0.034	0.001 - 0.051	0.001 - 0.012	0.001 - 0.369	0.001 - 0.019	0.002 - 0.029	0.009 - 0.009	0.009 - 0.89	0.004 - 0.022	0.001 - 0.005
Iron - total (mg/L)		0.14 - 0.14	0.17 - 0.17	0.071 - 0.071	1.4 - 1.4	0.71 - 0.71					
Lead - total (mg/L)	0.002 - 0.003	0.001 - 0.003	0.001 - 0.008		0.001 - 0.003	0.001 - 0.006	0.001 - 0.019				
Manganese - total (mg/L)	0.138 - 0.159	0.12 - 1.49	0.294 - 1.4	0.007 - 0.007	0.696 - 4.35	0.346 - 1.4	0.074 - 0.116			0.006 - 0.006	
Molybdenum - total (mg/L)		0.001 - 0.006	0.001 - 0.005	0.001 - 0.004	0.002 - 0.005	0.007 - 0.033	0.003 - 0.005	0.195 - 0.216	0.001 - 0.017	0.004 - 0.011	0.002 - 0.008
Nickel - total (mg/L)	0.001 - 0.001	0.001 - 0.003	0.001 - 0.014	0.001 - 0.004	0.001 - 0.004	0.001 - 0.014	0.001 - 0.002		0.001 - 0.033	0.001 - 0.002	0.001 - 0.009
Selenium - total (mg/L)					0.003 - 0.003						
Silicon - total (mg/L)		29 - 29	13 - 13	15 - 15	18 - 18	14 - 14					
Uranium - total (mg/L)		0.002 - 0.007	0.003 - 0.006	0.003 - 0.007	0.001 - 0.003	0.002 - 0.006	0.003 - 0.005	0.448 - 0.459	0.004 - 0.156	0.003 - 0.1	0.002 - 0.008
Vanadium - total (mg/L)		0.01 - 0.011		0.003 - 0.003		0.001 - 0.002				0.003 - 0.003	
Zinc - total (mg/L)	0.017 - 0.022	0.006 - 0.024	0.006 - 0.035	0.074 - 0.074	0.007 - 0.038	0.006 - 0.02	0.011 - 0.028			0.061 - 0.061	
Nutrients											
Nitrite + Nitrate as N (mg/L)		0.03 - 0.18	0.02 - 0.08	0.89 - 2.56	0.28 - 0.28	0.02 - 0.04	0.39 - 0.39				0.12 - 0.12
Total Kjeldahl Nitrogen as N (mg/L)		0.1 - 0.1	3.2 - 3.7	0.1 - 0.4	0.2 - 0.3	0.3 - 0.4	0.1 - 0.1				
Total Nitrogen as N (mg/L)		0.1 - 0.3	3.2 - 3.7	1 - 3	0.2 - 0.5	0.3 - 0.4	0.5 - 0.5				0.1 - 0.1
Total Phosphorus as P (mg/L)		0.02 - 0.06	0.26 - 0.26	0.02 - 0.03	0.03 - 0.08	0.03 - 0.06	0.04 - 0.04				0.01 - 0.01
Physico-Chemical Parameters											
Electrical Conductivity (µS/cm)		389 - 1560	331 - 1340	246 - 1130	233 - 950	164 - 996	951 - 1130	28600 - 31300	883 - 7280	1250 - 3190	653 - 1280
pH (lab)		6.98 - 8.06	7.56 - 8.66	7.24 - 8.2	7.25 - 8.33	7.1 - 8.4	7.31 - 7.71	8.07 - 8.09	7.46 - 8.24	7.71 - 8.2	7.01 - 8.39
Total Dissolved Solids (mg/L)		750 - 750	820 - 820	470 - 470	560 - 560	600 - 600					
Turbidity (NTU)		0.1 - 32.9	0.2 - 47.8	0.3 - 41.4	0.4 - 50.7	0.3 - 18.5	0.3 - 16.2	9.6 - 16.6	1.9 - 20	0.6 - 16.1	0.2 - 61.4

Table 33 Groundwater monitoring bore exceedances of EA Limit A

Row Labels	BARC071	BAWB01	BAWB02	BAWB03	BAWB04	BAWB05	BAWB07	BAWBR01	BAWBR02	BAWBR03	Bore E
Barium - dissolved (mg/L)											
1. Pre-open cut mining		✓			✓	✓					
2. Open cut mining		✓			✓	✓					
3. Post-open cut mining		✓			✓	✓					
Copper - dissolved (mg/L)											
1. Pre-open cut mining		✓									
2. Open cut mining		✓									
3. Post-open cut mining											
Electrical Conductivity (µS/cm)											
1. Pre-open cut mining		✓		✓							
2. Open cut mining		✓		✓							
3. Post-open cut mining				9							
Electrical Conductivity (field) (µS/cm)											
1. Pre-open cut mining		✓		✓							
2. Open cut mining		✓		✓							
3. Post-open cut mining				✓							
Fluoride (mg/L)											
1. Pre-open cut mining		✓									
2. Open cut mining		✓									
3. Post-open cut mining		✓	1								

✓: indicates occurrence of exceedances

Table 34 Groundwater monitoring bore exceedances of EA Limit B

Row Labels	BARC071	BAWB01	BAWB02	BAWB03	BAWB04	BAWB05	BAWB07	BAWBR01	BAWBR02	BAWBR03	Bore E
Barium - dissolved (mg/L)											
1. Pre-open cut mining		✓			✓	✓					
2. Open cut mining		✓			✓						
3. Post-open cut mining					✓	✓					
Chromium - dissolved (mg/L)											
1. Pre-open cut mining		✓									
2. Open cut mining											
3. Post-open cut mining											
Cobalt - dissolved (mg/L)											
1. Pre-open cut mining		✓	✓								
2. Open cut mining		✓									
Copper - dissolved (mg/L)											
1. Pre-open cut mining											
2. Open cut mining		✓									
3. Post-open cut mining											
Electrical Conductivity (µS/cm)											
1. Pre-open cut mining		✓		✓							
2. Open cut mining		✓		✓							
3. Post-open cut mining				✓							
Electrical Conductivity (field) (µS/cm)											
1. Pre-open cut mining		✓		✓							
2. Open cut mining		✓		✓							
3. Post-open cut mining				✓							
Fluoride (mg/L)											
1. Pre-open cut mining											
2. Open cut mining											
3. Post-open cut mining		✓									
pH (field)											
1. Pre-open cut mining		✓									
2. Open cut mining		✓									
3. Post-open cut mining		✓									
pH (lab)											
2. Open cut mining		✓									
Sulfate (as SO4) (mg/L)											
1. Pre-open cut mining		✓	✓								
2. Open cut mining		✓									
3. Post-open cut mining					✓						

✓: indicates occurrence of exceedances

Table 35 Groundwater monitoring bore exceedances of ANZG Livestock Water Quality guidelines

Row Labels	BARC071	BAWB01	BAWB02	BAWB03	BAWB04	BAWB05	BAWB07	BAWBR01	BAWBR02	BAWBR03	Bore E
Electrical Conductivity (µS/cm)											
1. Pre-open cut mining											
2. Open cut mining											
3. Post-open cut mining								✓	✓		
Electrical Conductivity (field) (µS/cm)											
1. Pre-open cut mining											
2. Open cut mining											
3. Post-open cut mining									✓		
Fluoride (mg/L)											
1. Pre-open cut mining											
2. Open cut mining											
3. Post-open cut mining				✓				✓			
Molybdenum - dissolved (mg/L)											
1. Pre-open cut mining											
2. Open cut mining											
3. Post-open cut mining								✓			
Molybdenum - total (mg/L)											
1. Pre-open cut mining											
2. Open cut mining											
3. Post-open cut mining								✓			
Selenium - dissolved (mg/L)											
3. Post-open cut mining								✓			
Selenium - total (mg/L)											
3. Post-open cut mining								✓			
Sulfate (as SO4) (mg/L)											
1. Pre-open cut mining											
2. Open cut mining											
3. Post-open cut mining								✓	✓		
Uranium - dissolved (mg/L)											
1. Pre-open cut mining											
3. Post-open cut mining								✓			
Uranium - total (mg/L)											
3. Post-open cut mining								✓			

✓: indicates occurrence of exceedance

Table 36 Groundwater monitoring bore exceedances of ANZG aquatic ecosystem (slightly to moderately disturbed) WQOs

Row Labels	BARC071	BAWB01	BAWB02	BAWB03	BAWB04	BAWB05	BAWB07	BAWBR01	BAWBR02	BAWBR03	Bore E
Aluminium - total (mg/L)											
1. Pre-open cut mining			✓	✓		✓					
Arsenic - dissolved (mg/L)											
1. Pre-open cut mining							✓				
Arsenic - total (mg/L)											
1. Pre-open cut mining							✓				
3. Post-open cut mining											
Cadmium - dissolved (mg/L)											
1. Pre-open cut mining						✓					
Cadmium - total (mg/L)											
1. Pre-open cut mining			✓		✓	✓					
Chromium - dissolved (mg/L)											
1. Pre-open cut mining		✓			✓	✓	✓			✓	
2. Open cut mining			✓								
3. Post-open cut mining								✓	✓	✓	
Chromium - total (mg/L)											
1. Pre-open cut mining			✓		✓	✓				✓	✓
2. Open cut mining			✓								✓
3. Post-open cut mining					✓			✓	✓	✓	✓
Copper - dissolved (mg/L)											
1. Pre-open cut mining	✓	✓	✓	✓	✓	✓	✓			✓	✓
2. Open cut mining		✓		✓	✓	✓			✓		✓
3. Post-open cut mining		✓	✓	✓	✓	✓		✓	✓	✓	✓
Copper - total (mg/L)											
1. Pre-open cut mining	✓	✓	✓	✓	✓	✓	✓			✓	✓
2. Open cut mining		✓	✓	✓	✓	✓			✓		✓
3. Post-open cut mining		✓	✓	✓	✓	✓		✓	✓	✓	✓
Lead - dissolved (mg/L)											
1. Pre-open cut mining							✓				
Lead - total (mg/L)											
1. Pre-open cut mining			✓			✓	✓				
Manganese - dissolved (mg/L)											
1. Pre-open cut mining					✓						
2. Open cut mining					✓						
Manganese - total (mg/L)											
1. Pre-open cut mining					✓						
2. Open cut mining					✓						
Selenium - dissolved (mg/L)											
3. Post-open cut mining								✓			
Selenium - total (mg/L)											
3. Post-open cut mining								✓			
Zinc - dissolved (mg/L)											
1. Pre-open cut mining	✓	✓	✓	✓	✓	✓				✓	
Zinc - total (mg/L)											
1. Pre-open cut mining	✓	✓	✓	✓	✓	✓	✓			✓	

8.4.2 Seepage monitoring bores

Table 37 and Table 38 present the range of analysis results above the LOR for selected analytes/parameters in the seepage monitoring bores. Time series and box & whisker plots are provided in Appendix H.

It is noted that monitoring and sampling of the EA seepage monitoring bore commenced during the open-cut mining. Therefore, there is no pre-mining information and data for these bores. The additional seepage monitoring bores were installed at the end of 2022; therefore, only post-open-cut mining results are available for these bores.

Table 39 to Table 40 show the occurrence of exceedances against the ANZECC livestock water quality guidelines and the ANZG 2018 DGVs for protecting aquatic (slightly to moderately disturbed) ecosystems. It is noted that groundwater quality objectives for the seepage monitoring bores have not been defined in EPML02840015.

The data and information indicate the following:

- The box & whisker plots show the variability of analyte concentrations within a given bore or between bore locations.
- Physico-chemical parameters:
  - Field pH values range from slightly acidic to alkaline, with pH generally increasing since the bores were installed. However, laboratory pH values range from near neutral to slightly alkaline, without an increasing trend. Note that the very alkaline pH in bore 6b is not considered representative of groundwater conditions at that location. Most likely, the pH is affected by cement or bentonite grout from the construction of the monitoring bore.
  - Based on field and laboratory EC, groundwater quality is brackish to saline, increasing with time. Salinity increased suddenly in bore 2a in November 2021. The reason for this increase is not obvious. Elevated salinity (relative to other bores) is observed at bores 2a, 5a and 6a. Bores 5a and 5b are located between the WRD and sediment dam.
- Major ions
  - Highest concentrations (relative to other bores) have been observed as follows:
    - Calcium: bores 1a, 5a, 6a and 6b
    - Magnesium: bores 5a and 6a
    - Potassium: bore 6b
    - Sodium: bore 2a
    - Chloride: bore 2a
    - Fluoride: bores 2a and 7a
    - Sulfate: bores 2a, 5a, 5b and 6a
    - Bicarbonate alkalinity: bores 4a, 4b 7a, 8a and 9a
  - Sodium, chloride, fluoride and sulfate concentrations in bore 2a increased suddenly in November 2021. Groundwater levels at bore 2a also increased suddenly in November 202, which may be related to the excavation of the sump. However, concentrations of these ions in the sump are less than in bore 2a and do not follow the same trend. The increase in ion concentrations may be related to leaching of chemicals from the natural lithology due to rising groundwater levels.
  - An increasing trend in calcium and magnesium concentrations can be discerned in most bores, except in bores 7a, 8a and 9a. An increasing trend in sodium, chloride and sulfate concentrations can be discerned in most bores, except in bores 6a, 6b, 7a, 8a and 9a.

- Dissolved metals
  - Highest metal concentrations (relative to other bores) have been observed as follows:
    - Bore 1b: As
    - Bore 2a: As, Mo, Cu, U
    - Bore 3a: Ba
    - Bore 4a: As, Ba
    - Bore 5a: Co, Cu, Se
    - Bore 6a: Co, Ni, Se
    - Bore 7a: As
    - Bore 2b: Ba, Se
    - Bore 3b: Ba
    - Bore 4b: As
    - Bore 5b: Co, Cu, Mo, Se
    - Bore 6b: Ba, Cr, Cu, Mo, Ni, Se
  - With respect to shallow bore 2a located north of the sediment dam and near the sump, arsenic, barium, copper and molybdenum concentrations are in the same range as for the sediment dam. However, uranium concentrations in bore 2b are higher. The elevated metal concentrations may be related to leaching of chemicals from the natural lithology due to rising groundwater levels.
  - The occurrence of high metal concentrations in bores 5a/5b and 6a/b, located between the WRD and sediment dam, may indicate some seepage from the WRD into the underlying groundwater.

Table 37 Range of analysis results above the LOR in the EA seepage monitoring bores

Row Labels	Seepage Bore 1a	Seepage Bore 1b	Seepage Bore 2a	Seepage Bore 2b	Seepage Bore 3a	Seepage Bore 3b	Seepage Bore 4a	Seepage Bore 4b
Alkalinity								
Bicarbonate Alkalinity as CaCO3 (mg/L)	446 - 578	135 - 697	286 - 690	160 - 694	38 - 1060	99 - 543	346 - 1200	645 - 1020
Carbonate Alkalinity as CaCO3 (mg/L)		8 - 8		8 - 8	13 - 13	8 - 8	412 - 412	35 - 35
Hydroxide Alkalinity as CaCO3 (mg/L)								
Total Alkalinity as CaCO3 (mg/L)	446 - 578	143 - 697	286 - 690	168 - 694	50 - 1060	107 - 543	758 - 1200	680 - 1020
Field Measurements								
Appearance or Colour	0	0	0	0	0	0	0	0
Depth of Bore (mbgl)	6 - 6	16 - 16	6 - 6.7	16 - 16	6 - 6	16 - 16	6 - 6	16 - 16
Depth to Water (mbRL)	3.17 - 6.43	3.09 - 9.17	0.67 - 7.12	0.05 - 3.63	1.34 - 3.6	0.05 - 3.23	3.91 - 6.49	3.98 - 7.56
Depth to Water (mbGL)	6.17 - 6.38	6.27 - 7.22	5.43 - 5.82	2.17 - 2.49	2.58 - 2.83	2.06 - 2.45	4.25 - 5.03	4.28 - 5.21
Depth to Water Comments	0		0				0	0
Dissolved Oxygen (field) (% sat)	0 - 136.1	0 - 193.4	2 - 110.6	0 - 252.5	0 - 343.1	0 - 468	0 - 68.3	0 - 133.1
Dry?	0		0				0	0
Electrical Conductivity (field) (µS/cm)	1241 - 2730	1232 - 3789	10.58 - 9912	1206 - 2554	1093 - 2746	974 - 1804	1508 - 2436	1514 - 2286
Groundwater Level (mAHD)	306.61 - 373.54	306.41 - 373.38	306.2 - 377.3	308.59 - 377.11	308.53 - 375.89	308.74 - 377.48	305.32 - 351.301	305.05 - 372.82
GWL Depth Reference Elevation	311.33 - 378.09	311.33 - 378.09	311.33 - 378.09	311.33 - 378.09	311.33 - 378.09	311.33 - 378.09	311.33 - 378.09	311.33 - 378.09
Odour	0	0	0	0	0	0	0	0
ORP (field) (mV)	-63.4 - 100.8	-64.3 - 231	-78.5 - 199.5	-43.4 - 216.7	-63.3 - 223.9	-59.9 - 231.4	-81.1 - -20.9	-66.8 - 193.9
pH (field)	7.1 - 7.9	6.1 - 8.03	7.75 - 8.92	6.02 - 8.1	6.33 - 7.75	5.95 - 7.66	7.16 - 8.1	6.18 - 8.03
Salinity (field) (PSU)	0.61 - 1.39	0.6 - 1.98	1.17 - 5.95	0.59 - 1.15	0.53 - 102	0.47 - 0.91	0.75 - 1.24	0.75 - 1.16
TDS (field) (ppm)	620 - 1365	616 - 1894	1148 - 5293	603 - 1127	547 - 1373	486 - 902	754 - 1217	757 - 1143
Temperature (field) (°C)	26.91 - 32.68	25.11 - 35.7	26.52 - 31.86	27.83 - 36.26	25.84 - 35.19	24.67 - 35.4	29.36 - 33.08	26.92 - 34
Turbidity (field) (FNU)		0.7 - 18.5	19.8 - 19.8	1.1 - 33.7	0 - 9.9	0 - 2.2		1.4 - 7.7
Hardness								
Total Hardness (mg CaCO3/L)	616 - 1180	90 - 1340	329 - 578	81 - 702	40 - 787	86 - 817	340 - 526	315 - 632
Ion Balance								
Ionic Balance (%)	0.11 - 5.53	0.68 - 10.9	0.28 - 6.68	0.24 - 10.7	0.22 - 12.3	1.1 - 10.2	0.06 - 6.13	1.05 - 9.67
Total Anions (meq/L)	14.4 - 34.2	3.81 - 44.6	26 - 109	3.99 - 23.4	1.36 - 33.6	2.57 - 22.2	19.2 - 28.1	16.2 - 23.4
Total Cations (meq/L)	14.4 - 34.2	3.2 - 46.7	25.5 - 119	3.21 - 26	1.27 - 36.6	3.07 - 27.2	19.4 - 28.4	17.4 - 24.4
Major Ions								
Calcium (mg/L)	207 - 415	18 - 280	86 - 150	16 - 160	11 - 170	18 - 182	4 - 70	31 - 85
Chloride (mg/L)	65 - 301	11 - 410	276 - 2170	12 - 154	6 - 294	8 - 162	62 - 161	44 - 122
Fluoride (mg/L)	0.2 - 0.9	1 - 2	1 - 5.8	1 - 1.6	0.5 - 1.6	0.9 - 1.3	1.4 - 2.1	1.9 - 4
Magnesium (mg/L)	24 - 89	11 - 166	23 - 64	10 - 79	3 - 92	10 - 88	74 - 122	56 - 108
Potassium (mg/L)	1 - 4	4 - 8	9 - 16	1 - 8	3 - 10	4 - 7	6 - 10	5 - 7
Sodium (mg/L)	46 - 353	32 - 453	414 - 2500	36 - 272	11 - 498	31 - 246	220 - 440	212 - 312
Sulfate (as SO4)	116 - 747	31 - 1130	515 - 1630	14 - 361	9 - 376	10 - 441	69 - 99	42 - 110
Metals (dissolved)								
Arsenic - dissolved (mg/L)		0.001 - 0.004	0.001 - 0.004	0.001 - 0.002	0.001 - 0.002	0.001 - 0.001	0.002 - 0.008	0.002 - 0.005
Barium - dissolved (mg/L)	0.084 - 0.329	0.06 - 0.274	0.06 - 0.121	0.106 - 0.239	0.123 - 0.25	0.089 - 0.274	0.085 - 0.202	0.068 - 0.131
Bismuth - dissolved (mg/L)								
Chromium - dissolved (mg/L)					0.002 - 0.002		0.001 - 0.001	
Cobalt - dissolved (mg/L)	0.001 - 0.009	0.001 - 0.006	0.001 - 0.002	0.001 - 0.001	0.001 - 0.005	0.001 - 0.002	0.001 - 0.002	0.001 - 0.003
Copper - dissolved (mg/L)	0.001 - 0.003	0.001 - 0.003	0.002 - 0.01	0.001 - 0.004	0.001 - 0.007	0.002 - 0.002	0.001 - 0.001	0.001 - 0.003
Molybdenum - dissolved (mg/L)	0.001 - 0.003	0.003 - 0.007	0.014 - 0.05	0.003 - 0.006	0.002 - 0.014	0.001 - 0.005	0.011 - 0.019	0.009 - 0.017
Nickel - dissolved (mg/L)	0.001 - 0.002	0.003 - 0.003	0.001 - 0.004	0.001 - 0.002	0.001 - 0.013		0.002 - 0.007	

Row Labels	Seepage Bore 1a	Seepage Bore 1b	Seepage Bore 2a	Seepage Bore 2b	Seepage Bore 3a	Seepage Bore 3b	Seepage Bore 4a	Seepage Bore 4b
Selenium - dissolved (mg/L)	0.02 - 0.02	0.02 - 0.03	0.05 - 0.06			0.02 - 0.02		
Uranium - dissolved (mg/L)	0.012 - 0.016	0.005 - 0.026	0.014 - 0.328	0.005 - 0.021	0.003 - 0.244	0.003 - 0.018	0.009 - 0.016	0.006 - 0.017
Metals (total)								
Arsenic - total (mg/L)	0.001 - 0.001	0.002 - 0.004	0.001 - 0.005	0.001 - 0.002	0.001 - 0.002	0.001 - 0.001	0.003 - 0.008	0.002 - 0.005
Barium - total (mg/L)	0.086 - 0.362	0.063 - 0.27	0.063 - 0.131	0.111 - 0.266	0.13 - 0.258	0.101 - 0.288	0.109 - 0.22	0.07 - 0.138
Bismuth - total (mg/L)				0.00014 - 0.00014				
Chromium - total (mg/L)			0.002 - 0.002	0.001 - 0.003	0.003 - 0.003	0.001 - 0.001	0.001 - 0.001	
Cobalt - total (mg/L)	0.001 - 0.01	0.001 - 0.007	0.001 - 0.005	0.001 - 0.005	0.001 - 0.006	0.001 - 0.003	0.001 - 0.005	0.001 - 0.004
Copper - total (mg/L)	0.001 - 0.01	0.001 - 0.01	0.003 - 0.02	0.002 - 0.07	0.001 - 0.013	0.001 - 0.027	0.001 - 0.01	0.001 - 0.008
Molybdenum - total (mg/L)	0.001 - 0.003	0.003 - 0.008	0.018 - 0.054	0.003 - 0.007	0.003 - 0.016	0.002 - 0.005	0.013 - 0.021	0.012 - 0.021
Nickel - total (mg/L)	0.001 - 0.003	0.001 - 0.002	0.001 - 0.01	0.001 - 0.004	0.001 - 0.004	0.001 - 0.001	0.001 - 0.002	0.001 - 0.001
Selenium - total (mg/L)	0.02 - 0.02	0.02 - 0.03	0.05 - 0.06			0.02 - 0.02		
Uranium - total (mg/L)	0.012 - 0.019	0.005 - 0.026	0.014 - 0.325	0.006 - 0.024	0.005 - 0.247	0.005 - 0.02	0.01 - 0.019	0.007 - 0.017
Physico-Chemical Parameters								
Electrical Conductivity (µS/cm)	1320 - 2880	267 - 3910	2340 - 11200	248 - 2210	109 - 2940	192 - 2200	1690 - 2550	1440 - 2080
pH (lab)	7.27 - 7.9	7.16 - 8.42	7.99 - 8.25	7.28 - 8.45	7.14 - 8.82	7.13 - 8.47	7.81 - 8.34	7.41 - 8.36
Turbidity (NTU)	0.4 - 8.9	0.2 - 48.4	0.4 - 9.4	0.2 - 74.8	0.2 - 36.2	0.1 - 51.2	0.4 - 6.9	0.4 - 8.6

Table 38 Range of analysis results above the LOR in the additional seepage monitoring bores

Row Labels	Seepage Bore 5a	Seepage Bore 5b	Seepage Bore 6a	Seepage Bore 6b	Seepage Bore 7a	Seepage Bore 8a	Seepage Bore 9a
Alkalinity							
Bicarbonate Alkalinity as CaCO3 (mg/L)	176 - 301	124 - 158	78 - 172		670 - 951	570 - 937	550 - 846
Carbonate Alkalinity as CaCO3 (mg/L)				175 - 659			
Hydroxide Alkalinity as CaCO3 (mg/L)				371 - 819			
Total Alkalinity as CaCO3 (mg/L)	176 - 301	124 - 158	78 - 172	601 - 1480	670 - 951	570 - 937	550 - 846
Field Measurements							
Appearance or Colour	0	0	0	0	0	0	0
Depth to Water (mbRL)	3.13 - 3.23	3.09 - 3.23	2.15 - 3.69	4.24 - 4.91	2.44 - 2.94	1.47 - 1.64	0.49 - 2.01
Dissolved Oxygen (field) (% sat)	28.7 - 47.1	56.9 - 56.9	68.5 - 92.6	26.2 - 30.8	118.2 - 265.1	77.2 - 246.7	58.8 - 155.6
Electrical Conductivity (field) (µS/cm)	1595 - 1777	2242 - 2242	1208 - 2581	4872 - 7459	1979 - 2512	1905 - 4305	2525 - 2599
Groundwater Level (mAHD)	323.53 - 323.63	323.67 - 352.581	331.54 - 333.08	319.01 - 322.52	324.32 - 352.871	325.12 - 354.341	323.43 - 324.75
GWL Depth Reference Elevation	326.76 - 326.76	326.76 - 355.811	335.23 - 335.23	323.92 - 326.76	326.76 - 355.811	326.76 - 355.811	323.92 - 326.76
Odour	0	0	0	0	0	0	0
ORP (field) (mV)	-54.4 - -44.3	-59.1 - -59.1	-56.1 - 14.9	-162.8 - 138.7	-58.5 - -5.5	-49.6 - -9	-54.7 - 1.4
pH (field)	9.08 - 9.23	9.06 - 9.06	7.52 - 8.26	12.64 - 12.8	8.21 - 8.32	8.18 - 8.56	8.03 - 8.14
Salinity (field) (PSU)	0.8 - 0.89	1.14 - 1.14	0.6 - 1.33	2.6 - 4.09	1 - 1.28	0.96 - 2.27	1.29 - 1.33
TDS (field) (ppm)	797 - 889	1122 - 1122	604 - 1291	2435 - 3730	990 - 1256	952 - 2151	1263 - 1300
Temperature (field) (°C)	28.08 - 29.5	28.67 - 28.67	27.2 - 27.54	26.54 - 28.07	30.01 - 30.61	28.8 - 29.73	29.71 - 30.6
Hardness							
Total Hardness (mg CaCO3/L)	448 - 2060	405 - 632	448 - 2500	372 - 692	227 - 380	118 - 529	577 - 765
Ion Balance							
Ionic Balance (%)	3.8 - 20.4	4.66 - 13	3.53 - 24	2.25 - 15.8	0.72 - 3.83	0.15 - 3.96	0.85 - 7.81
Total Anions (meq/L)	12.9 - 43	17.3 - 23.6	10.1 - 46.2	21.8 - 48.2	21 - 28.6	20 - 50.1	27.5 - 30.2
Total Cations (meq/L)	17.1 - 62.9	20.6 - 27.7	13 - 69.1	26.7 - 50.4	22.7 - 30.6	20.5 - 49.7	29.4 - 32.6
Major Ions							
Calcium (mg/L)	110 - 483	91 - 161	102 - 481	149 - 316	35 - 66	21 - 94	74 - 106
Chloride (mg/L)	23 - 171	52 - 82	13 - 118	76 - 116	97 - 155	127 - 453	129 - 185
Fluoride (mg/L)	0.5 - 1	1.2 - 1.5	0.2 - 0.3	1.4 - 2.2	3.3 - 5.2	0.8 - 1.4	1.7 - 2.4
Magnesium (mg/L)	41 - 211	39 - 71	35 - 316	13 - 13	34 - 59	16 - 100	88 - 125
Potassium (mg/L)	7 - 19	2 - 4	4 - 16	48 - 120	2 - 5	2 - 11	2 - 2
Sodium (mg/L)	183 - 494	287 - 353	83 - 442	382 - 794	390 - 526	394 - 916	368 - 447
Sulfate (as SO4)	418 - 1660	626 - 879	392 - 1910	327 - 738	235 - 286	243 - 895	382 - 650
Metals (dissolved)							
Arsenic - dissolved (mg/L)	0.001 - 0.001	0.001 - 0.002		0.001 - 0.003	0.003 - 0.007	0.001 - 0.002	0.002 - 0.003
Barium - dissolved (mg/L)	0.083 - 0.125	0.098 - 0.15	0.046 - 0.102	0.178 - 0.301	0.075 - 0.093	0.042 - 0.178	0.146 - 0.192
Bismuth - dissolved (mg/L)							
Chromium - dissolved (mg/L)		0.005 - 0.005		0.012 - 0.05	0.002 - 0.002	0.003 - 0.003	
Cobalt - dissolved (mg/L)	0.001 - 0.004	0.002 - 0.004	0.001 - 0.006	0.002 - 0.002	0.001 - 0.002	0.001 - 0.002	0.002 - 0.003
Copper - dissolved (mg/L)	0.002 - 0.029	0.003 - 0.013	0.002 - 0.005	0.027 - 0.04	0.001 - 0.004	0.001 - 0.004	0.001 - 0.002
Molybdenum - dissolved (mg/L)	0.007 - 0.02	0.066 - 0.1	0.001 - 0.004	0.234 - 0.612	0.015 - 0.027	0.003 - 0.008	0.003 - 0.006
Nickel - dissolved (mg/L)	0.001 - 0.003	0.004 - 0.006	0.001 - 0.015	0.012 - 0.015	0.001 - 0.003	0.001 - 0.001	0.001 - 0.001
Selenium - dissolved (mg/L)	0.02 - 0.14	0.01 - 0.03	0.02 - 0.3	0.02 - 0.04			0.01 - 0.02
Uranium - dissolved (mg/L)	0.009 - 0.032	0.002 - 0.004	0.001 - 0.006		0.018 - 0.03	0.008 - 0.038	0.006 - 0.016
Metals (total)							
Arsenic - total (mg/L)	0.001 - 0.001	0.002 - 0.002		0.002 - 0.004	0.003 - 0.01	0.001 - 0.004	0.002 - 0.003
Barium - total (mg/L)	0.08 - 0.126	0.094 - 0.148	0.048 - 0.107	0.178 - 0.308	0.087 - 0.107	0.049 - 0.268	0.148 - 0.196

Row Labels	Seepage Bore 5a	Seepage Bore 5b	Seepage Bore 6a	Seepage Bore 6b	Seepage Bore 7a	Seepage Bore 8a	Seepage Bore 9a
Bismuth - total (mg/L)							
Chromium - total (mg/L)	0.003 - 0.005	0.006 - 0.006		0.012 - 0.132	0.002 - 0.002	0.023 - 0.023	0.002 - 0.002
Cobalt - total (mg/L)	0.001 - 0.006	0.002 - 0.004	0.001 - 0.006	0.002 - 0.005	0.001 - 0.004	0.001 - 0.016	0.003 - 0.004
Copper - total (mg/L)	0.003 - 0.02	0.006 - 0.014	0.002 - 0.009	0.031 - 0.073	0.002 - 0.019	0.001 - 0.014	0.003 - 0.016
Molybdenum - total (mg/L)	0.009 - 0.021	0.074 - 0.105	0.001 - 0.005	0.234 - 0.66	0.016 - 0.026	0.003 - 0.01	0.004 - 0.007
Nickel - total (mg/L)	0.001 - 0.004	0.004 - 0.005	0.002 - 0.142	0.014 - 0.016	0.002 - 0.004	0.001 - 0.01	0.001 - 0.002
Selenium - total (mg/L)	0.02 - 0.15	0.01 - 0.04	0.03 - 0.29	0.02 - 0.04			0.01 - 0.02
Uranium - total (mg/L)	0.009 - 0.032	0.003 - 0.005	0.001 - 0.006	0.002 - 0.002	0.017 - 0.034	0.01 - 0.046	0.006 - 0.022
Physico-Chemical Parameters							
Electrical Conductivity (µS/cm)	1570 - 5510	1770 - 2600	1170 - 5430	3660 - 7640	1960 - 2660	2040 - 4430	2520 - 2840
pH (lab)	7.5 - 8.09	7.55 - 8.05	6.65 - 7.68	11.7 - 12.1	7.59 - 8.23	7.31 - 8.2	7.49 - 8.09
Turbidity (NTU)	0.3 - 25.8	0.5 - 4.2	0.5 - 7.3	3.1 - 42.6	4.7 - 61.2	1 - 477	1.5 - 24.5

Table 39 Seepage monitoring bore exceedances of ANZG Livestock Water Quality guidelines

Row Labels	Seepage Bore 1a	Seepage Bore 1b	Seepage Bore 2a	Seepage Bore 2b	Seepage Bore 3a	Seepage Bore 3b	Seepage Bore 4a	Seepage Bore 4b	Seepage Bore 5a	Seepage Bore 5b	Seepage Bore 6a	Seepage Bore 6b	Seepage Bore 7a	Seepage Bore 8a	Seepage Bore 9a
Chromium - dissolved (mg/L)															
2. Open cut mining					✓										
3. Post-open cut mining										✓		✓	✓	✓	
Chromium - total (mg/L)															
2. Open cut mining			✓	✓											
3. Post-open cut mining			✓		✓				✓	✓		✓	✓	✓	✓
Copper - dissolved (mg/L)															
2. Open cut mining		✓	✓	✓	✓	✓		✓							
3. Post-open cut mining	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓
Copper - total (mg/L)															
2. Open cut mining		✓	✓	✓	✓	✓	✓	✓							
3. Post-open cut mining	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Selenium - dissolved (mg/L)															
3. Post-open cut mining	✓	✓	✓			✓			✓	✓	✓	✓			✓
Selenium - total (mg/L)															
3. Post-open cut mining	✓	✓	✓			✓			✓	✓	✓	✓			✓

✓: indicates occurrence of exceedance

Table 40 Seepage monitoring bore exceedances of ANZG aquatic ecosystem (slightly to moderately disturbed) WQOs

Row Labels	Seepage Bore 1a	Seepage Bore 1b	Seepage Bore 2a	Seepage Bore 2b	Seepage Bore 3a	Seepage Bore 3b	Seepage Bore 4a	Seepage Bore 4b	Seepage Bore 5a	Seepage Bore 5b	Seepage Bore 6a	Seepage Bore 6b	Seepage Bore 7a	Seepage Bore 8a	Seepage Bore 9a
Chromium - dissolved (mg/L)															
2. Open cut mining					✓										
3. Post-open cut mining										✓		✓	✓	✓	
Chromium - total (mg/L)															
2. Open cut mining			✓	✓											
3. Post-open cut mining			✓		✓				✓	✓		✓	✓	✓	✓
Copper - dissolved (mg/L)															
2. Open cut mining		✓	✓	✓	✓	✓		✓							
3. Post-open cut mining	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓
Copper - total (mg/L)															
2. Open cut mining		✓	✓	✓	✓	✓	✓	✓							
3. Post-open cut mining	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Selenium - dissolved (mg/L)															
3. Post-open cut mining	✓	✓	✓			✓			✓	✓	✓	✓			✓
Selenium - total (mg/L)															
3. Post-open cut mining	✓	✓	✓			✓			✓	✓	✓	✓			✓

✓: indicates occurrence of exceedance

9 Hydrogeological conceptual site model

Based on the available data and information, the BCP hydrogeological conceptual model is presented in Table 41. Hydrogeological cross-sections through the Project area, showing the underlying geology/lithology and groundwater levels in June 2018 and April 2022, are presented in Plate 28 and Plate 29, respectively. The location of the cross-section is presented in Figure 18.

Table 41 BCP hydrogeological conceptual model

Aspect	Description
Groundwater occurrence/aquifers	• The primary aquifer occurs within the Leichardt Metamorphics, generally at the base of the weathered zone. • There is little regolith at the Project site, and no regolith aquifers are identifiable. • Deposition of alluvium within drainage systems is minimal, and no paleochannels are present in the area. There is little or no potential for the development of alluvial aquifers at the Project site
Hydraulic properties	• Results of falling head permeability tests indicate that hydraulic conductivities are generally very low.
Recharge/ discharge mechanisms	• Direct rainfall recharge through overlying soil and sediments is minor. • The main recharge mechanism to the Leichhardt Metamorphics aquifer at Barbara Copper Project is episodic recharge via lineaments aligned with watercourses.
Depth to groundwater	• Depth to groundwater, as measured in open mineral exploration bores in October 2013, ranged from 7 to 37 mbgl. • In 2018, depth to water in monitoring bores ranged between 5 and 25 mbgl. • Since 2019, groundwater levels have declined, reflecting the open-cut mining operations and dewatering of the aquifers due to groundwater seepage/inflow into the open pits. The decline rate slowed down since mining started in June 2019. • Since mining finished in March 2021, groundwater levels seem to be slowly recovering to pre-mining levels.
Groundwater flow	Prior to the commencement of mining, the contours and potentiometric surface profile show that, provided hydraulic continuity exists throughout the Leichhardt Metamorphics. Groundwater flow will be from south-west to north-east within the Barbara Shear Zone.
Groundwater – Surface water interaction	Pre-mining depth to groundwater at the Barbara Copper Project ws more than 8m below ground level. The drainage features at the Barbara Copper Project are immature and only incised to a shallow depth. None of the drainage incisions reach 8m depth. Therefore, groundwater-surface water interaction on a semi local/regional scale is minimal. Ephemeral water bodies (groundwater seeps/springs) are known to occur at and in the vicinity of the mine site. These water bodies are the results of significant rainfall events, with rainfall and flow in the creeks accumulating in lower-lying creek sections. Some minor temporary interaction with shallow groundwater is expected. However, this interaction dissipates as shallow groundwater levels drop.
Water quality	• Groundwater can generally be classified as a sodium-bicarbonate type with minor variations.

Aspect	Description
	• Bedrock groundwater is generally fresh and near neutral to slightly alkaline. • There is no indication of high sulphate content in the groundwater. • Top 5 naturally occurring metals (in order of highest to lowest concentration) include manganese, iron, barium, copper and boron. • The data and information indicate no evidence that the mining operations have adversely impacted the natural bedrock groundwater quality.
Groundwater beneficial use	• Two (2) private registered water bores are located within 10km radius of the mining lease. • There are no homesteads within the immediate vicinity of the Project area that would rely on groundwater for drinking water or domestic use. However, the two private, existing bores could potentially be used for farm water supply (e.g. livestock watering or irrigation). • The Project site is not situated near any township, and the surrounding landscape is not likely to be utilised by the public for recreational purposes. • No aquaculture practices or industrial activities are occurring in the surrounding landscape. • Terrestrial GDEs have been identified within 5 km of the Project site. • Groundwater environmental values would include the protection of aquatic ecosystems, livestock watering and cultural/spiritual values.
Groundwater dependent ecosystems	• No aquatic or subterranean GDEs were identified through the BOM GDE Atlas within a 5 km radius of the Project site. • Terrestrial GDEs identified within 5km radius comprise mainly eucalyptus within open forest and woodlands drainage lines and alluvial plains. Most of this vegetation has been classified as low potential to moderate potential GDEs.
Stygofauna	• Survey in 2014 indicated that the Project site yielded a comparatively low abundance and diversity of taxa compared with other Stygofauna sampling sites across Australia.

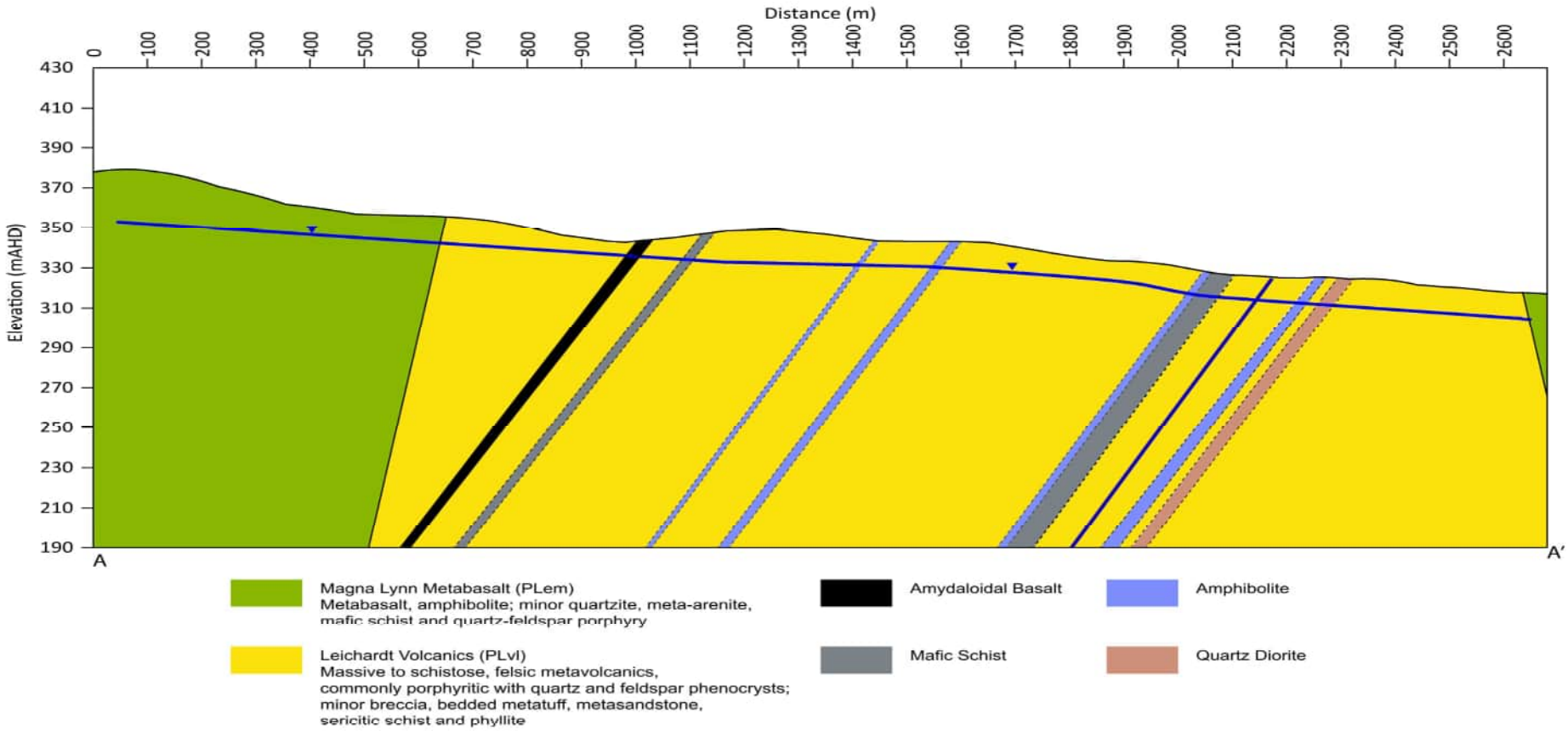


Plate 28 Hydrogeological cross-section (A-A') with June 2018 groundwater levels

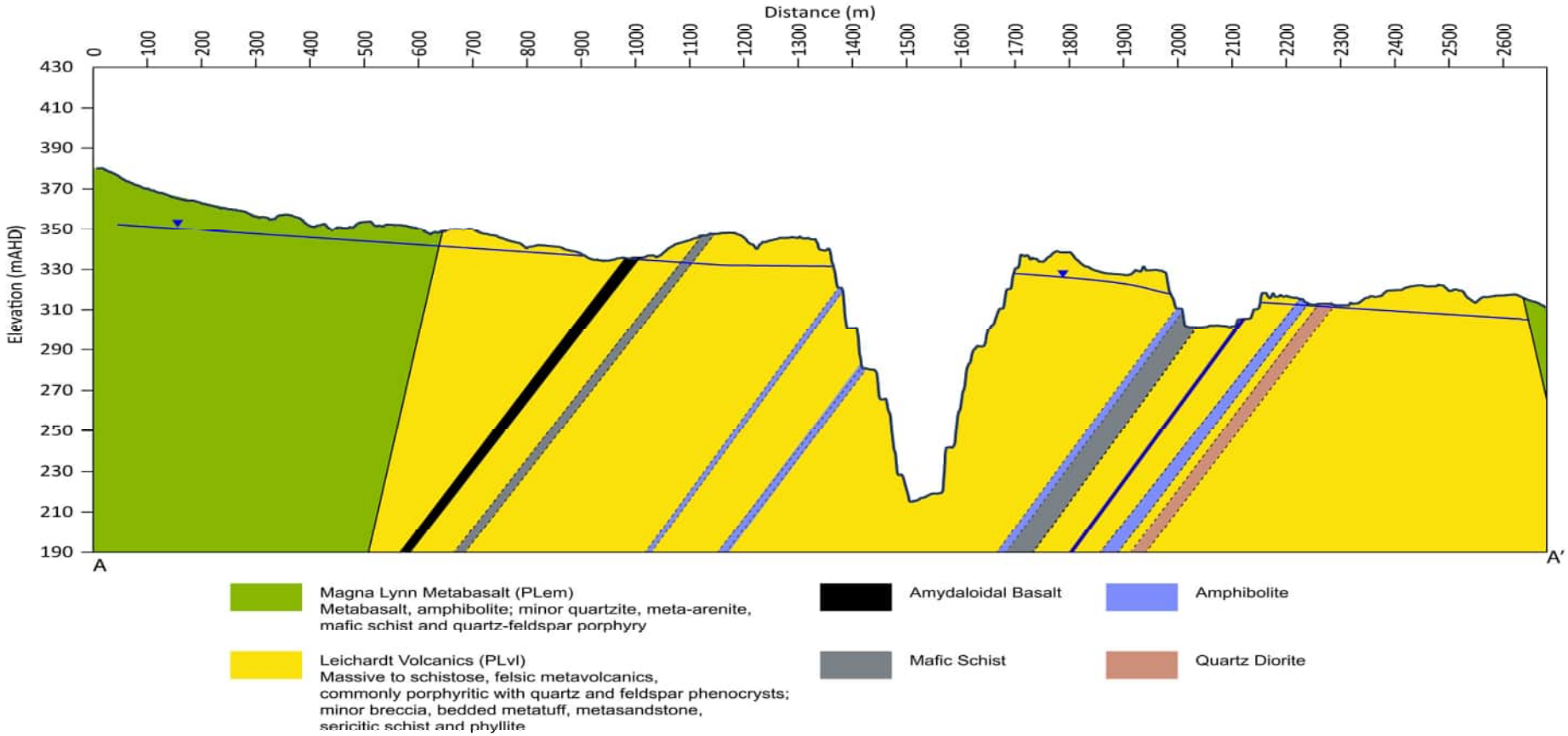


Plate 29 Hydrogeological cross-section (A-A') with April 2022 groundwater levels

10 Groundwater impact assessment

10.1 Introduction

The groundwater impact assessment included the following:

1. Assessment of extent and level drawdown from the proposed underground mining and potential impacts on surface water bodies.
2. Assessment of the level of groundwater inflow into the open pits and underground workings.
3. Assessment of final void water quality and impacts on environmental values.
4. Assessment of final underground workings water quality and impacts on environmental values.
5. Open pits stratification assessment

Given the relative impermeability (i.e. low hydraulic conductivity) of the aquifers and the short duration of the underground mining (i.e. four years), analytical models have been adopted for the groundwater impact assessment. The analytical models are based on scientific equations and calculations, as detailed in the below sections. The analytical models represent the open pits and underground workings as large-diameter wells with a radius and depth representative of the final void volume and depth during the different stages of mining/dewatering.

Numerical, 2D or 3D modelling is not considered warranted at this stage, as the groundwater impact assessment did not identify non-manageable adverse impacts on the receiving environment.

10.2 Extent and level of drawdown around open pits and underground workings

A “radius of influence” is defined as the maximum distance at which drawdown can be detected with the usual measure devices in the field (Dragoni, 1999). Empirical, analytical formulas can be used to calculate the radius of influence around a void that can be represented by a large diameter pumping well.

The radius of influence, R, can be estimated using Sichardt’s equation (Powers, 1992) as follows:

$$R = 3000\,(H - h)\sqrt{K_{sat}} + r_0$$

with: R = radius of influence [m]

H = groundwater level at extent of drawdown (i.e. regional groundwater level) [mAHD]

h = water level in the void [mAHD]

s = (H – h) = drawdown in the void

K_{sat} = saturated hydraulic conductivity [m/s]

r_o = equivalent well radius, calculated taking into consideration the void geometry as

$$r_0 = \sqrt{\frac{a \times b}{\pi}}$$ with a= average height of the void; b = average width of the void

Detailed calculations of the radius of influence for the North Pit, South Pit and underground workings are presented in Appendix I.

Plate 30, Plate 31 and Plate 32 show the calculated radii of influence during mining from the North Pit, South Pit and underground workings, respectively.

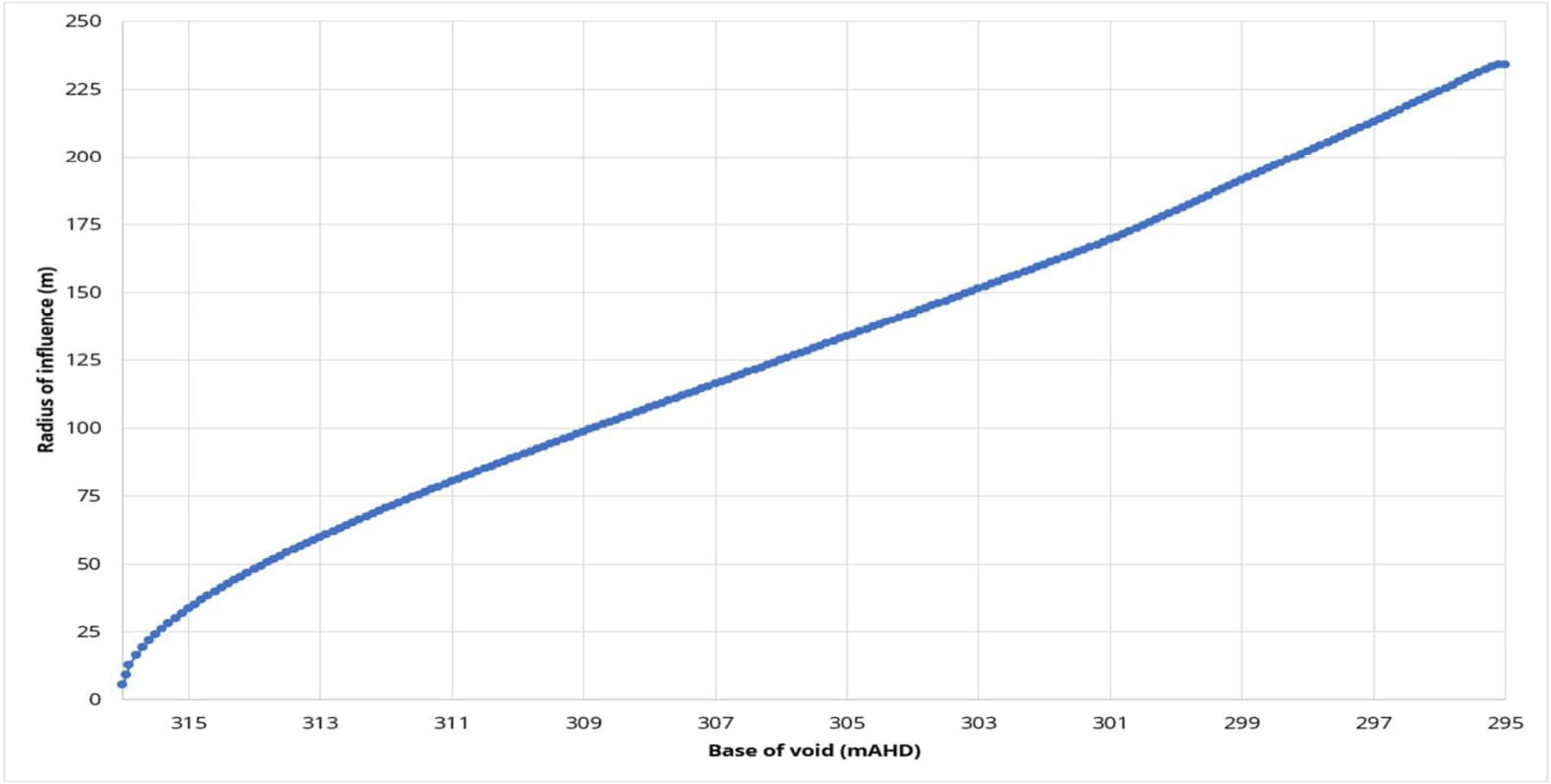


Plate 30 North Pit radius of influence/drawdown

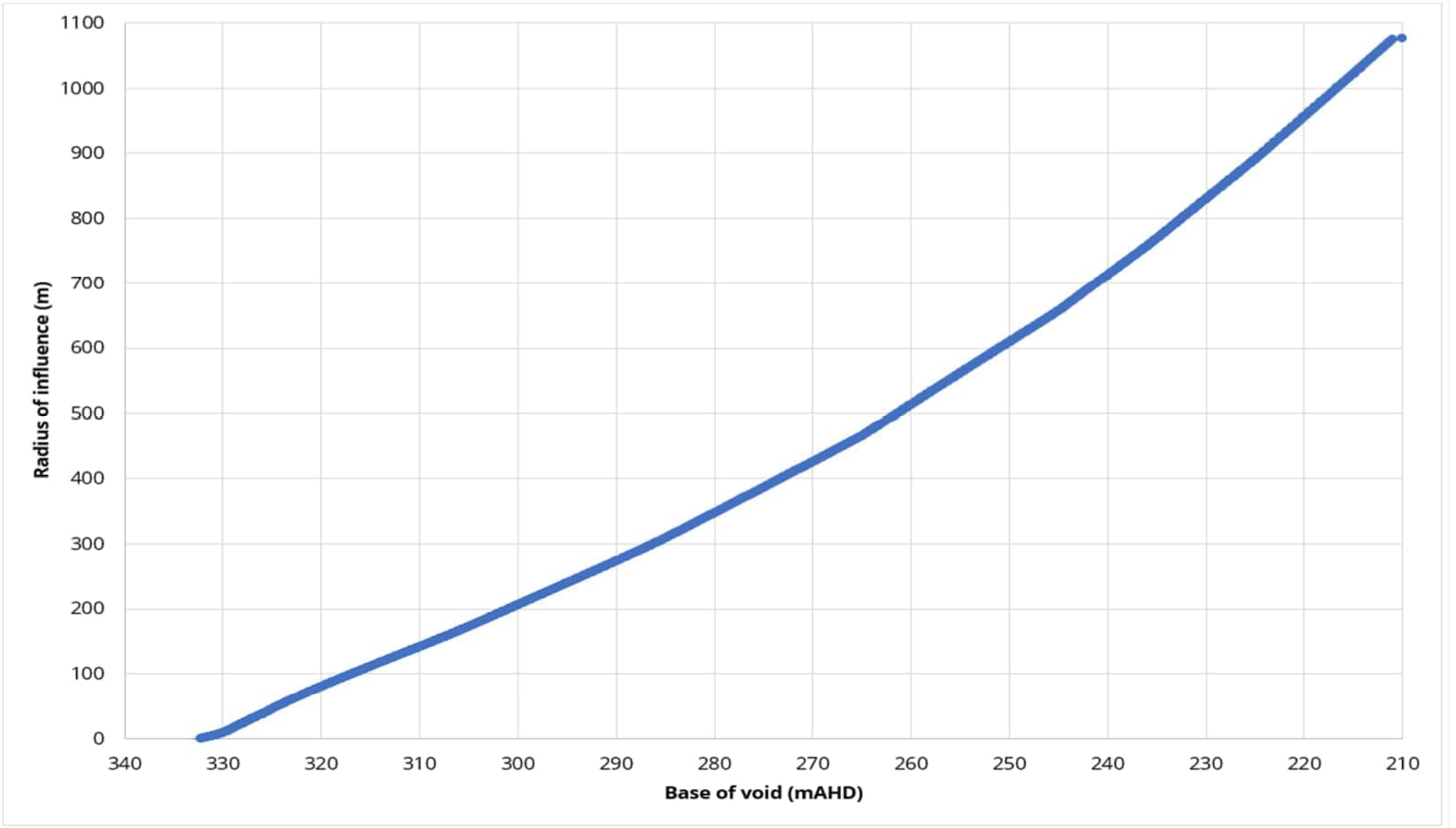


Plate 31 South Pit radius of influence/drawdown

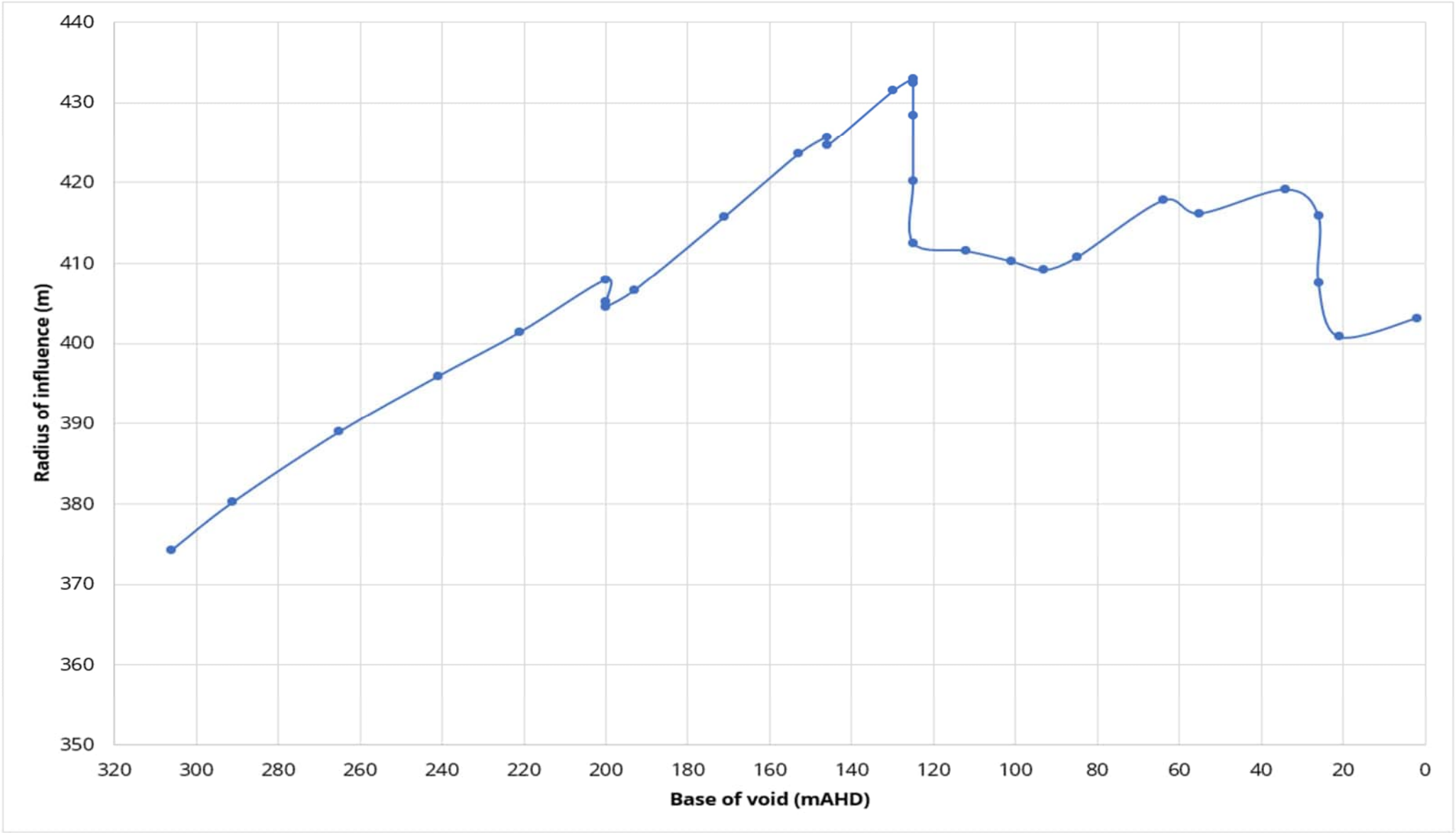


Plate 32 Underground workings radius of influence/drawdown

It is noted that the calculated radii are considered conservative and an overestimate of the actual radius of influence as:

- The empirical equations apply to “steady-state” (i.e. indefinite time) conditions only, without consideration of the temporal influence of storativity within the aquifers.
- The equations do not consider the decrease in saturated hydraulic conductivity with depth or the potential presence of boundary conditions (e.g. faults, lithological barriers).

Overall, the potential radius of influence would be much less than the empirically calculated radius and remain within the ML boundaries. Gauging of existing groundwater monitoring bores (BAWB01 to BAWB07, BAWBR01 to BAWBR03) does not show a significant impact of the open-cut mining on groundwater levels.

Data searches have indicated that there are only three registered water bores within ML90241 with a designated “water supply” role, i.e. bores RN146953, RN146954 and RN184272. However, these bores were drilled and installed by the mining company owning the mining lease at the time of installation. None of these bores are currently operational for water supply purposes, nor are they intended to be in the future. No active water supply bores are located within the conservative radius of influence/drawdown of the open pits and underground workings.

10.3 Impacts on groundwater/surface water interaction

Based on the monitoring data, the groundwater/surface water interaction can be summarised as follows:

- On a semi-local to regional scale, groundwater levels are generally at a depth below ground level that would limit any groundwater/surface water interaction. This is evidenced by the ephemeral nature of the creeks at and near the mine site.
- On a local scale, two semi-permanent water bodies are present within the creek, named BCP Spring (S) and BCP Spring (N). The water bodies are most likely the results of significant rainfall events leading to significant flow within the creeks, with water stagnating in lower-lying parts of the creek. Monitoring of shallow groundwater levels and levels at the water bodies indicates that there is limited hydraulic connectivity between the shallow groundwater and the creek.

Although the current open pits act as a groundwater sink, these pits/voids do not adversely impact the surface water environment due to the limited (to almost non-existent) connectivity between the deeper groundwater and the creek.

In a similar vein, the proposed underground operations will not impact the groundwater/surface water interaction, as such interaction does not exist.

10.4 Groundwater inflows into open pits and underground works

10.4.1 Introduction

Interaction between groundwater and surface water bodies at and near BCP is considered minimal, with groundwater levels generally below the base of the creeks/drainages. Creeks and drainage lines are generally ephemeral, with temporary flow only occurring after significant rainfall/runoff events. Springs/seeps occur at and near BCP.

Given the limited groundwater/surface water interaction, a numerical, 3D groundwater model to assess groundwater inflows into the open pits and underground working is not considered warranted. An analytical solution to assess potential groundwater inflow into the open pits and

the underground mine during and upon cessation of mining and mine dewatering has been adopted. Analytical models, based on the equations developed by Marinelli and Niccoli (Marinelli & Niccoli, 2000) for inflow into a mine pit, were developed for the open pit and the underground works.

10.4.2 Marinelli and Niccoli method for inflow into mine pits

Plate 33 presents the conceptual model used by the analytical equations of Marinelli and Niccoli to calculate the groundwater inflow into a mine pit.

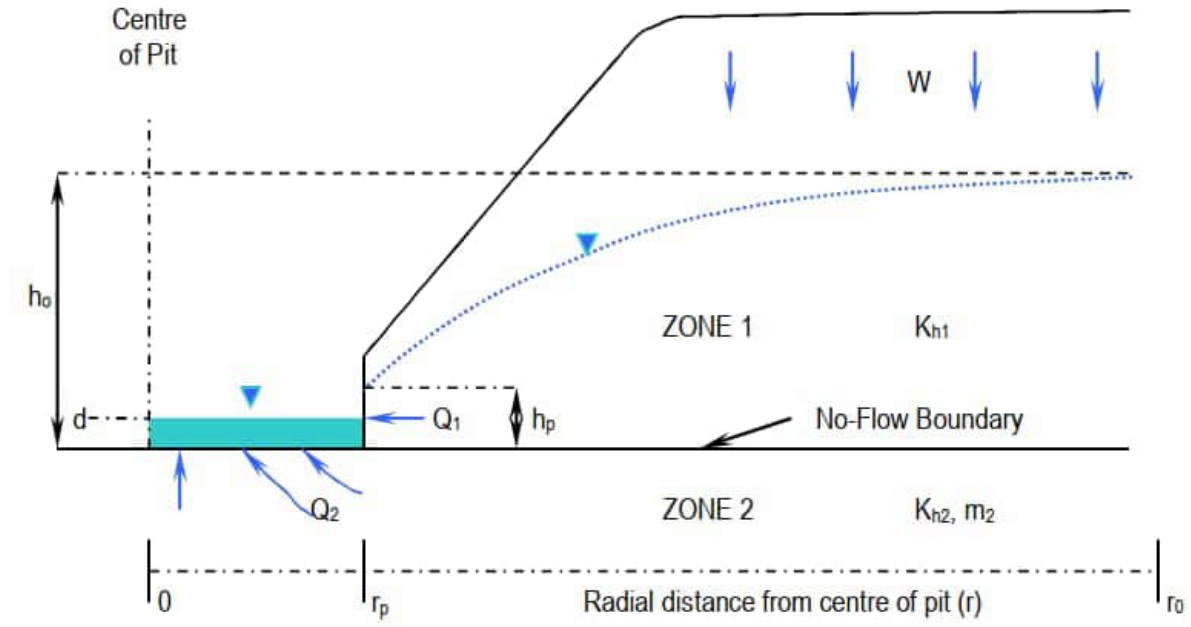


Plate 33 Mine pit inflow conceptual model (Marinelli & Niccoli, 2000)

With Marinelli and Niccoli's method, groundwater flow into a mine pit/underground works is divided into two zones, with Zone 1 representing lateral flow through the pit/underground workings walls and Zone 2 the inflows from the base of the pit/underground working. Table 42 presents the equations and assumptions used to calculate the groundwater inflows from each zone.

Table 42 Groundwater inflow into mine pit equations and assumptions

Zone 1	Zone 2
Inflow Equations	
$Q_1 = W \pi (r_0^2 - r_p^2)$	$Q_2 = 4 r_p \left(\frac{K_{h2}}{m_2}\right) (h_0 - d)$ $m_2 = \sqrt{\frac{K_{h2}}{m_2}}$
Q_1 = volumetric flow rate from Zone 1 W = recharge flux	Q_2 = volumetric flow rate from Zone 2 K_{h2} = horizontal hydraulic conductivity

Zone 1	Zone 2
r_0 = radius of influence r_p = effective pit radius	K_{v2} = vertical hydraulic conductivity m_2 = anisotropy parameter h_0 = pre-mining saturated thickness above base of Zone 1 d = depth of water in pit
Assumptions	
• Pit walls are approximated as a circular cylinder. • Groundwater flow is horizontal and the Dupuit-Forchheimer approximation can be used to account for changes in saturated thickness due to depression of the water table. • The static (pre-mining) water table is approximately horizontal. • Uniform distributed recharge occurs across the site as a result of surface infiltration from rainfall. • All recharge within the radius of influence (cone of depression), of the pit is assumed to be captured by the pit. • Groundwater flow toward the pit is axially symmetric. • The aquifer is infinite in extent (i.e. the cone of depression does not encounter any zero recharge boundaries).	• Hydraulic head is initially uniform (hydrostatic) throughout Zone 2. Initial head is equal to the elevation of the initial water table in Zone 1. • The disk sink has a constant hydraulic head equal to the elevation of the pit lake water surface. If the pit is completely dewatered, the disk sink head is equal to elevation of the pit bottom. • Flow to the disk sink is three-dimensional and axially symmetric. • Materials within Zone 2 are anisotropic, and the principal coordinate directions for hydraulic conductivity are horizontal and vertical.

10.4.3 Steady-state groundwater inflow into open pits

Groundwater inflow rates into the open pits were calculated using the open pit geometry (open area versus depth), proposed mining and backfilling schedule, calculations of equivalent effective radius and several assumptions for equation input values reflecting the BCP hydrogeological conceptual model.

Appendices I.1 and I.2 present the geometry and void volume details and detailed groundwater inflow calculations for the North and South Pit, respectively. Table 43 presents the parameters, values and assumptions made in the calculations.

Table 43 Assumptions and variables for open pit groundwater inflow calculations

Variable		Assumptions	North pit	South pit
Zone 1				
W	recharge flux	Assumed 2% of long-term annual rainfall in Mt Isa (461 mm/year)	0.000025 m/day	
r_0	radius of influence	Based on the distance from the centre of the open	100 m	200 m

Variable		Assumptions	North pit	South pit
		pit/underground workings to groundwater bore BAWBR03, representing the actual extent of the cone of depression due to mining.		
r_p	effective pit radius	Calculated for different pit levels, based on pit geometry and open pit area.	See Appendix I.	
Zone 2				
K_{h2}	horizontal hydraulic conductivity	Aquifer tests indicated hydraulic conductivity of 2.29 10^{-08} m/s or 0.00198 m/day. Based on the conceptual model, hydraulic conductivity decreases with depth.	0.00198 m/day	
K_{v2}	vertical hydraulic conductivity	The conceptual model indicates very limited vertical flow.	0.00020 m/day (10% of horizontal hydraulic conductivity)	
m_2	anisotropy parameter	Calculated	See Appendix I.	
h_0	pre-mining saturated thickness above base of Zone 1	Calculated as the difference between average groundwater level measured in 2018 (at 324 mAHD) and base of the open pits.	See Appendix I.	
d	depth of water in pit	Calculated as the difference between the elevation of the water level and the base of the open pits.	See Appendix I.	
Calculated groundwater inflow				
Q_1, Q_2	Groundwater inflow	Calculated	See Appendix I.	

Plate 34 and Plate 35 present the calculated steady-state groundwater inflows with depth into the open pits based on the water level in the pits. It is noted that the estimates of groundwater represent the groundwater that resided in the orebody prior to mining, with long-term natural recovery of groundwater levels expected to be slow. As such, the inflow estimates are conservative. The actual inflows will depend on the water balance model results, presented in ATC William's report "*Barbara Copper Project. WMP Update for Underground Workings – Water Balance Model. Ref 118131.16.R00, 31 February 2024*" (ATC Williams, 2024).

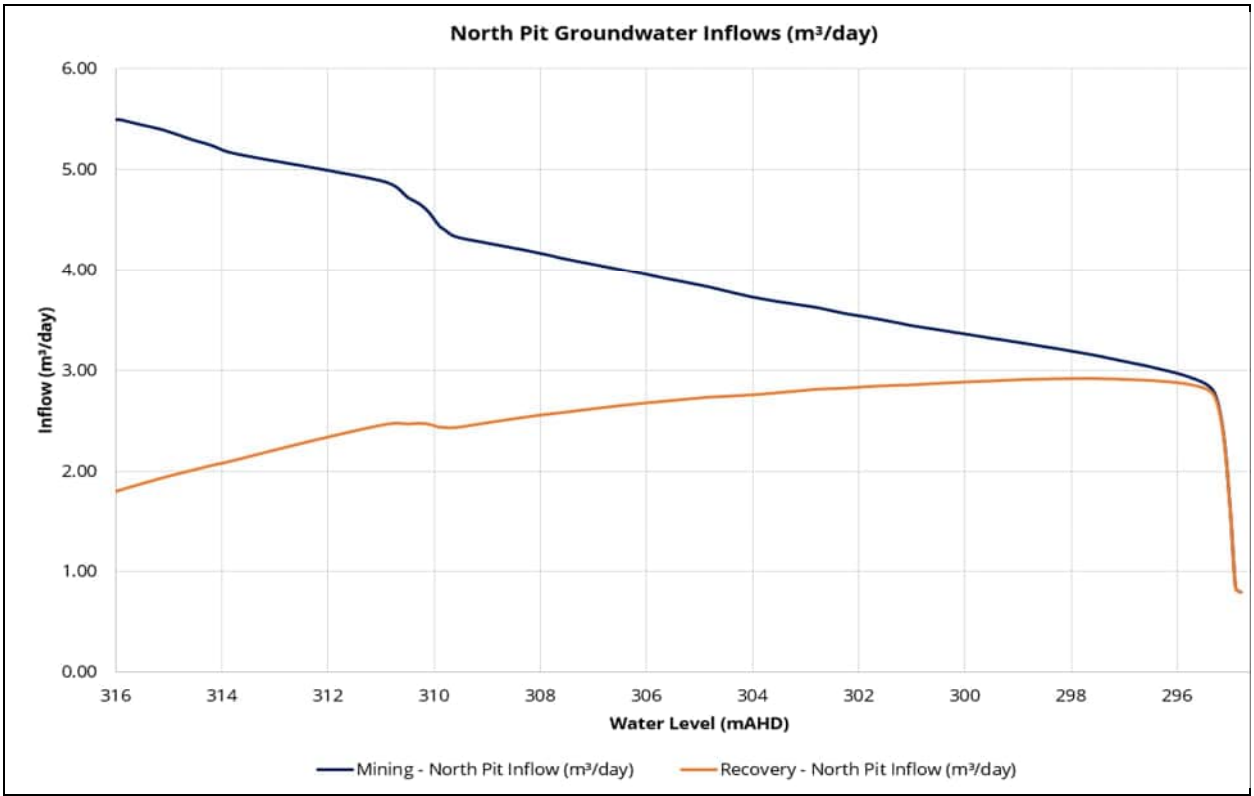


Plate 34 Calculated steady-state North Pit groundwater inflows

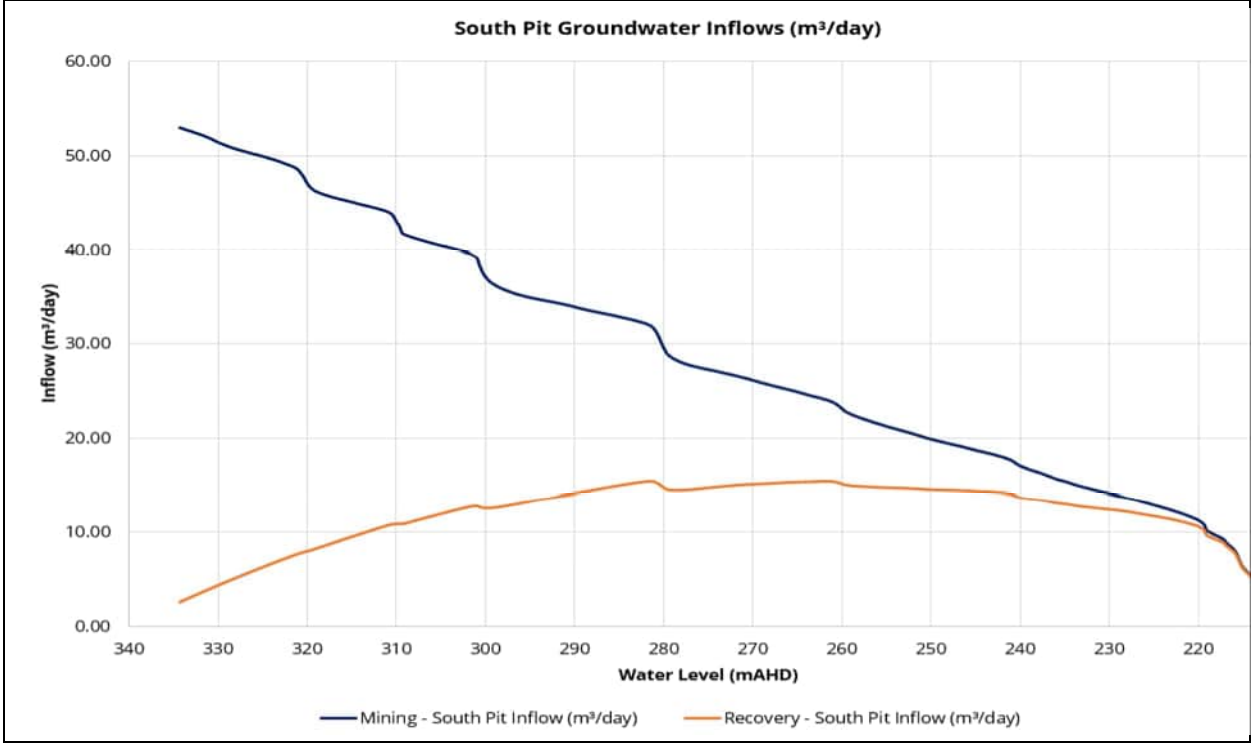


Plate 35 Calculated steady-state South Pit groundwater inflows

10.4.4 Steady-state groundwater inflow into underground works

Groundwater inflow rates into the underground works were calculated using the underground works geometry (open area versus depth), calculations of equivalent effective void radius and several assumptions for equation input values reflecting the hydrogeological conceptual model at MTC.

Table 44 presents the parameters, values and assumptions made in the calculations. Appendix I.3 presents the calculated steady-state groundwater inflows.

Table 44 Assumptions and variables for underground works groundwater inflow calculations

Variable		Assumptions	North pit	South pit	Underground workings
Zone 1					
W	recharge flux	Assumed 2% of long-term annual rainfall in Mt Isa (461 mm/year)	0.000025 m/day		
r_0	radius of influence	Based on the distance from the centre of the underground workings to groundwater bore BAWBR03, representing the actual extent of the cone of depression due to mining.	100 m		
r_p	effective pit radius	Calculated for different void levels, based on void geometry.	See Appendix I.		
Zone 2					
K_{h2}	horizontal hydraulic conductivity	Aquifer tests indicated hydraulic conductivity of 2.29 10^{-08} m/s or 0.00198 m/day. Based on the conceptual model, hydraulic conductivity decreases with depth.	0.00198 m/day		
K_{v2}	vertical hydraulic conductivity	The conceptual model indicates very limited vertical flow.	0.00020 m/day (10% of horizontal hydraulic conductivity)		
m_2	anisotropy parameter	Calculated	See Appendix I.		
h_0	pre-mining saturated thickness above base of Zone 1	Calculated as the difference between average groundwater level measured in 2018 (at 324 mAHD) and base of the UG void.	See Appendix I.		
d	depth of water in pit	Calculated as the difference between the elevation of the water level and the base of the UG void.	See Appendix I.		
Calculated groundwater inflow					

Variable		Assumptions	North pit	South pit	Underground workings
Q_1, Q_2	Groundwater inflow	Calculated	See Appendix I.		

It is noted that the estimates of groundwater represent the groundwater that resided in the orebody prior to mining, with long-term natural recovery of groundwater levels expected to be slow. As such, the inflow estimates are conservative.

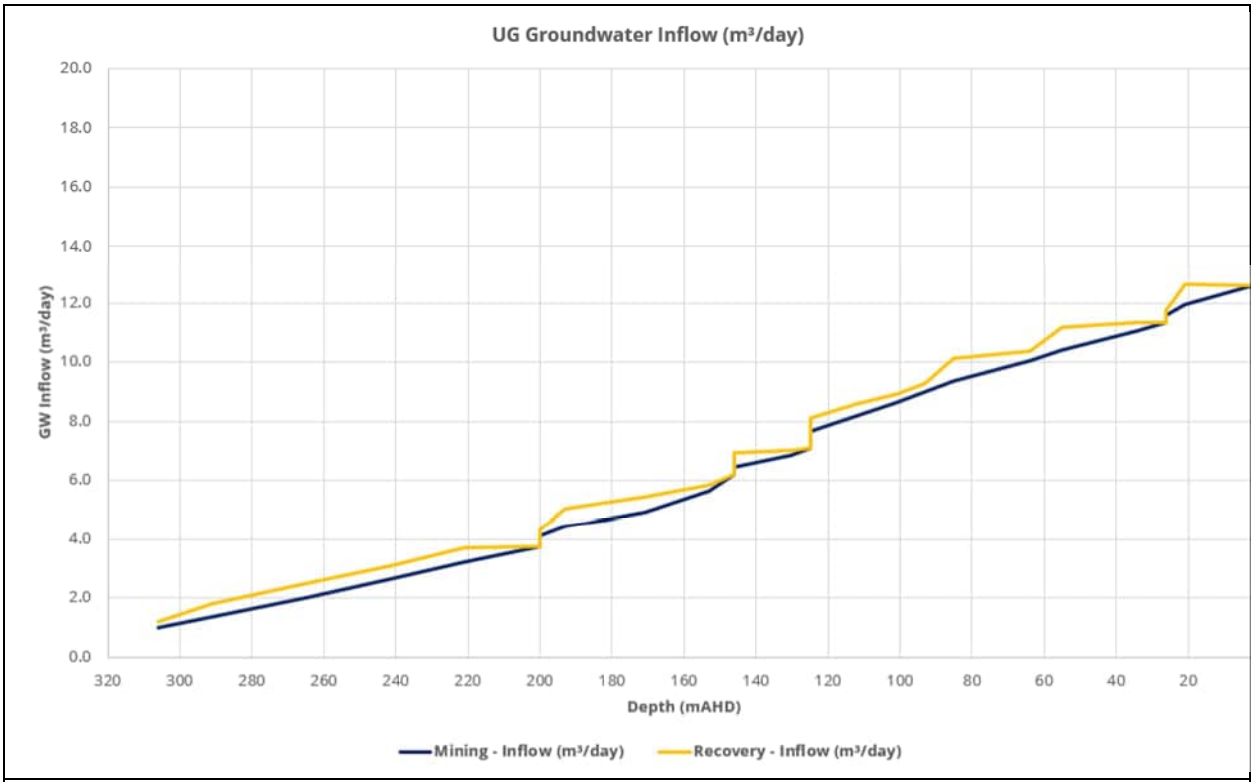


Plate 36 Calculated steady-state underground works groundwater inflows

10.4.5 BCP water balance model results

ATC Williams developed a water balance model (WBM) for BCP using Goldsim Pro (Goldsim v12.1). The WBM was used to assess the impact of surface water runoff (mine impacted and non-impacted), evaporation and groundwater in/outflows on/into the open pit and underground voids. The outcomes of the WBM are presented in ATC William's report "*Barbara Copper Project. WMP Update for Underground Workings – Water Balance Model. Ref 118131.16.R00, 31 February 2024*" (ATC Williams, 2024).

Plate 37 presents a schematic of the BCP mine water balance model. A detailed description of the model input data, the modelled processes, the scenarios, and the modelling results is provided in ATC Williams' report (ATC Williams, 2024) and included as an appendix to the main EA amendment report.

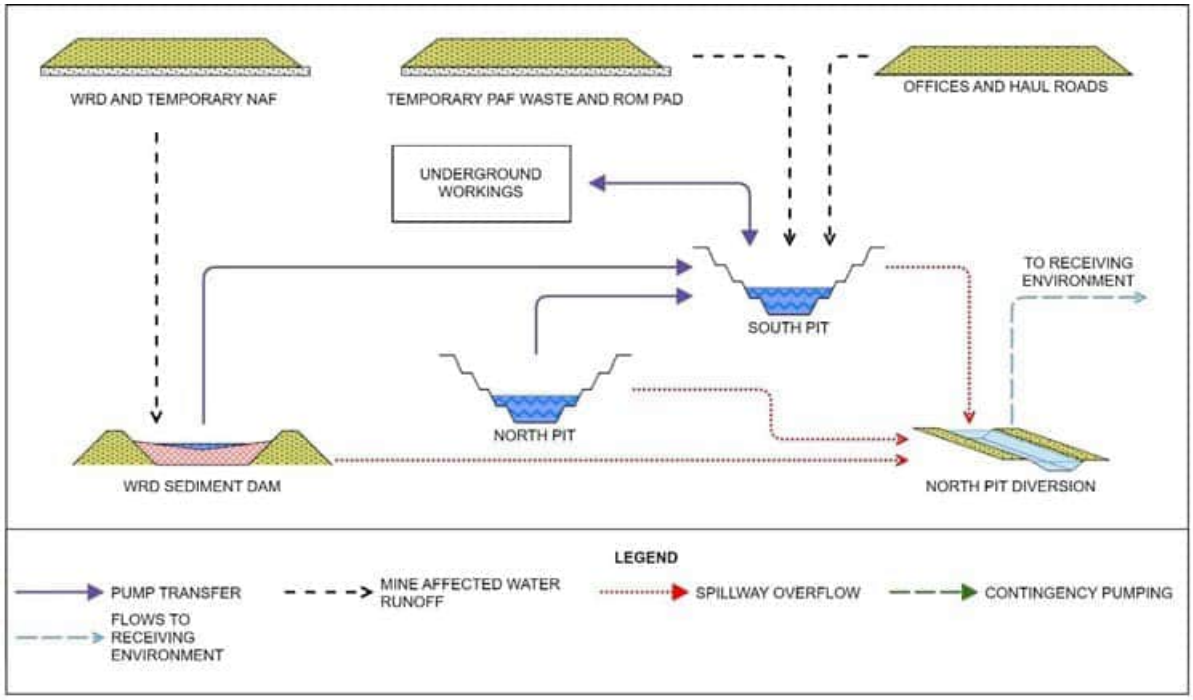


Plate 37 Schematic BCP water balance model (ATC Williams, 2024)

The results of the WBM can be summarised as follows.

South Pit

The WBM indicates the following:

- Under median climatic conditions, the South Pit will be rapidly dewatered by October 2025 to meet site water demands.
- Under median climatic conditions, the South Pit does not store any water until February 2041, as all rainfall and runoff enters the Underground Workings as the crown pillar has been removed.
- The maximum modelled water level in the South Pit is 290 m AHD, under the 99th percentile realisation. As the pit crest is 334 m AHD, this indicates the South Pit does not overtop or spill. The level of 290 m AHD is only reached in sequentially very wet years.
- The long-term median water level in the South Pit is approximately 260 m AHD, approximately 10 metres above the current recorded water level.
- There were no modelled groundwater outflows from the South Pit as the South Pit is a regional groundwater sink. The 0.55 ML/day of site water demands are met by the South Pit from January 2025 to October 2025. Beyond October 2025, the South Pit meets site water demands when water is available in the South Pit.

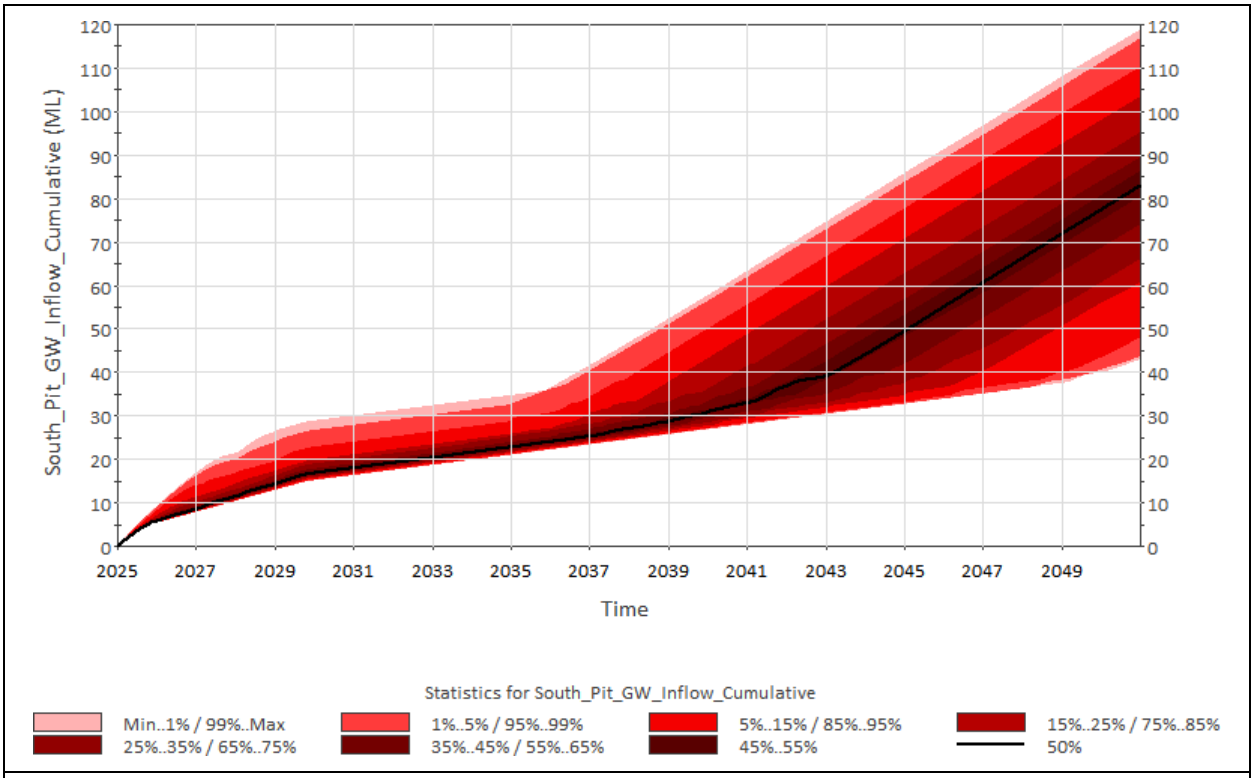


Plate 38 South Pit accumulated groundwater inflows

Underground Workings

The WBM indicates the following:

- Under operational conditions, the Underground Workings do not store any water between 2025 and 2029, as they are being actively dewatered.
- Under mean climatic conditions, the Underground Workings commence filling in 2030 and will be filled by 2041. This is primarily driven by water ingress from the South Pit, which is connected to the Underground Workings via the removal of the crown pillar.

Plate 39 depicts the variation in groundwater inflow over time. From this chart, the following insights can be derived:

- Given the complexity of the underground workings, characterised by changes in available volume over time, stage storage curves were not adopted in the WBM. Instead, the model incorporates projections of groundwater inflow over time. This explains the invariability of the groundwater estimations between different realizations shown on Plate 39.
- The mean accumulated groundwater inflow into the Underground Workings between 2025 and 2050 is approximately 20 ML, or 4.11 ML/year.
- The remainder of the water required to fill the Underground Workings is supplied by inflows from the South Pit.

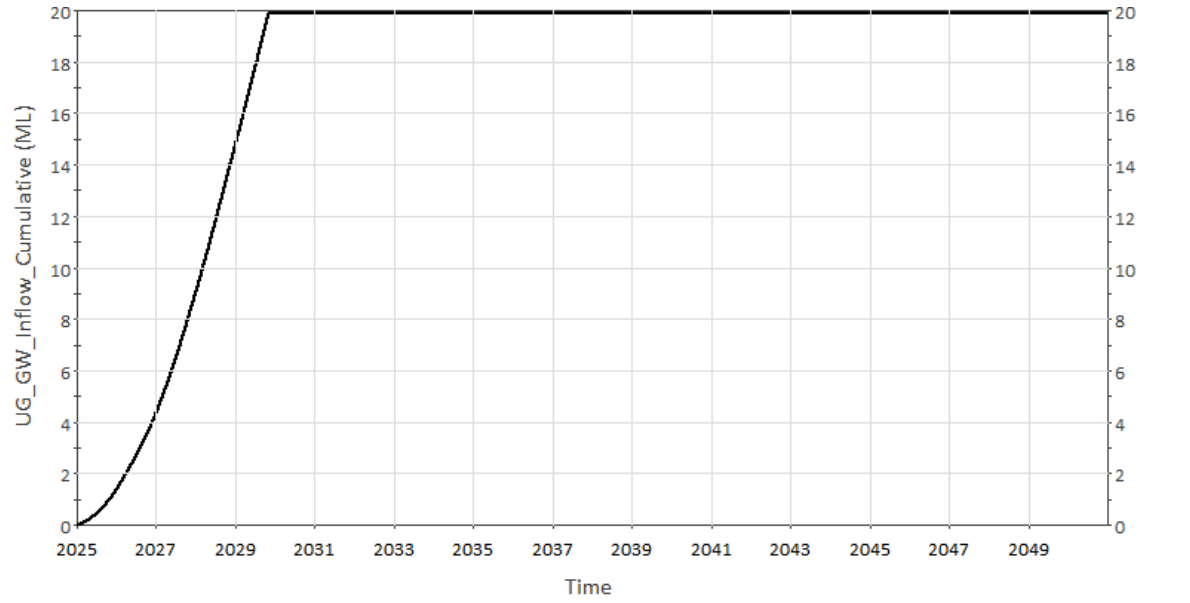


Plate 39 Underground workings accumulated groundwater inflows

North Pit

The WBM indicates the following:

- Under median climatic conditions, the North Pit will be rapidly dewatered by March 2026 to meet site water demands.
- Under median climatic conditions, between March 2026 and October 2029 (excluding the January-March period each year), the North Pit is dry, indicating the site may be in a net water deficit.
- The maximum modelled water level in the North Pit is 307 m AHD. As the pit crest is 316 m AHD, this indicates the North Pit does not overtop or spill. The level of 307 m AHD is only reached in sequentially very wet years.
- The long-term median water level in the North Pit varies between 298 m AHD and 299 m AHD, which is approximately 10 metres below the current recorded water level.

Plate 40 depicts the variation in groundwater inflow over time.

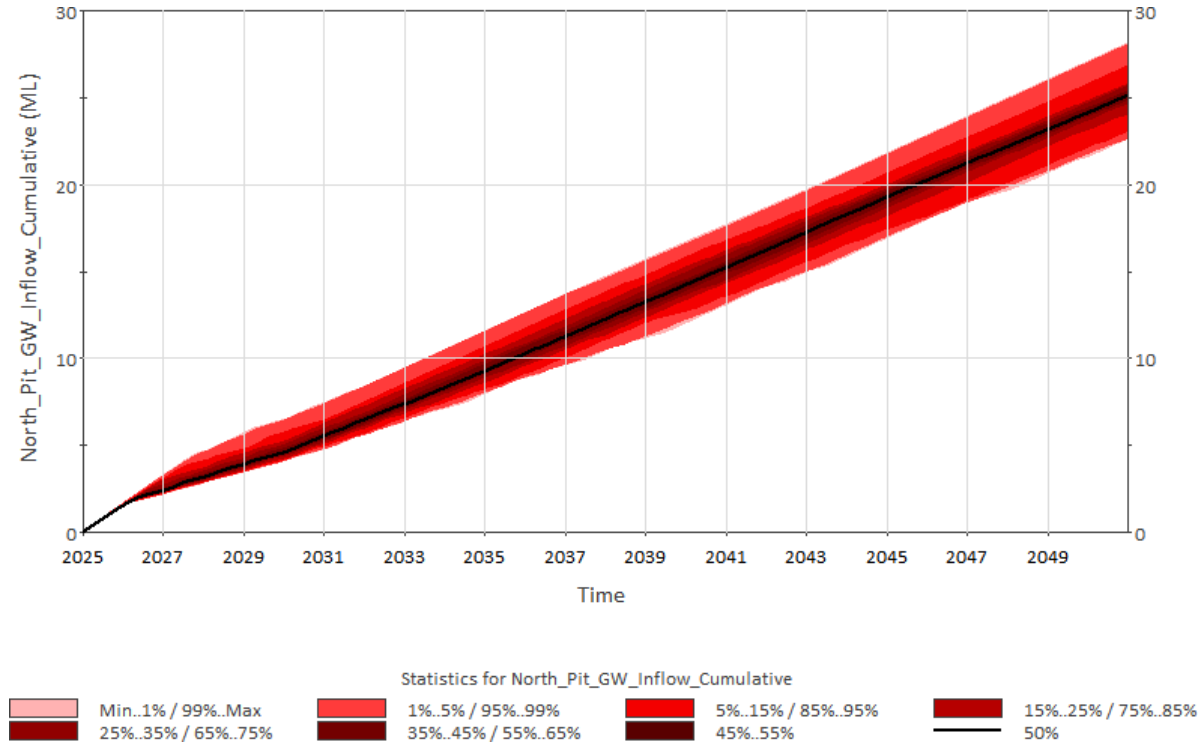


Plate 40 North Pit accumulated groundwater inflows

WRD Sediment Dam

The WBM indicates the following:

- Under median climatic conditions, the WRD Sediment Dam will be dewatered by October 2026.
- Under median climatic conditions, between October 2026 and October 2029 (excluding January-March each year), there are periods where the WRD Sediment Dam is dry, indicating the site may be in a net water deficit.
- The maximum modelled water level in the WRD Sediment Dam is 336.8 m AHD. The spillway level is at 336.8m AHD. There are 2 realisations where the WRD Sediment Dam spills. This only occurs in sequentially very wet years.
- The long-term median water level in the WRD Sediment Dam varies between 330 m AHD to 331.2 m AHD, approximately 2.5 metres below the current recorded water level.
- Due to the presence of the HDPE liner on the WRD Sediment Dam, no groundwater inflows or outflows were modelled.

10.5 North Pit, South Pit and WRD Sediment Dam final void water quality

Appendix J provides a detailed description of the water quality models (WQMs) for the final void water quality in the North Pit, South Pit and WRD Sediment Dam. Relevant aspects and results are summarised as follows.

10.5.1 Development of Water Quality Models

In 2023 and as part of the preparation of the PRCP for the BCP Project, ATC Williams developed water quality models (WQMs) for the North Pit, South Pit and WRD Sediment Dam by linking the output of the Goldsim WBM with a PHREEQC (USGS, ver. 3.6.2.15100) geochemical model. It is noted that these WQMs models did not include the proposed underground workings. However, the results of these WQMs are still considered relevant and representative to assess final void water quality in the open pits and WRD Sediment Dam. An assessment of the underground workings final void water quality is presented in Section 10.6 and Section 10.7.3.

Given the complexity of linking the Goldsim probabilistic output to PHREEQC, three different water balance scenarios were evaluated, corresponding with the following Goldsim™ WBM stochastic results:

- The median climatic conditions corresponding with an occurrence probability of 50% (i.e. 50th percentile or P50).
- Interquartile climatic conditions, corresponding with 25th percentile ant 75th percentile climatic conditions.

Higher probabilities were not considered since increased rainfall, groundwater discharge into the pit void, and lower evaporation rates would result in improved water quality and represent a lower risk to the downstream environment or closure condition.

With respect to the geochemical process, two main scenarios were considered to evaluate the mixing of the different water types:

- A first scenario/model that only included the mixing of different water types (in terms of volumes and water quality) followed by evaporative processes in the voids/sediment dam. This model is denoted as the "mixing" model.
- A second scenario/model included speciation equilibrium modelling, i.e. the precipitation/dissolution of minerals from/into solution when the different water types are mixed. In the first instance, only the mineral phase considered was gypsum, whereby gypsum precipitation could occur if calcium and sulphate concentrations in the mixed water were sufficiently elevated. This model is denoted as the "equilibrium" model.

Assumptions made in the water quality model include the following (ATC Williams, March 2023):

- In general, surface water inflow into the pit void was equilibrated with standard atmosphere conditions (CO_2(g) -3.2, O_2(g) 0.67)) and groundwater with carbonate (CO_2(g) -1.5) to maintain the pH values of site water quality solutions used in this assessment.
- To reduce the number of parameters in the model and allow for the focus on bulk water chemistry, the models assume that no stratification occurs within the pit void.
- Concerning the equilibrium model, an equilibrium reaction with gypsum was the only parameter considered relevant for the loss of solids from solution in the pit voids and sediment dam.

10.5.2 WRD Sediment Dam final void water quality

Detailed description and time series of the modelled long-term water quality in the WRD Sediment Dam are provided in Appendix J. Final void water quality can be summarised as follows:

- The solute concentrations at all times and for both models (i.e. mixing and equilibrium models) remain below the applicable ANZECC 2000 Water Quality Guideline values for livestock watering.
- The main processes that impact solute levels in the sediment dam are dilution due to rainfall runoff into the pit and concentration due to evaporation from the open pit. Due to the presence of the HDPE liner, groundwater inflow or outflow does not occur. The short-term or seasonal variations in solute concentrations can be correlated with the net balance between rainfall and evaporation.
- Under the 75th percentile climatic conditions, the WRD sediment Dam runs dry between early-2040 and end-2045. This affects the water quality in the WRD Sediment Dam.

10.5.3 North Pit water quality

Detailed time series of the modelled long-term water quality in the North Pit are provided in Appendix J. Final void water quality can be summarised as follows:

- The solute concentrations at all times and for both models (i.e. mixing and equilibrium models) remain below the applicable ANZECC 2000 Water Quality Guideline values for livestock watering.
- The main physical processes that impact solute levels in the open pit are dilution due to rainfall runoff, groundwater inflow into the pit, and concentration due to evaporation from the open pit. Groundwater inflow only plays a minor role, with long-term groundwater inflows comprising only ±10% of total inflows into the open pit. Short-term variations in solute concentrations are related to the net flow balance between inflows and evaporation. Whilst groundwater inflow is only a minor component of pit inflows, it does buffer the effect of evaporation on solute concentrations.

10.5.4 South Pit water quality

Detailed time series of the modelled long-term water quality in the South Pit are provided in Appendix J. Final void water quality can be summarised as follows:

- The solute concentrations at all times and for both models (i.e. mixing and equilibrium models) and scenarios remain below the applicable ANZECC 2000 Water Quality Guideline values for livestock watering.
- The main physical processes that impact solute levels in the open pit are dilution due to rainfall runoff, groundwater inflow into the pit, and concentration due to evaporation from the open pit. Groundwater inflow plays a moderate role, with long-term groundwater inflows (a combination of regional inflow and seepage from the North Pit) comprising ±20% of total inflows into the open pit. Short-term variations in solute concentrations are related to the net flow balance between inflows and evaporation. Groundwater inflow buffers the effect of evaporation on solute concentrations.

10.5.5 Summary

The water quality modelling indicates that the modelled solute concentrations at all times and for both models (i.e. mixing and equilibrium models) remain below the applicable ANZECC 2000 Water Quality Guideline values for livestock watering.

Long-term water quality in the pits and voids is determined by climatic conditions and geochemical reactions and tends to stabilise. The net flow balance between rainfall runoff plus groundwater inflow and evaporation determines short-term variations.

Based on the WQM results, the North Pit, South Pit and WRD Sediment Dam are considered suitable as PMLUs for livestock watering.

10.6 Underground workings final void water quality

10.6.1 Methodology

A WQM model was developed for the underground workings, based on the 2024 water balance model results for the underground working and considering the water quality results for the open pits, sediment dam, groundwater, surface water and rainfall.

The initial WQM model was a mixing model, assessing the underground workings water quality by mixing the water from the different WBM components that contribute to the water in the voids. The mixing model does not take into consideration the solubility limits of analytes and geochemical equilibrium mechanisms, such as the precipitation of minerals. As such, a mixing model is considered conservative and potentially overestimates final void water quality. A geochemical equilibrium model is only considered warranted if the mixing model results indicate potential impacts on environmental values.

Appendix K presents the results of the deterministic water balance models and detailed data and calculations for the underground workings final void water quality.

The following steps were undertaken in the final void quality assessment:

- Rainfall and evaporation time series/scenarios representing 5th, 25th, 50th, 75th and 100th percentile (a.k.a. the P05, P25, P50, P75 and P100 scenarios) were generated using the probabilistic WBM developed by ATC Williams (Appendix K.1).
- ATC Williams ran the WBM model in deterministic mode for each scenario to obtain detailed water balance volumes (i.e. inflows, storages and outflows) for the underground workings (Appendix K.2).
- A mixing model was developed for each scenario, using the water balance volumes and water quality characteristics of the different components to calculate the long-term water quality in the underground workings (Appendix K.3).

10.6.2 Summary of water balance model volumes

Appendix K.1 presents time series of the deterministic water balance model volumes, which can be summarised as follows:

- Direct rainfall and evaporation volumes have not been included in the UG workings water balance, as these processes do not interact with the UG workings.
- Cumulative water volumes in the UG voids are determined by the UG's water management requirements, which include initial transfer of water from the North Pit, transfers from the WRD Sediment Dam and semi-regular transfers of water from the South Pit.
- Groundwater inflow in the underground voids occurs steadily over time.

10.6.3 Modelled final void water quality

Representative initial water quality conditions

A review of existing water quality data was undertaken to determine representative water quality input conditions (i.e. solute concentrations) for the different components of the WQM model. Table 45 presents the adopted input/initial concentrations for the solutes included in the mixing WQM.

Table 45 Initial concentrations of relevant solutes/parameters for UG WQM

WBM Component	Rainfall	North Pit			South Pit			Sediment Dam		Underground works
Process	Rain	Start in Pit	Runoff water	GW Inflow	Start in Pit	Runoff water	GW Inflow	Start in Dam	Runoff water	GW Inflow
Source of concentrations	Literature	BCP North Pit	EA receiving waters reference sites	BAWB03	BCP South Pit	EA receiving waters reference sites	BAWB03	WRD SSD	EA receiving waters reference sites	BAWB03
Physico-chemical										
Electrical Conductivity (µS/cm)	22	1324	1035.85	1,045	1591	1035.85	1,045	4507	1035.85	1,045
pH (-)	7.325	8.8	8.9255	8.112	8.958	8.9255	8.112	8.645	8.9255	8.112
Total Dissolved Solids	15	662	597	470	797	597	470	2428	597	470
Major ions (mg/L)										
Calcium	17.025	113	37	74.2	148.8	37	74.2	303.5	37	74.2
Magnesium	4.61	41.5	47.7	25	59.2	47.7	25	210	47.7	25
Sodium	4.84	133.5	168.85	146	100.8	168.85	146	543.2	168.85	146
Potassium	3.49	29.5	58.9	14	24.2	58.9	14	41.8	58.9	14
Chloride	5.8	97.5	74	20.4	21.2	74	20.4	146.1	74	20.4
Fluoride	0.22	1.75	0.5	0.9	1.08	0.5	0.9	1.59	0.5	0.9
Sulfate	51	515.5	24.6	53.4	638.2	24.6	53.4	1654	24.6	53.4
Alkalinity (mg/L $CaCO_3$)										

WBM Component	Rainfall	North Pit			South Pit			Sediment Dam		Underground works
Process	Rain	Start in Pit	Runoff water	GW Inflow	Start in Pit	Runoff water	GW Inflow	Start in Dam	Runoff water	GW Inflow
Source of concentrations	Literature	BCP North Pit	EA receiving waters reference sites	BAWB03	BCP South Pit	EA receiving waters reference sites	BAWB03	WRD SSD	EA receiving waters reference sites	BAWB03
Bicarbonate Alkalinity as CaCO3	35	256.5	389.1	483.2	92.6	389.1	483.2	101.9	389.1	483.2
Major alkalinity ions (mg/L)										
Bicarbonate	42.7	312.93	474.702	589.504	112.972	474.702	589.504	124.318	474.702	589.504
Total Metals (mg/L)										
Aluminium	0.0416	NA	NA	0.09	NA	NA	0.09	NA	NA	0.09
Arsenic	0.001	0.003	0.004	0.001	0.0118	0.004	0.001	0.0049	0.004	0.001
Barium	NA	0.0875	0.21445	0.148	0.0528	0.21445	0.148	0.129	0.21445	0.148
Beryllium	NA	<0.001	NA	<0.0001	NA	NA	<0.0001	<0.001	NA	<0.0001
Bismuth	NA	<0.0001	<0.001	<0.0001	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.0001
Boron	<1	<0.05	NA	0.15	NA	NA	0.15	0.07	NA	0.15
Cadmium	0.0666	NA	NA	<0.0001	NA	NA	<0.0001	NA	NA	<0.0001
Chromium	<0.05	<0.001	0.0148	0.001	<0.001	0.0148	0.001	<0.01	0.0148	0.001
Cobalt	0.0007	0.00375	0.0059	0.0017	0.0147	0.0059	0.0017	0.0027	0.0059	0.0017
Copper	0.513	0.056	0.034	0.00765	0.0628	0.034	0.00765	0.0308	0.034	0.00765

WBM Component	Rainfall	North Pit			South Pit			Sediment Dam		Underground works
Process	Rain	Start in Pit	Runoff water	GW Inflow	Start in Pit	Runoff water	GW Inflow	Start in Dam	Runoff water	GW Inflow
Source of concentrations	Literature	BCP North Pit	EA receiving waters reference sites	BAWB03	BCP South Pit	EA receiving waters reference sites	BAWB03	WRD SSD	EA receiving waters reference sites	BAWB03
Iron	1.14	<0.05	NA	0.071	NA	NA	0.071	<0.05	NA	0.071
Lead	0.414	NA	NA	<0.001	NA	NA	<0.001	NA	NA	<0.001
Manganese	0.728	NA	NA	0.007	NA	NA	0.007	NA	NA	0.007
Mercury	NA	NA	NA	<0.0001	NA	NA	<0.0001	NA	NA	<0.0001
Molybdenum	<0.05	0.0215	0.00365	0.003	0.0482	0.00365	0.003	0.0684	0.00365	0.003
Nickel	<0.05	0.0145	0.0072	0.0038	0.0228	0.0072	0.0038	0.006	0.0072	0.0038
Selenium	<0.05	0.029	<0.001	<0.003	0.01	<0.001	<0.003	0.1265	<0.001	<0.003
Uranium	NA	0.011	0.0057	0.007	0.008	0.0057	0.007	0.0154	0.0057	0.007
Vanadium	NA	<0.01	NA	0.003	NA	NA	0.003	<0.01	NA	0.003
Zinc	1.23	NA	NA	0.074	NA	NA	0.074	NA	NA	0.074

NA: no analysis results

Literature source of rainfall water quality: Crosbie RS, Morrow D, Cresswell RG, Leaney FW, Lamontagne S and Lefournour M (2012) New insights into the chemical and isotopic composition of rainfall across Australia. CSIRO Water for a Healthy Country Flagship, Australia.

Modelled water quality in underground workings

Appendix K.3 presents the time series of modelled water quality in the underground workings final void for selected solutes over a period of 25 years (including 4 years of mining and 21 years post-mining). The time series of the modelled results indicate the following:

- Initial water quality is determined by the water quality of the water transferred into the UG voids (i.e. initial transfer of water from the North Pit, transfers from the WRD Sediment Dam and semi-regular transfers of water from the South Pit).
- Mid- to long-term water quality is governed by the mixing of the transferred water with groundwater inflow.

Table 46 presents a statistical summary of the WQM results, compared against the ANZECC Livestock Water Quality Guidelines and the PRCP schedule PRCP EPML02840015 – Water quality limits for North and South Pits and WRD Sediment Dam. The results indicate that the short- and long-term water quality within the UG workings remains below these guideline values.

Conclusions

The results of the mixing modelling indicate that groundwater quality in the UG voids remains below the relevant water quality guidelines values (livestock watering and PRCP criteria for voids) and that the underground workings are suitable for a livestock watering PLMU.

Table 46 Modelled UG workings final void water quality concentrations (mg/L)

	Guideline values	P05		P25		P50		P75		P100	
Analyte		Average	Max.	Average	Max.	Average	Max.	Average	Max.	Average	Max.
Aluminium	5 (1)	0.0602	0.0902	0.0546	0.0902	0.0591	0.0854	0.0506	0.0902	0.0576	0.0902
Arsenic	0.5 (1)(2)	0.0022	0.0030	0.0024	0.0027	0.0023	0.0026	0.0026	0.0029	0.0023	0.0026
Barium	-	0.1703	0.1797	0.1724	0.1797	0.1710	0.1788	0.1742	0.1829	0.1692	0.1761
Bicarbonate	-	539.3	590.6	524.6	590.6	539.1	576.3	515.2	590.6	527.0	590.58
Boron	5 (1)	0.0984	0.1503	0.0910	0.1503	0.0957	0.1358	0.0842	0.1503	0.0958	0.1503
Cadmium	0.01 (1)(2)	0.0048	0.0279	0.0045	0.0163	0.0051	0.0443	0.0049	0.0197	0.0044	0.0178
Calcium	500 (2) 1000 (1)	73.8	107.0	77.7	112.3	70.7	88.3	77.3	109.5	77.6	118.2
Chloride	-	44.1	67.3	49.0	53.6	43.9	49.1	51.7	56.4	46.5	50.3
Chromium	1 (1)	0.0055	0.0076	0.0060	0.0078	0.0058	0.0074	0.0065	0.0083	0.0055	0.0071
Cobalt	1 (1)	0.0032	0.0038	0.0034	0.0039	0.0033	0.0037	0.0035	0.0040	0.0032	0.0036
Copper	1 (1)(2)	0.0542	0.2223	0.0534	0.1348	0.0567	0.3440	0.0581	0.1620	0.0518	0.1457
Fluoride	2 (1)(2)	0.8218	0.9640	0.8226	1.0469	0.8047	0.9513	0.8083	1.0303	0.8282	1.0860
Iron		0.1269	0.5117	0.1175	0.3276	0.1309	0.7826	0.1222	0.3753	0.1188	0.3501
Lead	0.1 (1)(2)	0.0297	0.1736	0.0278	0.1016	0.0315	0.2755	0.0308	0.1227	0.0274	0.1109
Magnesium	150 (2) 2000 (1)	41.1	74.8	46.2	57.9	39.7	43.6	48.0	55.8	44.5	60.2
Manganese	1 (2)	0.0567	0.3085	0.0530	0.1833	0.0598	0.4869	0.0578	0.2194	0.0525	0.1994

	Guideline values	P05		P25		P50		P75		P100	
Analyte		Average	Max.	Average	Max.	Average	Max.	Average	Max.	Average	Max.
Molybdenum		0.0061	0.0189	0.0076	0.0133	0.0055	0.0087	0.0080	0.0127	0.0073	0.0143
Nickel	1 [(1)]	0.0050	0.0055	0.0052	0.0056	0.0051	0.0054	0.0054	0.0058	0.0051	0.0054
Potassium	-	30.4	36.7	32.7	37.9	30.9	35.8	34.5	39.8	30.9	35.4
Selenium		0.0055	0.0316	0.0085	0.0195	0.0043	0.0118	0.0091	0.0185	0.0079	0.0213
Sodium	-	172.5	223.5	182.6	219.0	168.5	181.1	185.0	213.1	179.2	227.6
Sulfate	2,000 [(1)]	118.1	444.1	153.9	306.5	102.4	197.2	161.4	293.7	147.7	330.1
Total Dissolved Solids	5,000 [(1)(2)]	602.4	907.6	652.9	815.0	584.2	632.6	666.1	789.9	637.1	849.4
Uranium	0.2 [(1)]	0.0070	0.0078	0.0071	0.0086	0.0069	0.0076	0.0071	0.0084	0.0071	0.0089
Vanadium	ND [(1)]	0.0019	0.0030	0.0017	0.0030	0.0019	0.0027	0.0016	0.0030	0.0018	0.0030
Zinc	20 [(1)(2)]	0.1353	0.5509	0.1253	0.3515	0.1397	0.8435	0.1304	0.4035	0.1265	0.3761

[(1)] ANZECC 2000 Liverstock (beef cattle) drinking water quality guidelines

[(2)] PRCP schedule PRCP EPML02840015 – Tabe 5: Water quality limits for North and South Pits and WRD Sediment Dam

10.7 Potential AMD impact on final void water quality

10.7.1 Summary of AMD investigations

Appendix L presents the results of the historical AMD investigations.

Waste rock characterisation

A waste rock geochemical assessment has been completed (EGi, 2014), which defines the geochemistry of waste rock materials. The assessment involved the analysis of 121 drill core samples from 14 diamond drill holes, representing the range of waste rock lithologies that were intersected during open pit mining operations across the North and the South Pit footprint. Detailed description of the methodology and results is provided in EGi's report "*Barbara Copper Project – Assessment of Waste Rock Geochemistry*" (EGi, 2014), included as Appendix G of the BCP PRCP Report.

Based on the analyses undertaken, the samples were classified by EGi (2014) into the following classes:

- Non-acid forming (NAF), the sample is not expected to generate acid in excess of the available acid neutralising capacity (ANC)
- Potentially acid forming (PAF), the sample may form sulphuric acid when in prolonged contact with water and oxygen
- Uncertain (UC), the sample may or may not form acid.

Based on the acid-forming properties of the material, water that remains in contact for medium to long-term durations may exhibit AMD.

NAPP and NAG characterisation demonstrates most waste rock samples are NAF, while ore samples are distributed between NAF and PAF. An AMD classification plot displaying the concurrence of NAPP and NAG test results is provided in Table 47.

Table 47 BCP AMD classification (EGi, 2014)

Waste/Ore	Classification	Number of Analyte Results	Proportion
Waste Rock (Cu ≤ 0.5% Grade)	PAF	7	7%
	NAF	83	89%
	UC	4	4%
Ore (Cu > 0.5% Grade)	PAF	15	56%
	NAF	12	44%

Additional kinetic NAG analyses were conducted for five samples (three waste, two ore) of PAF rock, to provide an indication of the lag time before significant acid generation occurs. Accordingly, the five samples analysed were PAF samples. The outcomes are presented in Table 48.

Table 48 Acid rock drainage samples - acid generation lag time (EGi, 2014)

Sample	Final pH	Lag Time
Ore #8050	3.1	Weeks to months
Ore #8112	2.7	At least a year to several years

Sample	Final pH	Lag Time
Waste #8066	4.7	At least a year to several years
Waste #8092	3.0	Several years
Waste #8072	6.3	At least a year to several years

Overall, lag times for samples classified as PAF were significant, and likely to exceed a year. Of the two analysed PAF ore samples, one was highly reactive (Ore #8050), with generation of acid expected to occur within weeks of being exposed to atmospheric conditions (water and oxygen).

NAF waste rock materials exhibited limited ANC, consequently blending of NAF and PAF samples may not result in significant changes to acid generation characteristics of the blended material, compared to the PAF material alone.

Additionally, sulphur speciation was conducted on the five samples used in the kinetic NAG analyses to determine the forms of sulphur present in rock. This revealed very minimal sulphate-sulphur present in rock with most sulphur present as sulphide-sulphur.

Kinetic column leach tests of waste rock and ROM oxide

A column leach test program involving samples representing waste rock and ROM oxide from the Project commenced on 30 August 2019, with leaching extending over 12 months during which a total of 13 leachate collections were made.

The results and the findings of the program are provided in EGi's report "*Kinetic Column Leach Testing of Waste Rock and ROM Oxide. Final Report - September 2020. Round Oak Mineral. Barbara Copper Project. Ref S4405/J000325/R1382*" (EGi, 2020) , included as Appendix I of the BCP PRCP Report.

The six samples (each sample comprised approximately 10 kg of rock pieces) were collected from the South Pit from various geological units according to geochemical characteristics. One sample was considered PAF, three samples represented NAF waste rock and the remaining two samples represented ROM oxide, as listed in Table 49 (EGi, 2020).

Table 49 Descriptions of Barbara waste rock and ROM oxide samples (EGi, 2020)

Material Class	Location	Northing	Easting	Depth in Pit	Geological Description
PAF1	South Pit	380252	7741437	330 RL	Oxidised sample quartz sericite schist, minor secondary copper.
NAF1	South Pit	380184	7741440	330 RL	Biotite schist
NAF2	South Pit	380122	7741495	325 RL	Biotite schist
NAF3 (previously PAF2)	South Pit	380193	7741549	325 RL	Oxidised sample quartz sericite schist with secondary copper, malachite and azurite.
NAF4	South Pit	na	na	na	na
ROM Oxide1	South Pit	380298	7741497	325 RL	Sample collected at the southern end of the shear zone and outside the ore zone. Very oxidised samples with minor

Material Class	Location	Northing	Easting	Depth in Pit	Geological Description
					secondary copper, malachite and azurite.
ROM Oxide2	South Pit	380224	7741519	325 RL	Sample collected from the hanging wall of the shear zone. Mainly oxidised schist, with secondary copper, malachite and azurite.

Chemical characterisation of three of the NAF samples and the two ROM oxide samples indicate NAF characteristics. One NAF sample recorded significant sulphide concentration, although this sample also presented moderate to high ANC which resulted in a negative NAPP test and was subsequently confirmed to be NAF. The PAF sample recorded a positive NAPP result and acidified during the NAG test. The acid forming characteristics of samples are summarised in Plate 41.

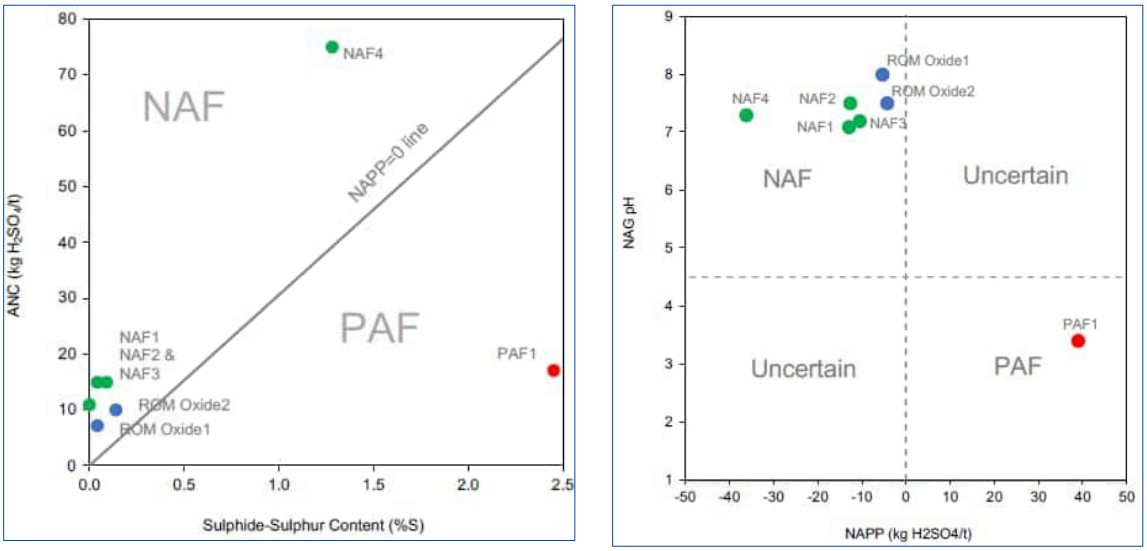


Plate 41 AMD plot for waste rock and ROM oxide and AMD classification (EGi, 2020)

The reactivity of sulphides in the PAF sample was assessed during a monitored NAG test (EGi, 2020). The monitored NAG test revealed an initial lag in acidification, attributed to the acid neutralising capacity of the rock material. After the lag period, pH began to decline while temperature increase as sulphidic material was oxidised. The results of the monitored NAG test indicate the sulphidic mineralisation is reactive, however, the lag period suggests acidification will only occur after many months or years under field conditions.

Two assessments for acid neutralising potential were conducted on samples, namely ANC and carbonate neutralising value (CNV). For all samples, CNVs were below ANC values. This suggests most acid neutralising capacity in rock is a result of carbonate mineralisation. This is particularly true for sample NAF4 which has the highest ANC. It is anticipated that for samples with very low ANCs, some acid neutralising may be derived from gangue minerals such as silicates.

The column leach test occurred for one year under conditions amenable to sulphide oxidation. The column was flushed every three weeks with the leachate collected for elemental analysis. The first-flush leachate collected from all samples was found to be alkaline, low in soluble salts, contained only trace concentrations of aluminium, iron and manganese. Dissolved metal concentrations were

generally below the limits of analytical detection. A summary of chemical characteristics for the leachate produced from each sample for weeks 4-52 is provided in Table 50. Detailed analysis results are provided in Appendix L.

Table 50 Summary of leachate analysis from week 4 to 52 (EGi, 2020)

Sample ID	Leachate Characteristics
PAF1	pH remained circum-neutral signifying the sample was in lag phase. Release of sulphate remained relatively low – ranging between 155 to 334 mg/L which indicates slow rate of sulphide oxidation. No leaching of iron or copper as a result of slow rates of pyrite and chalcopyrite oxidation. Despite significant enrichment of cobalt and selenium and minor enrichment of arsenic and nickel in the sample, arsenic concentration was below detection limits while only trace concentrations of cobalt, nickel and selenium were present in leachate. Only minor leaching of manganese and aluminium were recorded.
NAF 1 and NAF2	pH of leachate remained alkaline. Sulphate concentrations remain very low for the duration of the column leach (NAF1 average of 20 mg/L and NAF2 average of 47 mg/L. Results indicate sulphide oxidation is near non-existent. Calcium was recorded as a major cation in leachate with the average calcium concentration of 11 mg/L and 21 mg/L in NAF1 and NAF2 respectively. Concentration of copper, cobalt and chromium indicates no significant leaching of these metals. NAF2 presented minor leach of arsenic with concentrations in leachate increasing in the first six months before stabilising at 0.03 mg/L.
NAF4	pH of leachate remained slightly alkaline for the duration of the column test. Although leachate remained alkaline, there was a significant release of sulphate during the test with and average sulphate concentration of 452 mg/L at a release rate of 32 mg/kg/week. This corresponds to an IOR of $4.8x10^{-8}$ $kg/O_2/m^3$/sec. which is in the moderate range for sulphidic rock. Significant leaching of calcium was detected which reflects the carbonate minerals within sample reacting with the acidity generated by sulphide oxidation. Release of magnesium was also reported, suggesting carbonate mineralisation may have been partially dolomitic. Although the sample had a high copper content, the concentration of copper in leachate was minor at around 0.01 to 0.04 mg/L. It is thought that copper released during oxidation likely reprecipitated as copper oxyhydroxide. No significant leaching of iron, manganese, or any other element of environmental significance was detected.
Oxide ROM1 and ROM2	Both ROM oxide samples remains circum-neutral during the column leach test. Release of sulphate occurred during the first few months of the test, however this decreased thereafter. The copper concentration of leachate indicates some evidence of copper leaching, although results indicate a pH-dependent solubility control for copper release. As such, copper leaching is expected to remain constant as a result of circum-neutral pH.

Sample ID	Leachate Characteristics
	No significant leaching of cobalt or other metals of environmental significance was detected.

Solute concentrations within the AMD leachate

Representative AMD solute concentrations have been obtained through the kinetic column leach testing undertaken in 2020 (EGi, 2020).

Results of the testing are presented in Appendix L.1. Charts comparing the kinetic column leach test results against the adopted livestock drinking WQG are presented in Appendix L.2, whilst chart comparing the results against the long-term water quality in the open pits are included in Appendix L.3.

The results indicate the following:

- Long-term kinetic column leach results (at week 52 of the test program) are below the adopted livestock drinking WQG values.
- Long-term kinetic column leach results (at week 52 of the test program) are below the modelled long-term solute concentrations (average of modelled concentrations/levels after 50 years) in the open pits, except for aluminium, arsenic, calcium, chromium and copper in one or more column samples. However, the leach results of these solutes are below the livestock drinking WQG (where specified).
- As the AMD impact groundwater inflow constitutes only a minor component of the total inflow into the open pits, the mass load of the AMD solutes will be diluted by rainfall runoff and the pit water volume already in storage.

10.7.2 Potential AMD impacts on final void water quality in open pits

The presence of some potentially acid forming (PAF) rock within the open pit shells has potential implications for final void water quality. Some sulphide mineralisation will be exposed on the final pit floor and footwall benches as these final surfaces will be close to ore zones. Direct runoff from the open pit walls that comes in contact with PAF rock wall material or groundwater seepage through PAF pit wall material could affect the evolution of final void water quality over time.

The semi-quantitative assessment of the potential impacts of AMD on final void water quality presented further below was based on the results of geochemical investigations into the waste rock and oxide ore and the results of the water balance modelling. The potential for AMD to impact on the final void water quality depends on several factors, including:

- the area within the pit shells with exposed PAF material
- the proportion of this leachate water relative to total inflows in the open pits (i.e. the dilution effect)
- the solute concentrations within the leachate water from the exposed material
- the solute concentration and mass balance in the open pits.

Exposure to PAF material from pit walls

Exposure of some PAF rock around the pit shell has implications for pit water quality, especially late in mine life and closure. At closure, some sulphide mineralisation will be exposed on the final pit floor and footwall benches as these final surfaces will be close to ore zones.

Classification of waste rock and ore material undertaken by EGi in 2014 indicates that:

- the majority (89%) of the waste rock from the open pits will have a low sulfur content and will be non-acid forming (NAF). It follows that most exposed waste rock in the pit shells will be NAF.
- whilst most of the ore samples tested had high to very high sulphide content, only ±56% were classified as PAF.

A waste rock and ore block model was developed to provide the basis for initial mine planning, as presented in "*Waste Rock Management Plan*" developed by URS Australia in 2014. This management plan includes several cross-sections through the North Pit and South Pit, depicting the occurrence of PAF waste, NAF waste and ore within the proposed open pits.

These cross-sections (Plate 42 and Plate 43) demonstrate that only a minor part of the pit shell would contain exposed PAF waste or ore.

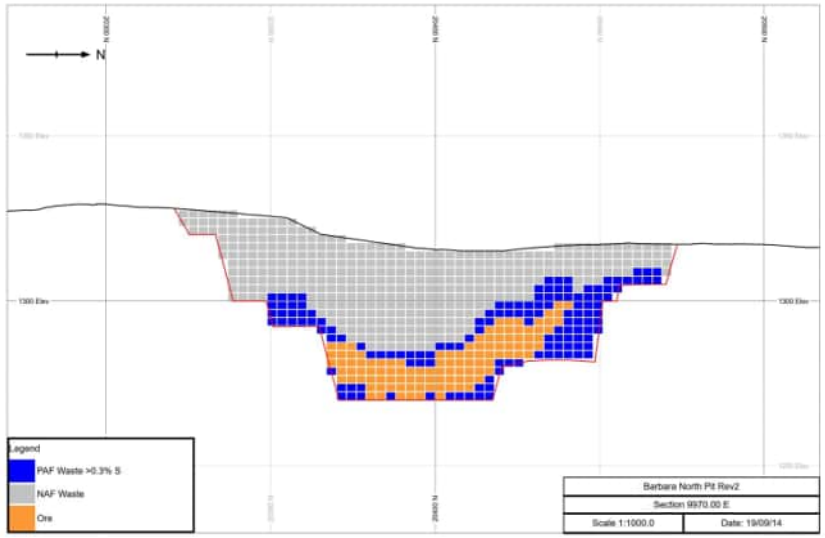
Proportion of AMD leachate relative to total inflows in the open pits

Exposed PAF rock may produce localised AMD from seepage of groundwater through the exposed PAF material. If PAF rock represents only a small fraction of total pit wall area then it is likely that any AMD produced would be diluted and neutralised to some extent by the much larger volume of alkaline runoff from NAF rock around the pit and by non-AMD impacted groundwater inflow.

Water balance modelling undertaken by ATC Williams (ATC Williams, 2023) indicate groundwater inflow into the open pits is minor compared to total inflow and existing pit volume. Cumulative groundwater inflow as percentage of total inflow are as follows:

- North Pit: ±10% of the total cumulative inflow
- South Pit: ±20% of total cumulative inflow

Assuming that only half of the groundwater inflow would pass through the PAF material in the pit shell, this potentially AMD impacted seepage water would only comprise ±5% and ±10% of total inflow, for North Pit and South Pit respectively. When considering the total inflow from rainfall runoff and the buffering effect of the water volume already present in the open pits, the volume of AMD impacted groundwater seeping into the open pits is sufficiently diluted to alleviate its potential adverse impacts on open pit water quality.



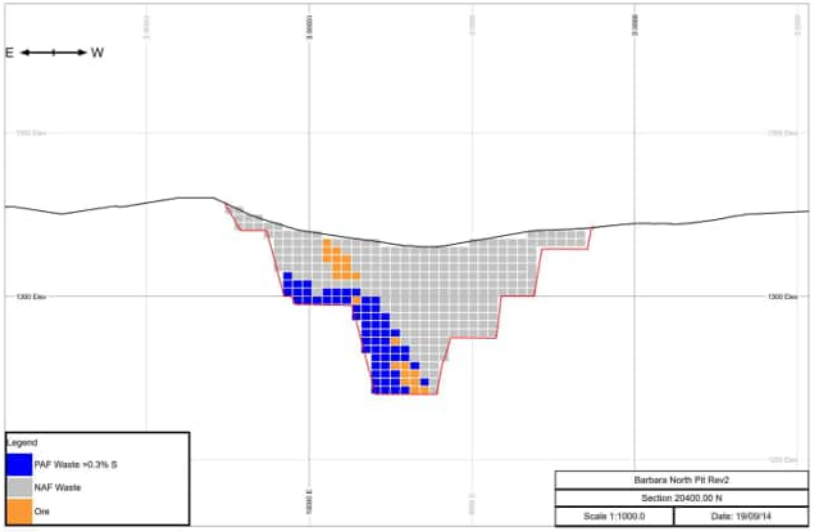
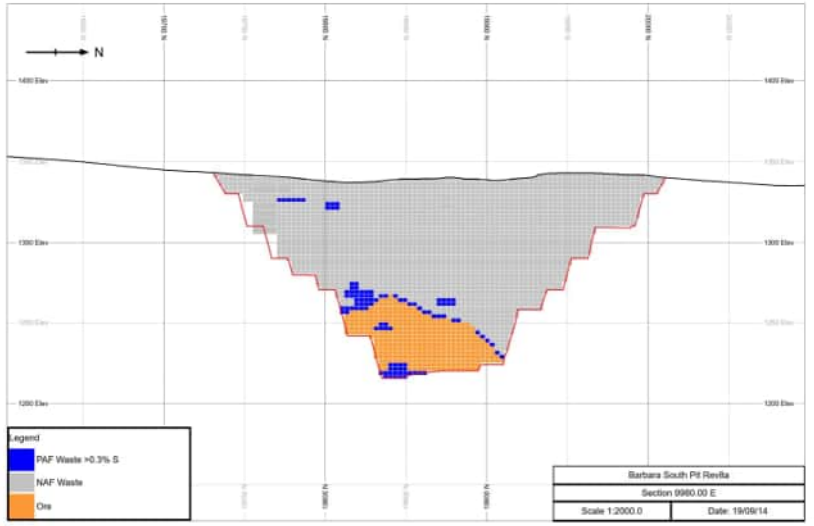


Plate 42 North Pit waste rock cross-sections (AECOM 2014)



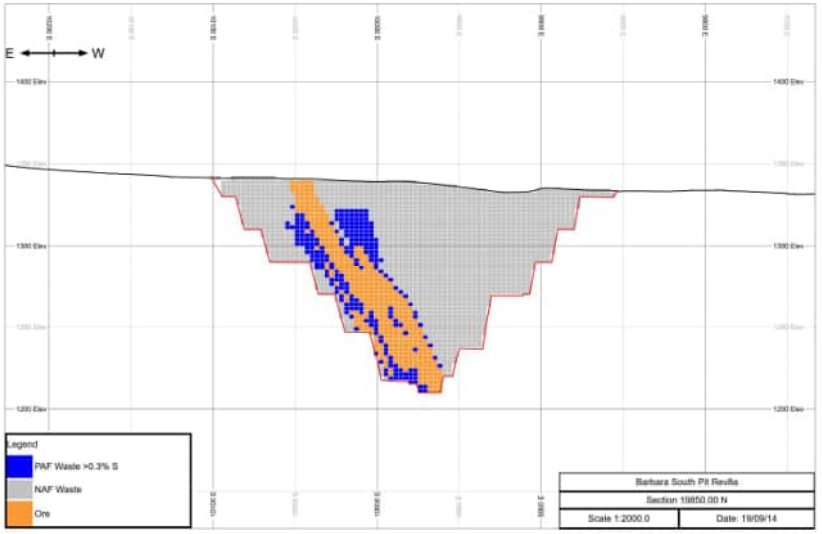


Plate 43 South Pit waste rock cross-sections (AECOM 2014)

Potential AMD impacts on open pit water quality

Saline drainage potential

Analyses of EC were performed to provide an indirect measure of the soluble salt content of mined rock and to assess the potential for saline drainage if material is exposed to atmospheric conditions (EGi, 2014). Plate 44 provides a summary of EC values per rock unit.

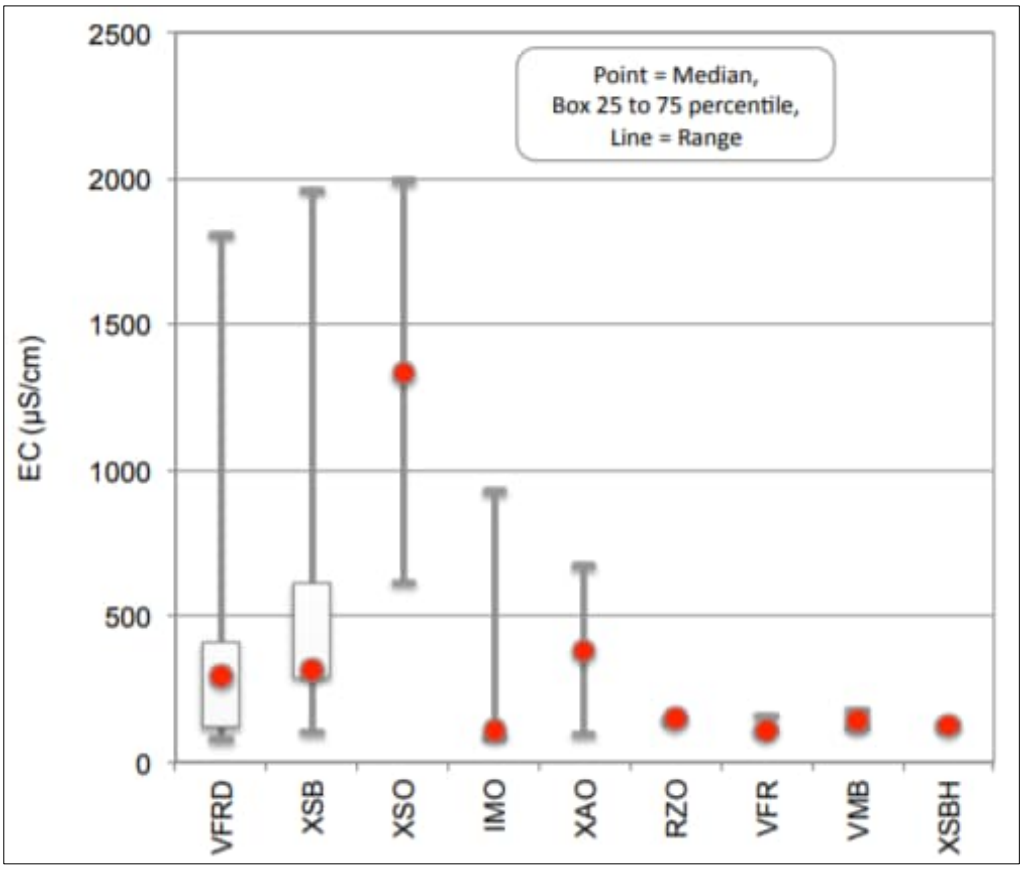


Plate 44 Summary of EC values for all rock units within Barbara drill core samples (EGi, 2014)

From the results presented in Plate 44, the following outcomes can be determined:

- 72% of the 87 VRFD (the dominant waste unit) analyses - generally comprising of the predominant waste rock unit (Porphyritic Rhyolite), resulted in an EC of less than 400 µS/cm, representative of 'non-saline water'.
- 21% of the 87 VRFD analyses resulted in an EC between 400 and 800 µS/cm, representative of 'slightly saline water'.
- 13 of the 121 drill core analyses conducted were classified indirectly as 'saline' (≥800 µS/cm). It is noted that 12 of the 13 analyses resulting in a 'saline' classification comprised high sulphur ore materials.

Based upon the EGi (2014) results, it is concluded that saline drainage was not considered a significant water quality issue, with respect to waste rock materials.

Metalliferous drainage potential

The elemental characterisation provides an indication of elements enriched in the solid rock material, however, may not be indicative of the potential for metal leaching to water. The leaching potential of ore and waste rock was, therefore, determined using an extraction with deionised water (kinetic column leach testing) (EGi, 2020).

The results indicate the following:

- Long-term kinetic column leach results (at week 52 of the test program) are below the adopted livestock drinking WQG values.
- Long-term kinetic column leach results (at week 52 of the test program) are below the modelled long-term solute concentrations (average of modelled concentrations/levels after 50 years) in the open pits, except for aluminium, arsenic, calcium, chromium and copper in one or more column samples. However, leach results of these solutes are below the livestock drinking WQG (where specified).

As the AMD impact groundwater inflow constitutes only a minor component of the total inflow into the open pits, the mass load of the AMD solutes will be diluted by rainfall runoff and the pit water volume already in storage.

Therefore, it is considered that the seepage of AMD groundwater will not adversely impact the long-term water quality in the open pits.

10.7.3 Potential AMD impacts on underground final void water quality

Introduction

As discussed in Section 3, the backfill method planned for Barbara UG is development waste rock placed into completed stope voids. Aeris waste balance indicates that ~390,747 tonnes (t) of waste rock are expected from UG mining, with ~306,456 t being non-acid-forming (NAF) and ~84,292 t being potentially acid-forming (PAF) material.

Waste rock will be characterised prior to disposal consistent with EA condition C3 to determine if it is PAF material. PAF material will be temporarily stockpiled within the ROM pad footprint before being returned underground as backfill. Additional waste rock (preferentially PAF) will be sourced from the existing WRD to backfill stope voids as there is a known waste rock deficit. NAF material may be used as a cover for the existing waste rock dump (WRD).

Methodology

The placement of PAF material within the UG voids has the potential to adversely affect the long-term water quality in the voids, which may, in turn, have an adverse impact on the environmental values of the receiving environment.

Geochemical modelling, using Phreeqc v3.0, was undertaken to assess the impact of the placement of PAF material on the UG void water quality. A mixing model was developed based on the following assumptions and input data:

- The mixing model considered the scenario whereby all PAF, NAF, and make-up material (e.g., PAF or ROM material) were placed in the UG voids, and these voids were filled with water.
- Water volumes in the final void were derived as follows:

  - Volumes of water leaching from the PAF, NAF and make-up material have been derived from the Aeris' waste balance calculations (Section 3), assuming all waste material has been placed with a porosity of 30%.
  - Volume of water in the underground voids has been derived from the UG workings WBM developed to assess final void water quality.
- Input water quality has been derived as follows:
  - Water quality from the PAF, NAF and make-up material has been calculated as the 95% percentile of the kinetic column leach test results.
  - Water quality of the UG final void water has been calculated as the 95% percentile of the UG mixing WQM model concentrations.
- Five different climate scenarios (P05, P25, P50, P75 and P100) were considered.

Table 51 shows the input water quality data and water volumes for the different scenarios.

Table 51 Input water quality and water volumes for UG PAF disposal WQM

	PAF Material	NAF Material	Make-up Material	P05	P25	P50	P75	P100
Water Quality (mg/L)								
Alkalinity (as HCO3)	22.0	28.0	22.0	571.9	553.4	567.3	540.5	558.0
pH	7.500	7.600	7.500	8.1120	8.1120	8.1120	8.1120	8.1120
Calcium	67.0	122.0	67.0	89.0	101.7	84.0	108.3	116.6
Magnesium	8.0	18.0	8.0	43.0	52.5	41.0	54.6	59.1
Sodium	1.0	1.0	1.0	184.3	206.2	176.2	209.6	224.5
Potassium	13.0	16.0	13.0	36.7	37.9	35.8	39.8	35.4
Chloride	<1.0	<0.1	<1.0	50.5	53.6	49.1	56.4	50.3
Fluoride	0.300	0.300	0.300	0.9477	0.9956	0.9179	1.0230	1.0796
Sulfate	197.0	331.0	197.0	165.8	246.5	141.4	286.6	319.6
Aluminium	0.020	0.140	0.020	0.0789	0.0776	0.0802	0.0784	0.0806
Arsenic	<0.001	0.029	<0.001	0.0026	0.0027	0.0026	0.0029	0.0026
Barium	0.020	0.020	0.020	0.1797	0.1797	0.1788	0.1829	0.1761
Boron	<0.050	<0.050	<0.050	0.1282	0.1302	0.1294	0.1305	0.1387
Cadmium	0.000	0.000	0.000	0.0070	0.0077	0.0075	0.0089	0.0063
Chromium	<0.001	<0.001	<0.001	0.0076	0.0078	0.0074	0.0083	0.0071
Cobalt	0.007	0.002	0.007	0.0038	0.0039	0.0037	0.0040	0.0036
Copper	0.028	0.019	0.028	0.0678	0.0722	0.0710	0.0817	0.0628
Iron	<0.050	0.070	<0.050	0.1777	0.1879	0.1857	0.2095	0.1666

	PAF Material	NAF Material	Make-up Material	P05	P25	P50	P75	P100
Lead	<0.001	<0.001	<0.001	0.0435	0.0477	0.0464	0.0552	0.0389
Manganese	0.040	0.130	0.040	0.0822	0.0895	0.0875	0.1027	0.0740
Molybdenum	0.003	0.005	0.003	0.0077	0.0110	0.0067	0.0124	0.0139
Nickel	0.004	0.001	0.004	0.0055	0.0056	0.0054	0.0058	0.0054
Selenium	<0.010	<0.010	<0.010	0.0086	0.0150	0.0068	0.0180	0.0205
Uranium	<0.001	0.001	<0.001	0.0077	0.0082	0.0074	0.0083	0.0088
Vanadium	-	-	-	0.0025	0.0024	0.0025	0.0024	0.0026
Zinc	<0.005	<0.005	<0.005	0.1896	0.2006	0.1983	0.2240	0.1776
Water Volume Calculations								
Water in voids (ML)	-	-	-	84.18	73.31	72.2	62.22	49.8
Waste Volume in UG Voids (tonnes)	84,2912	306456	139253	-	-	-	-	-
Porosity (%)	30%	30%	30%	-	-	-	-	-
Water Volume (tonnes)	25,287	91,937	41,776	-	-	-	-	-
Conversion from water ton to ML	0.001018	0.001018	0.001018	-	-	-	-	-
Water Volume (ML)	25.75	93.62	42.54	-	-	-	-	-
% volumes for mixing WQM								
Water Volume (ML)	25.75	93.62	42.54	84.18	73.31	72.2	62.22	49.8
P05 - % volume	0.105	0.380	0.173	0.34	-	-	-	-
P25 - % volume	0.109	0.398	0.181	-	0.312	-	-	-
P50 - % volume	0.1100	0.3999	0.1817	-	-	0.3084	-	-
P75 - % volume	0.1149	0.4177	0.1898	-	-	-	0.2776	-
P100 - % volume	0.1216	0.4422	0.2009	-	-	-	-	0.2352

Modelling results

Phreeqc v3.0 was used to model the mixing of the different water types and volumes with specific water quality characteristics for the five climate scenarios. Appendix K.4 presents the Phreeqc input and output files for each scenario.

Table 52 presents the modelled end-point water quality in the UG void. The modelled concentrations are below the ANZECC 2000 Livestock Drinking Water guidelines and below the BCP PRCP groundwater criteria.

Table 52 End-point UG water quality (mg/L) with PAF/NAF disposal

Analyte		Guideline Values	P05	P25	P50	P75	P100
Aluminium	Al	5 [1]	0.0858	0.0858	0.0866	0.0864	0.0873
Arsenic	As	0.5 [1][2]	0.0119	0.0124	0.0124	0.0129	0.0134
Boron	B	5 [1]	0.0439	0.0407	0.0399	0.0363	0.0326
Barium	Ba	-	0.0747	0.0699	0.0690	0.0654	0.0567
Calcium	Ca	500 [2] 1000 [1]	95.5	99.8	94.3	101.6	103.0
Cadmium	Cd	-	0.0024	0.0024	0.0023	0.0025	0.0015
Chloride	Cl	-	17.3	16.7	15.1	15.7	11.8
Cobalt	Co	1 [1]	0.0040	0.0040	0.0040	0.0041	0.0040
Chromium	Cr	1 [1]	0.0026	0.0024	0.0023	0.0023	0.0017
Copper	Cu	1 [1][2]	0.0382	0.0382	0.0377	0.0392	0.0322
Fluoride	F	2 [1][2]	0.5219	0.5175	0.4907	0.5014	0.4837
Iron	Fe	-	0.0875	0.0866	0.0853	0.0876	0.0701
Potassium	K	-	22.3	21.9	21.2	21.7	19.68
Magnesium	Mg	150 [2] 2000 [1]	23.8	25.9	22.2	25.2	24.5
Manganese	Mn	1 [2]	0.0887	0.0913	0.0907	0.0951	0.0878
Molybdenum	Mo	-	0.0054	0.0063	0.0049	0.0065	0.0065
Sodium	Na	200[2]	63.7	65.1	55.0	59.1	53.6
Nickel	Ni	1 [1]	0.0034	0.0033	0.0032	0.0032	0.0030
Lead	Pb		0.0149	0.0149	0.0143	0.0154	0.0092
Sulfate	SO4	2,000 [1]	237.1	265.6	233.3	277.8	284.9
Selenium	Se		0.0029	0.0047	0.0021	0.0050	0.0048
Uranium	U	0.2 [1]	0.0030	0.0030	0.0027	0.0027	0.0025
Vanadium	V		0.0009	0.0007	0.0008	0.0007	0.0006
Zinc	Zn	20 [1][2]	0.0649	0.0627	0.0611	0.0623	0.0418

[1] ANZECC 2000 Livestock (beef cattle) drinking water quality guidelines

[2] PRCP schedule PRCP EPML02840015 – Tabe 5: Water quality limits for North and South Pits and WRD Sediment Dam

Potential impacts of PAF/NAF disposal in UG voids on environmental values of receiving environment

The results of the geochemical modelling indicate that the disposal of PAF, NAF and make-up material in the UG voids does not adversely impact the environmental values and that the underground workings are suitable for a livestock watering PLMU.

10.8 Preliminary assessment of final void stratification

10.8.1 Introduction

All pit lakes are subject to physical and chemical processes that will determine the water quality of the pit lake, whether the pit lake can support aquatic life and terrestrial food webs, and the impact of the release of water to the receiving environment.

Some processes, such as wind forcing and convective mixing, are common to all pit lakes, while other factors (e.g., site-specific geochemistry, hydrology and mine pit morphology) will be specific to the mine pit and its mineralogical character.

Pit lakes undergo annual water temperature cycles due to heat exchange between water and the atmosphere. Heat exchange occurs through longwave radiation, shortwave radiation, conduction and evaporation, and temperature exchanges between the different vertical layers in the lake and the sediments. Temperature gradients in lakes can result in a water column with two or more stratified layers. Some shallow pit lakes may be perpetually mixed by wind and never stratify (Castendyk et al., 2015).

In Northern Australia, where the climate is characterised by a wet and dry season, lake stratification can occur. Stratification of a lake occurs during the summer 'wet' season, where warmer, fresher waters sit atop colder, more saline waters in a lake. With the onset of the winter 'dry' season, the fresher top layer increases in salinity due to evapoconcentration, and the water cools due to a decrease in temperature. This results in denser upper layer water mixing with water below (Boland and Padovan, 2002)

Stratification constrains the mixing of surface and deeper waters, can minimise replenishment of deep waters with oxygen, and can, therefore, control redox states, geochemical cycles, and acidification processes.

Based on thermal stratification, three different types of lakes can be defined:

- Holomictic lakes have a uniform density and temperature regardless of depth in a particular period of the year. The layers within a holomictic lake circulate or intermix at least once a year due to the breakdown of thermal stratification and wind power. Mixing is complete or partial.
- Meromictic lakes have layers of water that do not intermix. These lakes are permanently stratified with a deep-water body of high density, usually because of high salt content in the deepest layer. The waters of meromictic lakes are divided into three layers and the top layer being the mixolimnion while the bottom layer is known as the monimolimnion. The layer between the two is known as the chemocline.
- Amictic lakes have water whose surface is covered with ice throughout the year, which prevents the mixing of the waters beneath, therefore allowing such lakes to exhibit inverse cold water stratification where water temperature increases with the increase in depth. Due to the extremely cold temperatures that characterise amictic lakes, such lakes are only found in the polar regions, both in the Arctic and in Antarctica.

Pit lakes are especially prone to meromixis (i.e. perennial stratification) owing to their depth, wind sheltering provided by pit walls, and their likelihood of containing elevated solutes that can produce vertical differences in water density (Vandenberg and McCullough, 2017).

10.8.2 Depth/area ratio assessment

Early studies of stratification in natural and pit mine lakes have focused on simple lake depth/area ratios (e.g., Lyons et al., 1994; Doyle and Runnels, 1997) on the assumption that large area/depth ratios allow more wind mixing and, thus, are less prone to stratification and the development of anoxia (*Jewell, P.W. Stratification controls of pit mine lakes. Mining Engineering, February 2009).*

Mining pit lakes with a high depth-to-width ratio are less apt to undergo complete lake turnover (Doyle and Runnells, 1997). The aspect ratio of a given pit lake can be quantified by Z_r, otherwise known as the "*relative depth*" (Hutchinson 1957):

$$Z_r(\%) = 50\ x\ Z_m\ x\ \frac{\sqrt{\pi}}{\sqrt{A}}$$

where Z_m is the maximum depth, and A is the surface area of the lake.

Using the above equation, the "*relative depth*" for the open pits and sediment dam at BCP are as presented in Table 53.

Table 53 "*Relative Depth*" of open pits and sediment dam

Void	Maximum depth (Z_m [m])	Surface Area (A [m²])	Relative Depth (Z_r [%])
North Pit	16.746	11,639	1376%
South Pit	78.095	29,433	4043%
WRD Sediment Dam	6.795	9,828	367%

In a survey of mining pit lakes around the world, Doyle and Runnells (1997) suggested that most artificial lakes with Z_r > 25% are meromictic. Based on the "relative depth" calculations, there is the potential for the North Pit, South Pit and WRD sediment Dam to become meromictic, i.e. permanently stratified.

Doyle and Runnells (1997) did observe that there were a few lakes with Z_r > 25% that were holomictic and many lakes with Z_r < 25% that were meromictic. There are other factors that dictate whether a given pit lake is permanently stratified.

10.8.3 One-dimension GLM model

Introduction

A one-dimensional model was developed for the North Pit and south Pit to further assess the potential for stratification, using "*The General Lake Model*" (GLM). GLM has been developed by the Aquatic EcoDynamics Research Group team at the University of Western Australia (http://aed.see.uwa.edu.au) in collaboration with the Lake Ecosystem Restoration research group at the University of Waikato (http://www.lernz.com).

GLM is a 1D lake water balance and vertical stratification model that computes vertical profiles of temperature, salinity and density by accounting for the effect of inflows/outflows, mixing and surface heating and cooling, including the effect of ice cover on heating and mixing of the lake.

GLM incorporates a flexible Lagrangian layer structure similar to the approach of several 1-D lake model designs (Imberger and Patterson 1981; Hamilton and Schladow 1997). The Lagrangian

approach was originally introduced in the model DYRESM developed by the Centre for Water Research and allows for layers to change thickness by contracting and expanding in response to inflows, outflows, mixing and surface mass fluxes. When sufficient energy becomes available to overcome density gradients, two layers will merge thus accounting for the process of mixing.

GLM model setup

1D GLM models were developed for the North Pit and South Pit, to assess the potential for stratification to develop in these final voids.

The input data for GLM models were obtained from the following sources:

- Final void/lake geometry, including water depth/surface area relationship, maximum depths, surface length and width, initial void conditions. Relevant information was obtained from the pit geometry developed for the ATCW water balance models.
- Climatic data, including shortwave solar radiation, cloud cover, air temperature, relative humidity, wind speed and rainfall. Information was obtained from the SILO Data Drill Program for the Site Location (https://www.longpaddock.qld.gov.au/silo/gridded-data/).
- Water quality data, including temperature and salinity. Data was obtained from the existing surface water and groundwater monitoring programs.
- Inflow and outflow data, including flow rate, temperature and salinity.

A detailed description of the science and mathematics behind GLM, data input requirements, assumptions and output is provided in "*GLM - General Lake Model: Model overview and user information* "(Hipsey et al., 2014).

A stochastic approach to climate conditions was not adopted as part of this preliminary assessment. Such an approach would only be considered warranted if the results of the preliminary assessment indicate stratification in the voids to the extent that this could adversely affect final void water quality.

The GLM models were developed using daily climate data from 1/01/1973 to 19/03/2023 obtained from the SILO Data Drill Program for the BCP site. Adopting a daily timestep for this period is considered adequate to represent long-term climatic conditions, together with short-term variations, for the BCP site.

North Pit GLM model results

GLM model results include detailed water balance results and plots of temperature and density to visually assess the stratification in the open pit with depth and over time.

Modelled depth distributions of temperature, density and salinity over time are presented in Plate 45, Plate 46 and Plate 47, respectively.

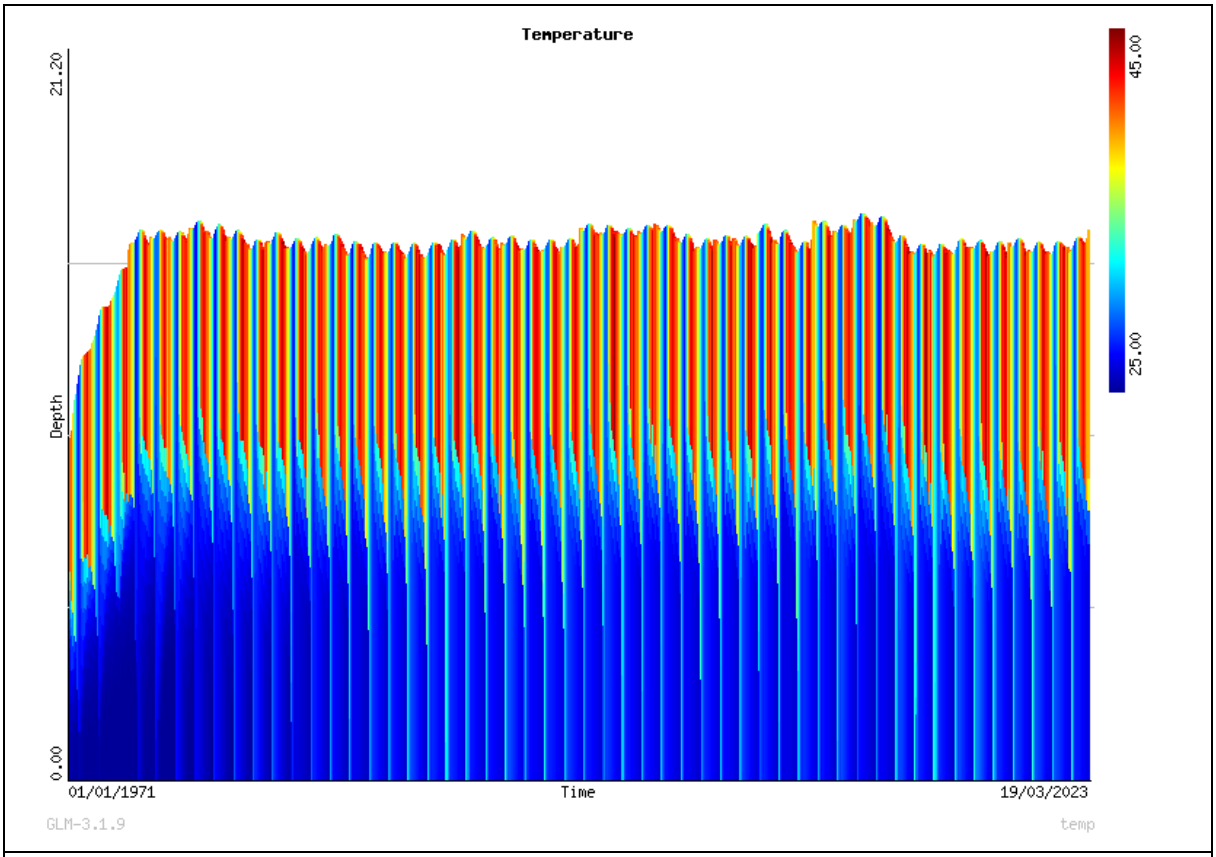


Plate 45 North Pit GLM model results – temperature (°C) distribution

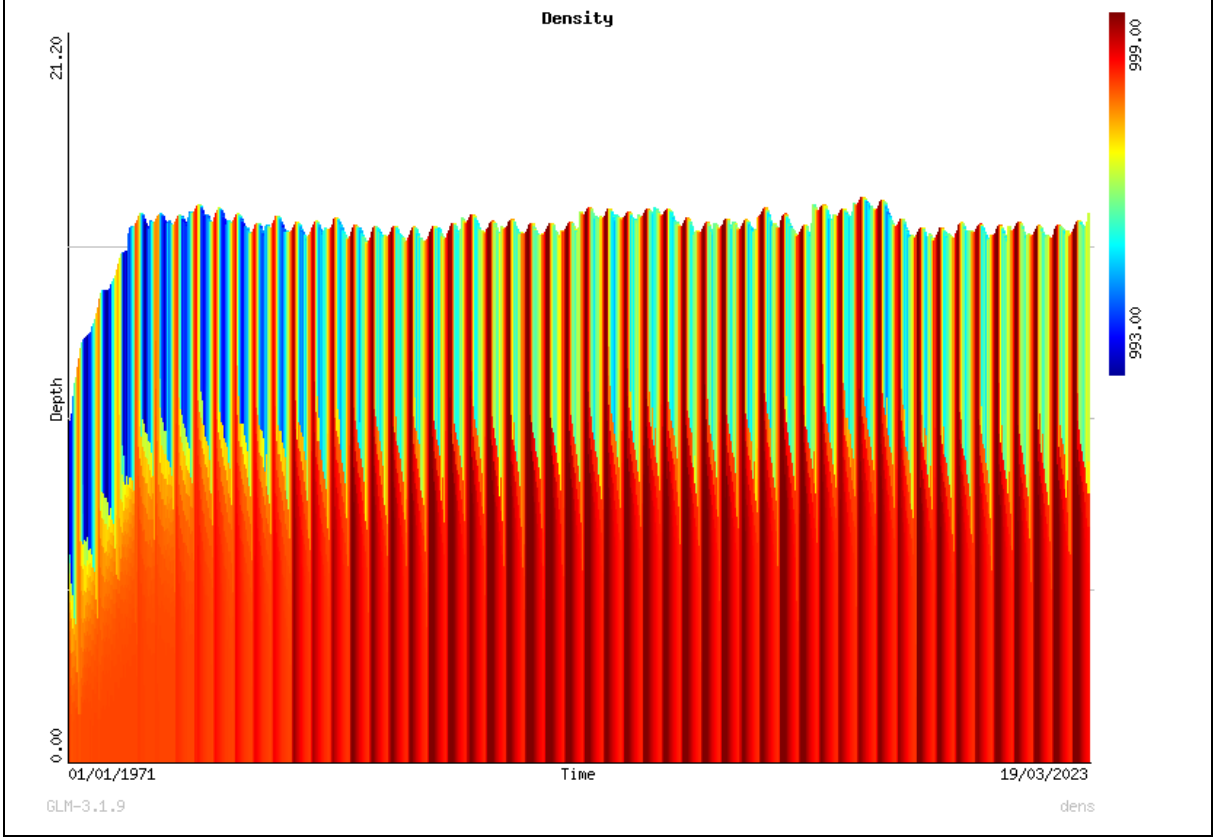


Plate 46 North Pit GLM model results – density distribution

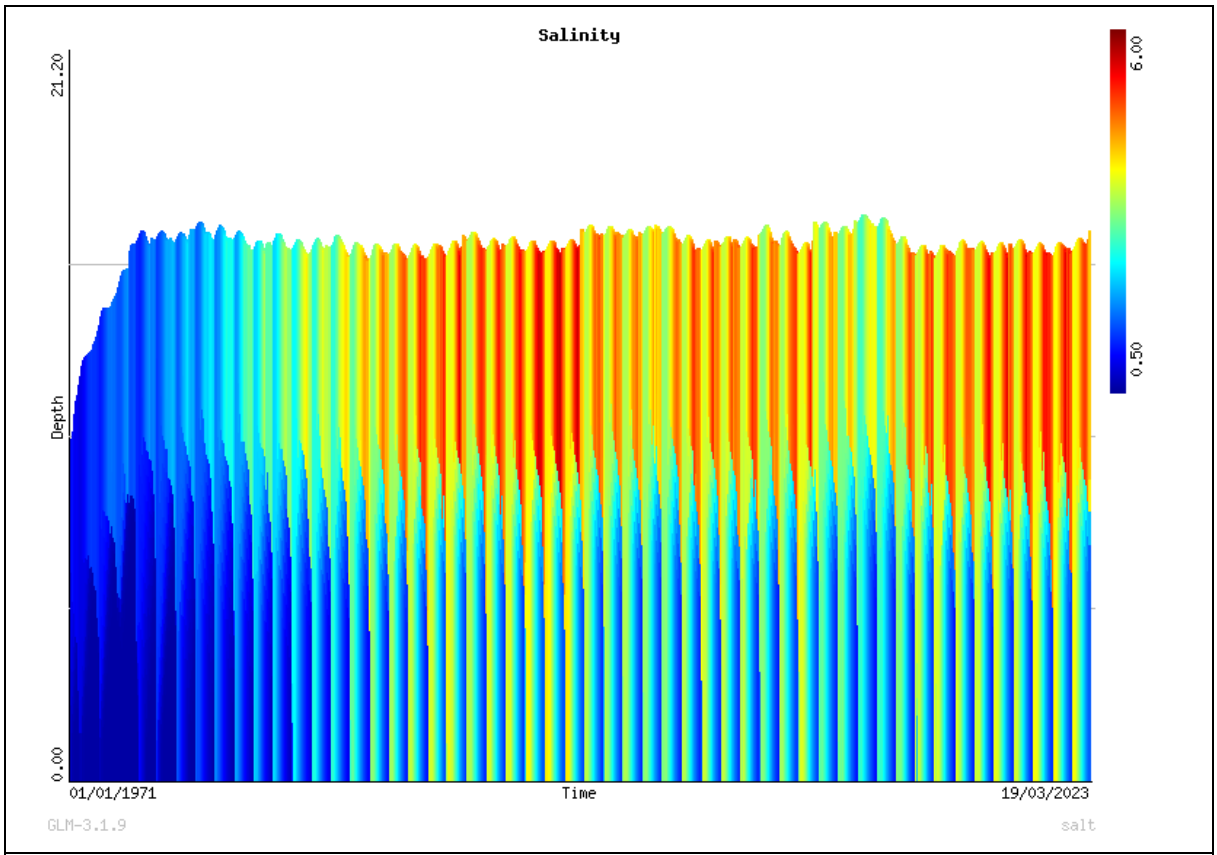


Plate 47 North Pit GLM model results – salinity (g/L) distribution

The preliminary GLM modelling results for the North Pit indicate the following:

- Thermal, density and salinity stratifications may develop over time on a seasonal basis within the North Pit.
- Three stratification zones may develop within the open pit during the dry, hot seasons. However, the stratifications dissipate during the wet season.
- As there is a uniform density and temperature distribution during at least one period of each year, the North Pit lake could be classified as a "holomictic" lake.

As the North Pit generally acts as a terminal groundwater sink, with minimal outflow/seepage towards the South Pit and as the stratification in the pit is seasonal, the PMLU of the pit as "water storage for livestock watering" is not adversely affected by the seasonal stratification.

South Pit GLM model results

GLM model results include detailed water balance results and plots of temperature and density to visually assess the stratification in the open pit with depth and over time.

Modelled depth distributions of temperature, density and salinity over time are presented in Plate 48, Plate 49 and Plate 50, respectively.

The preliminary GLM modelling results for the South Pit indicate the following:

- Thermal, density and salinity stratifications may develop over time on a seasonal basis within the South Pit.
- Three stratification zones may develop within the open pit during the dry, hot seasons. However, the stratifications dissipate during the wet seasons.

- As there is a uniform density and temperature distribution during at least one period of each year, the South Pit lake could be classified as a "holomictic" lake.

As the South Pit generally acts as a terminal groundwater sink and as the stratification in the pit is seasonal, the PMLU of the pit as "water storage for livestock watering" is not adversely affected by the seasonal stratification.

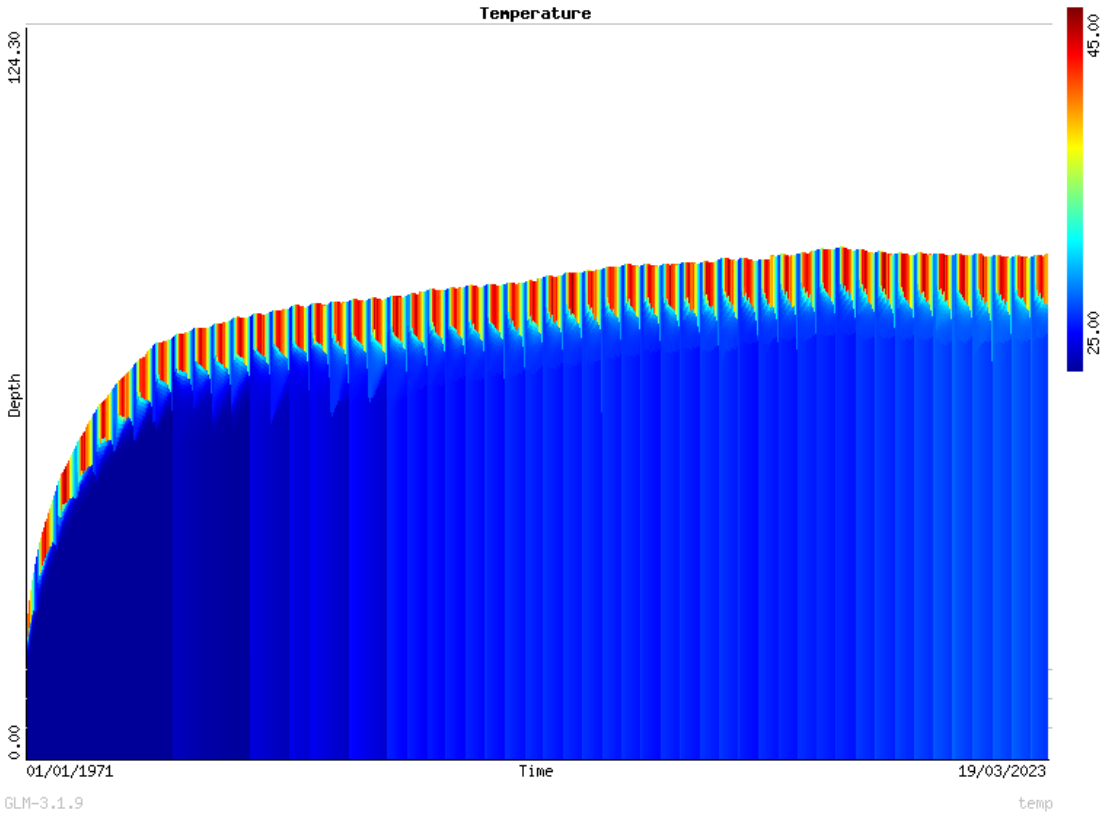


Plate 48 South Pit GLM model results – temperature (°C) distribution

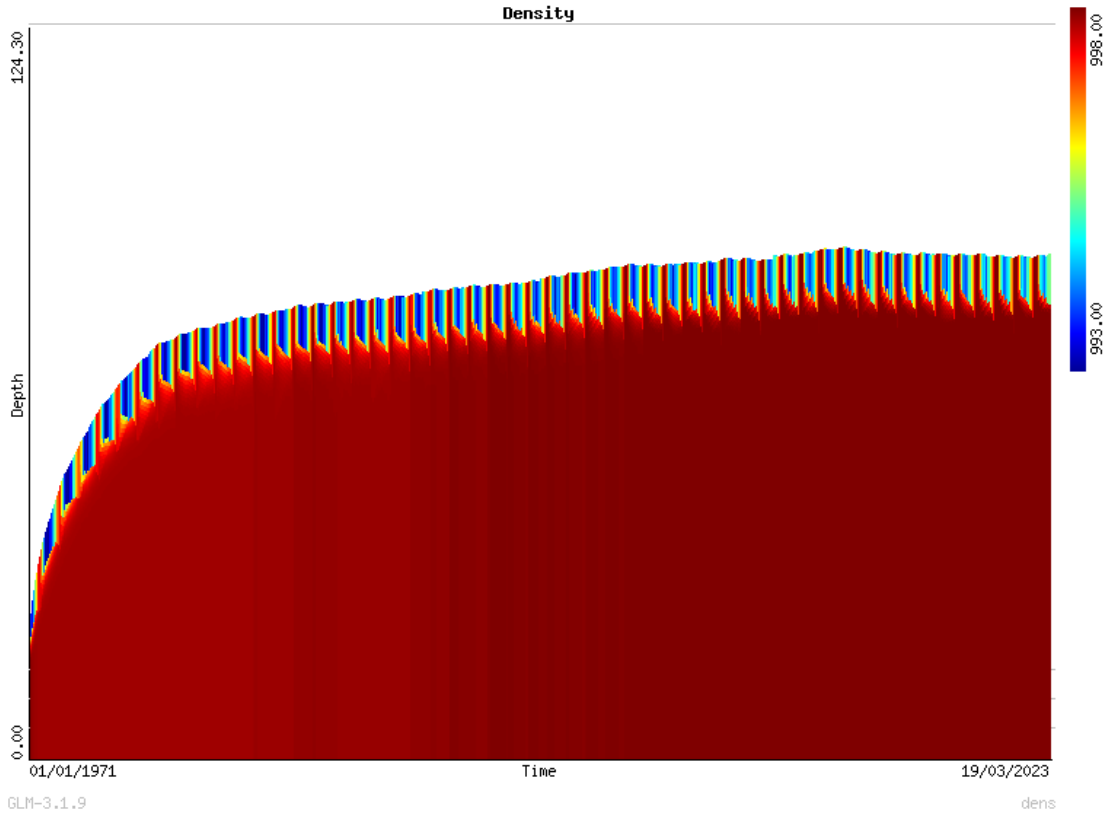


Plate 49 South Pit GLM model results – density distribution

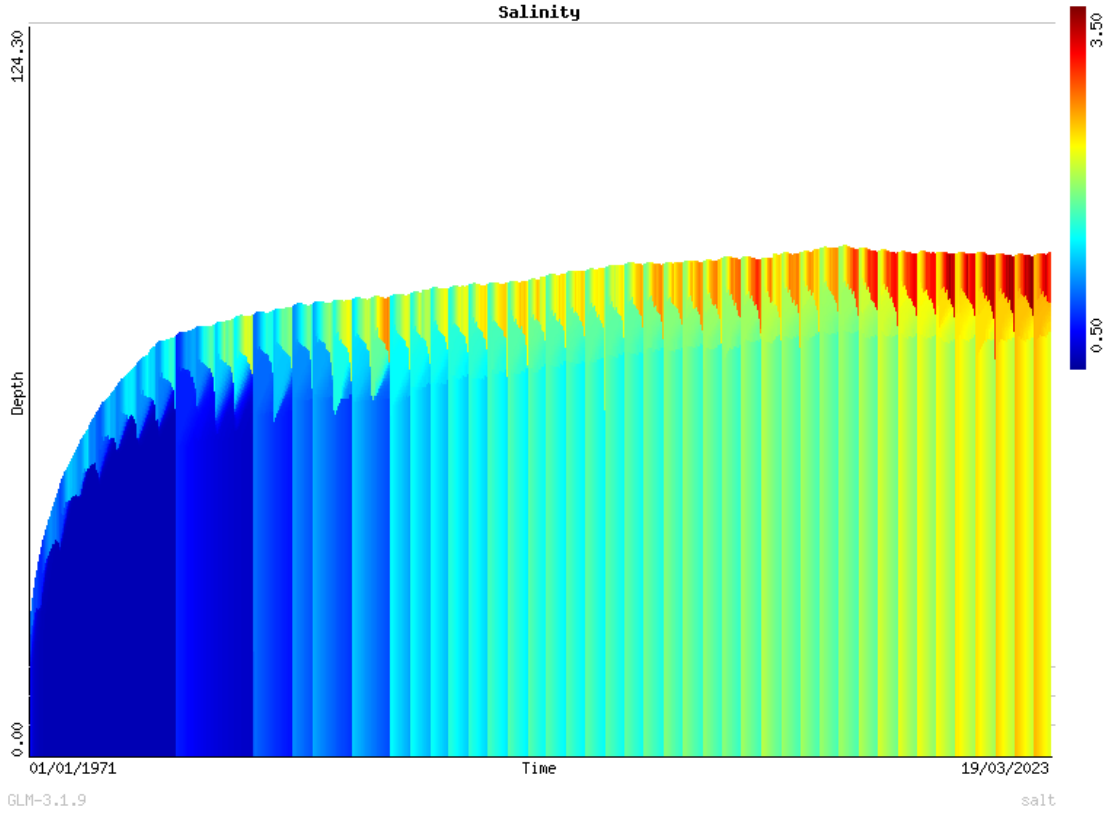


Plate 50 North Pit GLM model results – salinity (g/L) distribution

11 Conclusions

11.1 Groundwater impact assessment

The conclusions of the groundwater impact assessment can be summarised as follows:

Extent and level of drawdown around open pits and underground working

Conservative radii of influence/drawdown around the open pits and underground workings range from a maximum of 225 metres for the North Pit to 1,040 metres for the South Pit and 433 metres for the underground workings.

Data searches have indicated that there are only three registered water bores within ML90241 with a designated “water supply” role, i.e. bores RN146953, RN146954 and RN184272. However, these bores were drilled and installed by the mining company owning the mining lease at the time of installation. None of these bores are currently operational for water supply purposes, nor are they intended to be in the future.

No active water supply bores are located within the conservative radius of influence/drawdown of the open pits and underground workings. The proposed mining operation will not impact other regional water bores.

Groundwater/surface water interaction

- On a semi-local to regional scale, groundwater levels are generally at a depth below ground level that would limit any groundwater/surface water interaction. This is evidenced by the ephemeral nature of the creeks at and near the mine site.
- On a local scale, two semi-permanent water bodies are present within the creek, named BCP Spring (S) and BCP Spring (N). The water bodies are most likely the results of significant rainfall events leading to significant flow within the creeks, with water stagnating in lower-lying parts of the creek. Monitoring of shallow groundwater levels and levels at the water bodies indicates that there is limited hydraulic connectivity between the shallow groundwater and the creek.
- Although the current open pits act as a groundwater sink, these pits/voids do not adversely impact the surface water environment due to the limited (to almost non-existent) connectivity between the deeper groundwater and the creek.
- In a similar vein, the proposed underground operations will not impact the groundwater/surface water interaction.
- There are no aquatic or subterranean GDEs within a 5km radius of the Project site. Only low-potential terrestrial GDEs are present within ML90241.

Final void water quality assessment

- The WQM indicates that the modelled solute concentrations in the North Pit, South Pit and WRD Sediment Dam remain below the applicable ANZECC 2000 Water Quality Guideline values for livestock watering.
- Regarding potential AMD impact on open pit water quality:
  - Long-term kinetic column leach results (at week 52 of the test program) are below the adopted livestock drinking WQG values.
  - Long-term kinetic column leach results (at week 52 of the test program) are below the modelled long-term solute concentrations (average of modelled concentrations/levels after 50 years) in the open pits, except for aluminium, arsenic, calcium, chromium and copper in one or more column samples. However, the leach results of these solutes are below the livestock drinking WQG (where specified).

  - As the AMD impact groundwater inflow constitutes only a minor component of the total inflow into the open pits, the mass load of the AMD solutes will be diluted by rainfall runoff and the pit water volume already in storage.
  - Therefore, it is considered that the seepage of AMD groundwater will not adversely impact the long-term water quality in the open pits.
- Regarding the potential impact on underground voids water quality:
  - Mixing water quality models indicate that the long-term water quality in the underground voids remains below the relevant water quality guidelines values (livestock watering and PRCP criteria for voids) and that the underground workings are suitable for a livestock watering PLMU.
  - Geochemical modelling using PHREEQC indicates that the placement of PAF and NAF material in the underground voids does not adversely impact the water quality, with long-term water quality remaining below the relevant water quality guidelines values (livestock watering and PRCP criteria for voids) and that the underground workings are suitable for a livestock watering PLMU.
- Preliminary pit lake stratification modelling indicates that in the north Pit and South Pit:
  - Thermal, density and salinity stratifications may develop over time on a seasonal basis within the North Pit, with three stratification zones developing during the dry, hot seasons. However, the stratifications dissipate during the wet season.
  - As the pits generally act as a terminal groundwater sink, with minimal outflow/seepage and as the stratification in the pits is seasonal, the PMLU of the pit as "water storage for livestock watering" is not adversely affected by the seasonal stratification.
- Based on the investigation and modelling results, the North Pit, South Pit, WRD Sediment Dam and underground workings are considered suitable as PMLUs for livestock watering.

11.2 Proposed EA amendment

The results of the groundwater impact assessment support the consideration that the EA amendment is a minor amendment only as:

- there is no significant increase in the level of environmental harm caused by the proposed relevant activity
- there is no change in any groundwater/surface water rehabilitation objectives in the EA in a way likely to result in significantly different impacts on environmental values than the impacts previously permitted under the EA
- the open pits, WRD sediment dam and underground voids remain as water storage PMLUs.

No changes to groundwater-related conditions of the current EA are warranted.

12 References

ATC Williams Pty Ltd (ATCW) (2020), Barbara Copper Project – Post Mine Land Use Plan Input

ATC Williams (2023a). *Aeris Resources - Barbara Copper Project - Progressive Rehabilitation and Closure Planning – Water Management Plan and Water Balance Model*, *Ref: 118131.12.R03*. Dated 17 February 2023.AustralAsian Resource Consultants Pty Ltd (AARC), (2014b), *Barbara Copper Project: Aquatic Ecology Report*.

ATC Williams (2023b). *Memorandum - Barbara Copper Project - Geochemical assessment of the North Pit, South Pit and the WRD Sediment Dam, Ref: 118131.12.M02.* Dated 24 March 2023.

AustralAsian Resource Consultants Pty Ltd (AARC), (2014c), *Barbara Copper Project: Terrestrial Flora and Fauna Assessment*.

Australia & New Zealand (ANZG). (2018), *Australia & New Zealand Guidelines for Fresh & Marine Water Quality.* https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/search

Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ). (2000), *National Water Quality Management Strategy – Paper No. 4: Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Natural Resource Ministerial Council, Australia

Department of Environment and Science (DES) (2019), '*Guideline – Progressive Rehabilitation and Closure Plans*', ESR/2019/4964, March 2021, version 2.00, Queensland Government

GeoResGlobe (2022), Queensland Government, Available: GeoResGlobe (information.qld.gov.au) (Accessed February 10th 2022)

Marinelli and Niccoli (2000), *Simple Analytical Equations for Estimating Groundwater Inflow to a Mine Pit, Vol 38, No. 2 – Groundwater – March – April 2000*

Neldner, V.J., Wilson, B.A., Dillewaard, H.A., Ryan, T.S. and Butler, D.W. (2017), *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland. Version 4.0. Updated May 2017*. Queensland Herbarium, Queensland Department of Science, Information Technology and Innovation, Brisbane

Powers, J.P. (1992). Construction Dewatering: New Methods and Applications. Wiley, New York. Second Edition.

Queensland Government (2009, updated 2013). *Queensland Water Quality Guidelines*.

Queensland Government (2022), Queensland Globe, Available: Queensland Globe (information.qld.gov.au) (Accessed February 9th 2022)

Rob Lait & Associates (October 2013). *Preliminary Groundwater Assessment. Barbara Project*. Prepared for CopperChem Limited.

Rob Lait & Associates (October 2014). *Barbara Copper Project. Hydrogeological Report*. Prepared for Copperchem Pty Ltd and Syndicated Metals Pty Ltd Joint Venture.

Rob Lait and Associates Pty Ltd (RLA) (2014b), *Hydrogeological Regime Wallace North Lease – Exco Resources*

Syndicated Metals Ltd, August (2014). *Regolith-Landform Characteristics and Groundwater Investigations at the Barbara Copper Project Area: Implications for the Development of Shallow Aquifers*

The Long Paddock, SILO Data Drill (2020), Queensland Government, https://www.longpaddock.qld.gov.au/silo/.

WMV Environmental Pty Ltd (2023). *Barbara Copper Project Progressive Rehabilitation and Closure Plan. Water Quality Assessment of North Pit, South Pit and WRD Sediment Dam*. March 2023.

13 Limitations

This report has been prepared by WMV Environmental Pty Ltd for Round Oak Minerals Ltd and may only be used and relied upon by Round Oak Minerals Ltd for the purpose agreed between WMV Environmental and Round Oak Minerals Ltd as set out in this report.

WMV Environmental Pty Ltd accepts no duty of care or liability to any third parties who may use or rely on this report other than as expressly agreed by WMV Environmental Pty Ltd. Without limiting the foregoing sentence in any way, in no circumstances will WMV Environmental Pty Ltd be liable to any third party whether that liability arises in contract, tort (including negligence or breach of statutory duty) or otherwise for any loss whatsoever arising out of or in any way related to this site investigation project. WMV Environmental Pty Ltd consents to the Department of Environment, Science and Innovation considering this report.

The services undertaken by WMV Environmental Pty Ltd in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions, and recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. WMV Environmental Pty Ltd does not accept responsibility arising from, or in connection with, any change to the site conditions. WMV Environmental Pty Ltd is also not responsible for updating this report if the site conditions change.

The opinions, conclusions and any recommendations in this report are based on assumptions made by WMV Environmental Pty Ltd described in this report. WMV Environmental Pty Ltd disclaims liability arising from any of the assumptions being incorrect.

For the purposes of this report, WMV Environmental Pty Ltd may have relied upon previous investigations carried out and a review of available reports. It is assumed by WMV Environmental Pty Ltd that all relevant information and reports have been provided by those persons from whom it has been requested and that such information provided is accurate.

Any advice, opinions, or recommendations contained in this document should be read and relied upon only in the context of the document as a whole and should be considered current to the date of this document. WMV Environmental Pty Ltd believes that its opinions are reasonably supported by the testing and analysis that have been done and that those opinions have been developed according to the professional standard of care for the environmental consulting profession in this area at this time.

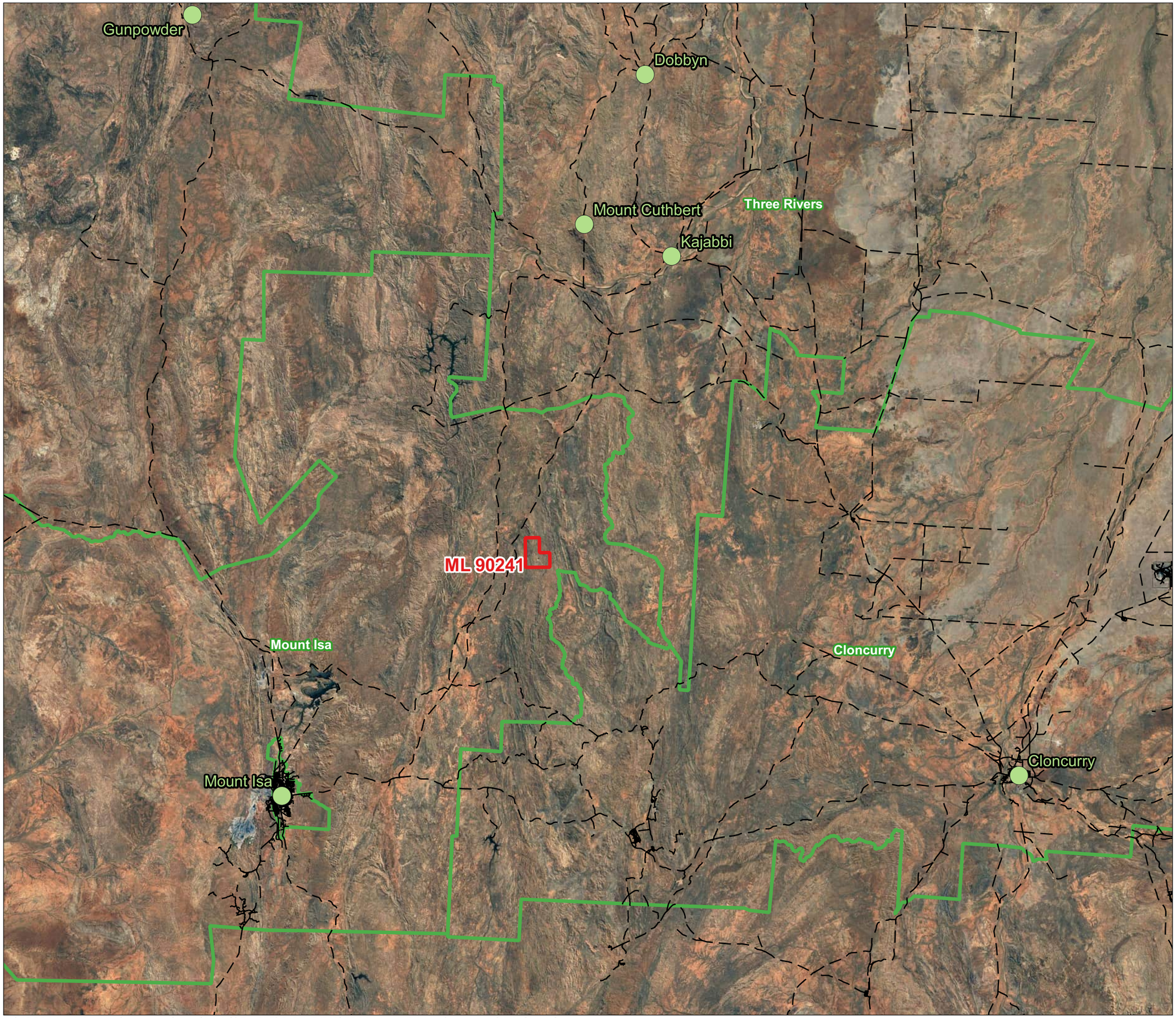
That standard of care may change, and new methods and practices of exploration, testing, analysis and remediation may develop in the future, which might produce different results. WMV Environmental Pty Ltd's professional opinions contained in this document are subject to modification if additional information is obtained through further investigation, observations, or testing and analysis during any future assessment or remedial activities.

This document may only be reproduced in its entirety.

Figures

Figure 1 Location of the Barbara Copper Project
Figure 2 Location of BCP groundwater monitoring wells (regional scale)
Figure 3 Location of BCP groundwater monitoring wells (local scale)
Figure 4 Pre-mining 2014 topography
Figure 5 2021 topography
Figure 6 Mapped pre-clear regional ecosystems
Figure 7 Watercourses near the Project site
Figure 8 Surface water monitoring locations (regional scale)
Figure 9 Surface water monitoring locations (local scale)
Figure 10 Regional geology at BCP
Figure 11 Registered water bores within 5 km of BCP
Figure 12 Registered water bores within ML90241
Figure 13 BOM groundwater dependent ecosystems
Figure 14 Contour map of June 2014 groundwater levels
Figure 15 Contour map of June 2018 groundwater levels
Figure 16 Contour map of April 2022 groundwater levels
Figure 17 Contour map of April 2023 groundwater levels
Figure 18 Location of hydrogeological cross-section

WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.



Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

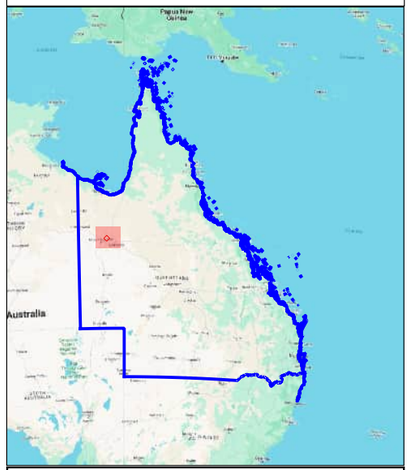
Figure 1 - Location of the Barbara Copper Project

0 10 20 km

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- Locality
- Road/track
- Populated place



Client: Aeris Resources Limited
Project No: J23011
Date created: 20/02/2024

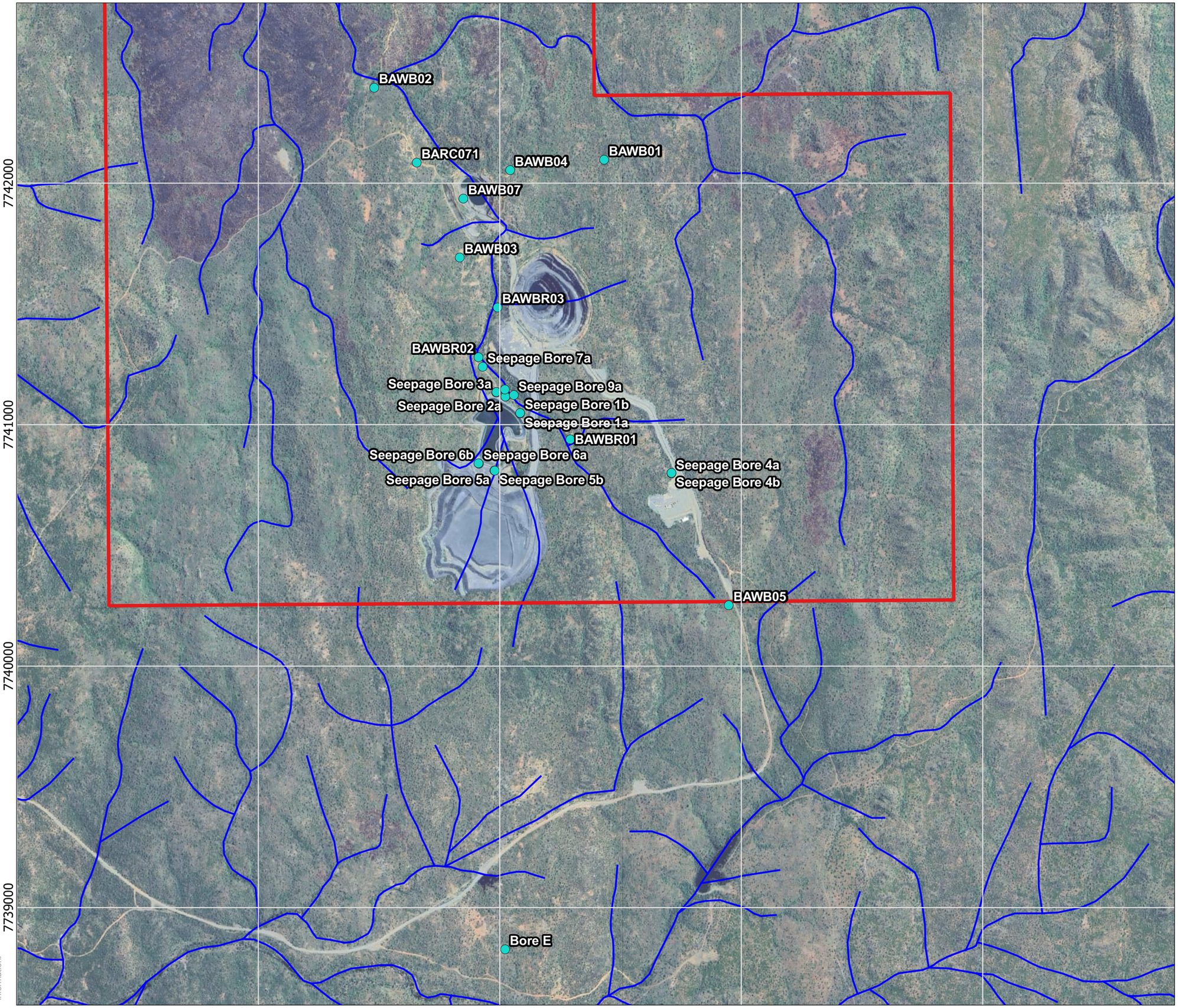
Data Attribution

© QLD Government 2023

Aeris RESOURCES

WMV environmental
Contaminated Land | Hydrogeology | Environment

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz



WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

Figure 2 - Location (regional) of BCP groundwater monitoring bores

0 200 400 600 800 m

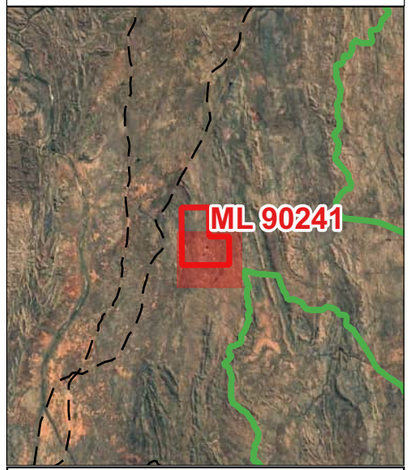
EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- Watercourse line

Monitoring Locations

- Monitoring bore



Client: Aeris Resources Limited
Project No: J23011
Date created: 20/02/2024

Data Attribution

© QLD Government 2023

Aeris RESOURCES

WMV environmental
Contaminated Land | Hydrogeology | Environment

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz

379000 379500 380000 380500 381000 381500

7742500 7742000 7741500 7741000 7740500

BAWB02
BARC071
BAWB04
BAWB01
BAWB07
BAWB03
BAWBR03
BAWBR02
Seepage Bore 7a
Seepage Bore 8a
Seepage Bore 3b
Seepage Bore 3a
Seepage Bore 9a
Seepage Bore 2a
Seepage Bore 1a
Seepage Bore 1b
BAWBR01
Seepage Bore 6b
Seepage Bore 6a
Seepage Bore 4a
Seepage Bore 5a
Seepage Bore 5b
Seepage Bore 4b
BAWB05

WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

Figure 3 - Location (local) of BCP groundwater monitoring bores

0 100 200 300 400 m

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- Watercourse line

Monitoring Locations

- Monitoring well

Client: Aeris Resources Limited
Project No: J23011
Date created: 20/02/2024

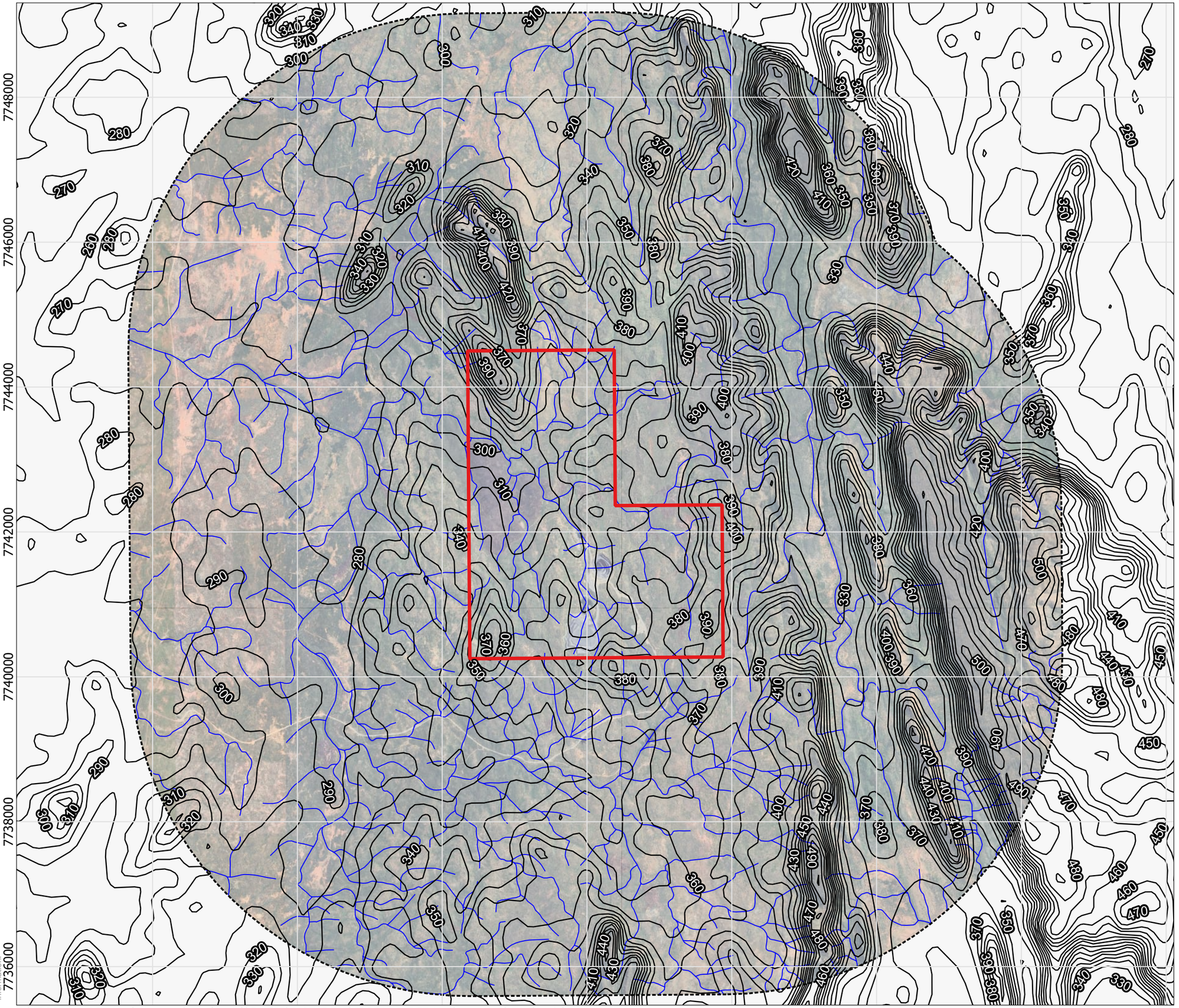
Data Attribution

© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

WMV environmental
Contaminated Land | Hydrogeology | Environment

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz



Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

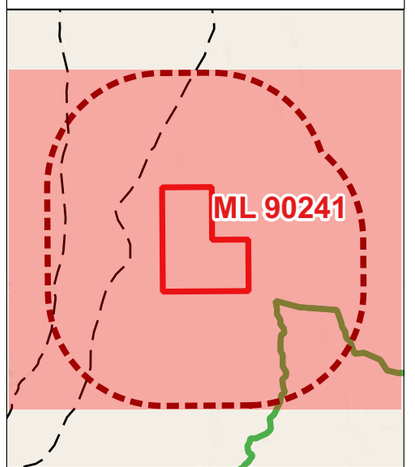
Figure 4 - Pre-mining 2014 topography

0 1 2 km

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- 2014 topography (mAHD)
- Watercourse
- 5000m Buffer



Client: Aeris Resources Limited
Project No: J23011
Date created: 28/02/2024

Data Attribution

© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

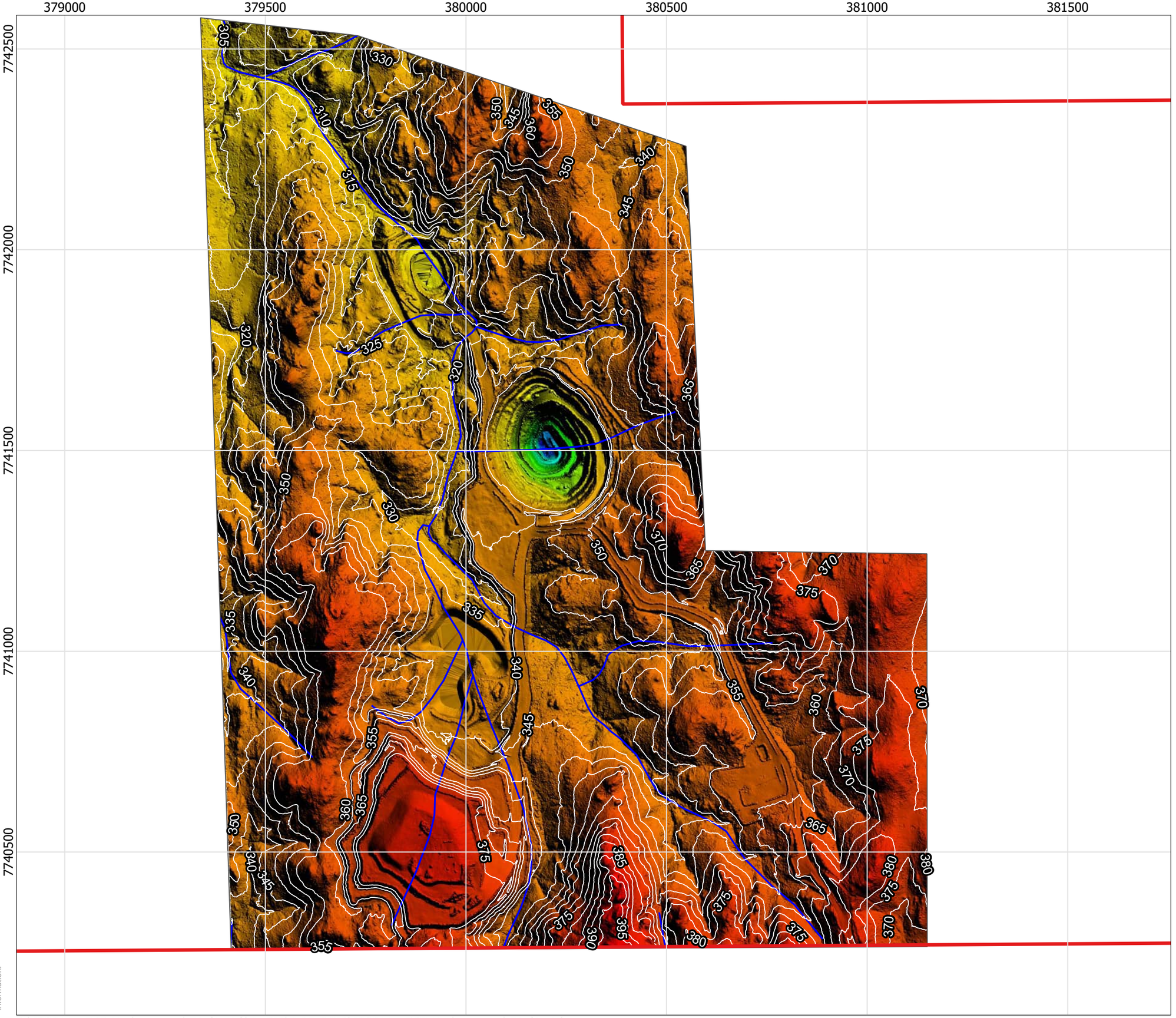
WMV environmental
Contaminated Land | Hydrogeology | Environment

WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz

379000 379500 380000 380500 381000 381500

7742500 7742000 7741500 7741000 7740500



Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

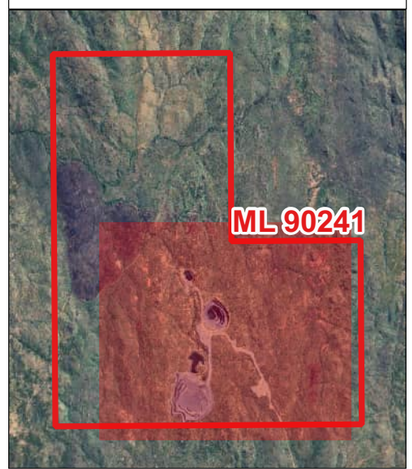
Figure 5 - 2021 topography

0 100 200 300 400 m

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- 2021 topography (mAHD)
- Watercourse



Client: Aeris Resources Limited
Project No: J23011
Date created: 28/02/2024

Data Attribution

© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

WMV environmental
Contaminated Land | Hydrogeology | Environment

WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz

374000 376000 378000 380000 382000 384000 386000 388000

7748000 7746000 7744000 7742000 7740000 7738000 7736000

Legend

Biodiversity status - preclear

- 1.11.2a
- 1.11.2a/1.11.3a
- 1.11.2a/1.11.3a/1.11.3b/1.11.8
- 1.11.2a/1.11.3a/1.11.8
- 1.11.2a/1.11.3a/1.5.16/1.11.8
- 1.11.2a/1.11.7
- 1.11.2a/1.11.8
- 1.11.2a/1.5.16/1.11.8
- 1.11.2a/1.7.7a
- 1.11.2a/1.7.7a/1.11.8
- 1.11.3a
- 1.11.3a/1.11.2a
- 1.11.3a/1.11.2a/1.3.7b
- 1.11.3a/1.11.2a/1.5.4d/1.11.8
- 1.11.3a/1.5.16/1.11.2a
- 1.11.3a/1.5.4d
- 1.11.3b
- 1.11.3b/1.11.3a/1.11.2a
- 1.12.1
- 1.12.3a
- 1.12.3a/1.12.1
- 1.3.13a/1.3.7b
- 1.3.6a/1.3.13a/1.3.7b
- 1.5.4d/1.12.3a
- 1.7.7a/1.11.2a
- 1.7.7a/1.11.2a/1.11.8

Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

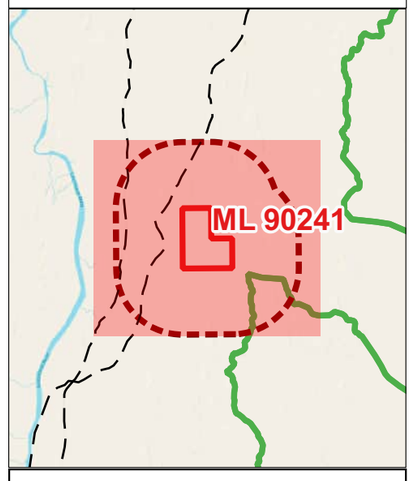
Figure 06 - Mapped pre-clear regional ecosystems

0 1 2 km

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- 5000m Buffer
- Watercourse line



Client: Aeris Resources Limited
Project No: J23011
Date created: 18/03/2024

Data Attribution

© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

WMV environmental Contaminated Land | Hydrogeology | Environment

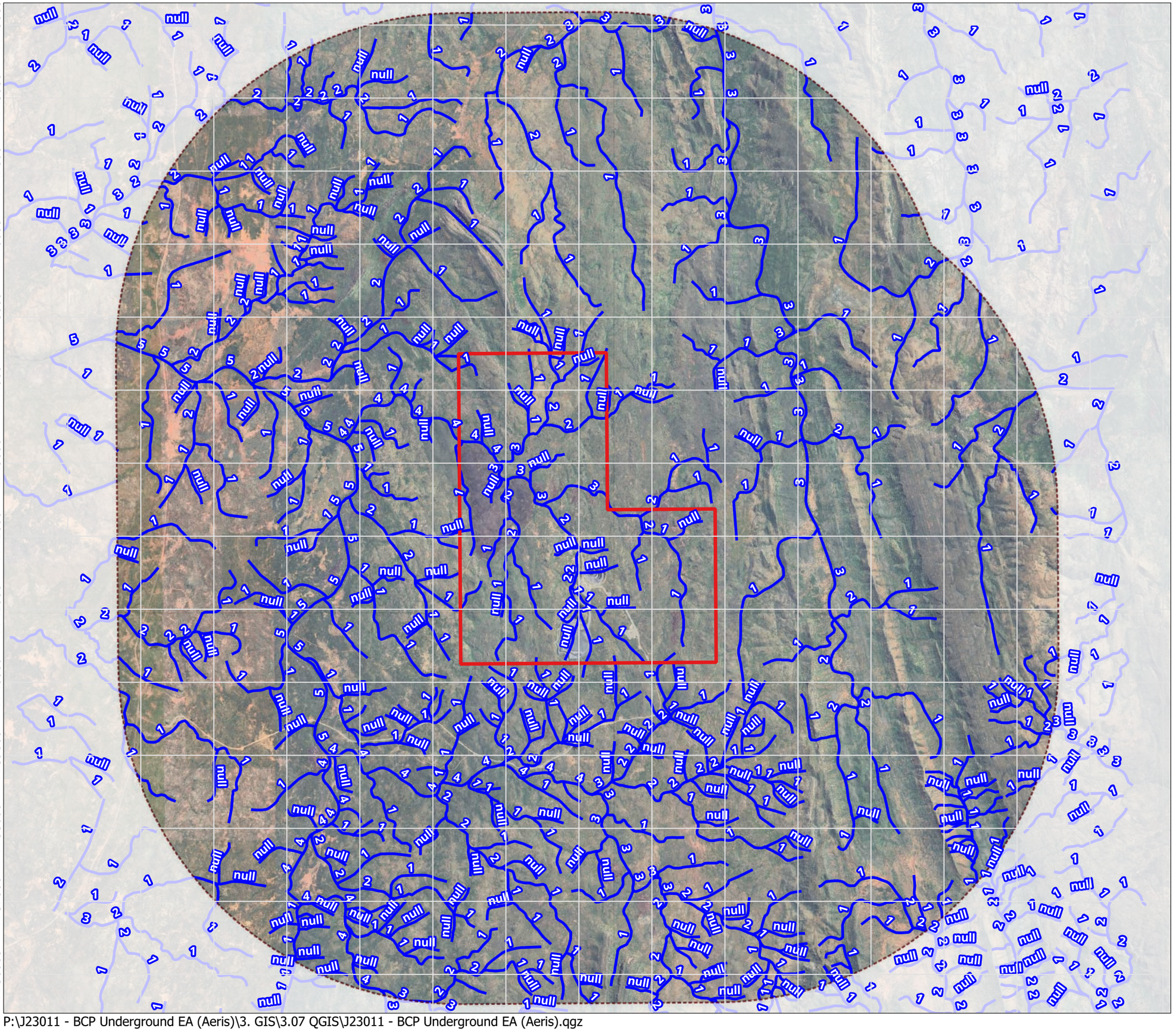
WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz

WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

373000 374000 375000 376000 377000 378000 379000 380000 381000 382000 383000 384000 385000 386000 387000 388000

7749000 7748000 7747000 7746000 7745000 7744000 7743000 7742000 7741000 7740000 7739000 7738000 7737000 7736000



Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

Figure 07 - Watercourses near the Project site

0 500 1,000 1,500 2,000 2,500 m

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- 5000m Buffer
- Watercourse (+ stream order)

Client: Aeris Resources Limited
Project No: J23011
Date created: 18/03/2024

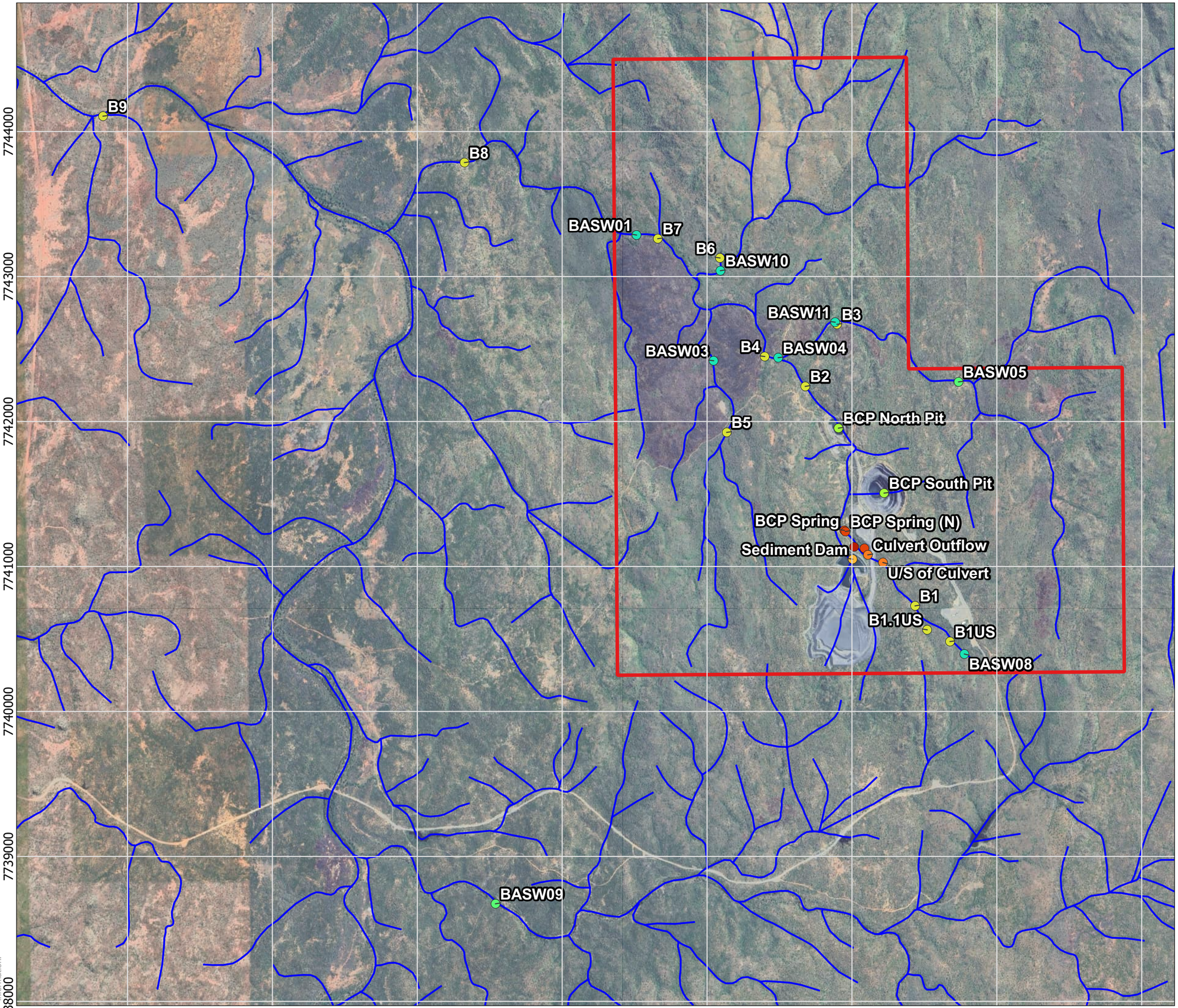
Data Attribution

© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

WMV environmental
Contaminated Land | Hydrogeology | Environment

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz



WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz

Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

Figure 8 - Surface water sampling locations (regional)

0 500 1,000 m

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- Watercourse line

Monitoring Locations

- EA receiving water compliance site
- EA receiving water reference site
- Open pit
- REMP Surface Water
- Sediment dam
- Site runoff
- Spring
- Sump

Client: Aeris Resources Limited
Project No: J23011
Date created: 20/02/2024

Data Attribution

© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

WMV environmental
Contaminated Land | Hydrogeology | Environment

379500 379750 380000 380250 380500

7742000 7741750 7741500 7741250 7741000

BCP North Pit

BCP South Pit

BCP Spring

BCP Spring (N)

Sump

BCP Spring (S)

Culvert Outflow

Sediment Dam

U/S of Culvert

Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

Figure 9 - Surface water sampling locations (local)

0 100 200 m

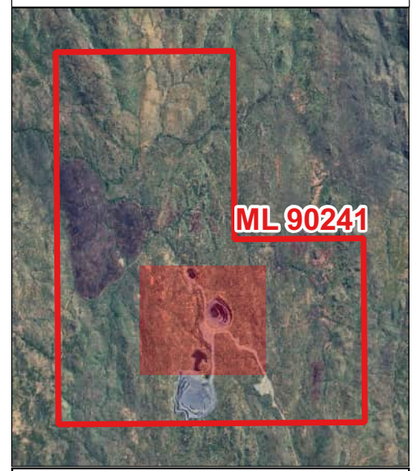
EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- Watercourse line

Monitoring Locations

- Open pit
- Sediment dam
- Site runoff
- Spring
- Sump



Client: Aeris Resources Limited
Project No: J23011
Date created: 20/02/2024

Data Attribution

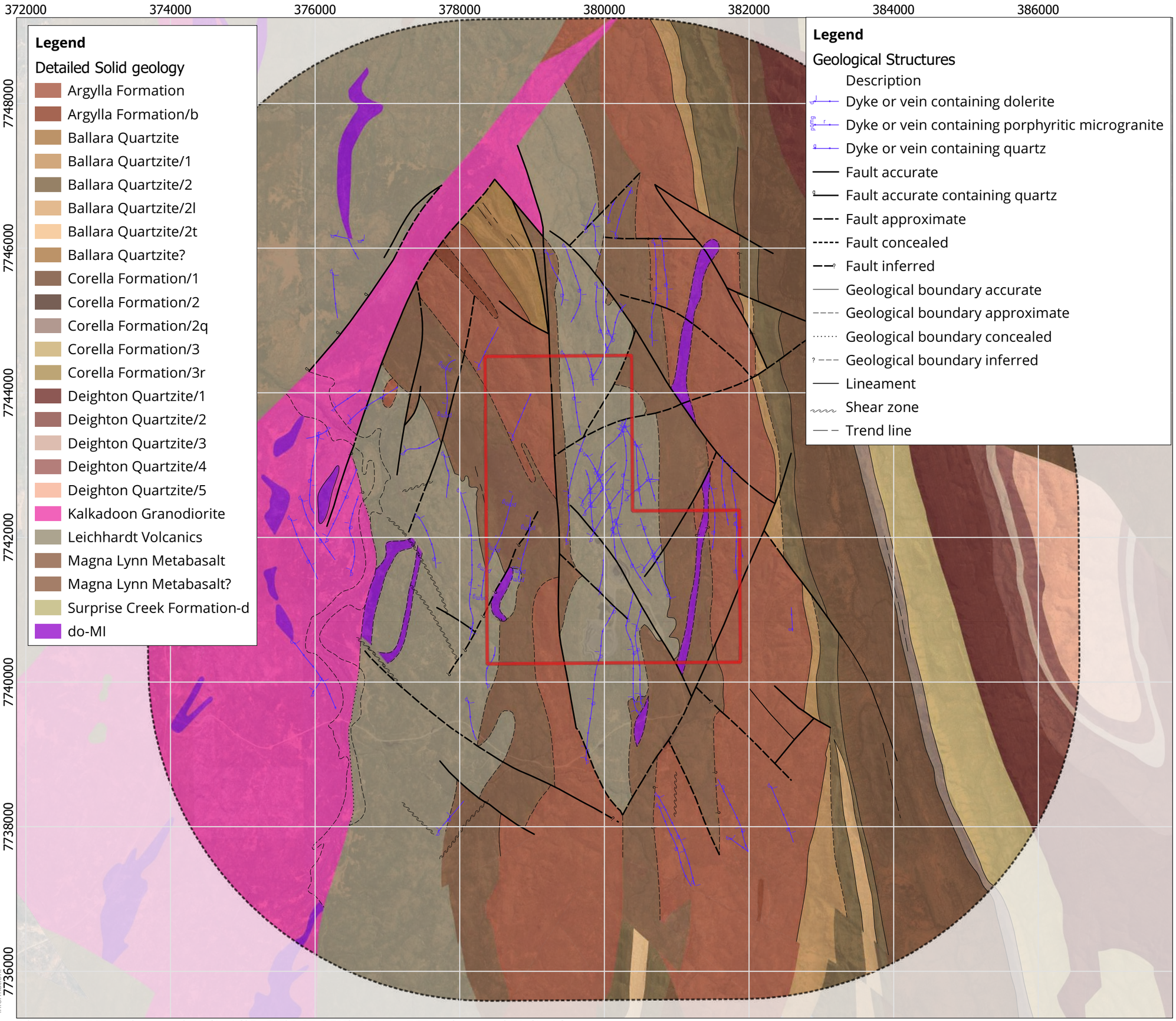
© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

WMV environmental
Contaminated Land | Hydrogeology | Environment

WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz



WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz

Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

Figure 10 - Regional geology at BCP

0 0.5 1 1.5 2 km

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

ML90241

5000m Buffer

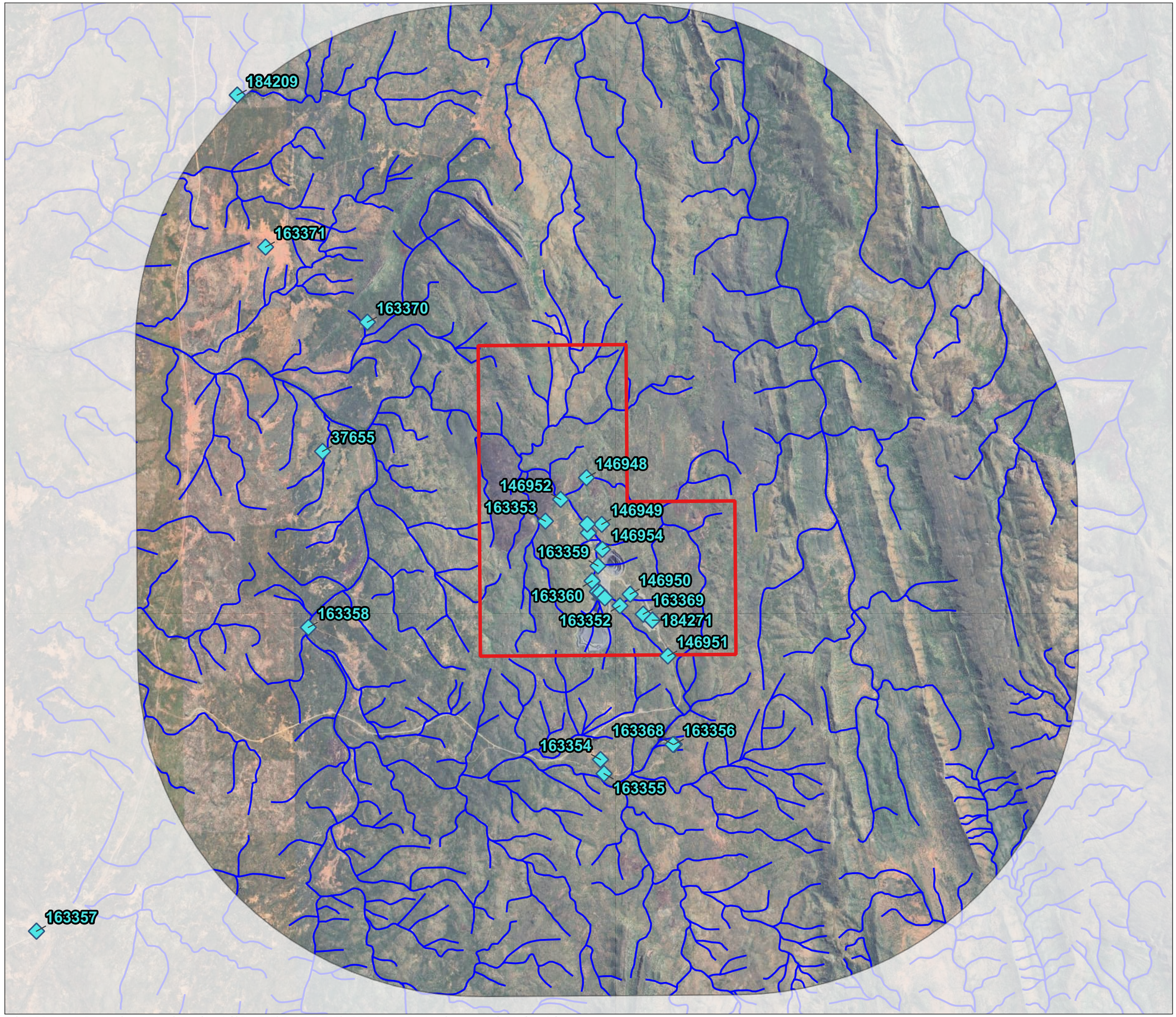
Client: Aeris Resources Limited
Project No: J23011
Date created: 18/03/2024

Data Attribution

© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

WMV environmental
Contaminated Land | Hydrogeology | Environment



Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

Figure 11 - Registered bores within 5km radius of BCP

0 0.5 1 1.5 2 km

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- 5000m Buffer
- Watercourse line
- Registered water bores

Client: Aeris Resources Limited
Project No: J23011
Date created: 21/02/2024

Data Attribution

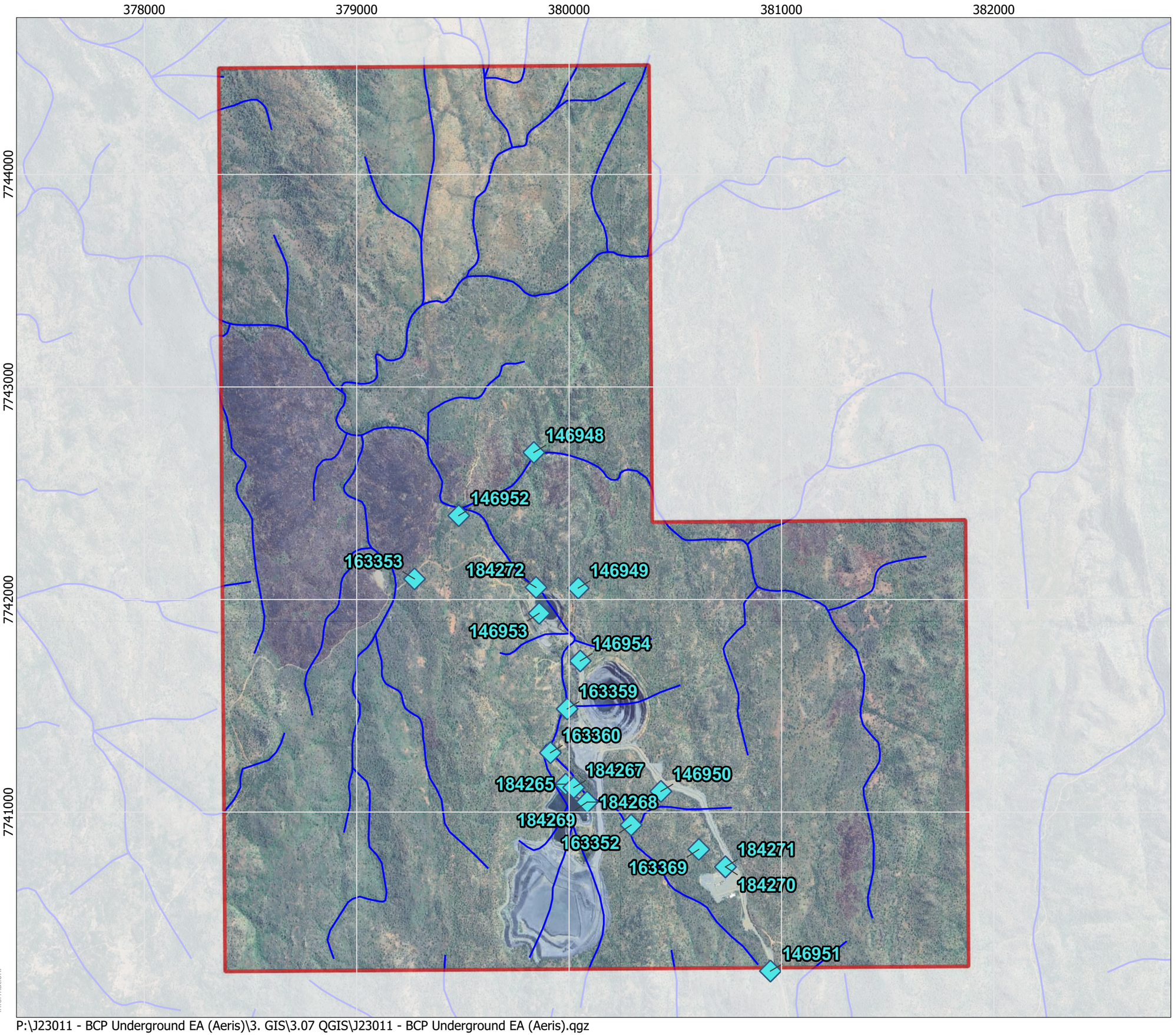
© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

WMV environmental
Contaminated Land | Hydrogeology | Environment

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz

WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.



Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

Figure 12 - Registered bores within ML90241

0 250 500 750 m

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- Watercourse line
- Registered water bores

Client: Aeris Resources Limited
Project No: J23011
Date created: 21/02/2024

Data Attribution

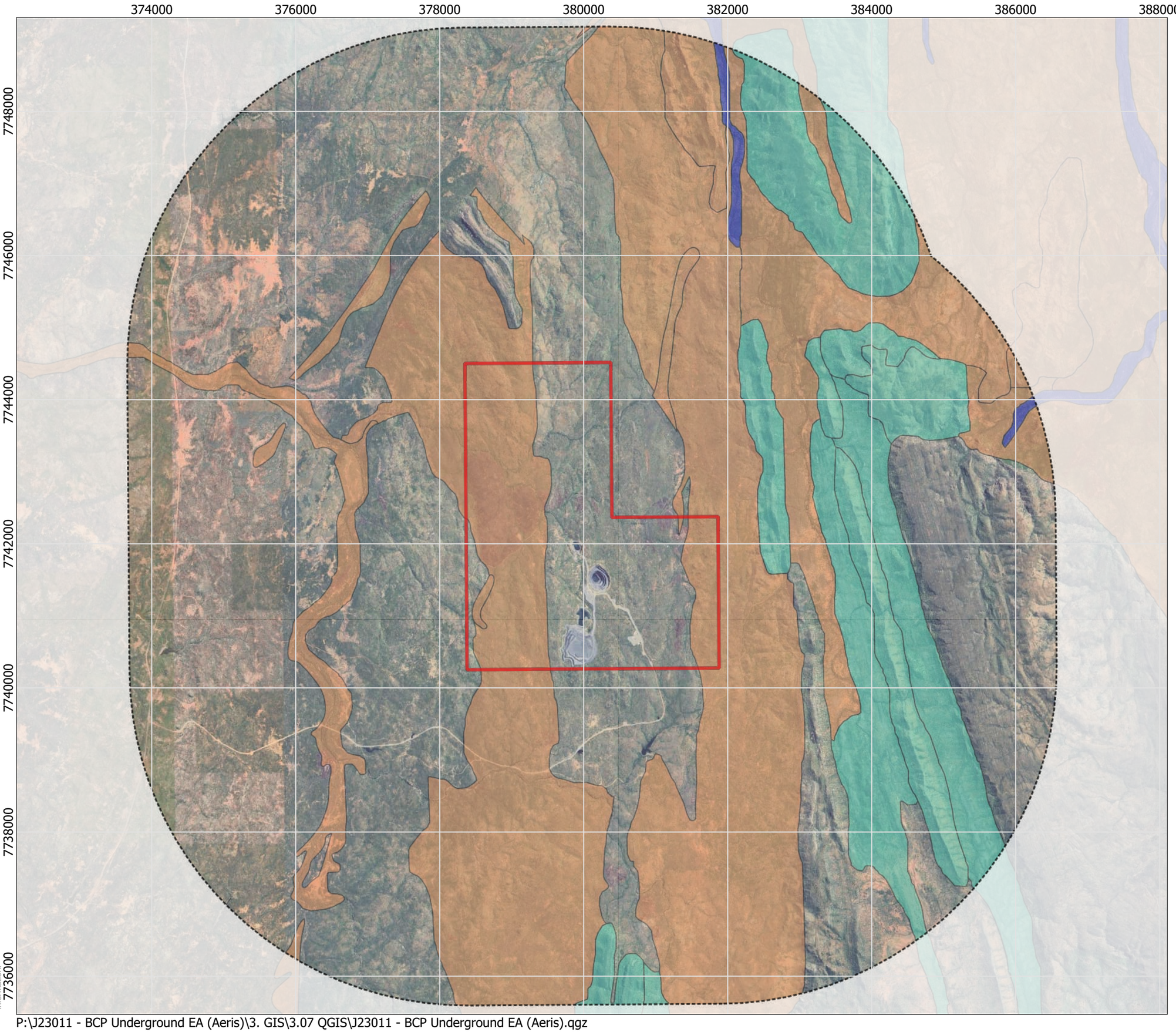
© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

WMV environmental
Contaminated Land | Hydrogeology | Environment

WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz



Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

Figure 13 - BOM Groundwater Dependent Ecosystems

0 1 2 km

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- 5000m Buffer

BOM Terrestrial GDEs

- High potential GDE
- Moderate potential GDE
- Low potential GDE

Client: Aeris Resources Limited
Project No: J23011
Date created: 25/02/2024

Data Attribution

© QLD Government 2023
© Aeris Resources 2023

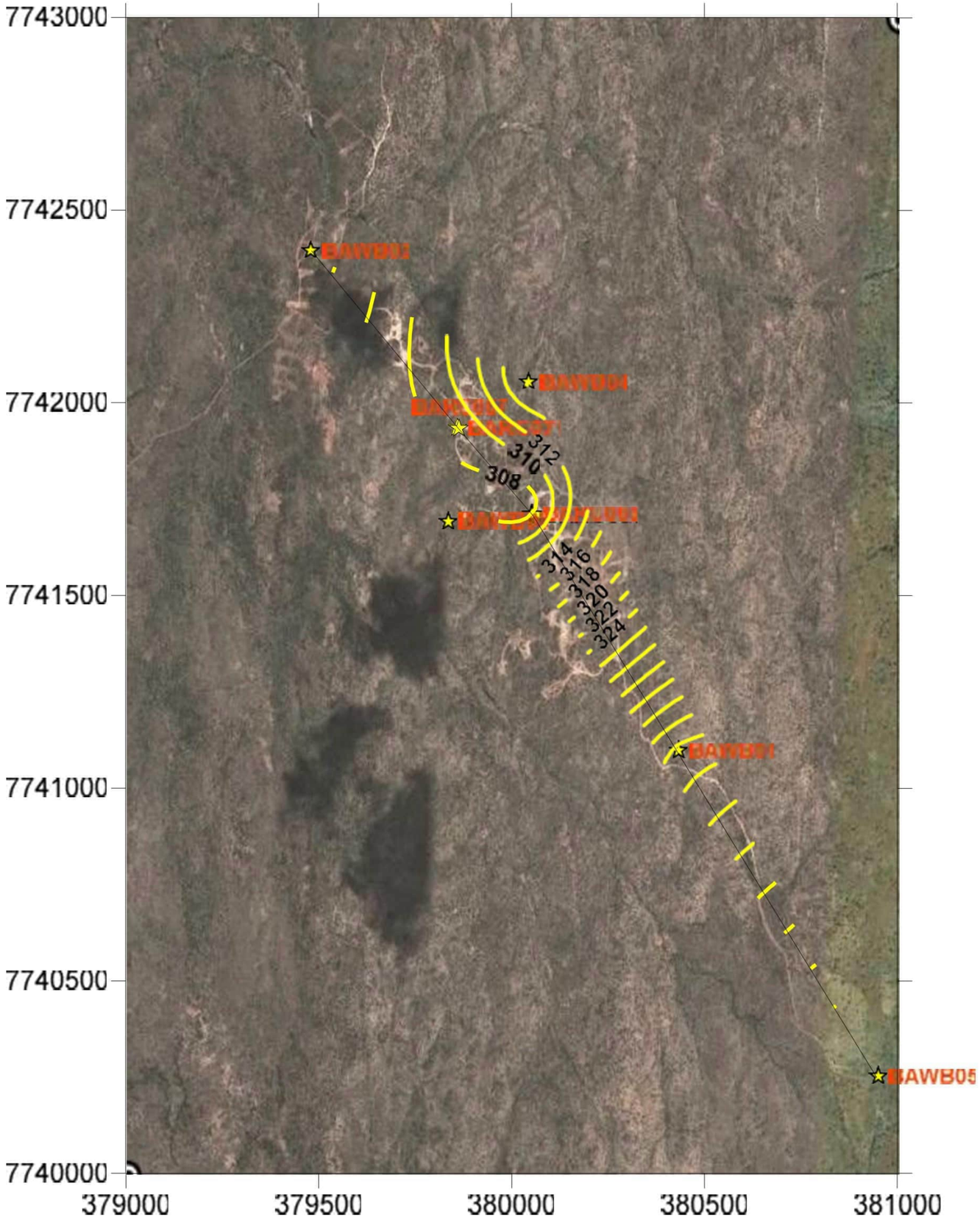
Aeris RESOURCES

WMV environmental
Contaminated Land | Hydrogeology | Environment

WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz

WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.



P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz

Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

Figure 14 - Contour map of June 2014 groundwater levels

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

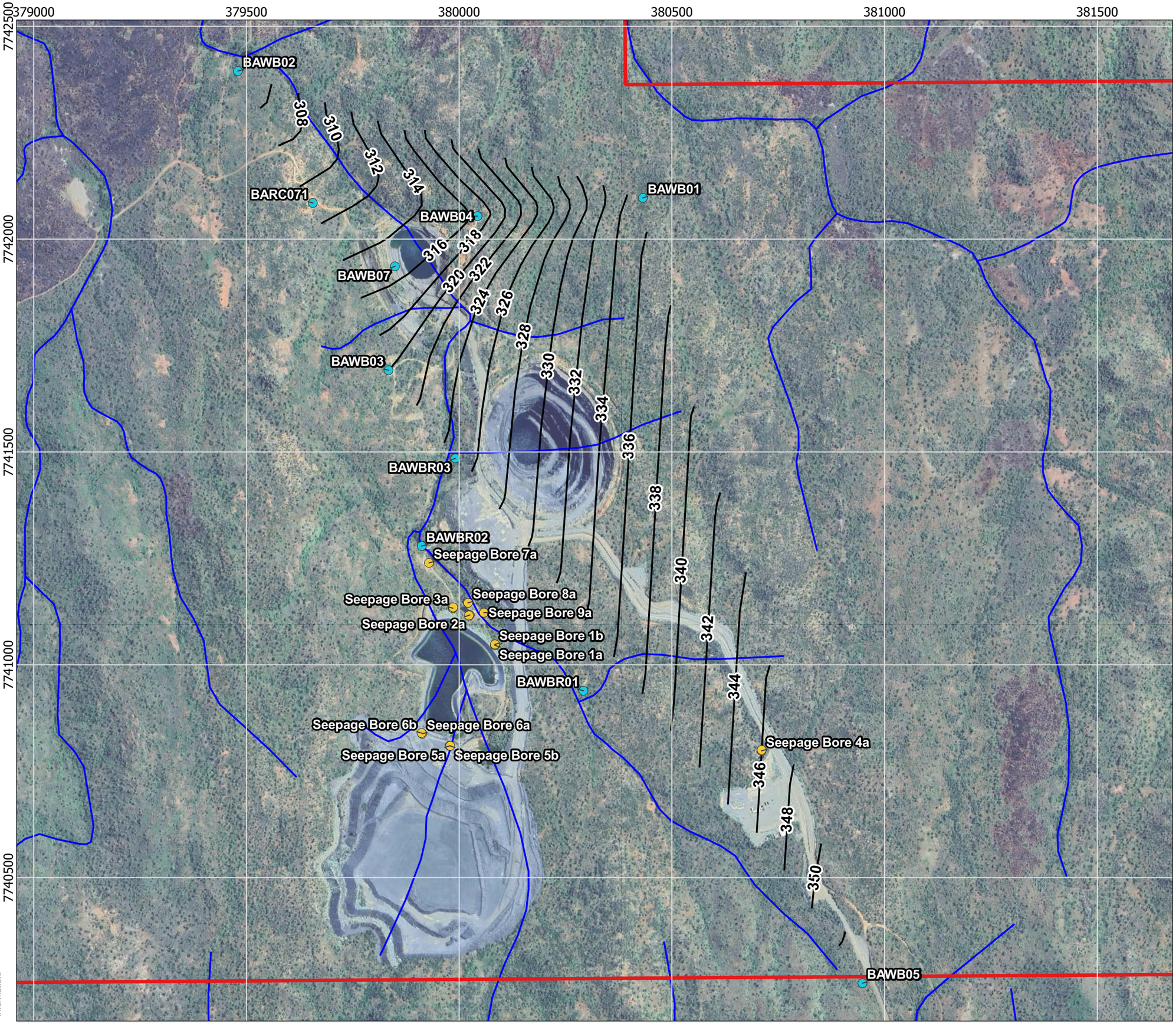
Client: Aeris Resources Limited
Project No: J23011
Date created: 18/03/2024

Data Attribution

© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

WMV environmental
Contaminated Land | Hydrogeology | Environment



Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

Figure 15 - Contour map of June 2018 groundwater levels

0 100 200 300 400 m

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- Watercourse line
- Groundwater level (mAHD)

Monitoring Locations

- Groundwater bore
- Seepage monitoring bore

Client: Aeris Resources Limited
Project No: J23011
Date created: 18/03/2024

Data Attribution

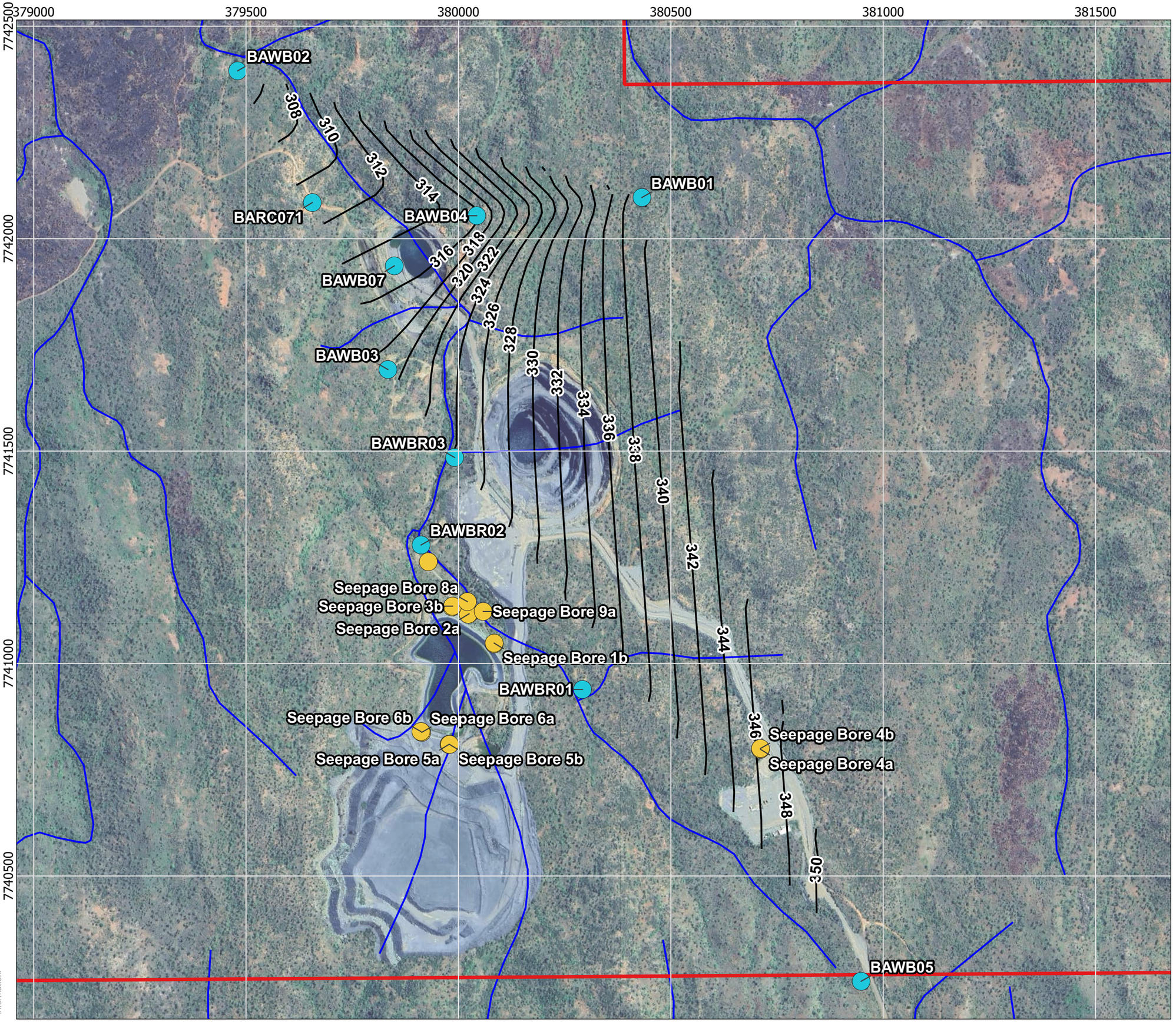
© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

WMV environmental Contaminated Land | Hydrogeology | Environment

WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz



Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

Figure 16 - Contour map of April 2022 groundwater levels

0 100 200 300 400 m

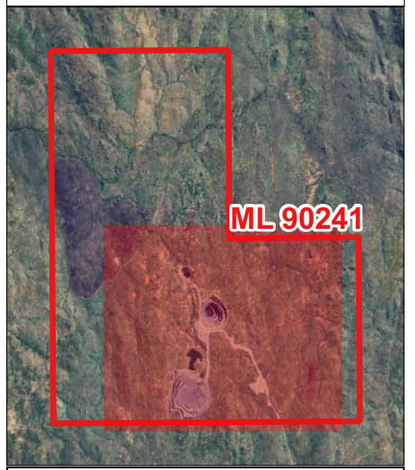
EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- Watercourse line
- Groundwater level (mAHD)

Monitoring Locations

- Groundwater bore
- Seepage monitoring bore



Client: Aeris Resources Limited
Project No: J23011
Date created: 18/03/2024

Data Attribution

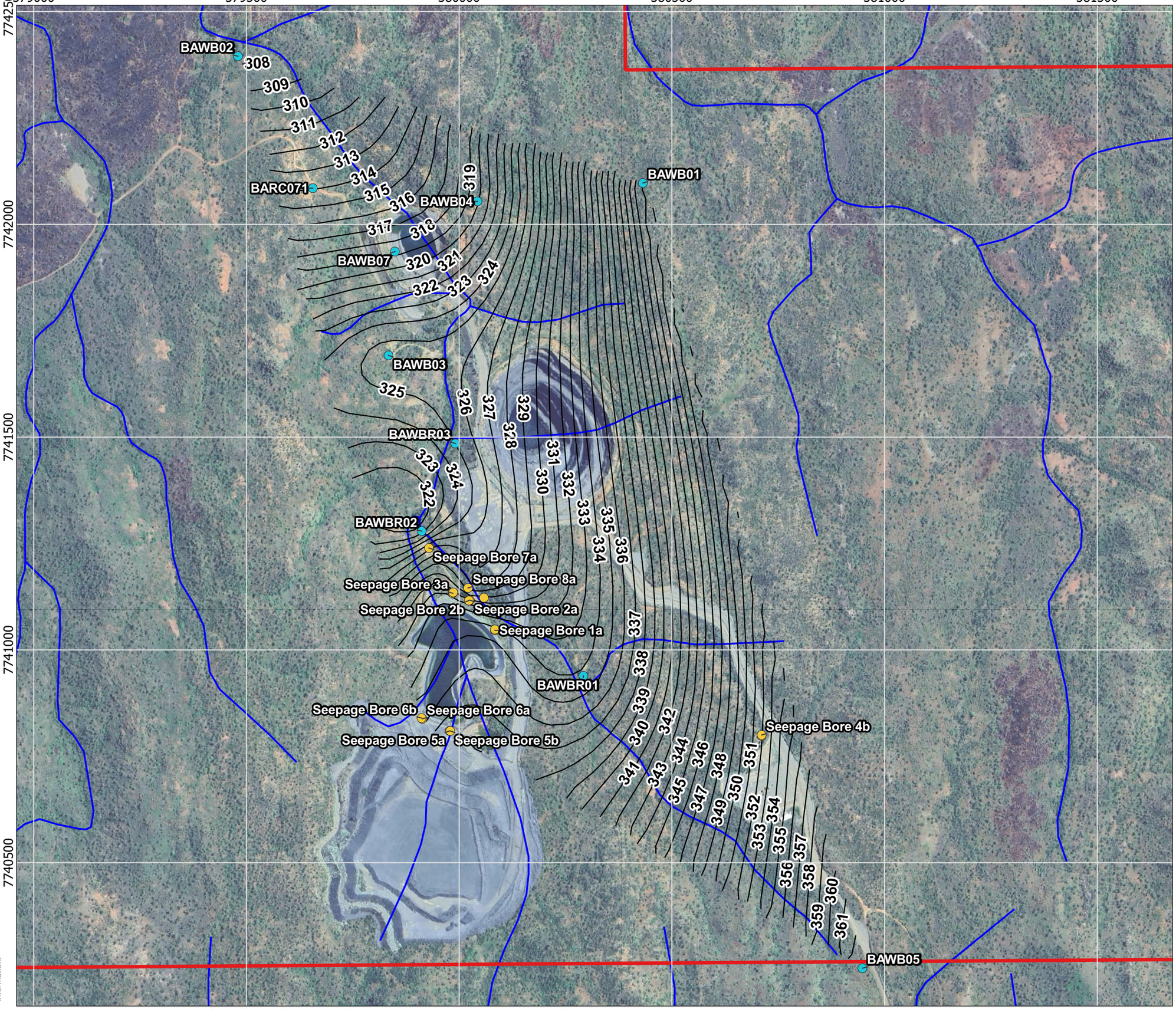
© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

WMV environmental
Contaminated Land | Hydrogeology | Environment

WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz



Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

Figure 17 - Contour map of April 2023 groundwater levels

0 100 200 300 400 m

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

- ML90241
- Watercourse line
- Groundwater level (mAHD)

Monitoring Locations

- Groundwater bore
- Seepage monitoring bore

Client: Aeris Resources Limited
Project No: J23011
Date created: 18/03/2024

Data Attribution

© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

WMV environmental
Contaminated Land | Hydrogeology | Environment

WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz

Barbara Copper Project

Groundwater Technical Report for Underground EA Amendment

Figure 18 - Location of hydrogeological cross-section

379000 379500 380000 380500 381000 381500

7742500 7742000 7741500 7741000 7740500 7740000

BAWB02 BARC071 BAWB01 BAWB04 BAWB07 BAWB03 BAWBR03 BAWBR02 BAWBR01 BAWB05

PLva PLvl PLem PLem? do

0 250 500 m

EPSG:28354
Datum:GDA94 / MGA zone 54

Legend

ML90241

Cross section

Monitoring bores

Groundwater bore

Legend

Local geology

- ?
- Amphibolite (ex basalt/dolerite)
- Amydaloidal basalt
- Gossan breccia
- Mafic schist
- Malachite bearing ore rock
- Malachite in gossan
- Meta basalt/dolerite - Magna Lynn Volcanics
- Pit
- Quartz diorite
- Quartz veining
- qz vn / stringer zone
- Schorl/qz/felsic breccia/veins
- Undifferentiated felsic rock - Leichardt Met

Client: Aeris Resources Limited
Project No: J23011
Date created: 18/03/2024

Data Attribution

© QLD Government 2023
© Aeris Resources 2023

Aeris RESOURCES

WMV environmental Contaminated Land | Hydrogeology | Environment

WMV Environmental does not warrant the accuracy or completeness of information displayed in this map and any person using it does so at their own risk. WMV Environmental shall bear no responsibility or liability for any errors, faults, defects, or omissions in the information.

P:\J23011 - BCP Underground EA (Aeris)\3. GIS\3.07 QGIS\J23011 - BCP Underground EA (Aeris).qgz

Appendix A EA EPML02840015

Permit

Environmental Protection Act 1994

Environmental authority EPML02840015

This environmental authority is issued by the administering authority under Chapter 5 of the Environmental Protection Act 1994.

Environmental authority number: EPML02840015

Environmental authority takes effect on 3 February 2020

Environmental authority holder(s)

Name(s)	Registered address
ROUND OAK MINERALS PTY LIMITED	Level 32 10 Eagle Street BRISBANE CITY QLD 4000 Australia

Environmentally relevant activity and location details

Environmentally relevant activity/activities	Location(s)
Schedule 3 17: Mining copper ore Schedule 3 18: Mining lead, silver or zinc seperately or in any combination Ancillary 08 - Chemical Storage 3: Storing more than 500 cubic metres of chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous goods class 3 under subsection (1)(c) Ancillary 15 - Fuel burning Using fuel burning equipment that is capable of burning at least 500kg of fuel in an hour	ML90241

Schedule 3 16: Mining gold ore Schedule 3 19: Mining metal ore, other than a metal ore mentioned in itms 11, 12, 14, 15, 16,17 or 18 Schedule 3 14: Mining iron ore Ancillary 63 - Sewage Treatment 1: Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of (a-i) 21 to 100EP if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme Ancillary 33 - Crushing, milling, grinding or screening Crushing, grinding, milling or screening more than 5000t of material in a year	

Additional information for applicants

Environmentally relevant activities

The description of any environmentally relevant activity (ERA) for which an environmental authority (EA) is issued is a restatement of the ERA as defined by legislation at the time the EA is issued. Where there is any inconsistency between that description of an ERA and the conditions stated by an EA as to the scale, intensity or manner of carrying out an ERA, the conditions prevail to the extent of the inconsistency.

An EA authorises the carrying out of an ERA and does not authorise any environmental harm unless a condition stated by the EA specifically authorises environmental harm.

A person carrying out an ERA must also be a registered suitable operator under the *Environmental Protection Act 1994* (EP Act).

Contaminated land

It is a requirement of the EP Act that an owner or occupier of contaminated land give written notice to the administering authority if they become aware of the following:

- the happening of an event involving a hazardous contaminant on the contaminated land (notice must be given within 24 hours); or
- a change in the condition of the contaminated land (notice must be given within 24 hours); or
- a notifiable activity (as defined in Schedule 3) having been carried out, or is being carried out, on the contaminated land (notice must be given within 20 business days);
- that is causing, or is reasonably likely to cause, serious or material environmental harm.

For further information, including the form for giving written notice, refer to the Queensland Government website www.qld.gov.au, using the search term 'duty to notify'.

Take effect

Please note that, in accordance with section 200 of the EP Act, an EA has effect:

a) if the authority is for a prescribed ERA and it states that it takes effect on the day nominated by the holder of the authority in a written notice given to the administering authority-on the nominated day; or

b) if the authority states a day or an event for it to take effect-on the stated day or when the stated event happens; or

c) otherwise-on the day the authority is issued.

However, if the EA is authorising an activity that requires an additional authorisation (a relevant tenure for a resource activity, a development permit under the *Sustainable Planning Act 2009* or an SDA Approval under the *State Development and Public Works Organisation Act 1971*), this EA will not take effect until the additional authorisation has taken effect.

If this EA takes effect when the additional authorisation takes effect, you must provide the administering authority written notice within 5 business days of receiving notification of the related additional authorisation taking effect.

If you have incorrectly claimed that an additional authorisation is not required, carrying out the ERA without the additional authorisation is not legal and could result in your prosecution for providing false or misleading information or operating without a valid environmental authority.

Kate Rutherford
Department of Environment and Science
Delegate of the administering authority
Environmental Protection Act 1994

Date issued: 03 February 2020

Enquiries:
Minerals Business Centre
Department of Environment and Science

Phone: 07 4222 5352
Email: ESCairns@des.qld.gov.au

Obligations under the *Environmental Protection Act 1994*

In addition to the requirements found in the conditions of this environmental authority, the holder must also meet their obligations under the EP Act, and the regulations made under the EP Act. For example, the holder must comply with the following provisions of the Act:

- general environmental duty (section 319)
- duty to notify environmental harm (section 320-320G)
- offence of causing serious or material environmental harm (sections 437-439)
- offence of causing environmental nuisance (section 440)
- offence of depositing prescribed water contaminants in waters and related matters (section 440ZG)
- offence to place contaminant where environmental harm or nuisance may be caused (section 443)

Schedule A – General

A1 This environmental authority authorises environmental harm referred to in the conditions. Where there is no condition or this environmental authority is silent on a matter, the lack of a condition or silence does not authorise environmental harm.

A2 Contaminants with the potential to cause environmental harm must not be released directly or indirectly to the receiving environment, except as permitted under the conditions of this environmental authority.

A3 The environmental authority holder must ensure that the activity is carried out in accordance with *Table A1* and *Schedule J – Map 1 Location of authorised disturbance*.

Table A1 - Authorised disturbance ('Table A1')

Name of disturbance area	Maximum area of disturbance (ha)	Mining Lease	Purpose
Run-of-mine (ROM) pad	3.5	ML90241	Temporary storage, crushing and handling of ore.
Road train loading area	1	ML90241	Loading of ore for transport off-site.
North Pit	1.5	ML90241	Mining of ore and site water management. Note: The North pit is a regulated dam with minimum hydraulic performance criteria detailed in *Table H1* of this environmental authority.
South pit	6	ML90241	Mining of ore and site water management. Note: The North pit is a regulated dam with minimum hydraulic performance criteria detailed in *Table H1* of this environmental authority.
Waste rock dump (WRD)	23	ML90241	Storage and disposal of waste rock.
ROM pad dam	0.6	ML90241	Water management for stormwater runoff from the ROM pad area.
WRD dam	4	ML90241	Water management for stormwater runoff from the WRD area.
Diversion drain	0.5	ML90241	Water management to prevent stormwater runoff entering mine workings.
Topsoil stockpiles	2.5	ML90241	Storage of topsoil for site rehabilitation works.
Access Road, Haul Roads and tracks	20.5	ML90241	Site access.
Light Infrastructure Area: including Administration buildings, Fuel storage, Power facility and Workshop area.	2.5	ML90241	Site administration, Fuel storage and power generation, Maintenance and storage.
Sewage treatment facility	0.5	ML90241	Treatment of sewage.
Explosives magazine	0.5	ML90241	Storage of explosives.

A4 The holder of this environmental authority must:

a) Install all measures, plant and equipment necessary to ensure compliance with the conditions of this environmental authority;

b) Maintain such measures, plant and equipment in a proper and efficient condition;

c) Operate such measures, plant and equipment in a proper and efficient manner; and

d) Ensure all instruments and devices used for the measurement or monitoring of any parameter under any condition of this environmental authority are properly calibrated.

Monitoring

A5 Except where specified in another condition of this environmental authority, all monitoring data, records and reports required by this environmental authority or related to environmental management of the activities must be:

a) Carried out by an appropriately qualified person;

b) Kept for a period of not less than five years; and

c) Provided to the administering authority in the specified format within 10 business days of a request.

A6 The following information must be recorded in relation to all monitoring required under a condition of this environmental authority:

a) The date and time when the sample was taken;

b) The location where the sample was taken; and

c) Any other pertinent details of relevance to interpreting the sampling results (*i.e.* stream flow, wind conditions or any unusual observations such as odour or colouration).

Financial assurance

A7 Financial assurance must be lodged with the administering authority in the amount, the form and within the time required by the administering authority.

Risk management

A8 The holder of this environmental authority must develop and implement a risk management system for mining activities which mirrors the content requirement of the Standard for Risk Management (ISO31000:2009), or the latest edition of an Australian standard for risk management, to the extent relevant to environmental management, by 5 October 2016.

Notification of emergencies, incidents and exceptions

A9 The holder of this environmental authority must notify the administering authority by written notification within 24 hours, after becoming aware of any emergency or incident which results in the release of contaminants not in accordance, or reasonably expected to be not in accordance with, the conditions of this environmental authority.

A10 Within 10 business days following the initial notification of an emergency or incident, or receipt of monitoring results, whichever is the latter, further written advice must be provided to the administering authority, including the following:

a) Results and interpretation of any samples taken and analysed;

b) Outcomes of actions taken at the time to prevent or minimise unlawful environmental harm; and

c) Proposed actions to prevent a recurrence of the emergency or incident.

Complaints

A11 The holder of this environmental authority must record all environmental complaints received about the mining activities including:

a) Name, address and contact number for of the complainant;

b) Time and date of complaint;

c) Reasons for the complaint;

d) Investigations undertaken;

e) Conclusions formed;

f) Actions taken to resolve the complaint;

g) Any abatement measures implemented; and

h) Person responsible for resolving the complaint.

A12 The holder of this environmental authority must, when requested by the administering authority, undertake relevant specified monitoring within a reasonable timeframe nominated or agreed to by the administering authority to investigate any complaint of environmental harm. The results of the investigation (including an analysis and interpretation of the monitoring results) and abatement measures, where implemented, must be provided to the administering authority within 10 business days of completion of the investigation, or no later than 10 business days after the end of the timeframe nominated by the administering authority to undertake the investigation.

Third-party reporting

A13 The holder of this environmental authority must:

a) Within one (1) year of the commencement of this environmental authority, obtain from an appropriately qualified person a report on compliance with the conditions of this environmental authority;

b) Obtain further such reports at regular intervals, not exceeding three (3) yearly intervals, from the completion of the report referred to above; and

c) Provide each report to the administering authority within 90 days of its completion.

A14 Where a condition of this environmental authority requires compliance with a standard, policy or guideline published externally to this environmental authority and the standard is amended or changed subsequent to the issue of this environmental authority, the holder of this environmental authority must:

a) Comply with the amended or changed standard, policy or guideline within two years of the amendment or change being made, unless a different period is specified in the amended standard or relevant legislation, or where the amendment or change relates specifically to regulated structures referred to in Schedule I, the time specified in that condition; and

b) Until compliance with the amended or changed standard, policy or guideline is achieved, continue to remain in compliance with the corresponding provision that was current immediately prior to the relevant amendment or change.

Exploration

A15 All exploration activities carried out on the mining lease must comply with each of the standard environmental conditions contained in the latest version of the *Eligibility criteria and standard conditions for exploration and mineral development projects.*

END OF CONDITIONS FOR SCHEDULE A

Schedule B – Air

B1 The activities must not cause an exceedance of the air quality objectives specified in *Table B1* beyond the boundaries of any mining lease/s listed on this environmental authority.

Table B1 - Air quality objectives ('Table B1')

Contaminant	Measurement period	Air Quality Objective
Dust Deposition		
Arsenic and its compounds as arsenic[3]	Annual average over the calendar year	Must not exceed background concentration[4]
Cadmium and its compounds as cadmium[3]		
Copper and its compounds as copper[3]		
Lead and its compounds as lead[3]		250 µg/m^2/day
Dust deposition (total insoluble matter)[1]		120 mg/m^2/day

[1] The dust deposition limit is calculated over a nominal month as per AS/NZS3580.10.1 of 2003 (or more recent editions) unless an appropriately qualified person recommends and justifies an alternative frequency.

[3] Metal analysis is to be carried out in accordance with a methodology, sufficient to produce representative results capable of comparison against the respective trigger values.

[4] The background concentration must be determined in accordance with condition B2 of this environmental authority and include sufficient background dust deposition monitoring locations that are not potentially impacted by the mining activities.

B2 Prior to commencing the mining activity, the environmental authority holder must ensure that an air quality monitoring program is developed and implemented by an appropriately qualified person that is capable of determining compliance with condition B1 of this environmental authority.

END OF CONDITIONS FOR SCHEDULE B

Schedule C - Waste management

C1 All waste generated as part of the mining activities must be disposed of in a lawful manner at an off-site facility, with the exception of:

a) Treated sewage effluent, which may only be released via sub-surface infiltration trench and must be undertaken in accordance with condition C2 of this environmental authority; and

b) Waste rock, which must be characterised, handled and disposed of in accordance with condition C3 of this environmental authority.

C2 The only contaminant permitted to be released to land is treated sewage effluent released in accordance with condition C1 (a) and the release limits specified in *Table C1.*

Table C1 - Contaminant release limits to land ('Table C1')

Contaminant	Unit	Release Limit	Limit Type	Frequency
5 day Biochemical oxygen demand (BOD)1	mg/L	20	Maximum	Monthly
Total suspended solids	mg/L	30	Maximum	Monthly
Nitrogen	mg/L	30	Maximum	Monthly
Phosphorus	mg/L	15	Maximum	Monthly
E-coli	Organisms/100ml	1000	Maximum	Monthly
pH	pH units	6.0-9.0	Range	Monthly

C3 All potentially acid forming waste rock must be:

(a) Identified and disposed of in a manner that minimises the potential generation and/or release of contaminants to the receiving environment;

(b) Where the characteristics of waste rock in regards to acid producing potential is uncertain, this material must be treated as potentially acid forming until demonstrated otherwise; and

(c) Details pertaining to meeting the requirements of this condition must be recorded and retained until this environmental authority is surrendered.

END OF CONDITIONS FOR SCHEDULE C

Schedule D – Noise

Noise limits

D1 The holder of this environmental authority must ensure that noise generated by the mining activities does not cause the criteria in *Table D1* to be exceeded at a sensitive place or commercial place.

Table D1 – Noise limits ('Table D1')

Sensitive place						
Noise level dB(A) measured as:	**Monday to Saturday**			**Sundays and public holidays**		
	7am to 6pm	**6pm to 10pm**	**10pm to 7am**	**9am to 6pm**	**6pm to 10pm**	**10pm to 9am**
$L_{Aeq, adj, 15 mins}$	CV = 50 AV = 5	CV = 45 AV = 5	CV = 40 AV = 0	CV = 45 AV = 5	CV = 40 AV = 5	CV = 35 AV = 0
$L_{A1, adj, 15 mins}$	CV = 55 AV = 10	CV = 50 AV = 10	CV = 45 AV = 5	CV = 50 AV = 10	CV = 45 AV = 10	CV = 40 AV = 5

Notes:

a) CV: Critical Value, AV: Adjustment Value
b) To calculate noise limits;
If bg ≤ (CV-AV): Noise limit = bg + AV
If (CV-AV) < bg ≤ CV: Noise limit = CV
If bg > CV: Noise limit = bg+0
c) In the event that measured bg (LA90,adj, 15 mins) is less than 30 dB(A), then 30 dB(A) can be substituted for the measured background level.
d) Bg = background noise level (LA90, adj, 15 mins) measured over 3 – 5 days at the nearest sensitive receptor.
e) If the project is unable to meet the noise limits as calculated above alternative limits may be calculated using the process outlined in the 'Planning for Noise Control' guideline.

Airblast overpressure nuisance

D2 The holder of this environmental authority must ensure that blasting does not cause the limits for peak particle velocity and air blast overpressure in *Table D2* to be exceeded at a sensitive place or commercial place.

Table D2 – Blasting noise limits ('Table D2')

Blasting noise limits	Sensitive or commercial blasting noise limits place limits	
	7am to 6pm	**6pm to 7am**
Airblast overpressure	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB (Linear) Peak at any time	No blasting
Ground vibration peak particle velocity	5mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time	No blasting

Monitoring and reporting

D3 Noise monitoring and recording must include the following descriptor characteristics and matters:

a) $L_{AN,T}$ (where N equals the statistical levels of 1, 10 and 90 and T = 15 mins)
b) background noise LA90
c) the level and frequency of occurrence of impulsive or tonal noise and any adjustment and penalties to statistical levels
d) atmospheric conditions including temperature, relative humidity and wind speed and directions
e) effects due to any extraneous factors such as traffic noise
f) location, date and time of monitoring
g) if the complaint concerns low frequency noise, Max LpLIN,T and one third octave band measurements in dB(LIN) for centre frequencies in the 10 – 200 Hz range.

END OF CONDITIONS FOR SCHEDULE D

Schedule E – Water

Contaminant release

E1 Contaminants must not be released to receiving waters unless there are natural flows in the receiving water of at least twenty times the volume of the release.

E2 Contaminants may only be released to receiving waters from a location specified in *Table E1* and must not exceed any release limit specified in *Table E2*.

Table E1 – Authorised contaminant release points ('Table E1')

Release point	Location		Release source	Monitoring Point	Receiving waters description
	Easting (GDA94 – Zone 54)	Northing (GDA94 – Zone 54)			
RP01	379862	7742050	North Pit (Mine water dam)	Pit	Drainage of unnamed tributary
RP02	380153	7741260	South Pit	Pit	Drainage of unnamed tributary
RP03	380007	7741120	WRD Dam	Dam Spillway	Drainage of unnamed tributary
RP04	380309	7741040	ROM Dam	Dam Spillway	Drainage of unnamed tributary

E3 Contaminated water released from a release point specified in *Table E1* must be monitored at the release point for all contaminants and at the frequency specified in *Table E2*.

Table E2 – Contaminant release limits ('Table E2)

Contaminant	Release limit[1, 2]	Monitoring frequency
pH (pH units)	6.0 or 20th percentile[3] of reference site[4] value, whichever is lower	- One sample must be taken within 2 hours of any release event commencing; and - For release events with duration of greater than twenty-four hours, samples must be taken daily for one week and once a week thereafter until the release event ceases.
	7.5 or 80th percentile[3] of reference site[4] value, whichever is higher	
EC (µs/cm)	1,500 or 20 times the 80th percentile[3] of reference site value[4], whichever is higher	
Turbidity (NTU)	20 x 80th percentile of reference site value[3]	
Sulfate	1,000 or 20 x 80th percentile[3] of reference site[4] concentration, whichever is higher	
Fluoride	2 or 20 x 80th percentile[3] of reference site[4] concentration, whichever is higher	
Arsenic	0.14 or 20 x 80th percentile[3] of reference site[4] concentration, whichever is higher	
Barium	20 x 80th percentile[3] of reference site[4] concentration	
Bismuth	20 x 80th percentile[3] of reference site[4] concentration	
Chromium	0.02 or 20 x 80th percentile[3] of reference site[4] concentration, whichever is higher	
Cobalt	0.056 or 20 x 80th percentile[3] of reference site[4] concentration, whichever is higher	
Copper	0.028 or 20 x 80th percentile[3] of reference site[4] concentration, whichever is higher	
Molybdenum	0.15 or 20 x 80th percentile[3] of reference site[4] concentration, whichever is higher	

Nickel	0.22 or 20 x 80th or percentile[3] of reference site[4] concentration, whichever is higher
Selenium	0.22 or 20 x 80th percentile[3] of reference site[4] concentration, whichever is higher
Uranium	0.4 or 20 x 80th percentile[3] of reference site[4] concentration, whichever is higher

[1] All metals and metalloids must be measured as both 'total' (from analysis of an unfiltered sample) and 'dissolved' (from analysis of a field filtered sample).

[2] Measured and reported in mg/L unless specified otherwise.

[3] The relevant reference site is specified in *Table E3*.

[4] Site-specific trigger levels and water quality objectives for water quality (20th, 80th and 95th percentile of reference site concentration) must be calculated in accordance with QWQG (2009) and ANZECC (2000) methodology if sufficient monitoring data is available. The environmental authority holder must maintain a database documenting all relevant water quality monitoring data and calculation of percentiles adopted as water quality trigger levels and water quality objectives.

E4 The environmental authority holder must notify the administering authority within twenty-four hours of any contaminant release commencing or ceasing.

Surface waters

E5 The quality of receiving waters must be monitored at the locations specified in *Table E3,* for the contaminants and at the frequency specified in *Table E4.*

Table E3 - Receiving waters reference and compliance monitoring sites ('Table E3')

Monitoring sites	Monitoring site description and purpose	Location	
		Easting (GDA94 – Zone 54)	Northing (GDA94 – Zone 54)
Reference sites			
BASW09	Drainage feature outside and northeast of disturbance footprint catchment	377540	7738673
BASW05	Drainage feature southwest and outside of disturbance footprint catchment	380736	7742273
Compliance sites			
BASW01	Watercourse at Mining Lease west boundary	378513	7743286
BASW04	Watercourse downstream of North Pit	379491	7742440
BASW08	Drainage feature at the top of catchment (Mining Lease entry)	380776	7740396
BASW11	Drainage feature upstream of junction with watercourse	379884	7743040

Table E4 - Receiving waters trigger levels and quality objectives ('Table E4')

Contaminant	Water quality[1, 3]		Sediment quality[7, 4]		Monitoring frequency
	Trigger levels	Water quality objectives	Trigger levels[2]	Sediment quality objectives[2]	
pH (pH units)	6.0 (minimum)	5.0 (minimum)	Not applicable		- For water quality: a) At least daily during release events, the first sample must be taken within two hours of the release event commencing; and b) At least once every three months (if surface water is present). - For sediment quality, at least twice per year, once at the end of the wet season and once at the end of the dry season.
	7.5 (maximum)	9.0 (maximum)	Not applicable		
Electrical conductivity (µS/cm)	500 or 80th percentile[6] of reference site[5], whichever is higher	1,000 or 95th percentile[6] of reference site[5], whichever is lower	Not applicable		
Turbidity (NTU)	80th percentile[6] of reference site[5]	25 or 95th percentile[6] of reference site[5], whichever is lower	Not applicable		
Sulfate	80th percentile[6] of reference site[5]	1,000 or 95th percentile[6] of reference site[5], whichever is lower	Not applicable		
Fluoride	80th percentile[6] of reference site[5]	2 or 95th percentile[6] of reference site[5], whichever is lower	Not applicable		
Arsenic	0.007 or 80th percentile[6] of reference site[5], whichever is higher	0.5 (total) or 95th percentile[6] of reference site[5] (dissolved), whichever is lower	20 or two times the reference site[5] value, whichever is higher	70 or two times the reference site[5] value, whichever is lower	
Barium	80th percentile of reference site[5]	95th percentile[6] of reference site[5] (dissolved)	Two times the reference site[5] value	Three times the reference site[5] value	
Bismuth	80th percentile[6] of reference site[5]	95th percentile[6] of reference site[5] (dissolved)	Two times the reference site[5] value	Three times the reference site[5] value	
Cobalt	0.0028 or 80th percentile[6] of reference site[5], whichever is higher	1 (total) or 95th percentile[6] of reference site[5] (dissolved), whichever is lower	Two times the reference site[5] value	Three times the reference site[5] value	
Chromium	0.001 or 80th percentile[6] of reference site[5], whichever is higher	1 (total) or 95th percentile[6] of reference site[5] (dissolved), whichever is lower	80 or two times the reference site[5] value, whichever is higher	370 or two times the reference site[5] value, whichever is lower	
Copper	0.0014 or 80th percentile[6] of reference site[5], whichever is higher	1 or (total) or 95th percentile[6] of reference site[5] (dissolved), whichever is lower	65 or two times the reference site[5] value, whichever is higher	270 or two times the reference site[5] value, whichever is lower	
Molybdenum	0.034 or 80th percentile[6] of reference site[5], whichever is higher	0.15 (total) and 95th percentile[6] of reference site[5] (dissolved), whichever is lower	Two times the reference site[5] value	Three times the reference site[5] value	
Nickel	0.011 or 80th percentile[6] of reference site[5], whichever is higher	1 (total) or 95th percentile[6] of reference site[5] (dissolved), whichever is lower	21 or two times the reference site[5] value, whichever is higher	52 or two times the reference site[5] value, whichever is lower	
Selenium	0.011 or 80th percentile[6] of reference site[5], whichever is higher	0.02 (total) and 95th percentile[6] of reference site[5] (dissolved), whichever is lower	Two times the reference site[5] value	Three times the reference site[5] value	

Uranium	0.02 or 80th percentile[6] of reference site[5], whichever is higher	0.2 (total) or 95th percentile[6] of reference site[5] (dissolved), whichever is lower	Two times the reference site[5] value, whichever is higher	Three times the reference site[5] value, whichever is lower
Major cations	For interpretation only		Not applicable	
Major anions	For interpretation only		Not applicable	
Total hardness	For interpretation only		Not applicable	
Total organic carbon	Not applicable		For interpretation only	

[1] For water quality, all metals and metalloids must be measured as both 'total' (from analysis of an unfiltered sample) and 'dissolved' (from analysis of a field filtered sample). All trigger levels are based on dissolved metal concentrations; for water quality objectives, the relevant method is specified in brackets for each contaminant where applicable.

[2] Analysis for metals/metalloids concentrations in sediment must be conducted on the <2mm fraction of the sample and measured as a dilute acid extractable concentration in a manner consistent with the *Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines*, CSIRO (May 2013).

[3] Measured and reported in mg/L unless specified otherwise.

[4] Measured and reported in mg/kg dry weight.

[5] The relevant reference site is specified in *Table E3*.

[6] Site-specific trigger levels and water quality objectives for water quality (80th and 95th percentile of reference site concentration) must be calculated in accordance with QWQG (2009) and ANZECC (2000) methodology if sufficient monitoring data is available. The environmental authority holder must maintain a database documenting all relevant water quality monitoring data and calculation of percentiles adopted as water quality trigger levels and water quality objectives.

[7] For sediment quality, compliance site monitoring results are to be compared:

a) Directly to the guideline values from the *Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines*, CSIRO (May 2013), if insufficient reference site monitoring data is available; or

b) The relevant reference site monitoring data, which must be normalised to account for any difference in particle size distribution (*i.e.* conduct a fractionated sediment analysis based on comparing the metals concentrations of the <63µm sediment fraction with the >63µm to <2mm sediment fraction).

E6 The contaminant concentrations measured in receiving waters including any compliance site specified in *Table E3* must not exceed a water quality objective or sediment quality objective specified in *Table E4*.

E7 If a contaminant concentration measured at a compliance site specified in *Table E3* exceeds any trigger level specified in *Table E4*, the environmental authority holder must compare this result to the applicable reference site; and

a) If the contaminant concentration measured at the compliance site is equal to or less than the contaminant concentration measured at the applicable reference site, no further action is required for this event; or

b) If the contaminant concentration measured at the compliance site is greater than the contaminant concentration measured at the applicable reference site:

i. Notify the administering authority within twenty-four hours of becoming aware of the trigger level exceedance; and

ii. Undertake further sampling of potentially impacted receiving waters for all contaminants specified in *Table E4*; and

iii. Complete an investigation into the potential for environmental harm to occur in accordance with ANZECC (2000) methodology, within three months of identifying this exceedance or the alternative timeframe specified by the administering authority; and

iv. Within one week of completing the investigation, provide a written report to the administering authority detailing all pertinent aspects of the investigation (such as objectives, applied methodology, investigation outcomes, assumptions relied upon and justification for any assertions made) and any actions undertaken and/or proposed to prevent or minimise environmental harm.

Note: Where a contaminant trigger level exceedance has occurred and is under investigation in accordance with condition E7, no further reporting is required for subsequent exceedance events of that contaminant during the course of the investigation.

Groundwater

E8 The holder of this environmental authority must not release contaminants to groundwater.

E9 The extraction of groundwater must not cause environmental harm to any groundwater dependent ecosystems.

E10 Groundwater quality and levels must be monitored:

a) at the locations specified in *Table E5 (Groundwater monitoring bore locations); and*

b) at the frequencies specified in *Table E5 (Groundwater monitoring bore locations); and*

c) for the quality characteristics identified in *Table E6 (Groundwater Quality Objectives)*.

Table E5 - Groundwater monitoring bore locations ('Table E5')

Monitoring Point	Location (GDA94 – Zone 54)		Surface RL (m)[1]	Total Depth (mbgl[2])	Screened interval (mbgl)	Monitoring Frequency	
	Easting	Northing				Standing water level	Groundwater quality
Compliance bores							
BAWB05	380948	7740252	377.32	102	35-102	Monthly	3 monthly
Bore E	380022	7738827	334.23	85	28-83		
BAWB01	380432	7742097	352.68	104	20-101	Monthly	3 monthly
BAWB02	379480	7742395	310.59	104	96-102		
BAWB03	379834	7741692	329.50	104	50-102		
BAWB04	380043	7742054	329.14	100	94-100		
BAWB07	379849	7741936	328.74	127	18-146		
BAWBR1	380292	7740939	334.49	14	5-6		
BAWBR2	379912	7741279	322.98	14	2-3		
BAWBR3	379991	7741485	326.02	14	3-4		
Seepage monitoring bores							
Seepage Bore 1a	380084	7741046	336.819	6	1-5	Monthly	3 monthly

Seepage Bore 1b	380084	7741048	336.487	16	5-15		
Seepage Bore 2a	380025	7741117	331.218	6	1-5		
Seepage Bore 2b	380023	7741116	331.342	16	5-15		
Seepage Bore 3a	379985	7741133	332.189	6	1-5		
Seepage Bore 3b	379986	7741135	331.962	16	5-15		
Seepage Bore 4a	380711	7740798	355.061	6	1-5		
Seepage Bore 4b	380711	7740800	355.111	16	5-15		

Notes:
1. RL must be measured to the nearest 5cm from the top of the bore casing.
2. Metres below ground level

Table E6 – Groundwater quality objectives ('Table E6')

Contaminant[1]	Units	Limit type	Bore(s)	Limit A[3]	Limit B[4]
pH	pH	Range	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	7.0-8.5
Electrical conductivity (EC)	µS/cm	Maximum	BAWB01, BAWB02, BAWB07	1260	1365
			BAWB03, BAWB04, BAWB05, BAWBR1, BAWBR2, BAWBR3, Bore E	950	1010
Sulfate	mg/L	Maximum	BAWB01, BAWB03, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	65	73
			BAWB02	190	200
			BAWB04	16	21
Fluoride	mg/L	Maximum	BAWB02, BAWB03, BAWB04, BAWB05, BAWBR1, BAWBR2, BAWBR3	0.8	0.9
			BAWB01, BAWB07, Bore E	1.6	1.7
Arsenic	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	0.013[2]
Barium	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	0.140	0.170
			BAWB04	0.400	0.420
			BAWB05	0.2	0.3
Bismuth	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	0.0007[5]
Cobalt	mg/L	Maximum	BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	0.0014[5]

			BAWB01	-	0.0028
Chromium	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	0.001[2]
Copper	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	0.003	0.008
Molybdenum	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	0.034[2]
Nickel	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	0.011[2]
Selenium	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	-	0.011[2]
Uranium	mg/L	Maximum	BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	0.006	0.007
Major cations			BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	For interpretation only	
Major anions			BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	For interpretation only	
Total Hardness			BAWB01, BAWB02, BAWB03, BAWB04, BAWB05, BAWB07, BAWBR1, BAWBR2, BAWBR3, Bore E	For interpretation only	

Notes:
1. All metals and metalloids must be measured as 'dissolved' (from analysis of a field filtered sample)
2. Contaminant limit based on ANZECC (2000), Table 3.4.1, 95% aquatic species protection level for slightly to moderately disturbed ecosystem.
3. Derived from site-specific values, based off dissolved concentration of metals (80th percentiles).
4. Derived from site-specific values, based off dissolved concentration of metals (95th percentiles).
5. Based off ANZECC (2000) low reliability metals and metalloids, Section 8.3.7.1

E11 Groundwater measured from any compliance bore specified in **Table E5** must not exceed the corresponding Limit A specified in **Table E6** on any five consecutive sampling occasions**.**

E12 Groundwater measured from any compliance bore specified in **Table E5** must not exceed the corresponding Limit B specified in **Table E6** on any three consecutive sampling occasions**.**

E13 If groundwater measured from any compliance bore specified in **Table E5** exceeds the corresponding Limit B specified in **Table E6** on any one sampling occasion the environmental authority holder must resample the groundwater within the compliance bore for all exceeding parameters within ten business days of receipt of results.

Bore construction and maintenance and decommissioning

E14 The construction, maintenance and decommissioning of groundwater monitoring bores must be undertaken in a manner that:

a) prevents contaminants entering the groundwater; and

b) ensures the integrity of the bores to obtain representative groundwater samples from the target aquifer; and

c) maintains the hydrogeological environment within the aquifer.

E15 A bore drill log must be kept for each reference, compliance and observation groundwater monitoring bore which includes:

a) bore identification reference and geographic coordinate location;

b) specific construction information including but not limited to depth of bore, depth and length of casing, depth and length of screening and bore sealing details;

c) standing groundwater level and water quality parameters including physical parameters and results of laboratory analysis for the possible trigger parameters;

d) lithological data and stratigraphic interpretation by an appropriately qualified person to identify important features associated with groundwater monitoring; and

e) target aquifer formation of the bore.

Groundwater Management Program

E16 A Groundwater Management Program must be developed, documented and implemented by appropriately qualified persons.

E17 The Groundwater Management Program required by Condition E16 must:

a) identify potential sources of contamination to groundwater from the activity; and

b) ensure that all potential groundwater impacts due to the activity are identified, monitored and mitigated; and

c) document sampling and monitoring methodology; and

d) ensure that adequate groundwater monitoring and data analysis is undertaken to achieve the following objectives:

i. detect any impacts to groundwater levels due to the activity;

ii. detect any impacts to groundwater quality due to the activity;

iii. determine compliance with condition E11 and E12; and

iv. determine trends in groundwater quality; and

e) include an appropriate quality assurance and quality control program; and

f) include a conceptual groundwater model; and

g) include a review process to identify improvements to the program that includes addresses any comments provided by the administering authority.

E18 The Groundwater Management Program must be reviewed on an annual basis by an appropriately qualified person to determine if it continues to meet the requirements stated in condition E17.

E19 Monitoring and sampling must be carried out in accordance with written procedures and must address the requirements of the latest version of the following documents unless otherwise approved by the administering authority:

a) for waters and aquatic environments, the Queensland Government's Monitoring and Sampling Manual – Environmental Protection (Water) Policy;

b) for groundwater, Groundwater Sampling and Analysis – A Field Guide (2009:27 GeoCat#6890.1) and Australian Standard AS/NZS 5667.11:1998 Water Quality – Sampling – Guidance on sampling of groundwaters;

c) for subterranean aquatic fauna, the Guideline for the Environmental Assessment of Subterranean Aquatic Fauna.

Receiving environment monitoring program

E20 The environmental authority holder must develop, document and implement a Receiving Environment Monitoring Program (REMP) to monitor, identify and describe any adverse impacts to environmental values of receiving waters by 5 October 2016. The REMP must include at minimum:

a) Monitoring the effects of the mining activities on the receiving environment periodically under natural flow conditions and while contaminants are being released (if applicable);

b) Encompass the waters of Leichardt River and connected or surrounding waterways within 10km downstream of the mining activities;

c) Identification of all environmental values of receiving waters;

d) An assessment of background reference water quality, the condition of downstream water quality compared against water quality objectives, and the suitability of current environmental authority conditions to protect downstream environmental values; and

e) Application of biological monitoring if required to determine whether the mining activities are being conducted in a manner that enhances or protects the environmental values of receiving waters;

E21 A report outlining the findings of the REMP that addresses all requirements specified under condition E20, including all monitoring results and any interpretations or assumptions relied upon, must be completed annually.

Water management

E22 A Water Management Plan must be developed by an appropriately qualified person, documented and implemented for all stages of the mining activity.

Erosion and sediment control

E23 An Erosion and Sediment Control Plan must be developed, documented and implemented by an appropriately qualified person for all stages of the mining activities to minimise erosion and the release of sediment to receiving waters.

END OF CONDITIONS FOR SCHEDULE E

Schedule F – Biodiversity

Biodiversity offsets

F1 Impacts to prescribed environmental matters, other than by low impact activities, are only authorised to occur if the impacts do not exceed the maximum extent of impact specified for that prescribed environmental matter specified in *Table F1 – Authorised impacts to prescribed environmental matters*.

F2 An environmental offset made under the *Environmental Offsets Act 2014* must be delivered for each impact specified in *Table F1 – Authorised impacts to prescribed environmental matters* as requiring an environmental offset.

F3 A notice of election must be provided to the administering authority no less than three months before the proposed commencement of the prescribed activities.

Table F1 – Authorised impacts to prescribed environmental matters ('Table F1')

Prescribed environmental matter	Location of prescribed environmental matter (GDA94 – Zone 54)	Maximum extent of impact	Environmental offset required
Protected wildlife habitat			
Habitat for an animal that is vulnerable wildlife – Purple-necked rock wallaby *Petrogale purpuriecollis*	379910 E, 7740390 N	5 ha	Yes

F4 Prior to the commencement of any impacts to a prescribed environmental matter for which an offset is required by condition F2, the authority holder must enter into an Agreed Delivery Arrangement with the administering authority

END OF CONDITIONS FOR SCHEDULE F

Schedule G – Land and Rehabilitation

G1 The environmental authority holder must rehabilitate all significantly disturbed land caused by the mining activities in a manner that ensures rehabilitated areas achieve the following rehabilitation objectives:

a) Safe for humans and wildlife;

b) Non-polluting;

c) Stable;

d) Able to sustain a post-mining land-use agreed to by the administering authority and any underlying landholders;

e) Revegetated with species endemic to the area with no declared pest species; and

f) Compliant with all conditions of this environmental authority.

G2 Two years from commencement of mining[1] the environmental authority holder must develop and document a Post Mine Land-use Plan ('PMLUP') that describes how the rehabilitation objectives in condition G1 will be achieved. The PMLUP must at minimum include:

a) Schematic representation of the proposed final land form inclusive of site drainage features;

b) Details of proposed slope design and erosion and sediment controls;

c) Proposed cover designs for encapsulation of waste material, including performance criteria;

d) Proposed re-vegetation methods inclusive of plant species selection, propagation methods and establishment of suitable plant growth medium (*i.e.* top soil);

e) Materials balance for all rehabilitation requirements including available top soil and material suitable for encapsulating waste in accordance with the proposed encapsulation methodology;

f) Geotechnical, geochemical and hydrological studies necessary to demonstrate likely success of proposed rehabilitation methodology to achieve the required rehabilitation outcomes;

g) An investigation of proposed residual voids including potential for generation/mobilisation of contaminants, potential pathways for release of contaminants to waters (including groundwater) and a long-term void water balance model; and

h) A rehabilitation monitoring program sufficient to identify if required rehabilitation outcomes have been achieved.

Note: Commencement of mining is taken to be the date that extraction of material from the pit commences.

G3 Rehabilitation must commence progressively in accordance with the Plan of Operations.

G4 Residual voids (including open pits and underground workings) must not cause any serious or material environmental harm, other than the environmental harm constituted by the existence of the residual void itself, subject to any other condition within this environmental authority.

G5 All explosives, flammable or corrosive substances, hazardous chemicals, toxic substances, gases and dangerous goods must be stored and handled in accordance with:

a) The current Australian Standard where applicable; or

b) Where no relevant Australian Standard exists, store such materials within an on-site containment system sufficient to prevent release to the receiving environment.

END OF CONDITIONS FOR SCHEDULE G

Schedule H – Regulated Dams

H1 The consequence category of any structure must be assessed by a suitably qualified and experienced person in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)* at the following times:

a) prior to the design and construction of the structure, if it is not an existing structure; or

b) if it is an existing structure, prior to the adoption of this schedule; or

c) prior to any change in its purpose or the nature of its stored contents.

H2 A consequence assessment report and certification must be prepared for each structure assessed and the report may include a consequence assessment for more than one structure.

H3 Certification must be provided by the suitably qualified and experienced person who undertook the assessment, in the form set out in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)*.

Design and construction of a regulated structure

H4 Conditions H5 to H9 inclusive do not apply to existing structures.

H5 All regulated structures must be designed by, and constructed5 under the supervision of, a suitably qualified and experienced person in accordance with the requirements of the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)*.

H6 Construction of a regulated structure is prohibited unless the holder has submitted a consequence category assessment report and certification to the administering authority has been certified by a suitably qualified and experienced person for the design and design plan and the associated operating procedures in compliance with the relevant condition of this authority.

H7 Certification must be provided by the suitably qualified and experienced person who oversees the preparation of the design plan in the form set out in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)*, and must be recorded in the Regulated Dams/Levees register.

H8 Regulated structures must:

a) be designed and constructed in accordance with and conform to the requirements of the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635);*

b) be designed and constructed with due consideration given to ensuring that the design integrity would not be compromised on account of:

i) floodwaters from entering the regulated dam from any watercourse or drainage line; and

ii) possible erosion by floodwaters arising from any watercourse or drainage line.

H9 Certification by the suitably qualified and experienced person who supervises the construction must be submitted to the administering authority on the completion of construction of the regulated structure, and state that:

a) the 'as constructed' drawings and specifications meet the original intent of the design plan for that regulated structure;

b) construction of the regulated structure is in accordance with the design plan.

Operation of a regulated structure

H10 Operation of a regulated structure**,** except for an existing structure, is prohibited unless:

a) the holder has submitted to the administering authority:

i) one paper copy and one electronic copy of the design plan and certification of the 'design plan' in accordance with condition H8, and

ii) a set of 'as constructed' drawings and specifications, and

iii) certification of those 'as constructed drawings and specifications' in accordance with condition H9, and

iv) where the regulated structure is to be managed as part of an integrated containment system for the purpose of sharing the DSA volume across the system, a copy of the certified system design plan.

v) the requirements of this authority relating to the construction of the regulated structure have been met;

vi) the holder has entered the details required under this authority, into a Register of Regulated Dams; and

vii) there is a current operational plan for the regulated structures.

H11 Each regulated structure must be maintained and operated, for the duration of its operational life until decommissioned and rehabilitated, in a manner that is consistent with the current operational plan and, if applicable, the current design plan and associated certified 'as constructed' drawings.

Mandatory reporting level

H12 Conditions H14 to H17 inclusive only apply to Regulated Structures which have not been certified as low consequence category for 'failure to contain – overtopping'.

H13 The Mandatory Reporting Level (the MRL) specified in *Table H1* must be marked on a regulated dam in such a way that during routine inspections of that dam, it is clearly observable.

H14 The holder must, as soon as practical and within forty-eight (48) hours of becoming aware, notify the administering authority when the level of the contents of a regulated dam reaches the MRL.

H15 The holder must, immediately on becoming aware that the MRL has been reached, act to prevent the occurrence of any unauthorised discharge from the regulated dam.

H16 The holder must record any changes to the MRL in the Register of Regulated Structures.

Design storage allowance

H17 The holder must assess the performance of each regulated dam or linked containment system over the preceding November to May period based on actual observations of the available storage in each regulated dam or linked containment system taken prior to 1 July of each year.

H18 By 1 November of each year, storage capacity must be available in each regulated dam (or network of linked containment systems with a shared DSA volume), to meet the Design Storage Allowance (DSA) volume for the dam (or network of linked containment systems), as specified in *Table H1*.

H19 The holder must, as soon as possible and within forty-eight (48) hours of becoming aware that the regulated dam (or network of linked containment systems) will not have the available storage to meet the DSA volume on 1 November of any year, notify the administering authority.

H20 The holder must, immediately on becoming aware that a regulated dam (or network of linked containment systems) will not have the available storage to meet the DSA volume on 1 November of any year, act to prevent the occurrence of any unauthorised discharge from the regulated dam or linked containment systems.

Annual inspection report

H21 Each regulated structure must be inspected each calendar year by a suitably qualified and experienced person.

H22 At each annual inspection, the condition and adequacy of all components of the regulated structure must be assessed and a suitably qualified and experienced person must prepare an annual inspection report containing details of the assessment and include recommended actions to ensure the integrity of the regulated structure.

H23 The suitably qualified and experienced person who prepared the annual inspection report must certify the report in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)*.

H24 The holder must:

a) Within 20 business days of receipt of the annual inspection report, provide to the administering authority:

i) The recommendations section of the annual inspection report; and

ii) If applicable, any actions being taken in response to those recommendations; and

b) If, following receipt of the recommendations and (if applicable) actions, the administering authority requests a full copy of the annual inspection report from the holder, provide this to the administering authority within 10 business days[6] of receipt of the request.

Transfer arrangements

H25 The holder must provide a copy of any reports, documentation and certifications prepared under this authority, including but not limited to any Register of Regulated Structures, consequence assessment, design plan and other supporting documentation, to a new holder on transfer of this authority.

Decommissioning and rehabilitation

H26 Dams must not be abandoned but be either:

a) decommissioned and rehabilitated to achieve compliance with condition H27; or

b) be left in-situ for a beneficial use(s) provided that:

i) it no longer contains contaminants that will migrate into the environment; and

ii) it contains water of a quality that is demonstrated to be suitable for its intended beneficial use(s); and

iii) the administering authority, the holder of the environmental authority and the landholder agree in writing that the dam will be used by the landholder following the cessation of the environmentally relevant activity(ies).

H27 After decommissioning, all significantly disturbed land caused by the carrying out of the environmentally relevant activity(ies) must be rehabilitated to meet the following final acceptance criteria:

a) the landform is safe for humans and fauna;

b) the landform is stable with no subsidence or significant erosion gullies for at least three (3) years;

c) any contaminated land (e.g. contaminated soils) is remediated and rehabilitated;

d) not allowing for acid mine drainage; or

e) there is no ongoing contamination to waters (including groundwater);

f) rehabilitation is undertaken in a manner such that any actual or potential acid sulfate soils on the area of significant disturbance are treated to prevent or minimise environmental harm in accordance with the Instructions for the treatment and management of acid sulfate soils (2001);

g) all significantly disturbed land is reinstated to the pre-disturbed soil suitability class;

h) for land that is not being cultivated by the landholder:

i. groundcover, that is not a declared pest species is established and self-sustaining

ii. vegetation of similar species richness and species diversity to pre-selected analogue sites is established and suited to the post mine land use, and

iii. the maintenance requirements for rehabilitated land is no greater than that required for the land prior to its disturbance caused by carrying out the petroleum activity(ies).

i) for land that is to be cultivated by the landholder, cover crop is revegetated, unless the landholder will be preparing the site for cropping within 3 months of petroleum activities being completed.

Register of Regulated Dams

H30 A Register of Regulated Dams must be established and maintained by the holder for each regulated dam.

H31 The holder must provisionally enter the required information in the Register of Regulated Dams when a design plan for a regulated dam is submitted to the administering authority.

H32 The holder must make a final entry of the required information in the Register of Regulated Dams once compliance with condition H10 and H11 has been achieved.

H33 The holder must ensure that the information contained in the Register of Regulated Dams is current and complete on any given day.

H34 All entries in the Register of Regulated Dams must be approved by the chief executive officer for the holder of this authority, or their delegate, as being accurate and correct.

H35 The holder must, at the same time as providing the annual return, supply to the administering authority a copy of the records contained in the Register of Regulated Dams, in the electronic format required by the administering authority.

Hydraulic performance of regulated dams

H36 All regulated dams must meet the hydraulic performance criteria specified in *Table H1*.

Table H1 – Hydraulic performance criteria ('Table H1')

Name of dam	Consequence category	Hydraulic performance criteria		
		Spillway capacity	Design Storage Allowance	Mandatory Reporting Level
North Pit	Significant	1:100 to 1:1000 AEP 72 hour duration storm event	1:20 AEP 2 month wet season	1:10 AEP 72 hour duration storm event
South Pit	Significant	1:100 to 1:1000 AEP72 hour duration storm event	1:20 AEP 2 month wet season	1:10 AEP 72 hour duration storm event
WRD Dam	Significant	1:100 to 1:1000 AEP72 hour duration storm event	1:20 AEP 2 month wet season	1:10 AEP 72 hour duration storm event
ROM Dam	Significant	1:100 to 1:1000 AEP72 hour duration storm event	1:20 AEP 2 month wet season	1:10 AEP 72 hour duration storm event

END OF CONDITIONS FOR SCHEDULE H

Schedule I – Definitions

Definitions
Key terms and/or phrases used in this document are defined in this section and bolded throughout this document. Applicants should note that where a term is not defined, the definition in the *Environmental Protection Act 1994*, its regulations or environmental protection policies must be used. If a word remains undefined it has its ordinary meaning.

Acid rock drainage means any contaminated discharge emanating from a mining activity formed through a series of chemical and biological reactions, when geological strata is disturbed and exposed to oxygen and moisture.

Administering Authority is the agency that administers the environmental authority provisions under the *Environmental Protection Act 1994*.

Affected person is someone whose drinking water can potentially be impacted as a result of discharges from a dam or their life can be put at risk due to dwellings or workplaces being in the path of a dam break flood.

Airblast overpressure means energy transmitted from the blast site within the atmosphere in the form of pressure waves. The maximum excess pressure in this wave, above ambient pressure is the peak airblast overpressure measured in decibels linear (dBL).

Annual inspection report means an assessment prepared by a suitably qualified and experienced person containing details of the assessment against the most recent consequence assessment report and design plan (or system design plan);

(a) against recommendations contained in previous annual inspections reports;

(b) against recognised dam safety deficiency indicators;

(c) for changes in circumstances potentially leading to a change in consequence category;

(d) for conformance with the conditions of this authority;

(e) for conformance with the 'as constructed' drawings;

(f) for the adequacy of the available storage in each regulated dam, based on an actual observation or observations taken after 31 May each year but prior to 1 November of that year, of accumulated sediment, state of the containment barrier and the level of liquids in the dam (or network of linked containment systems);

(g) for evidence of conformance with the current operational plan.

Annual exceedance probability or AEP the probability that at least one event in excess of a particular magnitude will occur in any given year.

Appropriately qualified person means a person who has professional qualifications, training, skills or experience relevant to the nominated subject matter and can give authoritative assessment, advice and analysis on performance relating to the subject matter using the relevant protocols, standards, methods or literature.

Assessed or **assessment** by a suitably qualified and experienced person in relation to a consequence assessment of a dam, means that a statutory declaration has been made by that person and, when taken together with any attached or appended documents referenced in that declaration, all of the following aspects are addressed and are sufficient to allow an independent audit of the assessment:

(a) exactly what has been assessed and the precise nature of that determination;

(b) the relevant legislative, regulatory and technical criteria on which the assessment has been based;

(c) the relevant data and facts on which the assessment has been based, the source of that material, and the efforts made to obtain all relevant data and facts; and

(d) the reasoning on which the assessment has been based using the relevant data and facts, and the relevant criteria.

Associated works in relation to a dam, means:

(a) operations of any kind and all things constructed, erected or installed for that dam; and

(b) any land used for those operations.

Authority means an environmental authority or a development approval.

Background, with reference to the water schedule means the average of samples taken prior to the commencement of mining from the same waterway that the current sample has been taken.

Blasting means the use of explosive materials to fracture:

(a) rock, coal and other minerals for later recovery, or

(b) structural components or other items to facilitate removal from a site or for reuse.

Certification means assessment and approval must be undertaken by a suitably qualified and experienced person in relation to any assessment or documentation required by this Manual, including design plans, 'as constructed' drawings and specifications, construction, operation or an annual report regarding regulated structures, undertaken in accordance with the Board of Professional Engineers of Queensland Policy Certification by RPEQs (ID: 1.4 (2A)).

Certification, Certifying or **Certified** by an appropriately qualified and experienced person in relation to a design plan or an annual report regarding dams/structures, means that a statutory declaration has been made by that person and, when taken together with any attached or appended documents referenced in that declaration, all of the following aspects are addressed and are sufficient to allow an independent audit at any time:

a) exactly what is being certified and the precise nature of that certification

b) the relevant legislative, regulatory and technical criteria on which the certification has been based

c) the relevant data and facts on which the certification has been based, the source of that material, and the efforts made to obtain all relevant data and facts

d) the reasoning on which the certification has been based using the relevant data and facts, and the relevant criteria.

Chemical means:

a) an agricultural chemical product or veterinary chemical product within the meaning of the Agricultural and *Veterinary Chemicals Code Act 1994* (Commonwealth), or

b) a dangerous good under the Australian Code for the Transport of Dangerous Goods by Road and Rail approved by the Australian Transport Council, or

c) a lead hazardous substance within the meaning of the Workplace Health and Safety Regulation 1997, or

d) a drug or poison in the Standard for the Uniform Scheduling of Drugs and Poisons prepared by the Australian Health Ministers' Advisory Council and published by the Commonwealth, or

e) any substance used as, or intended for use as:

i. a pesticide, insecticide, fungicide, herbicide, rodenticide, nematocide, miticide, fumigant or related product, or

ii. a surface active agent, including, for example, soap or related detergent, or

iii. a paint solvent, pigment, dye, printing ink, industrial polish, adhesive, sealant, food additive, bleach, sanitiser, disinfectant, or biocide, or

iv. a fertiliser for agricultural, horticultural or garden use, or

v. a substance used for, or intended for use for mineral processing or treatment of metal, pulp and paper, textile, timber, water or wastewater, or

vi. manufacture of plastic or synthetic rubber.

Commercial place means a workplace used as an office or for business or commercial purposes, which is not part of the mining activity and does not include employees' accommodation or public roads.

Construction or constructed in relation to a regulated structure includes building a new regulated structure and lifting or otherwise modifying an existing regulated structure, but does not include investigations and testing necessary for the purpose of preparing a design plan.

Coal seam gas water means groundwater that is necessarily or unavoidably brought to the surface in the process of coal seam gas exploration or production.

Coal seam gas water concentrate means the concentrated saline water waste stream from a water treatment process that does not exceed a total dissolved solid concentration of 40 000 mg/L.

Coal seam gas evaporation dam is defined as a impoundment, enclosure or structure that is designed to be used to hold coal seam gas water for evaporation.

Consequence in relation to a structure as defined, means the potential for environmental harm resulting from the collapse or failure of the structure to perform its primary purpose of containing, diverting or controlling flowable substances.

Consequence category means a category, either low, significant or high, into which a dam is assessed as a result of the application of tables and other criteria in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)*.

Dam means a land-based structure or a void that contains, diverts or controls flowable substances, and includes any substances that are thereby contained, diverted or controlled by that land-based structure or void and **associated works**.

Dam crest volume means the volume of material (liquids and/or solids) that could be within the walls of a dam at any time when the upper level of that material is at the crest level of that dam. That is, the instantaneous maximum volume within the walls, without regard to flows entering or leaving (for example, via spillway).

Design plan is a document that contains the design, operation, monitoring and revegetation criteria of a watercourse diversion that addresses the outcomes stated in conditions on the environmental authority relating to the diversion. The document should include, but not be limited to:

a) required information under a functional design
b) the location, function and description of geomorphic and riparian vegetation features within the proposed watercourse diversion
c) results from hydrologic, hydraulic and sediment transportation modelling used in the design of the diversion
d) a revegetation and vegetation management plan (a revegetation plan) for the diversion
e) engineering drawings depicting the physical attributes and dimensions of the diversion
f) (if relevant) the staged development of a permanent watercourse diversion including the proposed use of temporary watercourse diversions with identified lifespans
g) all investigation and other reports relied on by the design
h) plans and specifications sufficient to complete construction and revegetation in accordance with the design.

Design storage allowance or DSA means an available volume, estimated in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)* published by the administering authority, must be provided in a dam as at 1 November each year in order to prevent a discharge from that dam to an annual exceedance probability (AEP) specified in that Manual.

Designer for the purposes of a regulated dam, means the certifier of the design plan for the regulated dam.

Development approval means a development approval under the *Integrated Planning Act 1997* or the *Sustainable Planning Act 2009* in relation to a matter that involves an environmentally relevant activity under the *Environmental Protection Act 1994*.

Disturbance of land includes:

a) compacting, removing, covering, exposing or stockpiling of earth
b) removal or destruction of vegetation or topsoil or both to an extent where the land has been made susceptible to erosion
c) carrying out mining within a watercourse, waterway, wetland or lake
d) the submersion of areas by tailings or hazardous contaminant storage and dam/structure walls

e) temporary infrastructure, including any infrastructure (roads, tracks, bridges, culverts, dam/structures, bores, buildings, fixed machinery, hardstand areas, airstrips, helipads etc) which is to be removed after the mining activity has ceased
f) releasing of contaminants into the soil, or underlying geological strata.

However, the following areas are not included when calculating areas of 'disturbance':

a) areas off lease (e.g. roads or tracks which provide access to the mining lease)
b) areas previously disturbed which have achieved the rehabilitation outcomes
c) by agreement with the administering authority, areas previously disturbed which have not achieved the rehabilitation objective(s) due to circumstances beyond the control of the mine operator (such as climatic conditions)
d) areas under permanent infrastructure. Permanent infrastructure includes any infrastructure (roads, tracks, bridges, culverts, dam/structures, bores, buildings, fixed machinery, hardstand areas, airstrips, helipads etc) which is to be left by agreement with the landowner
e) disturbance that pre-existed the grant of the tenure.

EC means electrical conductivity.

Effluent treated waste water released from sewage treatment plants.

Emergency action plan means documentation forming part of the operational plan held by the holder or a nominated responsible officer, that identifies emergency conditions that sets out procedures and actions that will be followed and taken by the dam owner and operating personnel in the event of an emergency. The actions are to minimise the risk and consequences of failure, and ensure timely warning to downstream communities and the implementation of protection measures. The plan must require dam owners to annually update contact.

Equilibrium: A state where 'balance' is achieved despite changing variables.

Existing structure means a structure that was in existence prior to the adoption of this schedule of conditions under the authority.

Extreme Storm Storage – means a storm storage allowance determined in accordance with the criteria in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)* published by the administering authority

Flare pit means containment area where any hydrocarbon that is discovered in an over-pressured reservoir during a drilling operation is diverted to, and combusted. The flare pit is only used during the drilling and work over process on a petroleum well.

Flowable substance means matter or a mixture of materials which can flow under any conditions potentially affecting that substance. Constituents of a flowable substance can include water, other liquids fluids or solids, or a mixture that includes water and any other liquids fluids or solids either in solution or suspension.
Functional design is a document that contains 'conceptual' information about the design, operation and revegetation criteria of a watercourse diversion that addresses the outcomes stated in the conditions on the environmental authority relating to the diversion. The document should include, but not be limited to:

a) geomorphic and vegetation assessment of the existing watercourse

b) hydrologic conditions of the existing watercourse

c) the proposed watercourse diversion route

d) results from hydrologic, hydraulic and sediment transportation modelling used in the design of the diversion.

Functionality: the purpose that something is designed or expected to fulfil.

Holder means:

a) where this document is an environmental authority, any person who is the holder of, or is acting under, that environmental authority; or

b) where this document is a development approval, any person who is the registered operator for that development approval.

Hazard category means a category, either low significant or high, into which a dam is assessed as a result of the application of tables and other criteria in 'Manual for Assessing Hazard Categories and Hydraulic Performance of Dams'.

Holder, for a mining tenement, means a holder of the tenement under the *Mineral Resources Act 1989*, and the holder of the associated environmental authority under the *Environmental Protection Act 1994.*

Hydraulic performance means the capacity of a regulated dam to contain or safely pass flowable substances based on the design criteria specified for the relevant consequence category in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)*.

Infrastructure means water storage dams, levees,, roads and tracks, buildings and other structures built for the purpose of the mining activity.

Land in the 'land schedule' of this document means land excluding waters and the atmosphere, that is, the term has a different meaning from the term as defined in the *Environmental Protection Act 1994*. For the purposes of the *Acts Interpretation Act 1954*, it is expressly noted that the term 'land' in this environmental authority relates to physical land and not to interests in land.

Land use means the selected post mining use of the land, which is planned to occur after the cessation of mining operations.

Leachate means a liquid that has passed through or emerged from, or is likely to have passed through or emerged from, a material stored, processed or disposed of at the operational land, which contains soluble, suspended or miscible contaminants likely to have been derived from the said material.

Levee means an embankment that only provides for the containment and diversion of stormwater or flood flows from a contributing catchment, or containment and diversion of flowable materials resulting from releases from other works, during the progress of those stormwater or flood flows or those releases; and does not store any significant volume of water or flowable substances at any other times.

Licensed place means the mining activities carried out at the mining tenements.

Low consequence dam means any dam that is not a high or significant consequence category as assessed using the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)*.

Low impact activities means activities which do not result in the clearing of native vegetation, cause disruption to soil profiles through earthworks or excavation, or result in significant disturbance to land which cannot be rehabilitated immediately using hand tools after the activity is completed. Examples of such activities include but are not necessarily limited to soil surveys (excluding test pits), topographic surveys, cadastral surveys and ecological surveys, the installation of monitoring equipment provided that it is within the meaning of low impact and traversing land by car or foot via existing access tracks or routes or in such a way that does not result in permanent damage to vegetation.

Mandatory reporting level or MRL means a warning and reporting level determined in accordance with the criteria in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)* published by the administering authority.

Manual means the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)* published by the administering authority.

Maximum extent of impacts means the total maximum, unabated, impact to a prescribed environmental matter that could to occur over the whole-of-project life.

Minimise is to reduce to the smallest possible amount or degree.

Modification or modifying (see definition of 'construction')

NATA means National Association of Testing Authorities, Australia.

Natural flow means the flow of water through waters caused by natural processes (*i.e.* rainfall in the catchment area and subsequent runoff into watercourses).

Non polluting means having no adverse impacts upon the receiving environment.

Notice of election has the meaning in section 18(2) *Environmental Offsets Act 2014* by which an authority holder elects to deliver an environmental offset.

Operational plan includes:

(a) Normal operating procedures and rules (including clear documentation and definition of process inputs in the DSA allowance);

(b) Contingency and emergency action plans including operating procedures designed to avoid and/or minimise environmental impacts including threats to human life resulting from any overtopping or loss of structural integrity of the regulated structure.

Peak particle velocity (ppv) means a measure of ground vibration magnitude which is the maximum rate of change of ground displacement with time, usually measured in millimetres/second (mm/s).

Permanent watercourse diversion is a man-made structure that incorporates the geomorphologic, hydraulic, hydrologic and ecological components of a local watercourse and is designed, constructed, operated and maintained according to an engineering standard that ultimately achieves a self-sustaining watercourse able to function without features or characteristics that rely on ongoing maintenance or that impose a financial or other burden on the proponent, government or the community.

Pre-existing watercourse is the section of watercourse from which the flow of water will be diverted as a result of the construction and operation of a watercourse diversion.

Prescribed environmental matters has the meaning in section 10 of the *Environmental Offsets Act 2014*, limited to the matters of State environmental significant listed in schedule 2 of the *Environmental Offsets Regulation 2014*.

Protected area means – a protected area under the *Nature Conservation Act 1992*, or

a) a marine park under the *Marine Parks Act 1992*, or

b) a World Heritage Area.

Receiving environment in relation to an activity that causes or may cause environmental harm, means the part of the environment to which the harm is, or may be, caused. The receiving environment includes (but is not limited to):

a) Waters;

b) Land;

c) Air; and

d) Any area that is not specified in Table A1 of this environmental authority.

Receiving waters means the waters into which this environmental authority authorises releases of contaminated water.

Regulated dam means any dam in the significant or high consequence category as assessed using the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)* published by the administering authority.

Register of Regulated Dams includes**:**

a) Date of entry in the register;

b) Name of the dam, its purpose and intended/actual contents;

c) The consequence category of the dam as assessed using the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635);

d) Dates, names, and reference for the design plan plus dates, names, and reference numbers of all document(s) lodged as part of a design plan for the dam;

e) Name and qualifications of the suitably qualified and experienced person who certified the design plan and 'as constructed' drawings;

f) For the regulated dam, other than in relation to any levees –

   i. The dimensions (metres) and surface area (hectares) of the dam measured at the footprint of the dam;

   ii. Coordinates (latitude and longitude in GDA94) within five metres at any point from the outside of the dam including its storage area

   iii. Dam crest volume (megalitres);

   iv. Spillway crest level (metres AHD).

   v. Maximum operating level (metres AHD);

   vi. Storage rating table of stored volume versus level (metres AHD);

   vii. Design storage allowance (megalitres) and associated level of the dam (metres AHD);

   viii. Mandatory reporting level (metres AHD);

g) The design plan title and reference relevant to the dam;

h) The date construction was certified as compliant with the design plan;

i) The name and details of the suitably qualified and experienced person who certified that the constructed dam was compliant with the design plan;

j) Details of the composition and construction of any liner;

k) The system for the detection of any leakage through the floor and sides of the dam;

l) Dates when the regulated dam underwent an annual inspection for structural and operational adequacy, and to ascertain the available storage volume for 1 November of any year;

m) Dates when recommendations and actions arising from the annual inspection were provided to the administering authority;

n) Dam water quality as obtained from any monitoring required under this authority as at 1 November of each year.

Regulated structure includes land-based containment structures, levees, bunds and voids, but not a tank or container designed and constructed to an Australian Standard that deals with strength and structural integrity.

Rehabilitation means the process of reshaping and revegetating land to restore it to a stable landform.

Release event means a discharge of water contaminated by the mining activity.

Representative means a sample set which covers the variance in monitoring or other data either due to natural changes or operational phases of the mining activities.

Residual drilling material means waste drilling materials including muds and cuttings or cement returns from well holes and which have been left behind after the drilling fluids are pumped out.

Revegetation is the re-establishment of vegetation[1] of a species and density of cover similar to surrounding undisturbed areas or the landform that existed before mining activities on soil surfaces associated with the construction or rehabilitation of a watercourse diversion.

RL means reduced level, relative to mean sea level as distinct from depths to water.

Saline drainage The movement of waters, contaminated with salts, as a result of the mining activity.

Self-sustaining means not requiring on-going intervention and maintenance to maintain functional riverine processes and characteristics

Sensitive place means:

a) a dwelling, residential allotment, mobile home or caravan park, residential marina or other residential premises, or

b) a motel, hotel or hostel, or

c) an educational institution, or

d) a medical centre or hospital, or

e) a protected area under the *Nature Conservation Act 1992*, the *Marine Parks Act 1992* or a World Heritage Area, or

f) a public park or gardens.

Significant residual impact has the meaning in section 8 *Environmental Offsets Act 2014.*

Spillway means a weir, channel, conduit, tunnel, gate or other structure designed to permit discharges form the dam, normally under flood conditions or in anticipation of flood conditions.

Structure means dam or levee.

Suitably qualified and experienced person in relation to regulated structures means a person who is a Registered Professional Engineer of Queensland (RPEQ) under the provisions of the *Professional Engineers Act 2002*, and has demonstrated competency and relevant experience:

- for regulated dams, an RPEQ who is a civil engineer with the required qualifications in dam safety and dam design.
- for regulated levees, an RPEQ who is a civil engineer with the required qualifications in the design of flood protection embankments.

Note: It is permissible that a suitably qualified and experienced person obtain subsidiary certification from an RPEQ who has demonstrated competence and relevant experience in either geomechanics, hydraulic design or engineering hydrology.

System design plan means a plan that manages an integrated containment system that shares the required DSA and/or ESS volume across the integrated containment system.

Temporary watercourse diversion is a man-made structure that may incorporate geomorphologic, hydraulic, hydrologic and ecological components of a local watercourse and is designed, constructed, operated and maintained to an engineering standard that ensures the diversion does not compromise the equilibrium and performance of the diversion and adjoining watercourses. A temporary diversion is replaced by a permanent diversion, or the re-establishment of the pre-existing watercourse, within the timeframe specified in the design plan.

the Act means the *Environmental Protection Act 1994*.

Void means any constructed, open excavation in the ground.

Water is defined under Schedule 4 of the *Water Act 2000.*

Watercourse has the meaning in Schedule 4 of the *Environmental Protection Act 1994* and means a river, creek or stream in which water flows permanently or intermittently—

(a) in a natural channel, whether artificially improved or not; or

(b) in an artificial channel that has changed the course of the watercourse.

Watercourse includes the bed and banks and any other element of a river, creek or stream confining or containing water.

Water quality means the chemical, physical and biological condition of water.

Waters includes all or any part of a river, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, unconfined water in natural or artificial watercourses, bed and banks of a watercourse, dams, non-tidal or tidal waters (including the sea), stormwater channel, stormwater drain, roadside gutter, stormwater run-off, and groundwater.

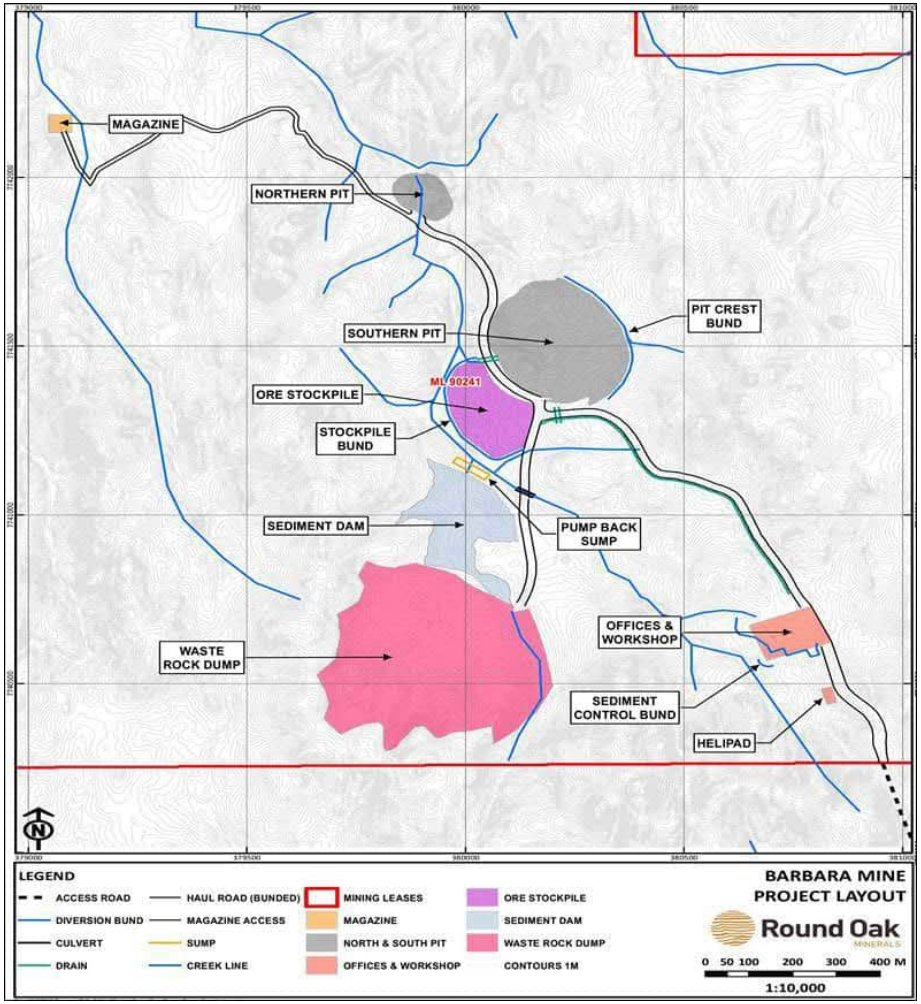
Water year means the 12-month period from 1 July to 30 June.

Wet season means the time of year, covering one or more months, when most of the average annual rainfall in a region occurs. For the purposes of DSA determination this time of year is deemed to extend from 1 November in one year to 31 May in the following year inclusive.

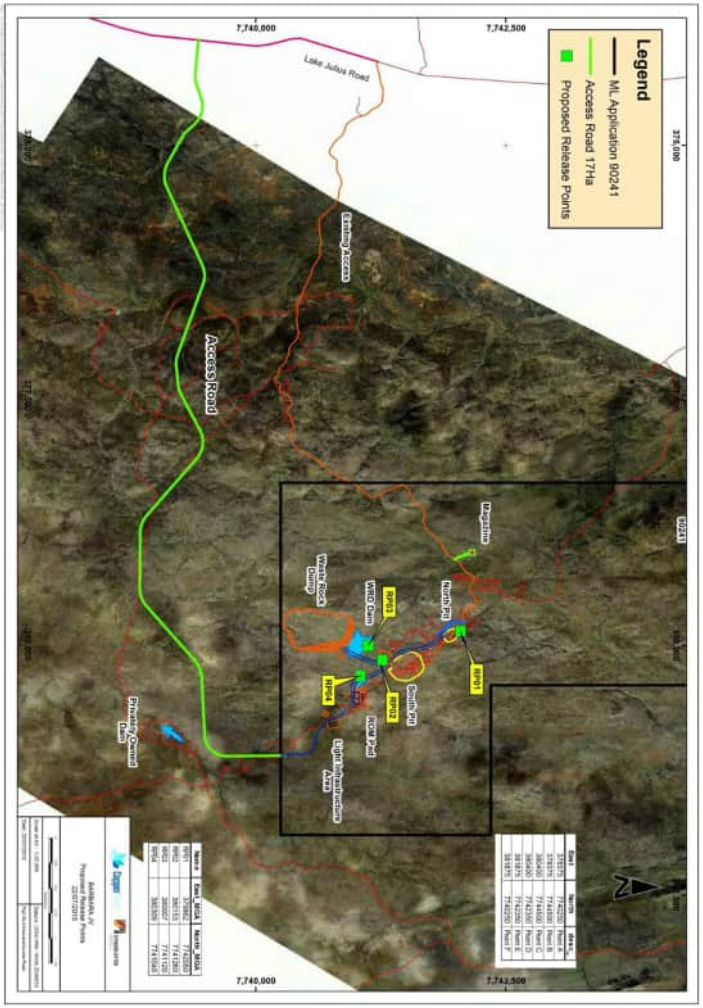
END OF SCHEDULE I

Schedule J – Maps and Plans

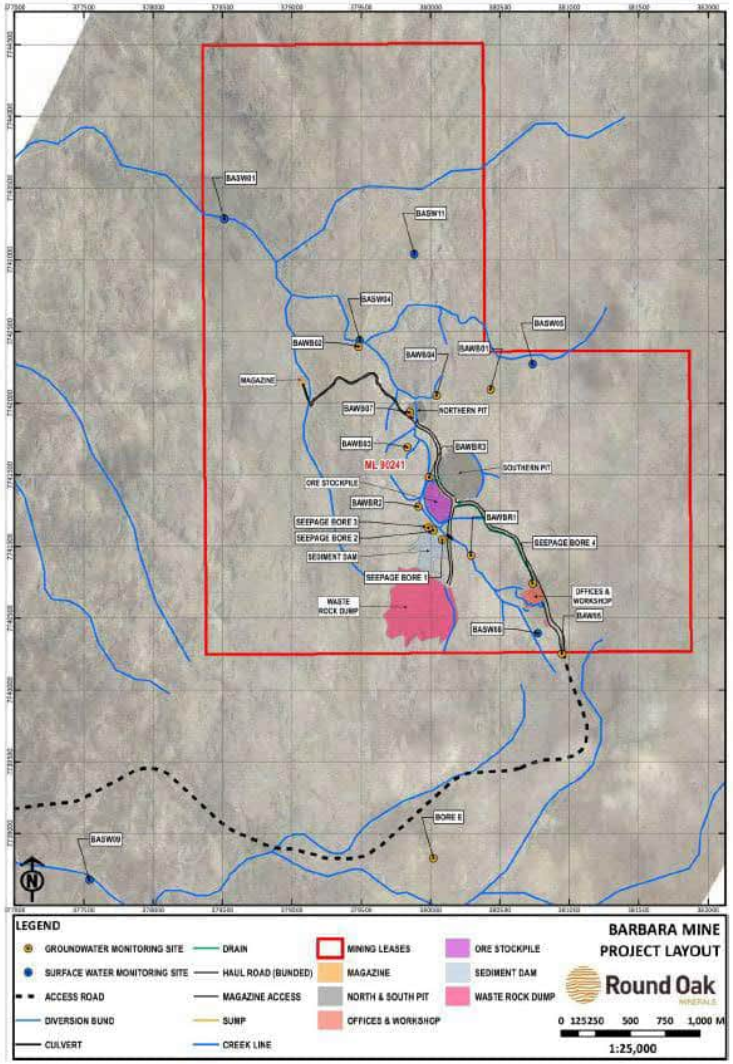
Map 1 – Location of authorised disturbance



Map 2—Release points



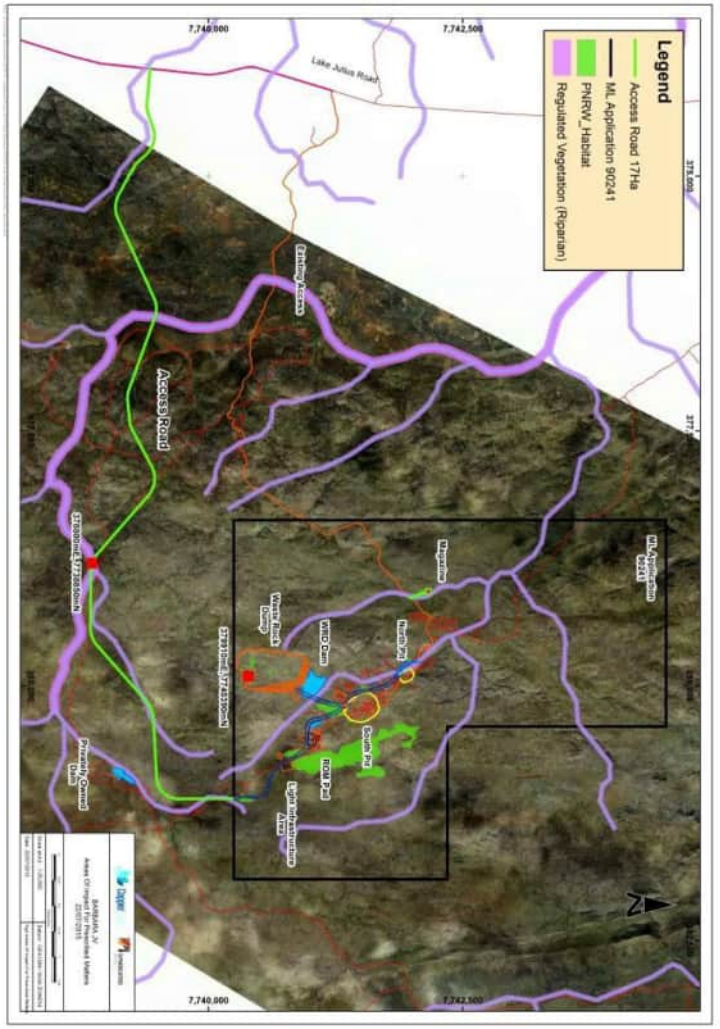
Map 3—Monitoring and reference sites



Permit

Environmental authority EPML02840015

Map 4—Areas of impact for prescribed matters



End of Schedule J

END OF PERMIT

Queensland Government

Appendix B Bore construction logs

Drill log form

Queensland Government

1028888

Authorisation details
Registered number _____ Development permit number _____ Works reference number BOWBR 1

SECTION A—LOCATION DETAILS
Name of landholder SYNDICATED METALS LTD Phone No. _____
Postal address GPO BOX 2810, PERTH WA Postcode 6000
Real property address MT ISA RD, MT ISA QLD Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 380292 Northing 7740939 Zone 54K

SECTION B—BORE COMPLETION DETAILS
Date commenced 4/10/14
Date completed 4/10/14

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☑ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
203	0	14

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	100	CLASS 12	0	6

SECTION F—CENTRALISERS TYPE

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
SLOTS	100	2.5	5	6

SECTION H—CEMENTING/ GRAVEL PACK/ ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
CEMENT	203	100	0	4
BENTONITE	203	100	4	5
4-8mm SAND	203	100	5	6

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☐ Industrial Other (please specify) MINING

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	2	RIVER STONE	
2	14	DOLERITE.	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
			DRY

Conductivity(EC) pH

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres) Depth to pump suction or bottom of drill stem (metres)
Type of test used ☐ Air ☐ Bail ☐ Pump
Est. supply (litres/second) Duration of test (hours) Drawdown level from surface (metres)

SECTION M—ARTESIAN BORE ON COMPLETION
Pressure (kPa) Free flow (litres/second) Temperature (°C)

SECTION N—REMARKS
MONITORING BORE. HOLE COLLAPSE DUE TO RIVER STONE

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided in sections A to E and section H above is true, accurate and complete to the best of my knowledge and belief.
Driller MARK SERRA Driller's Licence No. 3250
Trainee Driller _____ Driller's Licence No. _____
Signature of Driller _____ Date 4/10/14
Contractor SERRA DRILLING PTY LTD

Department of Environment and Resource Management

White — foward to the Department of Environment and Resource Management. Pink — provide to landholder. Blue — Driller to retain.

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002* (Qld) and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.derm.qld.gov.au/privacy.

Drill log form

Queensland Government

1028887

Authorisation details
Registered number _____ Development permit number _____ Works reference number BAWBR 2.

SECTION A—LOCATION DETAILS
Name of landholder SYNDICATED METALS LTD Phone No. _____
Postal address GPO BOX 2810, PERTH WA Postcode 6000
Real property address MT BARIDERA, MT ISA QLD Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 379912 Northing 7741279 Zone 54K

SECTION B—BORE COMPLETION DETAILS
Date commenced 4/10/14
Date completed 4/10/14

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☑ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
203	0	14

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	100	CLASS 12	0	3

SECTION F—CENTRALISERS TYPE

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
SLOTS	100	2.5	2	3

SECTION H—CEMENTING/ GRAVEL PACK/ ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
CEMENT	203	100	0	1
BENTONITE	203	100	1	2
4-8mm SAND	203	100	2	3

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☐ Industrial Other (please specify) MINING

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	1	RIVER STONE	
1	14	DOLERITE	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
			DRY

Conductivity(EC) pH

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres) Depth to pump suction or bottom of drill stem (metres)
Type of test used ☑ Air ☐ Bail ☐ Pump
Est. supply (litres/second) Duration of test (hours) Drawdown level from surface (metres)

SECTION M—ARTESIAN BORE ON COMPLETION
Pressure (kPa) Free flow (litres/second) Temperature (°C)

SECTION N—REMARKS
MONITORING BORE HOLE COLLAPSE DUE TO RIVER STONE.

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided in sections A to E and section H above is true, accurate and complete to the best of my knowledge and belief.
Driller MARK SERRA Driller's Licence No. 3250
Trainee Driller _____ Driller's Licence No. _____
Signature of Driller _____ Date 4/10/14
Contractor SERRA DRILLING PTY LTD

Department of Environment and Resource Management

White — foward to the Department of Environment and Resource Management. Pink — provide to landholder. Blue — Driller to retain.

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002* (Qld) and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.derm.qld.gov.au/privacy.

Drill log form

Queensland Government

1028886

Authorisation details
Registered number _____ Development permit number _____ Works reference number BAWBR 3

SECTION A—LOCATION DETAILS
Name of landholder SYNDICATED METALS LTD Phone No. _____
Postal address GPO BOX 2810, PERTH WA Postcode 6000
Real property address MT BARISERRA, MT ISA QLD Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 379991 Northing 7746485 Zone 54K

SECTION B—BORE COMPLETION DETAILS
Date commenced 4/10/14
Date completed 4/10/14

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☑ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
203	0	14

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	100	CLASS 12	0	4

SECTION F—CENTRALISERS TYPE

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
SLOTS	100	2.5	3	4

SECTION H—CEMENTING/ GRAVEL PACK/ ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
CEMENT	203	100	0	2
BENTONITE	203	100	2	3
4-8 mm SAND	203	100	3	4

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☐ Industrial Other (please specify) MINING

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	1	RIVER STONE	
1	14	DOLERITE.	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
			DRY

Conductivity(EC) _____ pH _____

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres) _____ Depth to pump suction or bottom of drill stem (metres) _____
Type of test used ☐ Air ☐ Bail ☐ Pump
Est. supply (litres/second) _____ Duration of test (hours) _____ Drawdown level from surface (metres) _____

SECTION M—ARTESIAN BORE ON COMPLETION
Pressure (kPa) _____ Free flow (litres/second) _____ Temperature (°C) _____

SECTION N—REMARKS
MONITORING BORE.
HOLE COLLAPSE DUE TO RIVER STONE

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided in sections A to E and section H above is true, accurate and complete to the best of my knowledge and belief.
Driller MARK SERRA Driller's Licence No. 3250
Trainee Driller _____ Driller's Licence No. _____
Signature of Driller _____ Date 4/10/14
Contractor SERRA DRILLING PTY LTD

White — foward to the Department of Environment and Resource Management. Pink — provide to landholder. Blue — Driller to retain.

epartment of Environment and Resource Management

e information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department d will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002* (Qld) and may be stored in a departmental database. For more information on the department's privacy commitment, please sit (www.derm.qld.gov.au/privacy).

Drill log form

sampled.

Queensland Government

1028998

Authorisation details
Registered number _____ Development permit number _____ Works reference number WB "E"

SECTION A—LOCATION DETAILS
Name of landholder SYNDICATED METALS LTD Phone No. _____
Postal address GPO BOX 2810, PERTH WA Postcode 6000
Real property address MT BARISERRA, MT ISA QLD Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 380026 Northing 7735835 Zone 54K

SECTION B—BORE COMPLETION DETAILS
Date commenced 26/9/14
Date completed 26/9/14

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☑ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
203	0	83

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	142	CLASS 12	0	83

SECTION F—CENTRALISERS TYPE

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
SLOTS	142	2.5	28	83

SECTION H—CEMENTING/ GRAVEL PACK/ ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
CEMENT	203	142	0	12
BENTONITE	203	142	12	14
4-8 mm SAND	203	142	14	83

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☐ Industrial Other (please specify) MINING

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	11	DECOMPOSED SCHIST	
11	29	BAKED BASALT	
29	31	FRACTURED BASALT	0.5
31	46	BASALT	
46	47	FRACTURED BASALT	0.3
47	83	BASALT / DOLERITE.	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
29	28.1	0.5	
46		0.3	

Conductivity(EC) 1162 pH _____

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level 28.1 (metres) Depth to pump suction or bottom of drill stem 83 (metres)
Type of test used ☑ Air ☐ Bail ☐ Pump
Est. supply 0.8 (litres/second) Duration of test 2 (hours) Drawdown level from surface (metres) _____

SECTION M—ARTESIAN BORE ON COMPLETION
Pressure (kPa) _____ Free flow (litres/second) _____ Temperature (°C) _____

SECTION N—REMARKS
PLACE PUMP SUCTION @ 60 M

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided in sections A to E and section H above is true, accurate and complete to the best of my knowledge and belief.
Driller MARK SERRA Driller's Licence No. 3250
Trainee Driller PETER SERRA / MORGAN GUNN Driller's Licence No. _____
Signature of Driller _____ Date 26/9/14
Contractor SERRA DRILLING PTY LTD

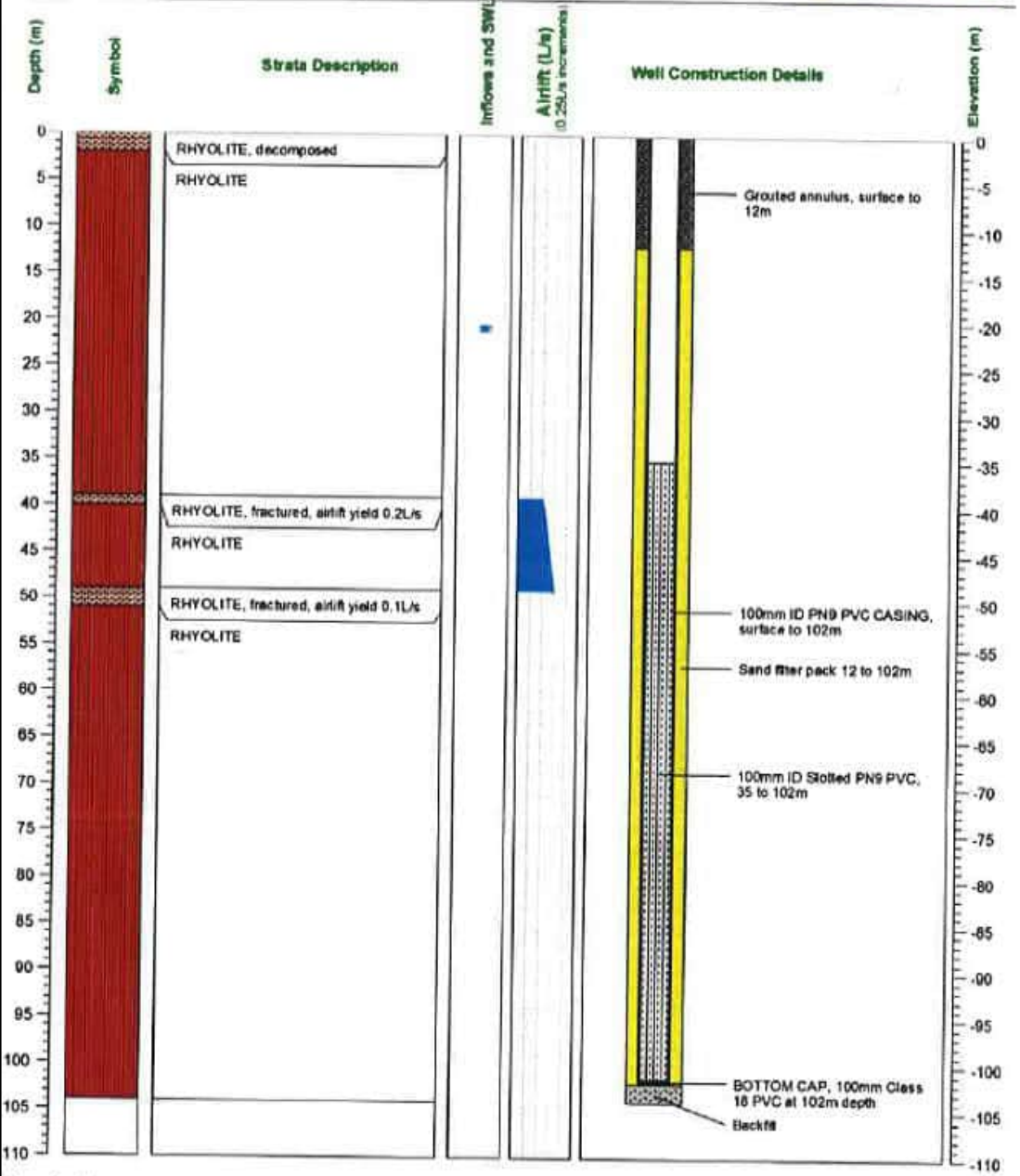
White — foward to the Department of Environment and Resource Management. Pink — provide to landholder. Blue — Driller to retain.

epartment of Environment and Resource Management

e information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department d will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002* (Qld) and may be stored in a departmental database. For more information on the department's privacy commitment, please sit (www.derm.qld.gov.au/privacy).

Borehole No: BAWB05
Location: Barbara **Date Drilled:** 1/2/2014
Easting: 380948 **Northing:** 7740252
Method: Rotary Air Blast **Driller:** M Serra

Client: Syndicated Metals/Copperchem
Project:
GL Elev (m):
Drilling Rig:



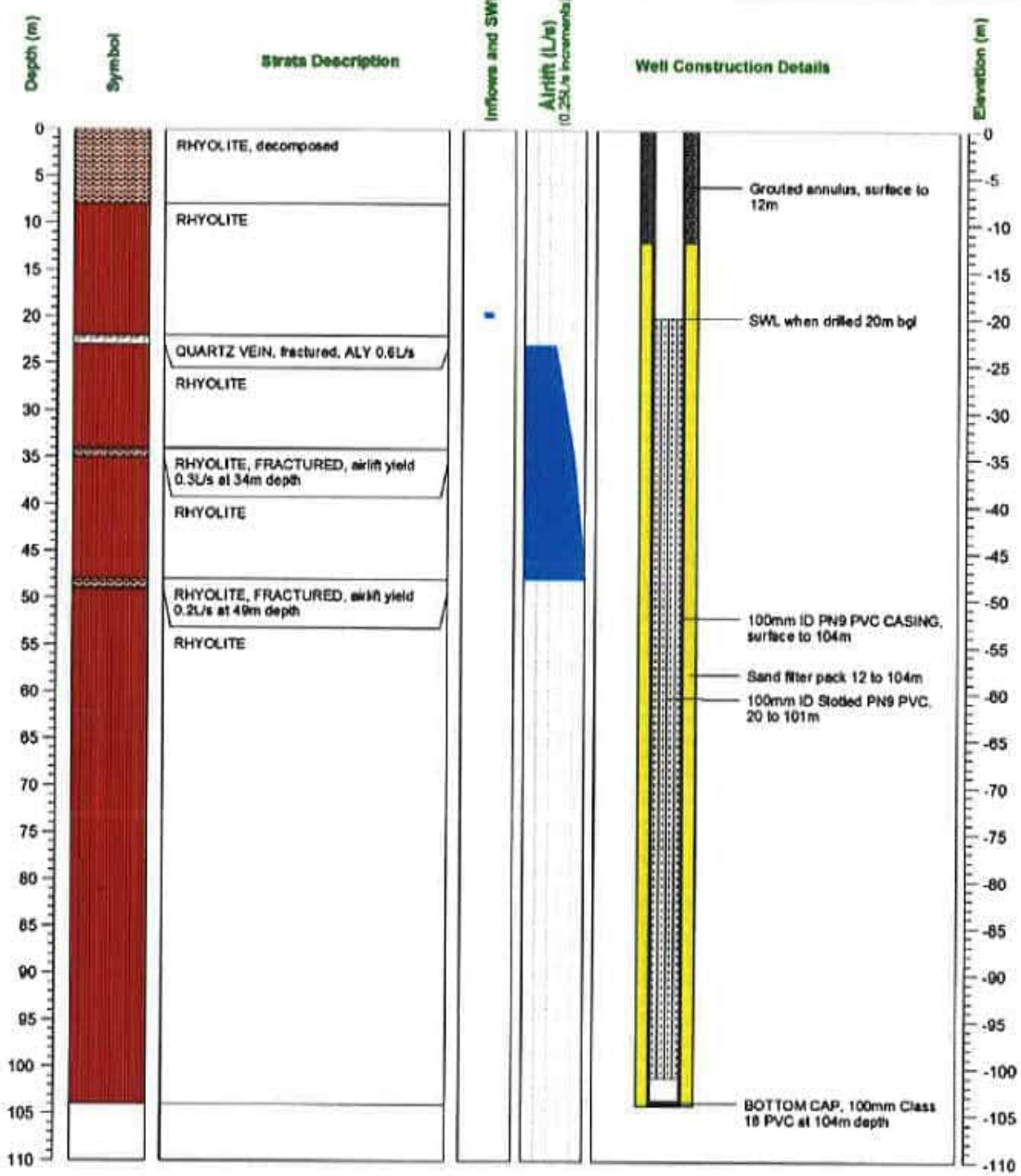
Notes:

Datum:GDA94

Barbara Project
Strata description compiled by driller

Borehole No: BAWB01
Location: Barbara **Date Drilled:** 31/1/2014
Easting: 380432 **Northing:** 7741097
Method: Rotary Air Blast **Driller:** M Serra

Client: Syndicated Metals/Copperchem
Project:
GL Elev (m):
Drilling Rig:



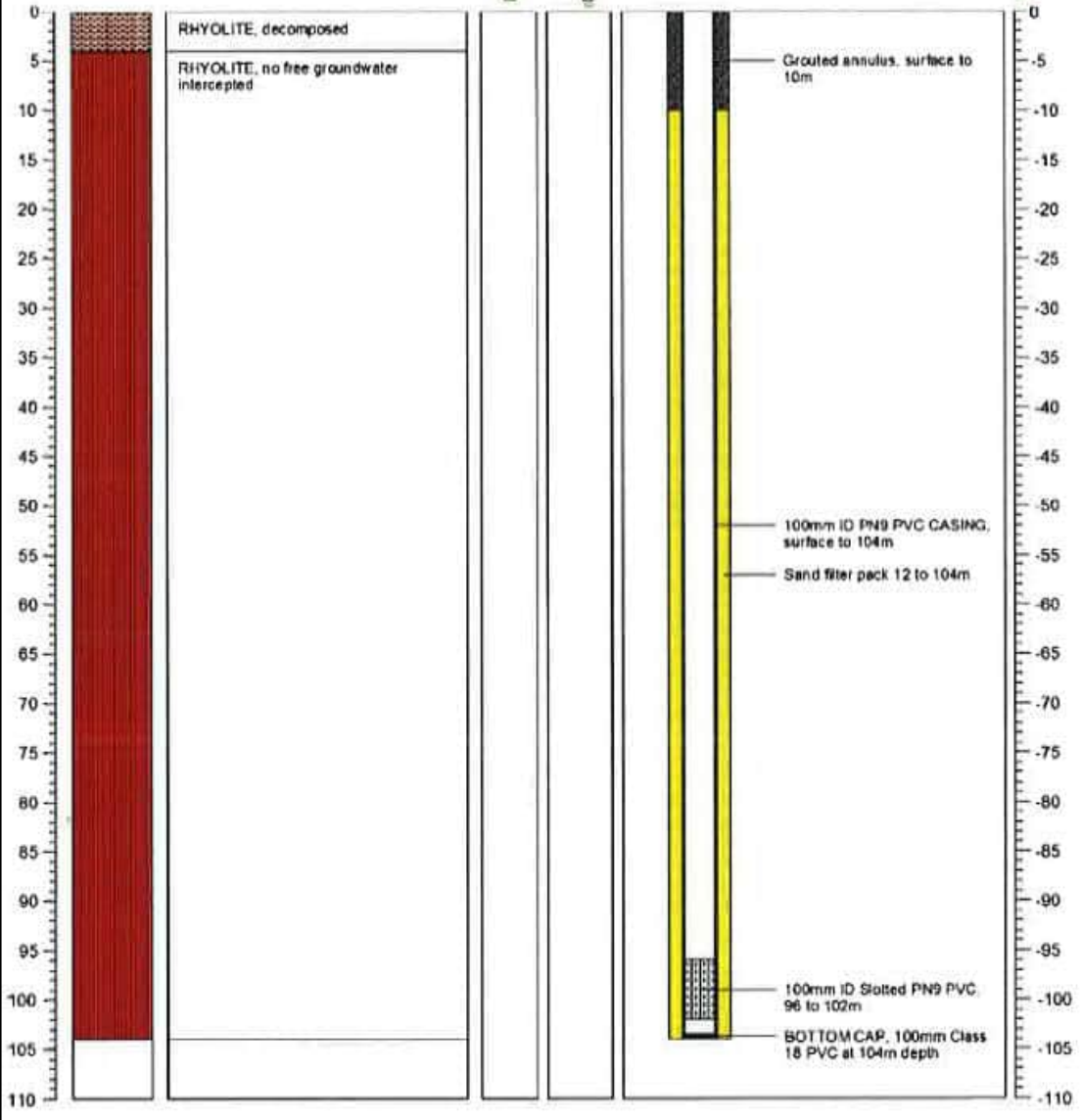
Notes:

Datum:GDA94

Barbara Project
Strata description compiled by driller

Borehole No: BAWB02
Location: Barbara **Date Drilled:** 2/2/2014
Easting: 379480 **Northing:** 7742395
Method: Rotary Air Blast **Driller:** M Serra

Client: Syndicated Metals/Copperchem
Project:
GL Elev (m):
Drilling Rig:



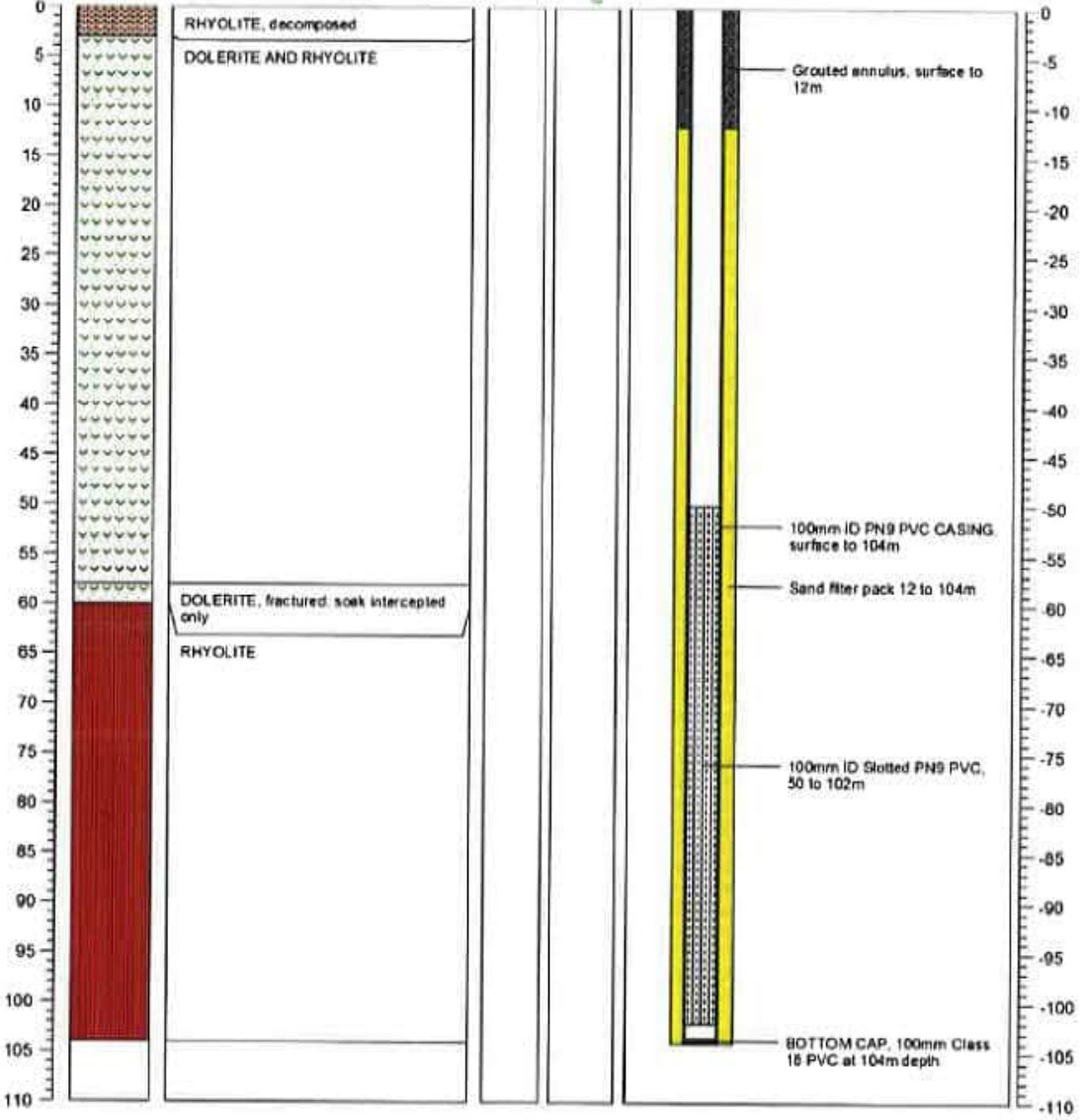
Notes:

Datum:GDA94

Barbara Project
Strata description compiled by driller

Borehole No: BAWB03
Location: Barbara **Date Drilled:** 26/1/2014
Easting: 379834 **Northing:** 7741692
Method: Rotary Air Blast **Driller:** M Serra

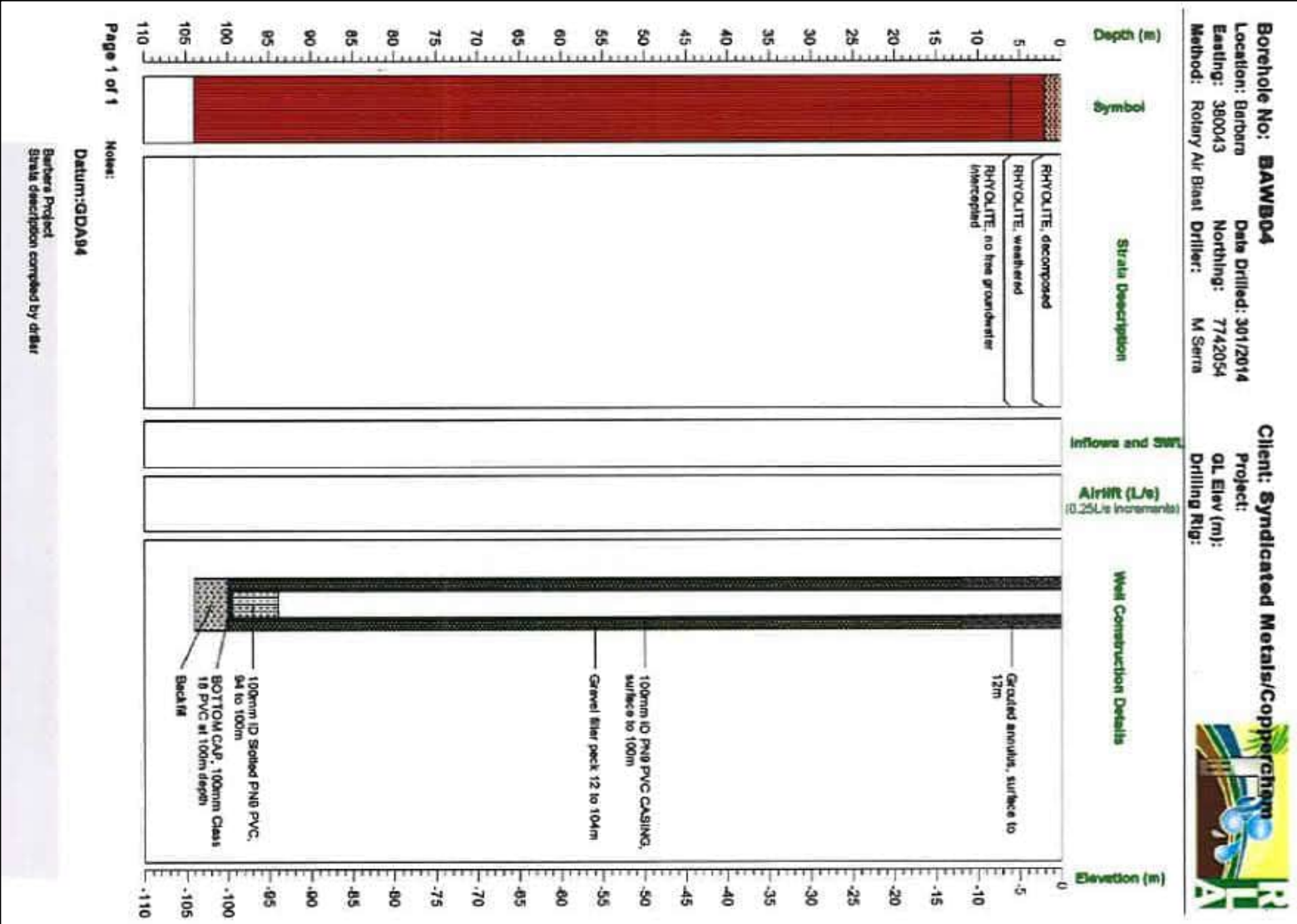
Client: Syndicated Metals/Copperchem
Project:
GL Elev (m):
Drilling Rig:



Notes:

Datum:GDA94

Barbara Project
Strata description compiled by driller



Drill log form

1028993

Queensland Government

Authorisation details
Registered number _____ Development permit number _____ Works reference number BAR E 065

SECTION A—LOCATION DETAILS
Name of landholder SYNDICATED METALS LTD Phone No. _____
Postal address GPO BOX 2810, PERTH WA Postcode 6000
Real property address MT BARBARA, MT ISA QLD Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 038052 Northing 7741711 Zone 54K

SECTION B—BORE COMPLETION DETAILS
Date commenced 4/2/14
Date completed 5/2/14

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☑ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
200	0	127

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	142	CLASS 12	0	127

SECTION F—CENTRALISERS TYPE

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
SLOTS	142	3	30	127

SECTION H—CEMENTING/ GRAVEL PACK/ ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
~~CEMENT~~ FOAM	200	142	0	6

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☑ Industrial Other (please specify) MINING

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed this(*)
0	1	DECOMPOSED RHORLITE	
1	33	RHORLITE	
33	35	FRACTURED RHORLITE @ 0.6	
35	38	FRACTURED RHORLITE @ 4	
38	127	RHORLITE.	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
33	21m	0.6	POTABLE
35		4	

Conductivity(EC) 960 MS pH

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level 21 (metres)
Depth to pump suction or bottom of drill stem 127 (metres)
Type of test used ☑ Air ☐ Bail ☐ Pump

Est. supply (litres/second)	Duration of test (hours)	Drawdown level from surface (metres)

SECTION M—ARTESIAN BORE ON COMPLETION

Pressure (kPa)	Free flow (litres/second)	Temperature (°C)

SECTION N—REMARKS
NOT FOR PERMANENT WATER SUPPLY. PLACE PUMP SUCTION @ 60m.

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided in sections A to E and section H above is true, accurate and complete to the best of my knowledge and belief.

Driller MARK SERRA Driller's Licence No. 3250
Trainee Driller _____ Driller's Licence No. _____
Signature of Driller _____ Date 5/2/14
Contractor SERRA DRILLING PTY LTD

White — foward to the Department of Environment and Resource Management. Pink — provide to landholder. Blue — Driller to retain

Department of Environment and Resource Management

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002* (Qld) and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.derm.qld.gov.au/privacy.

Drill log form

Queensland Government

1028992

Authorisation details
Registered number _____ Development permit number _____ Works reference number BARC 071

SECTION A—LOCATION DETAILS
Name of landholder SYNDICATED METALS LTD Phone No. _____
Postal address GPO BOX 2810, PERTH WA Postcode 6000
Real property address MT BARKBARA, MT ISA QLD Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 0379859 Northing 7741935 Zone 54K

SECTION B—BORE COMPLETION DETAILS
Date commenced 3/2/14
Date completed 4/2/14

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☑ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
200	0	146

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	142	CLASS 18	0	146

SECTION F—CENTRALISERS TYPE

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
SLOTS	142	3	18	146

SECTION H—CEMENTING/ GRAVEL PACK/ ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
Form	200	142	0	6

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☑ Industrial Other (please specify) MINING

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	3	DECOMPOSED RHORLITE	
3	19	RHORLITE	
19	22	FRACTURED RHORLITE * 0.5	
22	108	RHORLITE	
108	109	FRACTURED RHORLITE * 0.3	
109	146	RHORLITE.	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
19	15m	0.5	POTABLE.
108		0.3	

Conductivity(EC) 990 mS pH

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level 15 (metres)
Depth to pump suction or bottom of drill stem 146 (metres)
Type of test used ☑ Air ☐ Bail ☐ Pump

Est. supply (litres/second)	Duration of test (hours)	Drawdown level from surface (metres)
0.7	2	

SECTION M—ARTESIAN BORE ON COMPLETION

Pressure (kPa)	Free flow (litres/second)	Temperature (°C)

SECTION N—REMARKS
NOT FOR PERMANANT WATER SOURCE, PLACE PUMP SUCTION @ 120 m

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided in sections A to E and section H above is true, accurate and complete to the best of my knowledge and belief.
Driller MARK SERRA Driller's Licence No. 3250
Trainee Driller _____ Driller's Licence No. _____
Signature of Driller _____ Date 4/2/14
Contractor SERRA DRILLING PTY LTD

Department of Environment and Resource Management

White — foward to the Department of Environment and Resource Management. Pink — provide to landholder. Blue — Driller to retain.

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002* (Qld) and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.derm.qld.gov.au/privacy.

Drill log form

Queensland Government

1028991

Authorisation details
Registered number _____ Development permit number _____ Works reference number BAWB 02

SECTION A—LOCATION DETAILS
Name of landholder SYNDICATED METAL LTD Phone No. _____
Postal address GPO BOX 2810 PERTH WA Postcode 6000
Real property address MT BARKBARA, MT ISA QLD Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 0379480 Northing 7742395 Zone 54K

SECTION B—BORE COMPLETION DETAILS
Date commenced 2/2/14
Date completed 2/2/14

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☑ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
200	0	104

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	142	CLASS 12	0	102

SECTION F—CENTRALISERS TYPE

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
SLOTS	142	3	96	102

SECTION H—CEMENTING/ GRAVEL PACK/ ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
CEMENT	200	142	0	10
4-8 mm GRAVEL/SAND	200	142	10	102

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☑ Industrial Other (please specify) MINING.

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	4	DECOMPOSED RHORLITE	
4	104	RHORLITE	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)

Conductivity(EC) pH

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres)
Depth to pump suction or bottom of drill stem 102 (metres)
Type of test used ☑ Air ☐ Bail ☐ Pump

Est. supply (litres/second)	Duration of test (hours)	Drawdown level from surface (metres)

SECTION M—ARTESIAN BORE ON COMPLETION

Pressure (kPa)	Free flow (litres/second)	Temperature (°C)

SECTION N—REMARKS
DRY MONITORING BORE

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided in sections A to E and section H above is true, accurate and complete to the best of my knowledge and belief.
Driller MARK SERRA Driller's Licence No. 3250
Trainee Driller _____ Driller's Licence No. _____
Signature of Driller _____ Date 2/2/14
Contractor SERRA DRILLING PTY LTD

Department of Environment and Resource Management

White — foward to the Department of Environment and Resource Management. Pink — provide to landholder. Blue — Driller to retain.

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002* (Qld) and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.derm.qld.gov.au/privacy.

Drill log form

Queensland Government

1028990

Authorisation details
Registered number _____ Development permit number _____ Works reference number BAWB05

SECTION A—LOCATION DETAILS
Name of landholder SYNDICATED METALS LTD Phone No. _____
Postal address GPO BOX 2810, PERTH WA Postcode 6000
Real property address MT BARIBARA', MT ISA QLD Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 0380948 Northing 7740252 Zone 54K

SECTION B—BORE COMPLETION DETAILS
Date commenced 1/12/14
Date completed 1/12/14

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☑ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
200	0	104

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	100	CLASS 18	0	102

SECTION F—CENTRALISERS TYPE

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
SLOTS	100	3	35	102

SECTION H—CEMENTING/ GRAVEL PACK/ ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
CEMENT	200	100	0	12
4-8mm SAND	200	100	12	102

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☑ Industrial Other (please specify) MINING.

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	2	DECOMPOSED RHORLITE	
2	39	RHORLITE	
39	40	FRACTURED RHORLITE	* 0.2
40	49	RHORLITE	
49	51	FRACTURED RHORLITE	* 0.1
51	104	RHORLITE.	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
39	21m	0.2	
49		0.1	

Conductivity(EC) 960 mS pH

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level _____ (metres)
Depth to pump suction or bottom of drill stem 102 (metres)
Type of test used ☑ Air ☐ Bail ☐ Pump
Est. supply 0.3 (litres/second) Duration of test 2 (hours) Drawdown level from surface _____ (metres)

SECTION M—ARTESIAN BORE ON COMPLETION
Pressure _____ (kPa) Free flow _____ (litres/second) Temperature _____ (°C)

SECTION N—REMARKS
MONITORING BORE.

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided in sections A to E and section H above is true, accurate and complete to the best of my knowledge and belief.
Driller MARK SERRA Driller's Licence No. 3250
Trainee Driller _____ Driller's Licence No. _____
Signature of Driller _____ Date 1/2/14
Contractor SERRA DRILLING PTY LTD

Department of Environment and Resource Management

White — foward to the Department of Environment and Resource Management. Pink — provide to landholder. Blue — Driller to retain.

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002* (Qld) and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.derm.qld.gov.au/privacy.

Drill log form

Queensland Government

1028989

Authorisation details
Registered number _____ Development permit number _____ Works reference number BAWB 01

SECTION A—LOCATION DETAILS
Name of landholder SYNDICATED METALS PTY LTD Phone No. _____
Postal address GPO BOX 2810, PERTH WA Postcode 6000
Real property address MT BARIBARA, MT ISA QLD Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 0380432 Northing 7741097 Zone 54K

SECTION B—BORE COMPLETION DETAILS
Date commenced 30/01/14
Date completed 31/01/14

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☑ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
200	0	104

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	100	CLASS 9	0	104

SECTION F—CENTRALISERS TYPE

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
SLOTS	100	3	20	101

SECTION H—CEMENTING/ GRAVEL PACK/ ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
CEMENT	200	100	0	12
4-8mm SAND	200	100	12	101

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☑ Industrial Other (please specify) MINING.

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	8	DECOMPOSED RHORLITE	
8	22	RHORLITE	
22	23	FRACTURED QUARTZ	* 0.5
23	34	RHORLITE	
34	35	FRACTURED RHORLITE	* 0.3
35	48	RHORLITE	
48	49	FRACTURED RHORLITE	* 0.2
49	104	RHORLITE.	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
23		0.5	
34	20m	0.3	POTABLE
48		0.2	

Conductivity(EC) 920 mS pH

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level 20 (metres)
Depth to pump suction or bottom of drill stem 101 (metres)
Type of test used ☑ Air ☐ Bail ☐ Pump
Est. supply 1 (litres/second) Duration of test 2 (hours) Drawdown level from surface _____ (metres)

SECTION M—ARTESIAN BORE ON COMPLETION
Pressure _____ (kPa) Free flow _____ (litres/second) Temperature _____ (°C)

SECTION N—REMARKS
MONITORING BORE.

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided in sections A to E and section H above is true, accurate and complete to the best of my knowledge and belief.
Driller MARK SERRA Driller's Licence No. 3250
Trainee Driller _____ Driller's Licence No. _____
Signature of Driller _____ Date 31/01/14
Contractor SERRA DRILLING PTY LTD

Department of Environment and Resource Management

White — foward to the Department of Environment and Resource Management. Pink — provide to landholder. Blue — Driller to retain.

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002* (Qld) and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.derm.qld.gov.au/privacy.

Drill log form

Queensland Government

1028988

Authorisation details
Registered number _____ Development permit number _____ Works reference number BAWB04

SECTION A—LOCATION DETAILS
Name of landholder SYNDICATED METALS LTD Phone No. _____
Postal address GPO BOX 2810, PERTH WA Postcode 6000
Real property address MT BARIBARA, MT ISA Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 038004.3 Northing 7742054 Zone 54K

SECTION B—BORE COMPLETION DETAILS
Date commenced 29/01/14
Date completed 30/01/14

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool ☐ Auger ☑ Rotary air ☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
200	0	104

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	100	CLASS 9	0	100

SECTION F—CENTRALISERS TYPE

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
SLOTS	100	3	94	100

SECTION H—CEMENTING/ GRAVEL PACK/ ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
CEMENT	200	100	0	12
4-8mm RIVER GRAVEL	200	100	12	100

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☑ Industrial Other (please specify) MINING.

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	2	DECOMPOSED RHOLITE	
2	6	WEATHERED RHOLITE	
6	104	RHOLITE.	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)

Conductivity(EC) pH

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres) Depth to pump suction or bottom of drill stem 100 (metres)
Type of test used ☑ Air ☐ Bail ☐ Pump

Est. supply (litres/second)	Duration of test (hours)	Drawdown level from surface (metres)

SECTION M—ARTESIAN BORE ON COMPLETION

Pressure (kPa)	Free flow (litres/second)	Temperature (°C)

SECTION N—REMARKS
DRY MONITORING BORE.

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided in sections A to E and section H above is true, accurate and complete to the best of my knowledge and belief.
Driller MARK SERRA Driller's Licence No. 3250
Trainee Driller _____ Driller's Licence No. _____
Signature of Driller _____ Date 30/01/14
Contractor SERRA DRILLING PTY LTD

Department of Environment and Resource Management

White — foward to the Department of Environment and Resource Management. Pink — provide to landholder. Blue — Driller to retain.

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002* (Qld) and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.derm.qld.gov.au/privacy.

Drill log form

Queensland Government

1028987

Authorisation details
Registered number _____ Development permit number _____ Works reference number BAWB03

SECTION A—LOCATION DETAILS
Name of landholder SYNDICATED METALS LTD Phone No. _____
Postal address GPO BOX 2810, PERTH WA Postcode 6000
Real property address MT BARIBARA, MT ISA Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 037934 Northing 7741692 Zone 54K

SECTION B—BORE COMPLETION DETAILS
Date commenced 26/01/2014
Date completed / /

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool ☐ Auger ☑ Rotary air ☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
200	0	104

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	100	CLASS 9	0	102

SECTION F—CENTRALISERS TYPE

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
SLOTS	100	3	50	102

SECTION H—CEMENTING/ GRAVEL PACK/ ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
CEMENT	200	100	0	12
4-8 mm RIVER GRAVEL	200	100	12	102

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☑ Industrial Other (please specify) MINING

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	3	DECOMPOSED ROLLITE/ DOLLOMITE.	
3	58	DOLLARITE/RHOROLITE	
58	60	FRACTURED DOLLARITE & SOME	
60	104	RHOROLITE.	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)

Conductivity(EC) pH

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres) Depth to pump suction or bottom of drill stem 102 (metres)
Type of test used ☑ Air ☐ Bail ☐ Pump

Est. supply (litres/second)	Duration of test (hours)	Drawdown level from surface (metres)
	4	

SECTION M—ARTESIAN BORE ON COMPLETION

Pressure (kPa)	Free flow (litres/second)	Temperature (°C)

SECTION N—REMARKS
MONITORING BORE. DRY

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided in sections A to E and section H above is true, accurate and complete to the best of my knowledge and belief.
Driller MARK SERRA Driller's Licence No. 3250
Trainee Driller _____ Driller's Licence No. _____
Signature of Driller _____ Date 26/01/14
Contractor SERRA DRILLING PTY LTD

Department of Environment and Resource Management

White — foward to the Department of Environment and Resource Management. Pink — provide to landholder. Blue — Driller to retain.

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002* (Qld) and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.derm.qld.gov.au/privacy.

Water bore drilling log

Barbara Seepage Bores

Queensland Government

2003994

Authorisation details
Registered number _____ Development permit number _____ Works reference number _____

SECTION A—LOCATION DETAILS
Name of landholder Round Oak Phone No. _____
Postal address _____ Postcode _____
Real property address Barbara Copper Project Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 340085 Northing 7241042 Zone _____

SECTION B—BORE COMPLETION DETAILS
Date commenced 15 / 1 / 19
Date completed 16 / 1 / 19

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☒ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
165	0	6

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☐ Industrial Other (please specify) Seepage Bore

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	6	Granite	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
	Dry		

Conductivity (µS/cm) _____ pH _____

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	125	4.9	0	6

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres) _____ Depth to pump suction or bottom of drill stem (metres) _____
Type of test used ☐ Air ☐ Bail ☐ Pump
Estimated supply (litres/second) _____ Duration of test (hours) _____ Drawdown level from surface (metres) _____

SECTION F—CENTRALISERS

Type	Location (metres) From	To

SECTION M—ARTESIAN BORE ON COMPLETION
Shut-in pressure (kPa) _____ Free flow (litres/second) _____ Temperature (°C) _____

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
PVC	125	1.0	1	5

SECTION N—REMARKS
SBIA

SECTION H—CEMENTING/GRAVEL PACK/ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
Concrete	190	125	0	0.5
Bentonite	190	125	0.5	1
Gravel Pack	190	125	1	6
		Stop Gravel Pack		

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided is true and accurate.
Driller R Watkins Driller's licence no. 3740
Trainee driller _____ Driller's licence no. _____
Signature of driller _____ Date 29 / 1 / 19
Contractor Kelly Drilling

Department of Natural Resources and Mines

White — foward to the Department of Natural Resources and Mines Pink — provide to landholder Blue — Driller to retain

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002 (Qld)* and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.dnrm.qld.gov.au.

Water bore drilling log

Queensland Government

2003995

Authorisation details
Registered number _____ Development permit number _____ Works reference number _____

SECTION A—LOCATION DETAILS
Name of landholder Round Oak Phone No. _____
Postal address _____ Postcode _____
Real property address Barbara Copper Project Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 340085 Northing 7241042 Zone _____

SECTION B—BORE COMPLETION DETAILS
Date commenced 16 / 1 / 19
Date completed 16 / 1 / 19

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☒ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
190	0	16

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☐ Industrial Other (please specify) _____

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	11	Granite	
11	11.5	Granite (water)	*
11.5	16	Granite	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
11	7	0.2	

Conductivity (µS/cm) 500 pH 6.9

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	125	4.9	0	16

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres) _____ Depth to pump suction or bottom of drill stem (metres) _____
Type of test used ☐ Air ☐ Bail ☐ Pump
Estimated supply (litres/second) _____ Duration of test (hours) _____ Drawdown level from surface (metres) _____

SECTION F—CENTRALISERS

Type	Location (metres) From	To

SECTION M—ARTESIAN BORE ON COMPLETION
Shut-in pressure (kPa) _____ Free flow (litres/second) _____ Temperature (°C) _____

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
PVC	125	1.0	5	15

SECTION N—REMARKS
SBIB

SECTION H—CEMENTING/GRAVEL PACK/ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
Concrete	190	125	0	2
Bentonite	190	125	2	3
Gravel Pack	190	125	3	16
	190	Sump pad		

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided is true and accurate.
Driller R Watkins Driller's licence no. 3740
Trainee driller _____ Driller's licence no. _____
Signature of driller _____ Date 29 / 1 / 19
Contractor Kelly Drilling

Department of Natural Resources and Mines

White — foward to the Department of Natural Resources and Mines Pink — provide to landholder Blue — Driller to retain

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002 (Qld)* and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.dnrm.qld.gov.au.

Water bore drilling log

Queensland Government

2003992

Authorisation details
Registered number _____ Development permit number _____ Works reference number _____

SECTION A—LOCATION DETAILS
Name of landholder Round Oak Phone No. _____
Postal address _____ Postcode _____
Real property address Barbara copper Project Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 290077 Northing 7741115 Zone _____

SECTION B—BORE COMPLETION DETAILS
Date commenced 15 / 7 / 19
Date completed 16 / 7 / 19

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☒ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
195	0	6

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	125	PN9	0	6

SECTION F—CENTRALISERS

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
PVC	125	1.0	1	5

SECTION H—CEMENTING/GRAVEL PACK/ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
Cement	195	125	0	0.5
Bentonite	195	125	0.5	1
Gravel	195	125	1	6

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☐ Industrial Other (please specify) Seepage Bore

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	6	Granite	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
		Dry	

Conductivity (µS/cm) _____ pH _____

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres) _____ Depth to pump suction or bottom of drill stem (metres) _____
Type of test used ☐ Air ☐ Bail ☐ Pump
Estimated supply (litres/second) _____ Duration of test (hours) _____ Drawdown level from surface (metres) _____

SECTION M—ARTESIAN BORE ON COMPLETION
Shut-in pressure (kPa) _____ Free flow (litres/second) _____ Temperature (°C) _____

SECTION N—REMARKS
SB2A

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided is true and accurate.
Driller R Watkins Driller's licence no. 3470
Trainee driller _____ Driller's licence no. _____
Signature of driller _____ Date 17 / 7 / 19
Contractor Kelly drilling

Department of Natural Resources and Mines

White — foward to the Department of Natural Resources and Mines Pink — provide to landholder Blue — Driller to retain

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002 (Qld)* and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.dnrm.qld.gov.au.

Water bore drilling log

Queensland Government

2003993

Authorisation details
Registered number _____ Development permit number _____ Works reference number _____

SECTION A—LOCATION DETAILS
Name of landholder Round Oak Phone No. _____
Postal address _____ Postcode _____
Real property address Barbara copper Project Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 290077 Northing 7741115 Zone _____

SECTION B—BORE COMPLETION DETAILS
Date commenced 15 / 7 / 19
Date completed 16 / 7 / 19

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☒ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
195	0	16

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	125	PN9	0	16

SECTION F—CENTRALISERS

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
PVC	125	1.0	15	16

SECTION H—CEMENTING/GRAVEL PACK/ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
Cement	195	125	0	4
Bentonite	195	125	4	5
Gravel Pack	195	125	5	16
		TOP CEMENT SEAL		

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☐ Industrial Other (please specify) _____

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	10	Granite	
10	103	Granite (Water)	*
103	16	Granite	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
76	3	0.7	

Conductivity (µS/cm) 500 pH 7.0

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres) _____ Depth to pump suction or bottom of drill stem (metres) _____
Type of test used ☐ Air ☐ Bail ☐ Pump
Estimated supply (litres/second) _____ Duration of test (hours) _____ Drawdown level from surface (metres) _____

SECTION M—ARTESIAN BORE ON COMPLETION
Shut-in pressure (kPa) _____ Free flow (litres/second) _____ Temperature (°C) _____

SECTION N—REMARKS
SB2B

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided is true and accurate.
Driller R Watkins Driller's licence no. 3740
Trainee driller _____ Driller's licence no. _____
Signature of driller _____ Date 17 / 7 / 19
Contractor Kelly drilling

Department of Natural Resources and Mines

White — foward to the Department of Natural Resources and Mines Pink — provide to landholder Blue — Driller to retain

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002 (Qld)* and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.dnrm.qld.gov.au.

Water bore drilling log

Queensland Government

2003990

Authorisation details
Registered number _____ Development permit number _____ Works reference number _____

SECTION A—LOCATION DETAILS
Name of landholder Round oak Phone No. _____
Postal address Po Box 28 Glenroy Postcode 4824
Real property address Barbara copper project Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 339824 Northing 7741131 Zone _____

SECTION B—BORE COMPLETION DETAILS
Date commenced 14 / 7 / 19
Date completed 15 / 7 / 19

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☒ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
146	0	6

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	125	4MM	0	6

SECTION F—CENTRALISERS

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
PVC	125	1.0	1	5

SECTION H—CEMENTING/GRAVEL PACK/ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
Cement	146	125	0	0.5
Bentonite	146	125	0.5	1
Gravel Pack	146	125	1	6

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☐ Industrial Other (please specify) Sampler Bore

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	6	Granite	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
		Dry	

Conductivity (µS/cm) _____ pH _____

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres) _____ Depth to pump suction or bottom of drill stem (metres) _____
Type of test used ☐ Air ☐ Bail ☐ Pump
Estimated supply (litres/second) _____ Duration of test (hours) _____ Drawdown level from surface (metres) _____

SECTION M—ARTESIAN BORE ON COMPLETION
Shut-in pressure (kPa) _____ Free flow (litres/second) _____ Temperature (°C) _____

SECTION N—REMARKS
SB3A

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided is true and accurate.
Driller R Watkins Driller's licence no. 3240
Trainee driller _____ Driller's licence no. _____
Signature of driller _____ Date 15 / 7 / 19
Contractor Kelly Drilling

Department of Natural Resources and Mines

White — foward to the Department of Natural Resources and Mines Pink — provide to landholder Blue — Driller to retain

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002 (Qld)* and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.dnrm.qld.gov.au.

Water bore drilling log

Queensland Government

2003991

Authorisation details
Registered number _____ Development permit number _____ Works reference number _____

SECTION A—LOCATION DETAILS
Name of landholder Round oak Phone No. _____
Postal address _____ Postcode _____
Real property address Barbara copper Project Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 339824 Northing 7741131 Zone _____

SECTION B—BORE COMPLETION DETAILS
Date commenced 14 / 7 / 19
Date completed 15 / 7 / 19

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☒ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
146	0	16

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	125	4MM	0	16

SECTION F—CENTRALISERS

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
PVC	125	1.0	5	15

SECTION H—CEMENTING/GRAVEL PACK/ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
Cement	146	125	0	5
Bentonite	146	125	5	12
Gravel Pack	146	125	12	16

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☐ Industrial Other (please specify) Sampler Bore

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	10	Granite	
10	14.5	Granite Water	*
14.5	16	Granite	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
14	3.8	0.7	

Conductivity (µS/cm) 800 pH 6.4

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres) _____ Depth to pump suction or bottom of drill stem (metres) _____
Type of test used ☐ Air ☐ Bail ☐ Pump
Estimated supply (litres/second) _____ Duration of test (hours) _____ Drawdown level from surface (metres) _____

SECTION M—ARTESIAN BORE ON COMPLETION
Shut-in pressure (kPa) _____ Free flow (litres/second) _____ Temperature (°C) _____

SECTION N—REMARKS
SB3B

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided is true and accurate.
Driller R Watkins Driller's licence no. 3240
Trainee driller _____ Driller's licence no. _____
Signature of driller _____ Date 29 / 7 / 19
Contractor Kelly Drilling

Department of Natural Resources and Mines

White — foward to the Department of Natural Resources and Mines Pink — provide to landholder Blue — Driller to retain

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002 (Qld)* and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.dnrm.qld.gov.au.

Water bore drilling log

Queensland Government

2003996

Authorisation details
Registered number _____ Development permit number _____ Works reference number _____

SECTION A—LOCATION DETAILS
Name of landholder Round Oak Phone No. _____
Postal address _____ Postcode _____
Real property address Barbara copper Project Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 280736 Northing 7740742 Zone _____

SECTION B—BORE COMPLETION DETAILS
Date commenced 25 / 7 / 19
Date completed 26 / 7 / 19

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☒ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
197	0	6

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	125	6mm	0	6

SECTION F—CENTRALISERS

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
Perf	125	1.0	1	5

SECTION H—CEMENTING/GRAVEL PACK/ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
Cement	197	125	0.5	0.5
Bentonite	197	125	0.5	1
Gravel Pack	197	125	1	6
Cement	197	125	6	7

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☐ Industrial Other (please specify) Seepage Bore

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed this(*)
0	6	Granite	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
	Dry		

Conductivity (µS/cm) _____ pH _____

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres) _____ Depth to pump suction or bottom of drill stem (metres) _____
Type of test used ☐ Air ☐ Bail ☐ Pump
Estimated supply (litres/second) _____ Duration of test (hours) _____ Drawdown level from surface (metres) _____

SECTION M—ARTESIAN BORE ON COMPLETION
Shut-in pressure (kPa) _____ Free flow (litres/second) _____ Temperature (°C) _____

SECTION N—REMARKS
SB4A

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided is true and accurate.
Driller R Watkins Driller's licence no. 3470
Trainee driller _____ Driller's licence no. _____
Signature of driller _____ Date 29 / 7 / 19
Contractor Kelly's drilling

epartment of Natural Resources and Mines

White — foward to the Department of Natural Resources and Mines Pink — provide to landholder Blue — Driller to retain

e information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this epartment and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002 (Qld)* and may be stored in a departmental database. For more information on the department's privacy mmitment, please visit www.dnrm.qld.gov.au.

Water bore drilling log

Queensland Government

2003997

Authorisation details
Registered number _____ Development permit number _____ Works reference number _____

SECTION A—LOCATION DETAILS
Name of landholder Round Oak Phone No. _____
Postal address _____ Postcode _____
Real property address Barbara copper Project Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 280736 Northing 7740742 Zone _____

SECTION B—BORE COMPLETION DETAILS
Date commenced 25 / 7 / 19
Date completed 26 / 7 / 19

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☒ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
197	0	16

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	125	6mm	0	11

SECTION F—CENTRALISERS

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
Perf	125	1.0	5	14

SECTION H—CEMENTING/GRAVEL PACK/ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
Cement	197	125	0	4
Bentonite	197	125	4	5
Gravel Pack	197	125	5	16
Cement	197	125	16	17

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☐ Industrial Other (please specify) Seepage Bore

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed this(*)
0	9	Granite	
9	9.5	Granite (Water)	✓
9.5	16	Granite	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
9	6	1.5	

Conductivity (µS/cm) 800 pH 7.0

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres) _____ Depth to pump suction or bottom of drill stem (metres) _____
Type of test used ☐ Air ☐ Bail ☐ Pump
Estimated supply (litres/second) _____ Duration of test (hours) _____ Drawdown level from surface (metres) _____

SECTION M—ARTESIAN BORE ON COMPLETION
Shut-in pressure (kPa) _____ Free flow (litres/second) _____ Temperature (°C) _____

SECTION N—REMARKS
SB4B

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided is true and accurate.
Driller R Watkins Driller's licence no. 3470
Trainee driller _____ Driller's licence no. _____
Signature of driller _____ Date 29 / 7 / 19
Contractor Kelly's drilling

epartment of Natural Resources and Mines

White — foward to the Department of Natural Resources and Mines Pink — provide to landholder Blue — Driller to retain

e information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this epartment and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002 (Qld)* and may be stored in a departmental database. For more information on the department's privacy mmitment, please visit www.dnrm.qld.gov.au.

Water bore drilling log

Queensland Government

2003998

Authorisation details
Registered number _____ Development permit number _____ Works reference number _____

SECTION A—LOCATION DETAILS
Name of landholder Mound Oak Phone No. _____
Postal address _____ Postcode _____
Real property address Pocharca Copper Project Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 139° 50'54 Northing 020 24'58 Zone _____

SECTION B—BORE COMPLETION DETAILS
Date commenced 28 / 7 / 19
Date completed 28 / 7 / 19

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☒ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
400	0	6
250	6	60

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	300	6MM	0	8
PVC	250	6MM	8	18

SECTION F—CENTRALISERS

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
PVC	250	1.0	20	30

SECTION H—CEMENTING/GRAVEL PACK/ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
Cement	400	300	0	6
Gravel Pack	250	250	6	60
Cement	250	250	0	6
Gravel Pack	250	250	6	60

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☐ Industrial Other (please specify) Dewatering Bore

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	2	Broken Strata	
2	11	Granite	
11	12	Granite Water	*
12	60	Granite	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
11	8	0.1L	

Conductivity (µS/cm) 500 pH 6.9

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres)
Depth to pump suction or bottom of drill stem (metres)
Type of test used ☐ Air ☐ Bail ☐ Pump
Estimated supply (litres/second)
Duration of test (hours)
Drawdown level from surface (metres)

SECTION M—ARTESIAN BORE ON COMPLETION
Shut-in pressure (kPa)
Free flow (litres/second)
Temperature (°C)

SECTION N—REMARKS
Dewatering Bore

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided is true and accurate.
Driller R Watkins Driller's licence no. 3470
Trainee driller _____ Driller's licence no. _____
Signature of driller _____ Date 29 / 7 / 19
Contractor Kellys Drilling

CDBS 1004

Department of Natural Resources and Mines

White — foward to the Department of Natural Resources and Mines Pink — provide to landholder Blue — Driller to retain

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002 (Qld)* and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.dnrm.qld.gov.au.

Water bore drilling log

Queensland Government

2003973

Authorisation details
Registered number _____ Development permit number _____ Works reference number _____

SECTION A—LOCATION DETAILS
Name of landholder Copper Chase Phone No. _____
Postal address _____ Postcode _____
Real property address West Leichhardt Station Gabba Mine Lobe Julimar Road Postcode 4825
Real property description Lot _____ Plan _____ or Bore location GPS. Latitude _____ Longitude _____ Datum _____
Easting 139° 49' 00E Northing 20° 28' 36S Zone _____

SECTION B—BORE COMPLETION DETAILS
Date commenced 20 / 3 / 19
Date completed 25 / 3 / 19

SECTION C—DRILLING METHOD
☐ Rotary mud ☐ Cable tool
☐ Auger ☒ Rotary air
☐ Other _____

SECTION D—HOLE SIZE

Diameter (mm)	Location (metres) From	To
150	0	15
140	15	60

SECTION E—CASING DETAILS

Type (PVC, steel etc)	Size O.D. (mm)	Wall thickness (mm)	Location (metres) From	To
PVC	200	6MM	0	15
Steel	140	6MM	0	50

SECTION F—CENTRALISERS

Type	Location (metres) From	To

SECTION G—PERFORATIONS/ SLOTS/ SCREENS

Type	Size O.D. (mm)	Aperture (mm)	Location (metres) From	To
Slotted	125	1.0	26	50

SECTION H—CEMENTING/GRAVEL PACK/ANNULAR FILL DETAILS

Type & material size	Hole diameter (mm)	Casing diameter (mm O.D.)	Location (metres) From	To
Cement	400	300	0	6
Gravel Pack	250	250	6	60
Cement	250	250	0	6
Gravel Pack	250	250	6	60

SECTION I—BORE PURPOSE
☐ Domestic ☐ Stock ☐ Irrigation ☐ Commercial
☐ Urban ☒ Industrial Other (please specify) _____

SECTION J—PARTICULARS OF STRATA

From (metres)	To (metres)	Strata description (use more than one line if required)	Water bed thus(*)
0	1	Brown clay	
1	3	River Rock Sand	
3	4	Clay Sand Rock	
4	10	Brown Clay	
10	15	Brown Clay Sand Sandstone	
15	32	Sand Soft Sand Stone	*
32	38	Broken Sand Stone	*
38	60	Sand Stone	

SECTION K—WATER BEARING BEDS

Depth struck (metres)	Water rose to (metres)	Supply (litres/second)	Quality (e.g. potable, brackish, salty)
38	5	1L	potable

Conductivity (µS/cm) 100 pH 6.9

SECTION L—SUB ARTESIAN BORE ON COMPLETION
Depth to standing water level from ground level (metres)
Depth to pump suction or bottom of drill stem (metres)
Type of test used ☐ Air ☐ Bail ☐ Pump
Estimated supply (litres/second)
Duration of test (hours)
Drawdown level from surface (metres)

SECTION M—ARTESIAN BORE ON COMPLETION
Shut-in pressure (kPa)
Free flow (litres/second)
Temperature (°C)

SECTION N—REMARKS

SECTION O—CERTIFICATION
I hereby certify that the bore is drilled and constructed according to the conditions of my driller's licence and the information provided is true and accurate.
Driller Robert Watkins Driller's licence no. 3470
Trainee driller _____ Driller's licence no. _____
Signature of driller _____ Date 4 / 4 / 19
Contractor Kellys Drilling

CDBS 1004

Department of Natural Resources and Mines

White — foward to the Department of Natural Resources and Mines Pink — provide to landholder Blue — Driller to retain

The information being collected in this form will be used by this department for the purpose of processing your drill log form to record your water bore drilling activity under the authority of section 313 of the *Water Act 2000*. Your personal details will be accessed only by authorised officers within this department and will not be disclosed to any other third party without your consent except where required by law. The information collected will be retained as required by the *Public Records Act 2002 (Qld)* and may be stored in a departmental database. For more information on the department's privacy commitment, please visit www.dnrm.qld.gov.au.

Appendix C Registered bore reports

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
37655	Sub-Artesian Facility	Abandoned and Destroyed	18/10/1971	Longreach	5300 - MT ISA C.

Details

Description	PALMERSON NO1		
Parish	1090 - CLACHAN		
Original Name	GOANNA HOLE		
Driller Name			
Drill Company			
Const Method	CABLE TOOL - E M JONES		
Bore Line			
D/O File No	515/010(152)	**Polygon**	
R/O File No	17/10/W/05	**Equipment**	NE
H/O File No	L39386B	**RN of Bore Replaced**	
Log Received Date		**Data Owner**	
Roles			

Location

Latitude	20-24-25	**Basin**	9130
Longitude	139-48-49	**Sub-area**	
GIS Latitude	-20.40682537	**Lot**	
GIS Longitude	139.8136911	**Plan**	
Easting	376213		
Northing	7743038	**Map Scale**	254 - 1: 250 000
Zone	54	**Map Series**	M - Metric Series
Accuracy		**Map No**	SF54-2
GPS Accuracy		**Map Name**	CLONCURRY
Checked	No	**Prog Section**	

Casing

2 *records for RN* **37655**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	18/10/1971	1	0.00	47.90	Steel Casing		WT - Wall Thickness	127
A	18/10/1971	2	13.10	47.20	Perforated or Slotted Casing		AP - Aperture Size	

Strata Logs

5 *records for RN* **37655**

Rec	Top (m)	Bottom (m)	Strata Description

From Year:

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	47.24	SCHIST,SAND & METAPHORIC ROCKS
2			WITH FRACTURES
902			18/10/1971 SWL 50FT/15.24M
903			18/10/1971 DISCH: 400GPH
910	15.24	32.00	QUALITY DESCRIP/CONDUCT: POTABLE

Stratigraphies

1 *records for RN* **37655**

Source	Rec	Top (m)	Bottom (m)	Strata Description
DNR	1			NOT RECORDED

Aquifers

1 *records for RN* **37655**

Rec	Top (m)	Bottom (m)	Lithology	Date	SWL (m)	Flow	Quality	Yield (L/s)	Contr	Cond	Formation Name
1	15.30	32.00	CONG - Conglomerate							FR	NOT RECORDED

Pump Tests Part 1

0 *records for RN* **37655**

Pump Tests Part 2

0 *records for RN* **37655**

Bore Conditions

0 *records for RN* **37655**

Elevations

0 *records for RN* **37655**

Water Analysis Part 1

0 *records for RN* **37655**

Water Analysis Part 2

0 *records for RN* **37655**

Water Levels

1 *records for RN* **37655**

Bore Report

From Year:

Pipe	Date	Time	Measure (m)	Meas	Point	Remark	Meas	Type	Coll Auth	Coll	Method	Project		Quality
A	18/10/1971		-15.24	N	Natural Surface		NR	Not Recorded	NR	NR	Not Recorded		130	Data is of unknown quality

Wire Line Logs

0 ***records for RN*** **37655**

Field Measurements

0 ***records for RN*** **37655**

Special Water Analysis

0 ***records for RN*** **37655**

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
146948	Sub-Artesian Facility	Existing	26/01/2014	Longreach	5300 - MT ISA C.

Details

Description			
Parish	1090 - CLACHAN		
Original Name	BAWB03		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	LON/515/010 (0152)	**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	19/02/2014	**Data Owner**	DNR
Roles	Mine Monitoring		

Location

Latitude	20-24-37	**Basin**	9130
Longitude	139-50-54	**Sub-area**	
GIS Latitude	-20.41030732	**Lot**	1
GIS Longitude	139.8482889	**Plan**	AA29
Easting	379834		
Northing	7742692	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

4 *records for RN* **146948**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	26/01/2014	1	0.00	102.00	Polyvinyl Chloride			100
A	26/01/2014	2	50.00	102.00	Perforated or Slotted Casing	3.000	AP - Aperture Size	100
X	26/01/2014	3	0.00	12.00	Grout			200
X	26/01/2014	4	12.00	102.00	Gravel Pack	8.000	GR - Gravel Size	200

From Year:

Strata Logs

4 *records for RN* **146948**

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	3.00	DECOMPOSED RHYOLITE AND DOLOMITE
2	3.00	58.00	DOLERITE AND RHYOLITE
3	58.00	60.00	FRACTURED RHYOLITE
4	60.00	104.00	RHYOLITE

Stratigraphies

0 *records for RN* **146948**

Aquifers

0 *records for RN* **146948**

Pump Tests Part 1

1 *records for RN* **146948**

Pipe	Date	Rec	RN of Pumped Bore	Top (m)	Bottom (m)	Dist (m)	Meth	Test Types	Pump Type	Suction Set (m)	Q Prior to Test (l/s)	Dur of Q PR (mins)	Pres on Arriv (m)	Q on Arriv (l/s/)
A	26/01/2014	1	146948				PUM		AIR	102.00				

Pump Tests Part 2

1 *records for RN* **146948**

Pipe	Date	Rec	Test Dur (mins)	SWL(m)	Recov Time (mins)	Resid DD (m)	Max DD or P RED (m)	Q at Max DD (l/s)	Time to Max DD (mins)	Max Q (l/s)	Calc Stat HD (m)	Design Yield (l/s)	Design BP (m)	Suct. Set (m)	Tmsy (m2/Day)	Stor
A	26/01/2014	1	240											102.00		

Bore Conditions

0 *records for RN* **146948**

Elevations

0 *records for RN* **146948**

Water Analysis Part 1

0 *records for RN* **146948**

Bore Report

From Year:

Water Analysis Part 2	**0** *records for RN* **146948**
Water Levels	**0** *records for RN* **146948**
Wire Line Logs	**0** *records for RN* **146948**
Field Measurements	**0** *records for RN* **146948**
Special Water Analysis	**0** *records for RN* **146948**

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
146949	Sub-Artesian Facility	Existing	30/01/2014	Longreach	5300 - MT ISA C.

Details

Description			
Parish	1090 - CLACHAN		
Original Name	BAWB04		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	LON/515/010 (0152)	Polygon	
R/O File No		Equipment	
H/O File No		RN of Bore Replaced	
Log Received Date	19/02/2014	Data Owner	DNR
Roles	Mine Monitoring		

Location

Latitude	20-24-58	Basin	9130
Longitude	139-51-01	Sub-area	
GIS Latitude	-20.41608411	Lot	1
GIS Longitude	139.8502509	Plan	AA29
Easting	380043		
Northing	7742054	Map Scale	
Zone	54	Map Series	
Accuracy		Map No	
GPS Accuracy		Map Name	
Checked	Yes	Prog Section	

Casing

4 *records for RN* 146949

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	30/01/2014	1	0.00	100.00	Polyvinyl Chloride			100
A	30/01/2014	2	94.00	100.00	Perforated or Slotted Casing	3.000	AP - Aperture Size	100
X	30/01/2014	3	0.00	12.00	Grout			200
X	30/01/2014	4	12.00	100.00	Gravel Pack	4.000	GR - Gravel Size	200

From Year:

Strata Logs

3 *records for RN* 146949

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	2.00	DECOMPOSE RHYOLITE
2	2.00	6.00	WEATHERED RHYOLITE
3	6.00	104.00	RHYOLITE

Stratigraphies

0 *records for RN* 146949

Aquifers

0 *records for RN* 146949

Pump Tests Part 1

1 *records for RN* 146949

Pipe	Date	Rec	RN of Pumped Bore	Top (m)	Bottom (m)	Dist (m)	Meth	Test Types	Pump Type	Suction Set (m)	Q Prior to Test (l/s)	Dur of Q PR (mins)	Pres on Arriv (m)	Q on Arriv (l/s/)
A	30/01/2014	1	146949						AIR	100.00				

Pump Tests Part 2

1 *records for RN* 146949

Pipe	Date	Rec	Test Dur (mins)	SWL(m)	Recov Time (mins)	Resid DD (m)	Max DD or PRED (m)	Q at Max DD (l/s)	Time to Max DD (mins)	Max Q (l/s)	Calc Stat HD (m)	Design Yield (l/s)	Design BP (m)	Suct. Set (m)	Tmsy (m2/Day)	Stor
A	30/01/2014	1												100.00		

Bore Conditions

0 *records for RN* 146949

Elevations

0 *records for RN* 146949

Water Analysis Part 1

0 *records for RN* 146949

Water Analysis Part 2

0 *records for RN* 146949

Bore Report

From Year:

Water Levels	**0** *records for RN* **146949**
Wire Line Logs	**0** *records for RN* **146949**
Field Measurements	**0** *records for RN* **146949**
Special Water Analysis	**0** *records for RN* **146949**

Queensland Government
Page: 4 of 4
Report Date: 16/06/2022 15:22
Groundwater Information
GWDB8250

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
146950	Sub-Artesian Facility	Existing	31/01/2014	Longreach	5300 - MT ISA C.

Details

Description			
Parish	1090 - CLACHAN		
Original Name	BAWB01		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	LON/515/010 (0152)	Polygon	
R/O File No		Equipment	
H/O File No		RN of Bore Replaced	
Log Received Date	19/02/2014	Data Owner	DNR
Roles	Mine Monitoring		

Location

Latitude	20-25-29	Basin	9130
Longitude	139-51-14	Sub-area	
GIS Latitude	-20.4247508	Lot	1
GIS Longitude	139.8539149	Plan	AA29
Easting	380432		
Northing	7741097	Map Scale	
Zone	54	Map Series	
Accuracy		Map No	
GPS Accuracy		Map Name	
Checked	Yes	Prog Section	

Casing

4 *records for RN* 146950

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	31/01/2014	1	0.00	104.00	Polyvinyl Chloride			100
A	31/01/2014	2	20.00	101.00	Perforated or Slotted Casing	3.000	AP - Aperture Size	100
X	31/01/2014	3	0.00	12.00	Grout			200
X	31/01/2014	4	12.00	101.00	Gravel Pack	8.000	GR - Gravel Size	200

From Year:

Strata Logs

8 *records for RN* 146950

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	8.00	DECOMPOSED RHYOLITE
2	8.00	22.00	RHYOLITE
3	22.00	23.00	FRACTURED QUARTZ
4	23.00	34.00	RHYOLITE
5	34.00	35.00	FRACTURED RHYOLITE
6	35.00	48.00	RHYOLITE
7	48.00	49.00	FRACTURED RHYOLITE
8	49.00	104.00	RHYOLITE

Stratigraphies

0 *records for RN* 146950

Aquifers

3 *records for RN* 146950

Rec	Top (m)	Bottom (m)	Lithology	Date	SWL (m)	Flow	Quality	Yield (L/s)	Contr	Cond	Formation Name
1	23.00		QUAR - Quartz	31/01/2014	-20.00	N	POTABLE	0.50	Y	FR	LEICHHARDT VOLCANICS
2	34.00		RHYO - Rhyolite, Acid Volcanic	31/01/2014	-20.00	N	POTABLE	0.50	Y	FR	
3	48.00		RHYO - Rhyolite, Acid Volcanic	31/01/2014	-20.00	N	POTABLE	0.20	Y	FR	

Pump Tests Part 1

1 *records for RN* 146950

Pipe	Date	Rec	RN of Pumped Bore	Top (m)	Bottom (m)	Dist (m)	Meth	Test Types	Pump Type	Suction Set (m)	Q Prior to Test (l/s)	Dur of Q PR (mins)	Pres on Arriv (m)	Q on Arriv (l/s/)
A	31/01/2014	1	146950				PUM		AIR	101.00				

Pump Tests Part 2

1 *records for RN* 146950

Bore Report

From Year:

Pipe	Date	Rec	Test Dur (mins)	SWL(m)	Recov Time (mins)	Resid DD (m)	Max DD or P RED (m)	Q at Max DD (l/s)	Time to Max DD (mins)	Max Q (l/s)	Calc Stat HD (m)	Design Yield (l/s)	Design BP (m)	Suct. Set (m)	Tmsy (m2/Day)	Stor
A	31/01/2014	1	120	-20.00				1.00						101.00		

Bore Conditions 0 *records for RN* 146950

Elevations 0 *records for RN* 146950

Water Analysis Part 1 0 *records for RN* 146950

Water Analysis Part 2 0 *records for RN* 146950

Water Levels 0 *records for RN* 146950

Wire Line Logs 0 *records for RN* 146950

Field Measurements 0 *records for RN* 146950

Special Water Analysis 0 *records for RN* 146950

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
146951	Sub-Artesian Facility	Existing	01/02/2014	Longreach	5300 - MT ISA C.

Details

Description			
Parish	1090 - CLACHAN		
Original Name	BAWB05		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	LON/515/010 (0152)	Polygon	
R/O File No		Equipment	
H/O File No		RN of Bore Replaced	
Log Received Date	19/02/2014	Data Owner	DNR
Roles	Mine Monitoring		

Location

Latitude	20-25-57	Basin	9130
Longitude	139-51-32	Sub-area	
GIS Latitude	-20.43242127	Lot	1
GIS Longitude	139.8588008	Plan	AA29
Easting	380948		
Northing	7740252	Map Scale	
Zone	54	Map Series	
Accuracy		Map No	
GPS Accuracy		Map Name	
Checked	Yes	Prog Section	

Casing

4 *records for RN* 146951

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	01/12/2014	1	0.00	102.00	Polyvinyl Chloride			100
A	01/12/2014	2	35.00	102.00	Perforated or Slotted Casing	3.000	AP - Aperture Size	100
X	01/12/2014	3	0.00	12.00	Grout			200
X	01/12/2014	4	12.00	102.00	Gravel Pack	8.000	GR - Gravel Size	200

From Year:

Strata Logs

6 *records for RN* 146951

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	2.00	DECOMPOSED RHYOLITE
2	2.00	39.00	RHYOLITE
3	39.00	40.00	FRACTURED RHYOLITE
4	40.00	49.00	RHYOLITE
5	49.00	51.00	FRACTURED RHYOLITE
6	51.00	104.00	RHYOLITE

Stratigraphies

0 *records for RN* 146951

Aquifers

2 *records for RN* 146951

Rec	Top (m)	Bottom (m)	Lithology	Date	SWL (m)	Flow	Quality	Yield (L/s)	Contr	Cond	Formation Name
1	39.00		RHYO - Rhyolite, Acid Volcanic	01/02/2014	-21.00	N		0.20	Y	FR	
2	49.00		RHYO - Rhyolite, Acid Volcanic	01/02/2014	-21.00	N		0.10	Y	FR	

Pump Tests Part 1

0 *records for RN* 146951

Pump Tests Part 2

0 *records for RN* 146951

Bore Conditions

0 *records for RN* 146951

Elevations

0 *records for RN* 146951

Water Analysis Part 1

0 *records for RN* 146951

Water Analysis Part 2

0 *records for RN* 146951

Bore Report

From Year:

Water Levels	**0** *records for RN* **146951**
Wire Line Logs	**0** *records for RN* **146951**
Field Measurements	**0** *records for RN* **146951**
Special Water Analysis	**0** *records for RN* **146951**

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
146952	Sub-Artesian Facility	Existing	02/02/2014	Longreach	5300 - MT ISA C.

Details

Description			
Parish	1090 - CLACHAN		
Original Name	BAWB02		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	LON/515/010 (0152)	Polygon	
R/O File No		Equipment	
H/O File No		RN of Bore Replaced	
Log Received Date	19/02/2014	Data Owner	DNR
Roles	Mine Monitoring		

Location

Latitude	20-24-47	Basin	9130
Longitude	139-50-42	Sub-area	
GIS Latitude	-20.41297048	Lot	1
GIS Longitude	139.8448793	Plan	AA29
Easting	379480		
Northing	7742395	Map Scale	
Zone	54	Map Series	
Accuracy		Map No	
GPS Accuracy		Map Name	
Checked	Yes	Prog Section	

Casing

4 *records for RN* 146952

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	02/02/2014	1	0.00	102.00	Polyvinyl Chloride			142
A	02/02/2014	2	96.00	102.00	Perforated or Slotted Casing	3.000	AP - Aperture Size	142
X	02/02/2014	3	0.00	10.00	Grout			200
X	02/02/2014	4	10.00	102.00	Gravel Pack	8.000	GR - Gravel Size	200

From Year:

Strata Logs

2 *records for RN* 146952

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	4.00	DECOMPOSED RHYOLITE
2	4.00	104.00	RHYOLITE

Stratigraphies

0 *records for RN* 146952

Aquifers

0 *records for RN* 146952

Pump Tests Part 1

1 *records for RN* 146952

Pipe	Date	Rec	RN of Pumped Bore	Top (m)	Bottom (m)	Dist (m)	Meth	Test Types	Pump Type	Suction Set (m)	Q Prior to Test (l/s)	Dur of Q PR (mins)	Pres on Arriv (m)	Q on Arriv (l/s/)
A	02/02/2014	1	146952						AIR	102.00				

Pump Tests Part 2

1 *records for RN* 146952

Pipe	Date	Rec	Test Dur (mins)	SWL(m)	Recov Time (mins)	Resid DD (m)	Max DD or P RED (m)	Q at Max DD (l/s)	Time to Max DD (mins)	Max Q (l/s)	Calc Stat HD (m)	Design Yield (l/s)	Design BP (m)	Suct. Set (m)	Tmsy (m2/Day)	Stor
A	02/02/2014	1												102.00		

Bore Conditions

0 *records for RN* 146952

Elevations

0 *records for RN* 146952

Water Analysis Part 1

0 *records for RN* 146952

Water Analysis Part 2

0 *records for RN* 146952

Bore Report

From Year:

Water Levels	**0** *records for RN* **146952**
Wire Line Logs	**0** *records for RN* **146952**
Field Measurements	**0** *records for RN* **146952**
Special Water Analysis	**0** *records for RN* **146952**

Queensland Government
Page: 4 of 4
Report Date: 16/06/2022 15:24
Groundwater Information
GWDB8250

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
146953	Sub-Artesian Facility	Existing	04/02/2014	Longreach	5300 - MT ISA C.

Details

Description			
Parish	1090 - CLACHAN		
Original Name	BARC071		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	LON/515/010 (0152)	Polygon	
R/O File No		Equipment	
H/O File No		RN of Bore Replaced	
Log Received Date	19/02/2014	Data Owner	DNR
Roles	Water Supply		

Location

Latitude	20-25-02	Basin	9130
Longitude	139-50-55	Sub-area	
GIS Latitude	-20.41714711	Lot	1
GIS Longitude	139.8484773	Plan	AA29
Easting	379859		
Northing	7741935	Map Scale	
Zone	54	Map Series	
Accuracy		Map No	
GPS Accuracy		Map Name	
Checked	Yes	Prog Section	

Casing

2 *records for RN* 146953

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	04/02/2014	1	0.00	146.00	Polyvinyl Chloride			142
A	04/02/2014	2	18.00	146.00	Perforated or Slotted Casing	3.000	AP - Aperture Size	142

Strata Logs

6 *records for RN* 146953

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	3.00	DECOMPOSED RHYOLITE
2	3.00	19.00	RHYOLITE
3	19.00	22.00	FRACTURED RHYOLITE
4	22.00	108.00	RHYOLITE
5	108.00	109.00	FRACTURED RHYOLITE
6	109.00	146.00	RHYOLITE

From Year:

Stratigraphies

0 *records for RN* 146953

Aquifers

2 *records for RN* 146953

Rec	Top (m)	Bottom (m)	Lithology	Date	SWL (m)	Flow	Quality	Yield (L/s)	Contr	Cond	Formation Name
1	19.00		RHYO - Rhyolite, Acid Volcanic	04/02/2014	-15.00	N	POTABLE	0.50	Y	FR	
2	108.00		RHYO - Rhyolite, Acid Volcanic	04/02/2014	-15.00	N	POTABLE	0.30	Y	FR	

Pump Tests Part 1

1 *records for RN* 146953

Pipe	Date	Rec	RN of Pumped Bore	Top (m)	Bottom (m)	Dist (m)	Meth	Test Types	Pump Type	Suction Set (m)	Q Prior to Test (l/s)	Dur of Q PR (mins)	Pres on Arriv (m)	Q on Arriv (l/s/)
A	04/02/2014	1	146953				PUM		AIR	146.00				

Pump Tests Part 2

1 *records for RN* 146953

Pipe	Date	Rec	Test Dur (mins)	SWL(m)	Recov Time (mins)	Resid DD (m)	Max DD or P RED (m)	Q at Max DD (l/s)	Time to Max DD (mins)	Max Q (l/s)	Calc Stat HD (m)	Design Yield (l/s)	Design BP (m)	Suct. Set (m)	Tmsy (m2/Day)	Stor
A	04/02/2014	1	120	-15.00				0.70						146.00		

From Year:

Bore Conditions	**0**	*records for RN*	146953
Elevations	**0**	*records for RN*	146953
Water Analysis Part 1	**0**	*records for RN*	146953
Water Analysis Part 2	**0**	*records for RN*	146953
Water Levels	**0**	*records for RN*	146953
Wire Line Logs	**0**	*records for RN*	146953
Field Measurements	**0**	*records for RN*	146953
Special Water Analysis	**0**	*records for RN*	146953

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
146954	Sub-Artesian Facility	Existing	05/02/2014	Longreach	5300 - MT ISA C.

Details

Description			
Parish	1090 - CLACHAN		
Original Name	BARC065		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	LON/515/010 (0152)	Polygon	
R/O File No		Equipment	
H/O File No		RN of Bore Replaced	
Log Received Date	19/02/2014	Data Owner	DNR
Roles	Water Supply		

Location

Latitude	20-25-09	Basin	9130
Longitude	139-51-01	Sub-area	
GIS Latitude	-20.41918265	Lot	1
GIS Longitude	139.850315	Plan	AA29
Easting	380052		
Northing	7741711	Map Scale	
Zone	54	Map Series	
Accuracy		Map No	
GPS Accuracy		Map Name	
Checked	Yes	Prog Section	

Casing

2 *records for RN* 146954

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	05/02/2014	1	0.00	127.00	Polyvinyl Chloride			142
A	05/02/2014	2	30.00	127.00	Perforated or Slotted Casing	3.000	AP - Aperture Size	142

Strata Logs

5 *records for RN* 146954

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	1.00	DECOMPOSED RHYOLITE
2	1.00	33.00	RHYOLITE
3	33.00	35.00	FRACTURED RHYOLITE
4	35.00	38.00	FRACTURED RHYOLITE
5	38.00	127.00	RHYOLITE

From Year:

Stratigraphies

0 *records for RN* 146954

Aquifers

2 *records for RN* 146954

Rec	Top (m)	Bottom (m)	Lithology	Date	SWL (m)	Flow	Quality	Yield (L/s)	Contr	Cond	Formation Name
1	33.00		RHYO - Rhyolite, Acid Volcanic	05/02/2014	-21.00	N	POTABLE	0.60	Y	FR	
2	35.00		RHYO - Rhyolite, Acid Volcanic	05/02/2014	-21.00	N	POTABLE	4.00	Y	FR	

Pump Tests Part 1

1 *records for RN* 146954

Pipe	Date	Rec	RN of Pumped Bore	Top (m)	Bottom (m)	Dist (m)	Meth	Test Types	Pump Type	Suction Set (m)	Q Prior to Test (l/s)	Dur of Q PR (mins)	Pres on Arriv (m)	Q on Arriv (l/s/)
A	05/02/2014	1	146954						AIR	127.00				

Pump Tests Part 2

1 *records for RN* 146954

Pipe	Date	Rec	Test Dur (mins)	SWL(m)	Recov Time (mins)	Resid DD (m)	Max DD or P RED (m)	Q at Max DD (l/s)	Time to Max DD (mins)	Max Q (l/s)	Calc Stat HD (m)	Design Yield (l/s)	Design BP (m)	Suct. Set (m)	Tmsy (m2/Day)	Stor
A	05/02/2014	1		-21.00										127.00		

Bore Conditions

0 *records for RN* 146954

Bore Report

From Year:

Elevations	**0** *records for RN* **146954**
Water Analysis Part 1	**0** *records for RN* **146954**
Water Analysis Part 2	**0** *records for RN* **146954**
Water Levels	**0** *records for RN* **146954**
Wire Line Logs	**0** *records for RN* **146954**
Field Measurements	**0** *records for RN* **146954**
Special Water Analysis	**0** *records for RN* **146954**

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

Bore Report

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
163352	Sub-Artesian Facility	Existing	04/10/2014	Longreach	5300 - MT ISA C.

Details

Description	BOWBR1		
Parish	1090 - CLACHAN		
Original Name	BOWBR1		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING PTY LTD		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	LON/515/010 (0152)	**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	04/10/2014	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-25-34	**Basin**	9130
Longitude	139-51-09	**Sub-area**	
GIS Latitude	-20.42617182	**Lot**	1
GIS Longitude	139.85255988	**Plan**	AA29
Easting	380292		
Northing	7740939	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

5 *records for RN* **163352**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	04/10/2014	1	0.00	6.00	Polyvinyl Chloride	6.300	WT - Wall Thickness	114
A	04/10/2014	2	5.00	6.00	Perforated or Slotted Casing	2.500	AP - Aperture Size	114
A	04/10/2014	3	5.00	6.00	Gravel Pack	6.000	GR - Gravel Size	203
X	04/10/2014	4	0.00	4.00	Grout			203
X	04/10/2014	5	4.00	5.00	Bentonite Seal			203

Bore Report

From Year:

Strata Logs

2 *records for RN* **163352**

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	2.00	RIVER STONE
2	2.00	14.00	DOLERITE

Stratigraphies

0 *records for RN* **163352**

Aquifers

0 *records for RN* **163352**

Pump Tests Part 1

0 *records for RN* **163352**

Pump Tests Part 2

0 *records for RN* **163352**

Bore Conditions

0 *records for RN* **163352**

Elevations

0 *records for RN* **163352**

Water Analysis Part 1

0 *records for RN* **163352**

Water Analysis Part 2

0 *records for RN* **163352**

Water Levels

0 *records for RN* **163352**

Wire Line Logs

0 *records for RN* **163352**

Field Measurements

0 *records for RN* **163352**

Special Water Analysis

0 *records for RN* **163352**

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

Bore Report

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
163353	Sub-Artesian Facility	Abandoned and Destroyed	25/09/2014	Longreach	5300 - MT ISA C.

Details

Description	WBA		
Parish	1090 - CLACHAN		
Original Name			
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING PTY LTD		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	LON/515/010 (0152)	**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	25/09/2014	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-24-56	**Basin**	9130
Longitude	139-50-34	**Sub-area**	
GIS Latitude	-20.4156453	**Lot**	1
GIS Longitude	139.84286255	**Plan**	AA29
Easting	379272		
Northing	7742097	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

2 *records for RN* **163353**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
X	25/09/2014	1	0.00	6.00	Cement or Grout Plug			203
X	25/09/2014	2	6.00	83.00	Cuttings or other fill between casing and hole wall			203

Strata Logs

2 *records for RN* **163353**

Rec	Top (m)	Bottom	Strata Description

From Year:

		(m)	
1	0.00	13.00	SCHIST, DECOMPOSED
2	13.00	83.00	DOLERITE

Stratigraphies 0 *records for RN* 163353

Aquifers 0 *records for RN* 163353

Pump Tests Part 1 0 *records for RN* 163353

Pump Tests Part 2 0 *records for RN* 163353

Bore Conditions 0 *records for RN* 163353

Elevations 0 *records for RN* 163353

Water Analysis Part 1 0 *records for RN* 163353

Water Analysis Part 2 0 *records for RN* 163353

Water Levels 0 *records for RN* 163353

Wire Line Logs 0 *records for RN* 163353

Field Measurements 0 *records for RN* 163353

Special Water Analysis 0 *records for RN* 163353

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
163354	Sub-Artesian Facility	Existing	26/09/2014	Longreach	5300 - MT ISA C.

Details

Description	WB E		
Parish	1090 - CLACHAN		
Original Name	WBE		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING PTY LTD		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	LON/515/010 (0152)	**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	26/09/2014	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-26-43	**Basin**	9130
Longitude	139-50-59	**Sub-area**	
GIS Latitude	-20.44516341	**Lot**	1
GIS Longitude	139.84986922	**Plan**	AA29
Easting	380026		
Northing	7738835	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

5 *records for RN* **163354**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	26/09/2014	1	0.00	83.00	Polyvinyl Chloride	7.650	WT - Wall Thickness	140
A	26/09/2014	2	28.00	83.00	Perforated or Slotted Casing	2.500	AP - Aperture Size	140
A	26/09/2014	3	14.00	83.00	Gravel Pack	6.000	GR - Gravel Size	203
X	26/09/2014	4	0.00	12.00	Grout			203
X	26/09/2014	5	12.00	14.00	Cuttings or other fill between casing and hole wall			203

From Year:

Strata Logs

6 *records for RN* **163354**

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	11.00	SCHIST, DECOMPOSED
2	11.00	29.00	BASALT, BAKED
3	29.00	31.00	BASALT, FRACTURED
4	31.00	46.00	BASALT
5	46.00	47.00	BASALT, FRACTURED
6	47.00	83.00	BASALT / DOLERITE

Stratigraphies

0 *records for RN* **163354**

Aquifers

1 *records for RN* **163354**

Rec	Top (m)	Bottom (m)	Lithology	Date	SWL (m)	Flow	Quality	Yield (L/s)	Contr	Cond	Formation Name
1	29.00		BSLT - Basic Volcanic	26/09/2014	-28.10	N	1162US/CM	0.80	Y	FR	ARGYLLA FORMATION

Pump Tests Part 1

1 *records for RN* **163354**

Pipe	Date	Rec	RN of Pumped Bore	Top (m)	Bottom (m)	Dist (m)	Meth	Test Types	Pump Type	Suction Set (m)	Q Prior to Test (l/s)	Dur of Q PR (mins)	Pres on Arriv (m)	Q on Arriv (l/s/)
A	26/09/2014	1	163354	29.00	47.00		PUM		AIR LIFT	60.00				

Pump Tests Part 2

1 *records for RN* **163354**

Pipe	Date	Rec	Test Dur (mins)	SWL(m)	Recov Time (mins)	Resid DD (m)	Max DD or PRED (m)	Q at Max DD (l/s)	Time to Max DD (mins)	Max Q (l/s)	Calc Stat HD (m)	Design Yield (l/s)	Design BP (m)	Suct. Set (m)	Tmsy (m2/Day)	Stor
A	26/09/2014	1	120	-28.10				0.80						60.00		

From Year:

Bore Conditions
0 *records for RN* 163354

Elevations
0 *records for RN* 163354

Water Analysis Part 1
0 *records for RN* 163354

Water Analysis Part 2
0 *records for RN* 163354

Water Levels
0 *records for RN* 163354

Wire Line Logs
0 *records for RN* 163354

Field Measurements
1 *records for RN* 163354

Pipe	Date	Depth (m)	Conduct (uS/cm)	pH	Temp (C)	NO3 (mg/L)	DO2 (mg/L)	Eh (mV)	Alkalinity (mV)	Samp	Method	Samp	Source
A	26/09/2014		1162							AI	Air Lifting	GB	Groundwater - from Bore

Special Water Analysis
0 *records for RN* 163354

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
163355	Sub-Artesian Facility	Abandoned and Destroyed	27/09/2014	Longreach	5300 - MT ISA C.

Details

Description	WBF		
Parish	1090 - CLACHAN		
Original Name	WBF		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING PTY LTD		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	LON/515/010 (0152)	**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	27/09/2014	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-26-49	**Basin**	9130
Longitude	139-51-01	**Sub-area**	
GIS Latitude	-20.44690112	**Lot**	1
GIS Longitude	139.85032598	**Plan**	AA29
Easting	380075		
Northing	7738643	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

2 *records for RN* 163355

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
X	27/09/2014	1	0.00	6.00	Cement or Grout Plug			203
X	27/09/2014	2	6.00	73.00	Cuttings or other fill between casing and hole wall			203

Strata Logs

3 *records for RN* 163355

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	6.00	SCHIST, DECOMPOSED (RUBBLE)
2	6.00	17.00	SCHIST, DECOMPOSED
3	17.00	75.00	DOLERITE

Stratigraphies

0 *records for RN* 163355

Aquifers

0 *records for RN* 163355

Pump Tests Part 1

0 *records for RN* 163355

Pump Tests Part 2

0 *records for RN* 163355

Bore Conditions

0 *records for RN* 163355

Elevations

0 *records for RN* 163355

Water Analysis Part 1

0 *records for RN* 163355

Water Analysis Part 2

0 *records for RN* 163355

Water Levels

0 *records for RN* 163355

Wire Line Logs

0 *records for RN* 163355

Field Measurements

0 *records for RN* 163355

Special Water Analysis

0 *records for RN* 163355

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
163356	Sub-Artesian Facility	Abandoned and Destroyed	28/09/2014	Longreach	5300 - MT ISA C.

Details

Description	WBO		
Parish	1090 - CLACHAN		
Original Name	WBO		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING PTY LTD		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	LON/515/010 (0152)	**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	28/09/2014	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-26-36	**Basin**	9130
Longitude	139-51-34	**Sub-area**	
GIS Latitude	-20.4433479	**Lot**	1
GIS Longitude	139.85955441	**Plan**	AA29
Easting	381035		
Northing	7739043	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

2 *records for RN* 163356

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
X	28/09/2014	1	0.00	6.00	Cement or Grout Plug			203
X	28/09/2014	2	6.00	83.00	Cuttings or other fill between casing and hole wall			203

Strata Logs

3 *records for RN* 163356

Rec	Top (m)	Bottom	Strata Description

Bore Report

From Year:

		(m)	
1	0.00	13.00	SCHIST, DECOMPOSED
2	13.00	40.00	DOLERITE
3	40.00	83.00	CALCITE / DOLERITE

Stratigraphies 0 *records for RN* 163356

Aquifers 0 *records for RN* 163356

Pump Tests Part 1 0 *records for RN* 163356

Pump Tests Part 2 0 *records for RN* 163356

Bore Conditions 0 *records for RN* 163356

Elevations 0 *records for RN* 163356

Water Analysis Part 1 0 *records for RN* 163356

Water Analysis Part 2 0 *records for RN* 163356

Water Levels 0 *records for RN* 163356

Wire Line Logs 0 *records for RN* 163356

Field Measurements 0 *records for RN* 163356

Special Water Analysis 0 *records for RN* 163356

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

Bore Report

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
163358	Sub-Artesian Facility	Abandoned and Destroyed	03/10/2014	Longreach	5300 - MT ISA C.

Details

Description	CK NEAR CORE SHED		
Parish	3750 - PARKSIDE		
Original Name			
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING PTY LTD		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	515/010(0152)	**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	03/10/2014	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-25-43	**Basin**	9130
Longitude	139-48-42	**Sub-area**	
GIS Latitude	-20.42857183	**Lot**	1
GIS Longitude	139.81166442	**Plan**	AA29
Easting	376027		
Northing	7740643	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

2 *records for RN* 163358

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
X	03/10/2014	1	0.00	6.00	Cement or Grout Plug			203
X	03/10/2014	2	6.00	30.00	Cuttings or other fill between casing and hole wall			203

Strata Logs

3 *records for RN* 163358

Rec	Top (m)	Bottom (m)	Strata Description

Bore Report

From Year:

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	8.00	RIVER STONE
2	8.00	21.00	GRANITE, DECOMPOSED
3	21.00	30.00	GRANITE

Stratigraphies

0 *records for RN* 163358

Aquifers

0 *records for RN* 163358

Pump Tests Part 1

0 *records for RN* 163358

Pump Tests Part 2

0 *records for RN* 163358

Bore Conditions

0 *records for RN* 163358

Elevations

0 *records for RN* 163358

Water Analysis Part 1

0 *records for RN* 163358

Water Analysis Part 2

0 *records for RN* 163358

Water Levels

0 *records for RN* 163358

Wire Line Logs

0 *records for RN* 163358

Field Measurements

0 *records for RN* 163358

Special Water Analysis

0 *records for RN* 163358

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
163359	Sub-Artesian Facility	Abandoned and Destroyed	04/10/2014	Longreach	5300 - MT ISA C.

Details

Description	BAWBR 3		
Parish	1090 - CLACHAN		
Original Name	BAWBR 3		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING PTY LTD		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	515/010(0152)	**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	04/10/2014	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-25-16	**Basin**	9130
Longitude	139-50-59	**Sub-area**	
GIS Latitude	-20.42122	**Lot**	1
GIS Longitude	139.84971179	**Plan**	AA29
Easting	379991		
Northing	7741485	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

5 ***records for RN*** **163359**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	04/10/2014	1	0.00	4.00	Polyvinyl Chloride	6.300	WT - Wall Thickness	114
A	04/10/2014	2	3.00	4.00	Perforated or Slotted Casing	2.500	AP - Aperture Size	114
A	04/10/2014	3	3.00	4.00	Gravel Pack	6.000	GR - Gravel Size	203
X	04/10/2014	4	0.00	2.00	Grout			203
X	04/10/2014	5	2.00	3.00	Bentonite Seal			203

Bore Report

From Year:

Strata Logs

2 *records for RN* **163359**

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	1.00	RIVERSTONE
2	1.00	14.00	DOLERITE

Stratigraphies

0 *records for RN* **163359**

Aquifers

0 *records for RN* **163359**

Pump Tests Part 1

0 *records for RN* **163359**

Pump Tests Part 2

0 *records for RN* **163359**

Bore Conditions

0 *records for RN* **163359**

Elevations

0 *records for RN* **163359**

Water Analysis Part 1

0 *records for RN* **163359**

Water Analysis Part 2

0 *records for RN* **163359**

Water Levels

0 *records for RN* **163359**

Wire Line Logs

0 *records for RN* **163359**

Field Measurements

0 *records for RN* **163359**

Special Water Analysis

0 *records for RN* **163359**

Queensland Government
Page: 3 of 3
Report Date: 16/06/2022 15:23
Groundwater Information
GWDB8250

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

Bore Report

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
163360	Sub-Artesian Facility	Abandoned and Destroyed	04/10/2014	Longreach	5300 - MT ISA C.

Details

Description	BAWBR 2		
Parish	1090 - CLACHAN		
Original Name	BAWBR 2		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING PTY LTD		
Const Method	ROTARY AIR		
Bore Line			
D/O File No	515/010(0152)	**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	04/10/2014	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-25-23	**Basin**	9130
Longitude	139-50-56	**Sub-area**	
GIS Latitude	-20.42307609	**Lot**	1
GIS Longitude	139.84894085	**Plan**	AA29
Easting	379912		
Northing	7741279	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

5 *records for RN* **163360**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	04/10/2014	1	0.00	3.00	Polyvinyl Chloride	6.300	WT - Wall Thickness	114
A	04/10/2014	2	2.00	3.00	Perforated or Slotted Casing	2.500	AP - Aperture Size	114
A	04/10/2014	3	2.00	3.00	Gravel Pack	6.000	GR - Gravel Size	203
X	04/10/2014	4	0.00	1.00	Grout			203
X	04/10/2014	5	1.00	2.00	Bentonite Seal			203

Bore Report

From Year:

Strata Logs

2 *records for RN* **163360**

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	1.00	RIVER STONE
2	1.00	14.00	DOLERITE

Stratigraphies

0 *records for RN* **163360**

Aquifers

0 *records for RN* **163360**

Pump Tests Part 1

0 *records for RN* **163360**

Pump Tests Part 2

0 *records for RN* **163360**

Bore Conditions

0 *records for RN* **163360**

Elevations

0 *records for RN* **163360**

Water Analysis Part 1

0 *records for RN* **163360**

Water Analysis Part 2

0 *records for RN* **163360**

Water Levels

0 *records for RN* **163360**

Wire Line Logs

0 *records for RN* **163360**

Field Measurements

0 *records for RN* **163360**

Special Water Analysis

0 *records for RN* **163360**

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
163368	Sub-Artesian Facility	Abandoned and Destroyed	28/09/2014	Longreach	5300 - MT ISA C.

Details

Description			
Parish	1090 - CLACHAN		
Original Name	WB "C"		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING PTY TLD		
Const Method	ROTARY AIR		
Bore Line			
D/O File No		**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	14/11/2014	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-26-36	**Basin**	9130
Longitude	139-51-34	**Sub-area**	
GIS Latitude	-20.4433573804	**Lot**	1
GIS Longitude	139.859394844	**Plan**	AA29
Easting	381018		
Northing	7739042	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

2 *records for RN* **163368**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
X	28/09/2014	1	0.00	6.00	Grout			203
X	28/09/2014	2	6.00	60.00	Cuttings or other fill between casing and hole wall			203

Strata Logs

3 *records for RN* **163368**

Rec	Top (m)	Bottom (m)	Strata Description

Bore Report

From Year:

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	21.00	DECOMPOSED SCHIST
2	21.00	46.00	DOLERITE/CALCITE
3	46.00	60.00	DOLERITE

Stratigraphies 0 *records for RN* 163368

Aquifers 0 *records for RN* 163368

Pump Tests Part 1 0 *records for RN* 163368

Pump Tests Part 2 0 *records for RN* 163368

Bore Conditions 0 *records for RN* 163368

Elevations 0 *records for RN* 163368

Water Analysis Part 1 0 *records for RN* 163368

Water Analysis Part 2 0 *records for RN* 163368

Water Levels 0 *records for RN* 163368

Wire Line Logs 0 *records for RN* 163368

Field Measurements 0 *records for RN* 163368

Special Water Analysis 0 *records for RN* 163368

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

Bore Report

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
163369	Sub-Artesian Facility	Abandoned and Destroyed	29/09/2014	Longreach	5300 - MT ISA C.

Details

Description			
Parish	1090 - CLACHAN		
Original Name	WB "B"		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING PTY LTD		
Const Method	ROTARY AIR		
Bore Line			
D/O File No		**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	14/11/2014	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-25-38	**Basin**	9130
Longitude	139-51-20	**Sub-area**	
GIS Latitude	-20.4272295428	**Lot**	1
GIS Longitude	139.8556071493	**Plan**	AA29
Easting	380611		
Northing	7740824	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

2 *records for RN* **163369**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
X	29/09/2014	1	0.00	6.00	Grout			203
X	29/09/2014	2	6.00	83.00	Cuttings or other fill between casing and hole wall			203

Strata Logs

3 *records for RN* **163369**

Rec	Top (m)	Bottom (m)	Strata Description

Bore Report

From Year:

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	26.00	DECOMPOSED SCHIST
2	26.00	32.00	DOLERITE
3	32.00	83.00	DOLERITE/CALCITE

Stratigraphies

0 *records for RN* **163369**

Aquifers

0 *records for RN* **163369**

Pump Tests Part 1

0 *records for RN* **163369**

Pump Tests Part 2

0 *records for RN* **163369**

Bore Conditions

0 *records for RN* **163369**

Elevations

0 *records for RN* **163369**

Water Analysis Part 1

0 *records for RN* **163369**

Water Analysis Part 2

0 *records for RN* **163369**

Water Levels

0 *records for RN* **163369**

Wire Line Logs

0 *records for RN* **163369**

Field Measurements

0 *records for RN* **163369**

Special Water Analysis

0 *records for RN* **163369**

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
163370	Sub-Artesian Facility	Existing	01/10/2014	Longreach	5300 - MT ISA C.

Details

Description			
Parish	3750 - PARKSIDE		
Original Name	WB "G"		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING PTY LTD		
Const Method	ROTARY AIR		
Bore Line			
D/O File No		**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	14/11/2014	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-23-27	**Basin**	9130
Longitude	139-49-11	**Sub-area**	
GIS Latitude	-20.3908894854	**Lot**	1
GIS Longitude	139.8197002792	**Plan**	AA29
Easting	376835		
Northing	7744820	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

5 ***records for RN*** **163370**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	01/10/2014	1	0.00	120.00	Polyvinyl Chloride	7.650	WT - Wall Thickness	142
A	01/10/2014	2	32.00	120.00	Perforated or Slotted Casing	2.500	AP - Aperture Size	142
X	01/10/2014	3	0.00	12.00	Grout			203
X	01/10/2014	4	12.00	14.00	Bentonite Seal			203
X	01/10/2014	5	14.00	120.00	Gravel Pack	8.000	GR - Gravel Size	203

From Year:

Strata Logs

5 *records for RN* 163370

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	34.00	DECOMPOSED SCHIST
2	34.00	38.00	FRACTURED SCHIST
3	38.00	86.00	SCHIST
4	86.00	87.00	FRACTURED SCHIST
5	87.00	120.00	SCHIST

Stratigraphies

0 *records for RN* 163370

Aquifers

2 *records for RN* 163370

Rec	Top (m)	Bottom (m)	Lithology	Date	SWL (m)	Flow	Quality	Yield (L/s)	Contr	Cond	Formation Name
1	34.00		SCHT - Schist	01/10/2014	-28.60	N	2492 US/CM	0.50	Y	FR	ARGYLLA FORMATION
2	86.00		SCHT - Schist	01/10/2014	-28.60	N	2492 US/CM	0.40	Y	FR	ARGYLLA FORMATION

Pump Tests Part 1

1 *records for RN* 163370

Pipe	Date	Rec	RN of Pumped Bore	Top (m)	Bottom (m)	Dist (m)	Meth	Test Types	Pump Type	Suction Set (m)	Q Prior to Test (l/s)	Dur of Q PR (mins)	Pres on Arriv (m)	Q on Arriv (l/s/)
A	01/10/2014	1	163370				PUM		AIR	120.00				

Pump Tests Part 2

1 *records for RN* 163370

Pipe	Date	Rec	Test Dur (mins)	SWL(m)	Recov Time (mins)	Resid DD (m)	Max DD or P RED (m)	Q at Max DD (l/s)	Time to Max DD (mins)	Max Q (l/s)	Calc Stat HD (m)	Design Yield (l/s)	Design BP (m)	Suct. Set (m)	Tmsy (m2/Day)	Stor

From Year:

Pipe	Date	Rec	Test Dur (mins)	SWL(m)	Recov Time (mins)	Resid DD (m)	Max DD or P RED (m)	Q at Max DD (l/s)	Time to Max DD (mins)	Max Q (l/s)	Calc Stat HD (m)	Design Yield (l/s)	Design BP (m)	Suct. Set (m)	Tmsy (m2/Day)	Stor
A	01/10/2014	1	120	-28.60				0.90						120.00		

Bore Conditions

0 *records for RN* 163370

Elevations

0 *records for RN* 163370

Water Analysis Part 1

0 *records for RN* 163370

Water Analysis Part 2

0 *records for RN* 163370

Water Levels

0 *records for RN* 163370

Wire Line Logs

0 *records for RN* 163370

Field Measurements

0 *records for RN* 163370

Special Water Analysis

0 *records for RN* 163370

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
163371	Sub-Artesian Facility	Abandoned and Destroyed	02/10/2014	Longreach	5300 - MT ISA C.

Details

Description			
Parish	3750 - PARKSIDE		
Original Name	STOCK YARDS		
Driller Name	SERRA, MARK ANTHONY		
Drill Company	SERRA DRILLING PTY LTD		
Const Method	ROTARY AIR		
Bore Line			
D/O File No		**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	14/11/2014	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-22-53	**Basin**	9130
Longitude	139-48-23	**Sub-area**	
GIS Latitude	-20.3815216251	**Lot**	1
GIS Longitude	139.8064050628	**Plan**	AA29
Easting	375440		
Northing	7745847	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

2 *records for RN* **163371**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
X	02/10/2014	1	0.00	6.00	Grout			203
X	02/10/2014	2	6.00	30.00	Cuttings or other fill between casing and hole wall			203

Strata Logs

4 *records for RN* **163371**

Rec	Top (m)	Bottom (m)	Strata Description

Bore Report

From Year:

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	1.00	TOPSOIL (RED)
2	1.00	20.00	GRANITE
3	20.00	22.00	SCHIST
4	22.00	30.00	GRANITE

Stratigraphies 0 *records for RN* 163371

Aquifers 0 *records for RN* 163371

Pump Tests Part 1 0 *records for RN* 163371

Pump Tests Part 2 0 *records for RN* 163371

Bore Conditions 0 *records for RN* 163371

Elevations 0 *records for RN* 163371

Water Analysis Part 1 0 *records for RN* 163371

Water Analysis Part 2 0 *records for RN* 163371

Water Levels 0 *records for RN* 163371

Wire Line Logs 0 *records for RN* 163371

Field Measurements 0 *records for RN* 163371

Special Water Analysis 0 *records for RN* 163371

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
184209	Sub-Artesian Facility	Existing	11/04/2014	Longreach	5300 - MT ISA C.

Details

Description			
Parish	6000 - NO LONGER USED		
Original Name			
Driller Name	SERRA, MARK		
Drill Company	SERRA DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No		Polygon	
R/O File No		Equipment	
H/O File No		RN of Bore Replaced	
Log Received Date	01/04/2019	Data Owner	
Roles	Water Supply		

Location

Latitude	20-21-46	Basin	9130
Longitude	139-48-10	Sub-area	
GIS Latitude	-20.3627074728	Lot	1
GIS Longitude	139.8028399982	Plan	AA29
Easting	375053		
Northing	7747926	Map Scale	
Zone	54	Map Series	
Accuracy		Map No	
GPS Accuracy		Map Name	
Checked	Yes	Prog Section	

Casing

4 *records for RN* 184209

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	11/09/2014	1	0.00	28.00	Polyvinyl Chloride	7.650	WT - Wall Thickness	142
A	11/09/2014	2	12.00	28.00	Perforated or Slotted Casing	2.500	AP - Aperture Size	142
X	11/09/2014	3	0.00	6.00	Grout			203
X	11/09/2014	4	6.00	28.00	Cuttings or other fill between casing and hole wall			203

Strata Logs

5 *records for RN* 184209

From Year:

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	12.00	DECOMPOSED IRONSTONE
2	12.00	13.00	FRACTURED IRONSTONE*
3	13.00	15.00	DOLERITE & IRONSTONE
4	15.00	16.00	FRACTURED DOLERITE*
5	16.00	28.00	DOLERITE & IRONSTONE

Stratigraphies

0 *records for RN* 184209

Aquifers

2 *records for RN* 184209

Rec	Top (m)	Bottom (m)	Lithology	Date	SWL (m)	Flow	Quality	Yield (L/s)	Contr	Cond	Formation Name
1	12.00			11/09/2014	-9.10	N	POTABLE	0.15	Y	FR	
2	15.00		DOLE - Dolerite SEDI - Sedimentary	11/09/2014	-9.10	N	POTABLE	0.10	Y	FR	

Pump Tests Part 1

0 *records for RN* 184209

Pump Tests Part 2

0 *records for RN* 184209

Bore Conditions

0 *records for RN* 184209

Elevations

0 *records for RN* 184209

Water Analysis Part 1

0 *records for RN* 184209

Water Analysis Part 2

0 *records for RN* 184209

Water Levels

0 *records for RN* 184209

Wire Line Logs

0 *records for RN* 184209

Bore Report

From Year:

Field Measurements

0 *records for RN* **184209**

Special Water Analysis

0 *records for RN* **184209**

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
184264	Sub-Artesian Facility	Existing	15/07/2019	Longreach	5300 - MT ISA C.

Details

Description			
Parish	6000 - NO LONGER USED		
Original Name	SB3A		
Driller Name	WATKINS, ROBERT		
Drill Company	KELLY DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No		Polygon	
R/O File No		Equipment	
H/O File No		RN of Bore Replaced	
Log Received Date	11/09/2019	Data Owner	
Roles	Mine Monitoring		

Location

Latitude	20-25-28	Basin	9130
Longitude	139-50-59	Sub-area	
GIS Latitude	-20.42441774	Lot	1
GIS Longitude	139.84962094	Plan	AA29
Easting	379984		
Northing	7741131	Map Scale	
Zone	54	Map Series	
Accuracy		Map No	
GPS Accuracy		Map Name	
Checked	Yes	Prog Section	

Casing

5 *records for RN* 184264

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	15/07/2019	1	0.00	6.00	Polyvinyl Chloride			125
A	15/07/2019	2	1.00	5.00	Perforated or Slotted Casing	1.000	AP - Aperture Size	125
X	15/07/2019	3	0.00	0.50	Grout			190
X	15/07/2019	4	0.50	1.00	Bentonite Seal			190
X	15/07/2019	5	1.00	6.00	Gravel Pack			190

From Year:

Strata Logs

1 *records for RN* 184264

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	6.00	GRANITE

Stratigraphies

0 *records for RN* 184264

Aquifers

0 *records for RN* 184264

Pump Tests Part 1

0 *records for RN* 184264

Pump Tests Part 2

0 *records for RN* 184264

Bore Conditions

0 *records for RN* 184264

Elevations

0 *records for RN* 184264

Water Analysis Part 1

0 *records for RN* 184264

Water Analysis Part 2

0 *records for RN* 184264

Water Levels

0 *records for RN* 184264

Wire Line Logs

0 *records for RN* 184264

Field Measurements

0 *records for RN* 184264

Special Water Analysis

0 *records for RN* 184264

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
184265	Sub-Artesian Facility	Existing	15/07/2019	Longreach	5300 - MT ISA C.

Details

Description			
Parish	6000 - NO LONGER USED		
Original Name	SB3B		
Driller Name	WATKINS, ROBERT		
Drill Company	KELLY DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No		**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	11/09/2019	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-25-28	**Basin**	9130
Longitude	139-50-59	**Sub-area**	
GIS Latitude	-20.42441774	**Lot**	1
GIS Longitude	139.84962094	**Plan**	AA29
Easting	379984		
Northing	7741131	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

5 ***records for RN*** **184265**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	15/07/2019	1	0.00	16.00	Polyvinyl Chloride			125
A	15/07/2019	2	5.00	15.00	Perforated or Slotted Casing	1.000	AP - Aperture Size	125
X	15/07/2019	3	0.00	4.00	Grout			190
X	15/07/2019	4	4.00	5.00	Bentonite Seal			190
X	15/07/2019	5	5.00	16.00	Gravel Pack			190

Bore Report

From Year:

Strata Logs

3 *records for RN* **184265**

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	14.00	GRANITE
2	14.00	14.50	GRANITE: WATER
3	14.50	16.00	GRANITE

Stratigraphies

0 *records for RN* **184265**

Aquifers

1 *records for RN* **184265**

Rec	Top (m)	Bottom (m)	Lithology	Date	SWL (m)	Flow	Quality	Yield (L/s)	Contr	Cond	Formation Name
1	14.00	14.50	GNTE - Acid Intrusive, Granite	15/07/2019	-2.80	N		0.70	Y	PS	

Pump Tests Part 1

0 *records for RN* **184265**

Pump Tests Part 2

0 *records for RN* **184265**

Bore Conditions

0 *records for RN* **184265**

Elevations

0 *records for RN* **184265**

Water Analysis Part 1

0 *records for RN* **184265**

Water Analysis Part 2

0 *records for RN* **184265**

Water Levels

0 *records for RN* **184265**

Wire Line Logs

0 *records for RN* **184265**

Field Measurements

1 *records for RN* **184265**

Bore Report

From Year:

Pipe	Date	Depth (m)	Conduct (uS/cm)	pH	Temp (C)	NO3 (mg/L)	DO2 (mg/L)	Eh (mV)	Alkalinity (mV)	Samp	Method	Samp	Source
A	15/07/2019		500	6.9						XX	Unknown	GB	Groundwater - from Bore

Special Water Analysis

0 *records for RN* **184265**

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
184266	Sub-Artesian Facility	Existing	16/07/2019	Longreach	5300 - MT ISA C.

Details

Description			
Parish	6000 - NO LONGER USED		
Original Name	SB2A		
Driller Name	WATKINS, ROBERT		
Drill Company	KELLY DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No		**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	11/09/2019	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-25-28	**Basin**	9130
Longitude	139-50-59	**Sub-area**	
GIS Latitude	-20.4245647	**Lot**	1
GIS Longitude	139.84998405	**Plan**	AA29
Easting	380022		
Northing	7741115	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

5 ***records for RN*** **184266**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	16/07/2019	1	0.00	6.00	Polyvinyl Chloride			125
A	16/07/2019	2	1.00	5.00	Perforated or Slotted Casing	1.000	AP - Aperture Size	125
X	16/07/2019	3	0.00	0.50	Grout			193
X	16/07/2019	4	0.50	1.00	Bentonite Seal			193
X	16/07/2019	5	1.00	6.00	Gravel Pack			193

Bore Report

From Year:

Strata Logs

1 *records for RN* **184266**

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	6.00	GRANITE

Stratigraphies

0 *records for RN* **184266**

Aquifers

0 *records for RN* **184266**

Pump Tests Part 1

0 *records for RN* **184266**

Pump Tests Part 2

0 *records for RN* **184266**

Bore Conditions

0 *records for RN* **184266**

Elevations

0 *records for RN* **184266**

Water Analysis Part 1

0 *records for RN* **184266**

Water Analysis Part 2

0 *records for RN* **184266**

Water Levels

0 *records for RN* **184266**

Wire Line Logs

0 *records for RN* **184266**

Field Measurements

0 *records for RN* **184266**

Special Water Analysis

0 *records for RN* **184266**

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

Bore Report

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
184267	Sub-Artesian Facility	Existing	16/07/2019	Longreach	5300 - MT ISA C.

Details

Description			
Parish	6000 - NO LONGER USED		
Original Name	SB2B		
Driller Name	WALKER, ADAM		
Drill Company	KELLY DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No		**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	11/09/2019	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-25-28	**Basin**	9130
Longitude	139-50-59	**Sub-area**	
GIS Latitude	-20.4245647	**Lot**	1
GIS Longitude	139.84998405	**Plan**	AA29
Easting	380022		
Northing	7741115	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

5 *records for RN* **184267**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	16/07/2019	1	0.00	16.00	Polyvinyl Chloride			125
A	16/07/2019	2	5.00	15.00	Perforated or Slotted Casing	1.000	AP - Aperture Size	125
X	16/07/2019	3	0.00	4.00	Grout			193
X	16/07/2019	4	4.00	5.00	Bentonite Seal			193
X	16/07/2019	5	5.00	16.00	Gravel Pack			193

Bore Report

From Year:

Strata Logs

3 *records for RN* **184267**

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	10.00	GRANITE
2	10.00	10.50	GRANITE: WATER
3	10.50	16.00	GRANITE

Stratigraphies

0 *records for RN* **184267**

Aquifers

1 *records for RN* **184267**

Rec	Top (m)	Bottom (m)	Lithology	Date	SWL (m)	Flow	Quality	Yield (L/s)	Contr	Cond	Formation Name
1	10.00	10.50	GNTE - Acid Intrusive, Granite	16/07/2019	-3.00	N		0.70	Y	PS	

Pump Tests Part 1

0 *records for RN* **184267**

Pump Tests Part 2

0 *records for RN* **184267**

Bore Conditions

0 *records for RN* **184267**

Elevations

0 *records for RN* **184267**

Water Analysis Part 1

0 *records for RN* **184267**

Water Analysis Part 2

0 *records for RN* **184267**

Water Levels

0 *records for RN* **184267**

Wire Line Logs

0 *records for RN* **184267**

Field Measurements

1 *records for RN* **184267**

Bore Report

From Year:

Pipe	Date	Depth (m)	Conduct (uS/cm)	pH	Temp (C)	NO3 (mg/L)	DO2 (mg/L)	Eh (mV)	Alkalinity (mV)	Samp	Method	Samp	Source
A	16/07/2019		500	7.0						XX	Unknown	GB	Groundwater - from Bore

Special Water Analysis

0 ***records for RN*** **184267**

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
184268	Sub-Artesian Facility	Existing	16/07/2019	Longreach	5300 - MT ISA C.

Details

Description			
Parish	6000 - NO LONGER USED		
Original Name	SB1A		
Driller Name	WATKINS, ROBERT		
Drill Company	KELLY DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No		Polygon	
R/O File No		Equipment	
H/O File No		RN of Bore Replaced	
Log Received Date	11/09/2019	Data Owner	
Roles	Mine Monitoring		

Location

Latitude	20-25-31	Basin	9130
Longitude	139-51-02	Sub-area	
GIS Latitude	-20.42518302	Lot	1
GIS Longitude	139.85058326	Plan	AA29
Easting	380085		
Northing	7741047	Map Scale	
Zone	54	Map Series	
Accuracy		Map No	
GPS Accuracy		Map Name	
Checked	Yes	Prog Section	

Casing

5 *records for RN* 184268

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	16/07/2019	1	0.00	6.00	Polyvinyl Chloride			125
A	16/07/2019	2	1.00	5.00	Perforated or Slotted Casing	1.000	AP - Aperture Size	125
X	16/07/2019	3	0.00	0.50	Grout			193
X	16/07/2019	4	0.50	1.00	Bentonite Seal			193
X	16/07/2019	5	1.00	6.00	Gravel Pack			193

Queensland Government
Groundwater Information
Bore Report
Report Date: 16/06/2022 15:24

From Year:

Strata Logs

1 *records for RN* 184268

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	6.00	GRANITE

Stratigraphies

0 *records for RN* 184268

Aquifers

0 *records for RN* 184268

Pump Tests Part 1

0 *records for RN* 184268

Pump Tests Part 2

0 *records for RN* 184268

Bore Conditions

0 *records for RN* 184268

Elevations

0 *records for RN* 184268

Water Analysis Part 1

0 *records for RN* 184268

Water Analysis Part 2

0 *records for RN* 184268

Water Levels

0 *records for RN* 184268

Wire Line Logs

0 *records for RN* 184268

Field Measurements

0 *records for RN* 184268

Special Water Analysis

0 *records for RN* 184268

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
184269	Sub-Artesian Facility	Existing	16/07/2019	Longreach	5300 - MT ISA C.

Details

Description			
Parish	6000 - NO LONGER USED		
Original Name	SB1B		
Driller Name	WATKINS, ROBERT		
Drill Company	KELLY DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No		**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	11/09/2019	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-25-31	**Basin**	9130
Longitude	139-51-02	**Sub-area**	
GIS Latitude	-20.42518302	**Lot**	1
GIS Longitude	139.85058326	**Plan**	AA29
Easting	380085		
Northing	7741047	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

5 ***records for RN*** **184269**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	16/07/2019	1	0.00	16.00	Polyvinyl Chloride			125
A	16/07/2019	2	5.00	15.00	Perforated or Slotted Casing	1.000	AP - Aperture Size	125
X	16/07/2019	3	0.00	4.00	Grout			193
X	16/07/2019	4	4.00	5.00	Bentonite Seal			193
X	16/07/2019	5	5.00	16.00	Gravel Pack			193

From Year:

Strata Logs

3 records for RN 184269

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	11.00	GRANITE
2	11.00	11.50	GRANITE: WATER
3	11.50	16.00	GRANITE

Stratigraphies

0 records for RN 184269

Aquifers

1 records for RN 184269

Rec	Top (m)	Bottom (m)	Lithology	Date	SWL (m)	Flow	Quality	Yield (L/s)	Contr	Cond	Formation Name
1	11.00	11.50	GNTE - Acid Intrusive, Granite	16/07/2019	-7.00	N		0.70	Y	PS	

Pump Tests Part 1

0 records for RN 184269

Pump Tests Part 2

0 records for RN 184269

Bore Conditions

0 records for RN 184269

Elevations

0 records for RN 184269

Water Analysis Part 1

0 records for RN 184269

Water Analysis Part 2

0 records for RN 184269

Water Levels

0 records for RN 184269

Wire Line Logs

0 records for RN 184269

Field Measurements

1 records for RN 184269

From Year:

Pipe	Date	Depth (m)	Conduct (uS/cm)	pH	Temp (C)	NO3 (mg/L)	DO2 (mg/L)	Eh (mV)	Alkalinity (mV)	Samp	Method	Samp	Source
A	16/07/2019		500	6.9						XX	Unknown	GB	Groundwater - from Bore

Special Water Analysis

0 records for RN 184269

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
184270	Sub-Artesian Facility	Existing	26/07/2019	Longreach	5300 - MT ISA C.

Details

Description			
Parish	6000 - NO LONGER USED		
Original Name	SB4A		
Driller Name	WATKINS, ROBERT		
Drill Company	KELLY DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No		**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	11/09/2019	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-25-41	**Basin**	9130
Longitude	139-51-24	**Sub-area**	
GIS Latitude	-20.4279796	**Lot**	1
GIS Longitude	139.85680197	**Plan**	AA29
Easting	380736		
Northing	7740742	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

5 *records for RN* **184270**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	26/07/2019	1	0.00	6.00	Polyvinyl Chloride			125
A	26/07/2019	2	1.00	5.00	Perforated or Slotted Casing	1.000	AP - Aperture Size	125
X	26/07/2019	3	0.00	0.50	Grout			193
X	26/07/2019	4	0.50	1.00	Bentonite Seal			193
X	26/07/2019	5	1.00	6.00	Gravel Pack			193

Bore Report

From Year:

Strata Logs

1 *records for RN* **184270**

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	6.00	GRANITE

Stratigraphies

0 *records for RN* **184270**

Aquifers

0 *records for RN* **184270**

Pump Tests Part 1

0 *records for RN* **184270**

Pump Tests Part 2

0 *records for RN* **184270**

Bore Conditions

0 *records for RN* **184270**

Elevations

0 *records for RN* **184270**

Water Analysis Part 1

0 *records for RN* **184270**

Water Analysis Part 2

0 *records for RN* **184270**

Water Levels

0 *records for RN* **184270**

Wire Line Logs

0 *records for RN* **184270**

Field Measurements

0 *records for RN* **184270**

Special Water Analysis

0 *records for RN* **184270**

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

Bore Report

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
184271	Sub-Artesian Facility	Existing	26/07/2019	Longreach	5300 - MT ISA C.

Details

Description			
Parish	6000 - NO LONGER USED		
Original Name	SB4B		
Driller Name	WATKINS, ROBERT		
Drill Company	KELLY DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No		**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	11/09/2019	**Data Owner**	
Roles	Mine Monitoring		

Location

Latitude	20-25-41	**Basin**	9130
Longitude	139-51-24	**Sub-area**	
GIS Latitude	-20.4279796	**Lot**	1
GIS Longitude	139.85680197	**Plan**	AA29
Easting	380736		
Northing	7740742	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

5 *records for RN* **184271**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	26/07/2019	1	0.00	14.00	Polyvinyl Chloride			125
A	26/07/2019	2	5.00	14.00	Perforated or Slotted Casing	1.000	AP - Aperture Size	125
X	26/07/2019	3	0.00	4.00	Grout			193
X	26/07/2019	4	4.00	5.00	Bentonite Seal			193
X	26/07/2019	5	5.00	16.00	Gravel Pack			193

Bore Report

From Year:

Strata Logs

3 *records for RN* **184271**

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	9.00	GRANITE
2	9.00	9.50	GRANITE: WATER
3	9.50	16.00	GRANITE

Stratigraphies

0 *records for RN* **184271**

Aquifers

1 *records for RN* **184271**

Rec	Top (m)	Bottom (m)	Lithology	Date	SWL (m)	Flow	Quality	Yield (L/s)	Contr	Cond	Formation Name
1	9.00	9.50	GNTE - Acid Intrusive, Granite	26/07/2019	-6.00	N		1.50	Y	PS	

Pump Tests Part 1

0 *records for RN* **184271**

Pump Tests Part 2

0 *records for RN* **184271**

Bore Conditions

0 *records for RN* **184271**

Elevations

0 *records for RN* **184271**

Water Analysis Part 1

0 *records for RN* **184271**

Water Analysis Part 2

0 *records for RN* **184271**

Water Levels

0 *records for RN* **184271**

Wire Line Logs

0 *records for RN* **184271**

Field Measurements

1 *records for RN* **184271**

Bore Report

From Year:

Pipe	Date	Depth (m)	Conduct (uS/cm)	pH	Temp (C)	NO3 (mg/L)	DO2 (mg/L)	Eh (mV)	Alkalinity (mV)	Samp	Method	Samp	Source
A	16/07/2019		500	7.0						XX	Unknown	GB	Groundwater - from Bore

Special Water Analysis

0 ***records for RN*** **184271**

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

Bore Report

From Year:

Registered Number	Facility Type	Facility Status	Drilled Date	Office	Shire
184272	Sub-Artesian Facility	Existing	28/07/2019	Longreach	5300 - MT ISA C.

Details

Description			
Parish	6000 - NO LONGER USED		
Original Name			
Driller Name	WATKINS, ROBERT		
Drill Company	KELLY DRILLING		
Const Method	ROTARY AIR		
Bore Line			
D/O File No		**Polygon**	
R/O File No		**Equipment**	
H/O File No		**RN of Bore Replaced**	
Log Received Date	11/09/2019	**Data Owner**	
Roles	Water Supply		

Location

Latitude	20-24-58	**Basin**	9130
Longitude	139-50-54	**Sub-area**	
GIS Latitude	-20.4160441975	**Lot**	1
GIS Longitude	139.8483438702	**Plan**	AA29
Easting	379844		
Northing	7742057	**Map Scale**	
Zone	54	**Map Series**	
Accuracy		**Map No**	
GPS Accuracy		**Map Name**	
Checked	Yes	**Prog Section**	

Casing

7 *records for RN* **184272**

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
A	28/07/2019	1	0.00	39.00	Polyvinyl Chloride			200
A	28/07/2019	2	27.00	39.00	Perforated or Slotted Casing	1.000	AP - Aperture Size	200
X	28/07/2019	3	0.00	6.00	Polyvinyl Chloride			300
X	28/07/2019	4	0.00	6.00	Grout			400
X	28/07/2019	5	0.00	6.00	Grout			270

Bore Report

From Year:

Pipe	Date	Rec	Top (m)	Bottom (m)	Material Description	Mat Size (mm)	Size Desc	Outside Diameter (mm)
X	28/07/2019	6	6.00	8.00	Bentonite Seal			270
X	28/07/2019	7	8.00	40.00	Gravel Pack			270

Strata Logs

4 *records for RN* **184272**

Rec	Top (m)	Bottom (m)	Strata Description
1	0.00	2.00	BROKEN GRANITE, SAND
2	2.00	11.00	GRANITE
3	11.00	12.00	GRANITE: WATER
4	12.00	40.00	GRANITE

Stratigraphies

0 *records for RN* **184272**

Aquifers

1 *records for RN* **184272**

Rec	Top (m)	Bottom (m)	Lithology	Date	SWL (m)	Flow	Quality	Yield (L/s)	Contr	Cond	Formation Name
1	11.00	12.00	GNTE - Acid Intrusive, Granite	28/07/2019	-6.00	N		0.80	Y	PS	

Pump Tests Part 1

0 *records for RN* **184272**

Pump Tests Part 2

0 *records for RN* **184272**

Bore Conditions

0 *records for RN* **184272**

Elevations

0 *records for RN* **184272**

Water Analysis Part 1

0 *records for RN* **184272**

Bore Report

From Year:

Water Analysis Part 2

0 *records for RN* **184272**

Water Levels

0 *records for RN* **184272**

Wire Line Logs

0 *records for RN* **184272**

Field Measurements

1 *records for RN* **184272**

Pipe	Date	Depth (m)	Conduct (uS/cm)	pH	Temp (C)	NO3 (mg/L)	DO2 (mg/L)	Eh (mV)	Alkalinity (mV)	Samp	Method	Samp	Source
A	28/07/2019		500	6.9						XX	Unknown	GB	Groundwater - from Bore

Special Water Analysis

0 *records for RN* **184272**

Bore Report

From Year:

User Licence and Conditions

Disclaimer

Open Licence (Single Supply)

Permitted use:
- You may use the supplied data for your own purposes (including supply to consultants for a specific consultancy project for you but the consultants must return or destroy the supplied data when the project is finished). You must not sell or distribute the supplied data.
- You must display this copyright notice on any copies of the supplied data however altered, reformatted or redisplayed if you supply to a consultant or copy for back up purposes: "© State of Queensland 2022".
- You may create and distribute hardcopy and digital products based on or containing the supplied data, provided all the following conditions are met:
- You must display this acknowledgment on the product(s): "Based on or contains data provided by the State of Queensland 2022. In consideration of the State permitting use of this data you acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."
- You must include metadata with the product(s) you create that use or incorporate the supplied data and the metadata must incorporate as a minimum the metadata provided with this supplied data.

Obligations:

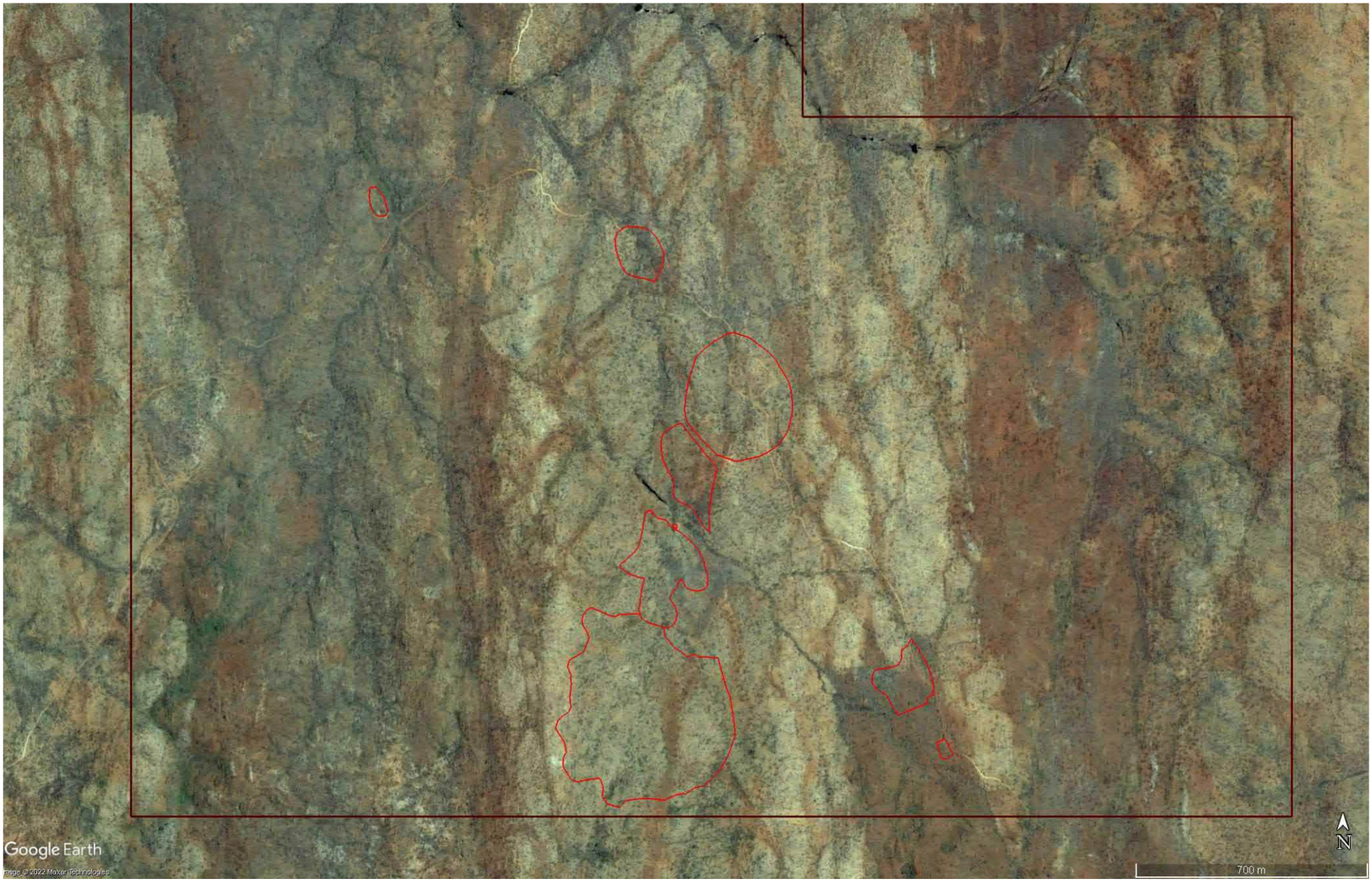
- You must not use the data for direct marketing or in breach of the privacy laws.

Ownership:

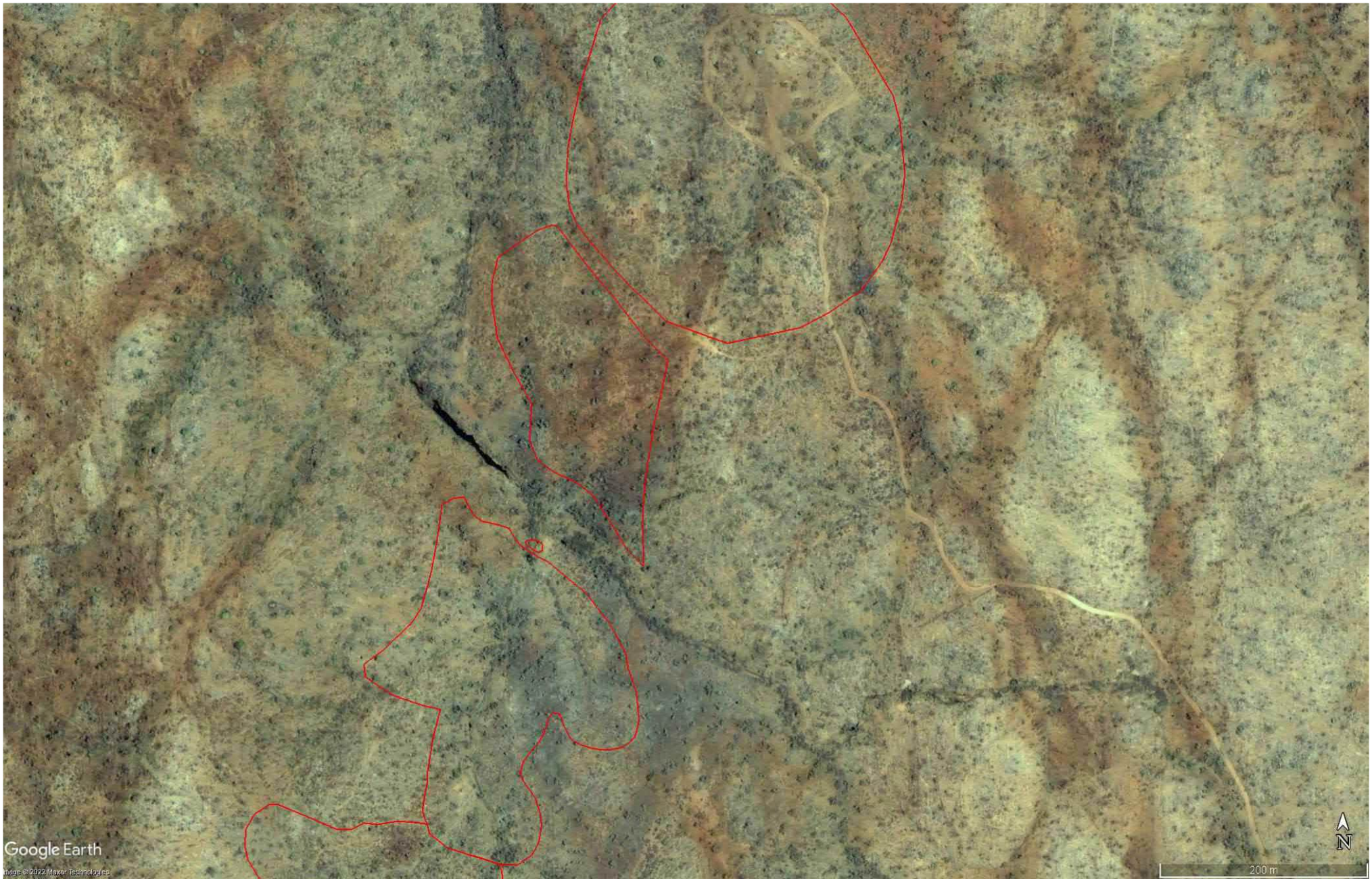
The State of Queensland is the owner of the intellectual property rights in and to the supplied data or has the right to make this supplied data available.

Disclaimer and indemnity:
You agree to accept all responsibility and risks associated with the use of the supplied data. The State makes no representations or warranties in relation to the supplied data, and, you agree that, to the extent permitted by law, all warranties relating to accuracy, reliability, completeness, currency or suitability for any particular purpose and all liability for any loss, damage or costs (including consequential damage) incurred in any way (including but not limited to that arising from negligence) in connection with any use of or reliance on the supplied data are excluded or limited. You agree to continually indemnify the State of Queensland (and its officers and employees) against any loss, cost, expense, damage and liability of any kind (including consequential damage and liability in negligence) arising directly or indirectly from or related to any claim relating to your use of the supplied data or any product made from the data.

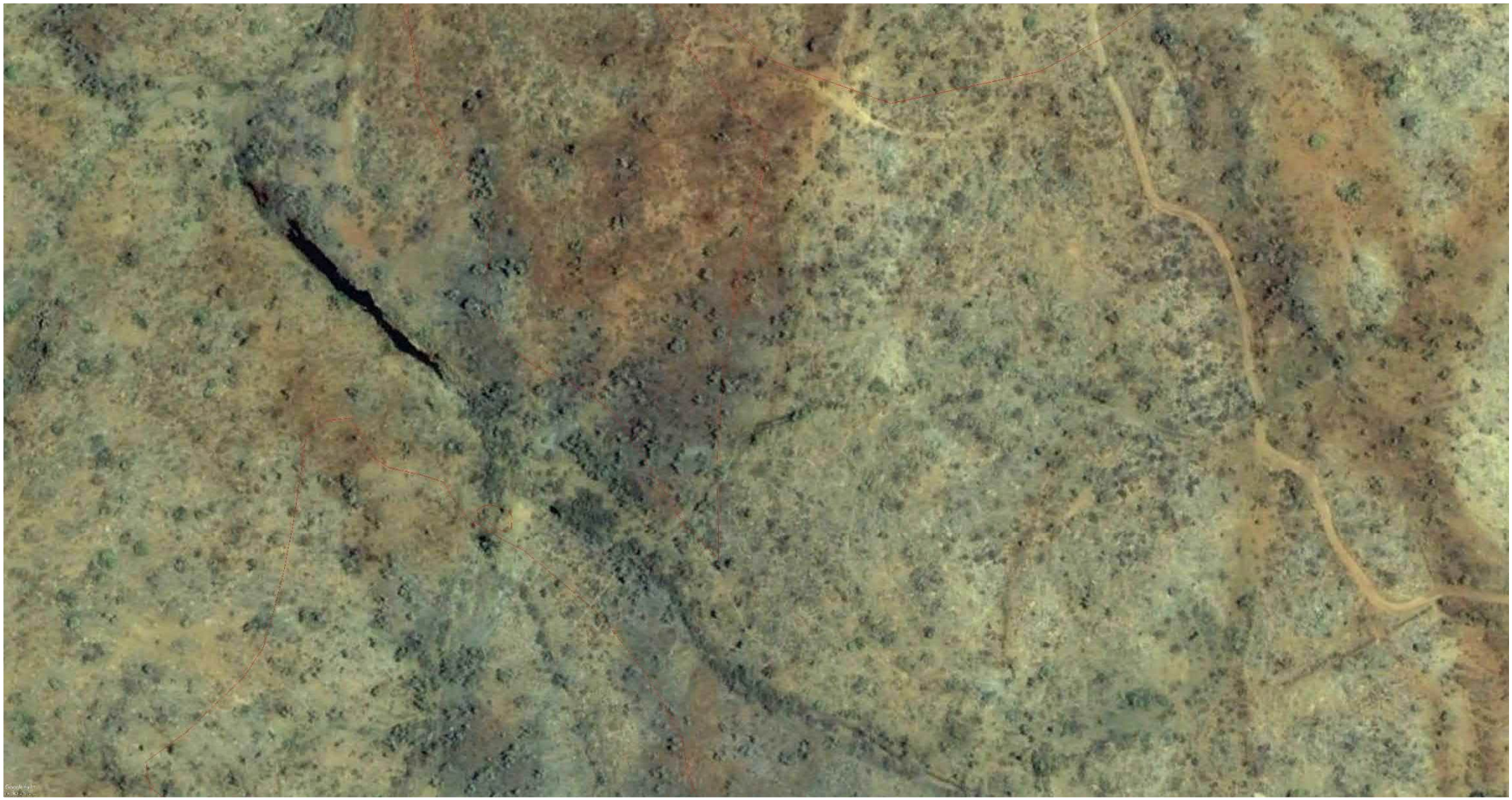
Appendix D Google Earth images of BCP Spring



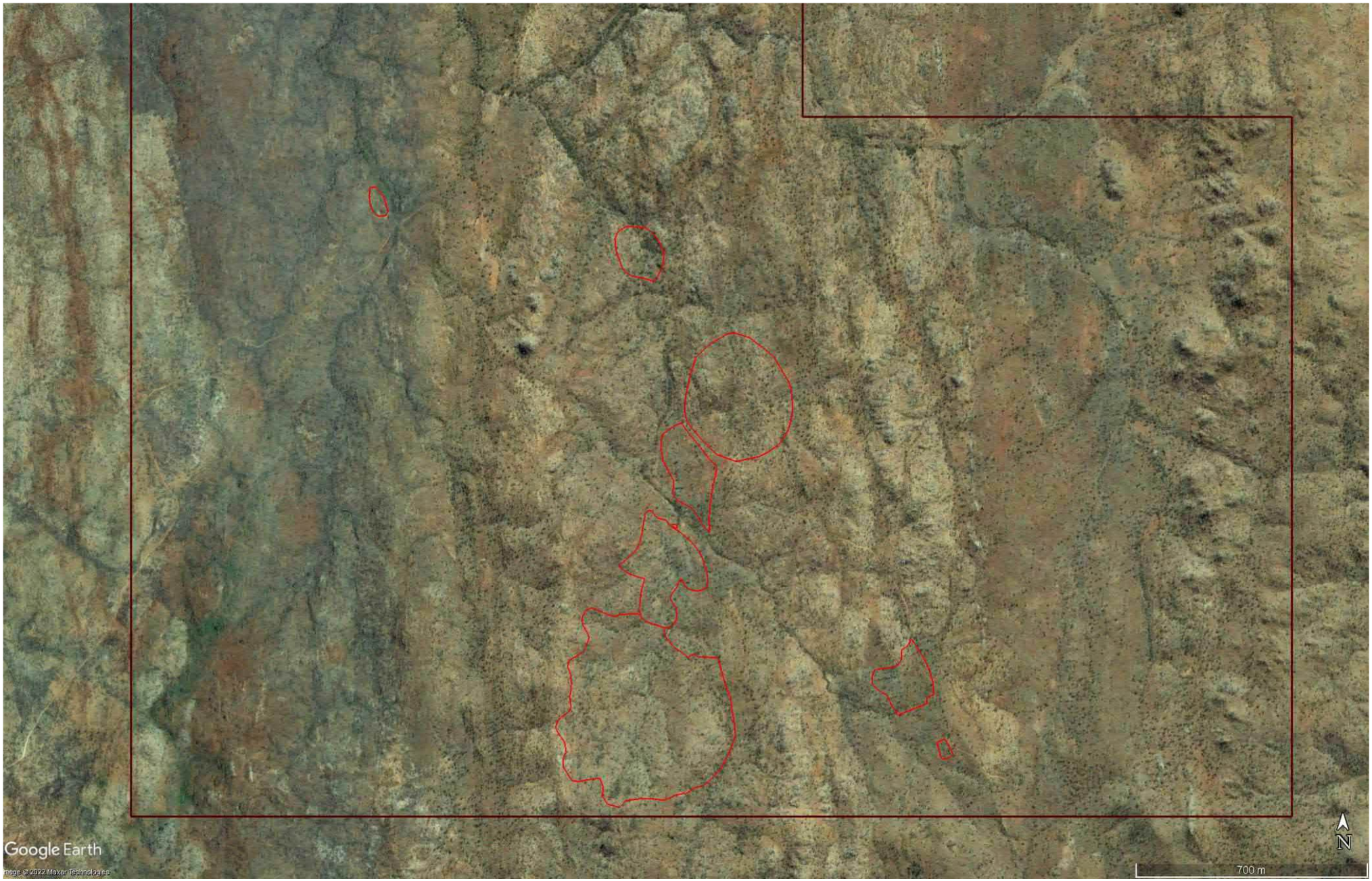
GE_2003_01 (a)



GE_2003_01 (b)



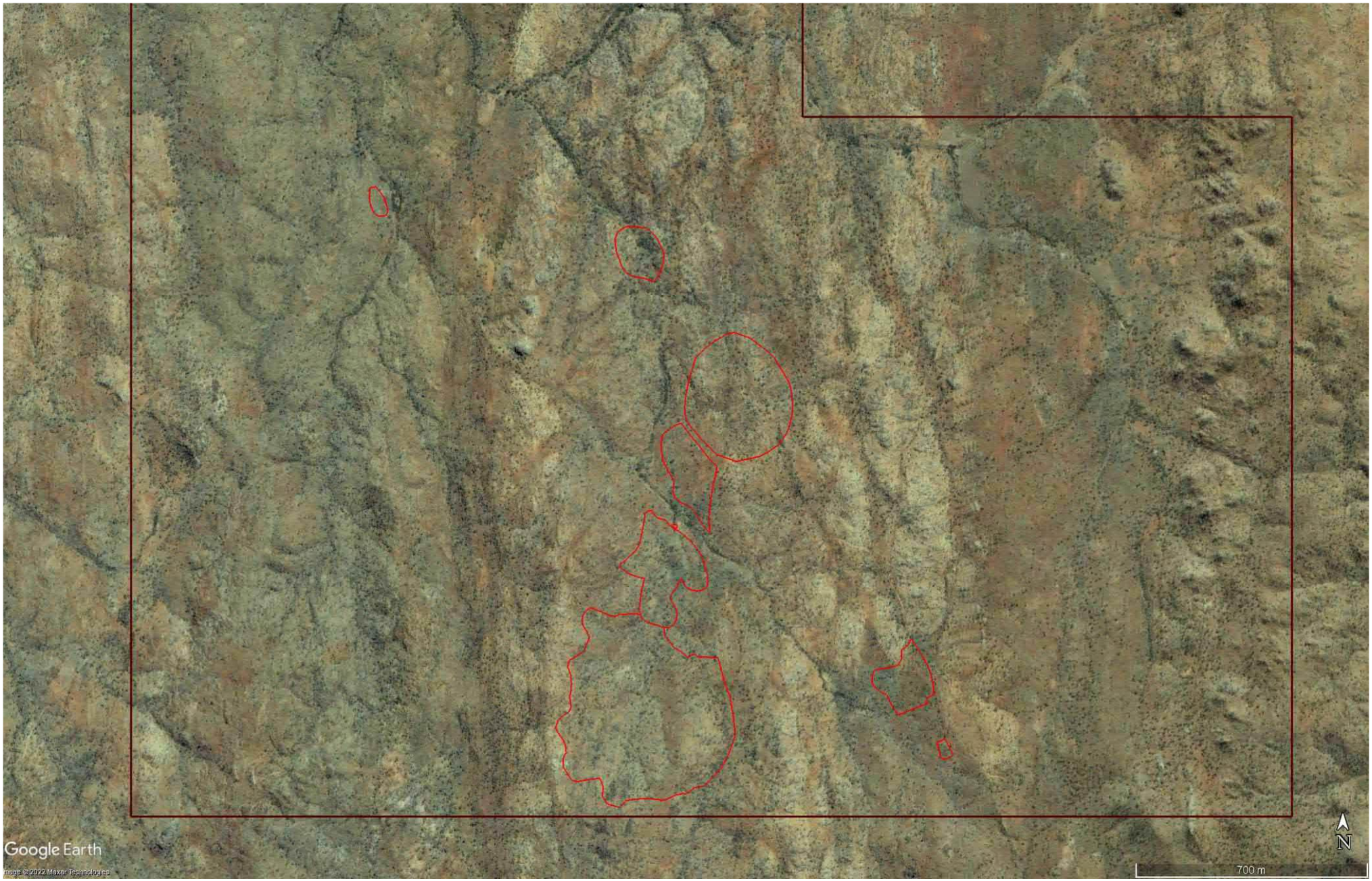
GE_2003_01 (c)



GE_2005_07 (a)

GE_2005_07 (b)

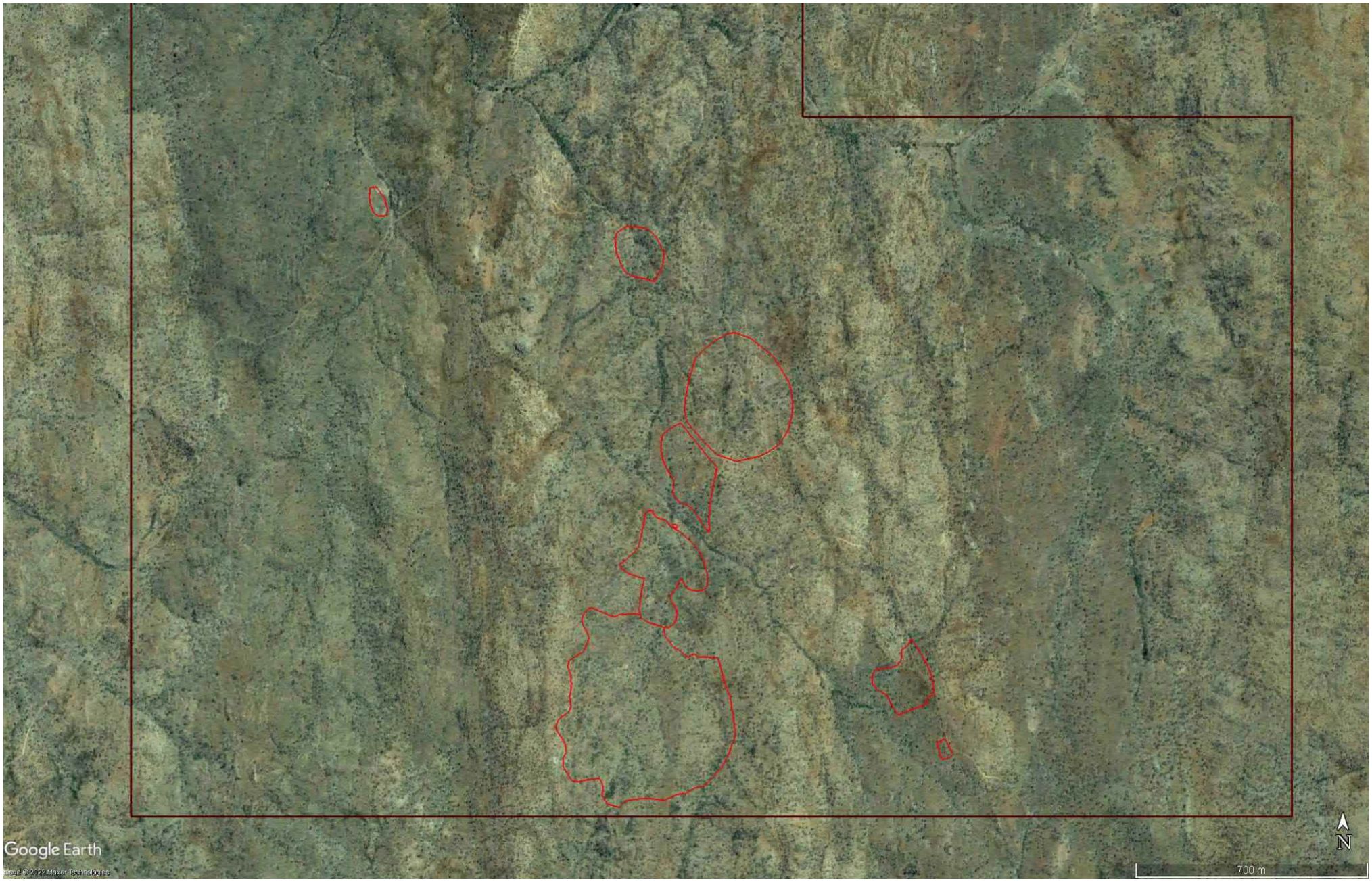
GE_2005_07 (c)



GE_2005_08 (a)

GE_2005_08 (b)

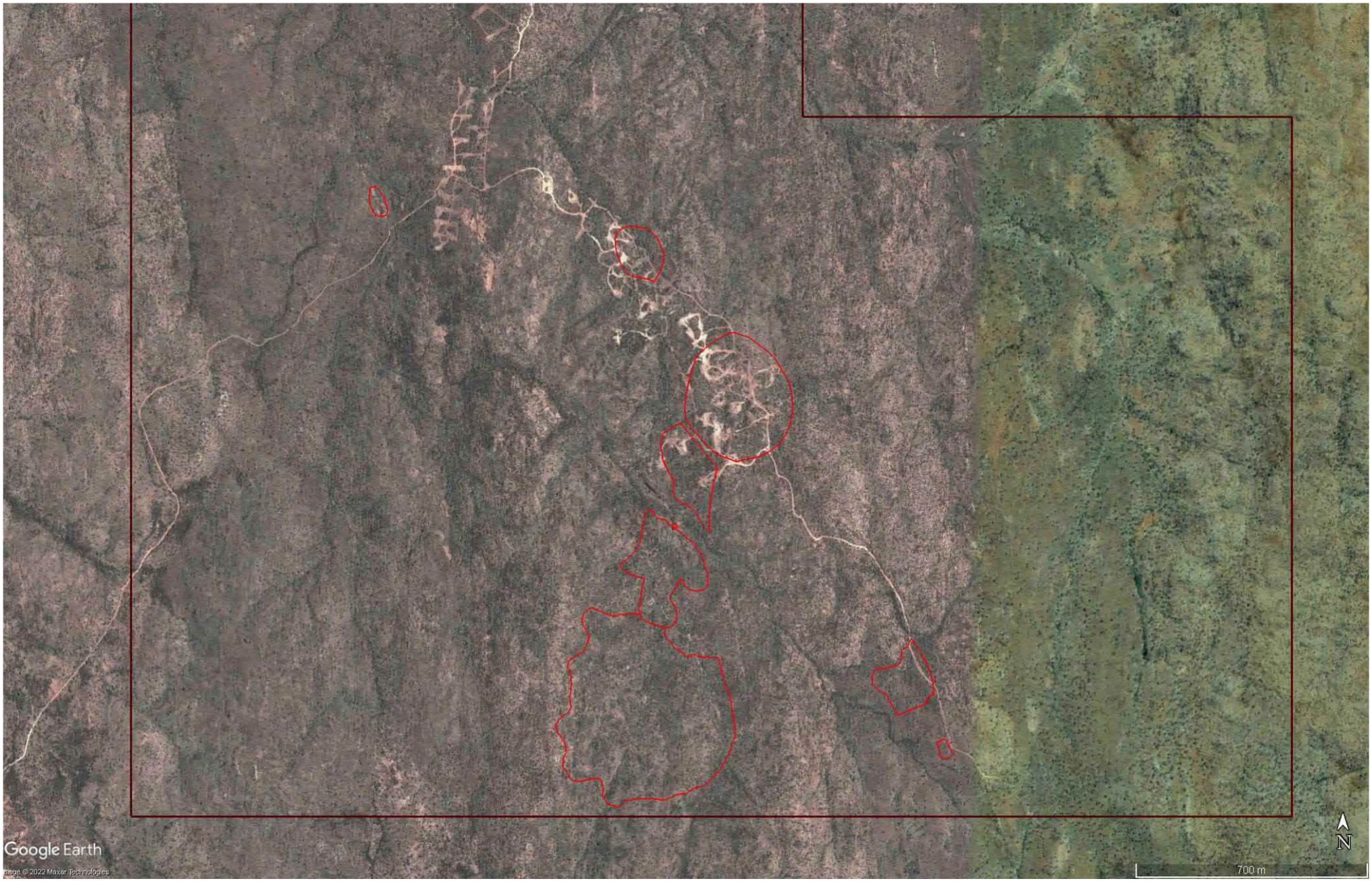
GE_2005_08 (c)



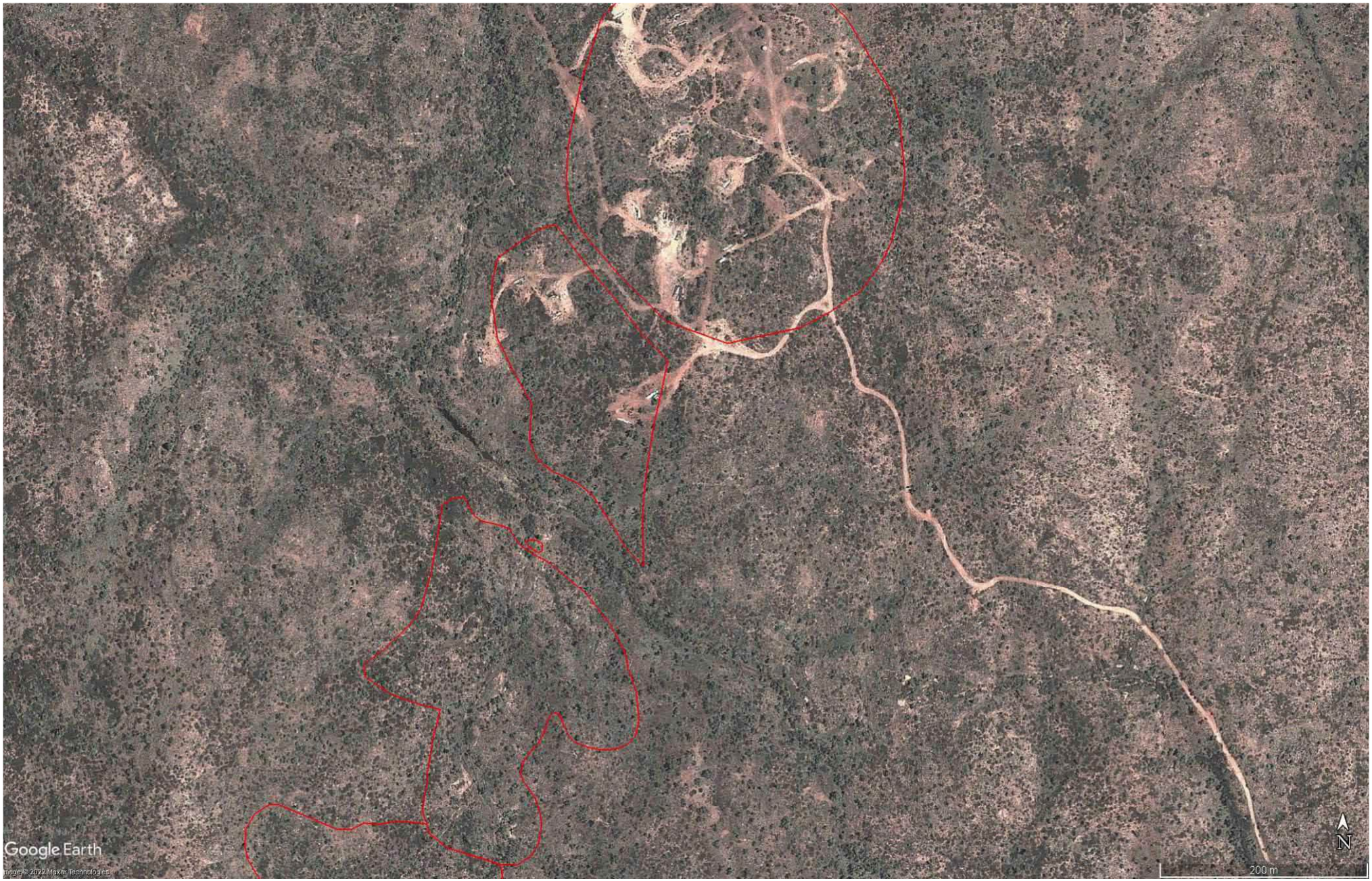
GE_2006_09 (a)

GE_2006_09 (b)

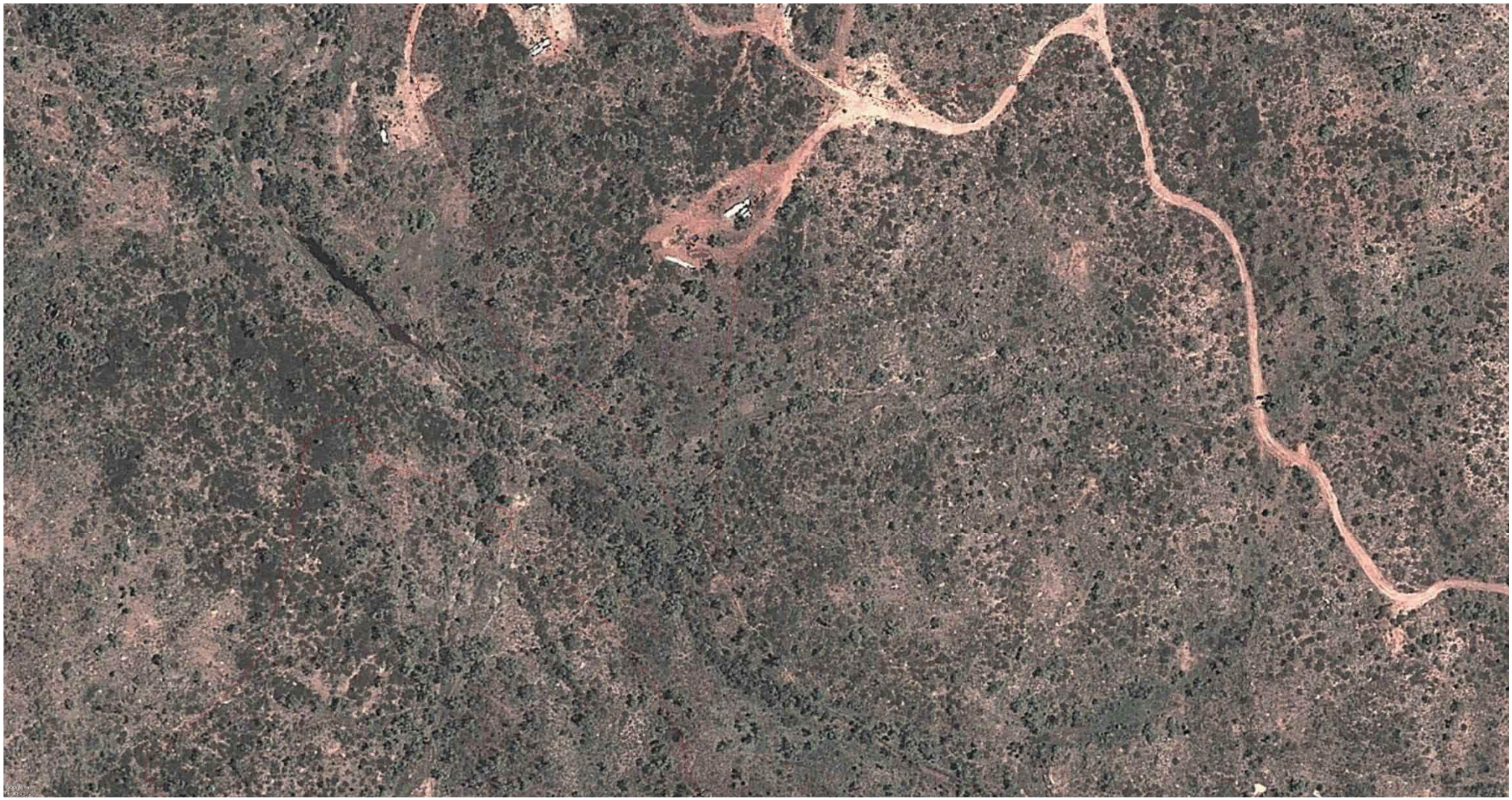
GE_2006_09 (c)



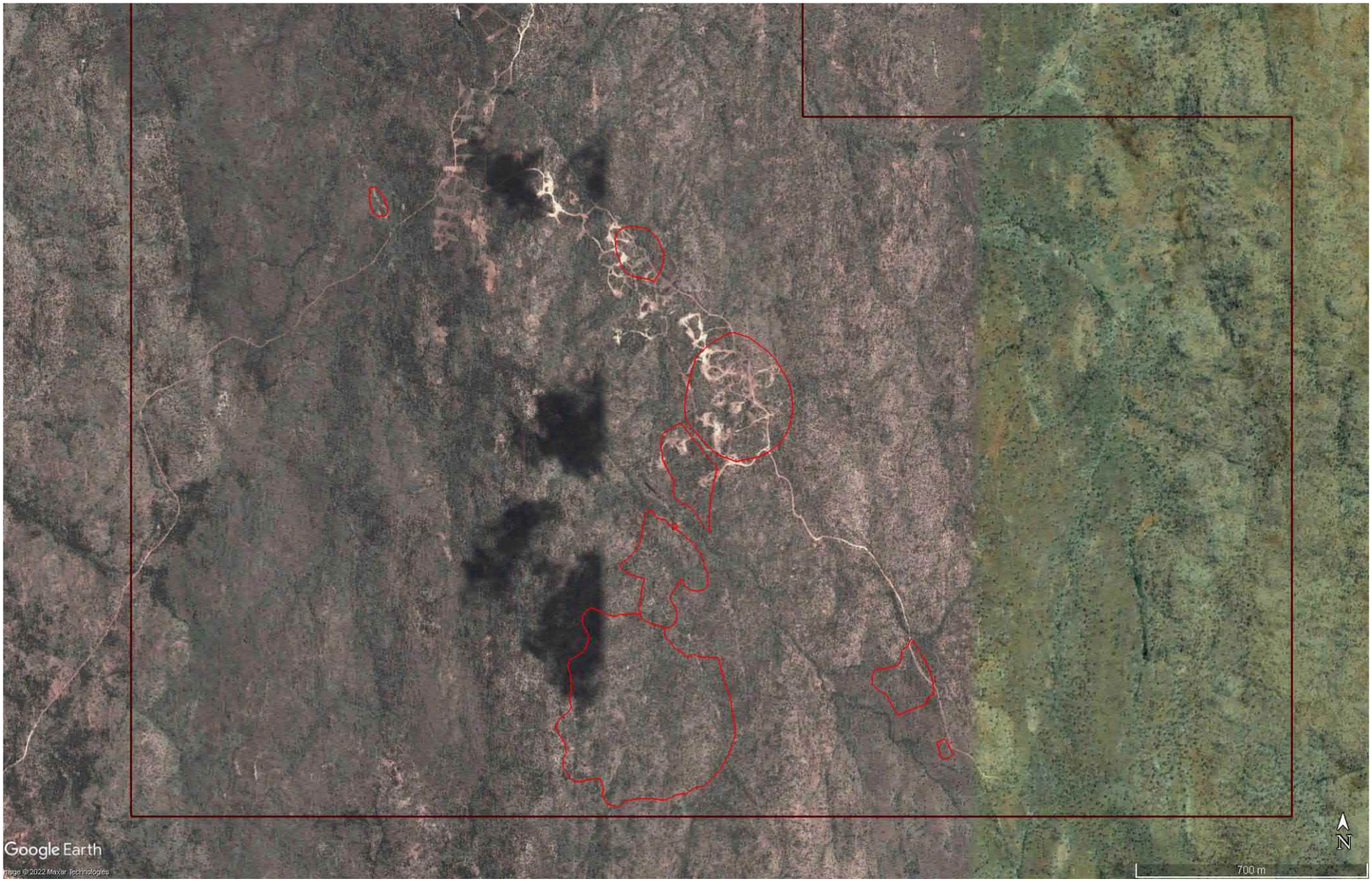
GE_2011_12 (a)



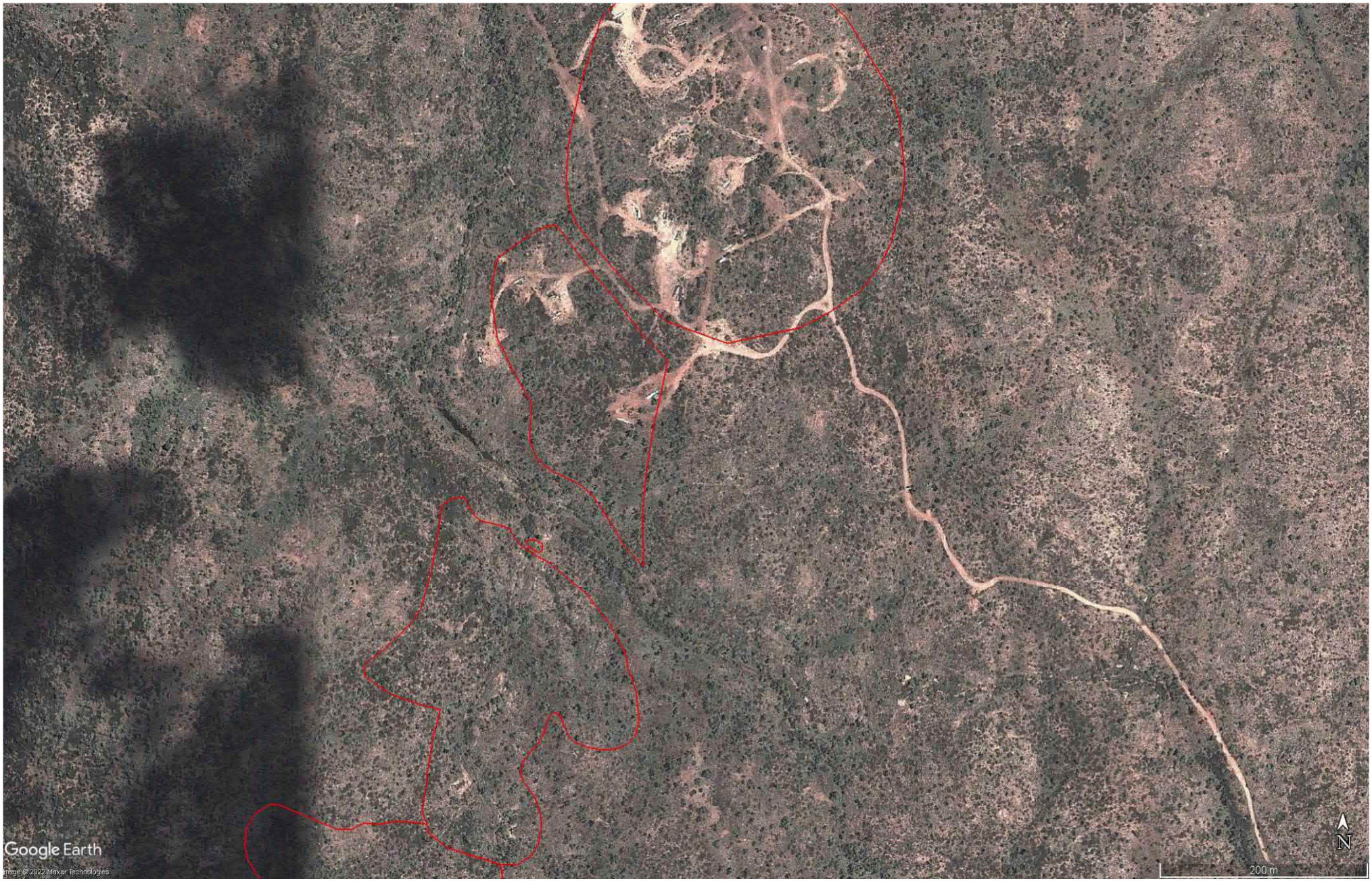
GE_2011_12 (b)



GE_2011_12 (c)

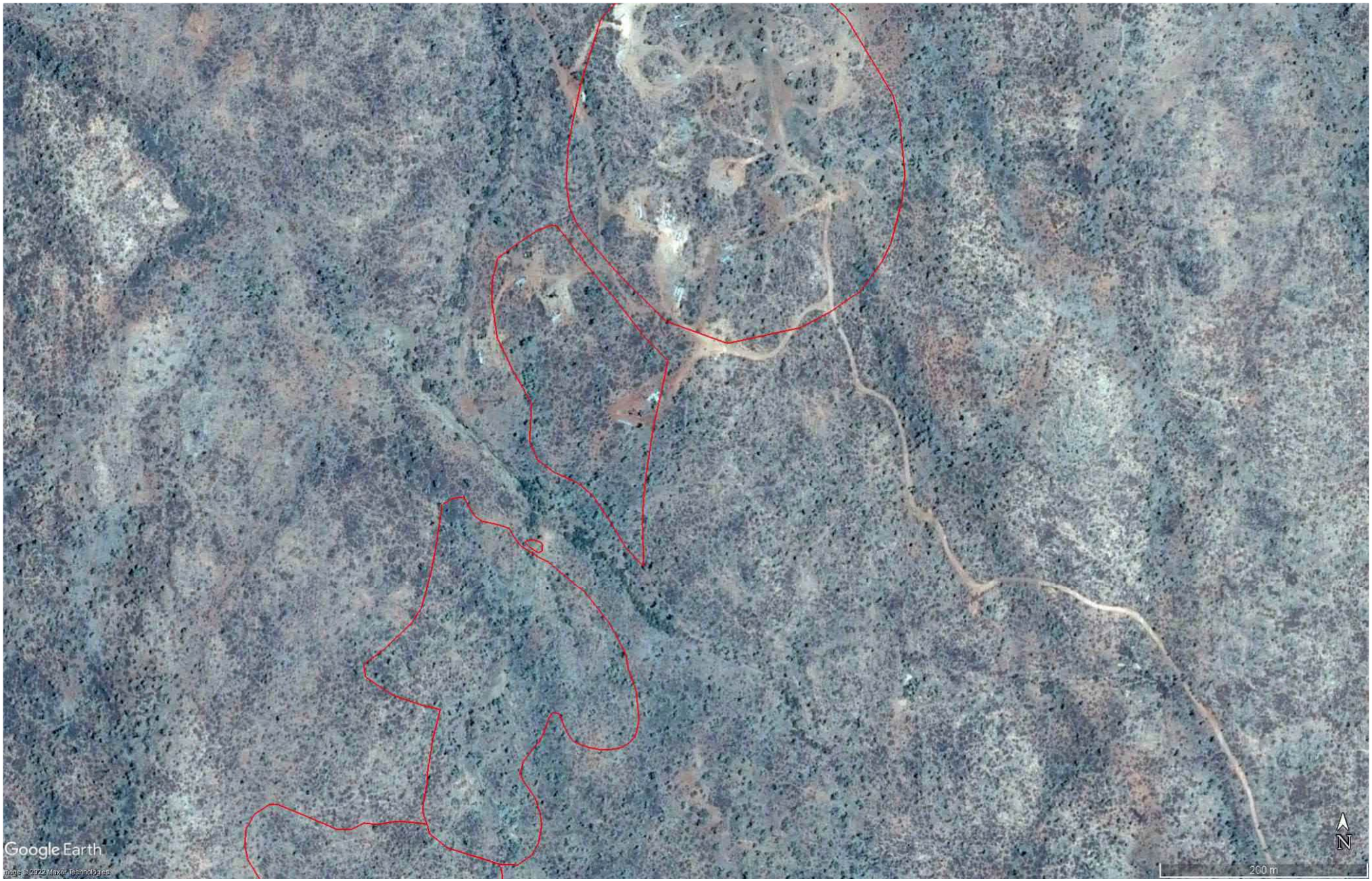


GE_2013_01 (a)



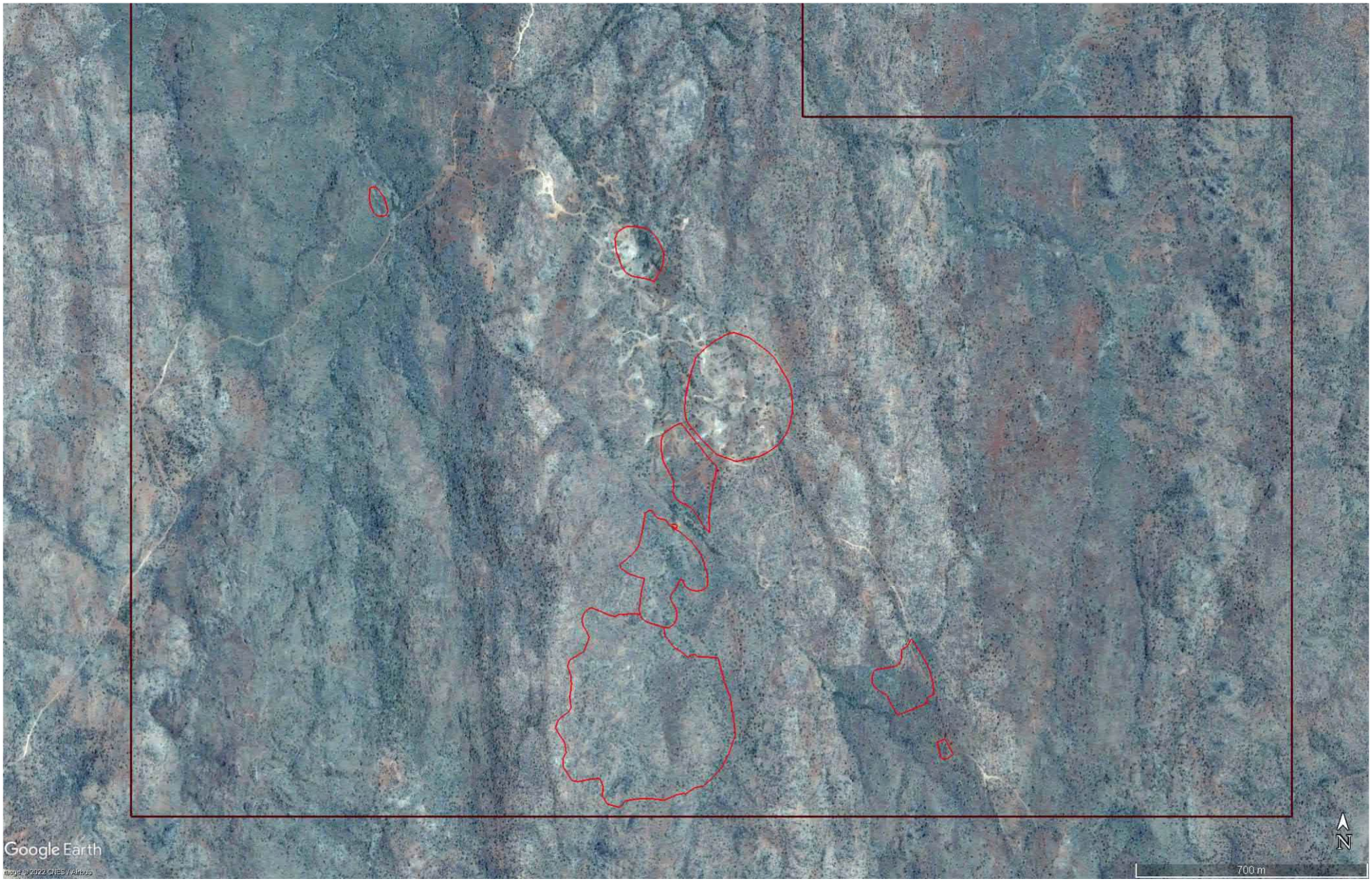
GE_2013_01 (b)

GE_2013_10 (a)



GE_2013_10 (b)

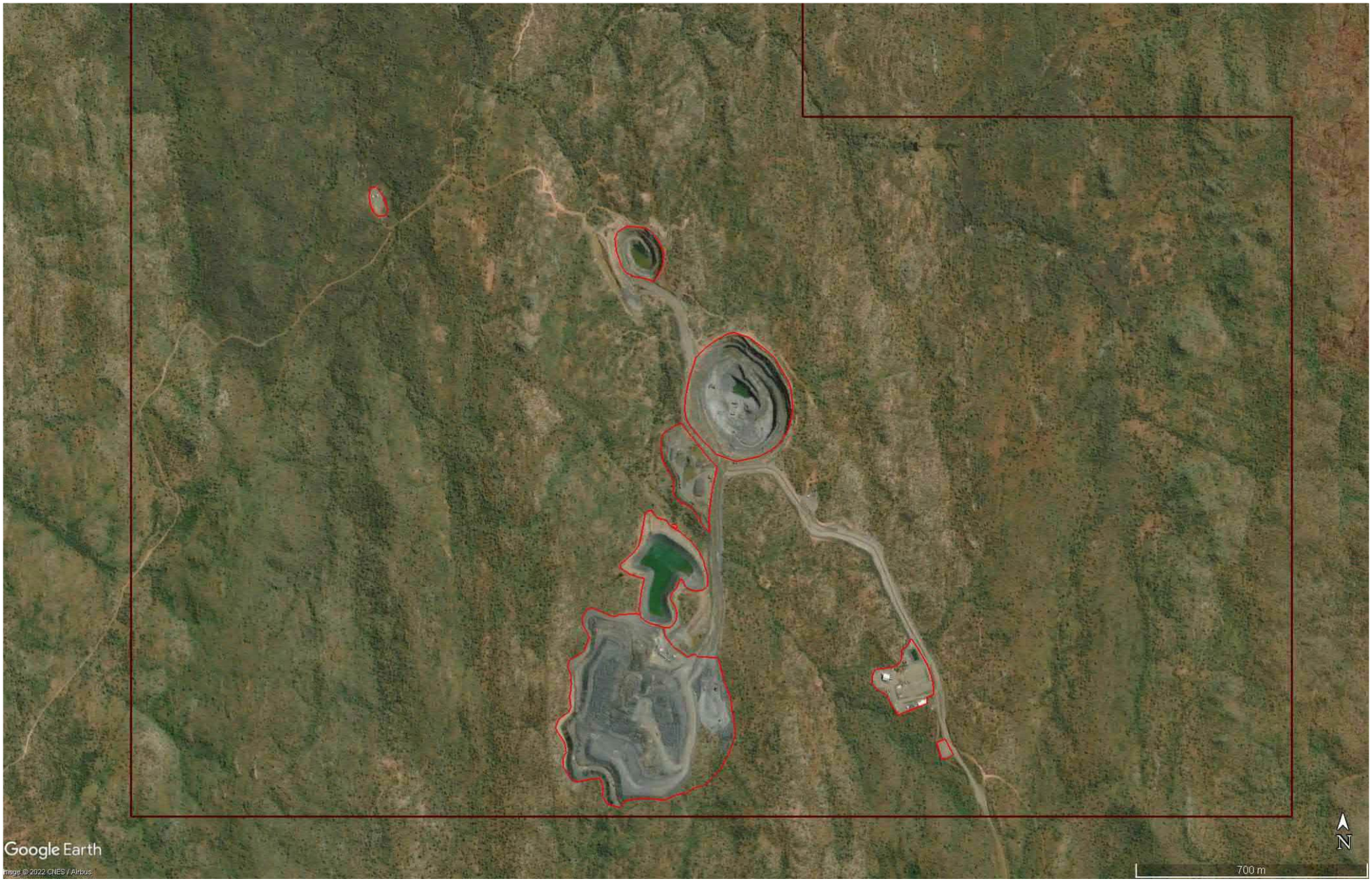
GE_2013_10 (c)



GE_2015_10 (a)

GE_2015_10 (b)

GE_2015_10 (c)



GE_2020_03 (a)

GE_2020_03 (b)

GE_2020_03 (c)

GE_2020_05 (a)

GE_2020_05 (b)

GE_2020_05 (c)

GE_2023_04 (a)

GE_2023_04 (b)

GE_2023_04 (c)

2021_05_01 (Orthomosaic)

Appendix E REMP and EA surface water monitoring data

E.1 Surface water data tables

Table D.1 REMP and EA surface water monitoring events

Year/ Month	B3	B4	B6	B7	B8	B9	BASW01	BASW04	BASW05	BASW08	BASW09	BASW11
2017												
11								✓				
2018												
3								✓		✓		
11								✓				
2019												
1							✓	✓		✓	✓	✓
2							✓	✓				✓
3								✓			✓	
4							✓	✓	✓	✓	✓	✓
5							✓	✓	✓	✓	✓	✓
6							✓	✓	✓	✓	✓	✓
7								✓	✓	✓		✓
8									✓		✓	✓
9												✓
10												✓
11							✓		✓		✓	✓
2020												
2							✓	✓	✓		✓	✓
2021												
1							✓	✓	✓		✓	✓
2								✓			✓	
3	✓		✓	✓	✓	✓						
4							✓	✓	✓		✓	✓
5							✓		✓		✓	✓
8	✓											
11							✓	✓				✓
2022												
2							✓	✓	✓		✓	✓
3	✓		✓	✓	✓							
6							✓	✓	✓	✓		✓
8	✓				✓							
11							✓	✓	✓		✓	✓
2023												
1							✓	✓	✓		✓	✓
4	✓	✓	✓	✓	✓	✓						

Table D.2 Descriptive statistics – all surface water monitoring results

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	No. distinct values (>LOR)	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	10%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	80%ile	90%ile (> LOR)	95%ile (>LOR)	99%ile (>LOR)
Alkalinity																				
Bicarbonate Alkalinity as CaCO3 (mg/L)	91	91			70	17	163.09	156.08	824	807	30.5	35	49	62	103	197	259	400	449.5	748.4
Carbonate Alkalinity as CaCO3 (mg/L)	91	13	78	85.7%	13	3	25.46	22.00	81	78	3.6	4.8	10	13	19	30	31.2	57.6	70.8	78.96
Hydroxide Alkalinity as CaCO3 (mg/L)	91		91	100.0%	1															
Total Alkalinity as CaCO3 (mg/L)	91	91			72	17	166.74	160.89	824	807	30.5	35	49	62	103	199.5	259	416	466	748.4
Carbon																				
Total Non-Purgeable Organic Carbon(mg/L)	6	6			4	7.1	10.33	2.12	13	5.9	7.55	8	8.9	9.175	10	12.25	13	13	13	13
Field Measurements																				
Depth to Water (mbRL)	2	2			2	0.3	0.65	0.35	1	0.7	0.335	0.37	0.44	0.475	0.65	0.825	0.86	0.93	0.965	0.993
Dissolved Oxygen (field) (% sat))	50	50			38	0	34.37	38.13	179.6	179.6	0	0	8.84	9.95	27.35	42.675	48.42	59.64	119.555	171.466
Electrical Conductivity (field) (µS/cm)	53	53			46	49	457.23	419.18	1723	1674	60	79.4	103.2	126	248	716	928.8	1055	1293	1505.64
ORP (field) (mV)	51	51			45	-133.6	78.76	81.43	231.7	365.3	-33.45	-8.4	25.1	28.5	76.3	136.8	168	186.5	206.45	230.25
pH (field)	53	53			42	5.34	7.90	0.84	9.52	4.18	6.34	7.01	7.294	7.43	7.9	8.61	8.63	8.778	8.97	9.2964
Salinity (field) (PSU)	52	52			29	0.02	0.23	0.21	0.87	0.85	0.03	0.04	0.052	0.06	0.13	0.355	0.468	0.519	0.65	0.7578
Temperature (field) (°C)	52	52			46	15	26.23	5.87	35.99	20.99	16.739	17.528	20.804	21.785	25.9	30.83	33.264	33.933	34.499	35.4035
Total Dissolved Solids (field) (ppm)	51	51			44	0.07	232.79	212.96	861	860.93	28.5	35	48	63	154	371	490	531	647	757
Turbidity (field) (FNU)	33	33			27	0	45.48	62.67	272	272	4.06	7.68	10.42	11.2	16.2	51.6	80.12	141.4	170	239.36
Hardness																				
Total Hardness (mg CaCO3/L)	91	91			66	9	94.44	82.10	402	393	19.5	26	35	41	60	111.5	140	230	275	321
Ion Balance																				
Ion Balance (%)	18	18			17	-10	-5.79	3.57	0.9	10.9	-10	-9.86	-9.08	-8.8	-6.9	-2.625	-2.02	-0.61	-0.205	0.679
Ionic Balance (%)	30	30			29	0.28	2.77	1.66	6.46	6.18	0.369	0.902	1.27	1.3725	2.65	3.715	3.806	5.419	5.931	6.3875
Total Anions (meq/L)	91	91			82	0.37	4.20	4.21	20	19.63	0.695	0.78	1.15	1.54	2.59	4.945	6.16	10.7	13	17.57
Total Cations (meq/L)	91	91			79	0.3	4.23	4.22	19.5	19.2	0.74	0.81	1.33	1.46	2.54	4.96	6.86	11.6	13	17.79
Major Ions																				
Calcium (mg/L)	139	139			38	2	16.79	12.35	73	71	4	5	8	9	13	19.5	22.4	36	40.4	59.16
Chloride (mg/L)	91	90	1	1.1%	42	1	22.01	25.67	111	110	2.45	3	4	6	10	27.75	30.8	59.1	79.85	110.11
Fluoride (mg/L)	88	63	25	28.4%	10	0.1	0.30	0.33	1.6	1.5	0.1	0.1	0.1	0.1	0.2	0.4	0.4	0.5	0.96	1.6
Magnesium (mg/L)	139	139			45	1	10.94	13.10	76	75	2	2.56	3	4	6	10.5	14.4	30	39.3	62.64
Potassium (mg/L)	139	139			39	2	10.55	16.89	160	158	3	3.48	4	4	6	9.95	12	17.6	30.2	68.86
Sodium (mg/L)	139	138	1	0.7%	70	1	42.30	53.13	270	269	3	4	8	10	22.5	43.75	57.6	114.4	149.4	232.52
Sulfate (as SO4)	91	68	23	25.3%	38	1	16.62	29.96	230	229	1.445	2	2.08	3	7	20	23.6	37.9	51	120.12
Metals (dissolved)																				
Aluminium - dissolved (mg/L)	18	9	9	50.0%	9	0.006	0.044	0.087	0.29	0.284	0.0064	0.0068	0.0082	0.009	0.013	0.02	0.024	0.082	0.186	0.2692
Arsenic - dissolved (mg/L)	92	32	60	65.2%	5	0.001	0.002	0.001	0.004	0.003	0.001	0.001	0.001	0.001	0.002	0.003	0.003	0.0039	0.004	0.004

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	No. distinct values (>LOR)	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	10%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	80%ile	90%ile (> LOR)	95%ile (>LOR)	99%ile (>LOR)
Barium - dissolved (mg/L)	91	91			52	0.005	0.052	0.060	0.419	0.414	0.015	0.017	0.02	0.021	0.034	0.0495	0.07	0.099	0.1545	0.3029
Bismuth - dissolved (mg/L)	91		91	100.0%	1															
Chromium - dissolved (mg/L)	92	3	89	96.7%	3	0.001	0.001	0.000	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.0015	0.0016	0.0018	0.0019	0.00198
Cobalt - dissolved (mg/L)	92	25	67	72.8%	6	0.001	0.003	0.001	0.005	0.004	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.005	0.005	0.005
Copper - dissolved (mg/L)	92	85	7	7.6%	21	0.001	0.011	0.031	0.208	0.207	0.001	0.001	0.002	0.002	0.004	0.009	0.0112	0.0172	0.0276	0.208
Molybdenum - dissolved (mg/L)	92	34	58	63.0%	8	0.0006	0.002	0.001	0.003	0.0024	0.0007	0.00093	0.001	0.001	0.00155	0.003	0.003	0.003	0.003	0.003
Nickel - dissolved (mg/L)	92	16	76	82.6%	7	0.001	0.003	0.002	0.008	0.007	0.001	0.001	0.001	0.001	0.002	0.00325	0.004	0.0055	0.00725	0.00785
Selenium - dissolved (mg/L)	92		92	100.0%	1															
Uranium - dissolved (mg/L)	91	23	68	74.7%	11	0.0005	0.003	0.002	0.012	0.0115	0.00091	0.001	0.001	0.0014	0.002	0.003	0.0036	0.0048	0.005	0.01046
Zinc - dissolved (mg/L)	6		6	100.0%	1															
Metals (total)																				
Aluminium - total (mg/L)	18	18			18	0.02	0.442	1.098	4.9	4.88	0.02255	0.0265	0.032	0.04275	0.09	0.2825	0.314	0.61	1.3725	4.1945
Arsenic - total (mg/L)	92	41	51	55.4%	7	0.001	0.002	0.001	0.006	0.005	0.001	0.001	0.001	0.001	0.002	0.003	0.003	0.004	0.004	0.0056
Barium - total (mg/L)	91	91			59	0.012	0.064	0.069	0.38	0.368	0.0185	0.02	0.026	0.0285	0.044	0.066	0.074	0.103	0.2095	0.3764
Bismuth - total (mg/L)	91		91	100.0%	1															
Chromium - total (mg/L)	92	10	82	89.1%	7	0.001	0.004	0.004	0.016	0.015	0.001	0.001	0.0018	0.002	0.002	0.00345	0.00368	0.0052	0.0106	0.01492
Cobalt - total (mg/L)	92	41	51	55.4%	9	0.001	0.003	0.002	0.011	0.01	0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.005	0.006	0.0094
Copper - total (mg/L)	92	88	4	4.3%	29	0.001	0.017	0.046	0.311	0.31	0.002	0.002	0.002	0.00275	0.0055	0.014	0.015	0.033	0.0416	0.311
Molybdenum - total (mg/L)	92	32	60	65.2%	9	0	0.002	0.001	0.004	0.004	0.000655	0.00082	0.001	0.001	0.002	0.003	0.003	0.0039	0.004	0.004
Nickel - total (mg/L)	92	25	67	72.8%	7	0.001	0.003	0.002	0.009	0.008	0.001	0.001	0.001	0.001	0.002	0.003	0.003	0.004	0.0064	0.00852
Selenium - total (mg/L)	92		92	100.0%	1															
Uranium - total (mg/L)	91	24	67	73.6%	13	0.0005	0.003	0.002	0.012	0.0115	0.001	0.001	0.001	0.001075	0.002	0.00325	0.004	0.00507	0.005865	0.01062
Nutrients																				
Nitrite + Nitrate as N (mg/L)	1		1	100.0%	1															
Total Kjeldahl Nitrogen as N (mg/L)	1	1			1	0.9	0.90	0.00	0.9	0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Total Nitrogen as N (mg/L)	1	1			1	0.9	0.90	0.00	0.9	0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Total Phosphorus as P (mg/L)	1	1			1	0.07	0.07	0.00	0.07	0	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Physico-Chemical Parameters																				
Electrical Conductivity (µS/cm)	89	89			78	39	374.22	356.91	1710	1671	74	85	127.8	136	244	460	553.8	935.4	1040	1613.2
pH (lab)	85	85			63	6.47	7.72	0.54	8.97	2.5	6.878	7.122	7.29	7.36	7.7	8.04	8.192	8.5	8.596	8.9448
Turbidity (NTU)	78	78			69	1.1	25.57	36.62	205	203.9	1.87	2.74	4.08	5.4	11.9	28.4	37.16	59.68	129.15	152.64

Table D.3 Descriptive statistics of surface water monitoring results – by location

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
B3														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	5	5			74	126.6	56.0771	200	126	75.8	83	86	190	198
Carbonate Alkalinity as CaCO3 (mg/L)	5	1	4	80.0%	8	8	0	8	0	8	8	8	8	8
Total Alkalinity as CaCO3 (mg/L)	5	5			74	128.2	54.9123	200	126	76.4	86	91	190	198
Hardness														
Total Hardness (mg CaCO3/L)	5	5			26	59.2	30.4985	110	84	28.4	38	45	77	103.4
Major Ions														
Calcium (mg/L)	5	5			6	12.3	4.9558	19	13	6.5	8.5	11	17	18.6
Chloride (mg/L)	5	5			7	15.2	10.1863	34	27	7.2	8	9	18	30.8
Fluoride (mg/L)	5	4	1	20.0%	0.1	0.15	0.0866	0.3	0.2	0.1	0.1	0.1	0.15	0.27
Magnesium (mg/L)	5	5			2.7	6.68	4.09067	14	11.3	2.96	4	4.5	8.2	12.84
Potassium (mg/L)	5	5			3.6	6.56	3.09877	12	8.4	3.64	3.8	5.7	7.7	11.14
Sodium (mg/L)	5	5			15	31.8	19.1353	66	51	15.2	16	23	39	60.6
Sulfate (as SO4)	5	5			1.9	4.64	3.75798	12	10.1	1.96	2.2	3	4.1	10.42
Metals (dissolved)														
Aluminium - dissolved (mg/L)	5	4	1	20.0%	0.007	0.0148	0.00907	0.03	0.023	0.0073	0.0085	0.011	0.0173	0.02745
Arsenic - dissolved (mg/L)	6		6	100.0%										
Barium - dissolved (mg/L)	5	5			0.015	0.028	0.01145	0.047	0.032	0.0158	0.019	0.025	0.034	0.0444
Bismuth - dissolved (mg/L)	5		5	100.0%										
Chromium - dissolved (mg/L)	6		6	100.0%										
Cobalt - dissolved (mg/L)	6		6	100.0%										
Copper - dissolved (mg/L)	6	6			0.001	0.0025	0.00096	0.004	0.003	0.0013	0.002	0.0025	0.003	0.00375
Molybdenum - dissolved (mg/L)	6	1	5	83.3%	7E-04	0.0007	0	0.0007	0	0.0007	0.0007	0.0007	0.0007	0.0007

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Nickel - dissolved (mg/L)	6		6	100.0%										
Selenium - dissolved (mg/L)	6		6	100.0%										
Uranium - dissolved (mg/L)	5	1	4	80.0%	0.001	0.001	0	0.001	0	0.001	0.001	0.001	0.001	0.001
Zinc - dissolved (mg/L)	1		1	100.0%										
Metals (total)														
Aluminium - total (mg/L)	5	5			0.067	0.2814	0.16307	0.55	0.483	0.0876	0.17	0.29	0.33	0.506
Arsenic - total (mg/L)	6		6	100.0%										
Barium - total (mg/L)	5	5			0.02	0.035	0.01753	0.068	0.048	0.0202	0.021	0.03	0.036	0.0616
Bismuth - total (mg/L)	5		5	100.0%										
Chromium - total (mg/L)	6		6	100.0%										
Cobalt - total (mg/L)	6	1	5	83.3%	0.001	0.001	0	0.001	0	0.001	0.001	0.001	0.001	0.001
Copper - total (mg/L)	6	6			0.002	0.0035	0.0015	0.006	0.004	0.002	0.00225	0.003	0.0045	0.00575
Molybdenum - total (mg/L)	6		6	100.0%										
Nickel - total (mg/L)	6	1	5	83.3%	0.001	0.001	0	0.001	0	0.001	0.001	0.001	0.001	0.001
Selenium - total (mg/L)	6		6	100.0%										
Uranium - total (mg/L)	5	1	4	80.0%	0.001	0.0011	0	0.0011	0	0.0011	0.0011	0.0011	0.0011	0.0011
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	4	4			130	247.5	147.203	500	370	137.5	167.5	180	260	452
pH (lab)	4	4			7.3	7.675	0.43229	8.4	1.1	7.315	7.375	7.5	7.8	8.28
B4														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	1	1			460	460	0	460	0	460	460	460	460	460
Carbonate Alkalinity as CaCO3 (mg/L)	1		1	100.0%										
Total Alkalinity as CaCO3 (mg/L)	1	1			460	460	0	460	0	460	460	460	460	460
Hardness														

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Total Hardness (mg CaCO3/L)	1	1			270	270	0	270	0	270	270	270	270	270
Major Ions														
Calcium (mg/L)	1	1			40	40	0	40	0	40	40	40	40	40
Chloride (mg/L)	1	1			110	110	0	110	0	110	110	110	110	110
Fluoride (mg/L)	1	1			0.5	0.5	0	0.5	0	0.5	0.5	0.5	0.5	0.5
Magnesium (mg/L)	1	1			42	42	0	42	0	42	42	42	42	42
Potassium (mg/L)	1	1			9	9	0	9	0	9	9	9	9	9
Sodium (mg/L)	1	1			270	270	0	270	0	270	270	270	270	270
Sulfate (as SO4)	1	1			230	230	0	230	0	230	230	230	230	230
Metals (dissolved)														
Aluminium - dissolved (mg/L)	1		1	100.0%										
Arsenic - dissolved (mg/L)	1		1	100.0%										
Barium - dissolved (mg/L)	1	1			0.08	0.08	0	0.08	0	0.08	0.08	0.08	0.08	0.08
Bismuth - dissolved (mg/L)	1		1	100.0%										
Chromium - dissolved (mg/L)	1		1	100.0%										
Cobalt - dissolved (mg/L)	1		1	100.0%										
Copper - dissolved (mg/L)	1	1			0.005	0.005	0	0.005	0	0.005	0.005	0.005	0.005	0.005
Molybdenum - dissolved (mg/L)	1	1			0.002	0.002	0	0.002	0	0.002	0.002	0.002	0.002	0.002
Nickel - dissolved (mg/L)	1		1	100.0%										
Selenium - dissolved (mg/L)	1		1	100.0%										
Uranium - dissolved (mg/L)	1	1			0.005	0.005	0	0.005	0	0.005	0.005	0.005	0.005	0.005
Zinc - dissolved (mg/L)	1		1	100.0%										
Metals (total)														
Aluminium - total (mg/L)	1	1			0.066	0.066	0	0.066	0	0.066	0.066	0.066	0.066	0.066
Arsenic - total (mg/L)	1		1	100.0%										

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Barium - total (mg/L)	1	1			0.085	0.085	0	0.085	0	0.085	0.085	0.085	0.085	0.085
Bismuth - total (mg/L)	1		1	100.0%										
Chromium - total (mg/L)	1		1	100.0%										
Cobalt - total (mg/L)	1	1			0.001	0.001	0	0.001	0	0.001	0.001	0.001	0.001	0.001
Copper - total (mg/L)	1	1			0.006	0.006	0	0.006	0	0.006	0.006	0.006	0.006	0.006
Molybdenum - total (mg/L)	1	1			0.002	0.002	0	0.002	0	0.002	0.002	0.002	0.002	0.002
Nickel - total (mg/L)	1		1	100.0%										
Selenium - total (mg/L)	1		1	100.0%										
Uranium - total (mg/L)	1	1			0.005	0.0051	0	0.0051	0	0.0051	0.0051	0.0051	0.0051	0.0051
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	1	1			1600	1600	0	1600	0	1600	1600	1600	1600	1600
B6														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	3	3			130	173.33	36.8179	220	90	134	150	170	195	215
Carbonate Alkalinity as CaCO3 (mg/L)	3		3	100.0%										
Total Alkalinity as CaCO3 (mg/L)	3	3			130	173.33	36.8179	220	90	134	150	170	195	215
Hardness														
Total Hardness (mg CaCO3/L)	3	3			55	88.333	23.9212	110	55	59.5	77.5	100	105	109
Major Ions														
Calcium (mg/L)	3	3			12	20.333	6.01849	26	14	13.1	17.5	23	24.5	25.7
Chloride (mg/L)	3	3			10	16.667	8.05536	28	18	10.2	11	12	20	26.4
Fluoride (mg/L)	3	3			0.1	0.1	#NUM!	0.1	0	0.1	0.1	0.1	0.1	0.1
Magnesium (mg/L)	3	3			5.7	9.3	2.98105	13	7.3	6.05	7.45	9.2	11.1	12.62
Potassium (mg/L)	3	3			4.1	4.8667	0.57927	5.5	1.4	4.19	4.55	5	5.25	5.45
Sodium (mg/L)	3	3			22	34	15.5778	56	34	22.2	23	24	40	52.8

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Sulfate (as SO4)	3	3			1.2	2.8	1.1431	3.8	2.6	1.42	2.3	3.4	3.6	3.76
Metals (dissolved)														
Aluminium - dissolved (mg/L)	3	2	1	33.3%	0.011	0.0155	0.0045	0.02	0.009	0.0115	0.01325	0.0155	0.0178	0.01955
Arsenic - dissolved (mg/L)	3	1	2	66.7%	0.002	0.002	0	0.002	0	0.002	0.002	0.002	0.002	0.002
Barium - dissolved (mg/L)	3	3			0.026	0.037	0.0086	0.047	0.021	0.0272	0.032	0.038	0.0425	0.0461
Bismuth - dissolved (mg/L)	3		3	100.0%										
Chromium - dissolved (mg/L)	3		3	100.0%										
Cobalt - dissolved (mg/L)	3		3	100.0%										
Copper - dissolved (mg/L)	3	1	2	66.7%	0.002	0.002	0	0.002	0	0.002	0.002	0.002	0.002	0.002
Molybdenum - dissolved (mg/L)	3	1	2	66.7%	6E-04	0.0006	0	0.0006	0	0.0006	0.0006	0.0006	0.0006	0.0006
Nickel - dissolved (mg/L)	3		3	100.0%										
Selenium - dissolved (mg/L)	3		3	100.0%										
Uranium - dissolved (mg/L)	3	1	2	66.7%	5E-04	0.0005	0	0.0005	0	0.0005	0.0005	0.0005	0.0005	0.0005
Zinc - dissolved (mg/L)	1		1	100.0%										
Metals (total)														
Aluminium - total (mg/L)	3	3			0.02	0.0237	0.0033	0.028	0.008	0.0203	0.0215	0.023	0.0255	0.0275
Arsenic - total (mg/L)	3	1	2	66.7%	0.002	0.002	0	0.002	0	0.002	0.002	0.002	0.002	0.002
Barium - total (mg/L)	3	3			0.026	0.043	0.01203	0.052	0.026	0.0285	0.0385	0.051	0.0515	0.0519
Bismuth - total (mg/L)	3		3	100.0%										
Chromium - total (mg/L)	3		3	100.0%										
Cobalt - total (mg/L)	3	1	2	66.7%	0.002	0.002	0	0.002	0	0.002	0.002	0.002	0.002	0.002
Copper - total (mg/L)	3	2	1	33.3%	0.001	0.0015	0.0005	0.002	0.001	0.0011	0.00125	0.0015	0.0018	0.00195
Molybdenum - total (mg/L)	3	1	2	66.7%	6E-04	0.0006	0	0.0006	0	0.0006	0.0006	0.0006	0.0006	0.0006
Nickel - total (mg/L)	3		3	100.0%										
Selenium - total (mg/L)	3		3	100.0%										

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Uranium - total (mg/L)	3	1	2	66.7%	5E-04	0.0005	0	0.0005	0	0.0005	0.0005	0.0005	0.0005	0.0005
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	3	3			230	336.67	94.6338	460	230	239	275	320	390	446
pH (lab)	2	2			7.8	7.9	0.1	8	0.2	7.81	7.85	7.9	7.95	7.99
B7														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	3	3			130	290	192.007	560	430	135	155	180	370	522
Carbonate Alkalinity as CaCO3 (mg/L)	3	1	2	66.7%	19	19	0	19	0	19	19	19	19	19
Total Alkalinity as CaCO3 (mg/L)	3	3			150	296.67	186.607	560	410	153	165	180	370	522
Hardness														
Total Hardness (mg CaCO3/L)	3	3			62	126.33	80.6074	240	178	63.5	69.5	77	158.5	223.7
Major Ions														
Calcium (mg/L)	3	3			15	23	10.6145	38	23	15.1	15.5	16	27	35.8
Chloride (mg/L)	3	3			12	44.333	37.5618	97	85	13.2	18	24	60.5	89.7
Fluoride (mg/L)	3	3			0.2	0.3	0.08165	0.4	0.2	0.21	0.25	0.3	0.35	0.39
Magnesium (mg/L)	3	3			6.1	16.3	12.5642	34	27.9	6.37	7.45	8.8	21.4	31.48
Potassium (mg/L)	3	3			5.6	7.8667	1.7632	9.9	4.3	5.85	6.85	8.1	9	9.72
Sodium (mg/L)	3	3			32	106.67	87.8534	230	198	34.6	45	58	144	212.8
Sulfate (as SO4)	3	3			8.9	28.967	26.2171	66	57.1	9.21	10.45	12	39	60.6
Metals (dissolved)														
Aluminium - dissolved (mg/L)	3	1	2	66.7%	0.013	0.013	0	0.013	0	0.013	0.013	0.013	0.013	0.013
Arsenic - dissolved (mg/L)	3	1	2	66.7%	0.002	0.002	0	0.002	0	0.002	0.002	0.002	0.002	0.002
Barium - dissolved (mg/L)	3	3			0.031	0.0477	0.01759	0.072	0.041	0.0319	0.0355	0.04	0.056	0.0688
Bismuth - dissolved (mg/L)	3		3	100.0%										
Chromium - dissolved (mg/L)	3		3	100.0%										

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Cobalt - dissolved (mg/L)	3		3	100.0%										
Copper - dissolved (mg/L)	3	3			0.002	0.0067	0.00411	0.012	0.01	0.0024	0.004	0.006	0.009	0.0114
Molybdenum - dissolved (mg/L)	3	3			0.001	0.0017	0.00092	0.003	0.002	0.001	0.00105	0.0011	0.0021	0.00281
Nickel - dissolved (mg/L)	3		3	100.0%										
Selenium - dissolved (mg/L)	3		3	100.0%										
Uranium - dissolved (mg/L)	3	2	1	33.3%	9E-04	0.0065	0.00555	0.012	0.011	0.0015	0.003675	0.00645	0.0092	0.011445
Zinc - dissolved (mg/L)	1		1	100.0%										
Metals (total)														
Aluminium - total (mg/L)	3	3			0.03	0.2933	0.32417	0.75	0.72	0.037	0.065	0.1	0.425	0.685
Arsenic - total (mg/L)	3	1	2	66.7%	0.002	0.002	0	0.002	0	0.002	0.002	0.002	0.002	0.002
Barium - total (mg/L)	3	3			0.033	0.054	0.01715	0.075	0.042	0.0351	0.0435	0.054	0.0645	0.0729
Bismuth - total (mg/L)	3		3	100.0%										
Chromium - total (mg/L)	3		3	100.0%										
Cobalt - total (mg/L)	3	1	2	66.7%	0.001	0.001	0	0.001	0	0.001	0.001	0.001	0.001	0.001
Copper - total (mg/L)	3	3			0.003	0.0097	0.00478	0.014	0.011	0.0039	0.0075	0.012	0.013	0.0138
Molybdenum - total (mg/L)	3	3			0.001	0.0017	0.00094	0.003	0.002	0.001	0.001	0.001	0.002	0.0028
Nickel - total (mg/L)	3	1	2	66.7%	0.001	0.001	0	0.001	0	0.001	0.001	0.001	0.001	0.001
Selenium - total (mg/L)	3		3	100.0%										
Uranium - total (mg/L)	3	2	1	33.3%	0.001	0.0065	0.0055	0.012	0.011	0.0016	0.00375	0.0065	0.0093	0.01145
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	3	3			280	700	498.264	1400	1120	294	350	420	910	1302
pH (lab)	2	2			8	8.2	0.2	8.4	0.4	8.02	8.1	8.2	8.3	8.38
B8														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	4	4			100	345	255.49	740	640	106	130	270	485	689

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Carbonate Alkalinity as CaCO3 (mg/L)	4		4	100.0%										
Total Alkalinity as CaCO3 (mg/L)	4	4			100	345	255.49	740	640	106	130	270	485	689
Hardness														
Total Hardness (mg CaCO3/L)	4	4			57	154.5	101.623	310	253	59.1	67.5	125.5	212.5	290.5
Major Ions														
Calcium (mg/L)	4	4			15	34.25	23.0367	73	58	15.6	18	24.5	40.75	66.55
Chloride (mg/L)	4	4			7	33.5	23.6907	60	53	7.9	11.5	33.5	55.5	59.1
Fluoride (mg/L)	4	4			0.1	0.2	0.12247	0.4	0.3	0.1	0.1	0.15	0.25	0.37
Magnesium (mg/L)	4	4			4.9	17	11.5566	30	25.1	5.08	5.8	16.55	27.75	29.55
Potassium (mg/L)	4	4			7	46.225	65.6945	160	153	7.195	7.975	8.95	47.2	137.44
Sodium (mg/L)	4	4			17	63.25	49.1089	140	123	18.05	22.25	48	89	129.8
Sulfate (as SO4)	4	4			2.6	13.95	13.6509	37	34.4	2.99	4.55	8.1	17.5	33.1
Metals (dissolved)														
Aluminium - dissolved (mg/L)	4	2	2	50.0%	0.006	0.148	0.142	0.29	0.284	0.0202	0.077	0.148	0.219	0.2758
Arsenic - dissolved (mg/L)	4	1	3	75.0%	0.004	0.004	0	0.004	0	0.004	0.004	0.004	0.004	0.004
Barium - dissolved (mg/L)	4	4			0.032	0.1063	0.10656	0.29	0.258	0.0337	0.04025	0.0515	0.1175	0.2555
Bismuth - dissolved (mg/L)	4		4	100.0%										
Chromium - dissolved (mg/L)	4		4	100.0%										
Cobalt - dissolved (mg/L)	4	1	3	75.0%	0.005	0.005	0	0.005	0	0.005	0.005	0.005	0.005	0.005
Copper - dissolved (mg/L)	4	4			0.001	0.0025	0.00112	0.004	0.003	0.0012	0.00175	0.0025	0.0033	0.00385
Molybdenum - dissolved (mg/L)	4	4			9E-04	0.0012	0.00045	0.002	0.001	0.0009	0.000975	0.001	0.0013	0.00185
Nickel - dissolved (mg/L)	4	1	3	75.0%	0.003	0.003	0	0.003	0	0.003	0.003	0.003	0.003	0.003
Selenium - dissolved (mg/L)	4		4	100.0%										
Uranium - dissolved (mg/L)	4	2	2	50.0%	0.002	0.0024	0.00055	0.0029	0.001	0.0019	0.002075	0.00235	0.0026	0.002845
Zinc - dissolved (mg/L)	1		1	100.0%										

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Metals (total)														
Aluminium - total (mg/L)	4	4			0.035	1.2988	2.07984	4.9	4.865	0.0418	0.06875	0.13	1.36	4.192
Arsenic - total (mg/L)	4	1	3	75.0%	0.006	0.006	0	0.006	0	0.006	0.006	0.006	0.006	0.006
Barium - total (mg/L)	4	4			0.036	0.1325	0.14326	0.38	0.344	0.038	0.04575	0.057	0.1438	0.33275
Bismuth - total (mg/L)	4		4	100.0%										
Chromium - total (mg/L)	4	1	3	75.0%	0.004	0.0036	0	0.0036	0	0.0036	0.0036	0.0036	0.0036	0.0036
Cobalt - total (mg/L)	4	1	3	75.0%	0.011	0.011	0	0.011	0	0.011	0.011	0.011	0.011	0.011
Copper - total (mg/L)	4	4			0.002	0.0113	0.0127	0.033	0.031	0.0022	0.00275	0.005	0.0135	0.0291
Molybdenum - total (mg/L)	4	4			0	0.0007	0.00041	0.001	0.001	0.0001	0.0006	0.0009	0.001	0.001
Nickel - total (mg/L)	4	1	3	75.0%	0.007	0.007	0	0.007	0	0.007	0.007	0.007	0.007	0.007
Selenium - total (mg/L)	4		4	100.0%										
Uranium - total (mg/L)	4	2	2	50.0%	0.002	0.0025	0.00045	0.0029	9E-04	0.002	0.002225	0.00245	0.0027	0.002855
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	3	3			200	466.67	328.87	930	730	207	235	270	600	864
pH (lab)	3	3			7.4	7.6333	0.16997	7.8	0.4	7.43	7.55	7.7	7.75	7.79
B9														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	2	2			160	230	70	300	140	167	195	230	265	293
Carbonate Alkalinity as CaCO3 (mg/L)	2		2	100.0%										
Total Alkalinity as CaCO3 (mg/L)	2	2			160	230	70	300	140	167	195	230	265	293
Hardness														
Total Hardness (mg CaCO3/L)	2	2			82	136	54	190	108	87.4	109	136	163	184.6
Major Ions														
Calcium (mg/L)	2	2			19	27.5	8.5	36	17	19.85	23.25	27.5	31.75	35.15
Chloride (mg/L)	2	2			7	41.5	34.5	76	69	10.45	24.25	41.5	58.75	72.55

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Fluoride (mg/L)	2	2			0.1	0.1	0	0.1	0	0.1	0.1	0.1	0.1	0.1
Magnesium (mg/L)	2	2			8.5	16.75	8.25	25	16.5	9.325	12.625	16.75	20.875	24.175
Potassium (mg/L)	2	2			8.7	10.85	2.15	13	4.3	8.915	9.775	10.85	11.925	12.785
Sodium (mg/L)	2	2			19	58.5	39.5	98	79	22.95	38.75	58.5	78.25	94.05
Sulfate (as SO4)	2	2			2	18	16	34	32	3.6	10	18	26	32.4
Metals (dissolved)														
Aluminium - dissolved (mg/L)	2		2	100.0%										
Arsenic - dissolved (mg/L)	2		2	100.0%										
Barium - dissolved (mg/L)	2	2			0.035	0.0525	0.0175	0.07	0.035	0.0368	0.04375	0.0525	0.0613	0.06825
Bismuth - dissolved (mg/L)	2		2	100.0%										
Chromium - dissolved (mg/L)	2		2	100.0%										
Cobalt - dissolved (mg/L)	2		2	100.0%										
Copper - dissolved (mg/L)	2	2			0.002	0.0025	0.0005	0.003	0.001	0.0021	0.00225	0.0025	0.0028	0.00295
Molybdenum - dissolved (mg/L)	2	1	1	50.0%	7E-04	0.0007	0	0.0007	0	0.0007	0.0007	0.0007	0.0007	0.0007
Nickel - dissolved (mg/L)	2		2	100.0%										
Selenium - dissolved (mg/L)	2		2	100.0%										
Uranium - dissolved (mg/L)	2	1	1	50.0%	0.002	0.0018	0	0.0018	0	0.0018	0.0018	0.0018	0.0018	0.0018
Zinc - dissolved (mg/L)	1		1	100.0%										
Metals (total)														
Aluminium - total (mg/L)	2	2			0.07	0.165	0.095	0.26	0.19	0.0795	0.1175	0.165	0.2125	0.2505
Arsenic - total (mg/L)	2		2	100.0%										
Barium - total (mg/L)	2	2			0.039	0.057	0.018	0.075	0.036	0.0408	0.048	0.057	0.066	0.0732
Bismuth - total (mg/L)	2		2	100.0%										
Chromium - total (mg/L)	2		2	100.0%										
Cobalt - total (mg/L)	2		2	100.0%										

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Copper - total (mg/L)	2	2			0.004	0.004	0	0.004	0	0.004	0.004	0.004	0.004	0.004
Molybdenum - total (mg/L)	2	1	1	50.0%	7E-04	0.0007	0	0.0007	0	0.0007	0.0007	0.0007	0.0007	0.0007
Nickel - total (mg/L)	2		2	100.0%										
Selenium - total (mg/L)	2		2	100.0%										
Uranium - total (mg/L)	2	1	1	50.0%	0.002	0.0019	0	0.0019	0	0.0019	0.0019	0.0019	0.0019	0.0019
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	2	2			260	550	290	840	580	289	405	550	695	811
pH (lab)	1	1			7.8	7.8	0	7.8	0	7.8	7.8	7.8	7.8	7.8
BASW01														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	14	14			24	86.643	58.8771	242	218	25.3	37.25	78	102.25	190.65
Carbonate Alkalinity as CaCO3 (mg/L)	14		14	100.0%										
Total Alkalinity as CaCO3 (mg/L)	14	14			24	86.643	58.8771	242	218	25.3	37.25	78	102.25	190.65
Field Measurements														
Depth to Water (mbRL)	1	1			1	1	0	1	0	1	1	1	1	1
Dissolved Oxygen (field) (% sat)	9	9			0	20.9	17.8651	53.4	53.4	0	9	14.4	32.7	49.36
Electrical Conductivity (field) (µS/cm)	10	10			60	330.7	356.263	1293	1233	64.05	100.5	208	340.75	977.55
ORP (field) (mV)	10	10			22.2	99.73	53.3547	185.8	163.6	29.175	55.45	96.05	140.03	179.05
pH (field)	10	10			5.87	7.642	0.81672	8.61	2.74	6.3605	7.2175	7.66	8.345	8.574
Salinity (field) (PSU)	10	10			0.03	0.16	0.18022	0.65	0.62	0.03	0.0425	0.1	0.1575	0.488
TDS (field) (ppm)	10	10			30	165.4	178.236	647	617	32.25	50.25	104	170.25	489.05
Temperature (field) (°C)	10	10			15	26.515	5.75156	34.13	19.13	18.15	22.2825	27.585	30.438	33.851
Hardness														
Total Hardness (mg CaCO3/L)	14	14			16	53.286	29.1288	126	110	19.25	35	42	69	105.2
Major Ions														

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Calcium (mg/L)	24	24			3	11	4.66369	19	16	4.15	8.5	10.5	14.25	18
Chloride (mg/L)	14	14			2	10.929	9.06693	30	28	2	4	9	13.5	29.35
Fluoride (mg/L)	14	9	5	35.7%	0.1	0.1667	0.06667	0.3	0.2	0.1	0.1	0.2	0.2	0.26
Magnesium (mg/L)	24	24			2	5.5	3.77492	19	17	2	3	4.5	6.25	11.55
Potassium (mg/L)	24	24			2	6.4583	5.02477	21	19	3	4	4	6	19.65
Sodium (mg/L)	24	24			4	24.25	20.4863	93	89	4	6	20	34.25	52.75
Sulfate (as SO4)	14	9	5	35.7%	4	13.778	12.1177	44	40	4.8	6	8	16	35.6
Metals (dissolved)														
Arsenic - dissolved (mg/L)	14	4	10	71.4%	0.001	0.001	0	0.001	0	0.001	0.001	0.001	0.001	0.001
Barium - dissolved (mg/L)	14	14			0.009	0.0304	0.01537	0.07	0.061	0.0149	0.02025	0.024	0.0405	0.0557
Bismuth - dissolved (mg/L)	14		14	100.0%										
Chromium - dissolved (mg/L)	14	1	13	92.9%	0.002	0.002	0	0.002	0	0.002	0.002	0.002	0.002	0.002
Cobalt - dissolved (mg/L)	14	4	10	71.4%	0.001	0.002	0.00071	0.003	0.002	0.0012	0.00175	0.002	0.0023	0.00285
Copper - dissolved (mg/L)	14	14			0.002	0.0098	0.00899	0.039	0.037	0.0027	0.00475	0.007	0.0105	0.02405
Molybdenum - dissolved (mg/L)	14	2	12	85.7%	0.001	0.0015	0.0005	0.002	0.001	0.0011	0.00125	0.0015	0.0018	0.00195
Nickel - dissolved (mg/L)	14	2	12	85.7%	0.002	0.005	0.003	0.008	0.006	0.0023	0.0035	0.005	0.0065	0.0077
Selenium - dissolved (mg/L)	14		14	100.0%										
Uranium - dissolved (mg/L)	14	1	13	92.9%	0.001	0.001	0	0.001	0	0.001	0.001	0.001	0.001	0.001
Metals (total)														
Arsenic - total (mg/L)	14	7	7	50.0%	0.001	0.0011	0.00035	0.002	0.001	0.001	0.001	0.001	0.001	0.0017
Barium - total (mg/L)	14	14			0.017	0.0382	0.01784	0.074	0.057	0.017	0.02325	0.0365	0.044	0.0701
Bismuth - total (mg/L)	14		14	100.0%										
Chromium - total (mg/L)	14	3	11	78.6%	0.001	0.0017	0.00094	0.003	0.002	0.001	0.001	0.001	0.002	0.0028
Cobalt - total (mg/L)	14	5	9	64.3%	0.001	0.002	0.00089	0.003	0.002	0.001	0.001	0.002	0.003	0.003
Copper - total (mg/L)	14	14			0.002	0.0129	0.0134	0.046	0.044	0.002	0.004	0.0075	0.0138	0.0408

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Molybdenum - total (mg/L)	14	2	12	85.7%	0.001	0.0015	0.0005	0.002	0.001	0.0011	0.00125	0.0015	0.0018	0.00195
Nickel - total (mg/L)	14	4	10	71.4%	0.002	0.0025	0.00087	0.004	0.002	0.002	0.002	0.002	0.0025	0.0037
Selenium - total (mg/L)	14		14	100.0%										
Uranium - total (mg/L)	14	1	13	92.9%	0.001	0.001	0	0.001	0	0.001	0.001	0.001	0.001	0.001
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	14	14			57	218.07	142.926	573	516	66.75	90.25	195.5	303.25	459.25
pH (lab)	14	14			6.48	7.4614	0.53461	8.43	1.95	6.7205	7.03	7.44	7.885	8.287
BASW04														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	17	17			40	195.47	153.065	499	459	47.2	99	130	294	451
Carbonate Alkalinity as CaCO3 (mg/L)	17	3	14	82.4%	22	25.333	4.71405	32	10	22	22	22	27	31
Total Alkalinity as CaCO3 (mg/L)	17	17			40	199.94	161.026	531	491	47.2	99	130	294	475
Field Measurements														
Depth to Water (mbRL)	1	1			0.3	0.3	0	0.3	0	0.3	0.3	0.3	0.3	0.3
Dissolved Oxygen (field) (% sat)	9	9			4.8	41.667	52.1629	179.6	174.8	6.32	8.9	16.1	48.5	131.04
Electrical Conductivity (field) (µS/cm)	9	9			126	571.89	428.157	1293	1167	140.4	198	307	980	1201.8
ORP (field) (mV)	7	7			1.8	70.586	65.9529	168.4	166.6	2.55	18.15	43.3	122.15	168.28
pH (field)	9	9			6.78	7.97	0.70312	8.89	2.11	6.968	7.42	8.24	8.61	8.782
Salinity (field) (PSU)	9	9			0.06	0.2778	0.21745	0.65	0.59	0.06	0.09	0.14	0.48	0.602
TDS (field) (ppm)	7	7			63	338.57	215.581	647	584	73.8	126.5	384	511.5	612.8
Temperature (field) (°C)	9	9			22.09	29.766	4.43648	35.99	13.9	23.49	26.21	30.83	33.7	35.098
Hardness														
Total Hardness (mg CaCO3/L)	17	17			30	126.53	96.306	312	282	38.8	49	76	199	286.4
Major Ions														
Calcium (mg/L)	24	24			7	24.292	15.5764	66	59	7.45	13	17	34.25	48

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Chloride (mg/L)	17	17			4	25.765	26.636	86	82	4	7	13	24	83.6
Fluoride (mg/L)	14	10	4	28.6%	0.1	0.68	0.63056	1.6	1.5	0.1	0.2	0.25	1.375	1.6
Magnesium (mg/L)	24	24			3	12.5	12.6326	49	46	3.15	4.75	6.5	12.25	39
Potassium (mg/L)	24	24			4	7.75	4.013	20	16	4	5	6	10.25	14.55
Sodium (mg/L)	24	24			4	50.5	51.2778	212	208	4.9	21.5	34.5	41.5	145
Sulfate (as SO4)	17	14	3	17.6%	1	20.429	19.2603	55	54	2.3	6	11.5	36	52.4
Metals (dissolved)														
Arsenic - dissolved (mg/L)	17	13	4	23.5%	0.001	0.0023	0.00114	0.004	0.003	0.001	0.001	0.002	0.003	0.004
Barium - dissolved (mg/L)	17	17			0.019	0.088	0.09779	0.419	0.4	0.0206	0.034	0.049	0.099	0.2742
Bismuth - dissolved (mg/L)	17		17	100.0%										
Chromium - dissolved (mg/L)	17		17	100.0%										
Cobalt - dissolved (mg/L)	17	8	9	52.9%	0.001	0.0029	0.00176	0.005	0.004	0.001	0.001	0.0025	0.005	0.005
Copper - dissolved (mg/L)	17	16	1	5.9%	0.004	0.0384	0.06456	0.208	0.204	0.004	0.01	0.012	0.0238	0.208
Molybdenum - dissolved (mg/L)	17	10	7	41.2%	0.001	0.0021	0.00094	0.003	0.002	0.001	0.001	0.0025	0.003	0.003
Nickel - dissolved (mg/L)	17	4	13	76.5%	0.001	0.0028	0.00249	0.007	0.006	0.001	0.001	0.0015	0.0033	0.00625
Selenium - dissolved (mg/L)	17		17	100.0%										
Uranium - dissolved (mg/L)	17	5	12	70.6%	0.002	0.0028	0.00075	0.004	0.002	0.002	0.002	0.003	0.003	0.0038
Metals (total)														
Arsenic - total (mg/L)	17	14	3	17.6%	0.001	0.0026	0.00117	0.005	0.004	0.001	0.002	0.003	0.003	0.00435
Barium - total (mg/L)	17	17			0.02	0.0921	0.08806	0.376	0.356	0.0256	0.037	0.061	0.098	0.2672
Bismuth - total (mg/L)	17		17	100.0%										
Chromium - total (mg/L)	17	3	14	82.4%	0.002	0.002	0	0.002	0	0.002	0.002	0.002	0.002	0.002
Cobalt - total (mg/L)	17	13	4	23.5%	0.001	0.0027	0.00186	0.006	0.005	0.001	0.001	0.002	0.004	0.006
Copper - total (mg/L)	17	17			0.003	0.0538	0.09459	0.311	0.308	0.0078	0.013	0.017	0.033	0.311
Molybdenum - total (mg/L)	17	8	9	52.9%	0.001	0.0029	0.00105	0.004	0.003	0.0014	0.002	0.003	0.004	0.004

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Nickel - total (mg/L)	17	7	10	58.8%	0.001	0.0023	0.00088	0.004	0.003	0.0013	0.002	0.002	0.0025	0.0037
Selenium - total (mg/L)	17		17	100.0%										
Uranium - total (mg/L)	17	5	12	70.6%	0.002	0.003	0.00063	0.004	0.002	0.0022	0.003	0.003	0.003	0.0038
Nutrients														
Nitrite + Nitrate as N (mg/L)	1		1	100.0%										
Total Kjeldahl Nitrogen as N (mg/L)	1	1			0.9	0.9	0	0.9	0	0.9	0.9	0.9	0.9	0.9
Total Nitrogen as N (mg/L)	1	1			0.9	0.9	0	0.9	0	0.9	0.9	0.9	0.9	0.9
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	17	17			120	456.76	360.353	1260	1140	124.8	194	274	746	1084
pH (lab)	17	17			7.17	7.8182	0.43797	8.58	1.41	7.218	7.41	7.76	8.01	8.58
BASW05														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	9	9			23	115.33	93.6542	295	272	29	40	92	140	280.6
Carbonate Alkalinity as CaCO3 (mg/L)	9		9	100.0%										
Total Alkalinity as CaCO3 (mg/L)	9	9			23	115.33	93.6542	295	272	29	40	92	140	280.6
Field Measurements														
Dissolved Oxygen (field) (% sat)	7	7			0	20.914	26.5333	72.6	72.6	0	0	0.8	36.5	63.33
Electrical Conductivity (field) (µS/cm)	8	8			79	413.5	304.395	1027	948	106.3	169.75	333.5	584.5	890.5
ORP (field) (mV)	8	8			-133.6	54.438	129.074	231.7	365.3	-129.09	-10.975	41.95	147.05	230.685
pH (field)	8	8			5.34	7.5125	0.90155	8.63	3.29	6.047	7.42	7.73	7.9175	8.399
Salinity (field) (PSU)	8	8			0.04	0.2013	0.15186	0.51	0.47	0.0505	0.0775	0.16	0.2875	0.44
TDS (field) (ppm)	8	8			40	206.88	152.372	514	474	53.3	84.75	166.5	292.75	445.75
Temperature (field) (°C)	8	8			15.31	22.956	4.73227	28.99	13.68	16.49	19.715	22.145	28.04	28.7835
Hardness														
Total Hardness (mg CaCO3/L)	9	9			18	74.222	53.4016	165	147	22	32	48	114	162.2

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Major Ions														
Calcium (mg/L)	17	17			4	17.176	11.8433	37	33	4	8	13	31	37
Chloride (mg/L)	9	8	1	11.1%	2	11.25	9.18899	27	25	2.35	3.75	6.5	20.25	24.9
Fluoride (mg/L)	9	5	4	44.4%	0.1	0.16	0.04899	0.2	0.1	0.1	0.1	0.2	0.2	0.2
Magnesium (mg/L)	17	17			2	7.1765	5.91345	21	19	2	3	5	9	20.2
Potassium (mg/L)	17	17			2	14.235	17.7185	60	58	2.8	4	7	12	56
Sodium (mg/L)	17	17			2	18.647	17.2693	57	55	2	5	13	26	52.2
Sulfate (as SO4)	9	4	5	55.6%	1	2.75	1.92029	6	5	1.15	1.75	2	3	5.4
Metals (dissolved)														
Arsenic - dissolved (mg/L)	9	4	5	55.6%	0.001	0.002	0.001	0.003	0.002	0.001	0.001	0.002	0.003	0.003
Barium - dissolved (mg/L)	9	9			0.015	0.063	0.05431	0.176	0.161	0.0166	0.021	0.04	0.088	0.1588
Bismuth - dissolved (mg/L)	9		9	100.0%										
Chromium - dissolved (mg/L)	9		9	100.0%										
Cobalt - dissolved (mg/L)	9	4	5	55.6%	0.001	0.003	0.00122	0.004	0.003	0.0013	0.0025	0.0035	0.004	0.004
Copper - dissolved (mg/L)	9	9			0.001	0.0062	0.00609	0.018	0.017	0.0014	0.002	0.003	0.008	0.0172
Molybdenum - dissolved (mg/L)	9	2	7	77.8%	0.002	0.002	0	0.002	0	0.002	0.002	0.002	0.002	0.002
Nickel - dissolved (mg/L)	9	3	6	66.7%	0.001	0.0017	0.00047	0.002	0.001	0.0011	0.0015	0.002	0.002	0.002
Selenium - dissolved (mg/L)	9		9	100.0%										
Uranium - dissolved (mg/L)	9	1	8	88.9%	0.001	0.001	0	0.001	0	0.001	0.001	0.001	0.001	0.001
Metals (total)														
Arsenic - total (mg/L)	9	7	2	22.2%	0.001	0.002	0.00107	0.004	0.003	0.001	0.001	0.002	0.0025	0.0037
Barium - total (mg/L)	9	9			0.026	0.0846	0.06289	0.215	0.189	0.0284	0.035	0.063	0.094	0.199
Bismuth - total (mg/L)	9		9	100.0%										
Chromium - total (mg/L)	9	2	7	77.8%	0.004	0.01	0.006	0.016	0.012	0.0046	0.007	0.01	0.013	0.0154
Cobalt - total (mg/L)	9	6	3	33.3%	0.003	0.0043	0.00137	0.007	0.004	0.003	0.00325	0.004	0.0048	0.0065

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Copper - total (mg/L)	9	9			0.002	0.0157	0.01321	0.039	0.037	0.0028	0.004	0.013	0.026	0.037
Molybdenum - total (mg/L)	9	3	6	66.7%	0.001	0.0017	0.00047	0.002	0.001	0.0011	0.0015	0.002	0.002	0.002
Nickel - total (mg/L)	9	5	4	44.4%	0.001	0.0036	0.0028	0.009	0.008	0.0012	0.002	0.003	0.003	0.0078
Selenium - total (mg/L)	9		9	100.0%										
Uranium - total (mg/L)	9	2	7	77.8%	0.001	0.001	0	0.001	0	0.001	0.001	0.001	0.001	0.001
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	9	9			58	254.33	203.169	666	608	65.6	102	200	282	616
pH (lab)	9	9			6.47	7.4122	0.49492	8.21	1.74	6.702	7.14	7.36	7.55	8.154
BASW08														
Field Measurements														
Dissolved Oxygen (field) (% sat)	1	1			48.4	48.4	0	48.4	0	48.4	48.4	48.4	48.4	48.4
Electrical Conductivity (field) (µS/cm)	1	1			1305	1305	0	1305	0	1305	1305	1305	1305	1305
ORP (field) (mV)	1	1			-21.1	-21.1	0	-21.1	0	-21.1	-21.1	-21.1	-21.1	-21.1
pH (field)	1	1			9.09	9.09	0	9.09	0	9.09	9.09	9.09	9.09	9.09
Salinity (field) (PSU)	1	1			0.65	0.65	0	0.65	0	0.65	0.65	0.65	0.65	0.65
TDS (field) (ppm)	1	1			653	653	0	653	0	653	653	653	653	653
Temperature (field) (°C)	1	1			20.94	20.94	0	20.94	0	20.94	20.94	20.94	20.94	20.94
BASW09														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	14	14			17	198.79	216.118	824	807	28.05	64.5	86	325.5	541.9
Carbonate Alkalinity as CaCO3 (mg/L)	14	4	10	71.4%	15	47.5	26.2536	81	66	17.25	26.25	47	68.25	78.45
Total Alkalinity as CaCO3 (mg/L)	14	14			17	212.36	227.899	824	807	28.05	64.5	86	351.75	594.55
Field Measurements														
Dissolved Oxygen (field) (% sat)	8	8			0	54.325	52.4341	163	163	7.455	21.3	32.15	65.425	146.62
Electrical Conductivity (field) (µS/cm)	9	9			49	560.22	577.104	1723	1674	61.8	84	127	980	1458.6

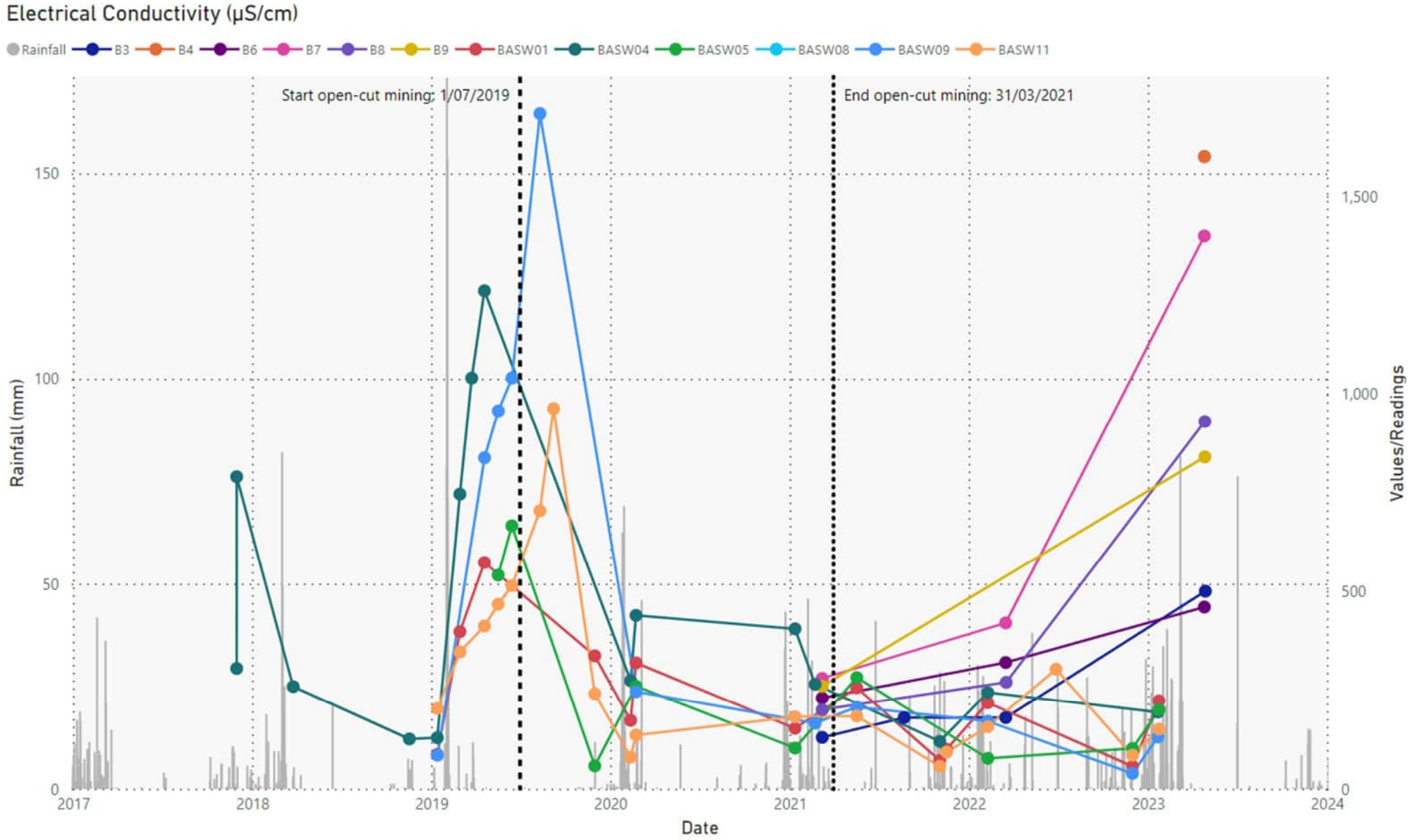
Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
ORP (field) (mV)	9	9			-45.8	68.789	62.488	170	215.8	-17.44	27.7	62.6	111	152.2
pH (field)	9	9			6.6	8.1833	0.82562	9.52	2.92	6.968	7.52	8.17	8.69	9.268
Salinity (field) (PSU)	8	8			0.02	0.3063	0.29389	0.87	0.85	0.027	0.04	0.24	0.49	0.7475
TDS (field) (ppm)	9	9			0.07	275.45	292.526	861	860.9	9.242	42	64	490	729
Temperature (field) (°C)	8	8			20.77	27.608	4.54958	34.84	14.07	22.405	25.4625	26.21	29.02	34.84
Hardness														
Total Hardness (mg CaCO3/L)	14	14			9	119.71	109.934	402	393	19.4	48	66.5	203.5	291.5
Major Ions														
Calcium (mg/L)	23	23			2	16.043	10.6464	44	42	3.2	10	12	20	42.1
Chloride (mg/L)	14	14			1	27	33.6261	111	110	2.3	4	6	49.75	86.95
Fluoride (mg/L)	14	10	4	28.6%	0.1	0.31	0.1578	0.5	0.4	0.1	0.2	0.3	0.475	0.5
Magnesium (mg/L)	23	23			1	19.174	22.2352	76	75	2.1	5	7	33	68.7
Potassium (mg/L)	23	23			3	14.13	18.3381	70	67	4	4.5	6	11	63.2
Sodium (mg/L)	23	22	1	4.3%	1	59.636	77.2125	234	233	2	8.25	15.5	118.75	222.25
Sulfate (as SO4)	14	9	5	35.7%	2	13.333	10.3387	30	28	2	2	20	20	26.4
Metals (dissolved)														
Arsenic - dissolved (mg/L)	14	5	9	64.3%	0.001	0.0018	0.00075	0.003	0.002	0.001	0.001	0.002	0.002	0.0028
Barium - dissolved (mg/L)	14	14			0.005	0.0421	0.04245	0.18	0.175	0.0122	0.018	0.0285	0.0443	0.115
Bismuth - dissolved (mg/L)	14		14	100.0%										
Chromium - dissolved (mg/L)	14	2	12	85.7%	0.001	0.001	0	0.001	0	0.001	0.001	0.001	0.001	0.001
Cobalt - dissolved (mg/L)	14	5	9	64.3%	0.001	0.0016	0.00049	0.002	0.001	0.001	0.001	0.002	0.002	0.002
Copper - dissolved (mg/L)	14	10	4	28.6%	0.001	0.0024	0.0012	0.005	0.004	0.001	0.002	0.002	0.0028	0.00455
Molybdenum - dissolved (mg/L)	14	5	9	64.3%	0.001	0.0024	0.0008	0.003	0.002	0.0012	0.002	0.003	0.003	0.003
Nickel - dissolved (mg/L)	14	1	13	92.9%	0.001	0.001	0	0.001	0	0.001	0.001	0.001	0.001	0.001
Selenium - dissolved (mg/L)	14		14	100.0%										

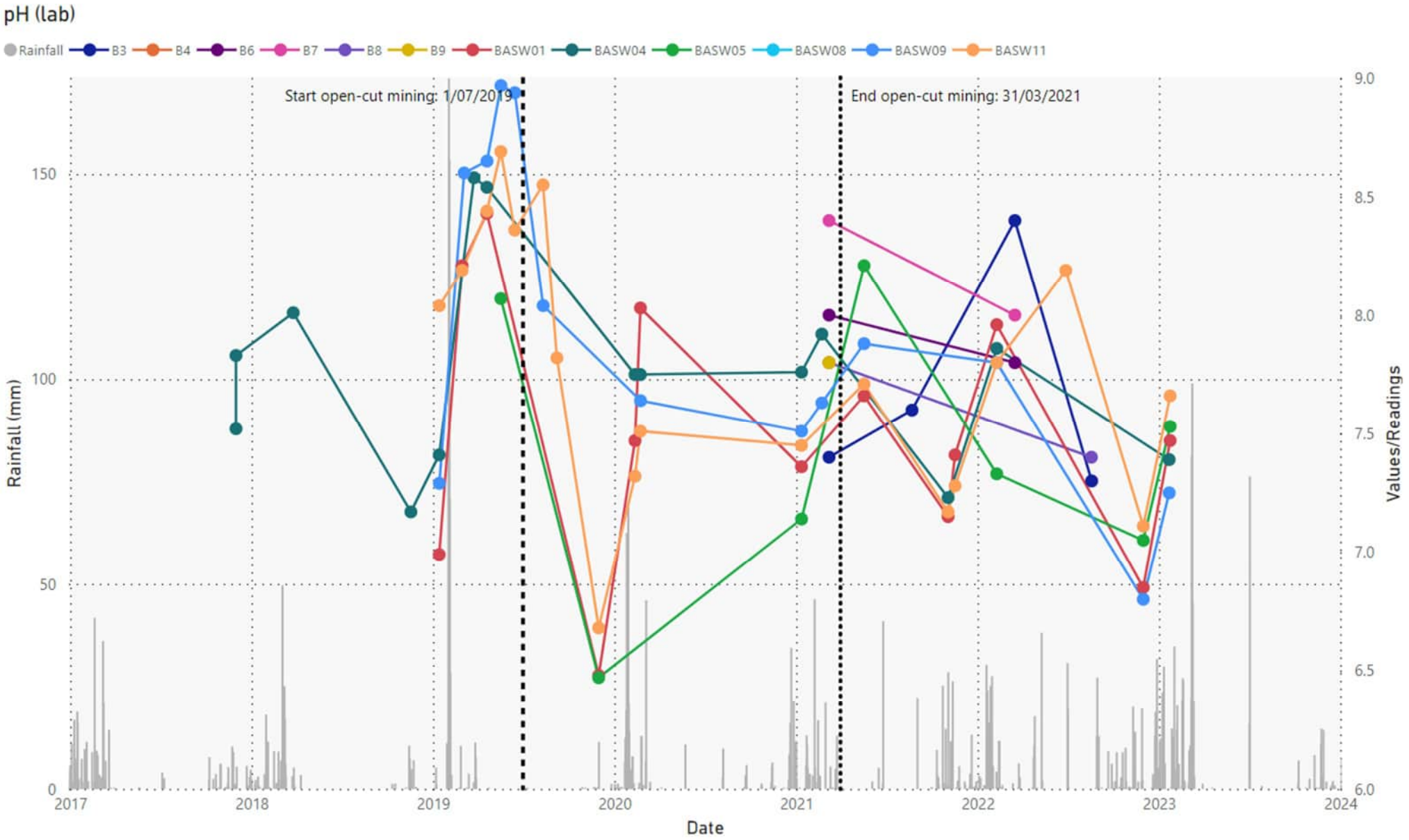
Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Uranium - dissolved (mg/L)	14	5	9	64.3%	0.002	0.0034	0.00102	0.005	0.003	0.0022	0.003	0.003	0.004	0.0048
Metals (total)														
Arsenic - total (mg/L)	14	6	8	57.1%	0.001	0.002	0.001	0.004	0.003	0.001	0.00125	0.002	0.002	0.0035
Barium - total (mg/L)	14	14			0.012	0.0656	0.08315	0.316	0.304	0.0172	0.025	0.033	0.0515	0.2432
Bismuth - total (mg/L)	14		14	100.0%										
Chromium - total (mg/L)	14	1	13	92.9%	0.002	0.002	0	0.002	0	0.002	0.002	0.002	0.002	0.002
Cobalt - total (mg/L)	14	7	7	50.0%	0.001	0.0023	0.00139	0.005	0.004	0.001	0.001	0.002	0.003	0.0044
Copper - total (mg/L)	14	13	1	7.1%	0.001	0.0029	0.0022	0.009	0.008	0.001	0.002	0.002	0.003	0.0072
Molybdenum - total (mg/L)	14	5	9	64.3%	0.002	0.0028	0.00075	0.004	0.002	0.002	0.002	0.003	0.003	0.0038
Nickel - total (mg/L)	14	2	12	85.7%	0.001	0.002	0.001	0.003	0.002	0.0011	0.0015	0.002	0.0025	0.0029
Selenium - total (mg/L)	14		14	100.0%										
Uranium - total (mg/L)	14	5	9	64.3%	0.002	0.004	0.00141	0.006	0.004	0.0022	0.003	0.004	0.005	0.0058
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	14	14			39	465.5	485.28	1710	1671	68.9	133	189	804.25	1274.5
pH (lab)	14	14			6.8	7.8779	0.65309	8.97	2.17	7.0925	7.345	7.72	8.46	8.9505
BASW11														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	19	19			27	113.74	93.7386	407	380	34.2	48.5	79	150.5	285.5
Carbonate Alkalinity as CaCO3 (mg/L)	19	4	15	78.9%	3	9.5	6.26498	18	15	3.15	3.75	8.5	14.25	17.25
Total Alkalinity as CaCO3 (mg/L)	19	19			27	115.74	96.1183	407	380	34.2	48.5	79	152	301.7
Field Measurements														
Dissolved Oxygen (field) (% sat)	16	16			0	32.869	26.9279	122.3	122.3	7.275	15	30.95	37.825	70.55
Electrical Conductivity (field) (µS/cm)	16	16			54	382.75	301.891	994	940	58.5	139.5	277	541	994
ORP (field) (mV)	16	16			-16.2	93.256	73.7353	216.1	232.3	-10.35	37.1	80.05	172.63	201.625
pH (field)	16	16			5.95	7.9681	0.78173	9.09	3.14	6.925	7.43	8.02	8.63	8.865

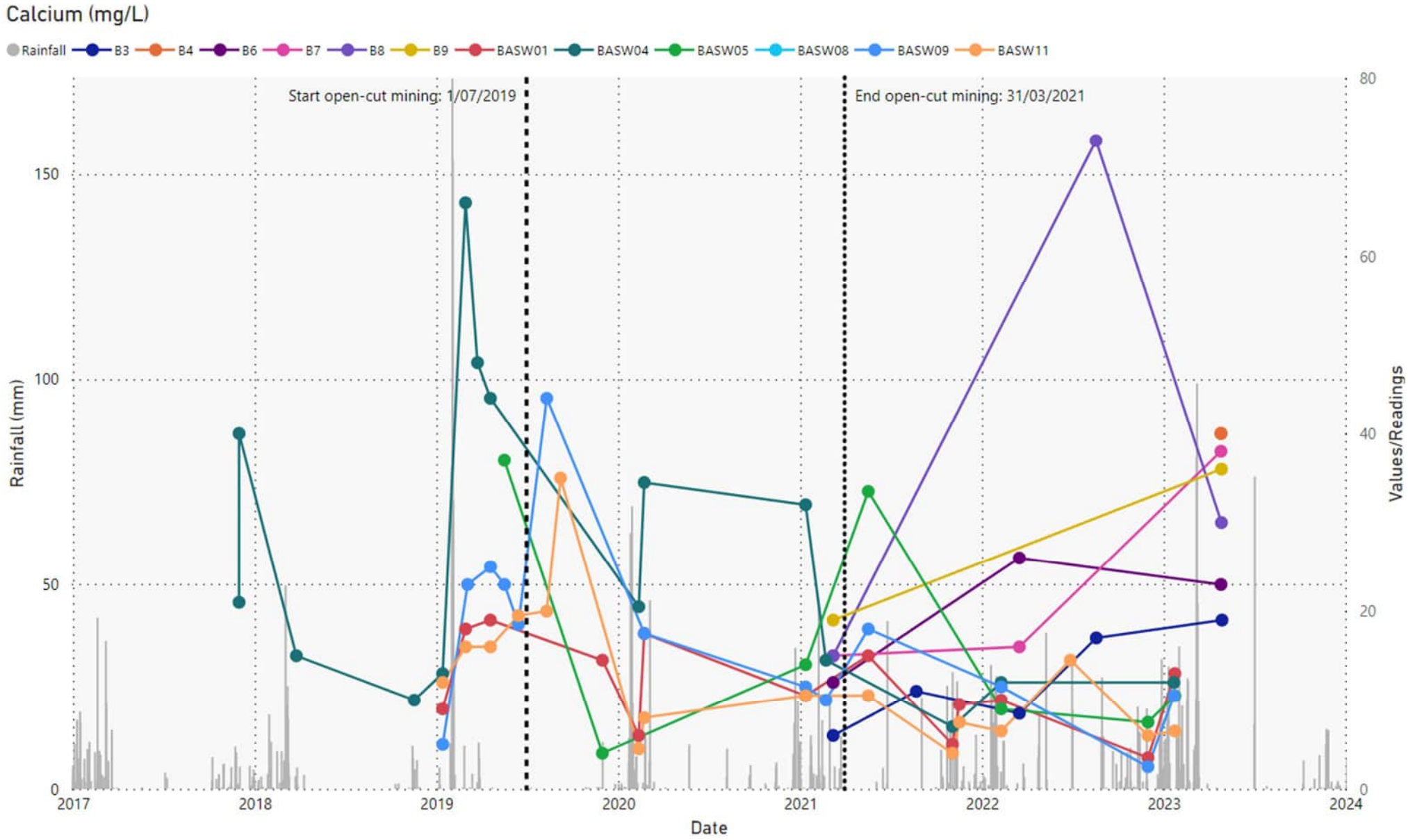
Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Salinity (field) (PSU)	16	16			0.02	0.1844	0.14975	0.49	0.47	0.0275	0.0675	0.13	0.26	0.49
TDS (field) (ppm)	16	16			27	191.31	150.929	497	470	29.25	69.75	138	270.75	497
Temperature (field) (°C)	16	16			16.2	25.353	6.53305	34.22	18.02	16.935	19.4625	24.355	31.47	34.01
Hardness														
Total Hardness (mg CaCO3/L)	19	19			18	65.947	50.6157	226	208	18	32.5	46	85	148.6
Major Ions														
Calcium (mg/L)	33	33			4	12.212	7.62276	36	32	4	7	11	16	26.2
Chloride (mg/L)	19	19			3	17.684	17.1527	70	67	3	6	9	26.5	46.6
Fluoride (mg/L)	19	12	7	36.8%	0.1	0.275	0.17381	0.6	0.5	0.1	0.1	0.25	0.4	0.545
Magnesium (mg/L)	33	33			2	8.2424	8.30126	33	31	2	3	4	10	26
Potassium (mg/L)	33	33			2	8.2424	7.12669	32	30	2.6	4	5	9	22.2
Sodium (mg/L)	33	33			3	36.182	37.9477	145	142	3.6	10	21	46	119.4
Sulfate (as SO4)	19	14	5	26.3%	1	10.643	9.18545	27	26	1.65	2.25	8	14.75	25.7
Metals (dissolved)														
Arsenic - dissolved (mg/L)	19	3	16	84.2%	0.001	0.0017	0.00094	0.003	0.002	0.001	0.001	0.001	0.002	0.0028
Barium - dissolved (mg/L)	19	19			0.01	0.0341	0.02529	0.127	0.117	0.01	0.0185	0.029	0.0395	0.0613
Bismuth - dissolved (mg/L)	19		19	100.0%										
Chromium - dissolved (mg/L)	19		19	100.0%										
Cobalt - dissolved (mg/L)	19	3	16	84.2%	0.002	0.0023	0.00047	0.003	0.001	0.002	0.002	0.002	0.0025	0.0029
Copper - dissolved (mg/L)	19	19			0.001	0.0037	0.00397	0.018	0.017	0.001	0.0015	0.002	0.004	0.0099
Molybdenum - dissolved (mg/L)	19	4	15	78.9%	0.001	0.0015	0.00087	0.003	0.002	0.001	0.001	0.001	0.0015	0.0027
Nickel - dissolved (mg/L)	19	5	14	73.7%	0.001	0.0026	0.00136	0.004	0.003	0.001	0.001	0.003	0.004	0.004
Selenium - dissolved (mg/L)	19		19	100.0%										
Uranium - dissolved (mg/L)	19	3	16	84.2%	0.001	0.0017	0.00047	0.002	0.001	0.0011	0.0015	0.002	0.002	0.002
Metals (total)														

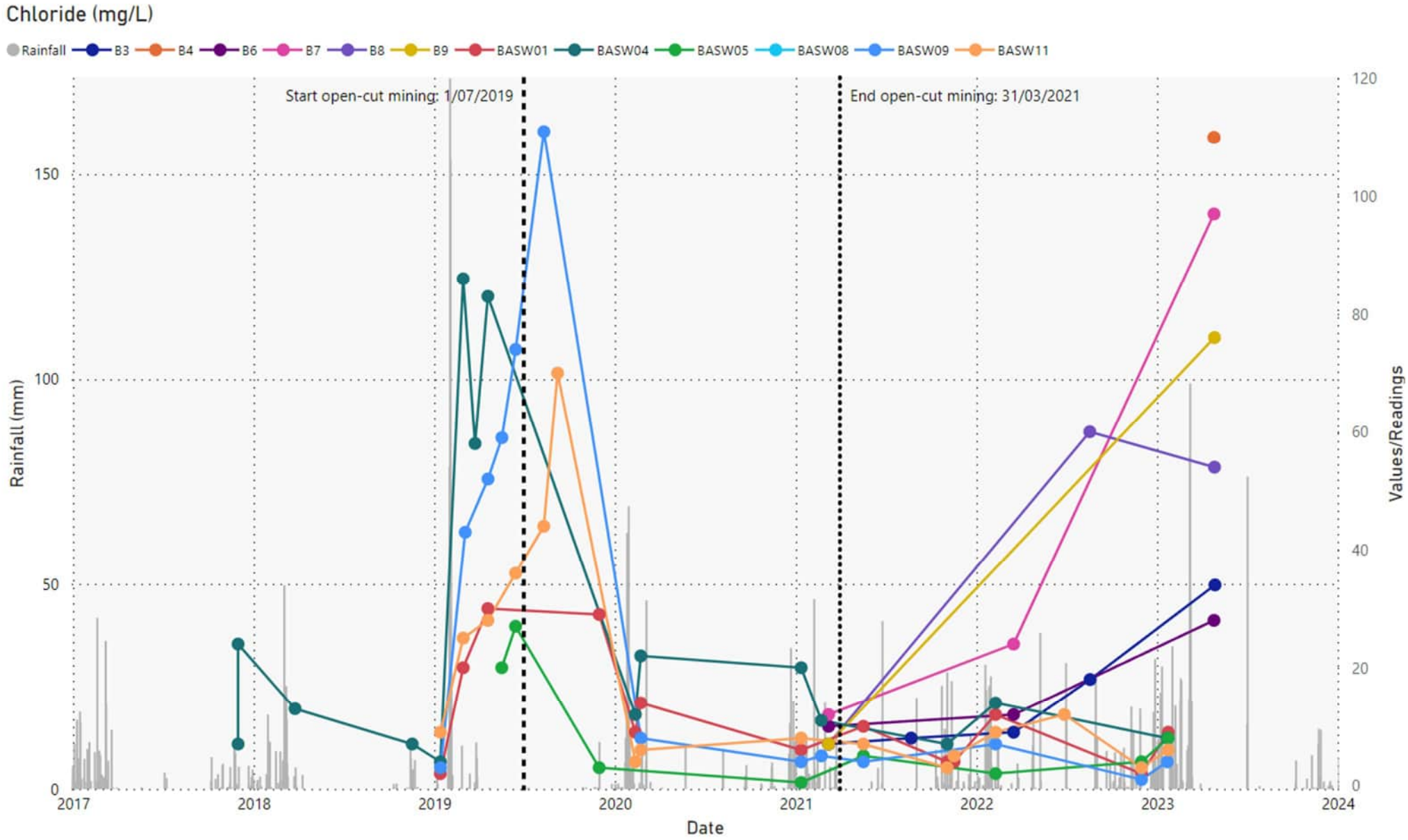
Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Arsenic - total (mg/L)	19	4	15	78.9%	0.001	0.0018	0.00083	0.003	0.002	0.001	0.001	0.0015	0.0023	0.00285
Barium - total (mg/L)	19	19			0.013	0.0432	0.03174	0.16	0.147	0.0139	0.026	0.033	0.05	0.079
Bismuth - total (mg/L)	19		19	100.0%										
Chromium - total (mg/L)	19		19	100.0%										
Cobalt - total (mg/L)	19	5	14	73.7%	0.001	0.0022	0.00075	0.003	0.002	0.0012	0.002	0.002	0.003	0.003
Copper - total (mg/L)	19	17	2	10.5%	0.002	0.0063	0.00593	0.024	0.022	0.002	0.002	0.004	0.008	0.0168
Molybdenum - total (mg/L)	19	4	15	78.9%	0.001	0.0013	0.00043	0.002	0.001	0.001	0.001	0.001	0.0013	0.00185
Nickel - total (mg/L)	19	4	15	78.9%	0.001	0.0015	0.0005	0.002	0.001	0.001	0.001	0.0015	0.002	0.002
Selenium - total (mg/L)	19		19	100.0%										
Uranium - total (mg/L)	19	3	16	84.2%	0.001	0.0017	0.00047	0.002	0.001	0.0011	0.0015	0.002	0.002	0.002
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	19	19			57	288.53	229.929	963	906	77.7	143.5	203	379.5	729.9
pH (lab)	19	19			6.68	7.79	0.53105	8.69	2.01	7.067	7.385	7.8	8.19	8.564

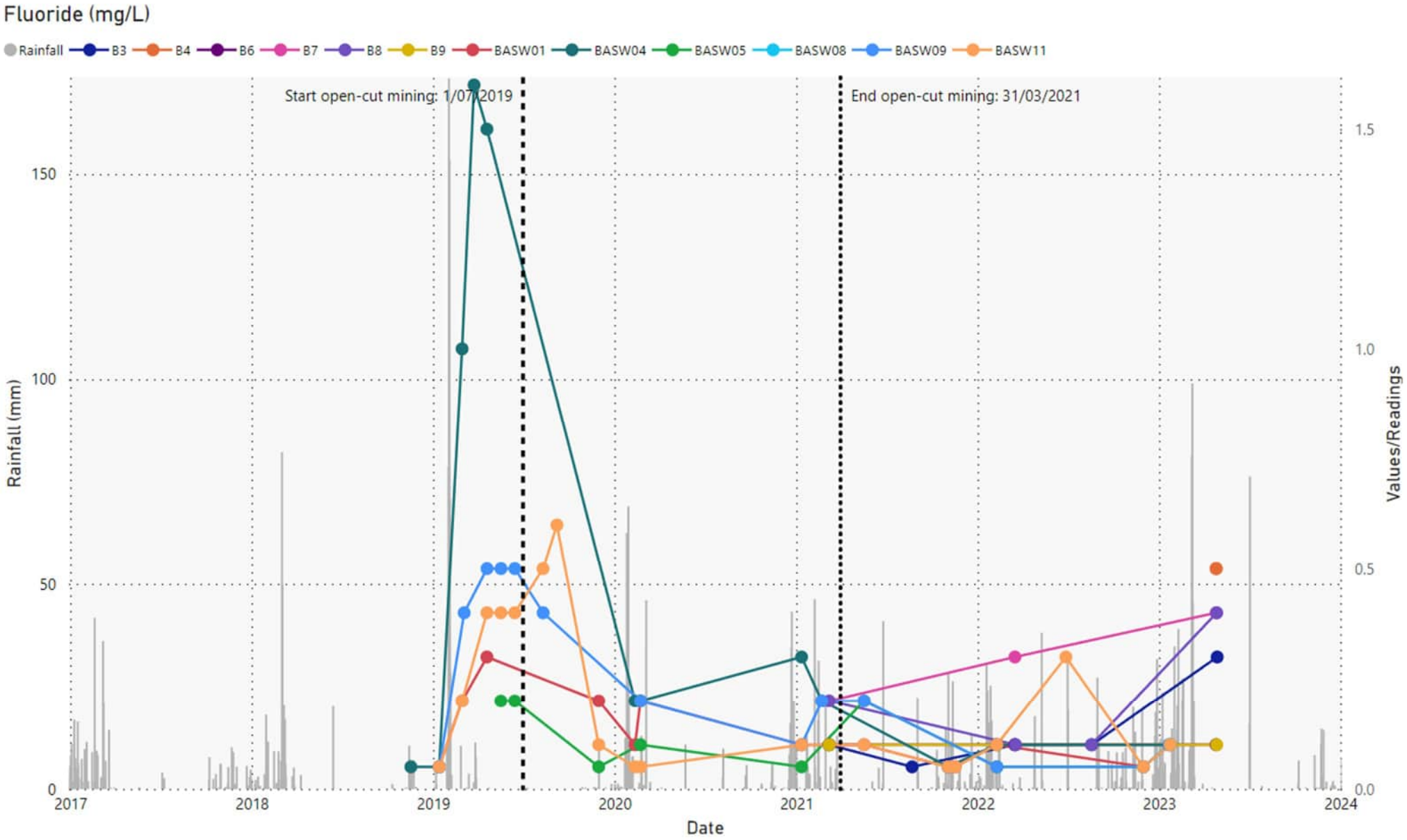
E.2 Water quality time series

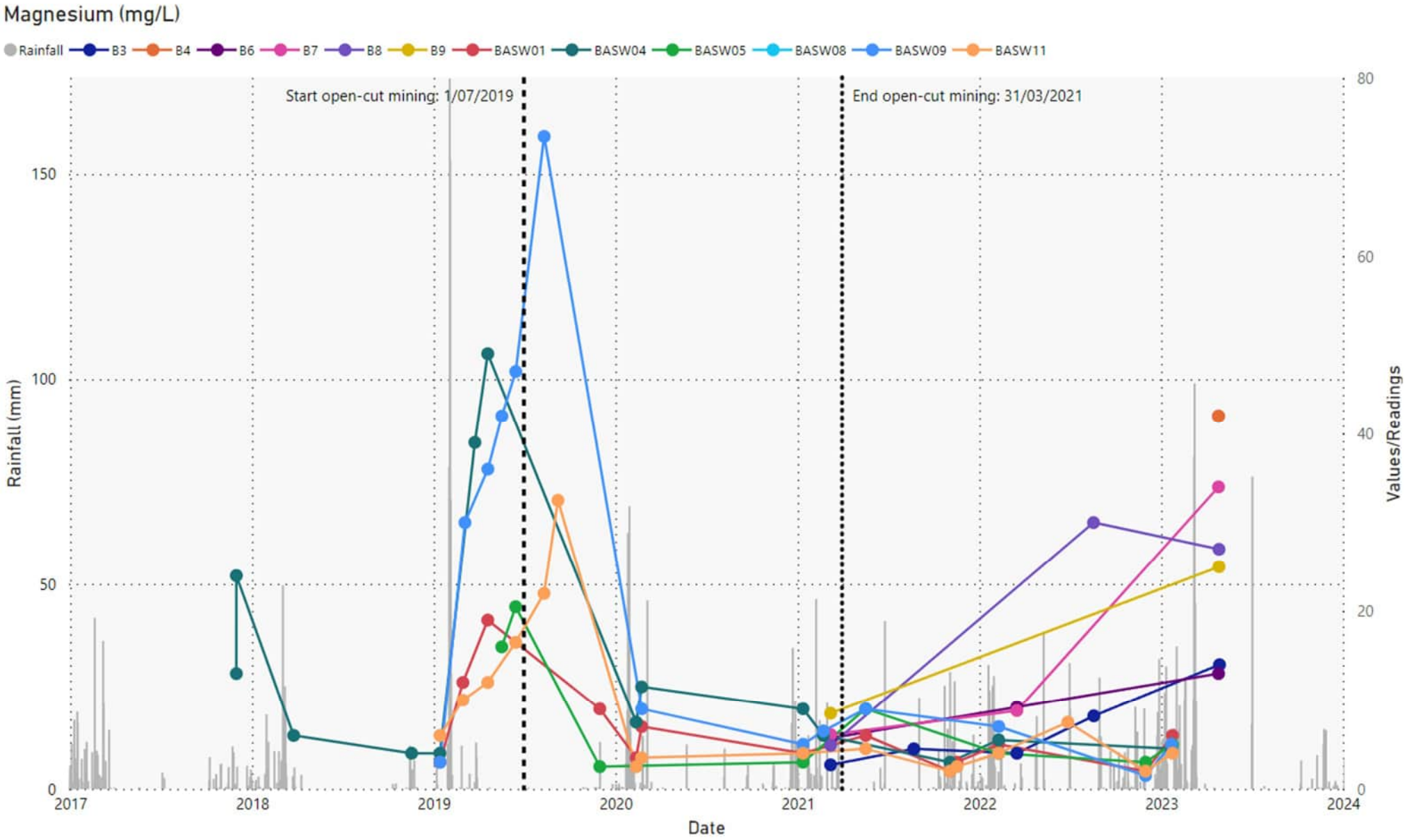

Electrical Conductivity (µS/cm)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
1,500
1,000
500
0
Values/Readings
2017
2018
2019
2020
2021
2022
2023
2024
Date

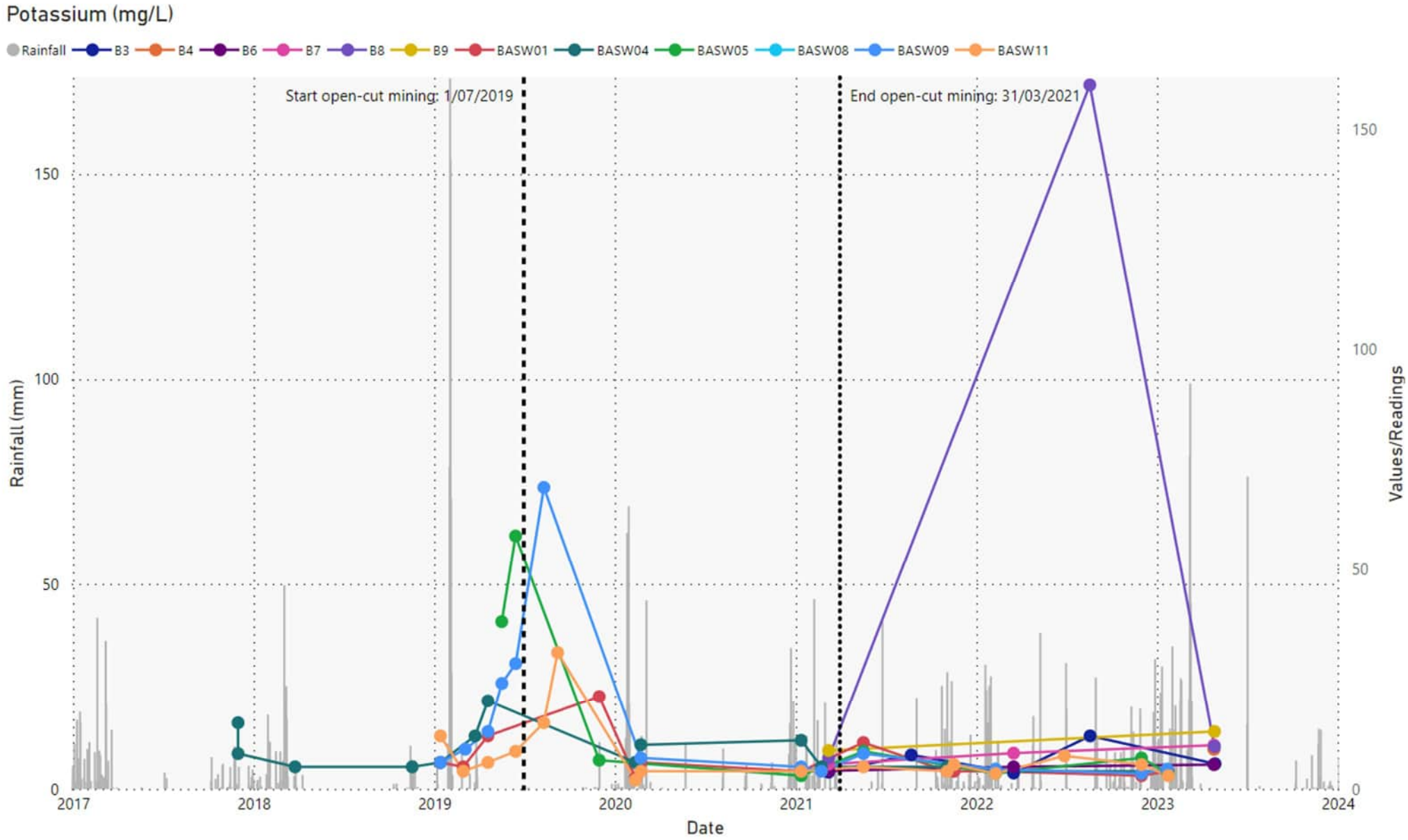

pH (lab)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
6.0
6.5
7.0
7.5
8.0
8.5
9.0
2017
2018
2019
2020
2021
2022
2023
2024

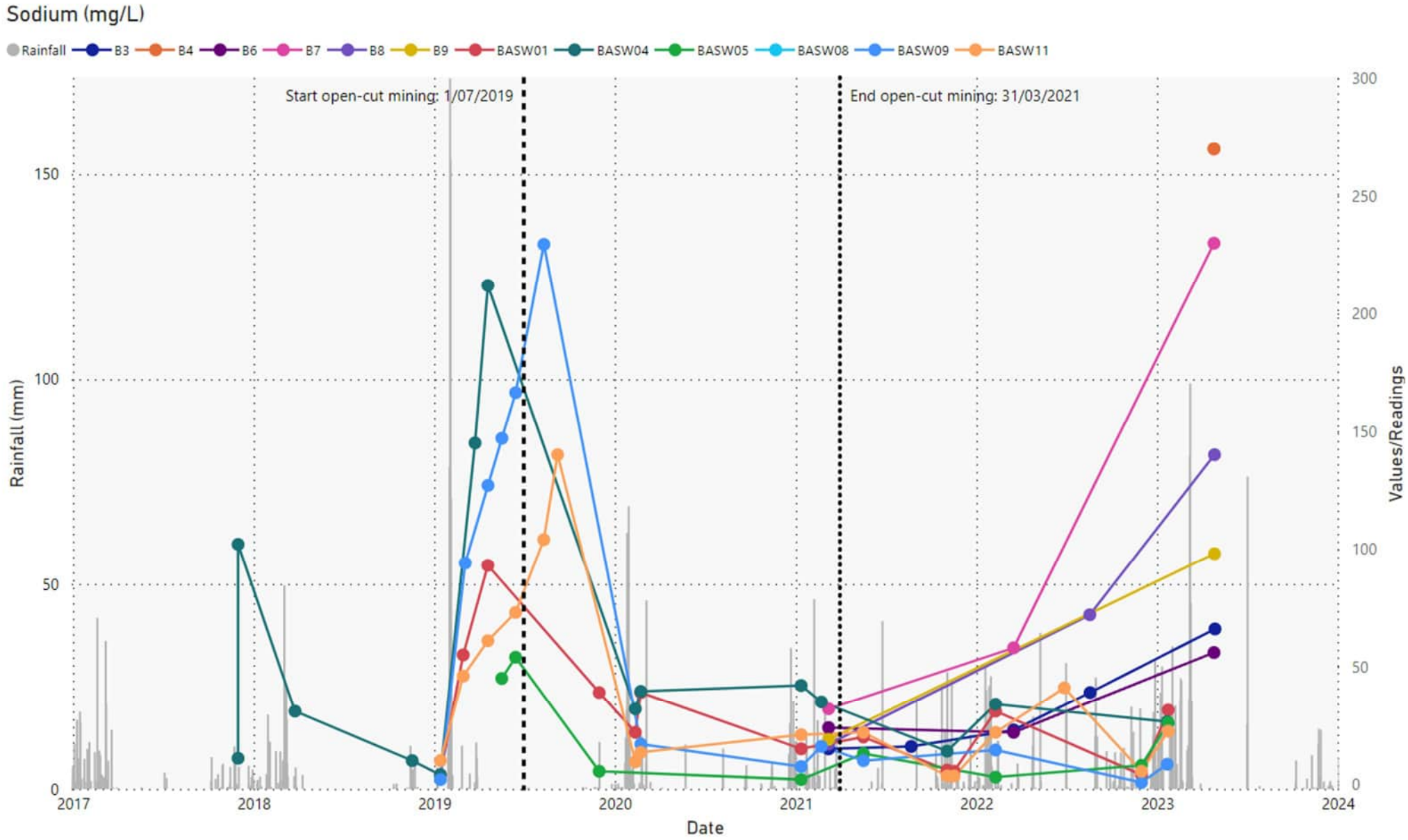

Calcium (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
0
20
40
60
80
2017
2018
2019
2020
2021
2022
2023
2024


Chloride (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
0
20
40
60
80
100
120
2017
2018
2019
2020
2021
2022
2023
2024

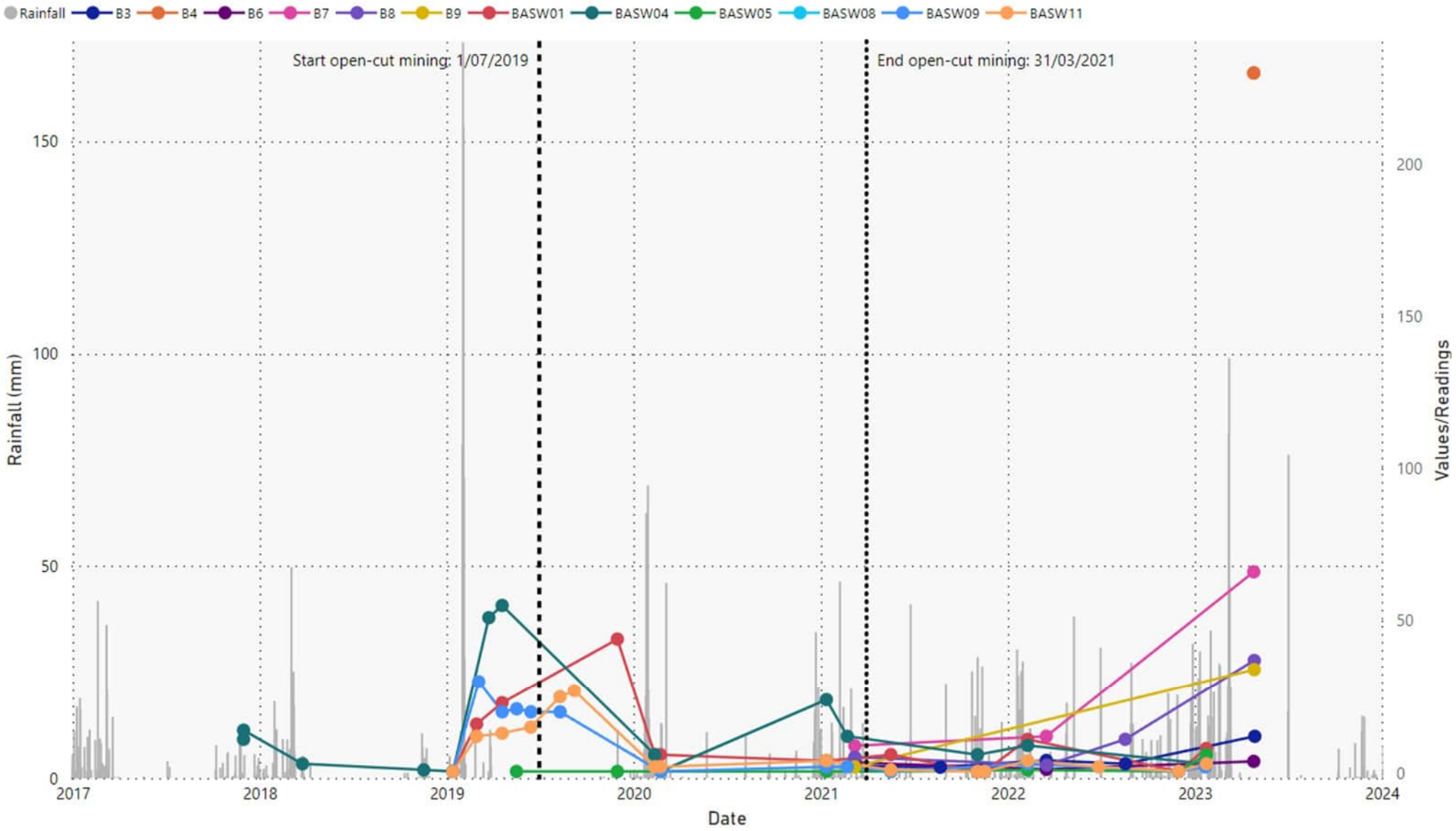

Fluoride (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
0.0
0.5
1.0
1.5
2017
2018
2019
2020
2021
2022
2023
2024

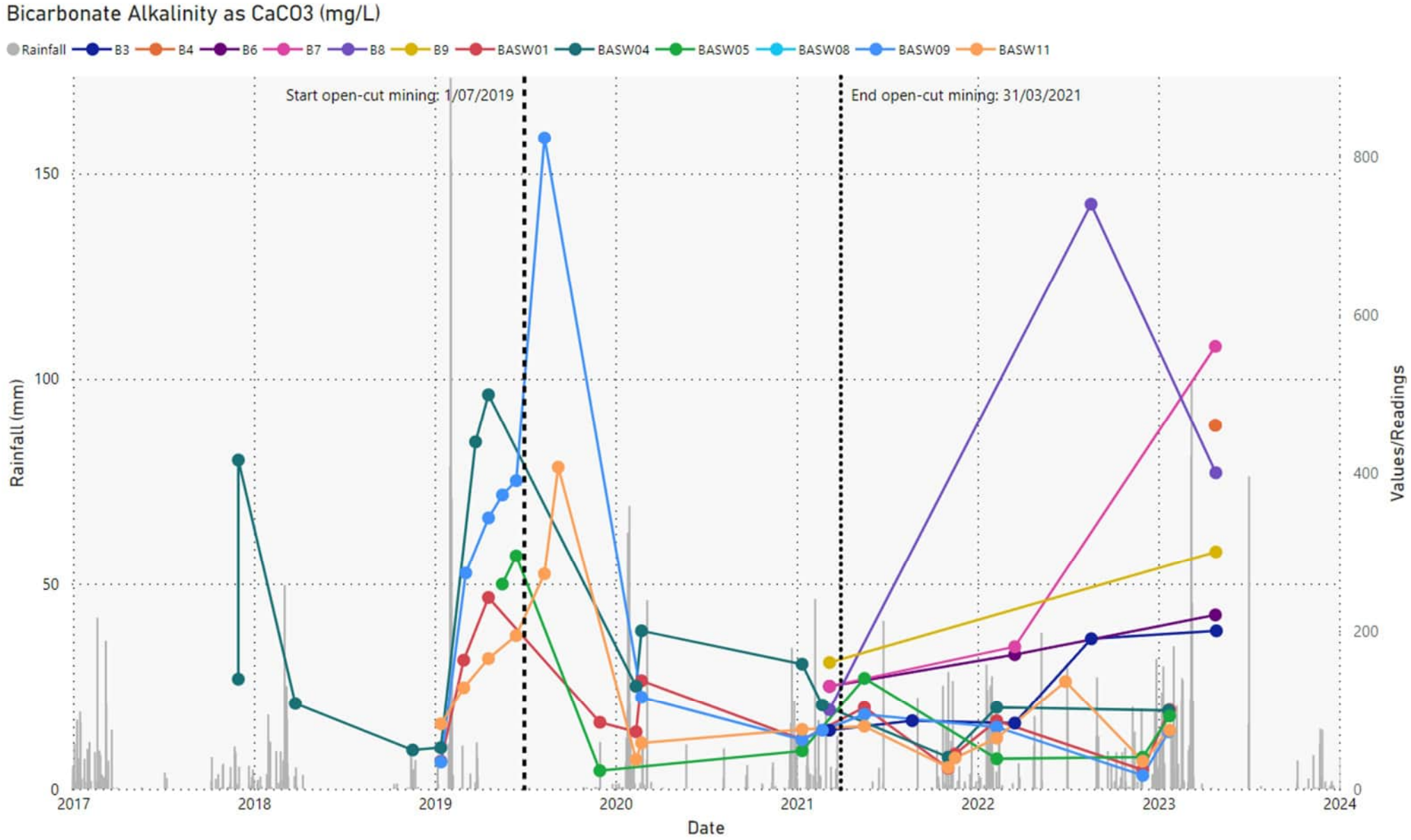

Magnesium (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
0
20
40
60
80
2017
2018
2019
2020
2021
2022
2023
2024

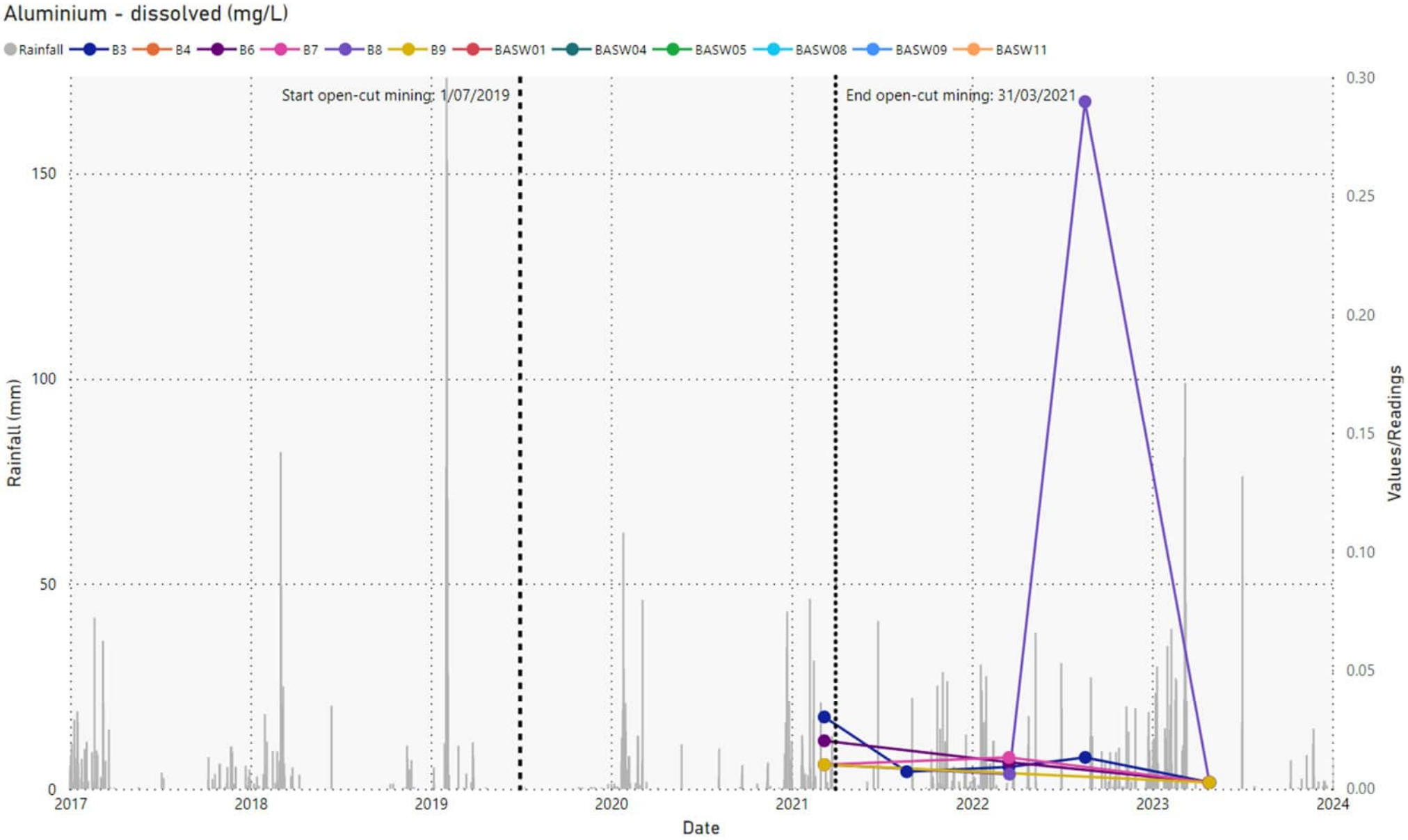

Potassium (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
2017
2018
2019
2020
2021
2022
2023
2024

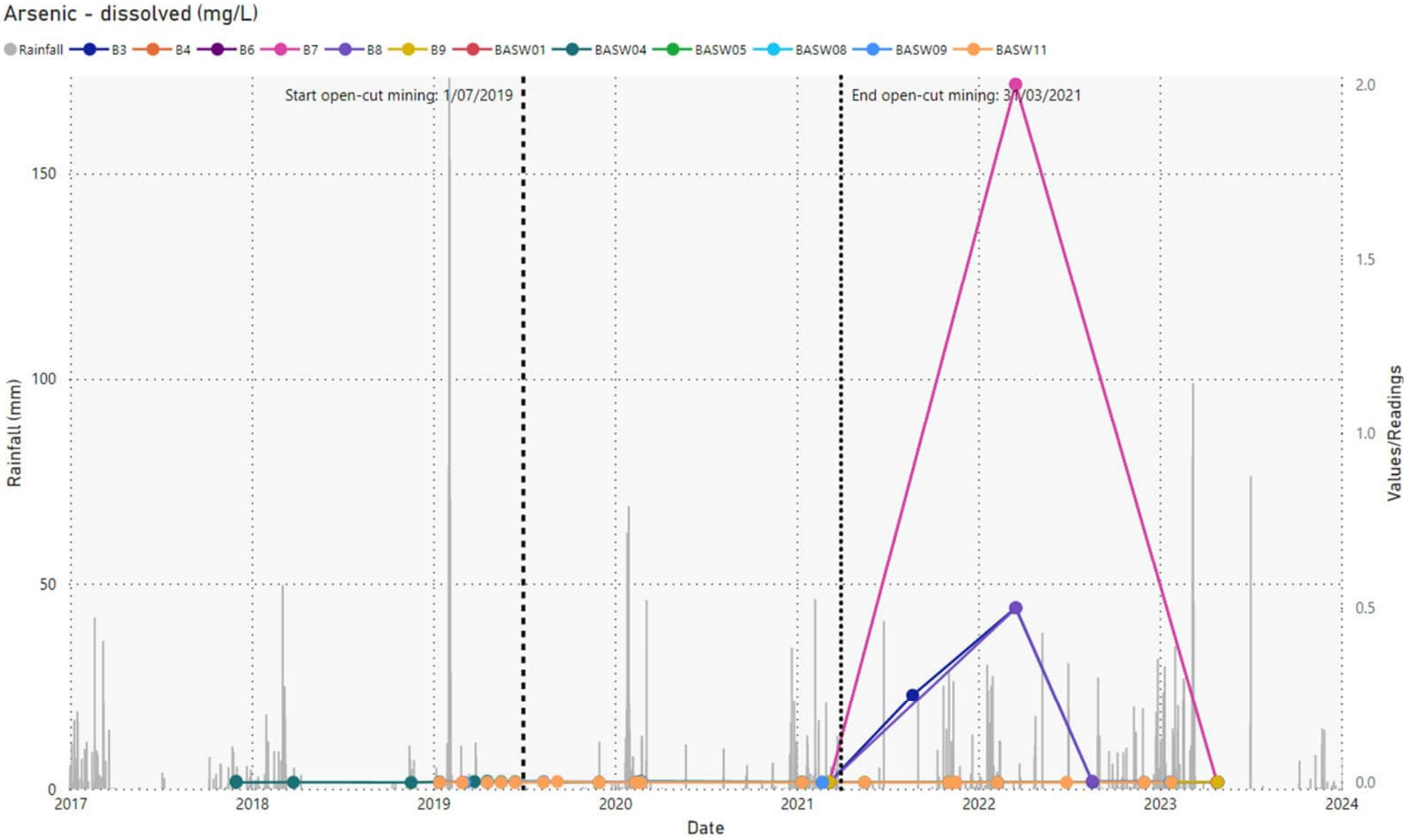

Sodium (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
200
250
300
2017
2018
2019
2020
2021
2022
2023
2024

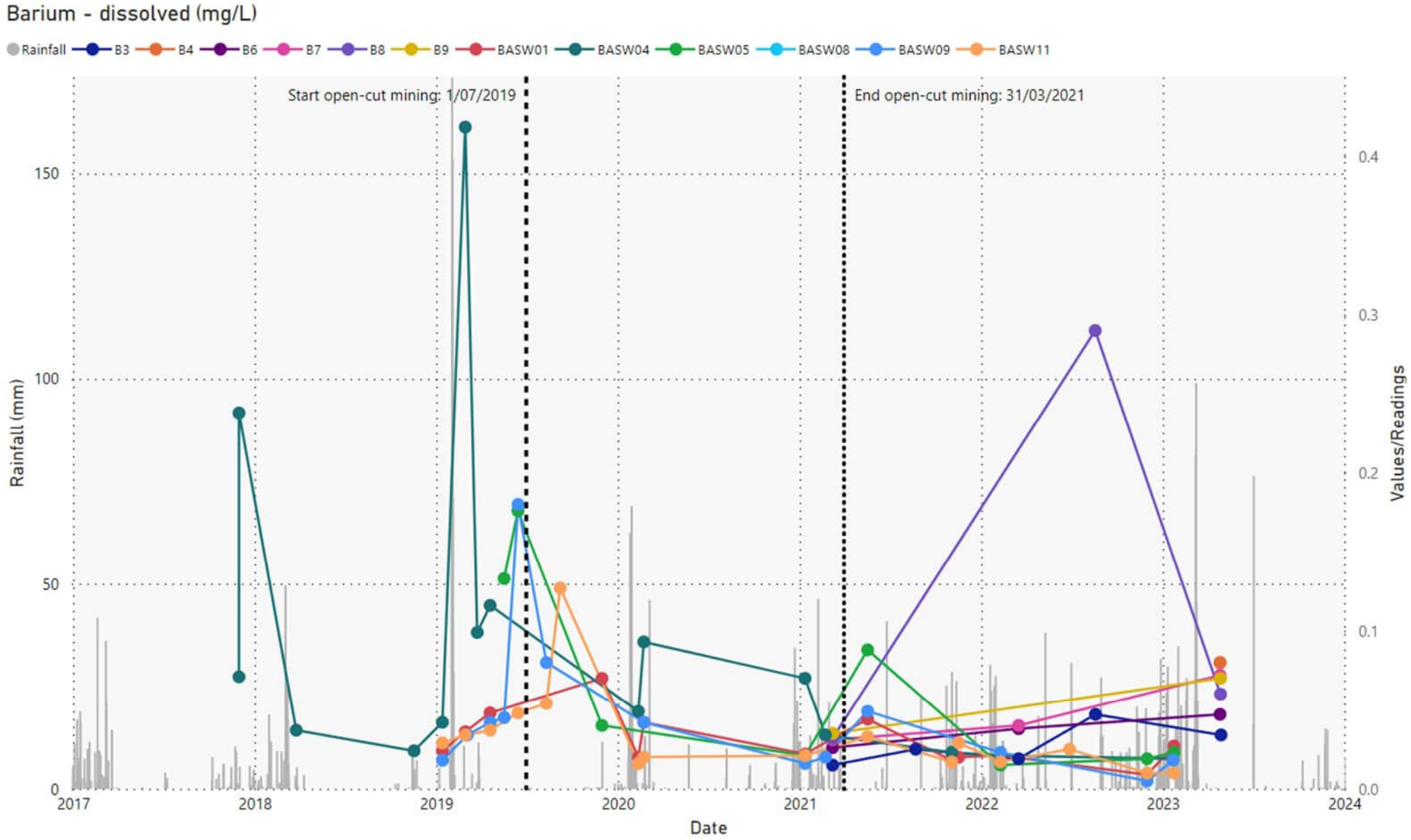
Sulfate (as SO4)

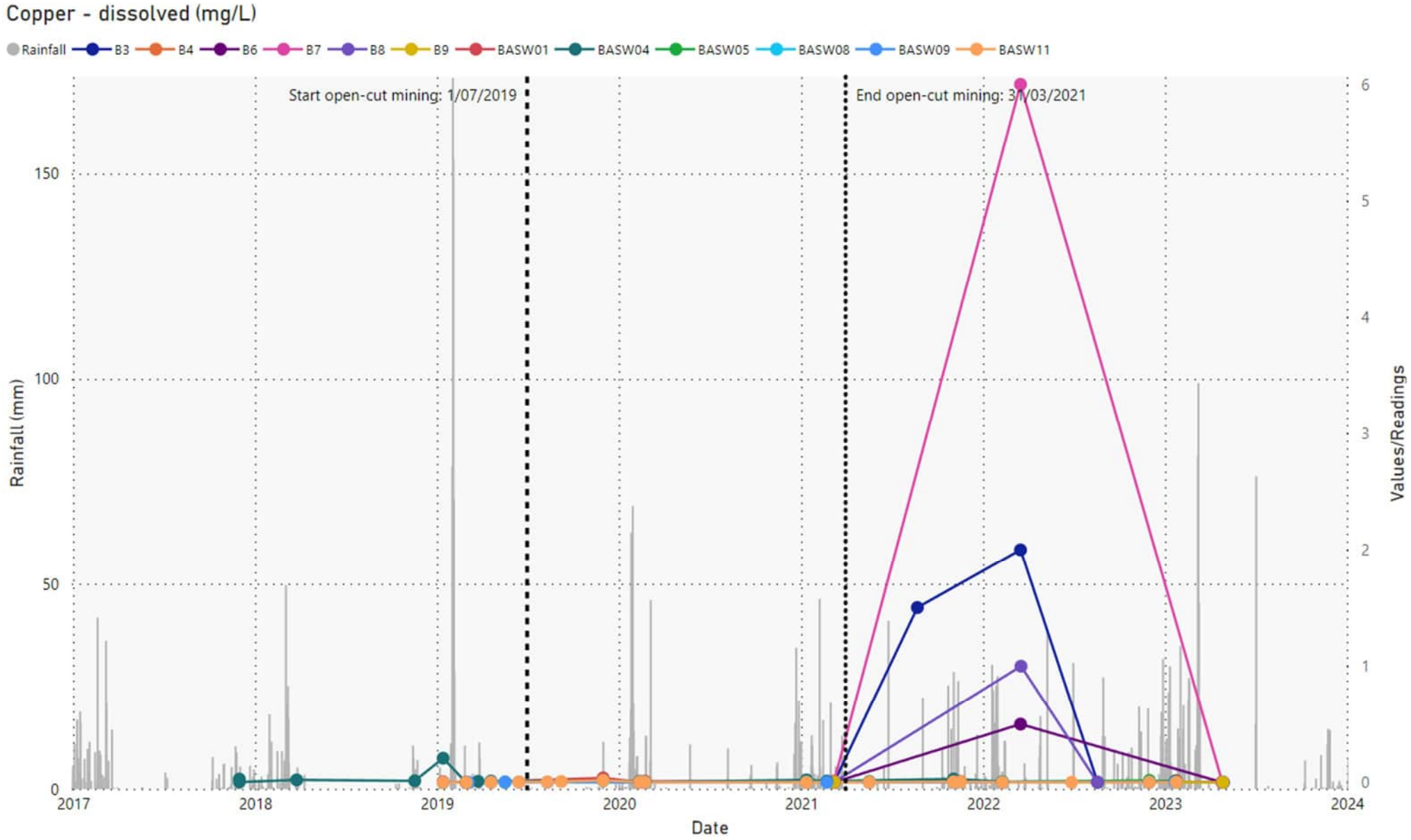


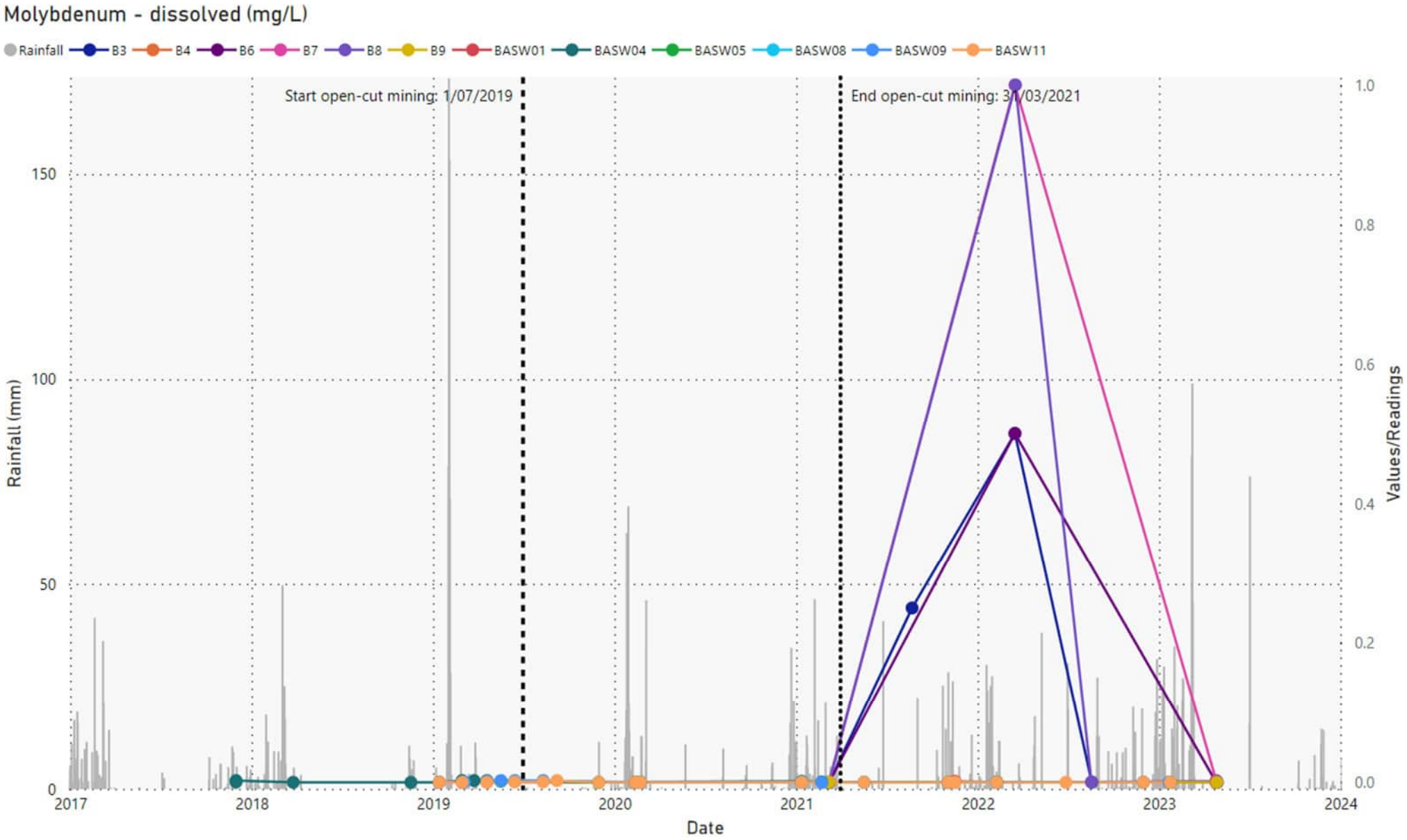

Bicarbonate Alkalinity as CaCO3 (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
200
400
600
800
2017
2018
2019
2020
2021
2022
2023
2024


Aluminium - dissolved (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
0.00
0.05
0.10
0.15
0.20
0.25
0.30
2017
2018
2019
2020
2021
2022
2023
2024

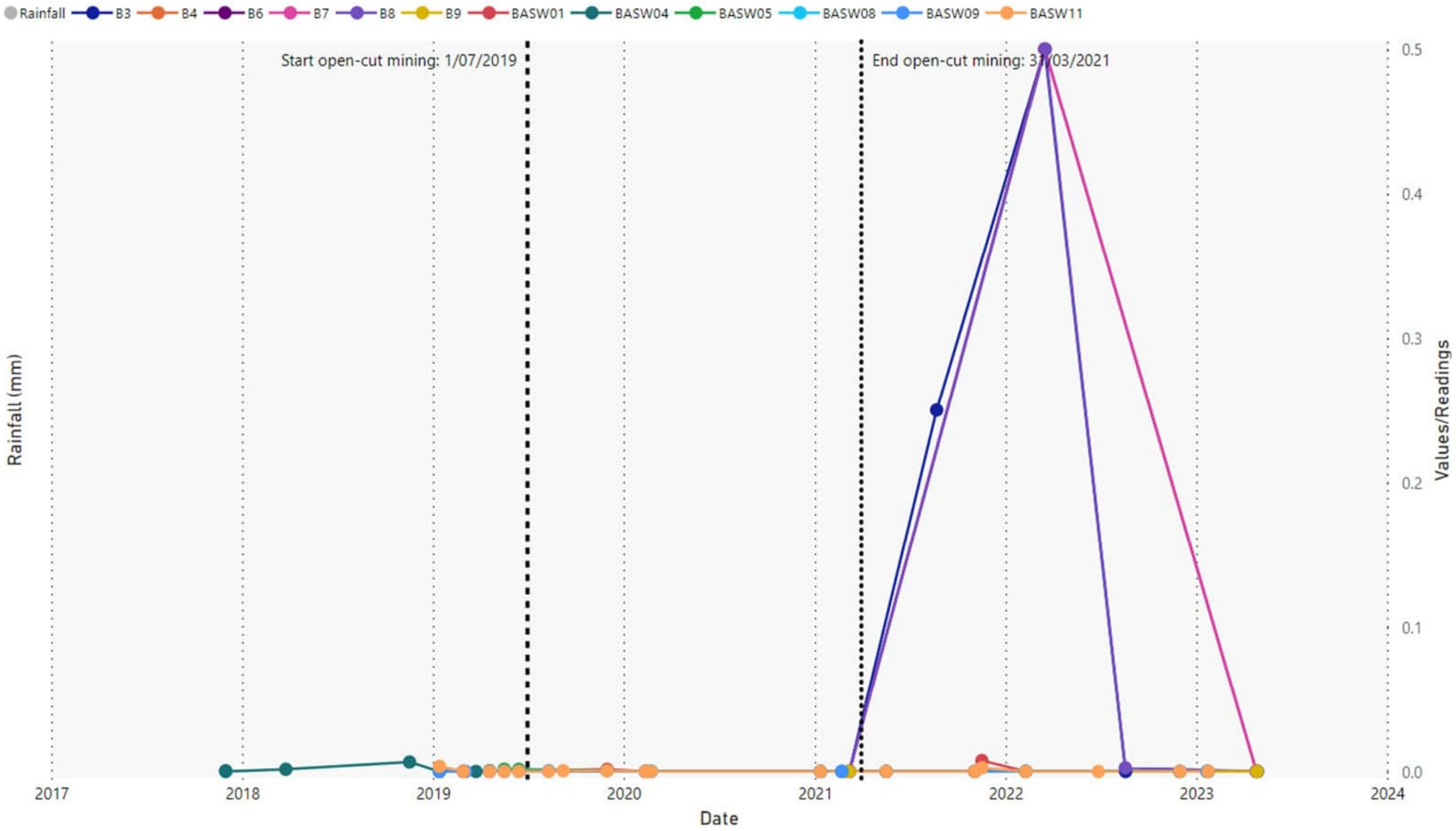

Arsenic - dissolved (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
0.0
0.5
1.0
1.5
2.0
2017
2018
2019
2020
2021
2022
2023
2024


Barium - dissolved (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
0.0
0.1
0.2
0.3
0.4
2017
2018
2019
2020
2021
2022
2023
2024

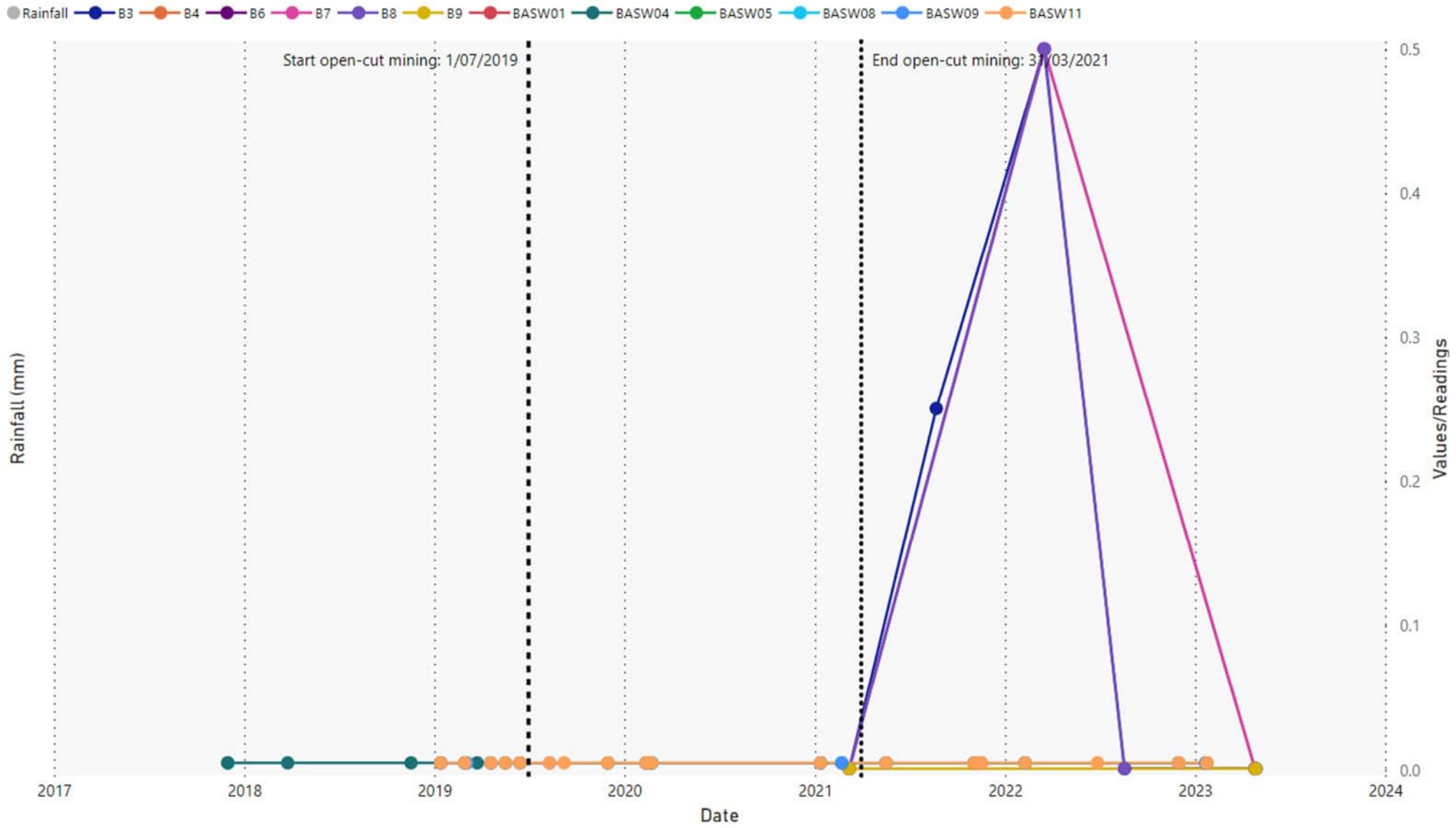

Copper - dissolved (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
0
1
2
3
4
5
6
2017
2018
2019
2020
2021
2022
2023
2024

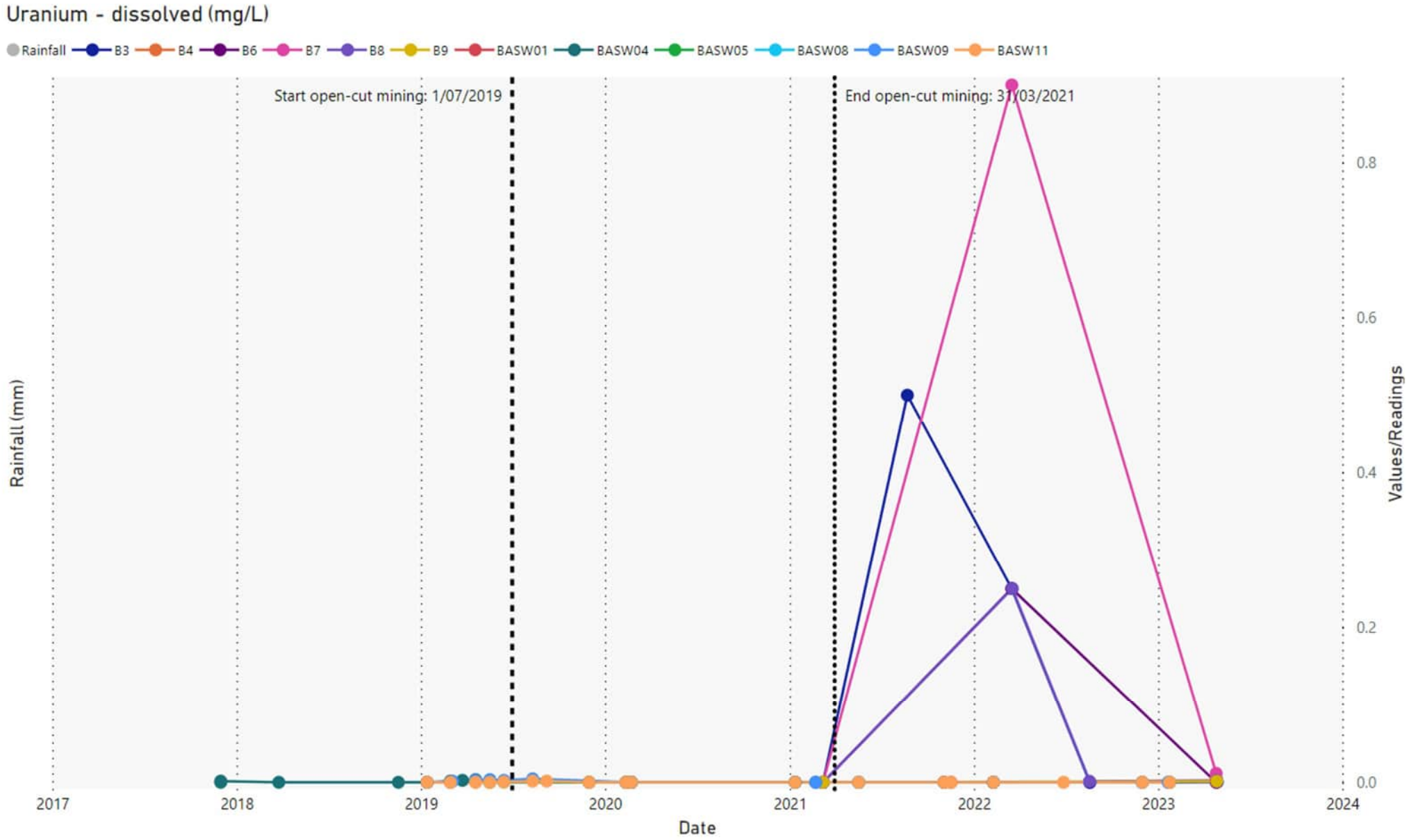

Molybdenum - dissolved (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
0.0
0.2
0.4
0.6
0.8
1.0
2017
2018
2019
2020
2021
2022
2023
2024

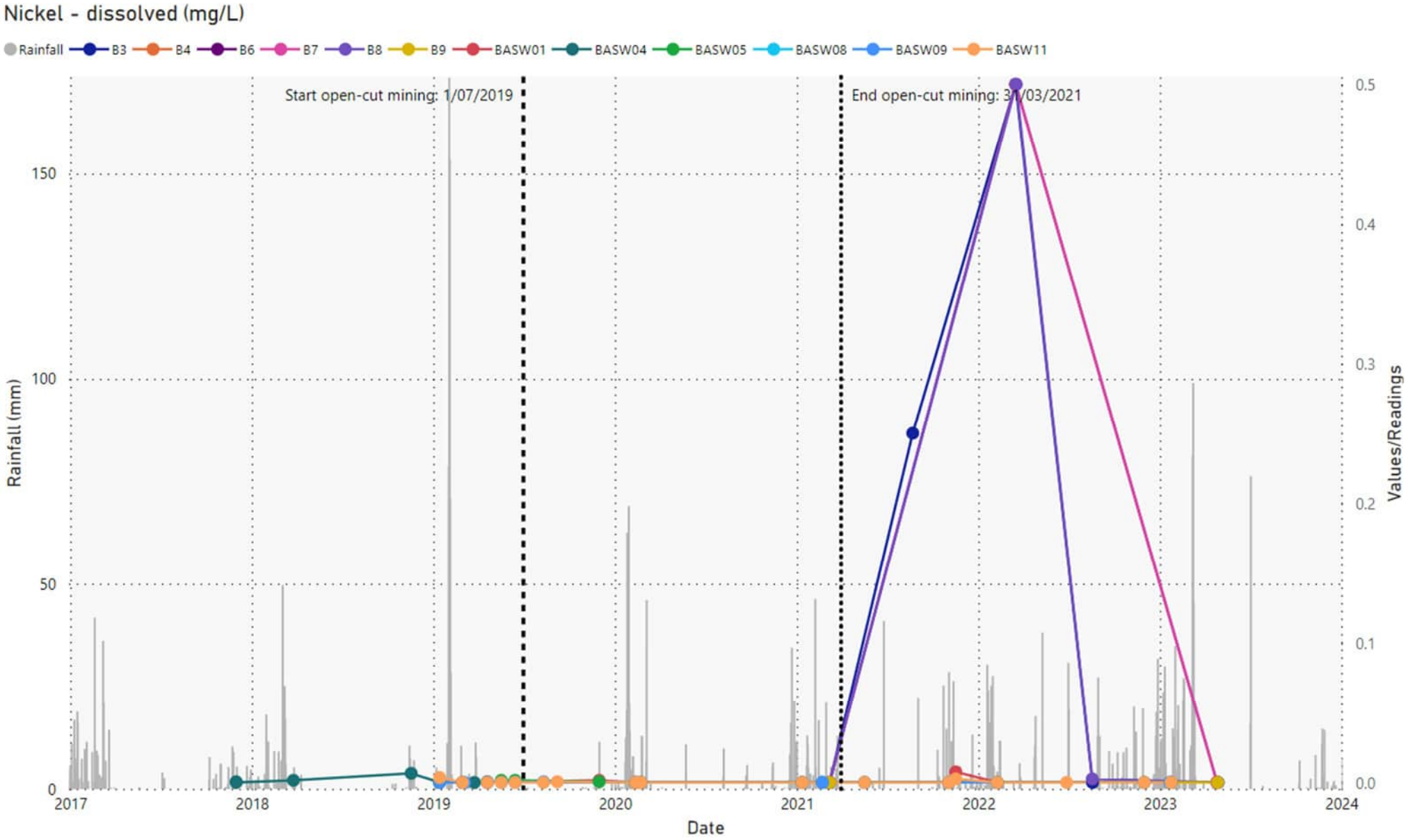
Nickel - dissolved (mg/L)

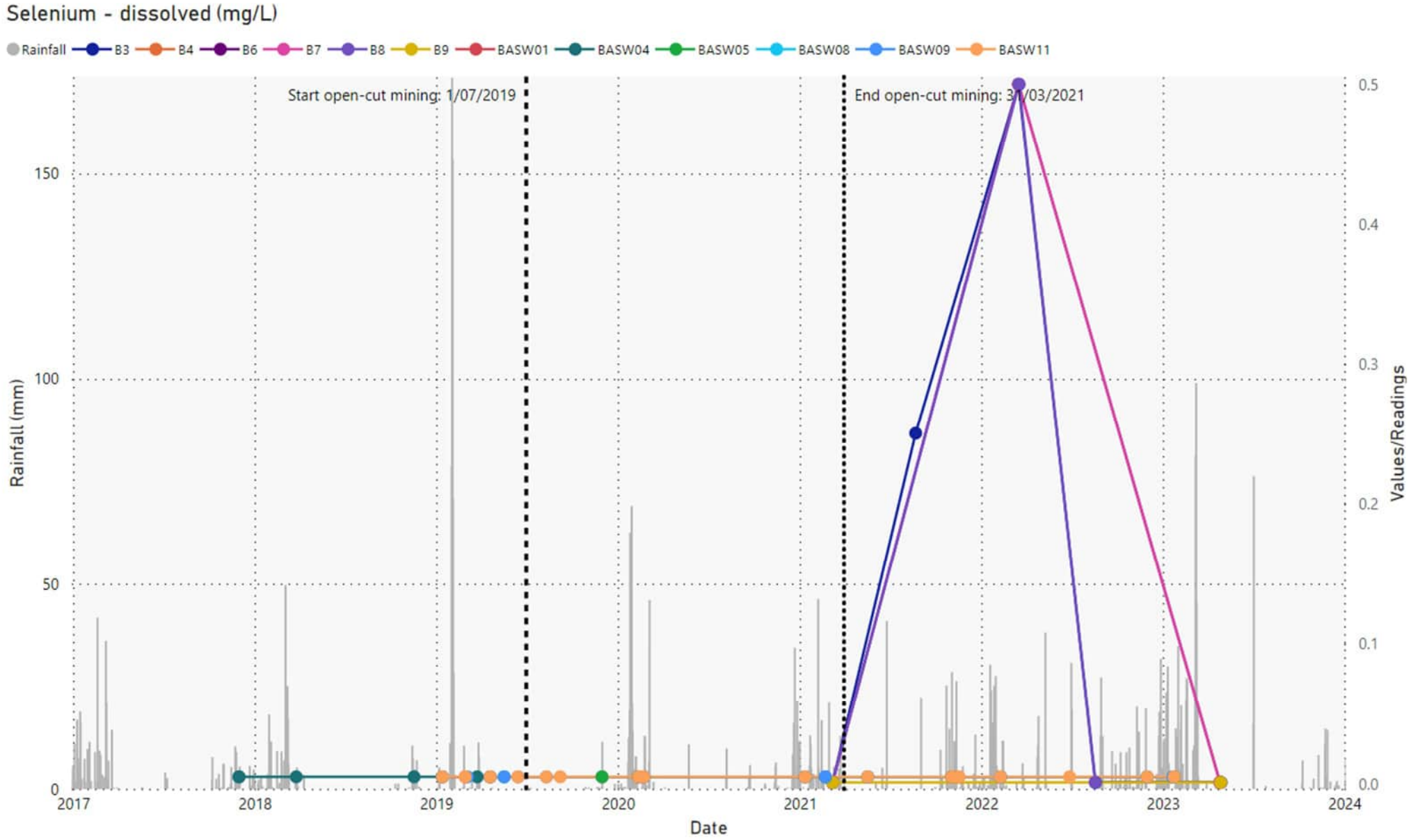


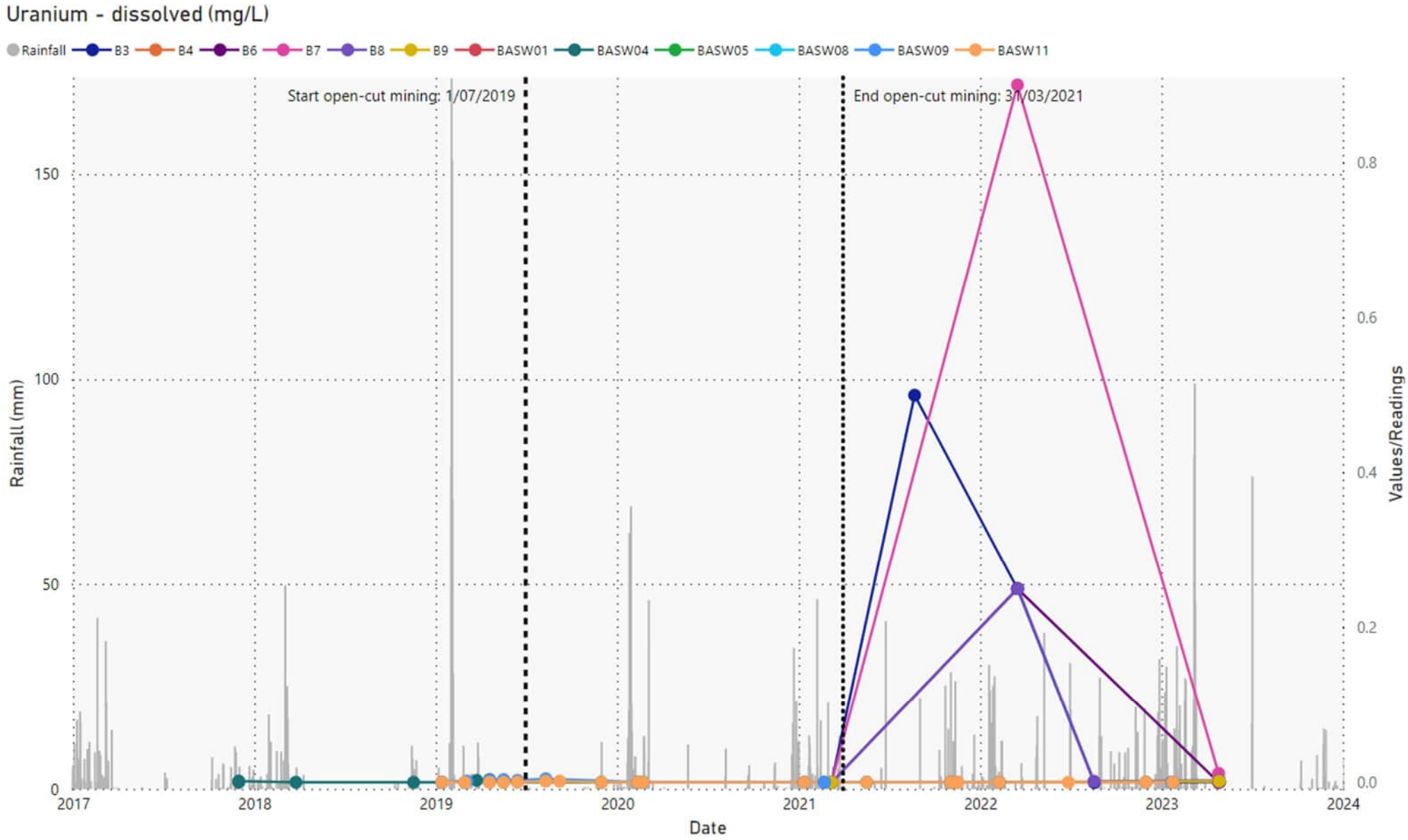
Selenium - dissolved (mg/L)




Uranium - dissolved (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
0.0
0.2
0.4
0.6
0.8
2017
2018
2019
2020
2021
2022
2023
2024
Date

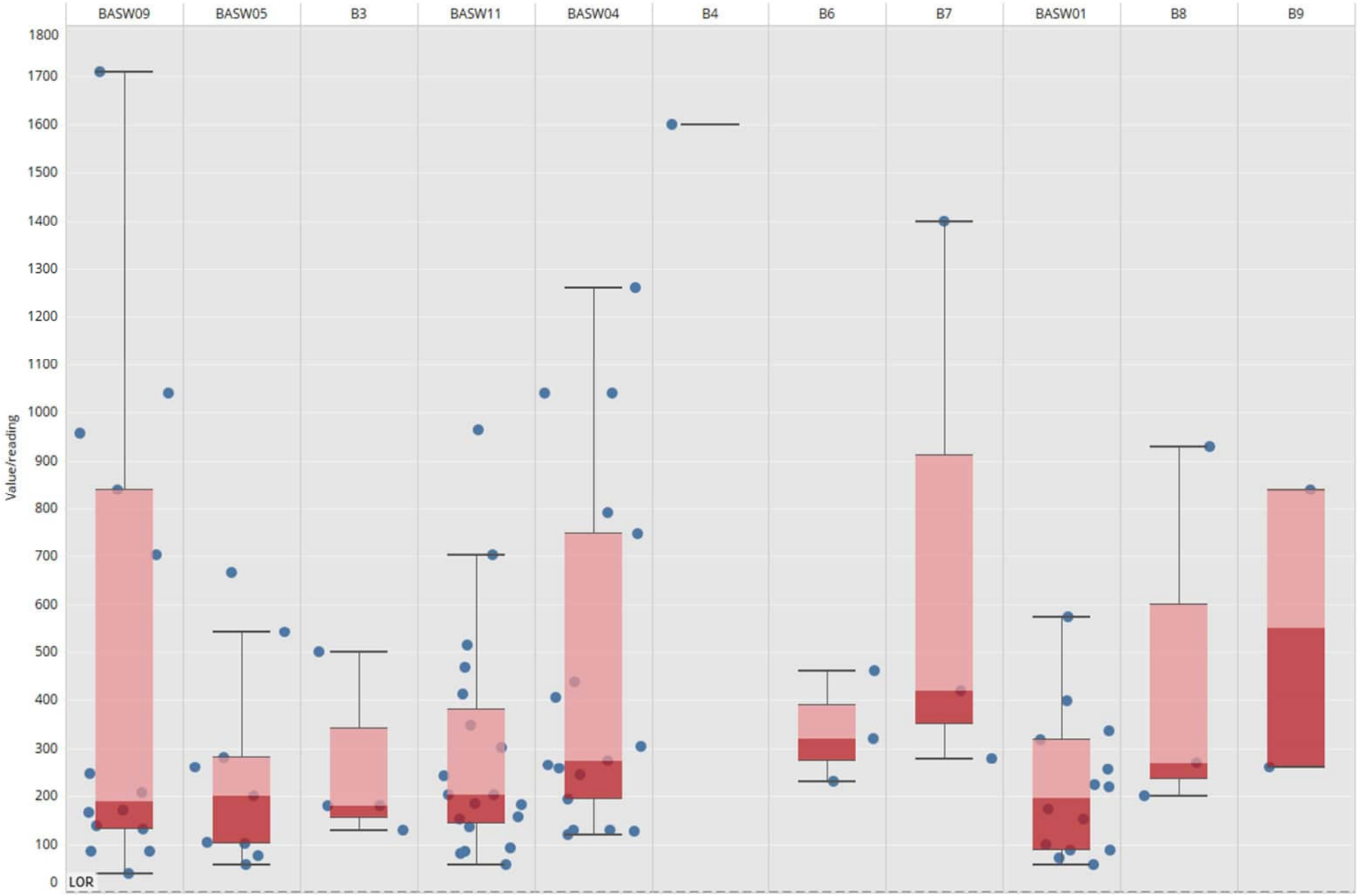

Nickel - dissolved (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
0.0
0.1
0.2
0.3
0.4
0.5
2017
2018
2019
2020
2021
2022
2023
2024


Selenium - dissolved (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings
Date
0
50
100
150
0.0
0.1
0.2
0.3
0.4
0.5
2017
2018
2019
2020
2021
2022
2023
2024

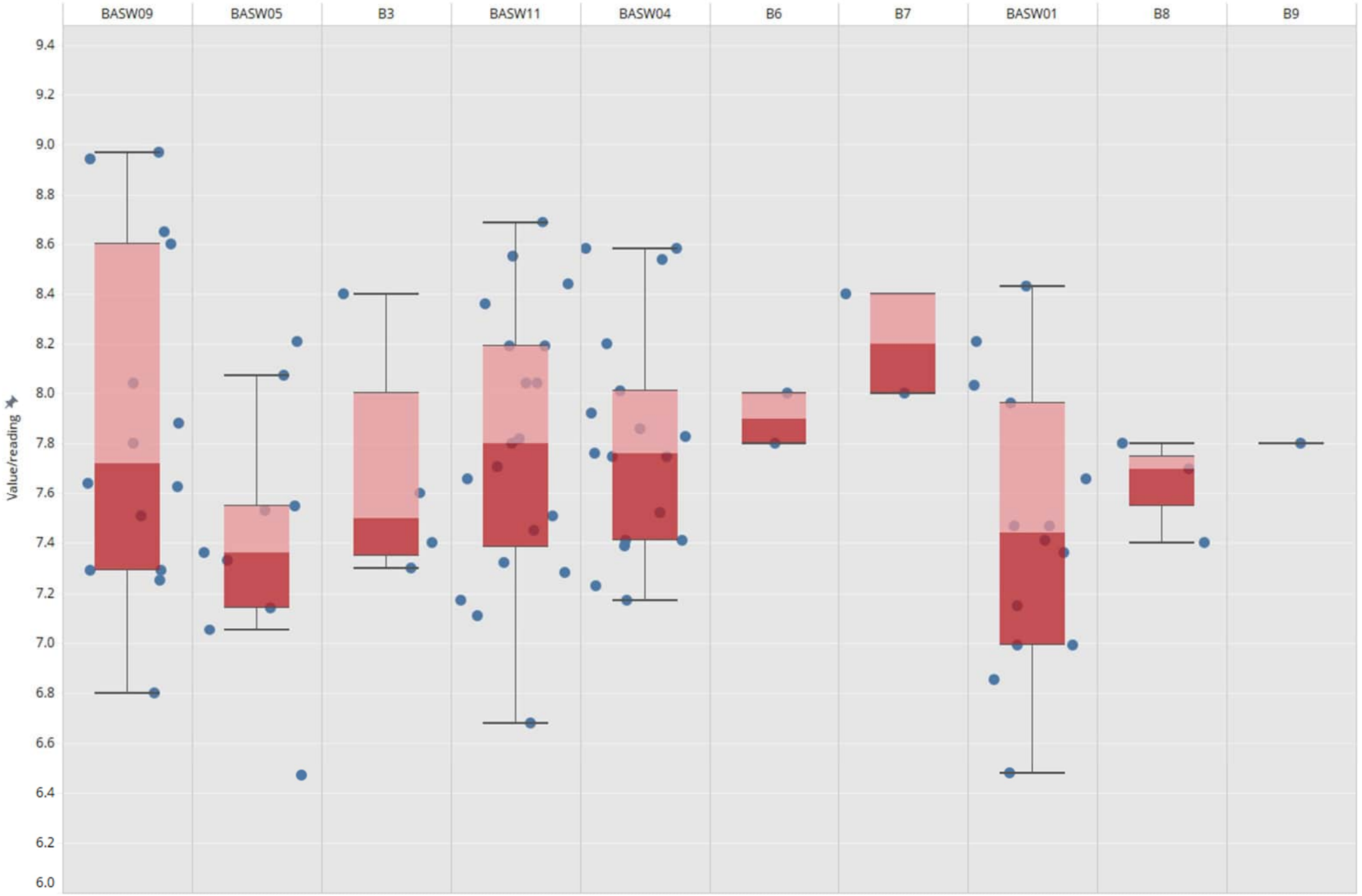

Uranium - dissolved (mg/L)
Rainfall
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW08
BASW09
BASW11
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
0.8
0.6
0.4
0.2
0.0
Values/Readings
2017
2018
2019
2020
2021
2022
2023
2024
Date

E.3 Water quality box & whisker plots

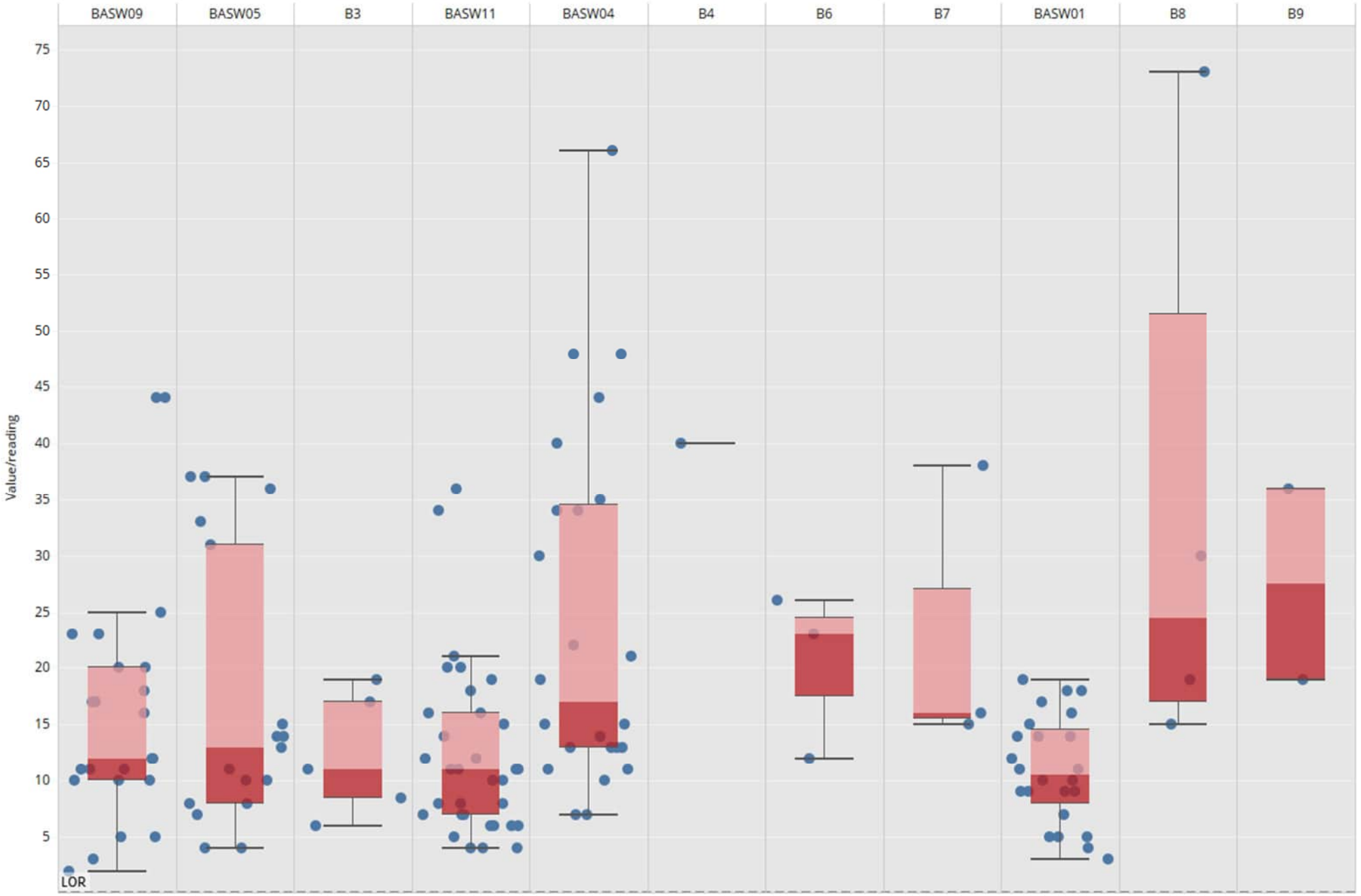
Electrical Conductivity (µS/cm)



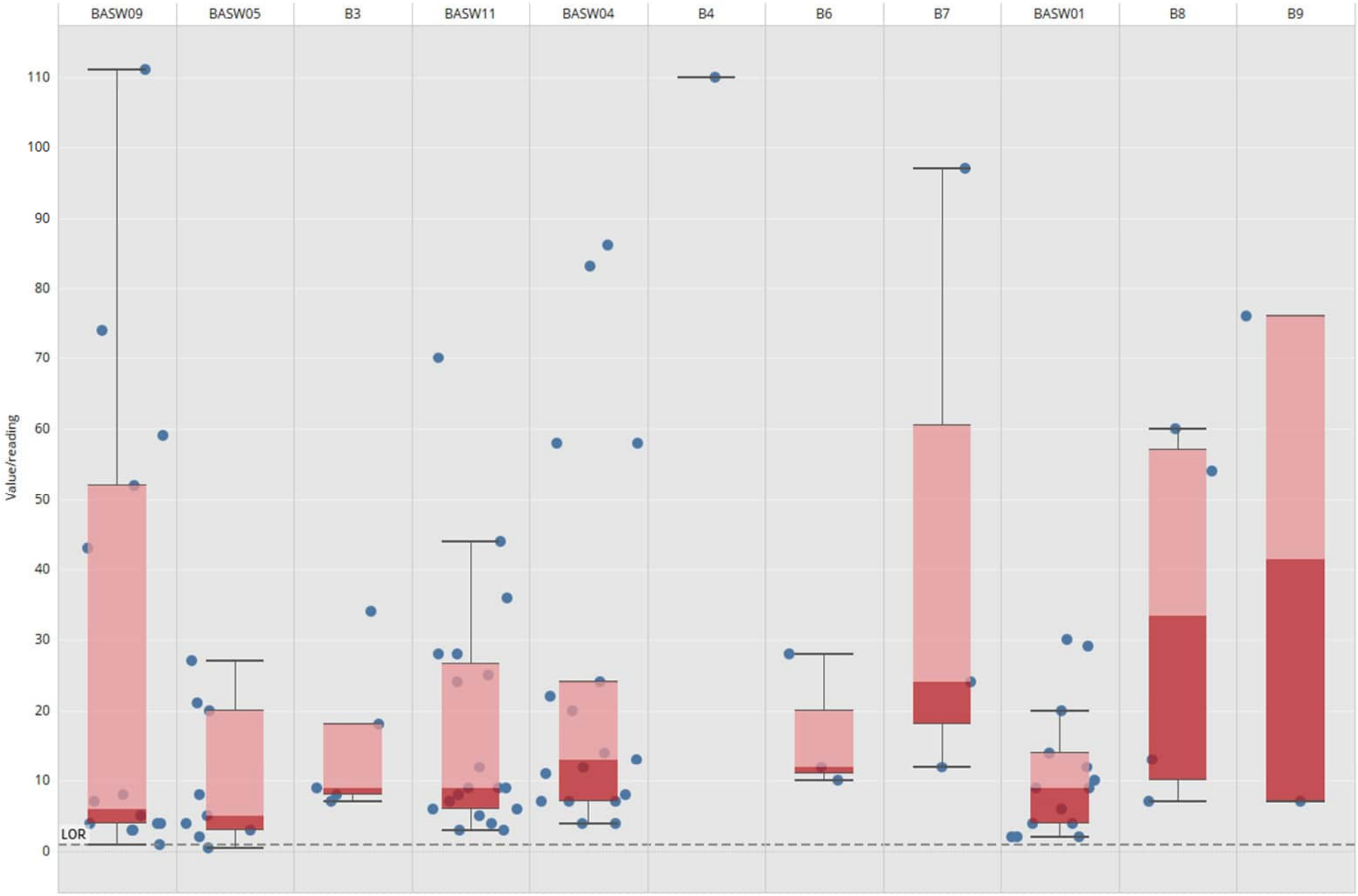
pH (lab)


BASW09
BASW05
B3
BASW11
BASW04
B6
B7
BASW01
B8
B9
Value/reading
9.4
9.2
9.0
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0
6.8
6.6
6.4
6.2
6.0

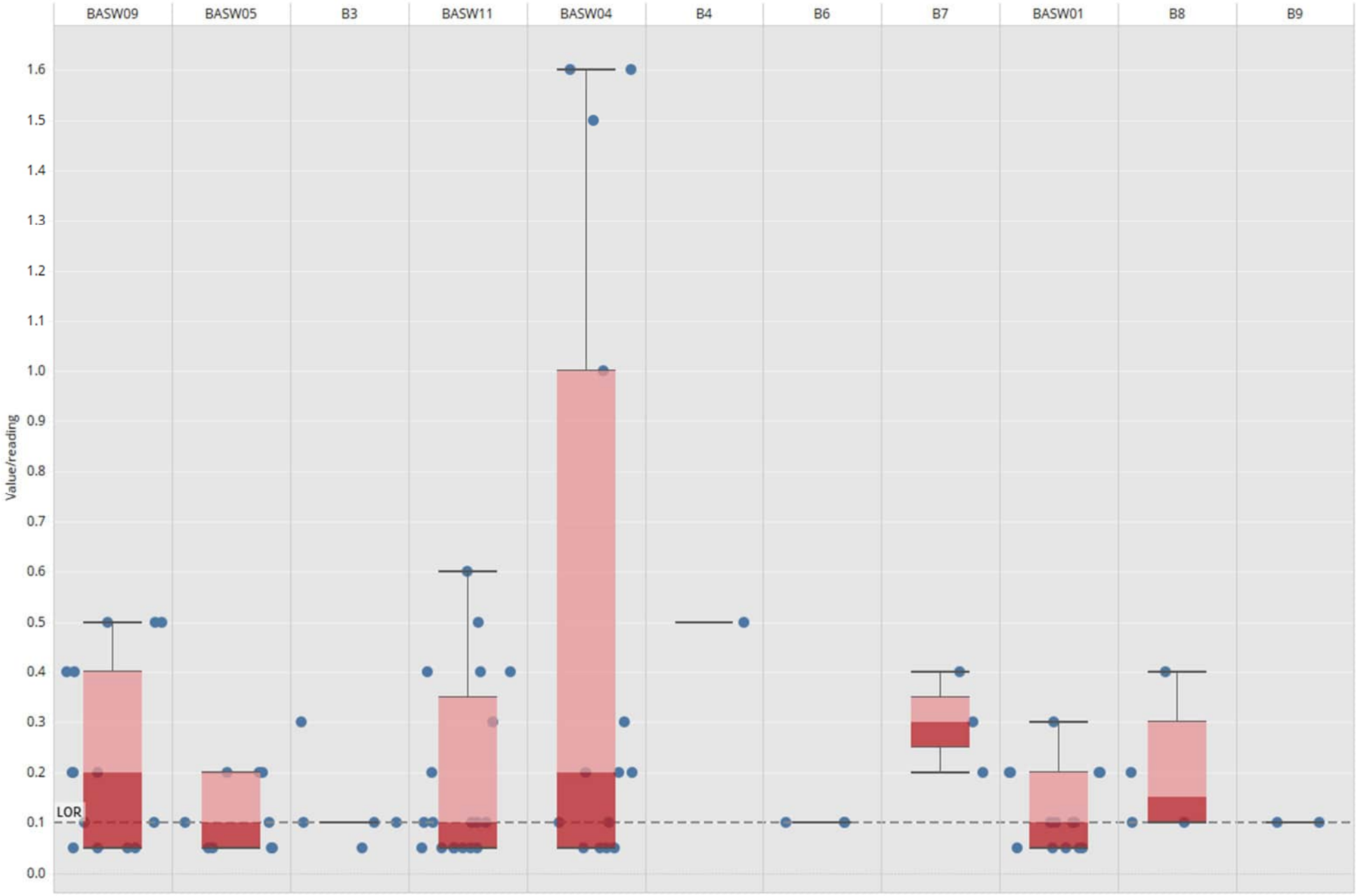
Calcium (mg/L)


BASW09
BASW05
B3
BASW11
BASW04
B4
B6
B7
BASW01
B8
B9
Value/reading
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
LOR

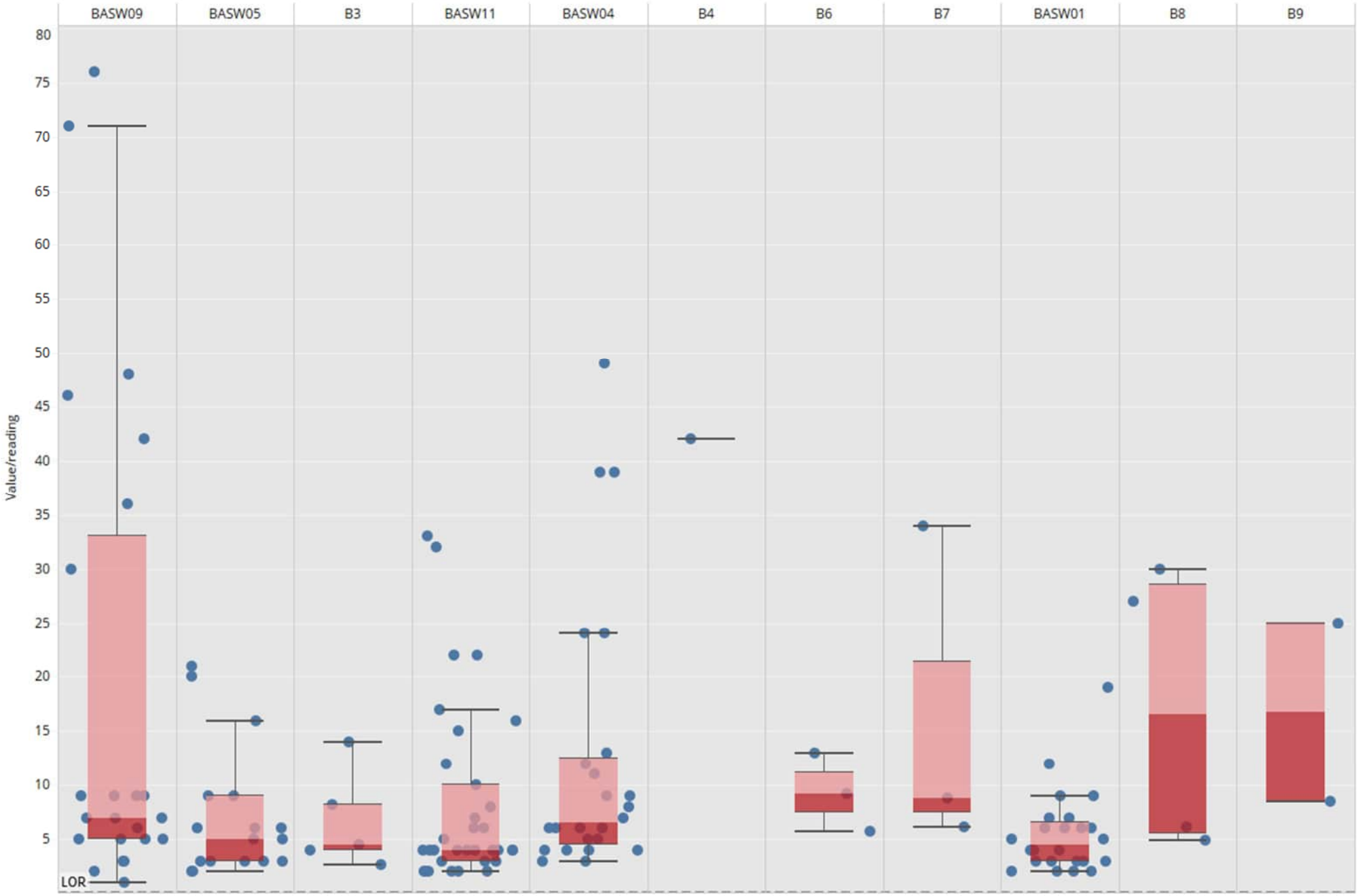
Chloride (mg/L)



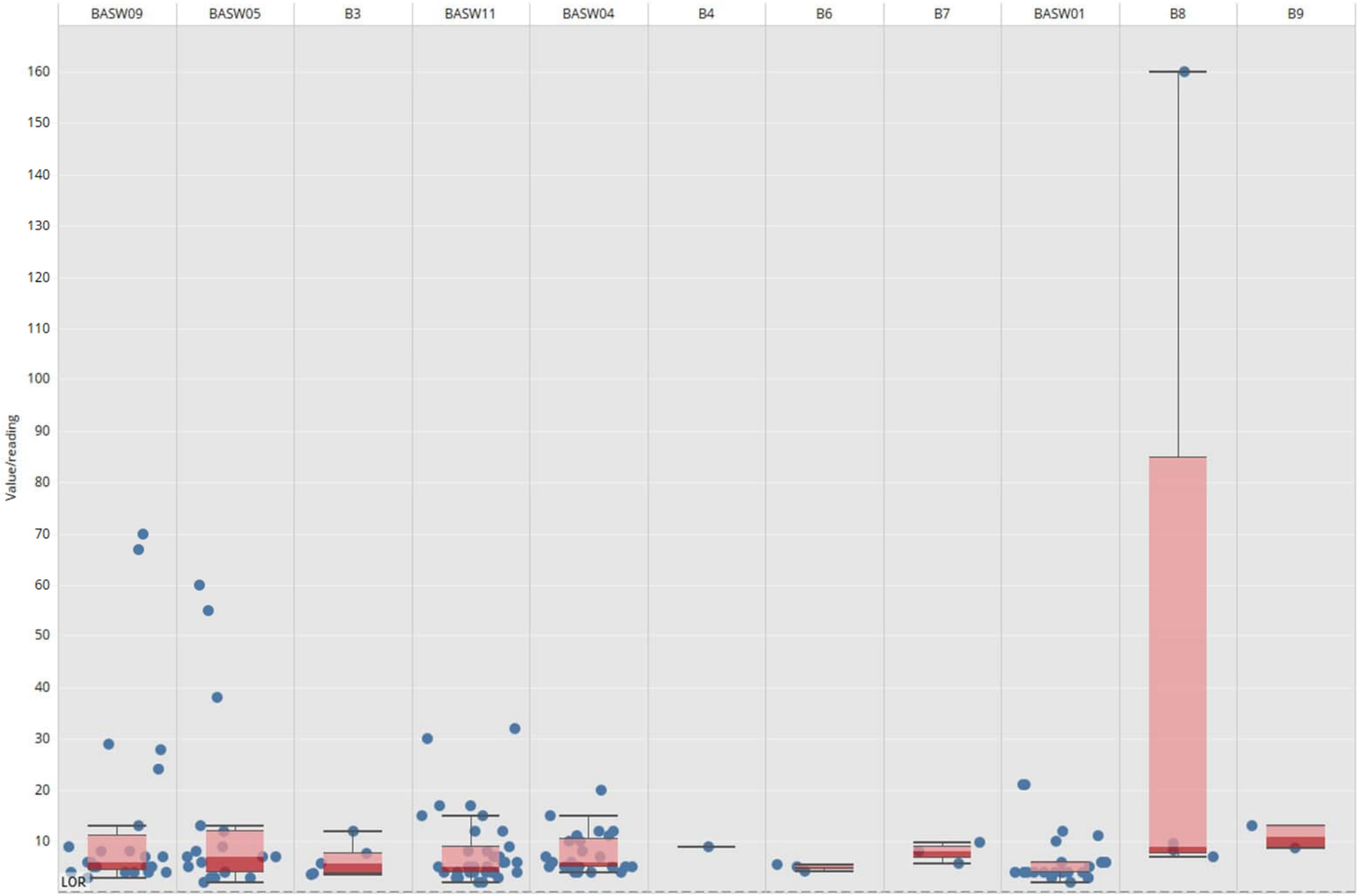
Fluoride (mg/L)



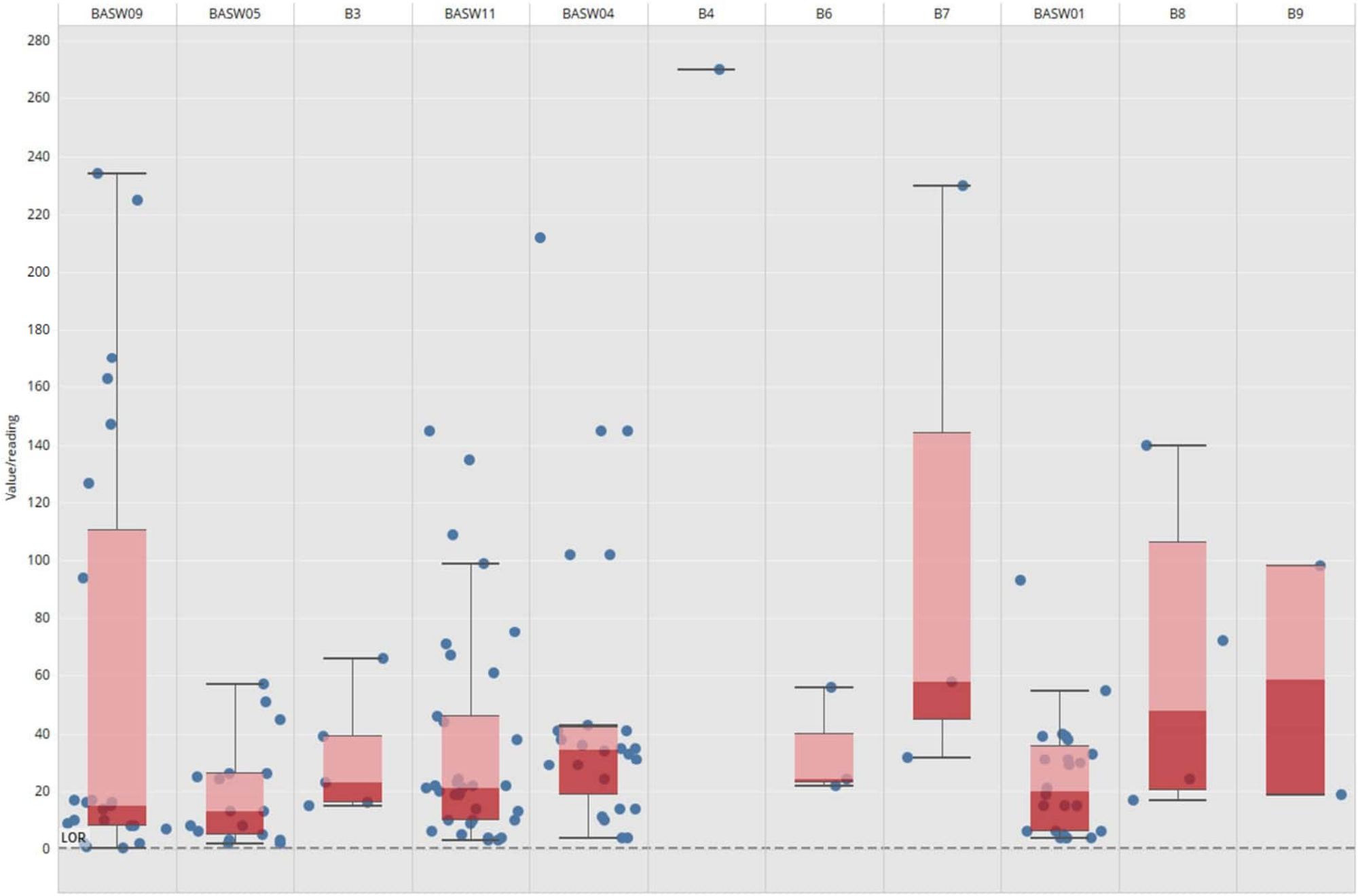
Magnesium (mg/L)



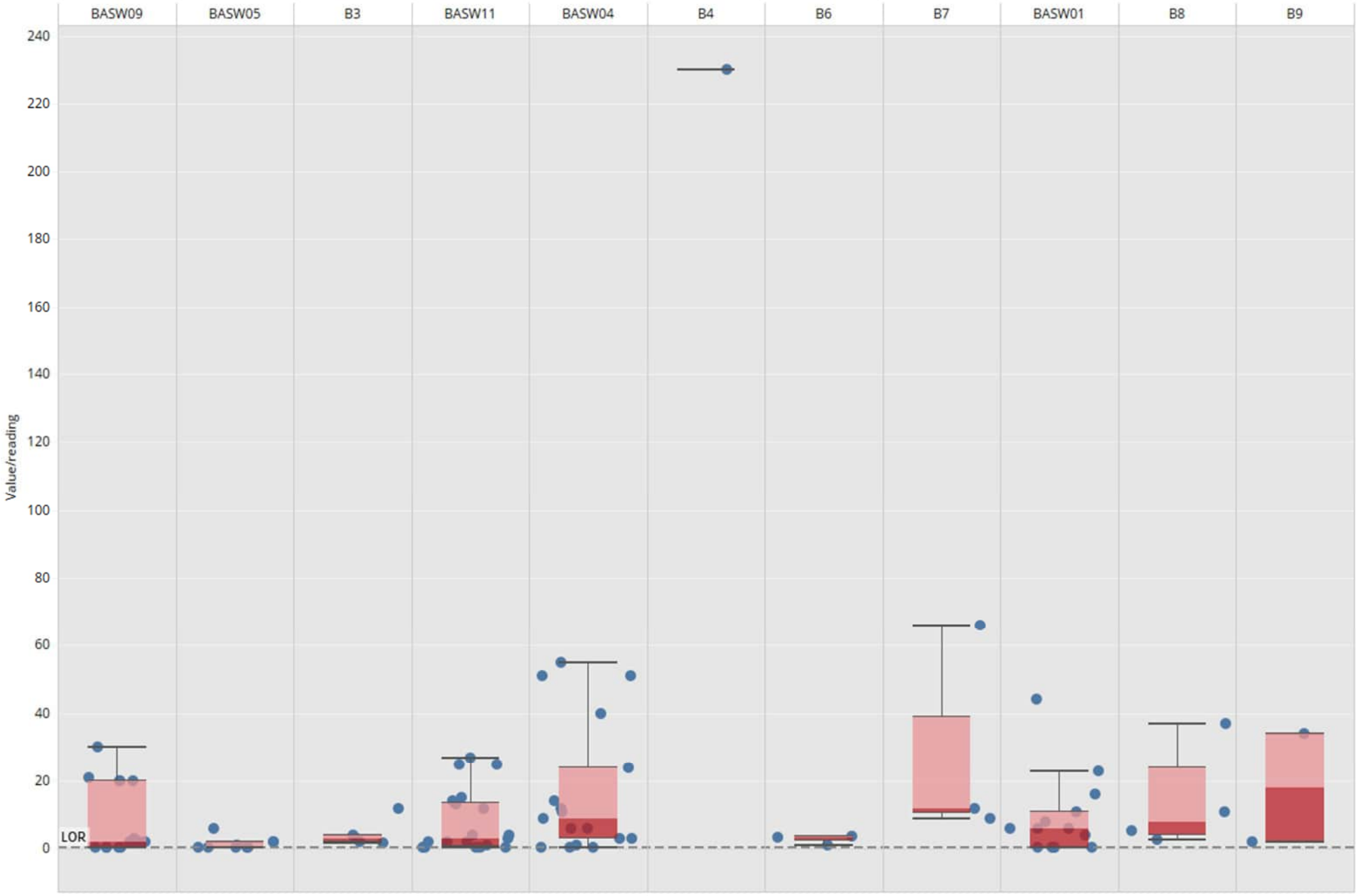
Potassium (mg/L)



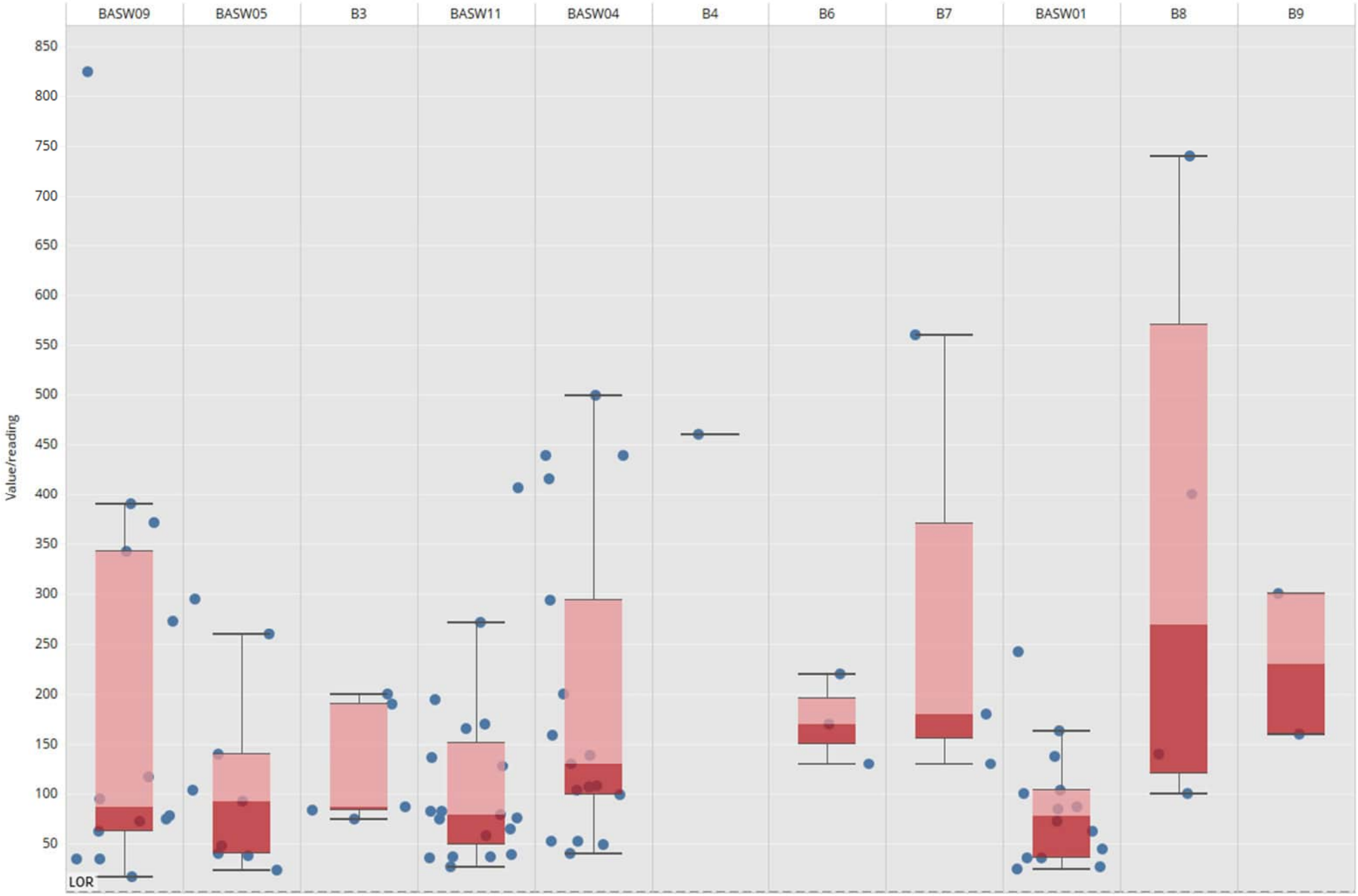
Sodium (mg/L)


BASW09
BASW05
B3
BASW11
BASW04
B4
B6
B7
BASW01
B8
B9
Value/reading
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
LOR

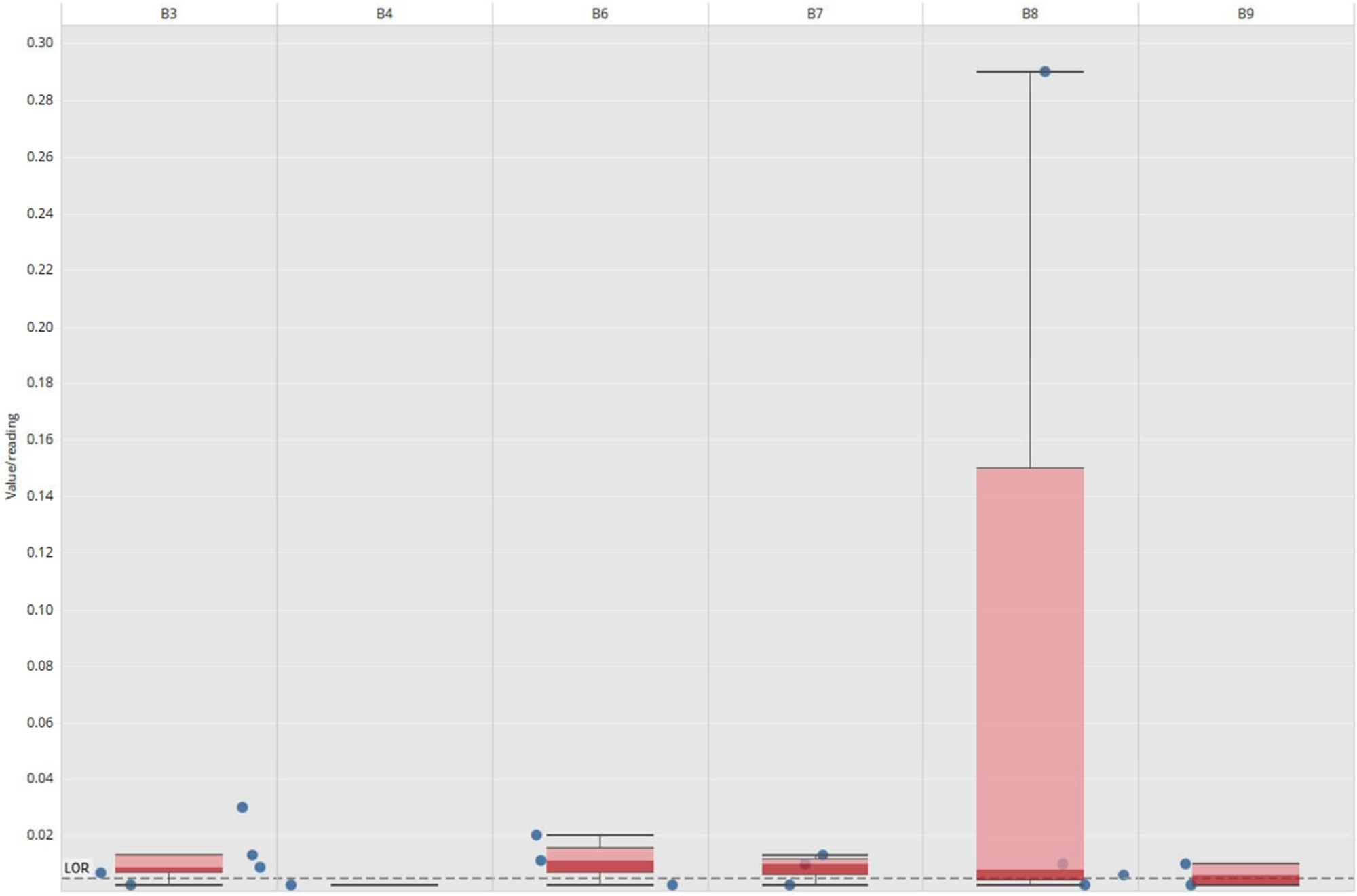
Sulfate (as SO4)



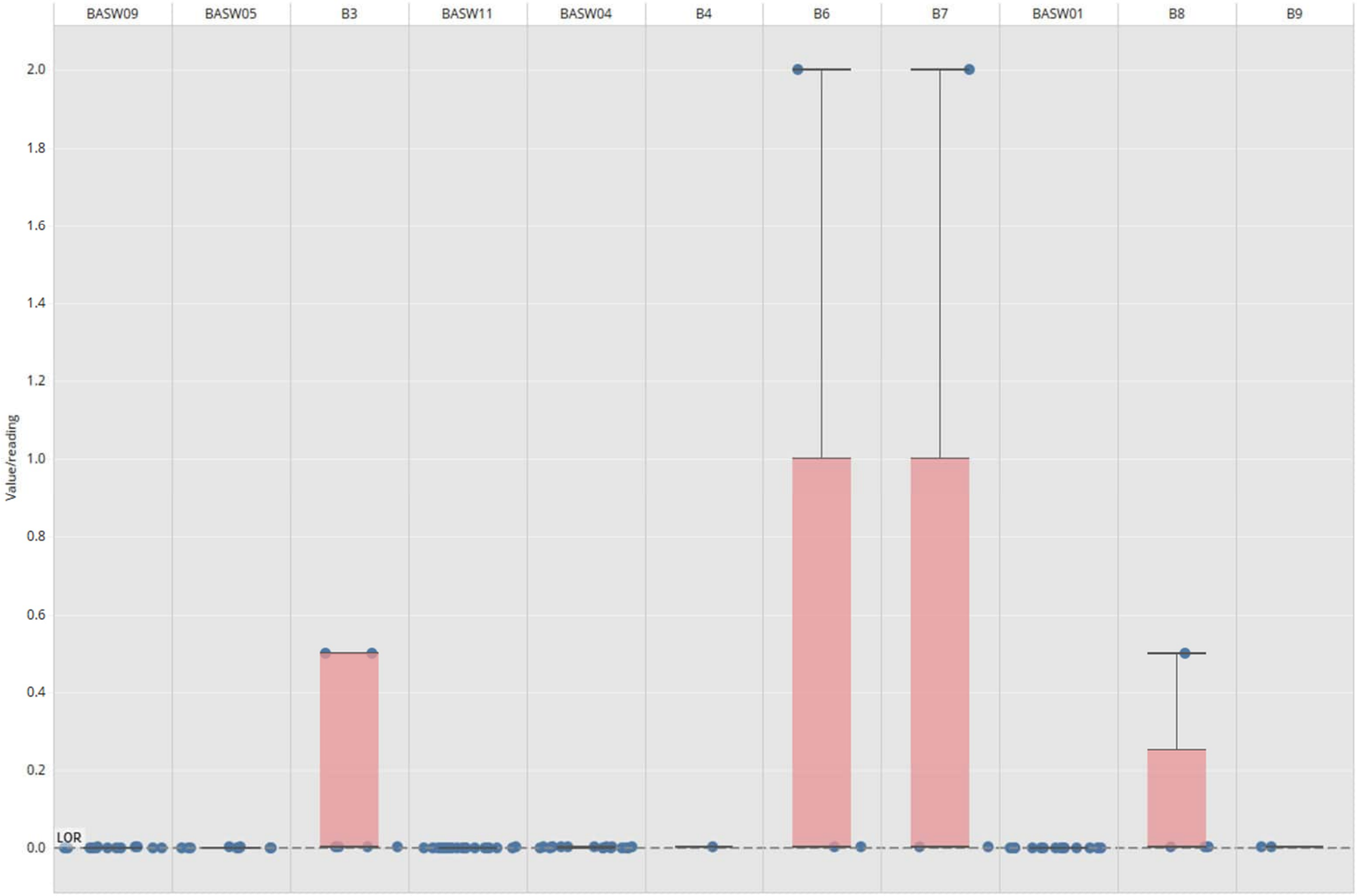
Bicarbonate Alkalinity as CaCO3 (mg/L)



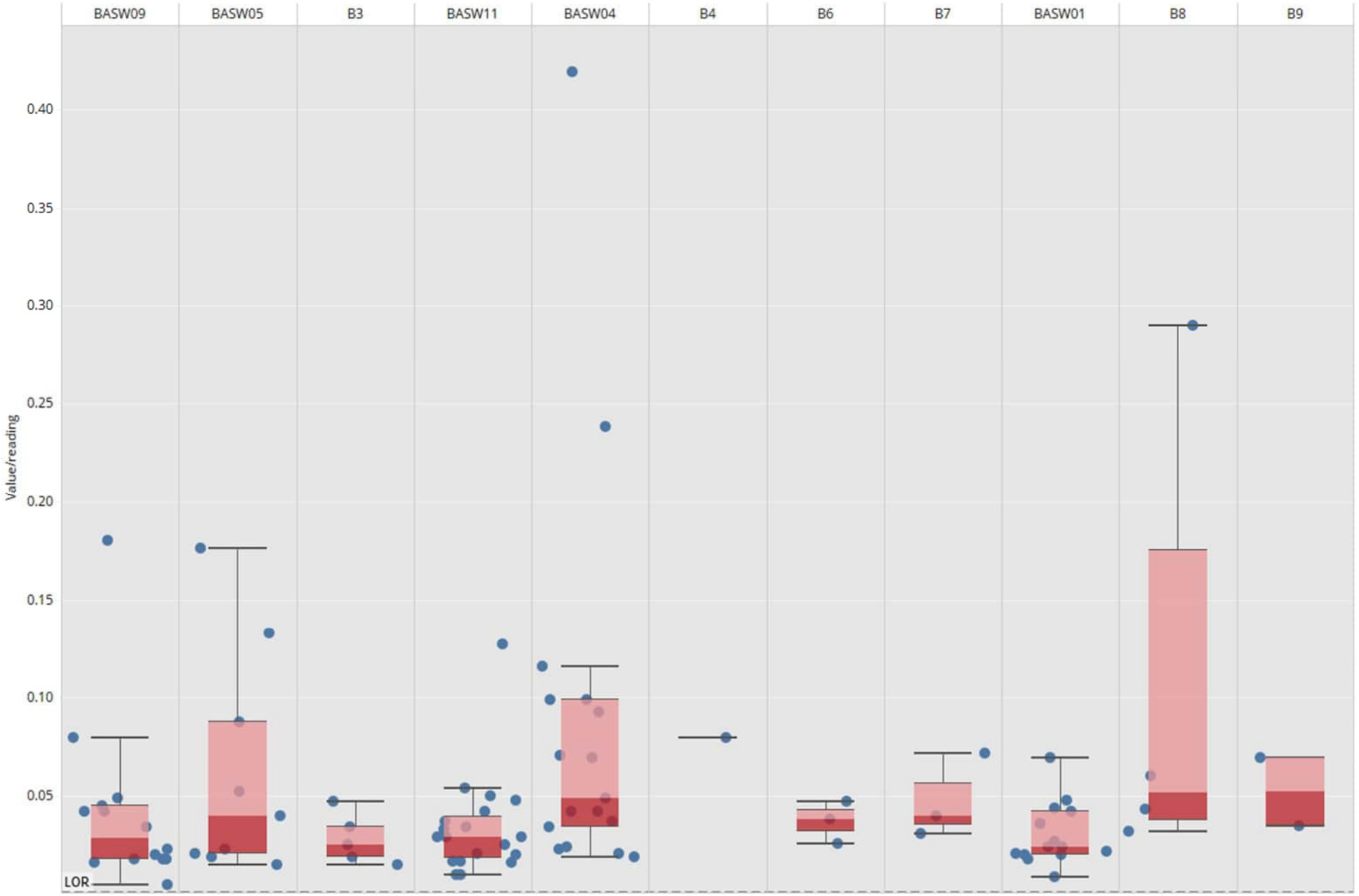
Aluminium - dissolved (mg/L)



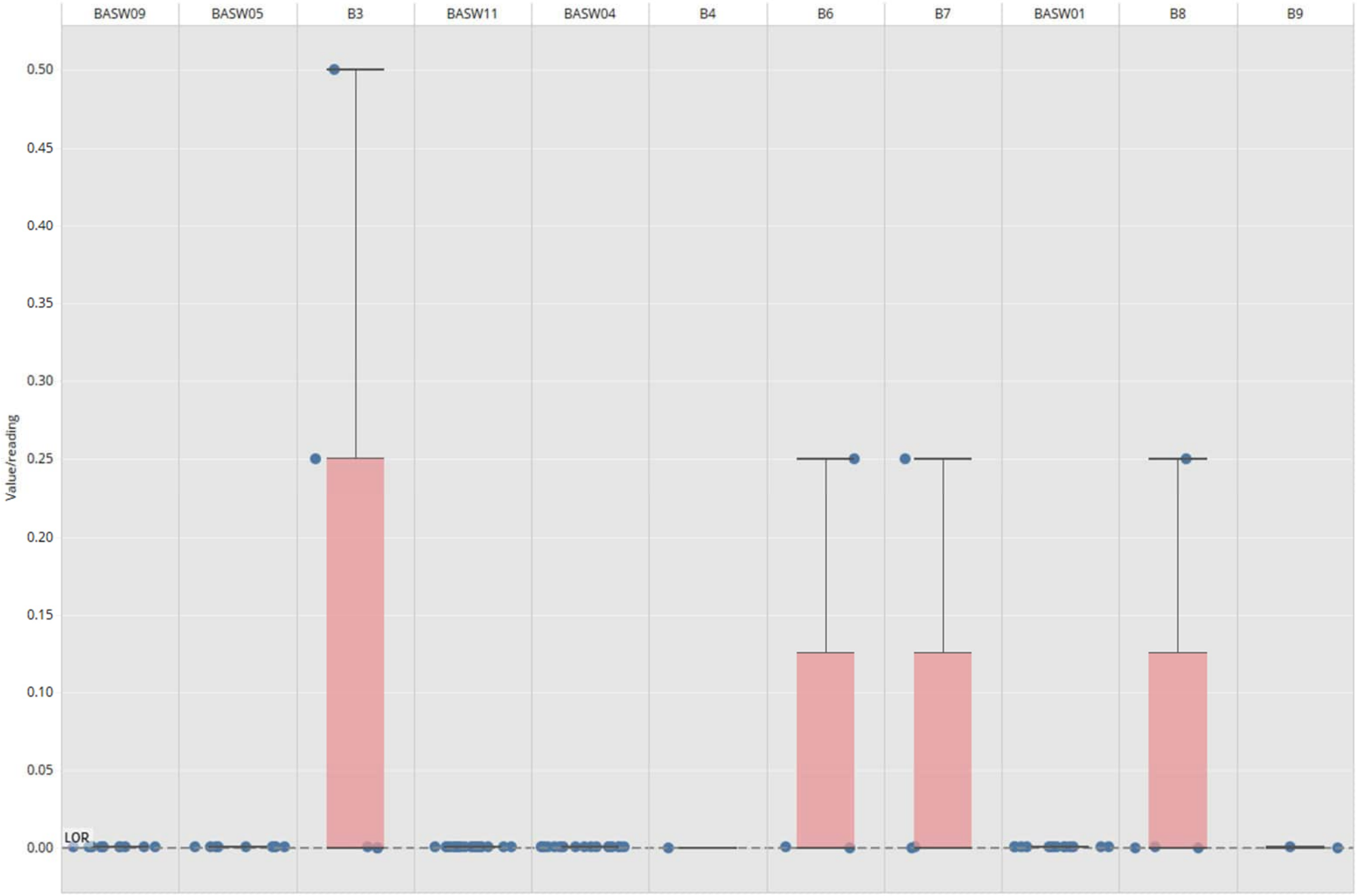
Arsenic - dissolved (mg/L)



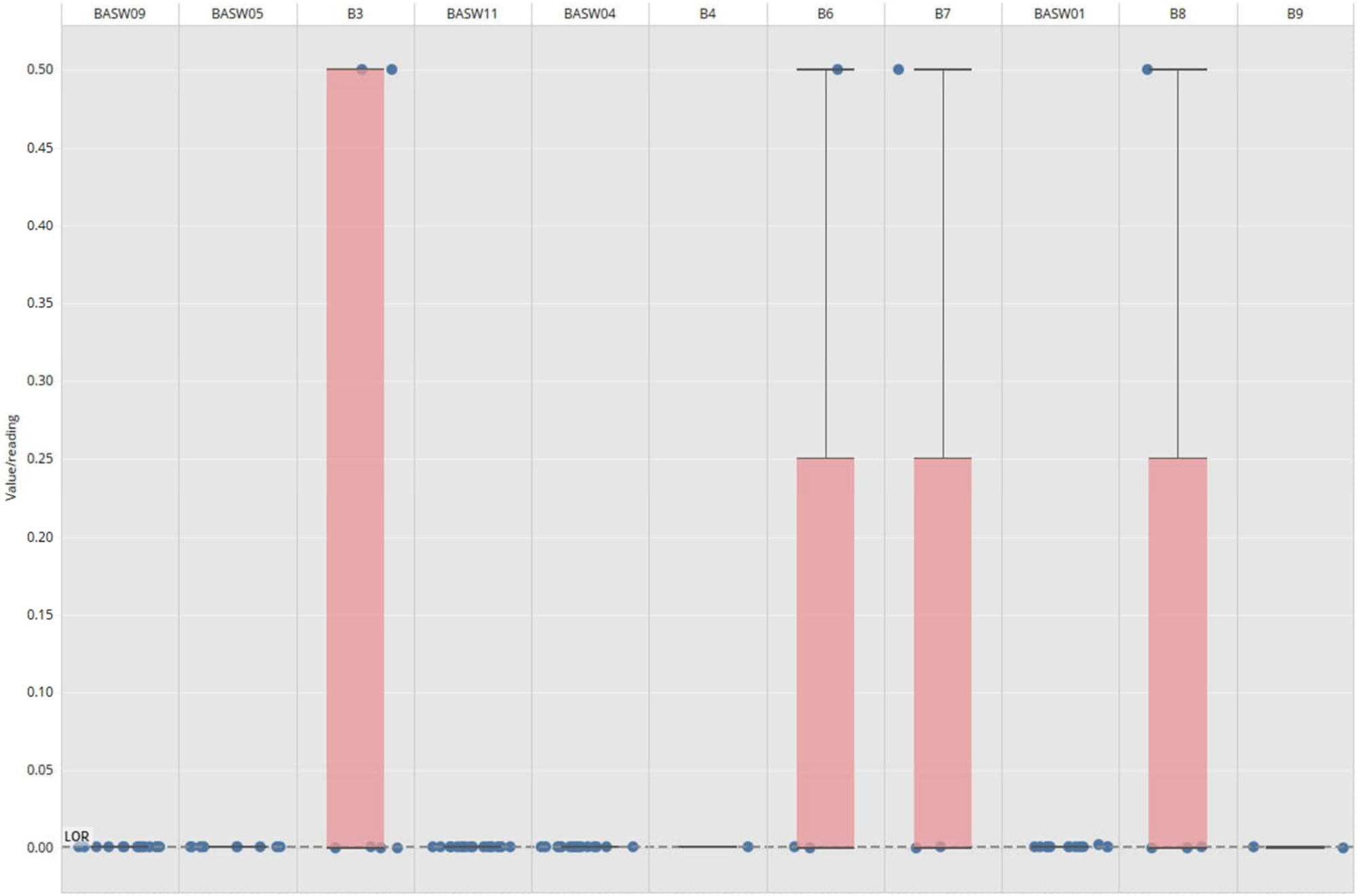
Barium - dissolved (mg/L)



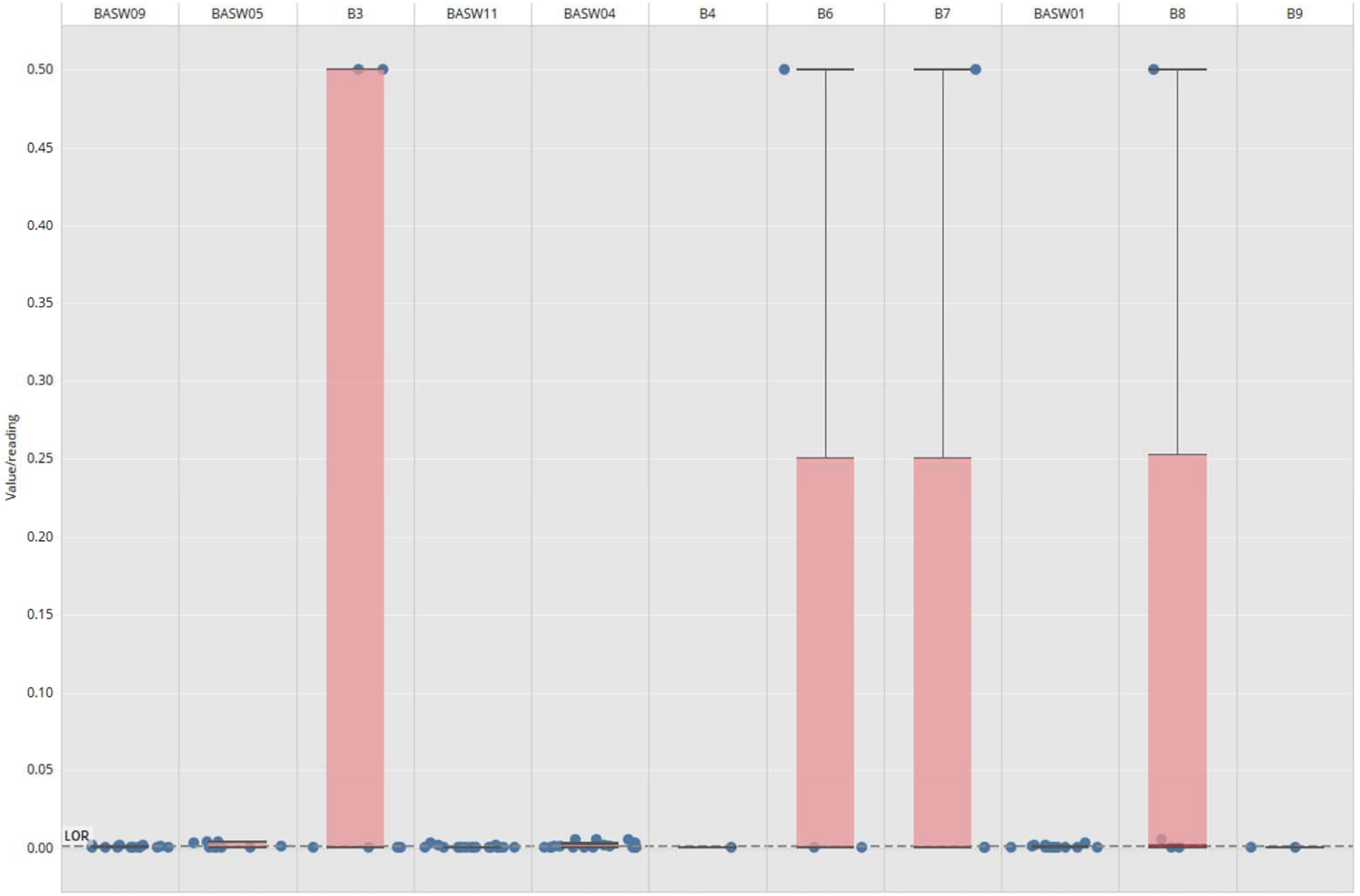
Bismuth - dissolved (mg/L)



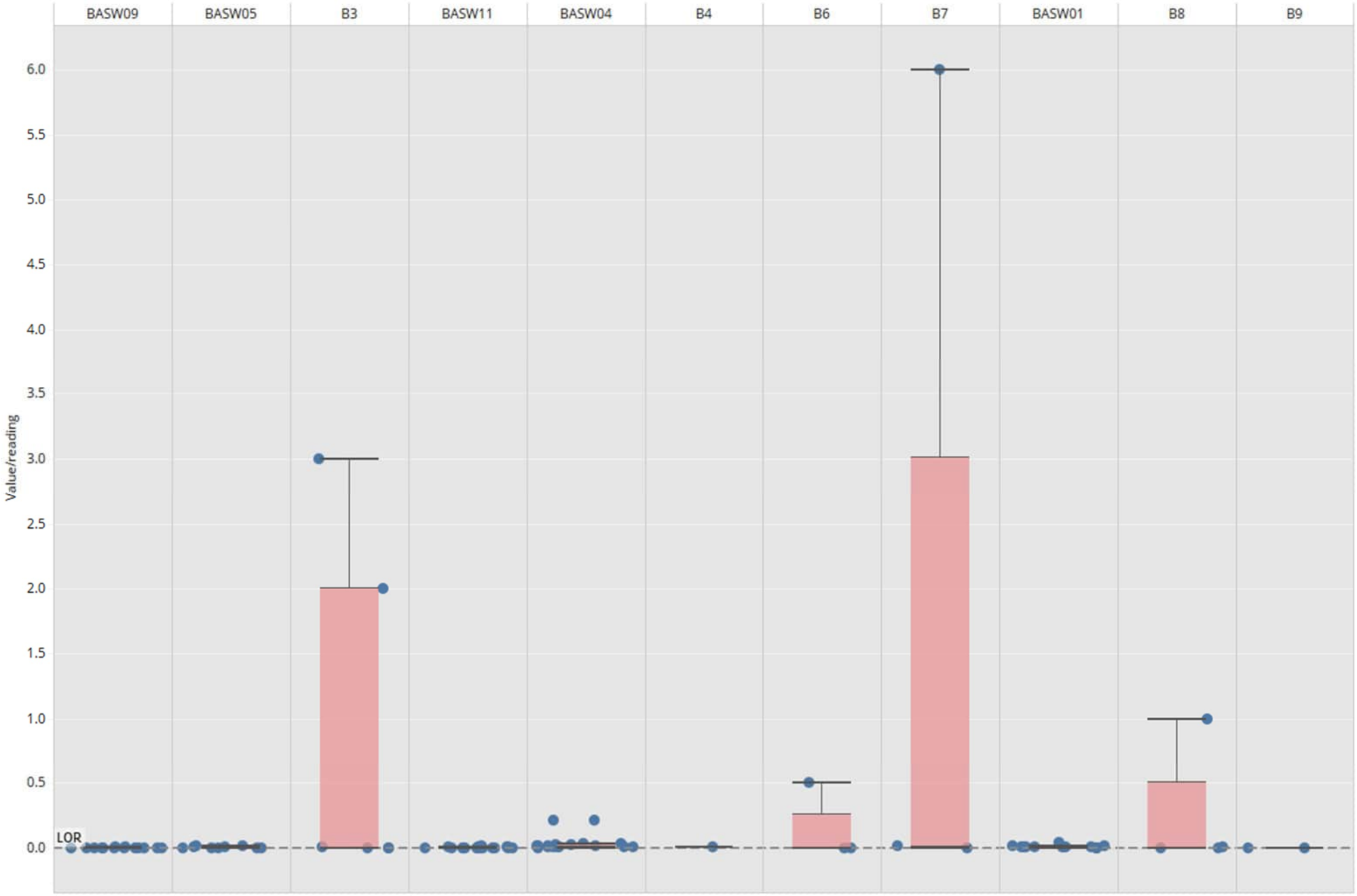
Chromium - dissolved (mg/L)



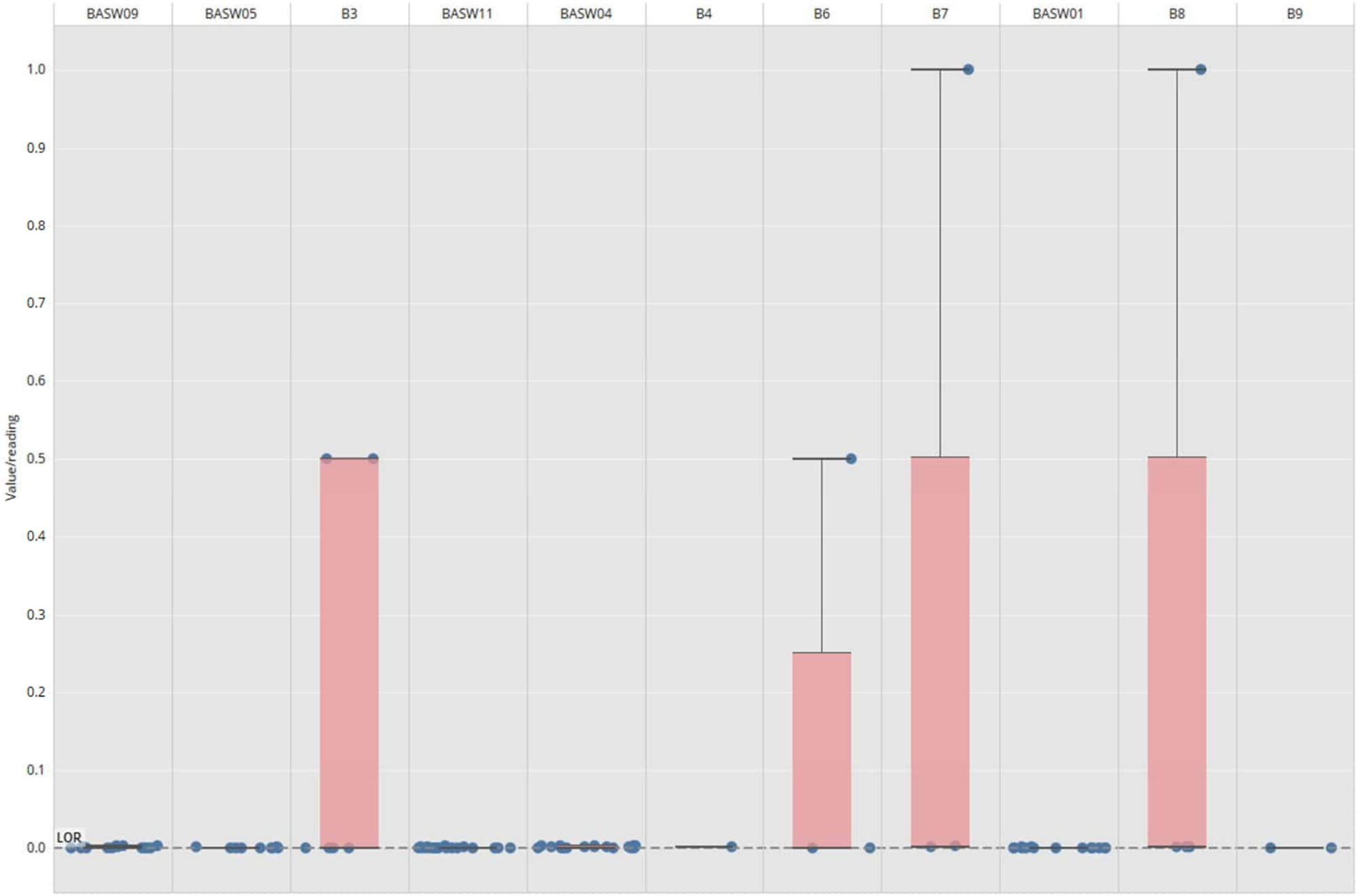
Cobalt - dissolved (mg/L)



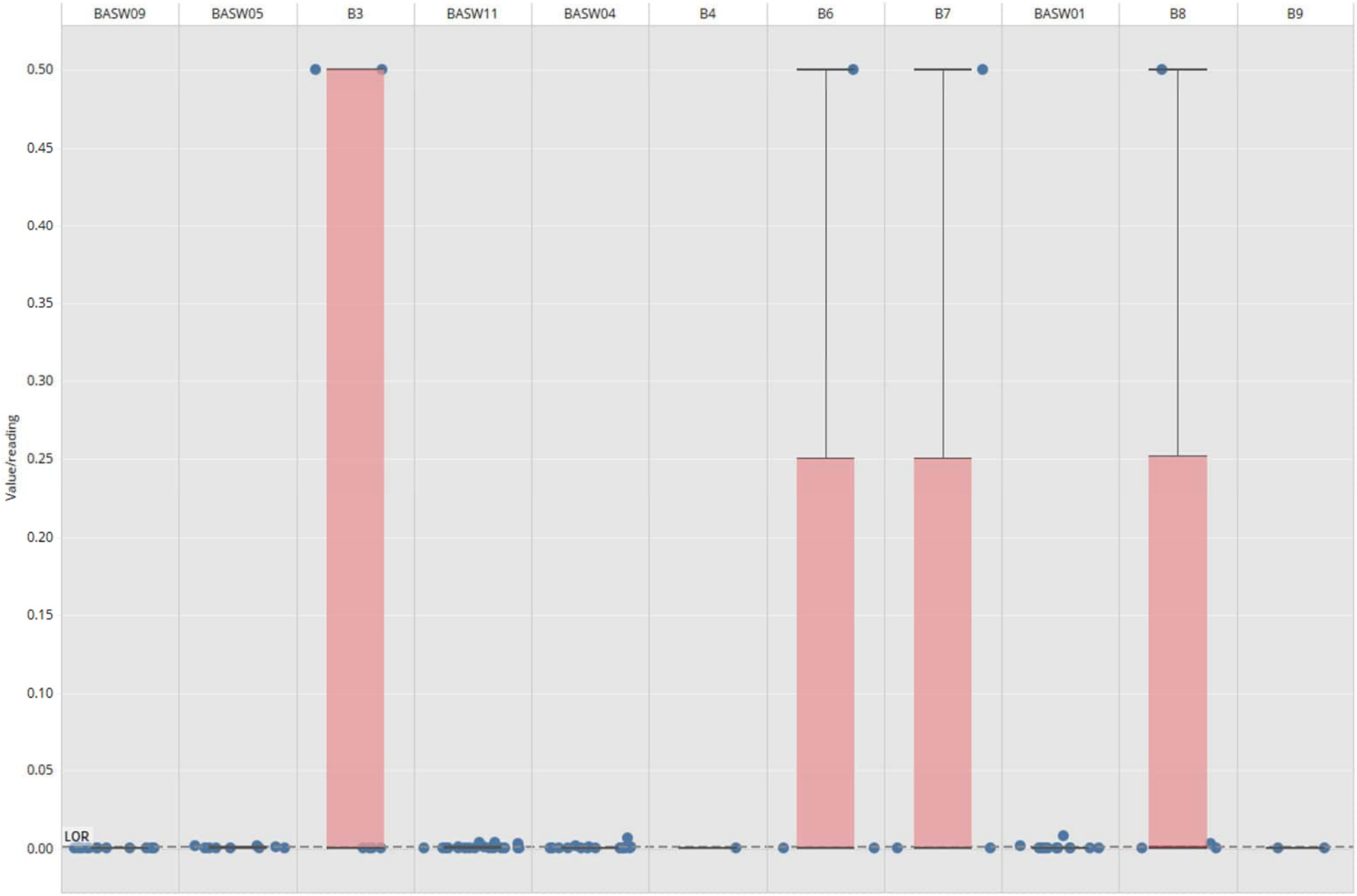
Copper - dissolved (mg/L)



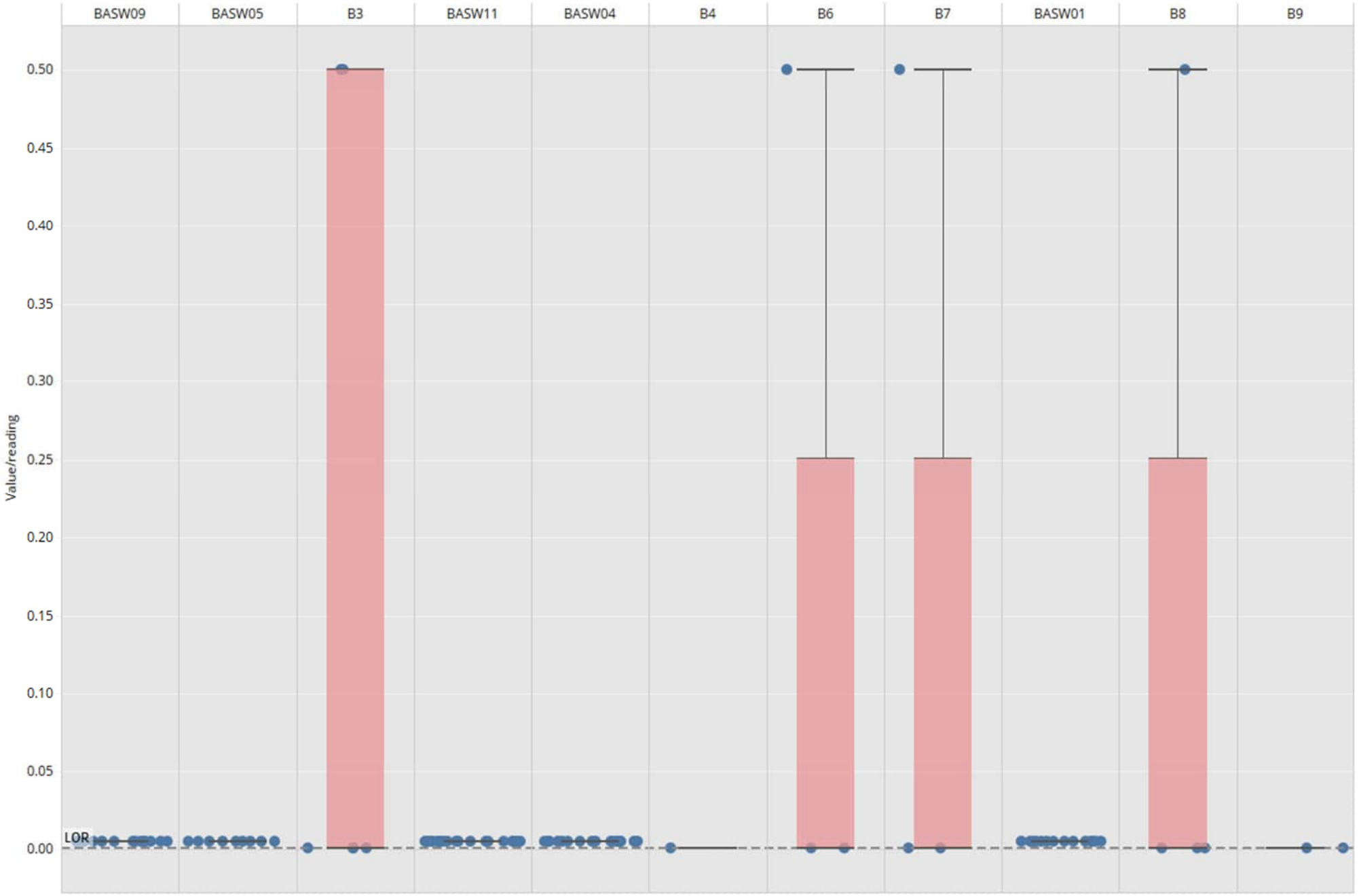
Molybdenum - dissolved (mg/L)



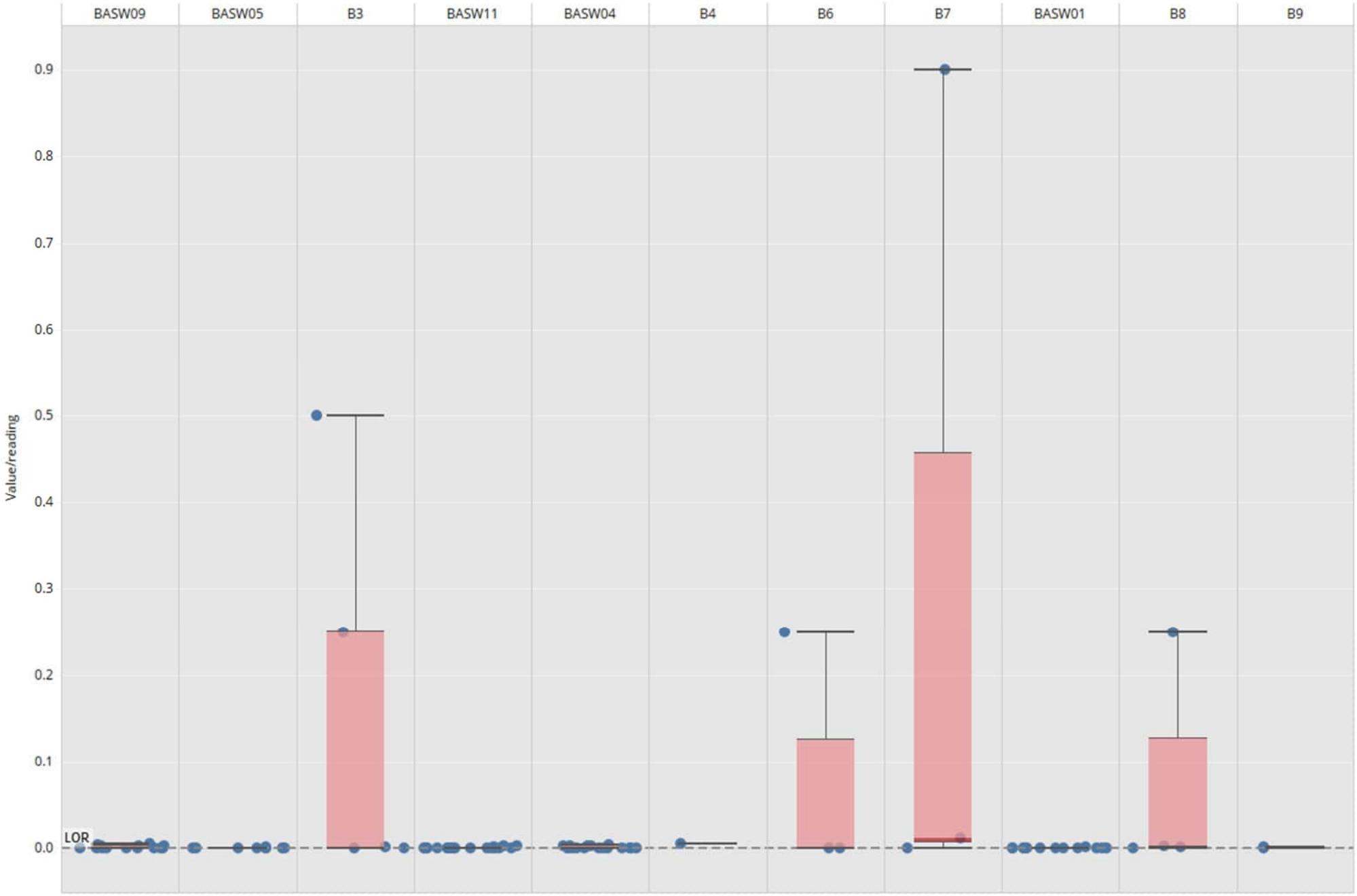
Nickel - dissolved (mg/L)



Selenium - dissolved (mg/L)

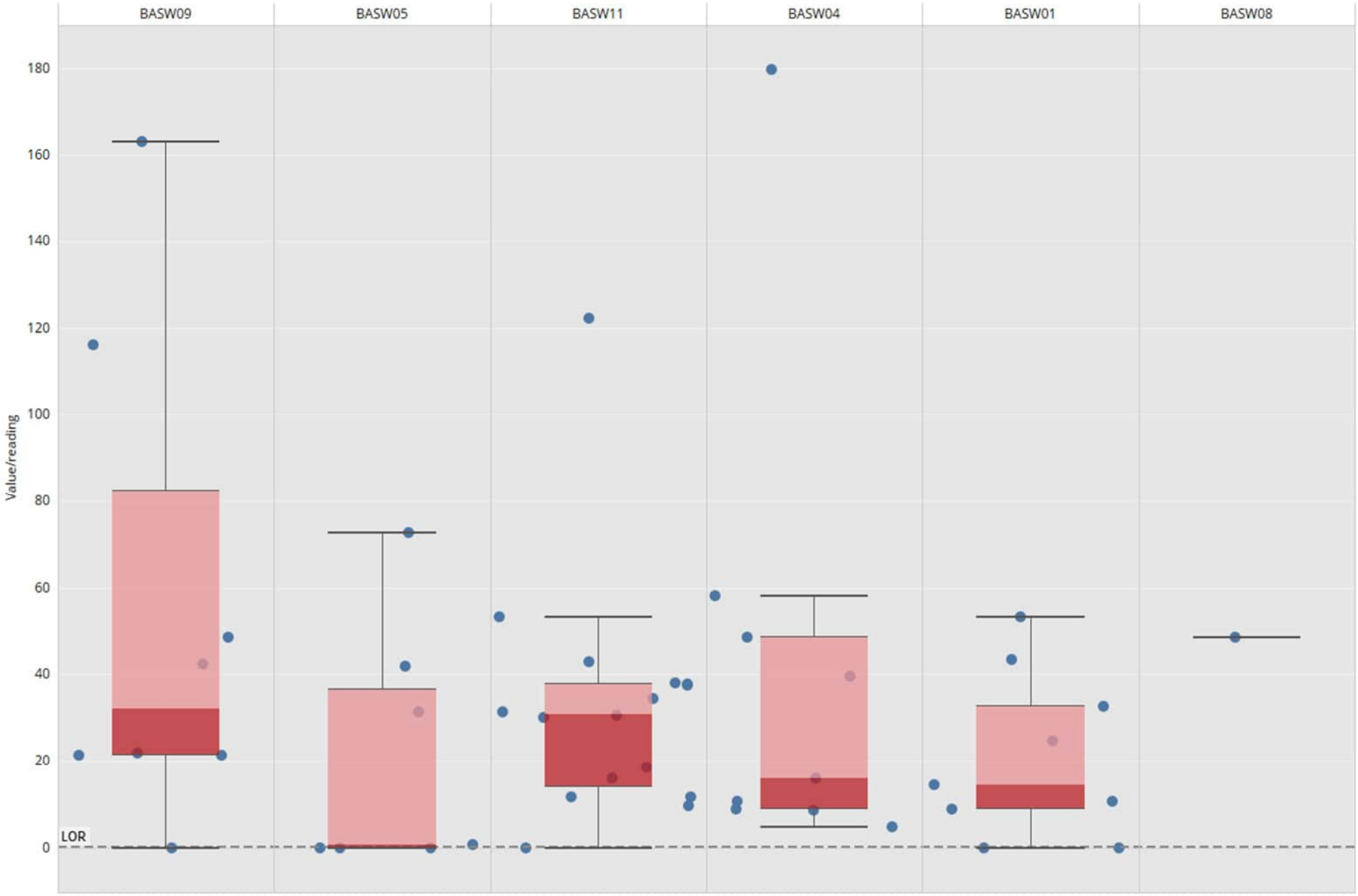


Uranium - dissolved (mg/L)

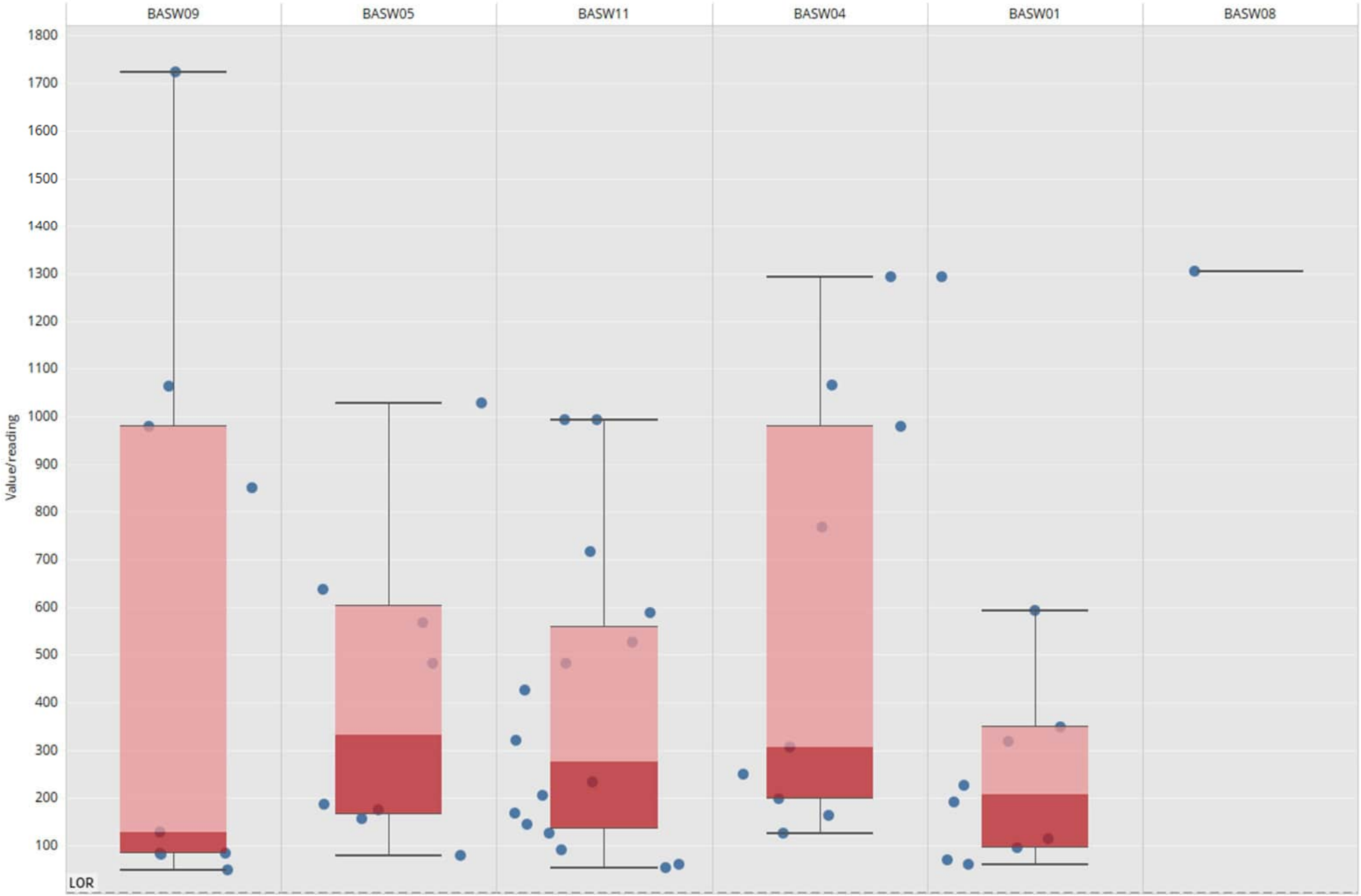


Zinc - dissolved (mg/L)

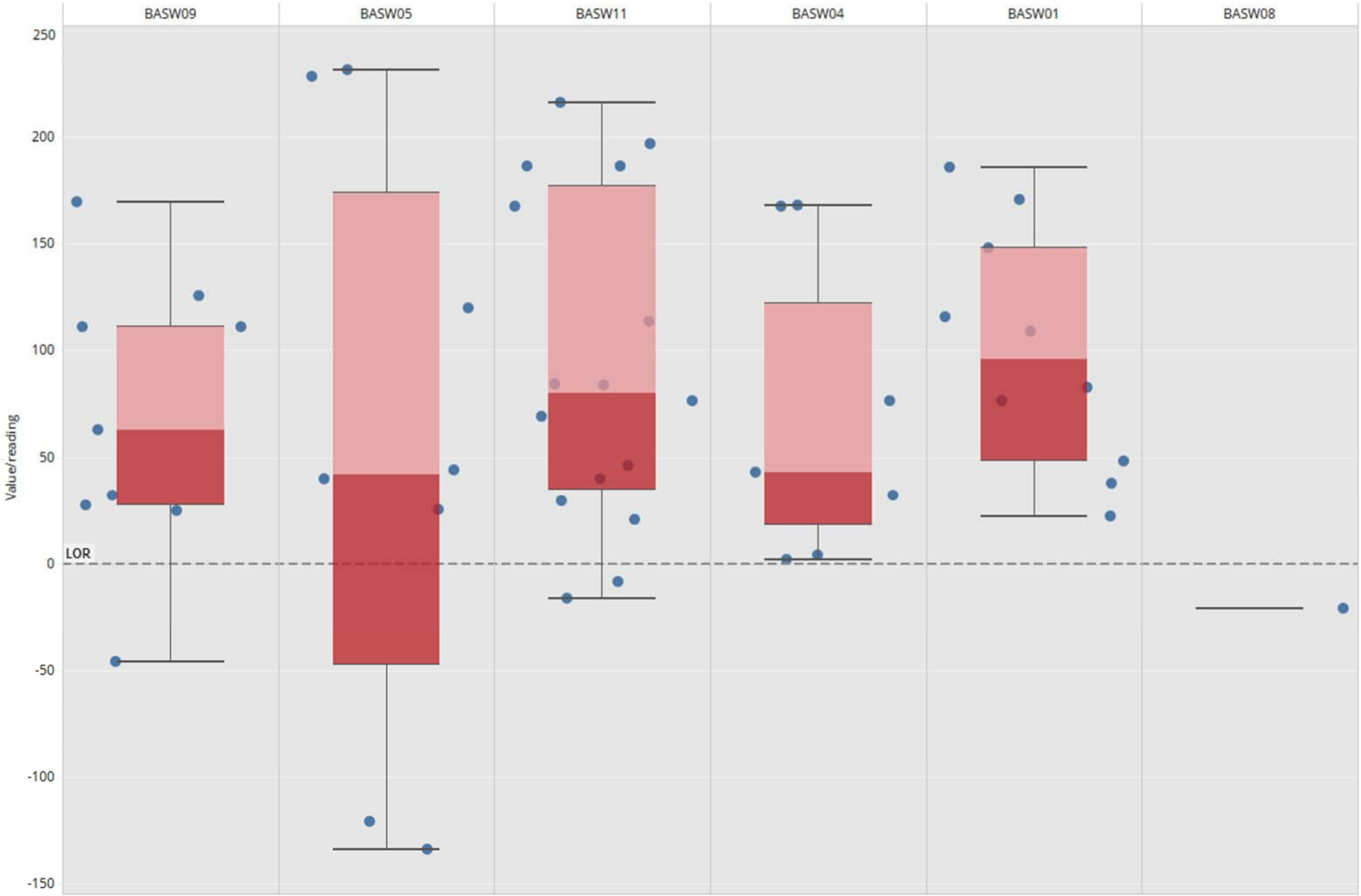
Dissolved Oxygen (field) (% sat)



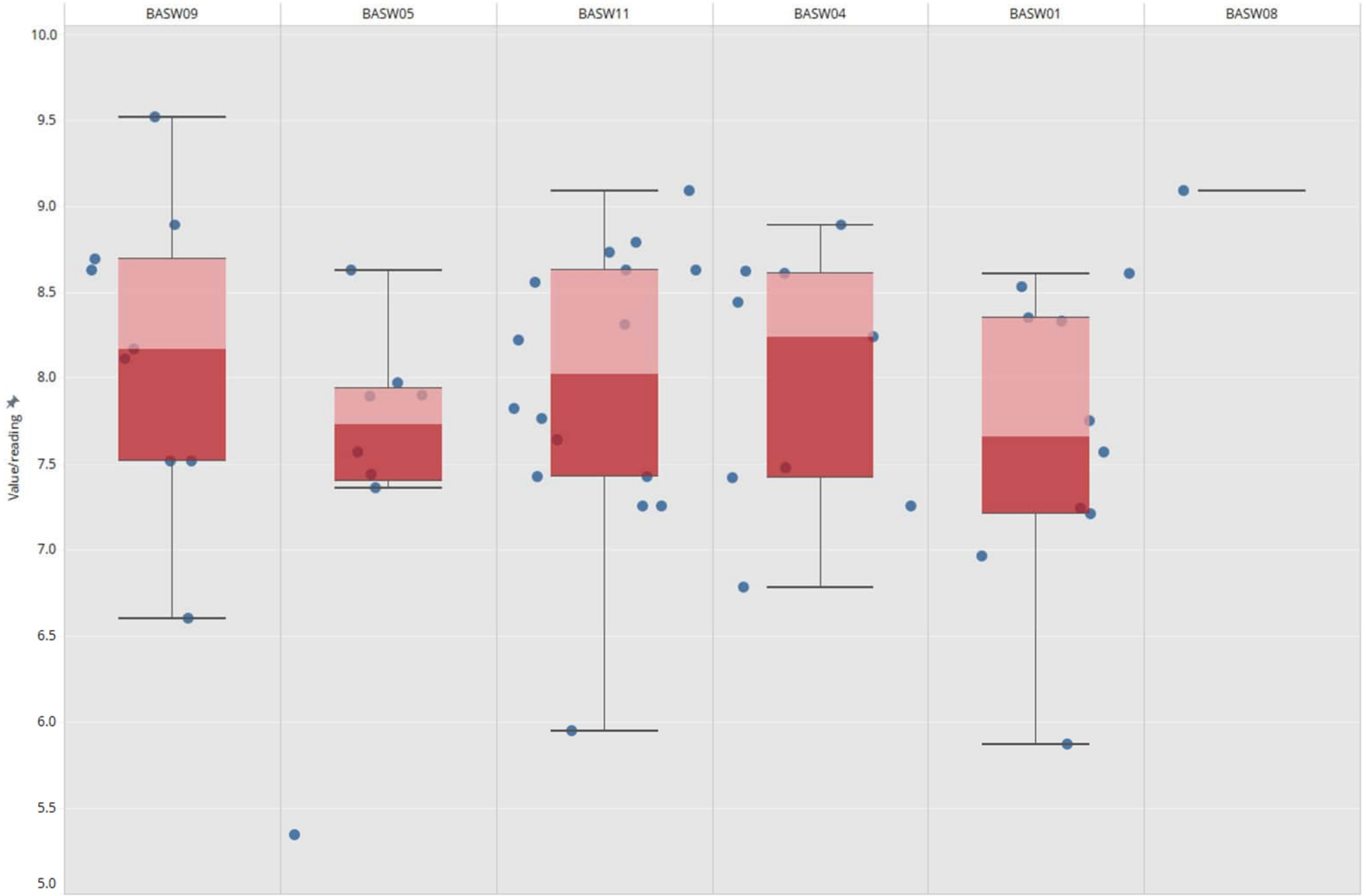
Electrical Conductivity (field) (µS/cm)



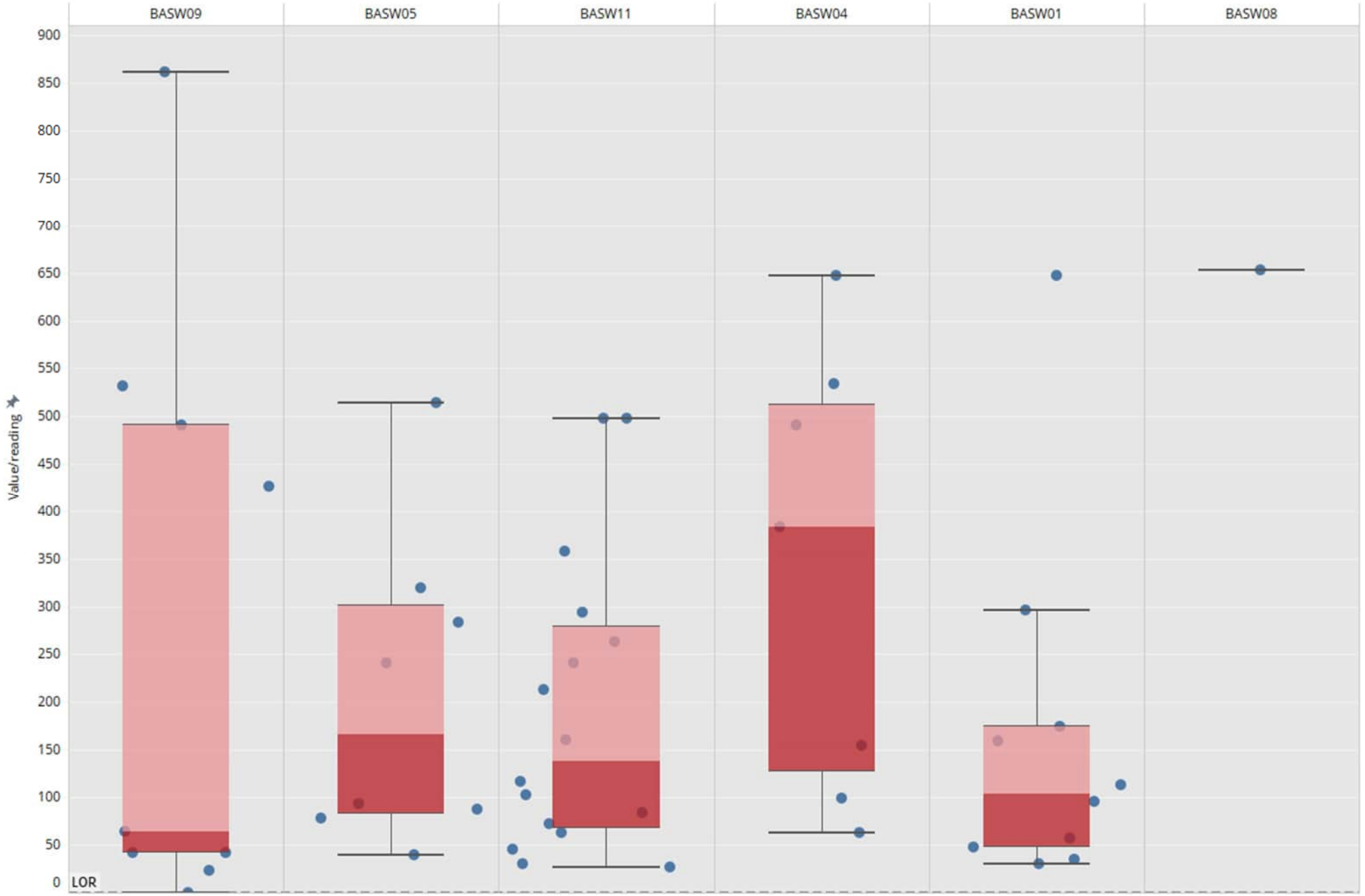
ORP (field) (mV)


BASW09
BASW05
BASW11
BASW04
BASW01
BASW08
250
200
150
100
50
0
-50
-100
-150
Value/reading
LOR

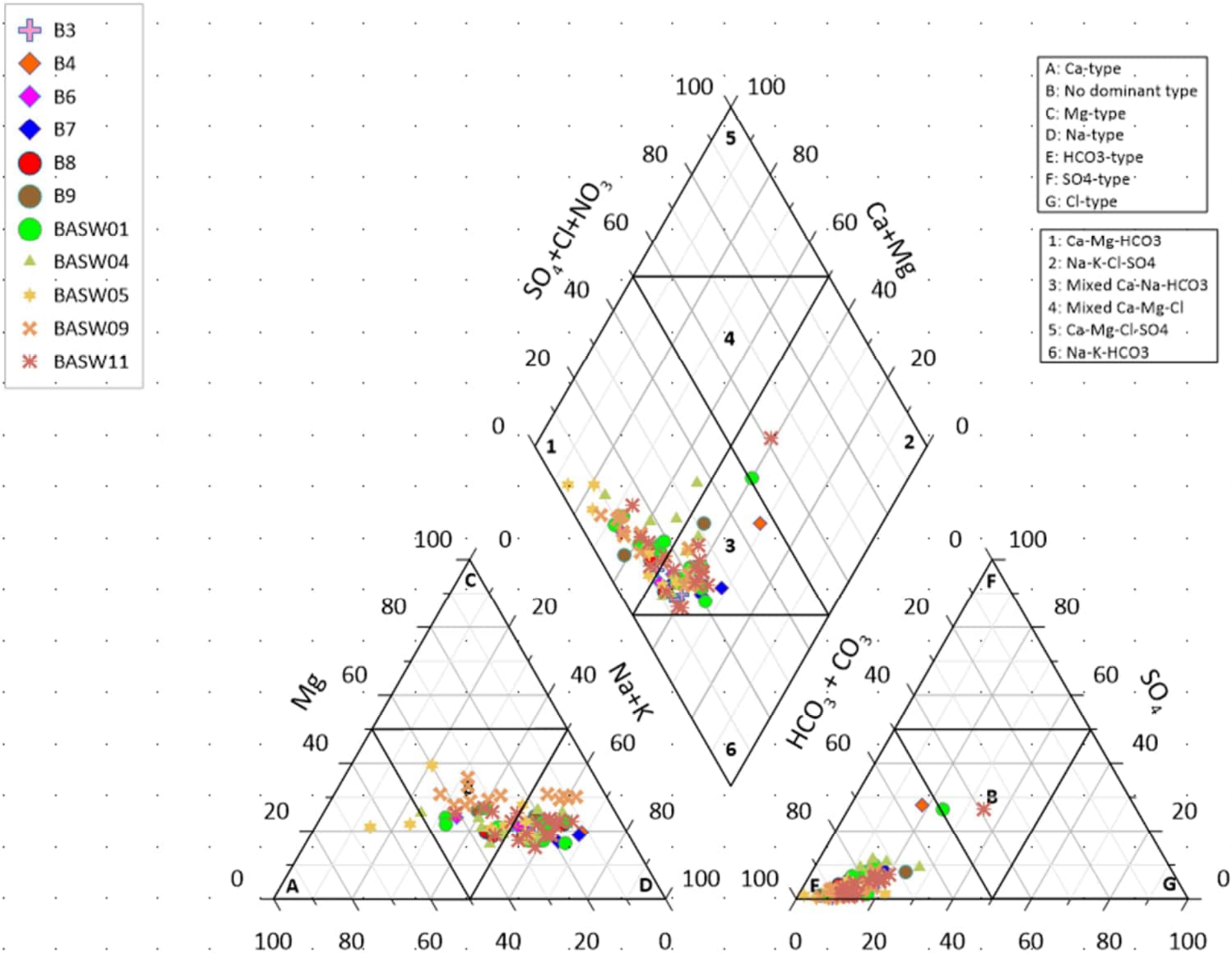
pH (field)

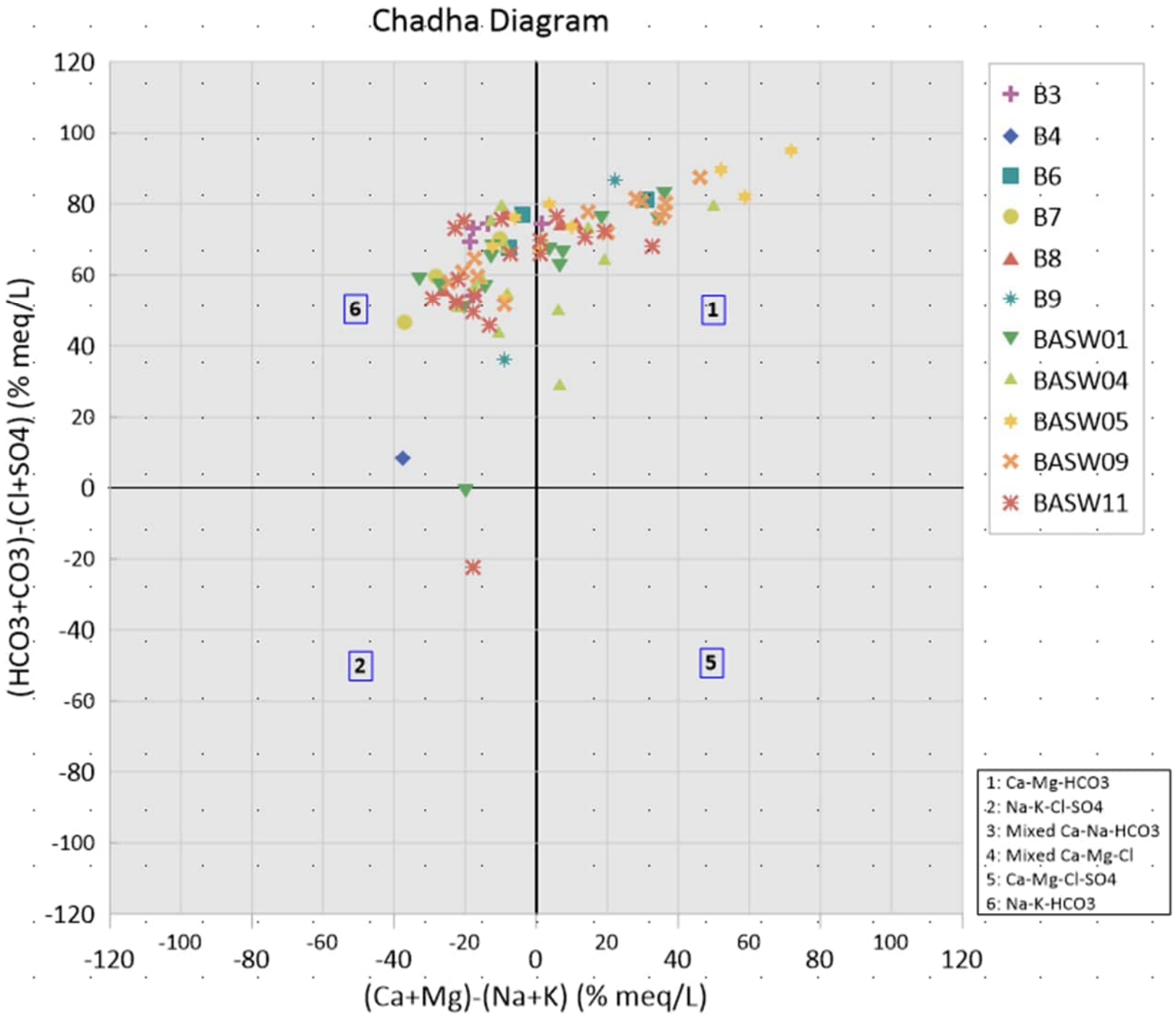

BASW09
BASW05
BASW11
BASW04
BASW01
BASW08
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
Value/reading

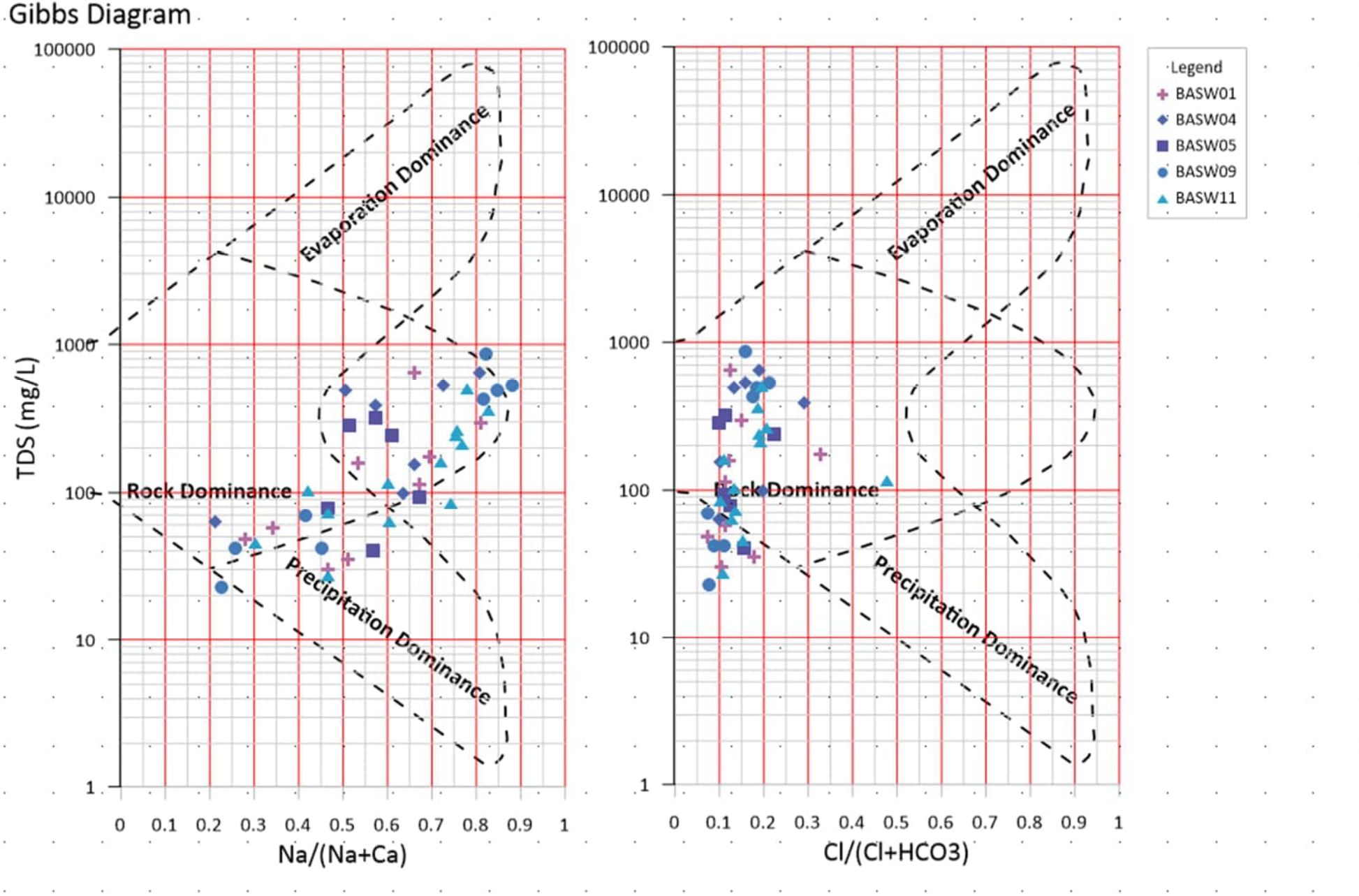
TDS (field) (ppm)

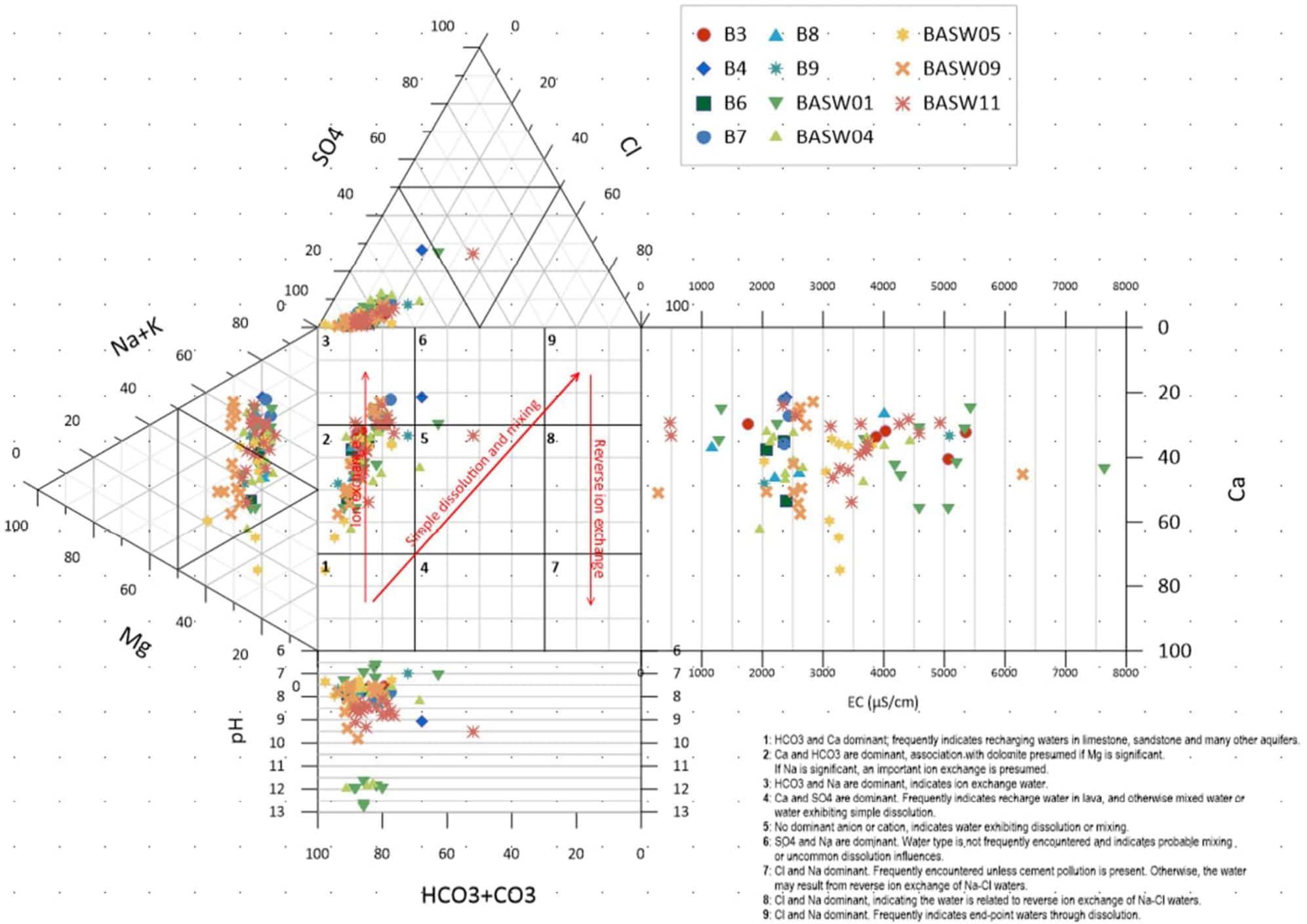


E.4 Hydrogeochemistry plots


B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW09
BASW11
A: Ca-type
B: No dominant type
C: Mg-type
D: Na-type
E: HCO3-type
F: SO4-type
G: Cl-type
1: Ca-Mg-HCO3
2: Na-K-Cl-SO4
3: Mixed Ca-Na-HCO3
4: Mixed Ca-Mg-Cl
5: Ca-Mg-Cl-SO4
6: Na-K-HCO3
SO4+Cl+NO3
Ca+Mg
Mg
Na+K
HCO3 + CO3
SO4


Chadha Diagram
(HCO3+CO3)-(Cl+SO4) (% meq/L)
(Ca+Mg)-(Na+K) (% meq/L)
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-120
-100
-80
-60
-40
-20
0
20
40
60
80
100
120
6
1
2
5
B3
B4
B6
B7
B8
B9
BASW01
BASW04
BASW05
BASW09
BASW11
1: Ca-Mg-HCO3
2: Na-K-Cl-SO4
3: Mixed Ca-Na-HCO3
4: Mixed Ca-Mg-Cl
5: Ca-Mg-Cl-SO4
6: Na-K-HCO3


Gibbs Diagram
TDS (mg/L)
100000
10000
1000
100
10
1
Evaporation Dominance
Rock Dominance
Precipitation Dominance
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Na/(Na+Ca)
Cl/(Cl+HCO3)
Legend
BASW01
BASW04
BASW05
BASW09
BASW11



1: HCO3 and Ca dominant; frequently indicates recharging waters in limestone, sandstone and many other aquifers.
2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant.
If Na is significant, an important ion exchange is presumed.
3: HCO3 and Na are dominant, indicates ion exchange water.
4: Ca and SO4 are dominant. Frequently indicates recharge water in lava, and otherwise mixed water or water exhibiting simple dissolution.
5: No dominant anion or cation, indicates water exhibiting dissolution or mixing.
6: SO4 and Na are dominant. Water type is not frequently encountered and indicates probable mixing, or uncommon dissolution influences.
7: Cl and Na dominant. Frequently encountered unless cement pollution is present. Otherwise, the water may result from reverse ion exchange of Na-Cl waters.
8: Cl and Na dominant, indicating the water is related to reverse ion exchange of Na-Cl waters.
9: Cl and Na dominant. Frequently indicates end-point waters through dissolution.

Appendix F Mine site surface water monitoring data

F.1 Mine site surface water data tables

Table F.1 Mine site surface water monitoring events

Year/ Month	BCP North Pit	BCP South Pit	BCP Spring	BCP Spring (N)	BCP Spring (S)	Pooled water S of sediment dam	Sediment Dam	Seepage	Sump
2019									
9								✓	
2020									
2	✓						✓		
10	✓						✓		
2021									
1	✓						✓		
4	✓	✓					✓		
7	✓	✓							
8			✓				✓		
9							✓		
10			✓				✓		✓
11	✓	✓	✓				✓		✓
2022									
2			✓				✓		✓
3	✓		✓				✓		✓
6	✓	✓	✓				✓		✓
7			✓						✓
8			✓	✓	✓		✓		✓
9	✓	✓	✓	✓			✓		✓
10				✓	✓		✓		✓
2023									
1	✓	✓		✓	✓		✓		✓
4	✓	✓	✓	✓	✓	✓	✓		✓
5				✓	✓	✓	✓		✓
6	✓	✓		✓	✓	✓	✓		✓
7				✓	✓	✓	✓		✓
8				✓	✓	✓	✓		✓
9				✓	✓				✓

Year/ Month	BCP North Pit	BCP South Pit	BCP Spring	BCP Spring (N)	BCP Spring (S)	Pooled water S of sediment dam	Sediment Dam	Seepage	Sump
10				✓	✓		✓		✓
11				✓	✓		✓		✓
12	✓			✓	✓		✓		✓

Table F.2 Descriptive statistics: mine site surface water monitoring results (all sites)

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	No. distinct values (>LOR)	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	10%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	80%ile	90%ile (> LOR)	95%ile (>LOR)	99%ile (>LOR)
Alkalinity																				
Bicarbonate Alkalinity as CaCO3 (mg/L)	101	101			87	38	532.149	471.345	1700	1662	56	70	87	93	473	884	913	1220	1450	1570
Carbonate Alkalinity as CaCO3 (mg/L)	101	50	51	50.5%	49	10	220.520	254.595	1400	1390	14.45	24.9	35.8	46	107	301	390.6	515.5	595.95	1096.2
Hydroxide Alkalinity as CaCO3 (mg/L)	101		101	100.0%	1															
Total Alkalinity as CaCO3 (mg/L)	101	101			82	50	640.842	637.433	2950	2900	62	73	87	93	526	950	1140	1500	1960	2200
Carbon																				
Total Non-Purgeable Organic Carbon(mg/L)	1	1			1	300	300.000	0.000	300	0	300	300	300	300	300	300	300	300	300	300
Field Measurements																				
Dissolved Oxygen (field) (% sat)	44	44			39	0	96.645	86.833	315.9	315.9	0	0.33	1.56	3.85	94.85	164.325	173.58	187.86	209.09	314.051
Electrical Conductivity (field) (µS/cm)	48	48			47	65	2423.500	1869.688	9392	9327	621.35	870.3	986.2	1014	1761	3246.75	3913.2	4951.9	5298.4	8120.18
ORP (field) (mV)	48	48			47	-58.8	37.127	85.281	252.9	311.7	-57.92	-51.54	-32.98	-27.925	3.7	86.825	110.44	180.8	200.61	245.521
pH (field)	48	48			40	7.76	8.710	0.503	10.06	2.3	7.9705	8.14	8.308	8.4125	8.66	8.9025	9.026	9.432	9.6025	9.9566
Salinity (field) (PSU)	48	48			43	0.03	1.231	1.002	5.24	5.21	0.287	0.414	0.484	0.5	0.88	1.68	1.988	2.488	2.682	4.488
TDS (field) (ppm)	48	48			47	32	1212.354	934.463	4695	4663	310.7	437.6	493.4	506	880.5	1623.75	1956.8	2475.2	2649.55	4059.56
Temperature (field) (°C)	48	48			47	19.72	27.471	3.466	33.96	14.24	21.894	22.557	24.226	25.7325	27.89	29.315	30.094	32.11	33.1325	33.8848
Turbidity (field) (FNU)	2	2			2	2.1	2.550	0.450	3	0.9	2.145	2.19	2.28	2.325	2.55	2.775	2.82	2.91	2.955	2.991
Hardness																				
Total Hardness (mg CaCO3/L)	61	61			56	37	742.246	682.970	3550	3513	138	215	324	348	522	834	916	1590	2100	3190
Ion Balance																				
Ion Balance (%)	4	4			4	-0.3	5.150	4.019	11	11.3	0.405	1.11	2.52	3.225	4.95	6.875	7.7	9.35	10.175	10.835
Ionic Balance (%)	96	96			90	0.63	6.282	6.359	32.3	31.67	0.8475	1.055	1.62	1.7525	3.7	9.2375	9.66	17.2	18.2	25.935
Total Anions (meq/L)	101	101			95	2.8	33.150	22.023	101	98.2	6.41	9.21	12.9	13.7	31	44.9	52.3	65	78.1	86.2
Total Cations (meq/L)	101	101			95	2.88	37.207	25.070	114	111.12	7.86	9.05	14.2	15.8	34.9	52.4	56.6	70.6	88.9	107
Major Ions																				
Bromide (mg/L)	7	7			7	0.086	0.761	0.828	2.36	2.274	0.0932	0.1004	0.112	0.115	0.21	1.22	1.424	1.88	2.12	2.312
Calcium (mg/L)	158	158			103	10	106.956	141.064	754	744	15	17.7	23.4	30.5	58.5	97.5	126.8	242.6	464.8	665.91
Chloride (mg/L)	101	101			84	14	198.168	184.513	912	898	17	18	28	39	178	263	326	474	554	721
Fluoride (mg/L)	101	101			22	0.2	1.173	0.479	2.6	2.4	0.4	0.6	0.8	0.8	1.1	1.6	1.6	1.8	1.9	2.5
Iodide (mg/L)	7	2	5	71.4%	3	0.62	0.650	0.030	0.68	0.06	0.623	0.626	0.632	0.635	0.65	0.665	0.668	0.674	0.677	0.6794
Magnesium (mg/L)	158	158			105	3	99.652	77.044	406	403	16	22	34	43	88.5	129	138.6	188.7	249	368.64
Potassium (mg/L)	158	158			38	2	16.753	11.639	84	82	4	5	7	8	14	22.75	25	34	36.3	42
Sodium (mg/L)	158	158			142	41	547.861	440.571	2260	2219	68.7	78.4	109.2	136.75	518.5	739.25	771.2	1140	1481.5	1786
Sulfate (as SO4)	101	101			99	32	709.079	518.658	3220	3188	142	227	390	431	604	820	920	1150	1710	2660
Metals (dissolved)																				
Aluminium - dissolved (mg/L)	4	3	1	25.0%	3	0.011	0.012	0.001	0.013	0.002	0.0112	0.0114	0.0118	0.012	0.013	0.013	0.013	0.013	0.013	0.013
Arsenic - dissolved (mg/L)	102	100	2	2.0%	20	0	0.005	0.005	0.035	0.035	0.001	0.001	0.002	0.002	0.0035	0.00725	0.01	0.012	0.01305	0.02114

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	No. distinct values (>LOR)	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	10%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	80%ile	90%ile (> LOR)	95%ile (>LOR)	99%ile (>LOR)
Barium - dissolved (mg/L)	101	101			65	0.021	0.088	0.031	0.176	0.155	0.04	0.046	0.06	0.067	0.089	0.109	0.11	0.127	0.139	0.15
Beryllium - dissolved (mg/L)	6		6	100.0%	1															
Bismuth - dissolved (mg/L)	101		101	100.0%	1															
Boron - dissolved (mg/L)	6	5	1	16.7%	5	0.06	0.082	0.026	0.13	0.07	0.06	0.06	0.06	0.06	0.07	0.09	0.098	0.114	0.122	0.1284
Chromium - dissolved (mg/L)	102	2	100	98.0%	2	0.002	0.002	0.000	0.002	0	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Cobalt - dissolved (mg/L)	102	63	39	38.2%	10	0.001	0.003	0.003	0.014	0.013	0.001	0.001	0.001	0.001	0.002	0.002	0.0026	0.0058	0.007	0.01276
Copper - dissolved (mg/L)	102	102			39	0.001	0.022	0.027	0.196	0.195	0.005	0.006	0.009	0.01	0.013	0.02375	0.027	0.0409	0.0539	0.1624
Iron - dissolved (mg/L)	6	1	5	83.3%	2	0.09	0.090	0.000	0.09	0	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Molybdenum - dissolved (mg/L)	102	102			38	0.001	0.017	0.019	0.146	0.145	0.003	0.004	0.005	0.006	0.008	0.02175	0.0248	0.0424	0.05	0.06097
Nickel - dissolved (mg/L)	102	58	44	43.1%	15	0.001	0.005	0.005	0.027	0.026	0.001	0.001	0.0014	0.002	0.002	0.005	0.006	0.0086	0.0163	0.02529
Selenium - dissolved (mg/L)	102	33	69	67.6%	17	0.002	0.062	0.071	0.28	0.278	0.0076	0.01	0.01	0.01	0.03	0.07	0.104	0.16	0.224	0.264
Uranium - dissolved (mg/L)	101	101			36	0.002	0.016	0.012	0.076	0.074	0.003	0.004	0.006	0.007	0.014	0.024	0.025	0.031	0.036	0.057
Vanadium - dissolved (mg/L)	6	1	5	83.3%	2	0.03	0.030	0.000	0.03	0	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Zinc - dissolved (mg/L)	1		1	100.0%	1															
Metals (total)																				
Aluminium - total (mg/L)	4	4			4	0.11	0.555	0.314	0.99	0.88	0.1685	0.227	0.344	0.4025	0.56	0.7125	0.768	0.879	0.9345	0.9789
Arsenic - total (mg/L)	102	102			21	0.001	0.006	0.008	0.066	0.065	0.001	0.0011	0.002	0.003	0.004	0.007	0.009	0.0129	0.01495	0.03387
Barium - total (mg/L)	101	101			69	0.024	0.097	0.035	0.188	0.164	0.041	0.049	0.064	0.076	0.098	0.117	0.123	0.142	0.163	0.179
Beryllium - total (mg/L)	6		6	100.0%	1															
Bismuth - total (mg/L)	101		101	100.0%	1															
Boron - total (mg/L)	6	5	1	16.7%	4	0.07	0.090	0.028	0.14	0.07	0.07	0.07	0.07	0.07	0.07	0.1	0.108	0.124	0.132	0.1384
Chromium - total (mg/L)	102	11	91	89.2%	6	0.0009	0.002	0.001	0.005	0.0041	0.00095	0.001	0.001	0.001	0.001	0.002	0.002	0.004	0.0045	0.0049
Cobalt - total (mg/L)	102	76	26	25.5%	11	0.001	0.003	0.003	0.016	0.015	0.001	0.001	0.002	0.002	0.002	0.003	0.003	0.006	0.00725	0.01525
Copper - total (mg/L)	102	102			48	0.006	0.034	0.048	0.392	0.386	0.009	0.0101	0.013	0.014	0.0215	0.034	0.0376	0.051	0.0967	0.22845
Iron - total (mg/L)	6	2	4	66.7%	3	0.3	0.680	0.380	1.06	0.76	0.338	0.376	0.452	0.49	0.68	0.87	0.908	0.984	1.022	1.0524
Molybdenum - total (mg/L)	102	102			41	0	0.019	0.022	0.156	0.156	0.00305	0.004	0.006	0.00625	0.01	0.02475	0.027	0.0447	0.0599	0.06894
Nickel - total (mg/L)	102	70	32	31.4%	15	0.001	0.004	0.004	0.025	0.024	0.001	0.001	0.001	0.002	0.002	0.005	0.006	0.0081	0.012	0.01948
Selenium - total (mg/L)	102	30	72	70.6%	16	0.002	0.069	0.073	0.28	0.278	0.0067	0.01	0.018	0.02	0.035	0.07	0.116	0.166	0.231	0.2684
Uranium - total (mg/L)	101	101			37	0.002	0.018	0.015	0.091	0.089	0.004	0.005	0.006	0.007	0.014	0.026	0.029	0.034	0.041	0.083
Vanadium - total (mg/L)	6	2	4	66.7%	3	0.01	0.025	0.015	0.04	0.03	0.0115	0.013	0.016	0.0175	0.025	0.0325	0.034	0.037	0.0385	0.0397
Nutrients																				
Nitrate as N (mg/L)	9	7	2	22.2%	8	0.09	14.979	14.185	34.6	34.51	0.105	0.12	0.176	0.23	17.3	26.2	30.64	34	34.3	34.54
Nitrite + Nitrate as N (mg/L)	9	7	2	22.2%	8	0.09	15.266	14.442	35.3	35.21	0.108	0.126	0.184	0.235	17.6	26.7	31.14	34.58	34.94	35.228
Nitrite as N (mg/L)	9	5	4	44.4%	6	0.01	0.392	0.225	0.65	0.64	0.066	0.122	0.234	0.29	0.46	0.55	0.57	0.61	0.63	0.646
Physico-Chemical Parameters																				
Electrical Conductivity (µS/cm)	100	100			91	279	3149.890	2003.047	9460	9181	759.9	948.9	1258	1435	3080	4270	4876	5975	7170	8856.1
pH (lab)	100	100			72	7.51	8.386	0.422	9.3	1.79	7.849	7.92	8.04	8.06	8.295	8.7225	8.782	8.971	9.1425	9.2802
Turbidity (NTU)	97	97			62	0.2	8.671	18.077	155	154.8	0.5	0.66	0.9	1	2	10.3	14.32	19.78	33.7	61.208

Table F.3 Descriptive statistics: mine site surface water monitoring results – by location

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
BCP North Pit														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	11	11			98	139.455	77.700	382	284	98	103	120	130	256.5
Carbonate Alkalinity as CaCO3 (mg/L)	11		11	100.0%										
Total Alkalinity as CaCO3 (mg/L)	11	11			98	139.455	77.700	382	284	98	103	120	130	256.5
Field Measurements														
Dissolved Oxygen (field) (% sat)	6	6			0	66.350	73.534	196	196	0	0.475	43.95	107.15	175.55
Electrical Conductivity (field) (µS/cm)	7	7			738	1038.571	194.327	1386	648	794.7	930.5	1014	1135.5	1332.6
ORP (field) (mV)	7	7			-34.1	59.743	86.179	237.2	271.3	-33.17	-3.95	43.2	89.9	193.97
pH (field)	7	7			7.89	8.413	0.303	8.86	0.97	7.965	8.235	8.44	8.615	8.803
Salinity (field) (PSU)	7	7			0.3	0.504	0.111	0.68	0.38	0.345	0.46	0.5	0.565	0.656
TDS (field) (ppm)	7	7			369	520.429	96.590	693	324	398.4	469	507	568	666.3
Temperature (field) (°C)	7	7			19.82	27.263	4.356	32.84	13.02	20.978	24.01	29.31	30.425	32.303
Hardness														
Total Hardness (mg CaCO3/L)	4	4			157	216.250	37.732	249	92	164.95	196.75	229.5	249	249
Major Ions														
Bromide (mg/L)	1	1			0.12	0.120	0.000	0.12	0	0.12	0.12	0.12	0.12	0.12
Calcium (mg/L)	15	15			38	65.800	23.302	128	90	38.7	51.5	60	75.5	107
Chloride (mg/L)	11	11			16	32.909	38.611	153	137	16	17	20	21.5	97.5
Fluoride (mg/L)	11	11			1	1.318	0.252	1.9	0.9	1	1.2	1.2	1.4	1.75
Iodide (mg/L)	1		1	100.0%										

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Magnesium (mg/L)	15	15			15	27.133	7.873	43	28	15.7	22	26	32	40.9
Potassium (mg/L)	15	15			9	18.333	6.204	33	24	9.7	15	17	22.5	28.1
Sodium (mg/L)	15	15			54	84.133	23.194	156	102	56.8	74.5	79	89	124.5
Sulfate (as SO4)	11	11			142	313.455	124.126	583	441	147.5	235.5	304	379	515.5
Metals (dissolved)														
Arsenic - dissolved (mg/L)	11	9	2	18.2%	0.001	0.002	0.001	0.003	0.002	0.001	0.002	0.002	0.002	0.0026
Barium - dissolved (mg/L)	11	11			0.041	0.058	0.017	0.093	0.052	0.0425	0.0465	0.05	0.0675	0.0865
Beryllium - dissolved (mg/L)	1		1	100.0%										
Bismuth - dissolved (mg/L)	11		11	100.0%										
Boron - dissolved (mg/L)	1		1	100.0%										
Chromium - dissolved (mg/L)	11		11	100.0%										
Cobalt - dissolved (mg/L)	11	5	6	54.5%	0.001	0.002	0.001	0.004	0.003	0.001	0.001	0.002	0.002	0.0036
Copper - dissolved (mg/L)	11	11			0.005	0.026	0.013	0.054	0.049	0.01	0.0175	0.024	0.0335	0.0475
Iron - dissolved (mg/L)	1		1	100.0%										
Molybdenum - dissolved (mg/L)	11	11			0.006	0.013	0.005	0.02	0.014	0.006	0.009	0.013	0.017	0.019
Nickel - dissolved (mg/L)	11	11			0.001	0.007	0.005	0.018	0.017	0.0015	0.0035	0.005	0.009	0.0145
Selenium - dissolved (mg/L)	11	4	7	63.6%	0.01	0.020	0.007	0.03	0.02	0.0115	0.0175	0.02	0.0225	0.0285
Uranium - dissolved (mg/L)	11	11			0.002	0.005	0.003	0.014	0.012	0.0025	0.004	0.004	0.0045	0.0105
Vanadium - dissolved (mg/L)	1		1	100.0%										
Metals (total)														
Arsenic - total (mg/L)	11	11			0.001	0.002	0.001	0.003	0.002	0.001	0.001	0.002	0.003	0.003
Barium - total (mg/L)	11	11			0.035	0.062	0.018	0.088	0.053	0.0405	0.049	0.056	0.081	0.0875
Beryllium - total (mg/L)	1		1	100.0%										

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Bismuth - total (mg/L)	11		11	100.0%										
Boron - total (mg/L)	1		1	100.0%										
Chromium - total (mg/L)	11		11	100.0%										
Cobalt - total (mg/L)	11	6	5	45.5%	0.001	0.003	0.001	0.004	0.003	0.00125	0.00225	0.003	0.003	0.00375
Copper - total (mg/L)	11	11			0.008	0.033	0.014	0.065	0.057	0.015	0.024	0.031	0.0395	0.056
Iron - total (mg/L)	1		1	100.0%										
Molybdenum - total (mg/L)	11	11			0.007	0.015	0.005	0.022	0.015	0.008	0.012	0.013	0.019	0.0215
Nickel - total (mg/L)	11	11			0.002	0.007	0.005	0.017	0.015	0.002	0.0035	0.005	0.009	0.0145
Selenium - total (mg/L)	11	3	8	72.7%	0.02	0.023	0.005	0.03	0.01	0.02	0.02	0.02	0.025	0.029
Uranium - total (mg/L)	11	11			0.003	0.006	0.003	0.016	0.013	0.0035	0.004	0.005	0.005	0.011
Vanadium - total (mg/L)	1		1	100.0%										
Nutrients														
Nitrate as N (mg/L)	1	1			0.09	0.090	0.000	0.09	0	0.09	0.09	0.09	0.09	0.09
Nitrite + Nitrate as N (mg/L)	1	1			0.09	0.090	0.000	0.09	0	0.09	0.09	0.09	0.09	0.09
Nitrite as N (mg/L)	1		1	100.0%										
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	11	11			556	945.455	216.313	1360	804	658.5	821	885	1055	1300
pH (lab)	11	11			7.85	8.097	0.099	8.26	0.41	7.955	8.06	8.09	8.15	8.225
BCP South Pit														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	5	5			78	86.000	6.603	93	15	78	78	90	91	92.6
Carbonate Alkalinity as CaCO3 (mg/L)	5		5	100.0%										
Total Alkalinity as CaCO3 (mg/L)	5	5			78	86.000	6.603	93	15	78	78	90	91	92.6

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Field Measurements														
Dissolved Oxygen (field) (% sat)	5	5			0	62.020	70.341	162.8	162.8	0.36	1.8	14.1	131.4	156.52
Electrical Conductivity (field) (µS/cm)	5	5			977	1245.800	230.741	1591	614	981.6	1000	1327	1334	1539.6
ORP (field) (mV)	5	5			-40.3	60.560	82.960	207.4	247.7	-28.24	20	35.3	80.4	182
pH (field)	5	5			8.14	8.540	0.321	9.12	0.98	8.2	8.44	8.45	8.55	9.006
Salinity (field) (PSU)	5	5			0.47	0.614	0.122	0.8	0.33	0.474	0.49	0.65	0.66	0.772
TDS (field) (ppm)	5	5			489	623.200	115.439	796	307	491.2	500	664	667	770.2
Temperature (field) (°C)	5	5			22.41	27.788	4.857	33.96	11.55	22.726	23.99	25.29	33.29	33.826
Major Ions														
Calcium (mg/L)	5	5			103	122.800	17.792	153	50	104.8	112	114	132	148.8
Chloride (mg/L)	5	5			14	17.200	2.993	22	8	14	14	18	18	21.2
Fluoride (mg/L)	5	5			0.8	0.940	0.120	1.1	0.3	0.8	0.8	1	1	1.08
Magnesium (mg/L)	5	5			53	55.800	2.315	60	7	53.4	55	55	56	59.2
Potassium (mg/L)	5	5			15	19.200	3.600	25	10	15.2	16	19	21	24.2
Sodium (mg/L)	5	5			72	89.000	12.426	101	29	72.8	76	96	100	100.8
Sulfate (as SO4)	5	5			481	566.800	78.288	713	232	490.2	527	549	564	683.2
Metals (dissolved)														
Arsenic - dissolved (mg/L)	5	5			0.006	0.009	0.002	0.012	0.006	0.0062	0.007	0.008	0.011	0.0118
Barium - dissolved (mg/L)	5	5			0.037	0.044	0.006	0.052	0.015	0.0376	0.04	0.041	0.052	0.052
Bismuth - dissolved (mg/L)	5		5	100.0%										
Chromium - dissolved (mg/L)	5		5	100.0%										
Cobalt - dissolved (mg/L)	5	3	2	40.0%	0.001	0.008	0.005	0.012	0.011	0.0021	0.0065	0.012	0.012	0.012
Copper - dissolved (mg/L)	5	5			0.011	0.023	0.023	0.069	0.058	0.011	0.011	0.012	0.012	0.0576

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Molybdenum - dissolved (mg/L)	5	5			0.024	0.031	0.007	0.043	0.019	0.0242	0.025	0.029	0.034	0.0412
Nickel - dissolved (mg/L)	5	5			0.007	0.012	0.007	0.024	0.017	0.007	0.007	0.008	0.016	0.0224
Selenium - dissolved (mg/L)	5	2	3	60.0%	0.01	0.010	0.000	0.01	0	0.01	0.01	0.01	0.01	0.01
Uranium - dissolved (mg/L)	5	5			0.006	0.007	0.001	0.008	0.002	0.0062	0.007	0.007	0.007	0.0078
Metals (total)														
Arsenic - total (mg/L)	5	5			0.007	0.009	0.002	0.012	0.005	0.007	0.007	0.008	0.011	0.0118
Barium - total (mg/L)	5	5			0.037	0.045	0.007	0.053	0.016	0.0372	0.038	0.046	0.052	0.0528
Bismuth - total (mg/L)	5		5	100.0%										
Chromium - total (mg/L)	5		5	100.0%										
Cobalt - total (mg/L)	5	4	1	20.0%	0.001	0.008	0.006	0.015	0.014	0.00115	0.00175	0.0075	0.0135	0.0147
Copper - total (mg/L)	5	5			0.012	0.028	0.023	0.072	0.06	0.0124	0.014	0.015	0.026	0.0628
Molybdenum - total (mg/L)	5	5			0.026	0.035	0.009	0.051	0.025	0.0262	0.027	0.036	0.037	0.0482
Nickel - total (mg/L)	5	5			0.007	0.012	0.007	0.025	0.018	0.007	0.007	0.008	0.014	0.0228
Selenium - total (mg/L)	5	2	3	60.0%	0.01	0.010	0.000	0.01	0	0.01	0.01	0.01	0.01	0.01
Uranium - total (mg/L)	5	5			0.007	0.008	0.000	0.008	0.001	0.007	0.007	0.008	0.008	0.008
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	5	5			1250	1328.000	99.076	1520	270	1252	1260	1290	1320	1480
pH (lab)	5	5			7.92	8.082	0.092	8.17	0.25	7.948	8.06	8.09	8.17	8.17
BCP Spring														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	12	12			321	1166.917	406.726	1700	1379	448.05	1012.5	1255	1482.5	1628.5
Carbonate Alkalinity as CaCO3 (mg/L)	12	11	1	8.3%	66	511.636	348.685	1400	1334	108	283	515	590.5	1090
Total Alkalinity as CaCO3 (mg/L)	12	12			470	1630.667	699.329	2950	2480	551.4	1260	1735	2085	2537.5

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Field Measurements														
Dissolved Oxygen (field) (% sat)	4	4			1.2	79.950	133.756	311.6	310.4	1.2	1.2	3.5	82.25	265.73
Electrical Conductivity (field) (µS/cm)	5	5			2278	4832.200	2568.608	9392	7114	2315.6	2466	4945	5080	8529.6
ORP (field) (mV)	5	5			-31.3	17.640	62.025	131.5	162.8	-30.36	-26.6	-21.9	36.5	112.5
pH (field)	5	5			8.78	9.378	0.487	10.06	1.28	8.796	8.86	9.57	9.62	9.972
Salinity (field) (PSU)	5	5			1.15	2.552	1.483	5.24	4.09	1.162	1.21	2.53	2.63	4.718
TDS (field) (ppm)	5	5			1139	2415.800	1283.956	4695	3556	1157.8	1233	2471	2541	4264.2
Temperature (field) (°C)	5	5			27.42	29.022	1.654	32.05	4.63	27.464	27.64	28.88	29.12	31.464
Hardness														
Total Hardness (mg CaCO3/L)	4	4			390	472.500	64.177	570	180	400.5	442.5	465	495	555
Major Ions														
Bromide (mg/L)	2	2			0.88	1.620	0.740	2.36	1.48	0.954	1.25	1.62	1.99	2.286
Calcium (mg/L)	12	12			12	21.250	7.907	39	27	13.1	15.75	18	26	35.15
Chloride (mg/L)	12	12			170	478.417	209.115	912	742	181	314.5	495.5	619	771.2
Fluoride (mg/L)	12	12			0.6	1.458	0.486	2.5	1.9	0.71	1.225	1.5	1.725	2.115
Iodide (mg/L)	2	1	1	50.0%	0.62	0.620	0.000	0.62	0	0.62	0.62	0.62	0.62	0.62
Magnesium (mg/L)	12	12			24	97.333	32.597	140	116	39.4	85.75	100	124.5	134.5
Potassium (mg/L)	12	12			7	20.167	11.253	42	35	7	13.25	16.5	24	40.35
Sodium (mg/L)	12	12			375	1247.083	563.806	2260	1885	421.75	830	1255	1647.5	2062
Sulfate (as SO4)	12	12			227	666.000	256.487	1040	813	280.9	484.5	714.5	868.5	987.2
Metals (dissolved)														
Aluminium - dissolved (mg/L)	4	3	1	25.0%	0.011	0.012	0.001	0.013	0.002	0.0112	0.012	0.013	0.013	0.013
Arsenic - dissolved (mg/L)	13	13			0	0.012	0.008	0.035	0.035	0.0018	0.01	0.012	0.014	0.0266

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Barium - dissolved (mg/L)	12	12			0.059	0.089	0.017	0.118	0.059	0.06175	0.079	0.0885	0.10175	0.1136
Beryllium - dissolved (mg/L)	1		1	100.0%										
Bismuth - dissolved (mg/L)	12		12	100.0%										
Boron - dissolved (mg/L)	1	1			0.09	0.090	0.000	0.09	0	0.09	0.09	0.09	0.09	0.09
Chromium - dissolved (mg/L)	13	1	12	92.3%	0.002	0.002	0.000	0.002	0	0.002	0.002	0.002	0.002	0.002
Cobalt - dissolved (mg/L)	13	9	4	30.8%	0.001	0.003	0.004	0.014	0.013	0.001	0.001	0.002	0.002	0.01
Copper - dissolved (mg/L)	13	13			0.011	0.059	0.057	0.196	0.185	0.0116	0.022	0.041	0.052	0.1762
Iron - dissolved (mg/L)	1	1			0.09	0.090	0.000	0.09	0	0.09	0.09	0.09	0.09	0.09
Molybdenum - dissolved (mg/L)	13	13			0.005	0.009	0.003	0.016	0.011	0.005	0.007	0.008	0.009	0.0148
Nickel - dissolved (mg/L)	13	12	1	7.7%	0.001	0.003	0.002	0.006	0.005	0.001	0.002	0.002	0.005	0.006
Selenium - dissolved (mg/L)	13	3	10	76.9%	0.002	0.012	0.012	0.029	0.027	0.0022	0.003	0.004	0.0165	0.0265
Uranium - dissolved (mg/L)	12	12			0.015	0.030	0.011	0.057	0.042	0.0161	0.023	0.0255	0.03725	0.0471
Vanadium - dissolved (mg/L)	1	1			0.03	0.030	0.000	0.03	0	0.03	0.03	0.03	0.03	0.03
Zinc - dissolved (mg/L)	1		1	100.0%										
Metals (total)														
Aluminium - total (mg/L)	4	4			0.11	0.555	0.314	0.99	0.88	0.1685	0.4025	0.56	0.7125	0.9345
Arsenic - total (mg/L)	13	13			0.004	0.017	0.016	0.066	0.062	0.004	0.009	0.013	0.016	0.0468
Barium - total (mg/L)	12	12			0.059	0.102	0.026	0.165	0.106	0.0656	0.087	0.099	0.112	0.1419
Beryllium - total (mg/L)	1		1	100.0%										
Bismuth - total (mg/L)	12		12	100.0%										
Boron - total (mg/L)	1	1			0.1	0.100	0.000	0.1	0	0.1	0.1	0.1	0.1	0.1
Chromium - total (mg/L)	13	4	9	69.2%	0.0009	0.002	0.002	0.005	0.0041	0.000915	0.000975	0.001	0.002	0.0044
Cobalt - total (mg/L)	13	12	1	7.7%	0.001	0.004	0.004	0.016	0.015	0.00155	0.002	0.002	0.00325	0.0116

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Copper - total (mg/L)	13	13			0.017	0.105	0.102	0.392	0.375	0.0284	0.048	0.051	0.13	0.2942
Iron - total (mg/L)	1	1			1.06	1.060	0.000	1.06	0	1.06	1.06	1.06	1.06	1.06
Molybdenum - total (mg/L)	13	13			0	0.010	0.006	0.025	0.025	0.003	0.008	0.01	0.011	0.0196
Nickel - total (mg/L)	13	12	1	7.7%	0.001	0.005	0.003	0.012	0.011	0.00155	0.002	0.003	0.00625	0.01035
Selenium - total (mg/L)	13	3	10	76.9%	0.002	0.020	0.024	0.054	0.052	0.0022	0.003	0.004	0.029	0.049
Uranium - total (mg/L)	12	12			0.016	0.037	0.020	0.091	0.075	0.01655	0.02275	0.0325	0.04175	0.07285
Vanadium - total (mg/L)	1	1			0.04	0.040	0.000	0.04	0	0.04	0.04	0.04	0.04	0.04
Nutrients														
Nitrate as N (mg/L)	2	1	1	50.0%	0.14	0.140	0.000	0.14	0	0.14	0.14	0.14	0.14	0.14
Nitrite + Nitrate as N (mg/L)	2	1	1	50.0%	0.15	0.150	0.000	0.15	0	0.15	0.15	0.15	0.15	0.15
Nitrite as N (mg/L)	2	1	1	50.0%	0.01	0.010	0.000	0.01	0	0.01	0.01	0.01	0.01	0.01
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	11	11			1890	5164.545	2116.650	8850	6960	2030	3700	5070	6865	8125
pH (lab)	11	11			8.61	9.021	0.223	9.3	0.69	8.67	8.89	9.05	9.235	9.29
BCP Spring (N)														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	12	12			243	987.000	321.112	1470	1227	532.85	848.25	894.5	1205	1459
Carbonate Alkalinity as CaCO3 (mg/L)	12	11	1	8.3%	93	245.818	129.342	490	397	96	107	278	300	455.5
Total Alkalinity as CaCO3 (mg/L)	12	12			243	1214.000	451.715	1960	1717	584.55	974.75	1140	1500	1910.5
Field Measurements														
Dissolved Oxygen (field) (% sat)	5	5			23.8	146.480	94.657	315.9	292.1	43.24	121	126.6	145.1	281.74
Electrical Conductivity (field) (µS/cm)	5	5			968	3808.600	1668.209	5416	4448	1347.8	2867	4824	4968	5326.4
ORP (field) (mV)	5	5			-58.8	-6.920	75.836	142.5	201.3	-58.68	-58.2	-34.4	-25.7	108.86

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
pH (field)	5	5			8.55	8.768	0.145	8.94	0.39	8.572	8.66	8.8	8.89	8.93
Salinity (field) (PSU)	5	5			0.48	1.896	0.834	2.71	2.23	0.668	1.42	2.4	2.47	2.662
TDS (field) (ppm)	5	5			484	1904.400	834.300	2708	2224	673.8	1433	2412	2485	2663.4
Temperature (field) (°C)	5	5			22.65	26.212	2.124	29.33	6.68	23.344	26.12	26.44	26.52	28.768
Hardness														
Total Hardness (mg CaCO3/L)	11	11			138	555.545	184.923	885	747	274.5	516	548	599.5	845.5
Major Ions														
Calcium (mg/L)	23	23			15	27.217	10.636	45	30	16.1	18.5	21	38	44
Chloride (mg/L)	12	12			52	320.083	149.631	554	502	134.5	210.5	285	434.5	536.4
Fluoride (mg/L)	12	12			0.6	1.533	0.332	1.9	1.3	0.985	1.4	1.6	1.7	1.9
Magnesium (mg/L)	23	23			21	121.174	44.882	204	183	28.7	103.5	115	138	200.1
Potassium (mg/L)	23	23			4	11.304	5.520	21	17	4.2	7	8	16	20.9
Sodium (mg/L)	23	23			174	920.522	415.032	1660	1486	218.2	638	747	1190	1582
Sulfate (as SO4)	12	12			112	839.083	407.548	1640	1528	358.4	589.25	708.5	1008.5	1546.5
Metals (dissolved)														
Arsenic - dissolved (mg/L)	12	12			0.002	0.008	0.004	0.017	0.015	0.0031	0.00475	0.008	0.012	0.0148
Barium - dissolved (mg/L)	12	12			0.046	0.077	0.017	0.109	0.063	0.0548	0.06625	0.076	0.0805	0.10845
Bismuth - dissolved (mg/L)	12		12	100.0%										
Chromium - dissolved (mg/L)	12		12	100.0%										
Cobalt - dissolved (mg/L)	12	6	6	50.0%	0.001	0.001	0.000	0.001	0	0.001	0.001	0.001	0.001	0.001
Copper - dissolved (mg/L)	12	12			0.014	0.024	0.014	0.067	0.053	0.014	0.01675	0.019	0.024	0.0472
Molybdenum - dissolved (mg/L)	12	12			0.004	0.006	0.002	0.012	0.008	0.004	0.005	0.006	0.007	0.0109
Nickel - dissolved (mg/L)	12	6	6	50.0%	0.001	0.002	0.000	0.002	0.001	0.00125	0.002	0.002	0.002	0.002

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Selenium - dissolved (mg/L)	12		12	100.0%										
Uranium - dissolved (mg/L)	12	12			0.005	0.021	0.007	0.033	0.028	0.0116	0.017	0.018	0.02475	0.03245
Metals (total)														
Arsenic - total (mg/L)	12	12			0.002	0.009	0.005	0.018	0.016	0.00365	0.005	0.0085	0.01225	0.0158
Barium - total (mg/L)	12	12			0.046	0.085	0.018	0.118	0.072	0.0581	0.07875	0.0825	0.0905	0.1147
Bismuth - total (mg/L)	12		12	100.0%										
Chromium - total (mg/L)	12	1	11	91.7%	0.001	0.001	0.000	0.001	0	0.001	0.001	0.001	0.001	0.001
Cobalt - total (mg/L)	12	11	1	8.3%	0.001	0.001	0.000	0.002	0.001	0.001	0.001	0.001	0.002	0.002
Copper - total (mg/L)	12	12			0.023	0.039	0.020	0.098	0.075	0.02465	0.02775	0.0315	0.03825	0.076
Molybdenum - total (mg/L)	12	12			0.004	0.008	0.003	0.013	0.009	0.00455	0.00575	0.0065	0.00925	0.01135
Nickel - total (mg/L)	12	8	4	33.3%	0.001	0.002	0.001	0.004	0.003	0.001	0.00175	0.002	0.0025	0.004
Selenium - total (mg/L)	12		12	100.0%										
Uranium - total (mg/L)	12	12			0.005	0.024	0.010	0.044	0.039	0.0116	0.01875	0.019	0.03	0.04015
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	12	12			956	4319.667	1545.528	7080	6124	2223.2	3397.5	4280	5305	6453
pH (lab)	12	12			8.27	8.836	0.226	9.19	0.92	8.4845	8.71	8.92	8.9725	9.0855
BCP Spring (S)														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	12	12			227	808.083	182.714	938	711	521.25	806.25	856.5	898.25	931.95
Carbonate Alkalinity as CaCO3 (mg/L)	12	5	7	58.3%	24	124.400	157.232	438	414	29	49	54	57	361.8
Total Alkalinity as CaCO3 (mg/L)	12	12			227	860.083	220.877	1230	1003	521.25	838.25	899	929	1099.1
Field Measurements														
Dissolved Oxygen (field) (% sat)	4	4			1.2	78.475	46.900	127.6	126.4	14.46	67.5	92.55	103.525	122.785

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Electrical Conductivity (field) (µS/cm)	4	4			674	2379.750	1011.387	3324	2650	984.65	2227.25	2760.5	2913	3241.8
ORP (field) (mV)	4	4			-58.6	-20.500	24.916	2.3	60.9	-53.845	-34.825	-12.85	1.475	2.135
pH (field)	4	4			8.3	8.503	0.135	8.64	0.34	8.324	8.42	8.535	8.6175	8.6355
Salinity (field) (PSU)	4	4			0.33	1.203	0.517	1.68	1.35	0.4845	1.1025	1.4	1.5	1.644
TDS (field) (ppm)	4	4			338	1190.000	505.227	1662	1324	493.1	1113.5	1380	1456.5	1620.9
Temperature (field) (°C)	4	4			22.62	26.628	2.512	28.88	6.26	23.1825	25.4325	27.505	28.7	28.844
Hardness														
Total Hardness (mg CaCO3/L)	11	11			110	680.273	209.599	916	806	315	645	709	807	887
Major Ions														
Calcium (mg/L)	23	23			15	69.565	20.192	93	78	19.4	63.5	76	81.5	90
Chloride (mg/L)	12	12			26	173.833	57.320	278	252	93.1	159	171.5	191.25	256.55
Fluoride (mg/L)	12	12			0.5	1.483	0.443	2.1	1.6	0.775	1.175	1.6	1.8	2.045
Magnesium (mg/L)	23	23			16	125.913	41.155	179	163	24.6	116	126	155.5	176.2
Potassium (mg/L)	23	23			4	5.522	1.347	8	4	4	4	5	6	8
Sodium (mg/L)	23	23			106	467.087	143.111	744	638	133.6	419	467	538.5	671.1
Sulfate (as SO4)	12	12			55	521.500	196.549	767	712	185.9	442.5	538.5	664.5	754.9
Metals (dissolved)														
Arsenic - dissolved (mg/L)	12	12			0.001	0.002	0.001	0.004	0.003	0.001	0.001	0.002	0.003	0.004
Barium - dissolved (mg/L)	12	12			0.033	0.121	0.039	0.176	0.143	0.0539	0.10625	0.1365	0.14175	0.1617
Bismuth - dissolved (mg/L)	12		12	100.0%										
Chromium - dissolved (mg/L)	12		12	100.0%										
Cobalt - dissolved (mg/L)	12	9	3	25.0%	0.001	0.002	0.000	0.002	0.001	0.001	0.001	0.002	0.002	0.002
Copper - dissolved (mg/L)	12	12			0.003	0.008	0.003	0.012	0.009	0.003	0.00475	0.0075	0.01025	0.012

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Molybdenum - dissolved (mg/L)	12	12			0.002	0.004	0.001	0.006	0.004	0.00255	0.003	0.0035	0.004	0.006
Nickel - dissolved (mg/L)	12	1	11	91.7%	0.002	0.002	0.000	0.002	0	0.002	0.002	0.002	0.002	0.002
Selenium - dissolved (mg/L)	12		12	100.0%										
Uranium - dissolved (mg/L)	12	12			0.002	0.011	0.003	0.014	0.012	0.0053	0.011	0.0115	0.014	0.014
Metals (total)														
Arsenic - total (mg/L)	12	12			0.001	0.002	0.001	0.004	0.003	0.001	0.00175	0.002	0.003	0.004
Barium - total (mg/L)	12	12			0.041	0.139	0.044	0.188	0.147	0.0619	0.1155	0.1605	0.16475	0.18305
Bismuth - total (mg/L)	12		12	100.0%										
Chromium - total (mg/L)	12		12	100.0%										
Cobalt - total (mg/L)	12	11	1	8.3%	0.001	0.002	0.001	0.003	0.002	0.0015	0.002	0.002	0.002	0.003
Copper - total (mg/L)	12	12			0.006	0.014	0.005	0.021	0.015	0.006	0.0105	0.015	0.01725	0.01935
Molybdenum - total (mg/L)	12	12			0.003	0.004	0.001	0.007	0.004	0.003	0.00375	0.004	0.00525	0.00645
Nickel - total (mg/L)	12	5	7	58.3%	0.001	0.002	0.001	0.004	0.003	0.001	0.001	0.001	0.001	0.0034
Selenium - total (mg/L)	12		12	100.0%										
Uranium - total (mg/L)	12	12			0.003	0.013	0.004	0.018	0.015	0.0052	0.012	0.013	0.0155	0.01745
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	12	12			619	2823.250	707.182	3420	2801	1741.55	2770	2930	3230	3370.5
pH (lab)	12	12			7.85	8.182	0.225	8.54	0.69	7.883	8.0275	8.105	8.3675	8.518
Pooled water S of sediment dam														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	5	5			73	104.000	35.287	152	79	73.4	75	78	142	150
Carbonate Alkalinity as CaCO3 (mg/L)	5		5	100.0%										
Total Alkalinity as CaCO3 (mg/L)	5	5			73	104.000	35.287	152	79	73.4	75	78	142	150

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Field Measurements														
Dissolved Oxygen (field) (% sat)	1	1			94.2	94.200	0.000	94.2	0	94.2	94.2	94.2	94.2	94.2
Electrical Conductivity (field) (µS/cm)	1	1			4632	4632.000	0.000	4632	0	4632	4632	4632	4632	4632
ORP (field) (mV)	1	1			-54.2	-54.200	0.000	-54.2	0	-54.2	-54.2	-54.2	-54.2	-54.2
pH (field)	1	1			8.23	8.230	0.000	8.23	0	8.23	8.23	8.23	8.23	8.23
Salinity (field) (PSU)	1	1			2.3	2.300	0.000	2.3	0	2.3	2.3	2.3	2.3	2.3
TDS (field) (ppm)	1	1			2315	2315.000	0.000	2315	0	2315	2315	2315	2315	2315
Temperature (field) (°C)	1	1			21.88	21.880	0.000	21.88	0	21.88	21.88	21.88	21.88	21.88
Hardness														
Total Hardness (mg CaCO3/L)	5	5			2100	2696.000	549.785	3550	1450	2100	2100	2780	2950	3430
Major Ions														
Calcium (mg/L)	10	10			430	574.500	107.239	754	324	444.85	477.25	591.5	606.5	749.5
Chloride (mg/L)	5	5			136	235.000	62.000	326	190	151	211	246	256	312
Fluoride (mg/L)	5	5			0.4	0.460	0.080	0.6	0.2	0.4	0.4	0.4	0.5	0.58
Magnesium (mg/L)	10	10			229	310.500	59.441	406	177	238	252	314	345.75	401.5
Potassium (mg/L)	10	10			21	28.100	4.415	34	13	21	25.5	29	30.75	34
Sodium (mg/L)	10	10			482	717.300	150.864	958	476	504.95	599.75	751	771.5	948.55
Sulfate (as SO4)	5	5			1540	2318.000	601.146	3220	1680	1592	1800	2370	2660	3108
Metals (dissolved)														
Arsenic - dissolved (mg/L)	5	5			0.001	0.001	0.000	0.002	0.001	0.001	0.001	0.001	0.001	0.0018
Barium - dissolved (mg/L)	5	5			0.069	0.088	0.019	0.12	0.051	0.0694	0.071	0.086	0.096	0.1152
Bismuth - dissolved (mg/L)	5		5	100.0%										
Chromium - dissolved (mg/L)	5		5	100.0%										

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Cobalt - dissolved (mg/L)	5	5			0.005	0.006	0.001	0.007	0.002	0.0052	0.006	0.007	0.007	0.007
Copper - dissolved (mg/L)	5	5			0.012	0.016	0.007	0.03	0.018	0.012	0.012	0.013	0.013	0.0266
Molybdenum - dissolved (mg/L)	5	5			0.009	0.013	0.003	0.018	0.009	0.0096	0.012	0.014	0.014	0.0172
Nickel - dissolved (mg/L)	5	2	3	60.0%	0.001	0.001	0.000	0.001	0	0.001	0.001	0.001	0.001	0.001
Selenium - dissolved (mg/L)	5	5			0.16	0.210	0.046	0.28	0.12	0.16	0.16	0.22	0.23	0.27
Uranium - dissolved (mg/L)	5	5			0.003	0.017	0.011	0.036	0.033	0.005	0.013	0.014	0.018	0.0324
Metals (total)														
Arsenic - total (mg/L)	5	5			0.001	0.001	0.001	0.003	0.002	0.001	0.001	0.001	0.001	0.0026
Barium - total (mg/L)	5	5			0.073	0.093	0.020	0.128	0.055	0.0736	0.076	0.085	0.104	0.1232
Bismuth - total (mg/L)	5		5	100.0%										
Chromium - total (mg/L)	5	2	3	60.0%	0.001	0.002	0.001	0.002	0.001	0.00105	0.00125	0.0015	0.00175	0.00195
Cobalt - total (mg/L)	5	5			0.005	0.007	0.001	0.007	0.002	0.0054	0.007	0.007	0.007	0.007
Copper - total (mg/L)	5	5			0.013	0.017	0.006	0.03	0.017	0.013	0.013	0.014	0.016	0.0272
Molybdenum - total (mg/L)	5	5			0.01	0.014	0.002	0.017	0.007	0.0106	0.013	0.015	0.016	0.0168
Nickel - total (mg/L)	5	3	2	40.0%	0.001	0.002	0.000	0.002	0.001	0.0011	0.0015	0.002	0.002	0.002
Selenium - total (mg/L)	5	5			0.16	0.212	0.047	0.28	0.12	0.16	0.16	0.22	0.24	0.272
Uranium - total (mg/L)	5	5			0.004	0.017	0.011	0.038	0.034	0.0058	0.013	0.014	0.018	0.034
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	5	5			5690	7232.000	1287.205	9460	3770	5814	6310	7170	7530	9074
pH (lab)	5	5			7.89	7.970	0.061	8.04	0.15	7.896	7.92	7.96	8.04	8.04
Sediment Dam														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	23	23			38	75.739	21.937	129	91	42.8	59	75	92	101.9

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Carbonate Alkalinity as CaCO3 (mg/L)	23	6	17	73.9%	10	18.000	6.904	28	18	11	14	14.5	24	27.75
Total Alkalinity as CaCO3 (mg/L)	23	23			50	80.435	21.930	129	79	52	64.5	78	94.5	122.2
Field Measurements														
Dissolved Oxygen (field) (% sat)	10	10			0	112.240	78.122	211.4	211.4	0.135	30.975	138.75	173.625	201.05
Electrical Conductivity (field) (µS/cm)	11	11			65	1386.091	654.250	2752	2687	502.5	1032.5	1282	1761	2338
ORP (field) (mV)	11	11			-22.1	88.945	93.203	252.9	275	-20.15	8.25	75.7	182.4	220.45
pH (field)	11	11			7.76	8.555	0.490	9.38	1.62	7.805	8.2	8.56	8.93	9.215
Salinity (field) (PSU)	11	11			0.03	0.696	0.343	1.43	1.4	0.24	0.51	0.63	0.88	1.215
TDS (field) (ppm)	11	11			32	695.091	329.146	1375	1343	251.5	514.5	641	880.5	1181
Temperature (field) (°C)	11	11			19.72	27.696	3.886	33.8	14.08	20.82	25.9	28.86	30.3	32.2
Hardness														
Total Hardness (mg CaCO3/L)	14	14			215	791.214	471.910	1720	1505	249.45	357.75	741	1070	1635.5
Major Ions														
Bromide (mg/L)	2	2			0.11	0.160	0.050	0.21	0.1	0.115	0.135	0.16	0.185	0.205
Calcium (mg/L)	37	37			42	155.622	86.961	358	316	55.6	80	128	218	308.4
Chloride (mg/L)	23	23			15	63.217	42.096	186	171	26	35	44	76	146.1
Fluoride (mg/L)	23	23			0.6	1.057	0.439	2.6	2	0.7	0.75	0.9	1.3	1.59
Iodide (mg/L)	2		2	100.0%										
Magnesium (mg/L)	37	37			19	91.297	61.213	248	229	26	44	61	124	216.6
Potassium (mg/L)	37	37			13	29.081	11.953	84	71	18.4	22	25	36	40.4
Sodium (mg/L)	37	37			42	227.784	163.701	690	648	56.8	115	180	282	572
Sulfate (as SO4)	23	23			168	740.130	452.957	2140	1972	189.4	472	639	930.5	1654
Metals (dissolved)														

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Arsenic - dissolved (mg/L)	23	23			0.002	0.003	0.001	0.006	0.004	0.0021	0.003	0.003	0.004	0.005
Barium - dissolved (mg/L)	23	23			0.06	0.098	0.015	0.139	0.079	0.0793	0.0915	0.101	0.104	0.11
Beryllium - dissolved (mg/L)	3		3	100.0%										
Bismuth - dissolved (mg/L)	23		23	100.0%										
Boron - dissolved (mg/L)	3	3			0.06	0.063	0.005	0.07	0.01	0.06	0.06	0.06	0.065	0.069
Chromium - dissolved (mg/L)	23		23	100.0%										
Cobalt - dissolved (mg/L)	23	8	15	65.2%	0.001	0.002	0.001	0.003	0.002	0.001	0.001	0.002	0.002	0.00265
Copper - dissolved (mg/L)	23	23			0.004	0.013	0.007	0.027	0.023	0.0051	0.008	0.011	0.02	0.0267
Iron - dissolved (mg/L)	3		3	100.0%										
Molybdenum - dissolved (mg/L)	23	23			0.019	0.042	0.026	0.146	0.127	0.0211	0.024	0.036	0.05	0.0607
Nickel - dissolved (mg/L)	23	16	7	30.4%	0.001	0.005	0.006	0.027	0.026	0.001	0.002	0.003	0.005	0.0105
Selenium - dissolved (mg/L)	23	12	11	47.8%	0.01	0.058	0.039	0.13	0.12	0.01	0.0175	0.06	0.0725	0.1245
Uranium - dissolved (mg/L)	23	23			0.002	0.008	0.004	0.021	0.019	0.0041	0.0055	0.007	0.008	0.0145
Vanadium - dissolved (mg/L)	3		3	100.0%										
Metals (total)														
Arsenic - total (mg/L)	23	23			0.002	0.003	0.001	0.005	0.003	0.0021	0.003	0.003	0.004	0.0049
Barium - total (mg/L)	23	23			0.057	0.102	0.017	0.142	0.085	0.0773	0.095	0.103	0.109	0.129
Beryllium - total (mg/L)	3		3	100.0%										
Bismuth - total (mg/L)	23		23	100.0%										
Boron - total (mg/L)	3	3			0.07	0.070	0.000	0.07	0	0.07	0.07	0.07	0.07	0.07
Chromium - total (mg/L)	23		23	100.0%										
Cobalt - total (mg/L)	23	7	16	69.6%	0.001	0.002	0.001	0.003	0.002	0.001	0.0015	0.002	0.002	0.0027
Copper - total (mg/L)	23	23			0.008	0.017	0.008	0.036	0.028	0.0091	0.0105	0.014	0.0195	0.0308

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Iron - total (mg/L)	3		3	100.0%										
Molybdenum - total (mg/L)	23	23			0.022	0.048	0.028	0.156	0.134	0.0231	0.0275	0.039	0.059	0.0684
Nickel - total (mg/L)	23	15	8	34.8%	0.001	0.003	0.002	0.006	0.005	0.001	0.002	0.003	0.0045	0.006
Selenium - total (mg/L)	23	10	13	56.5%	0.01	0.066	0.036	0.14	0.13	0.0145	0.06	0.06	0.07	0.1265
Uranium - total (mg/L)	23	23			0.004	0.009	0.004	0.023	0.019	0.005	0.0065	0.008	0.009	0.0154
Vanadium - total (mg/L)	3		3	100.0%										
Nutrients														
Nitrate as N (mg/L)	4	4			17.3	26.075	8.050	34.6	17.3	17.525	18.425	26.2	33.85	34.45
Nitrite + Nitrate as N (mg/L)	4	4			17.6	26.575	8.158	35.3	17.7	17.855	18.875	26.7	34.4	35.12
Nitrite as N (mg/L)	4	4			0.29	0.488	0.132	0.65	0.36	0.3155	0.4175	0.505	0.575	0.635
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	23	23			739	2204.739	1185.648	5280	4541	997	1365	1680	3060	4507
pH (lab)	23	23			7.51	8.142	0.321	8.73	1.22	7.555	7.97	8.17	8.305	8.645
Seepage														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	1	1			744	744.000	0.000	744	0	744	744	744	744	744
Carbonate Alkalinity as CaCO3 (mg/L)	1		1	100.0%										
Total Alkalinity as CaCO3 (mg/L)	1	1			744	744.000	0.000	744	0	744	744	744	744	744
Hardness														
Total Hardness (mg CaCO3/L)	1	1			450	450.000	0.000	450	0	450	450	450	450	450
Major Ions														
Calcium (mg/L)	2	2			50	54.000	4.000	58	8	50.4	52	54	56	57.6
Chloride (mg/L)	1	1			49	49.000	0.000	49	0	49	49	49	49	49

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Fluoride (mg/L)	1	1			1.9	1.900	0.000	1.9	0	1.9	1.9	1.9	1.9	1.9
Magnesium (mg/L)	2	2			78	78.500	0.500	79	1	78.05	78.25	78.5	78.75	78.95
Potassium (mg/L)	2	2			6	6.500	0.500	7	1	6.05	6.25	6.5	6.75	6.95
Sodium (mg/L)	2	2			195	204.000	9.000	213	18	195.9	199.5	204	208.5	212.1
Sulfate (as SO4)	1	1			79	79.000	0.000	79	0	79	79	79	79	79
Metals (dissolved)														
Arsenic - dissolved (mg/L)	1	1			0.003	0.003	0.000	0.003	0	0.003	0.003	0.003	0.003	0.003
Barium - dissolved (mg/L)	1	1			0.124	0.124	0.000	0.124	0	0.124	0.124	0.124	0.124	0.124
Bismuth - dissolved (mg/L)	1		1	100.0%										
Chromium - dissolved (mg/L)	1		1	100.0%										
Cobalt - dissolved (mg/L)	1	1			0.001	0.001	0.000	0.001	0	0.001	0.001	0.001	0.001	0.001
Copper - dissolved (mg/L)	1	1			0.001	0.001	0.000	0.001	0	0.001	0.001	0.001	0.001	0.001
Molybdenum - dissolved (mg/L)	1	1			0.014	0.014	0.000	0.014	0	0.014	0.014	0.014	0.014	0.014
Nickel - dissolved (mg/L)	1		1	100.0%										
Selenium - dissolved (mg/L)	1		1	100.0%										
Uranium - dissolved (mg/L)	1	1			0.011	0.011	0.000	0.011	0	0.011	0.011	0.011	0.011	0.011
Metals (total)														
Arsenic - total (mg/L)	1	1			0.003	0.003	0.000	0.003	0	0.003	0.003	0.003	0.003	0.003
Barium - total (mg/L)	1	1			0.133	0.133	0.000	0.133	0	0.133	0.133	0.133	0.133	0.133
Bismuth - total (mg/L)	1		1	100.0%										
Chromium - total (mg/L)	1	1			0.001	0.001	0.000	0.001	0	0.001	0.001	0.001	0.001	0.001
Cobalt - total (mg/L)	1	1			0.002	0.002	0.000	0.002	0	0.002	0.002	0.002	0.002	0.002
Copper - total (mg/L)	1	1			0.007	0.007	0.000	0.007	0	0.007	0.007	0.007	0.007	0.007

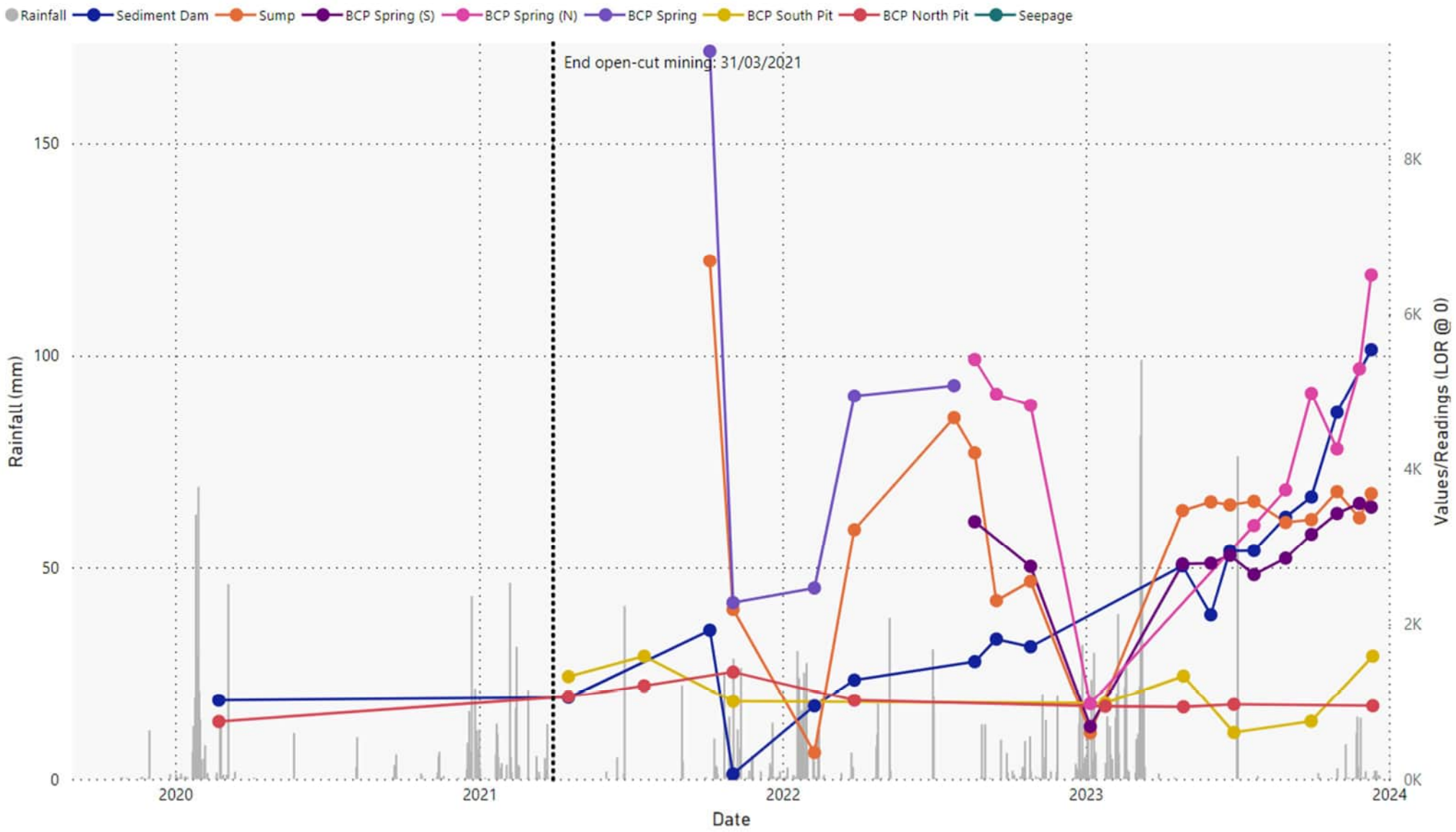
Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Molybdenum - total (mg/L)	1	1			0.018	0.018	0.000	0.018	0	0.018	0.018	0.018	0.018	0.018
Nickel - total (mg/L)	1	1			0.002	0.002	0.000	0.002	0	0.002	0.002	0.002	0.002	0.002
Selenium - total (mg/L)	1		1	100.0%										
Uranium - total (mg/L)	1	1			0.012	0.012	0.000	0.012	0	0.012	0.012	0.012	0.012	0.012
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	1	1			1500	1500.000	0.000	1500	0	1500	1500	1500	1500	1500
pH (lab)	1	1			7.73	7.730	0.000	7.73	0	7.73	7.73	7.73	7.73	7.73
Sump														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	20	20			83	661.650	293.321	1300	1217	121.95	502.75	650.5	872	1008.35
Carbonate Alkalinity as CaCO3 (mg/L)	20	17	3	15.0%	25	115.529	101.945	331	306	29.8	42	64	182	303.8
Total Alkalinity as CaCO3 (mg/L)	20	20			83	759.500	354.590	1420	1337	121.95	539.25	756	987	1258.5
Field Measurements														
Dissolved Oxygen (field) (% sat)	9	9			0.4	106.833	80.733	186.6	186.2	2.04	16.9	161.2	184.1	185.76
Electrical Conductivity (field) (µS/cm)	10	10			340	3022.700	1796.789	6686	6346	453.85	2219.25	2886.5	4024.5	5775.2
ORP (field) (mV)	10	10			-57.4	16.530	65.835	133	190.4	-54.25	-33.825	-3.8	57.8	128.05
pH (field)	10	10			8.12	8.941	0.528	9.84	1.72	8.21	8.6625	8.77	9.3775	9.7005
Salinity (field) (PSU)	10	10			0.16	1.550	0.965	3.64	3.48	0.214	1.1175	1.475	2.03	3.037
TDS (field) (ppm)	10	10			171	1511.200	898.332	3343	3172	227.25	1109	1443.5	2012.75	2887.15
Temperature (field) (°C)	10	10			24.15	27.959	2.008	32.25	8.1	25.1625	26.87	27.89	28.8975	30.8775
Hardness														
Total Hardness (mg CaCO3/L)	11	11			37	356.455	158.778	546	509	63.5	325	348	465.5	544.5
Major Ions														

Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Bromide (mg/L)	2	2			0.086	0.823	0.737	1.56	1.474	0.1597	0.4545	0.823	1.1915	1.4863
Calcium (mg/L)	31	31			10	38.903	18.655	75	65	12	21	45	52	65.5
Chloride (mg/L)	20	20			17	261.050	143.215	721	704	27.45	193.5	244.5	311	402.75
Fluoride (mg/L)	20	20			0.2	0.855	0.304	1.2	1	0.2	0.75	1	1	1.2
Iodide (mg/L)	2	1	1	50.0%	0.68	0.680	0.000	0.68	0	0.68	0.68	0.68	0.68	0.68
Magnesium (mg/L)	31	31			3	50.581	29.575	96	93	3	30.5	51	79.5	93
Potassium (mg/L)	31	31			2	8.935	2.602	12	10	4	8	9	11	12
Sodium (mg/L)	31	31			41	708.581	288.949	1410	1369	96	651.5	703	780.5	1145
Sulfate (as SO4)	20	20			32	616.200	244.181	970	938	63.35	471.25	687	804.25	841.75
Metals (dissolved)														
Arsenic - dissolved (mg/L)	20	20			0.001	0.005	0.003	0.012	0.011	0.00195	0.003	0.004	0.008	0.01105
Barium - dissolved (mg/L)	20	20			0.021	0.090	0.035	0.15	0.129	0.0286	0.0725	0.099	0.11375	0.13955
Beryllium - dissolved (mg/L)	1		1	100.0%										
Bismuth - dissolved (mg/L)	20		20	100.0%										
Boron - dissolved (mg/L)	1	1			0.13	0.130	0.000	0.13	0	0.13	0.13	0.13	0.13	0.13
Chromium - dissolved (mg/L)	20	1	19	95.0%	0.002	0.002	0.000	0.002	0	0.002	0.002	0.002	0.002	0.002
Cobalt - dissolved (mg/L)	20	17	3	15.0%	0.001	0.002	0.001	0.003	0.002	0.001	0.001	0.002	0.002	0.003
Copper - dissolved (mg/L)	20	20			0.008	0.016	0.009	0.04	0.032	0.008	0.01	0.012	0.018	0.0343
Iron - dissolved (mg/L)	1		1	100.0%										
Molybdenum - dissolved (mg/L)	20	20			0.001	0.006	0.002	0.008	0.007	0.00195	0.00475	0.0065	0.007	0.008
Nickel - dissolved (mg/L)	20	5	15	75.0%	0.001	0.001	0.000	0.002	0.001	0.001	0.001	0.001	0.002	0.002
Selenium - dissolved (mg/L)	20	7	13	65.0%	0.01	0.026	0.009	0.04	0.03	0.013	0.02	0.03	0.03	0.037
Uranium - dissolved (mg/L)	20	20			0.002	0.026	0.014	0.076	0.074	0.00485	0.02275	0.0255	0.02925	0.03325

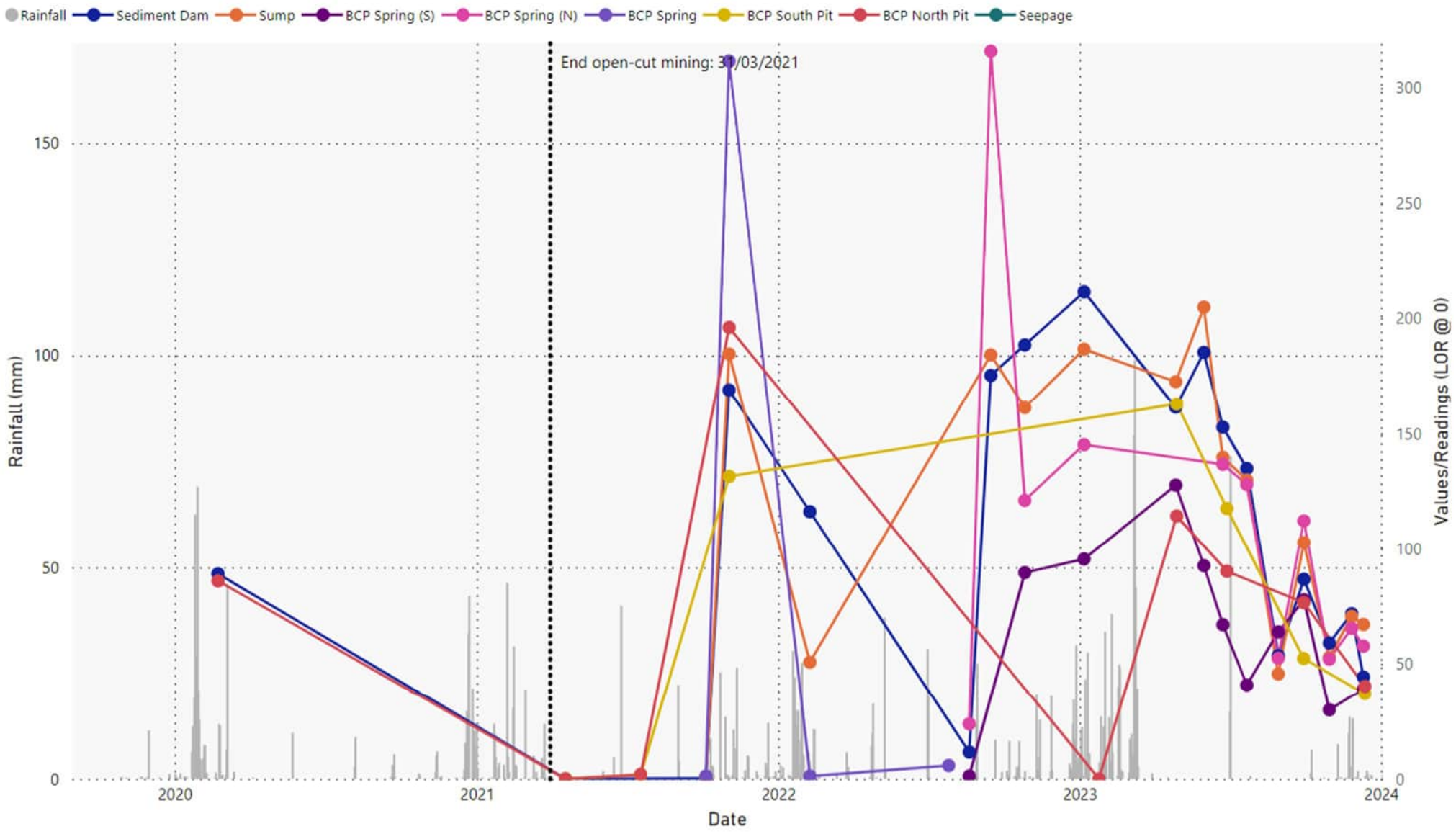
Analyte/Parameter	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Vanadium - dissolved (mg/L)	1		1	100.0%										
Metals (total)														
Arsenic - total (mg/L)	20	20			0.002	0.006	0.003	0.013	0.011	0.002	0.003	0.004	0.009	0.01205
Barium - total (mg/L)	20	20			0.024	0.100	0.037	0.163	0.139	0.03635	0.0775	0.109	0.12575	0.13925
Beryllium - total (mg/L)	1		1	100.0%										
Bismuth - total (mg/L)	20		20	100.0%										
Boron - total (mg/L)	1	1			0.14	0.140	0.000	0.14	0	0.14	0.14	0.14	0.14	0.14
Chromium - total (mg/L)	20	3	17	85.0%	0.001	0.002	0.001	0.004	0.003	0.0011	0.0015	0.002	0.003	0.0038
Cobalt - total (mg/L)	20	19	1	5.0%	0.001	0.002	0.001	0.004	0.003	0.001	0.002	0.002	0.003	0.0031
Copper - total (mg/L)	20	20			0.011	0.024	0.011	0.051	0.04	0.0129	0.015	0.02	0.02875	0.05005
Iron - total (mg/L)	1	1			0.3	0.300	0.000	0.3	0	0.3	0.3	0.3	0.3	0.3
Molybdenum - total (mg/L)	20	20			0.001	0.007	0.002	0.009	0.008	0.00195	0.006	0.0075	0.008	0.009
Nickel - total (mg/L)	20	10	10	50.0%	0.001	0.002	0.001	0.003	0.002	0.001	0.001	0.001	0.002	0.00255
Selenium - total (mg/L)	20	7	13	65.0%	0.01	0.027	0.009	0.04	0.03	0.013	0.025	0.03	0.03	0.037
Uranium - total (mg/L)	20	20			0.002	0.028	0.015	0.083	0.081	0.00485	0.02475	0.0285	0.032	0.03645
Vanadium - total (mg/L)	1	1			0.01	0.010	0.000	0.01	0	0.01	0.01	0.01	0.01	0.01
Nutrients														
Nitrate as N (mg/L)	2	1	1	50.0%	0.32	0.320	0.000	0.32	0	0.32	0.32	0.32	0.32	0.32
Nitrite + Nitrate as N (mg/L)	2	1	1	50.0%	0.32	0.320	0.000	0.32	0	0.32	0.32	0.32	0.32	0.32
Nitrite as N (mg/L)	2		2	100.0%										
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	20	20			279	3352.750	1346.902	6290	6011	475.65	2975	3540	3870	5007.5
pH (lab)	20	20			8	8.544	0.280	9.14	1.14	8.0095	8.44	8.5	8.765	8.9215

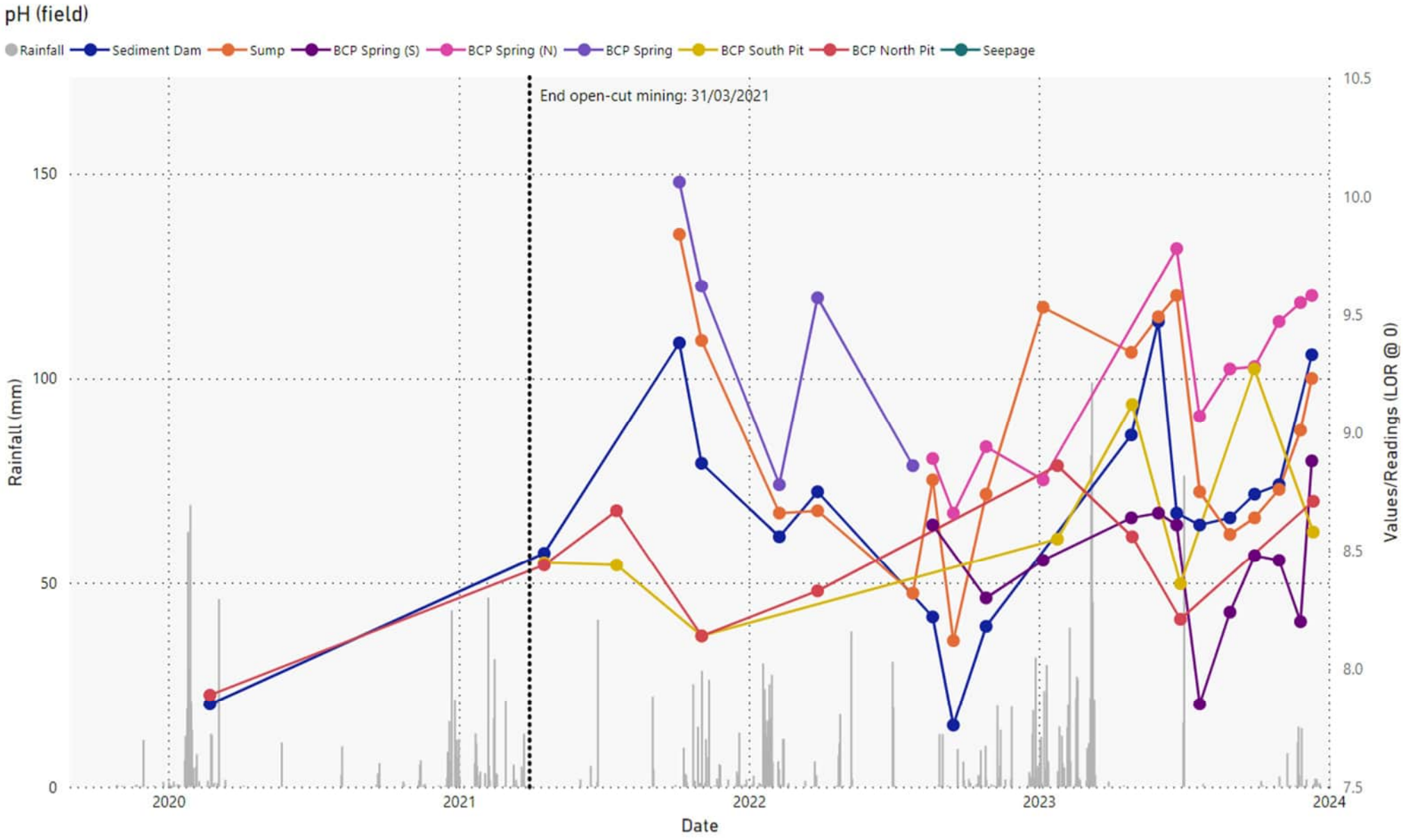
F.2 Water quality time series

Electrical Conductivity (field) (µS/cm)

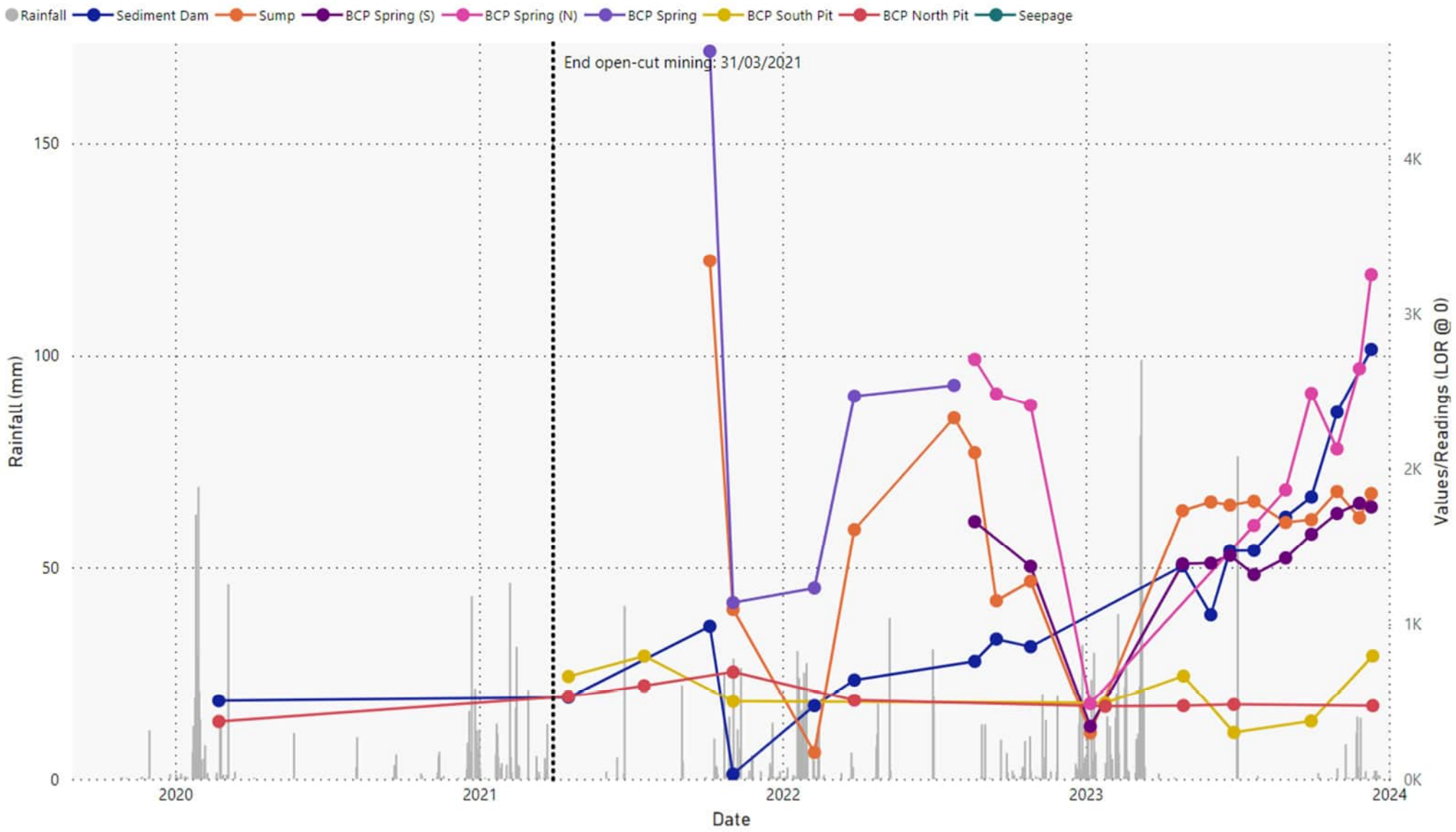


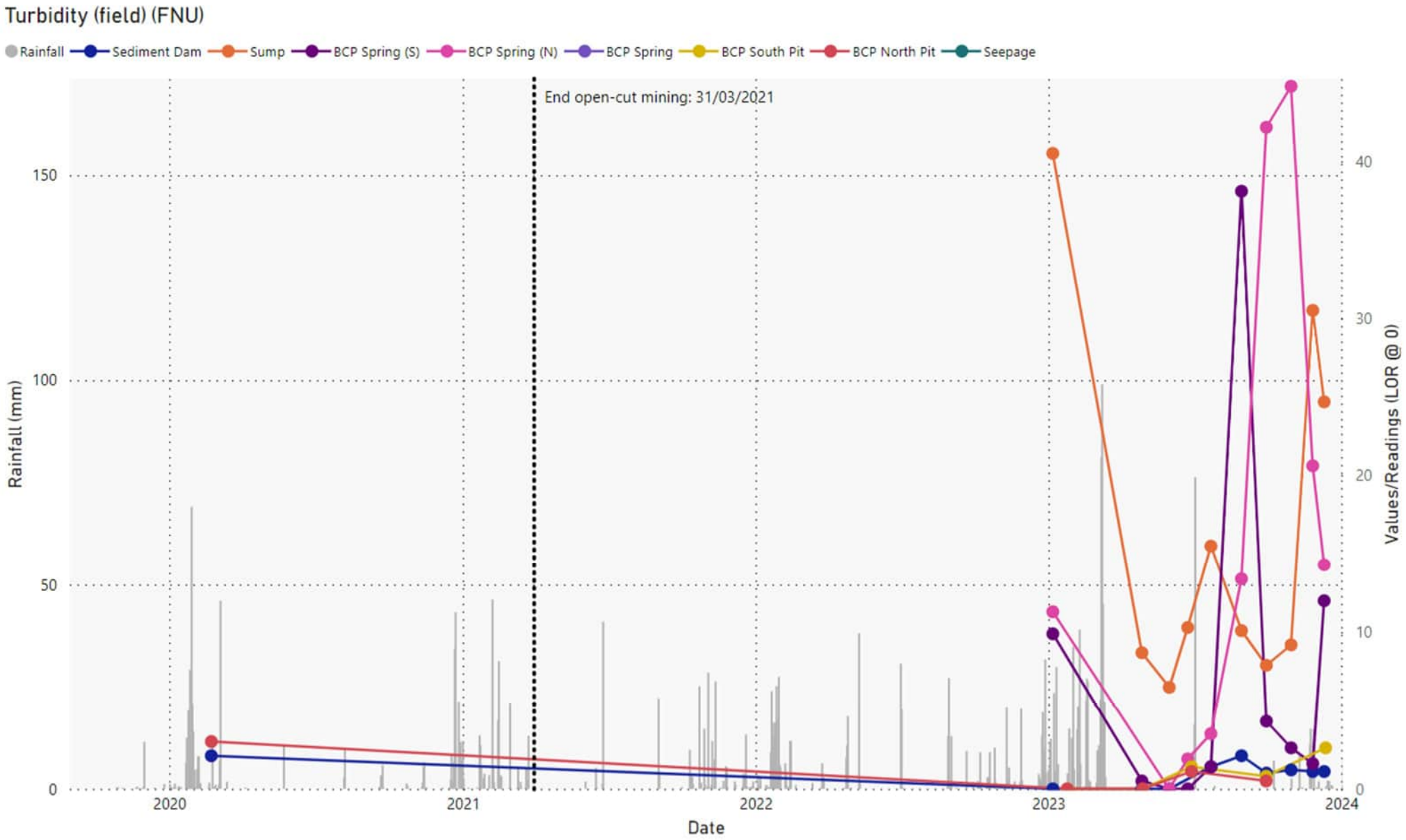
Dissolved Oxygen (field) (% sat)



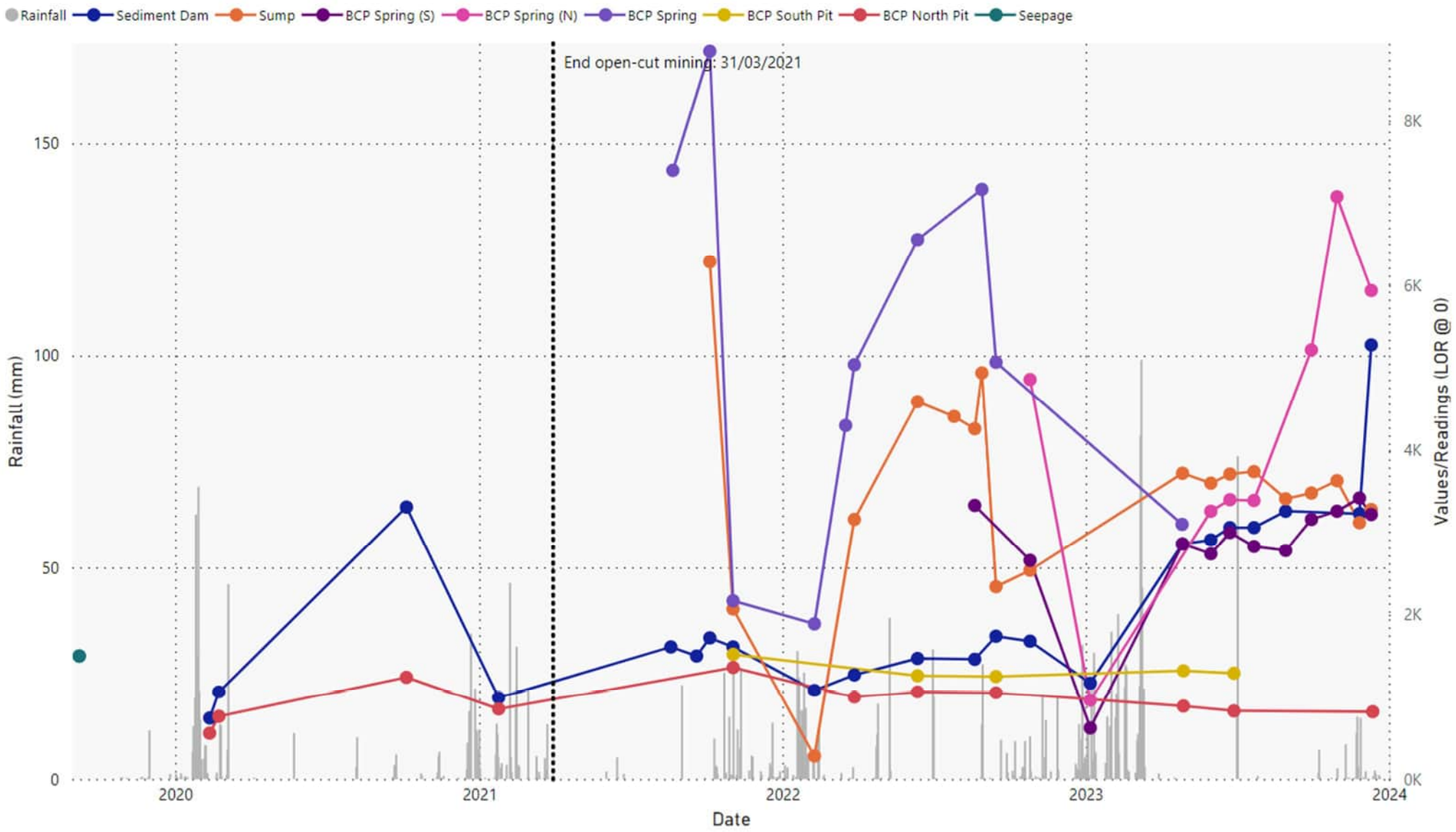

pH (field)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
Values/Readings (LOR @ 0)
10.5
10.0
9.5
9.0
8.5
8.0
7.5
2020
2021
2022
2023
2024
Date

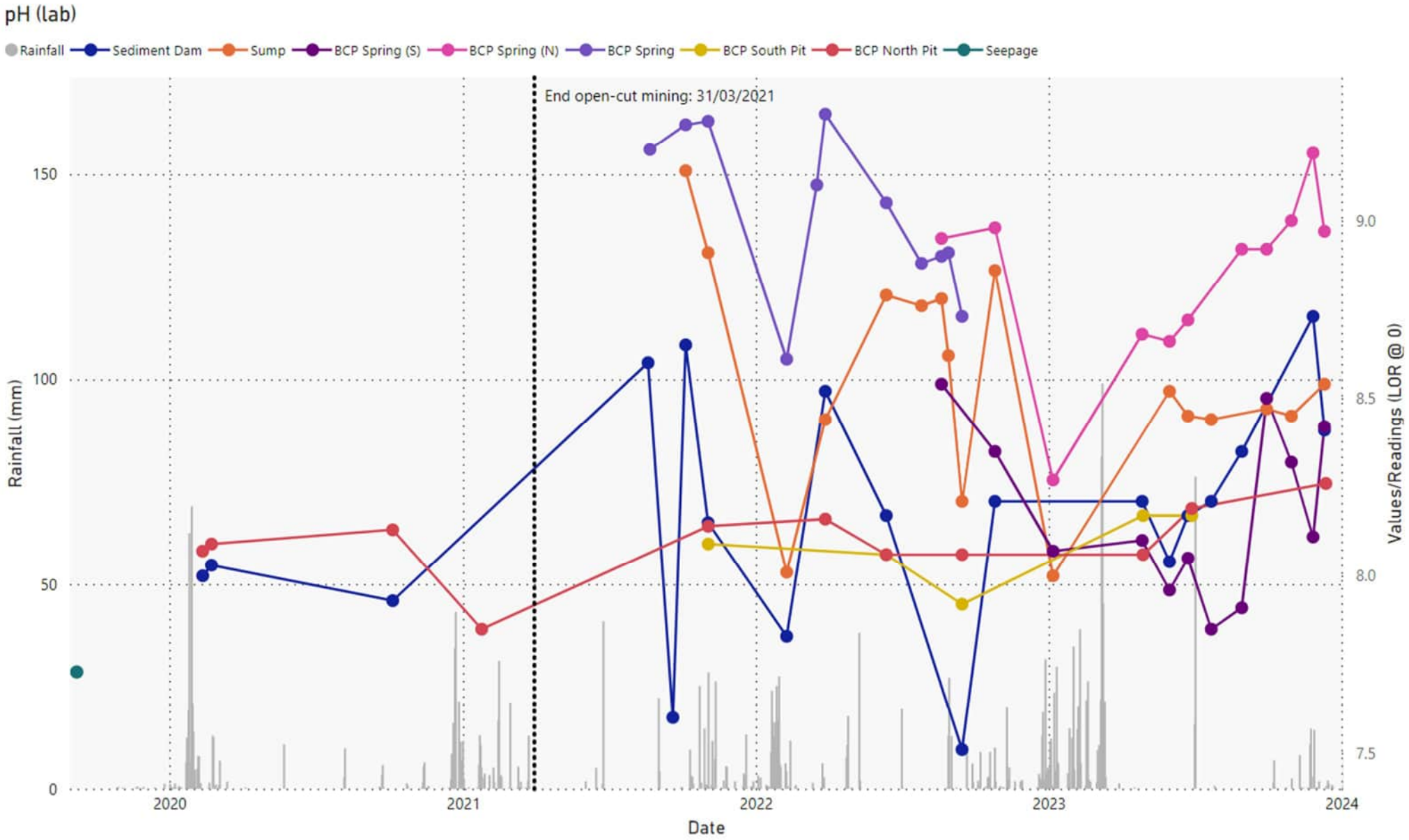
TDS (field) (ppm)

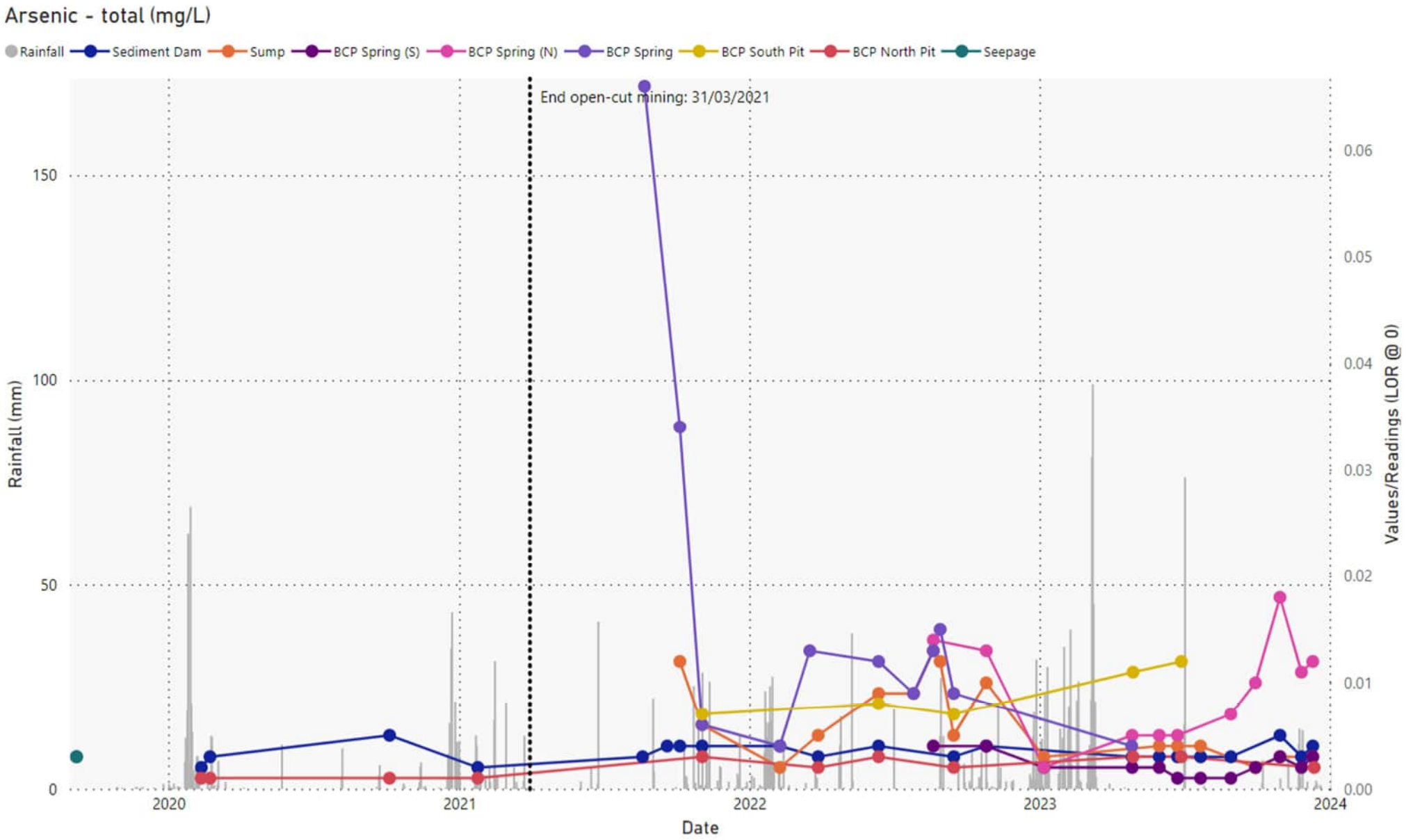


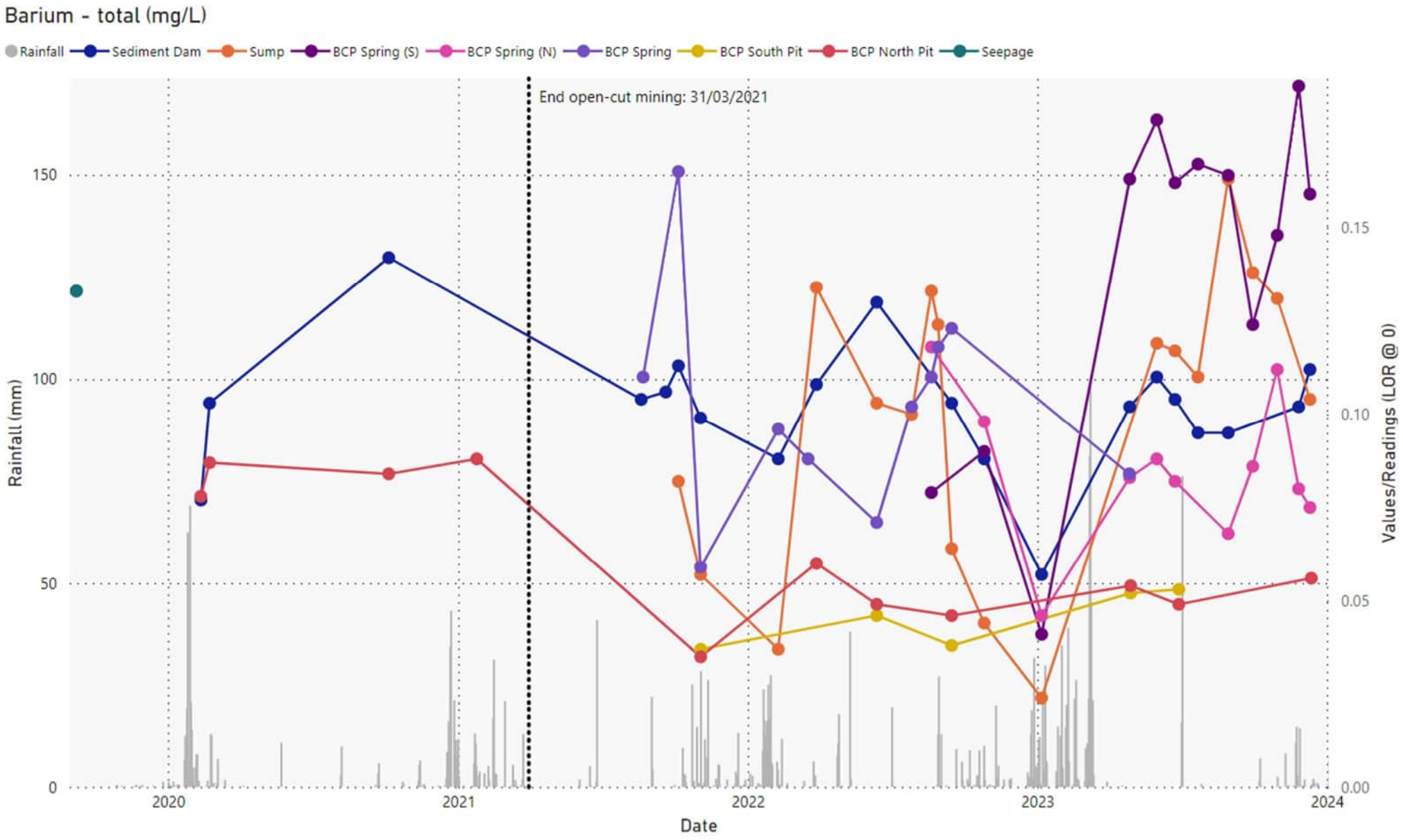

Turbidity (field) (FNU)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
10
20
30
40
2020
2021
2022
2023
2024

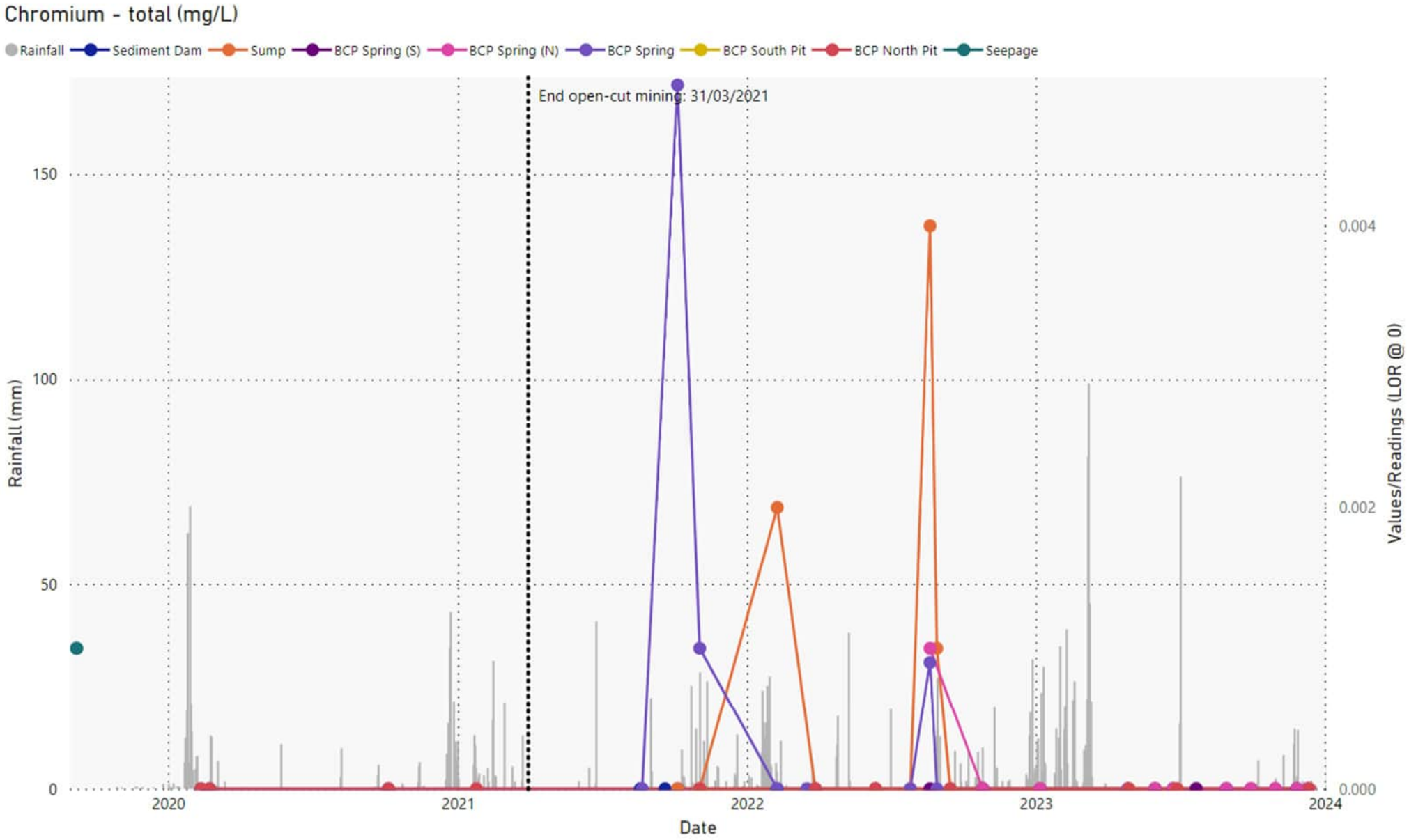
Electrical Conductivity (µS/cm)



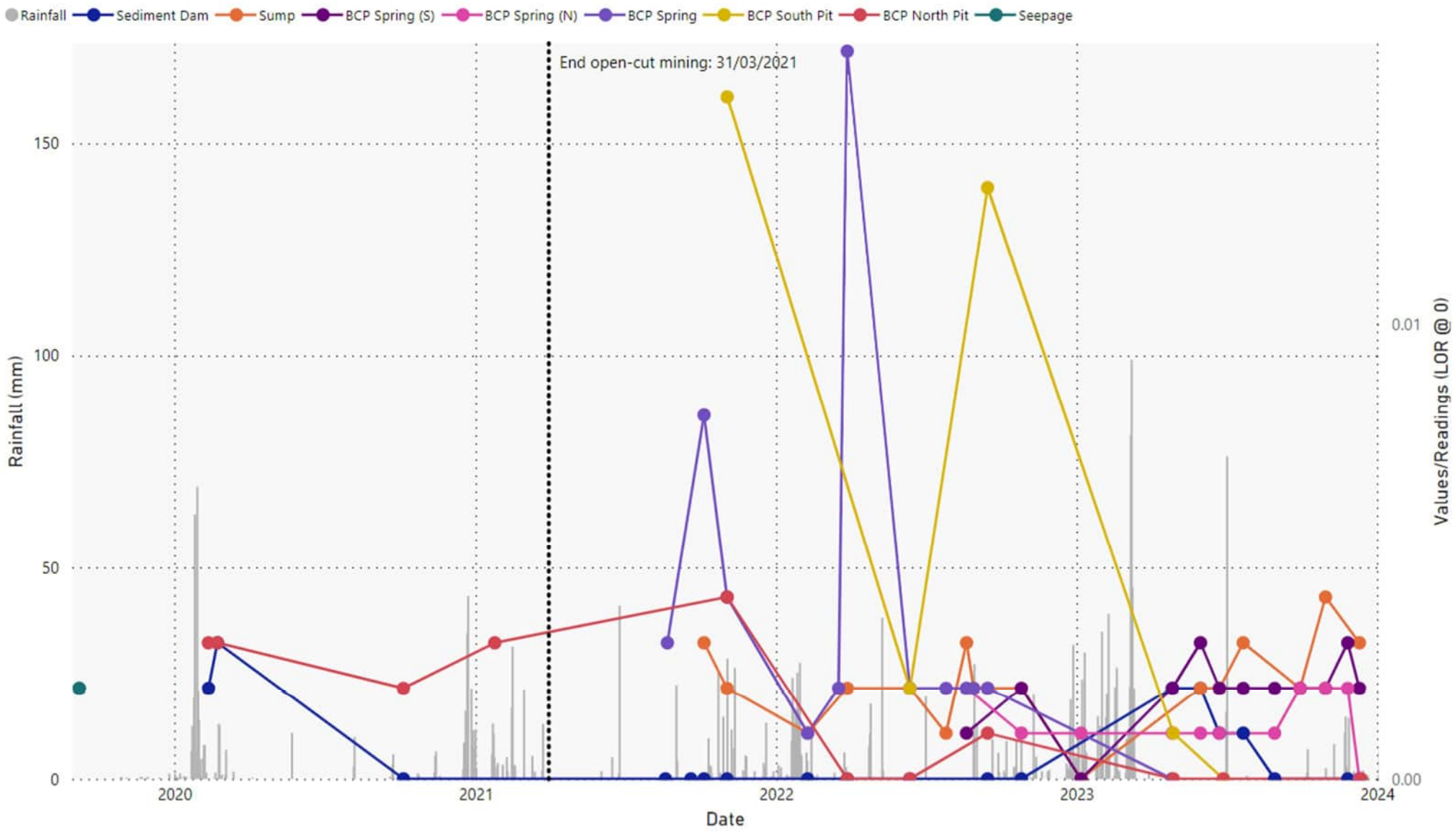

pH (lab)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
9.0
8.5
8.0
7.5
Values/Readings (LOR @ 0)
2020
2021
2022
2023
2024
Date

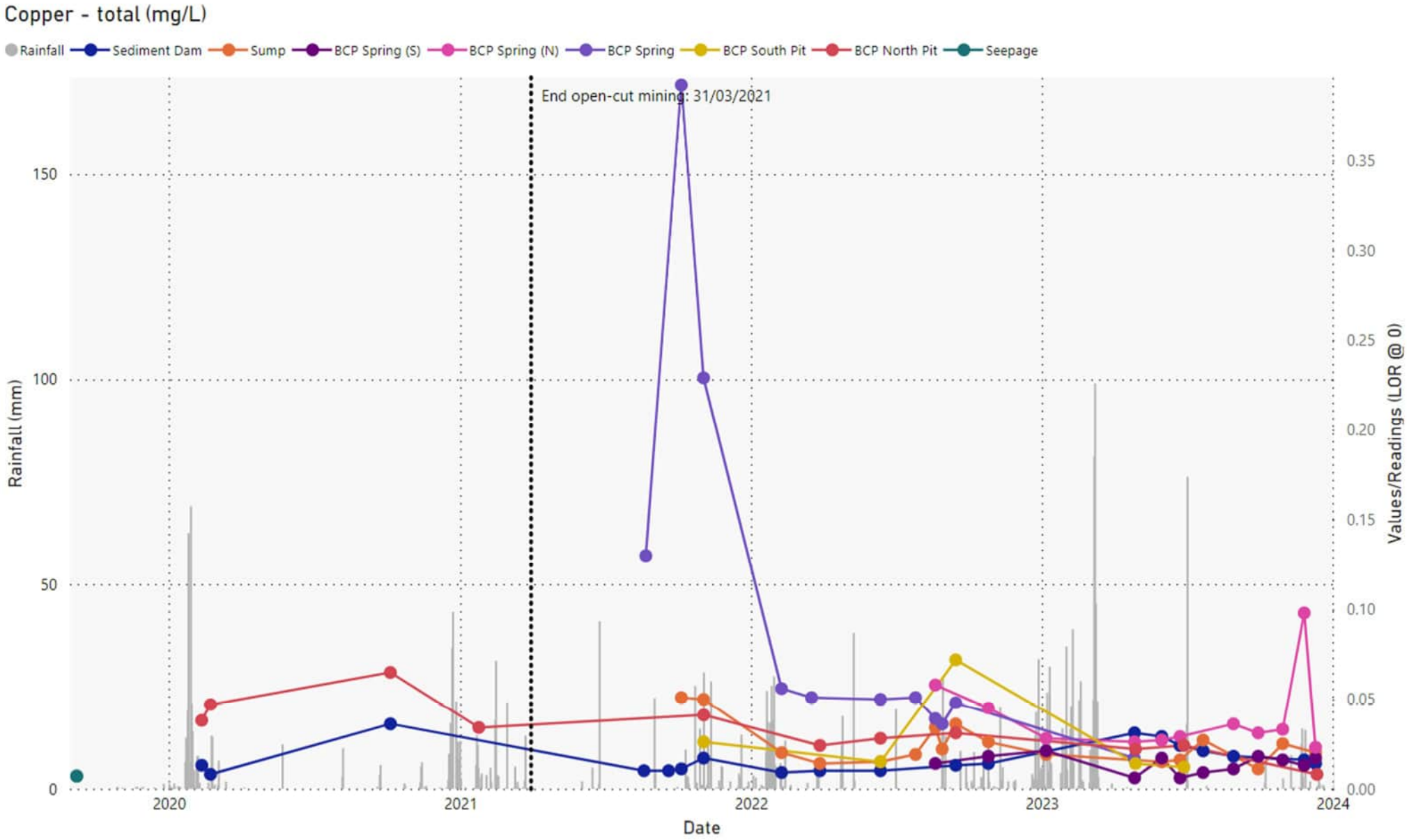

Arsenic - total (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.01
0.02
0.03
0.04
0.05
0.06
2020
2021
2022
2023
2024

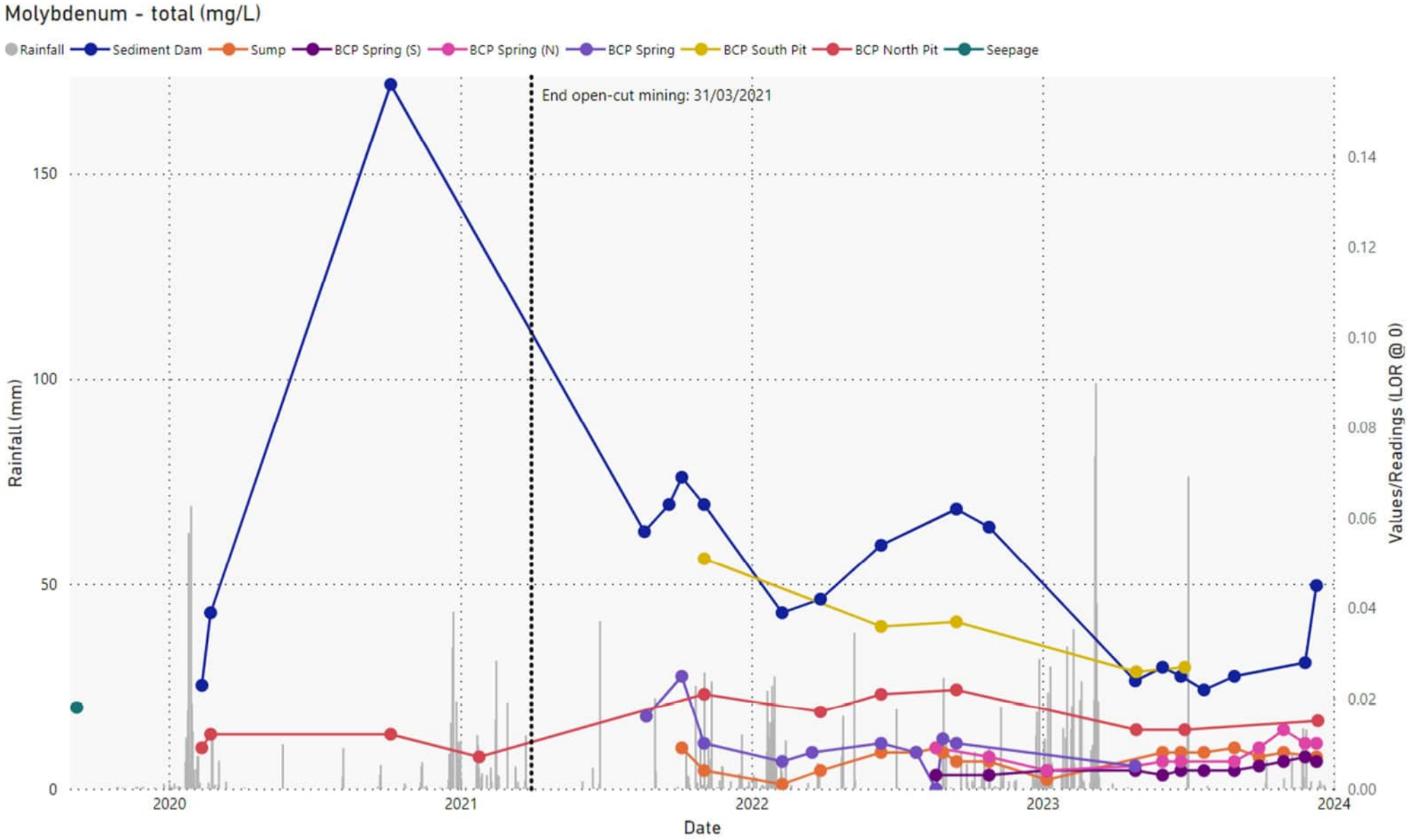

Barium - total (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
Values/Readings (LOR @ 0)
0.15
0.10
0.05
0.00
2020
2021
2022
2023
2024
Date

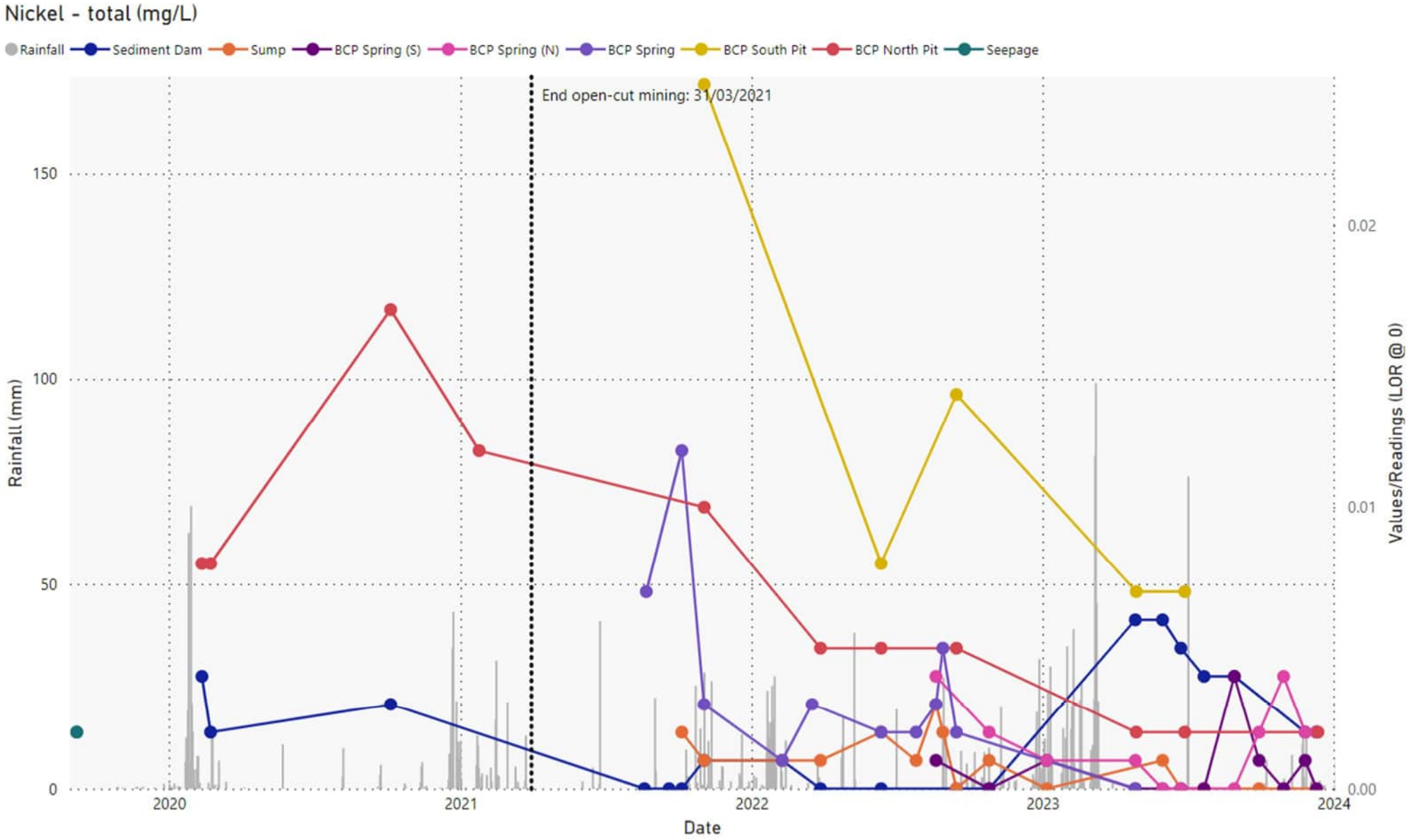

Chromium - total (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
150
100
50
0
Rainfall (mm)
0.004
0.002
0.000
Values/Readings (LOR @ 0)
2020
2021
2022
2023
2024
Date

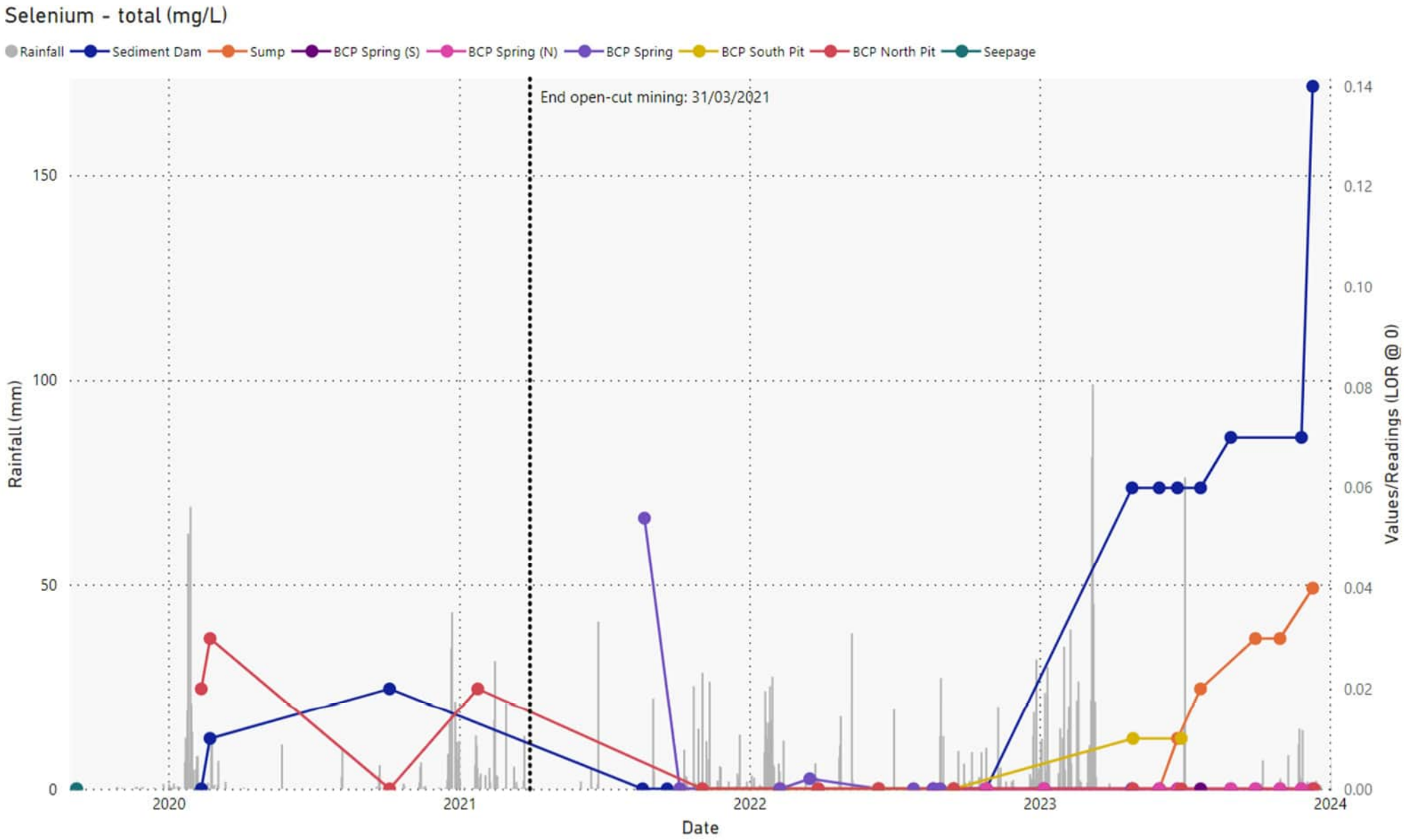
Cobalt - total (mg/L)

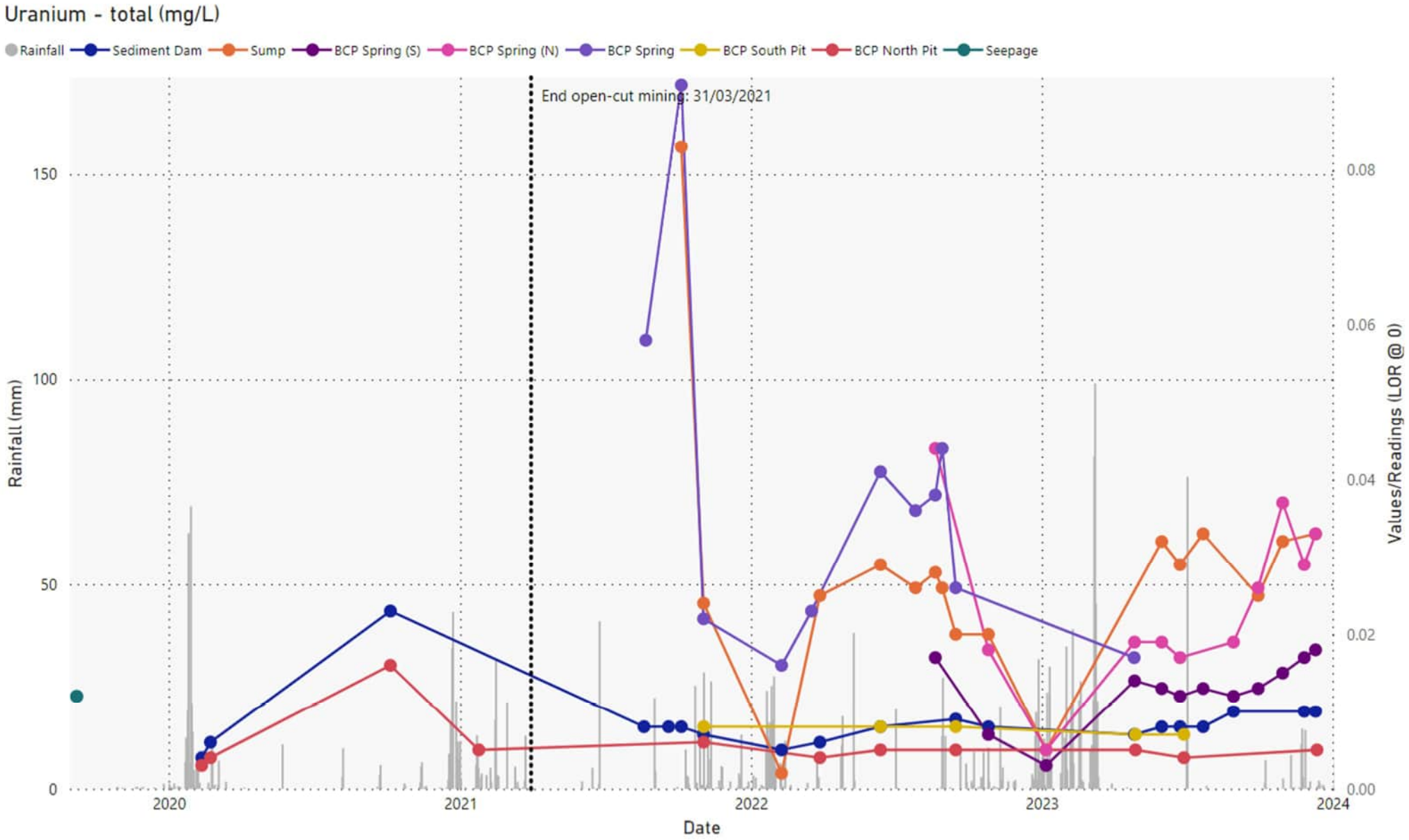


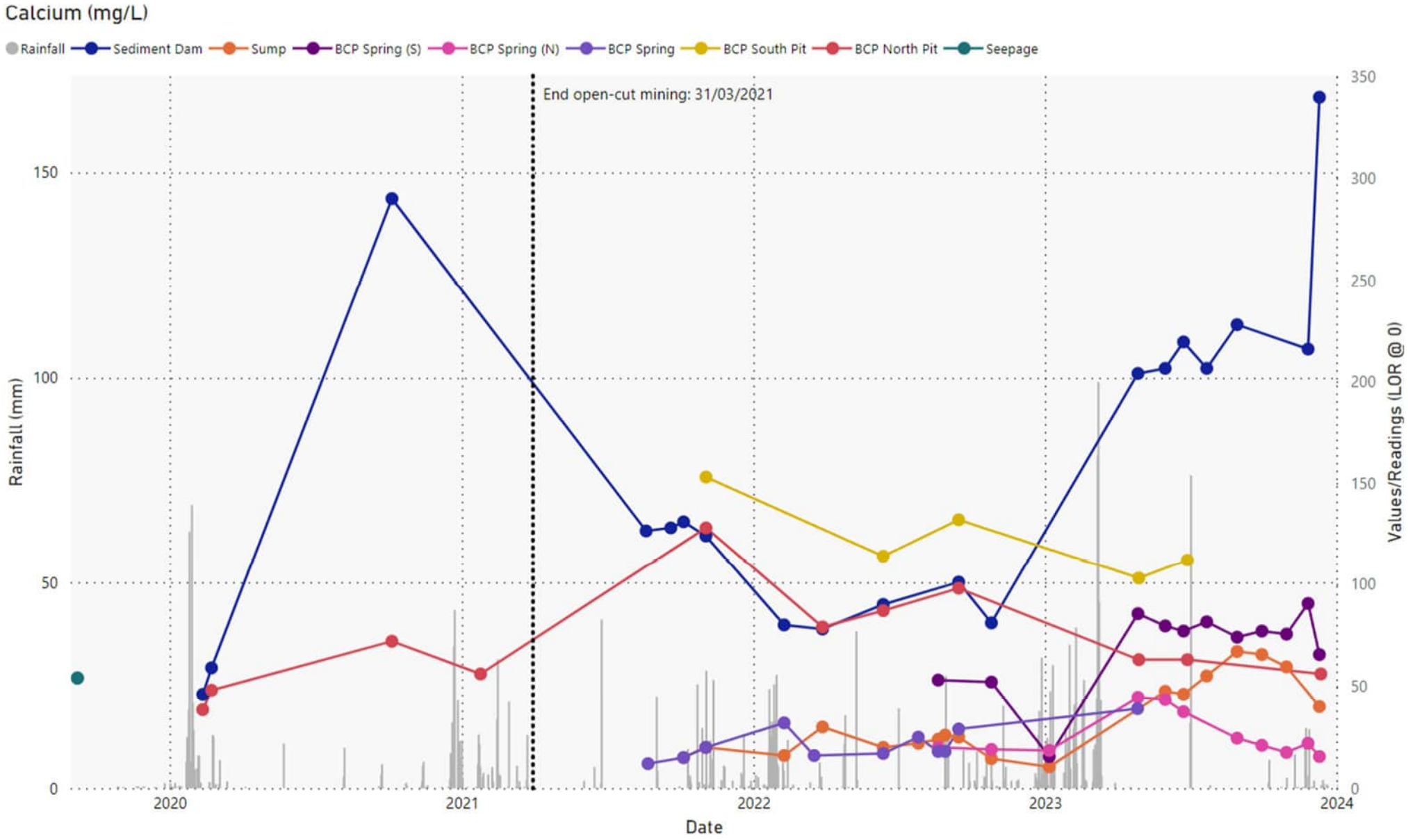

Copper - total (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
2020
2021
2022
2023
2024

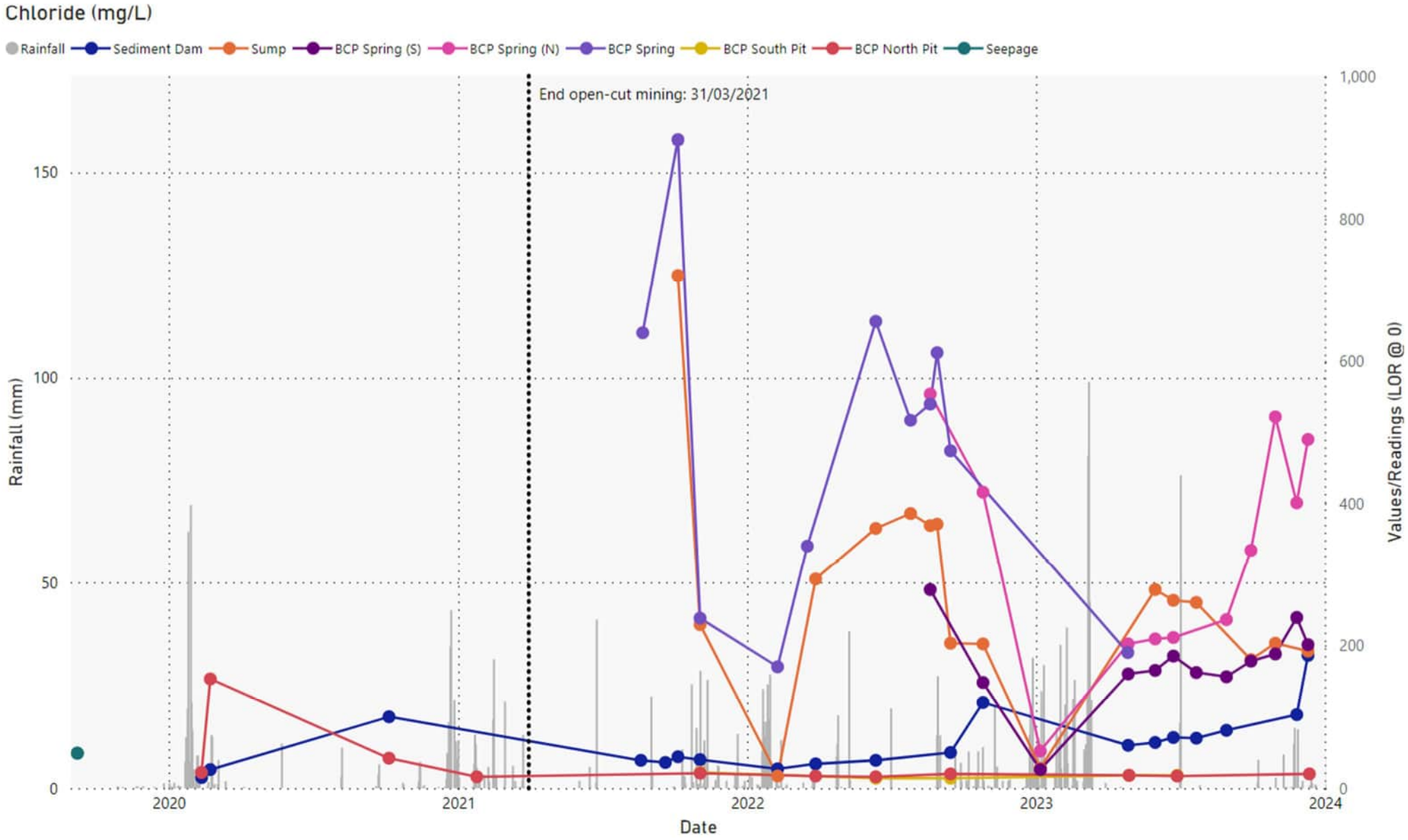

Molybdenum - total (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
2020
2021
2022
2023
2024

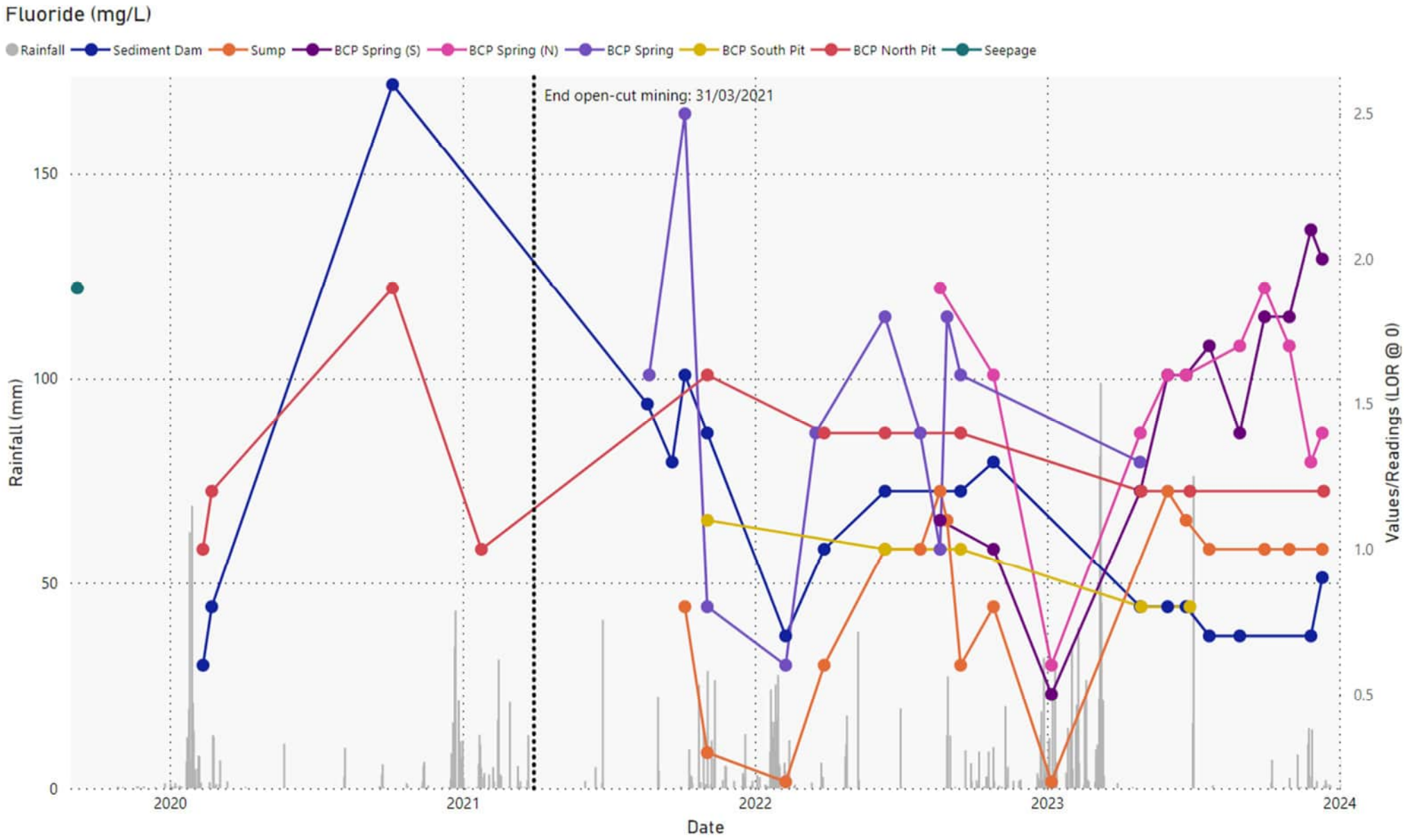

Nickel - total (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
0.02
0.01
0.00
Values/Readings (LOR @ 0)
2020
2021
2022
2023
2024
Date

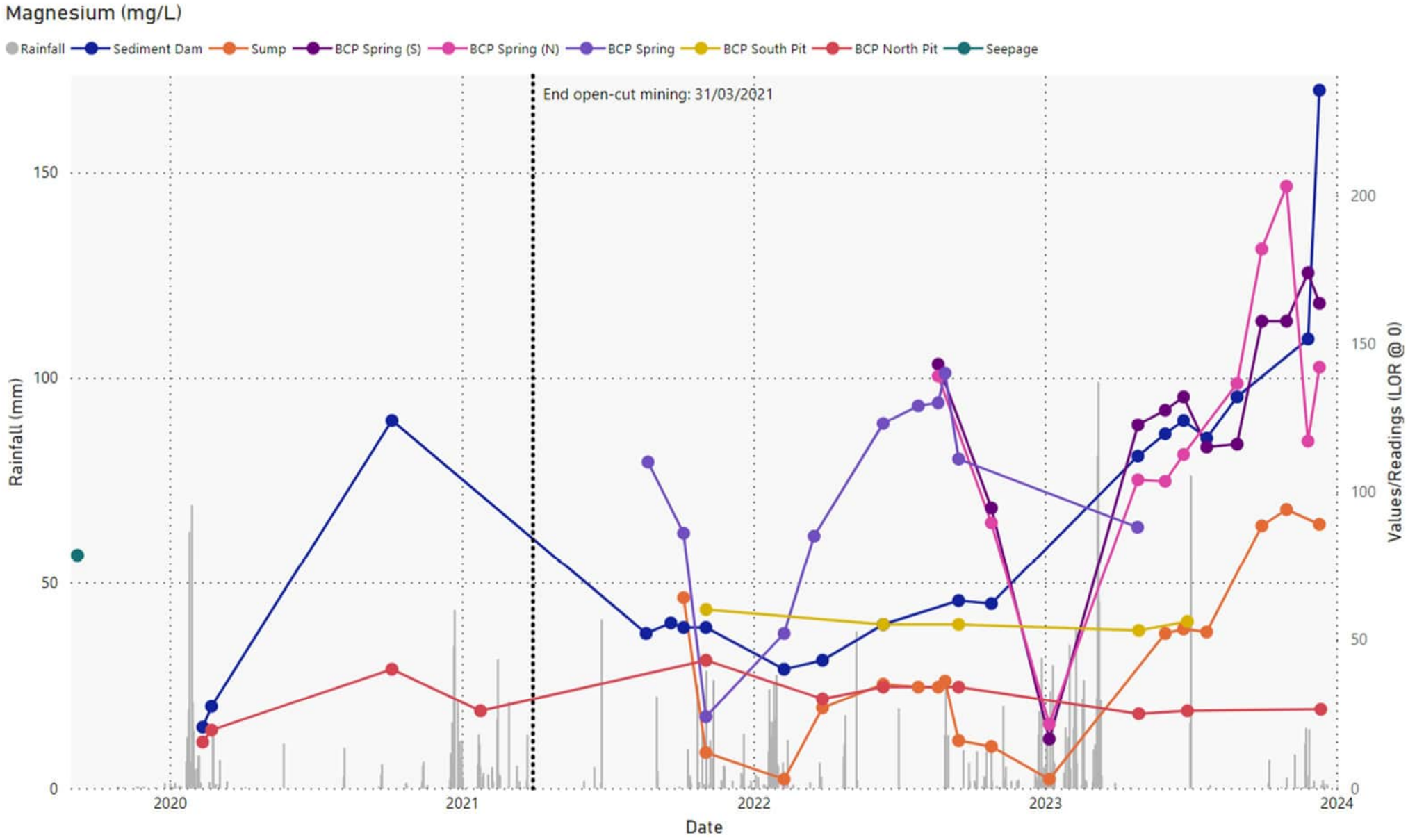

Selenium - total (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
2020
2021
2022
2023
2024

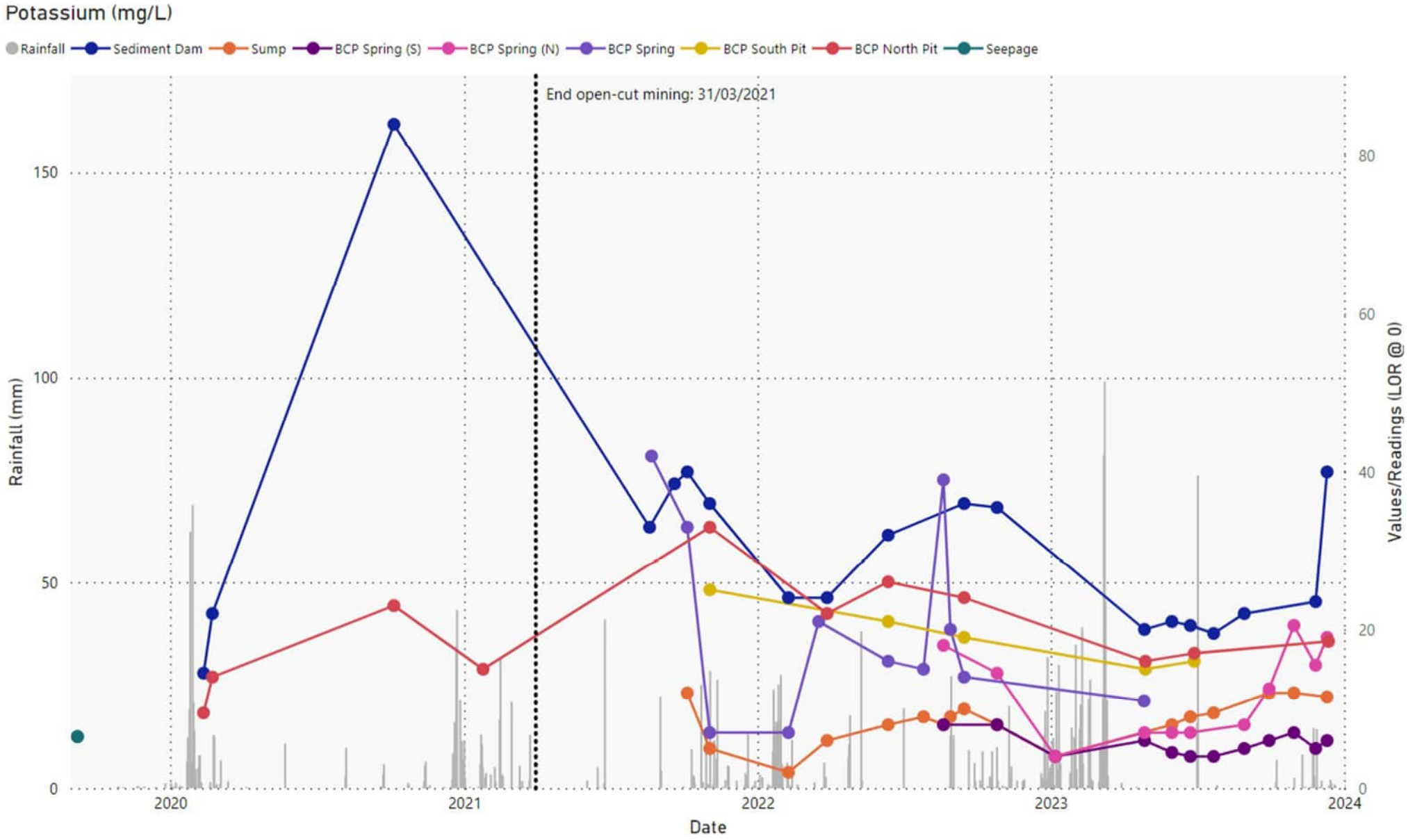

Uranium - total (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.02
0.04
0.06
0.08
2020
2021
2022
2023
2024

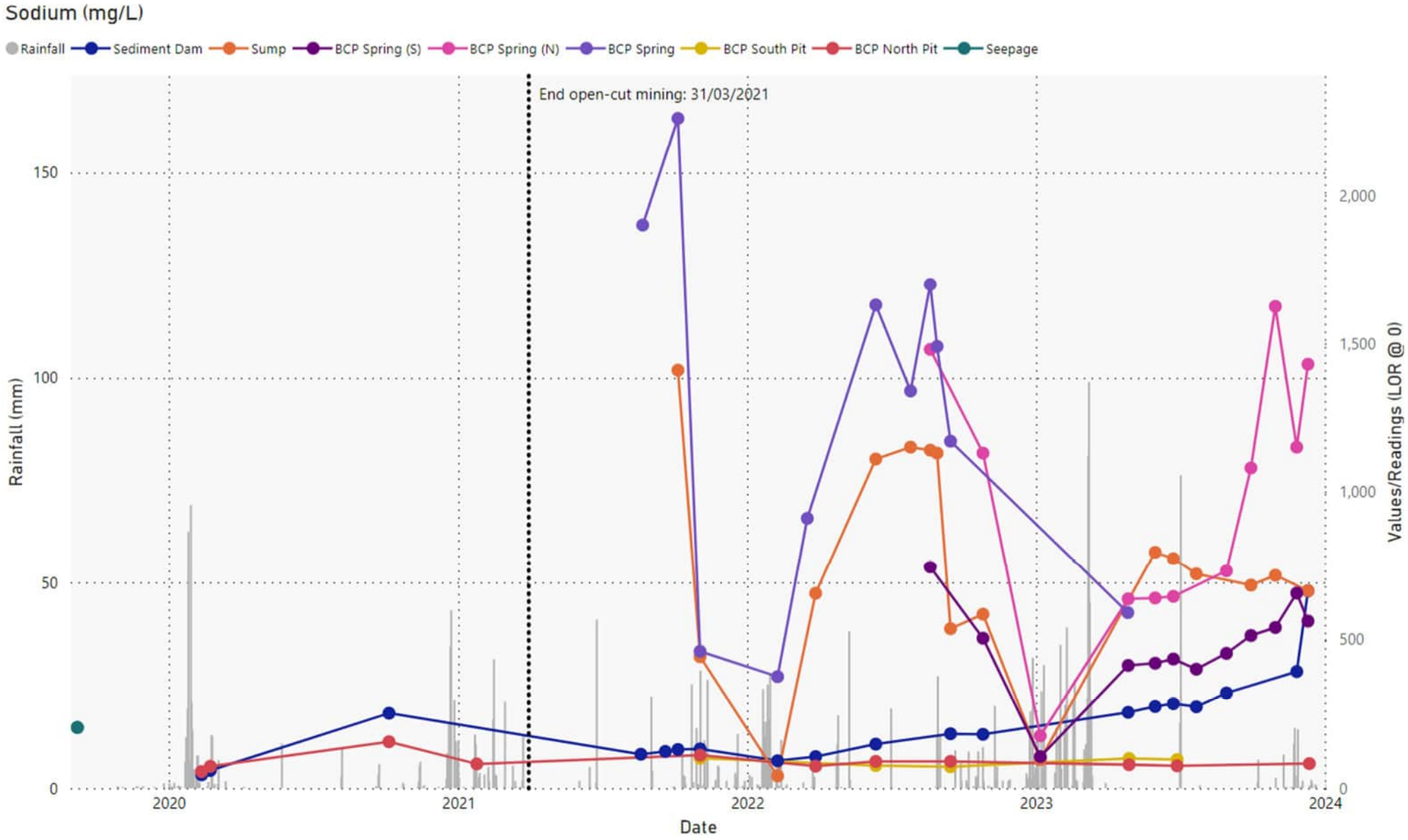

Calcium (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
200
250
300
350
2020
2021
2022
2023
2024


Chloride (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
200
400
600
800
1,000
2020
2021
2022
2023
2024

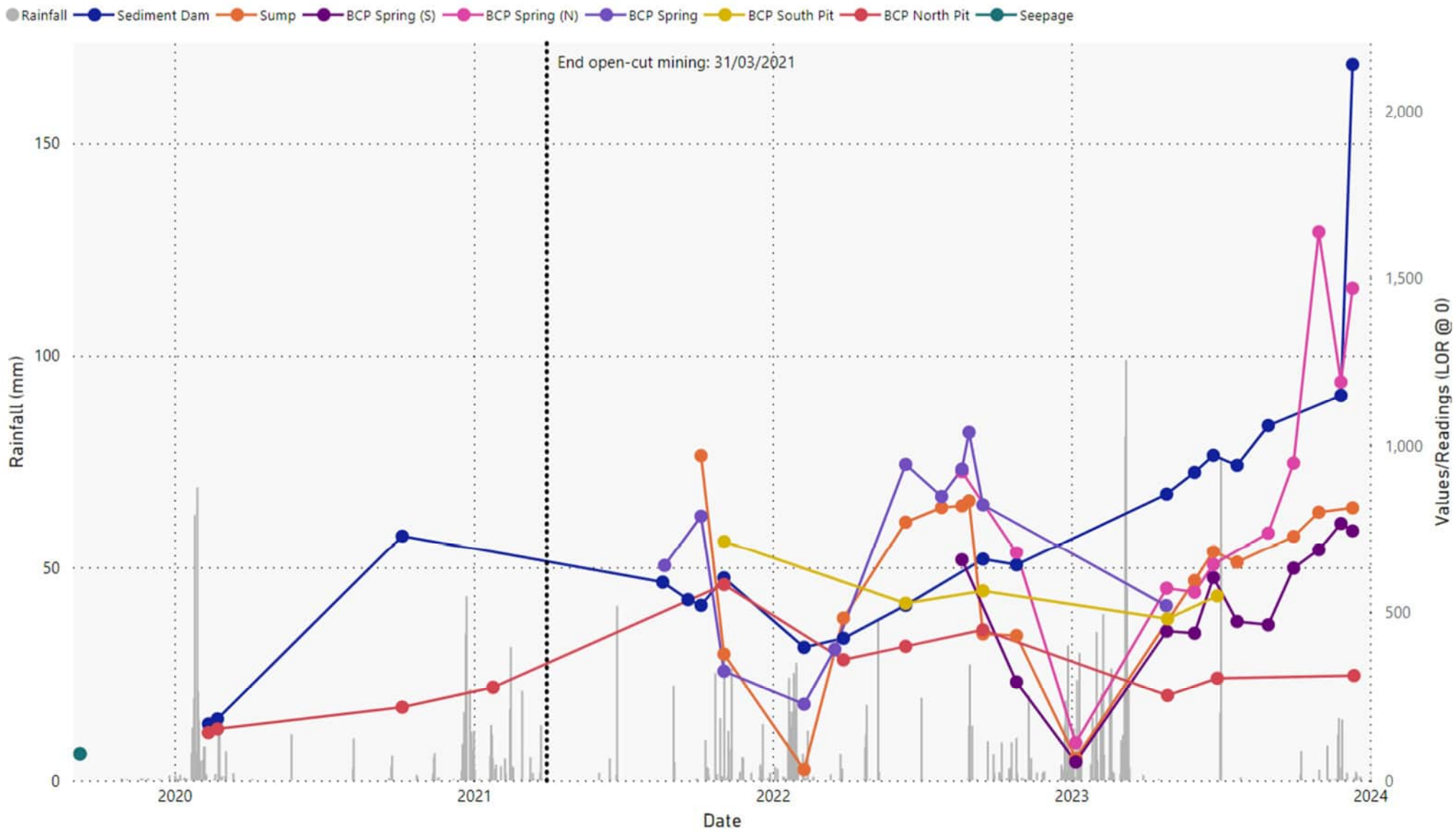

Fluoride (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.5
1.0
1.5
2.0
2.5
2020
2021
2022
2023
2024


Magnesium (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
200
2020
2021
2022
2023
2024

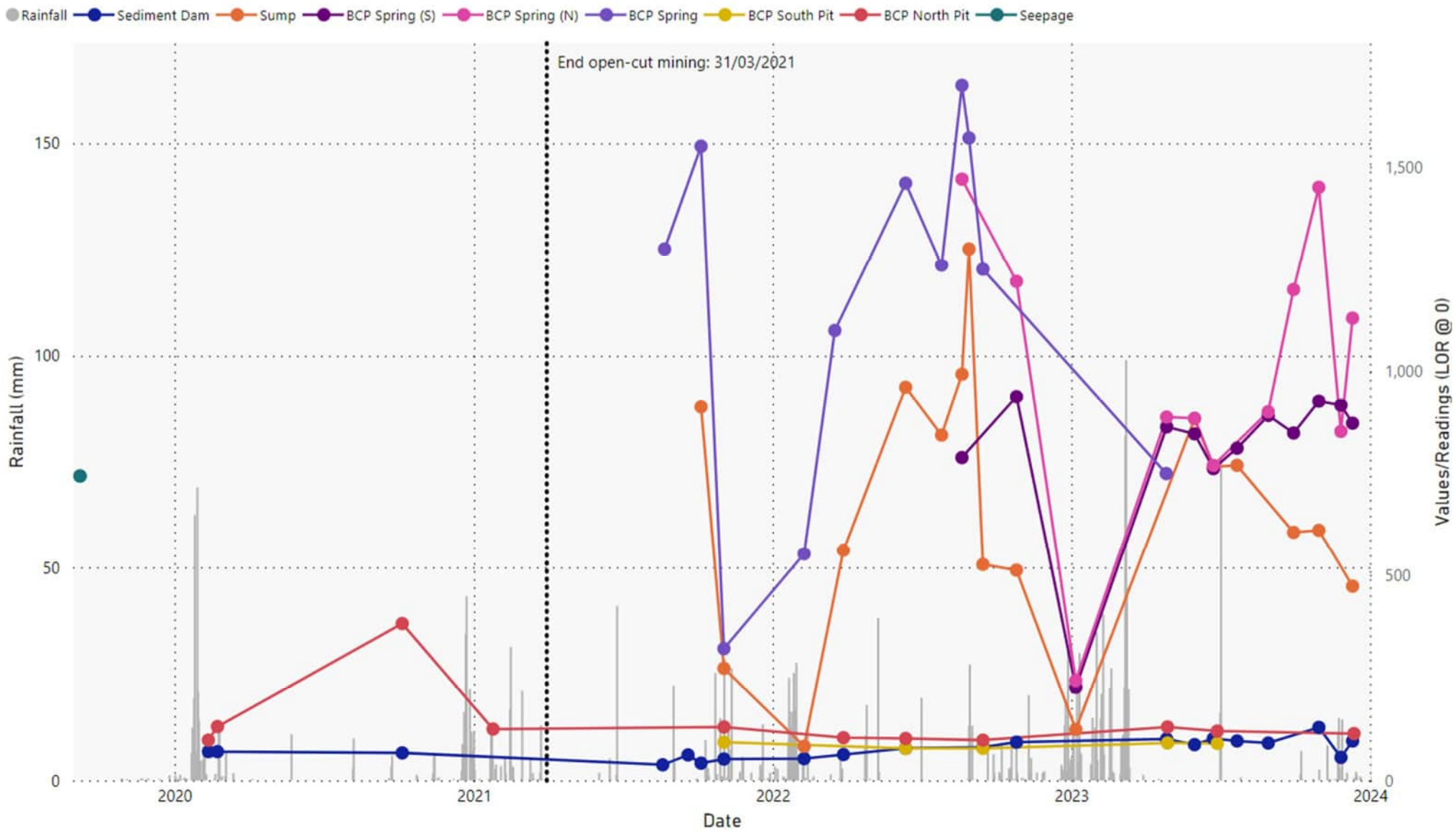

Potassium (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
20
40
60
80
2020
2021
2022
2023
2024

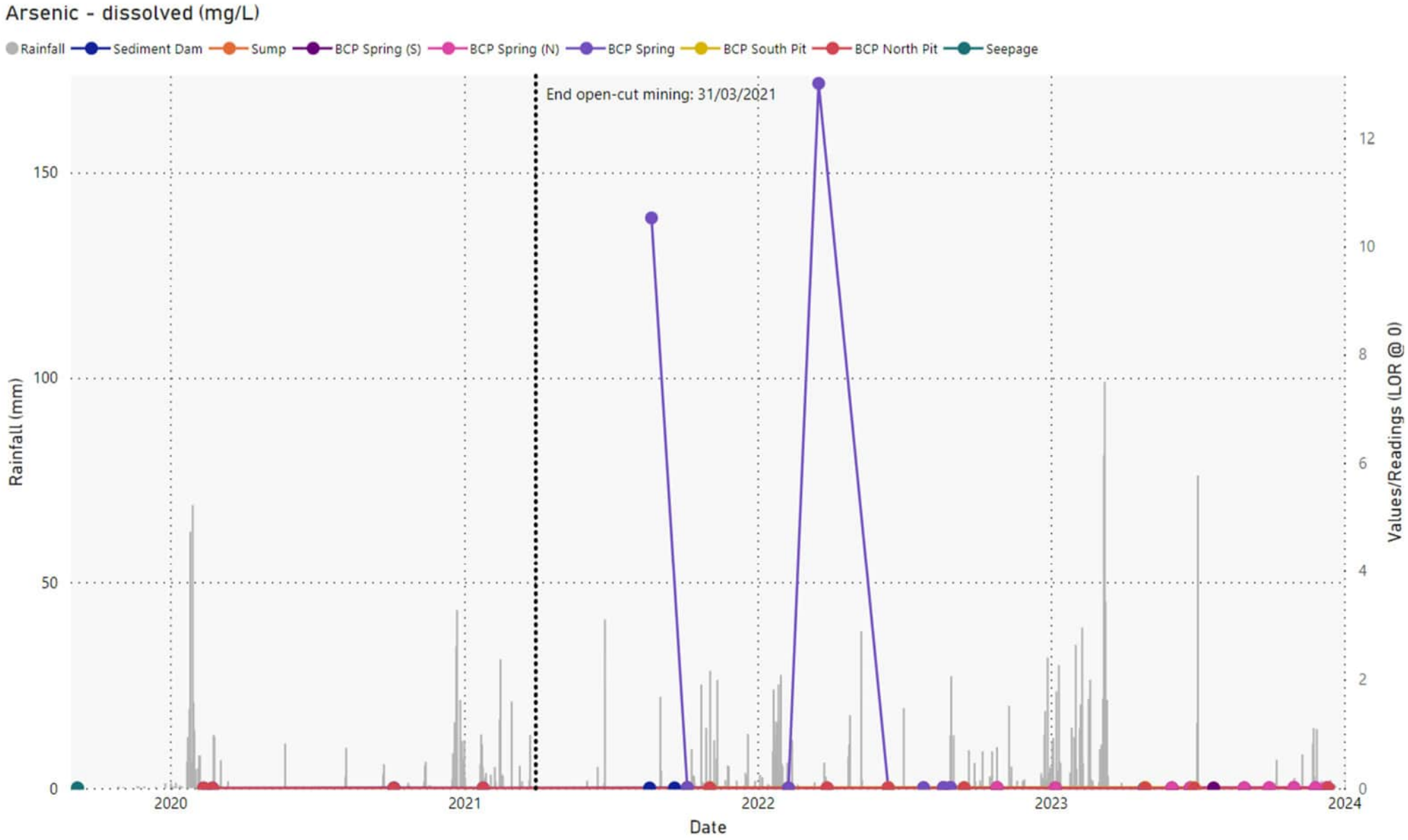

Sodium (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
500
1,000
1,500
2,000
2020
2021
2022
2023
2024

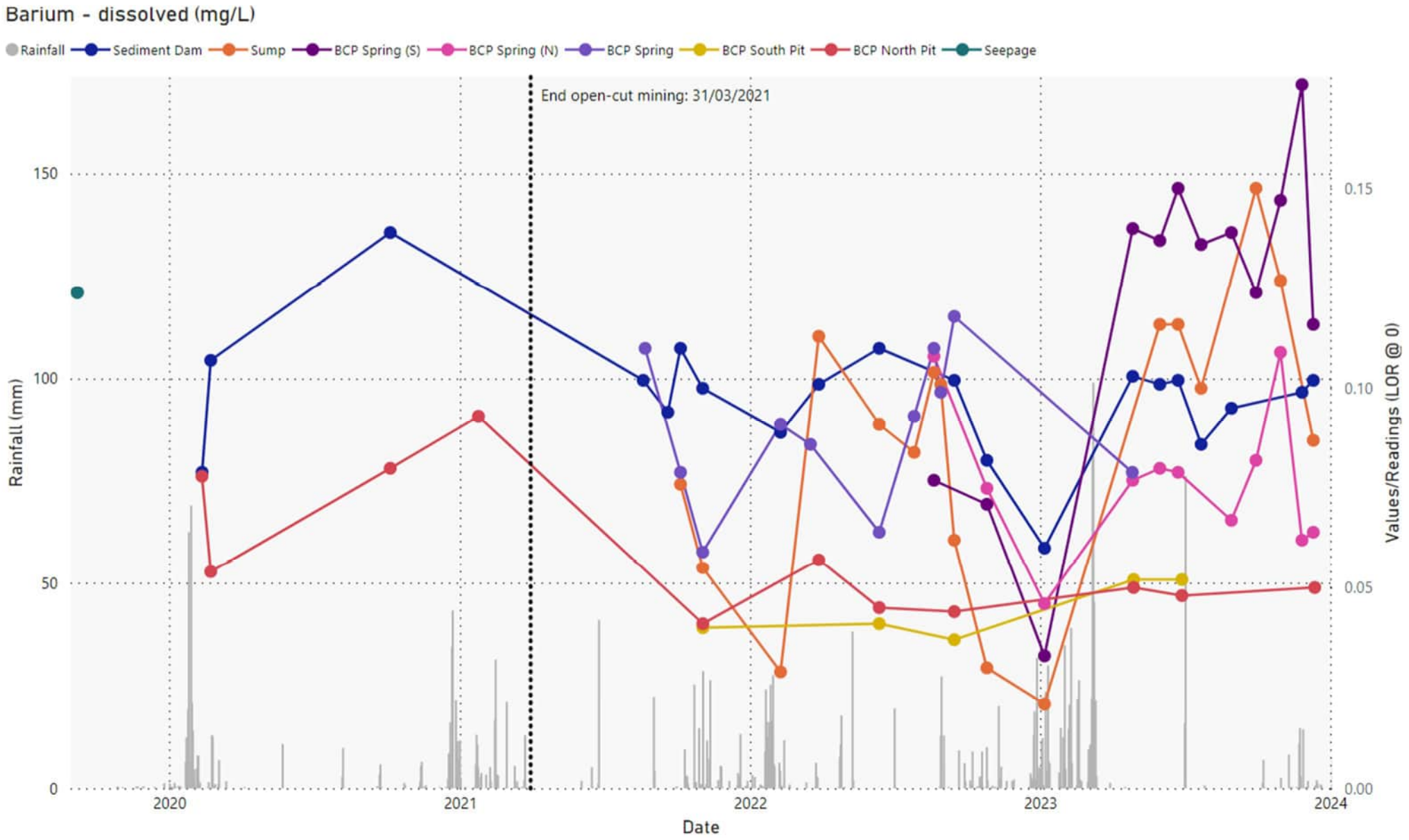
Sulfate (as SO4)

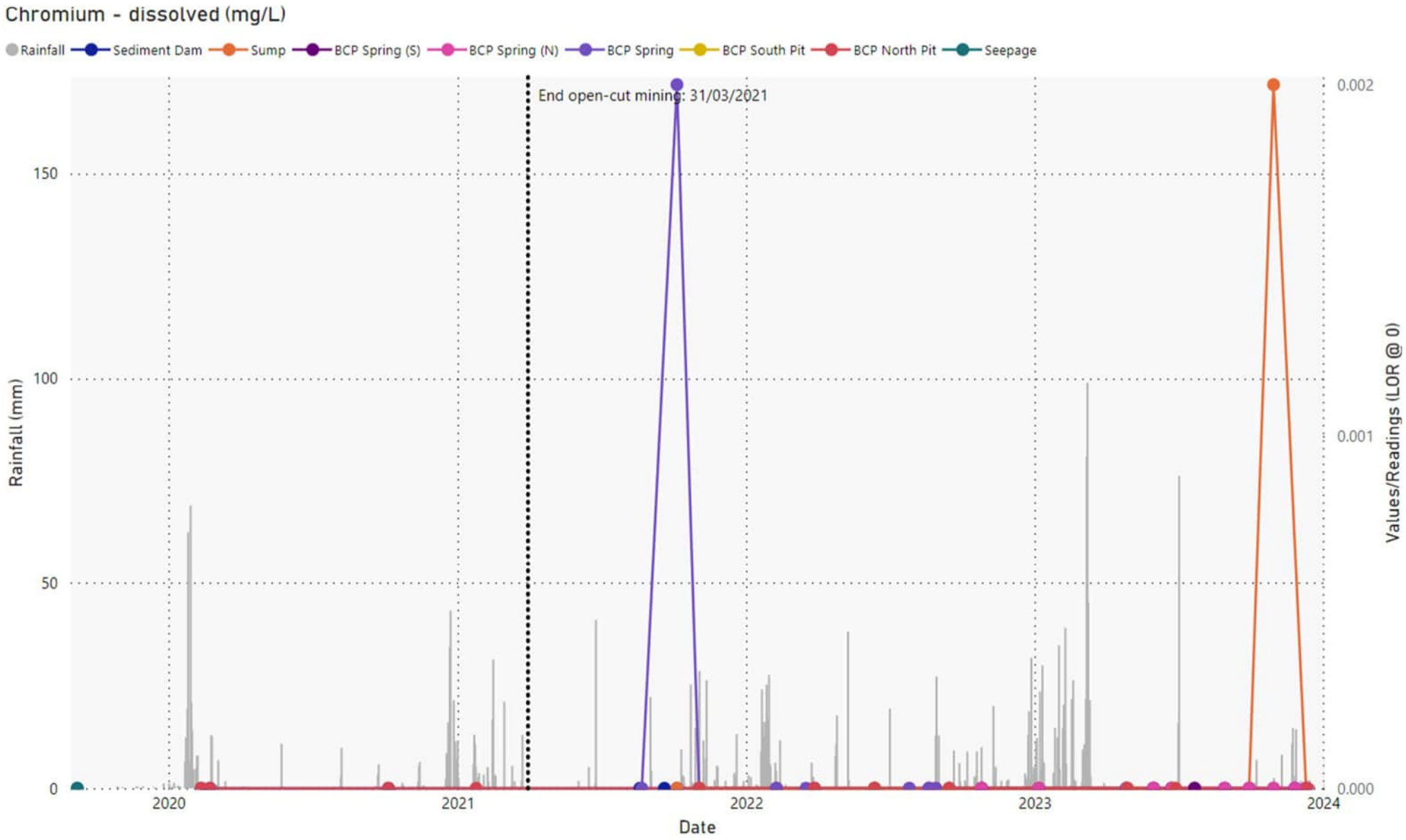


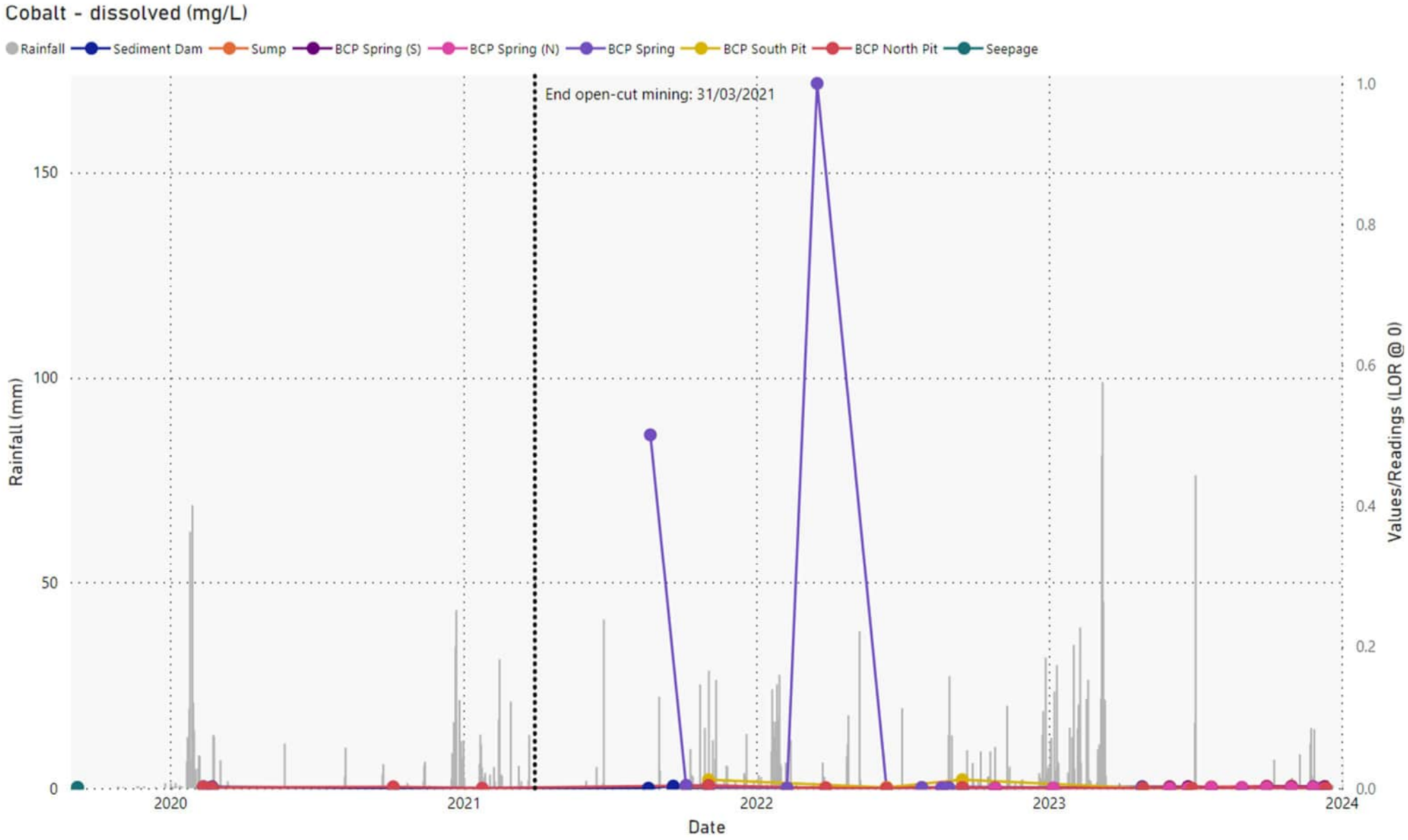
Bicarbonate Alkalinity as CaCO3 (mg/L)

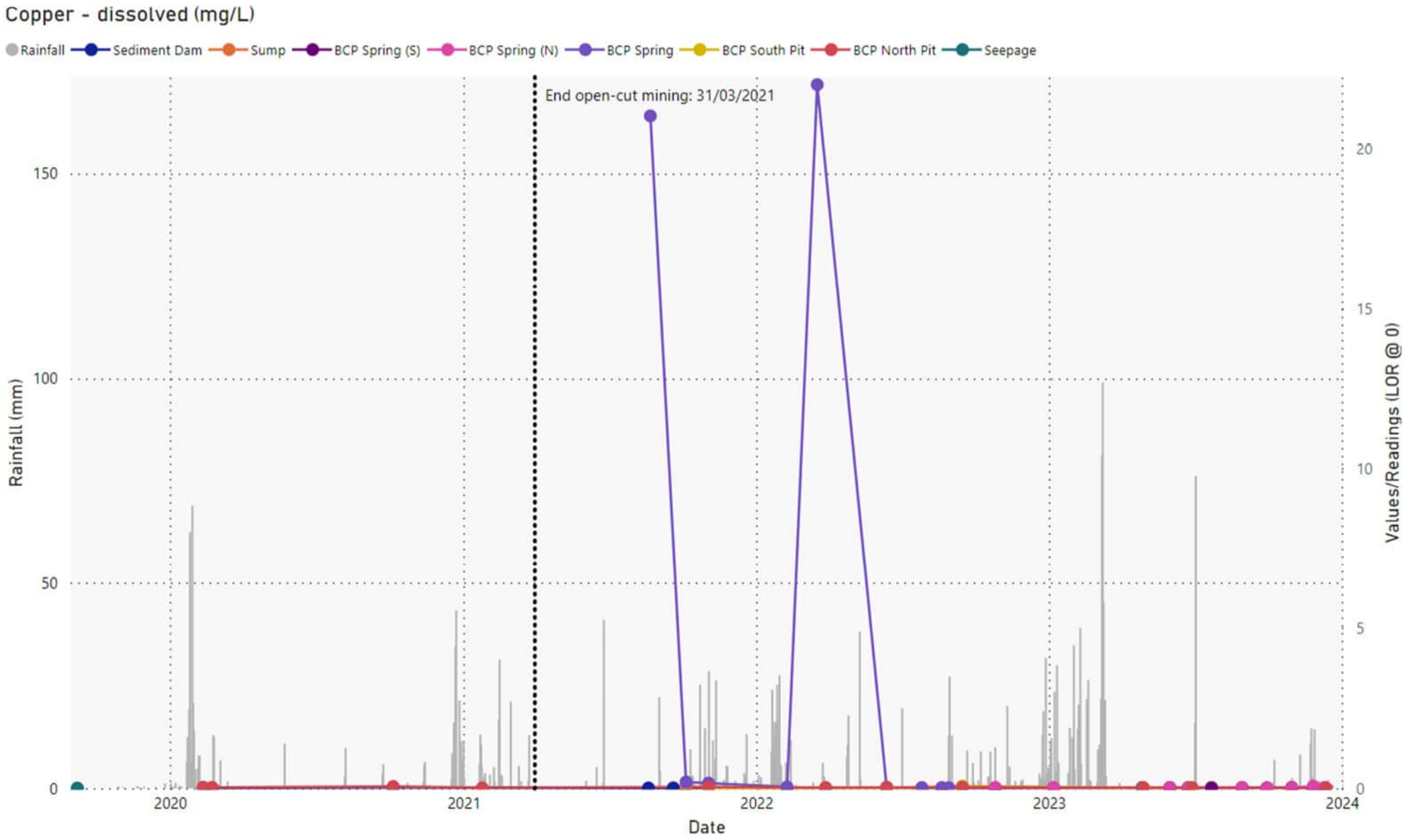



Arsenic - dissolved (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
Values/Readings (LOR @ 0)
12
10
8
6
4
2
0
2020
2021
2022
2023
2024
Date

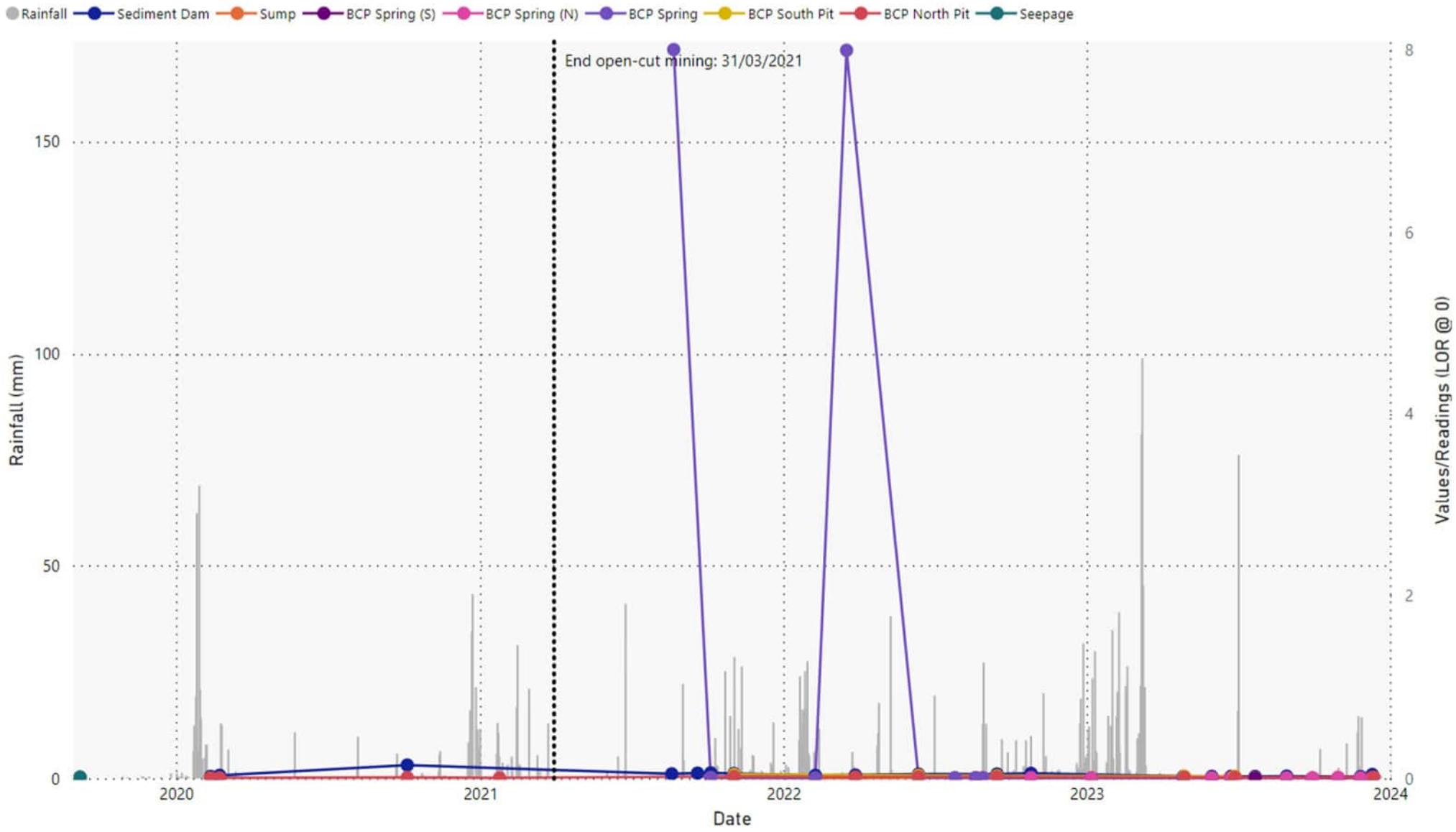

Barium - dissolved (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.05
0.10
0.15
2020
2021
2022
2023
2024

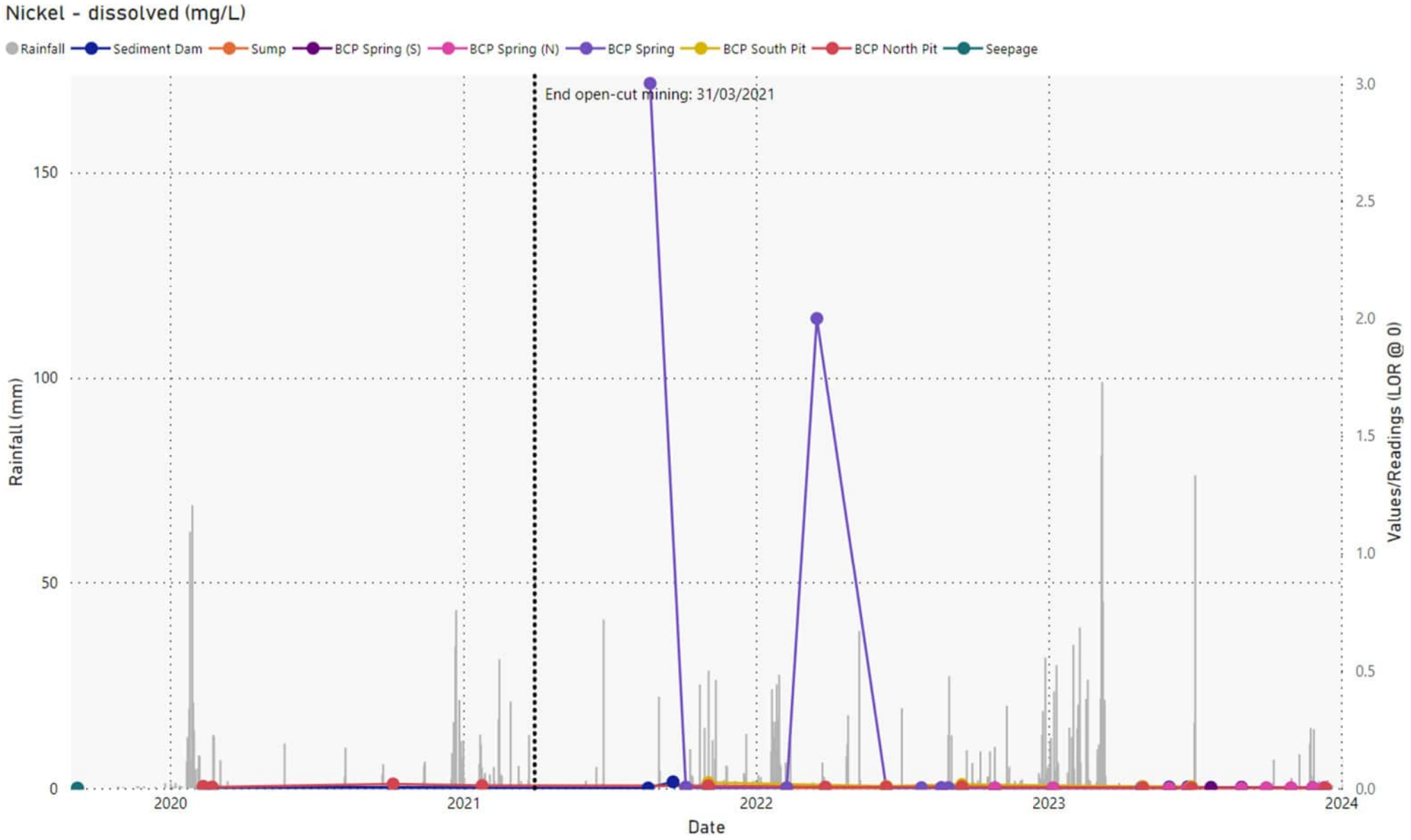

Chromium - dissolved (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
0.002
0.001
0.000
Values/Readings (LOR @ 0)
2020
2021
2022
2023
2024
Date

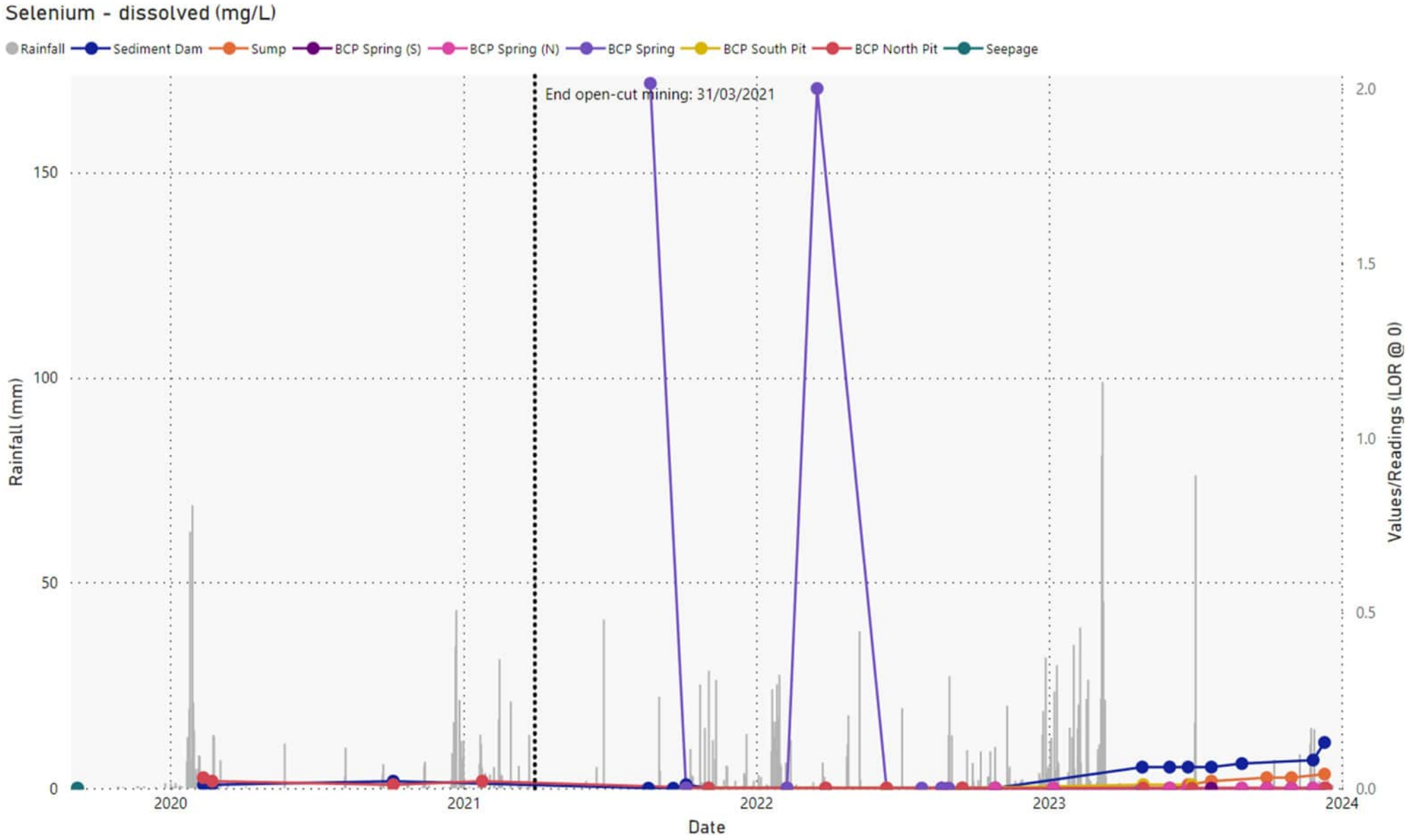

Cobalt - dissolved (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.0
0.2
0.4
0.6
0.8
1.0
2020
2021
2022
2023
2024

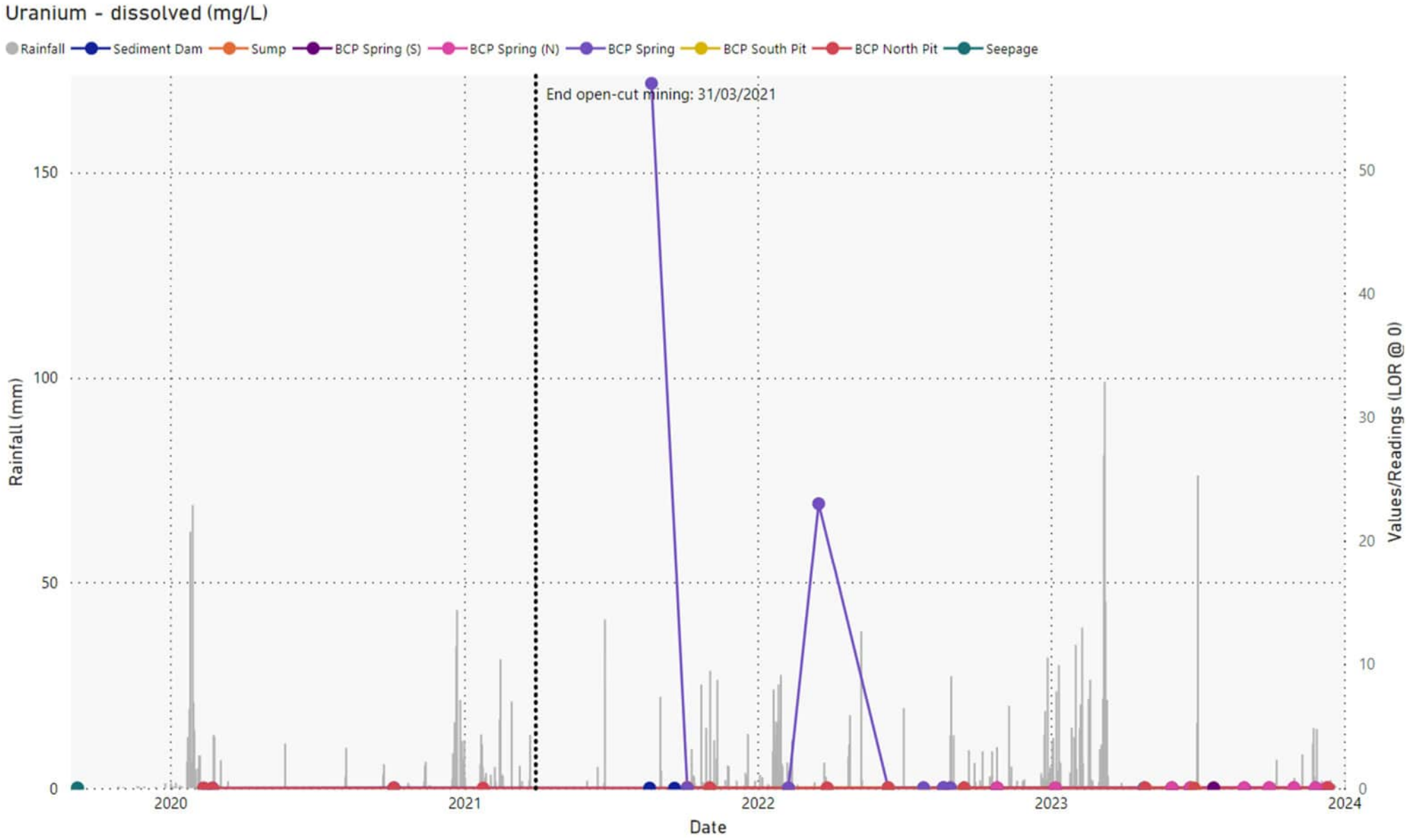

Copper - dissolved (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
5
10
15
20
2020
2021
2022
2023
2024

Molybdenum - dissolved (mg/L)



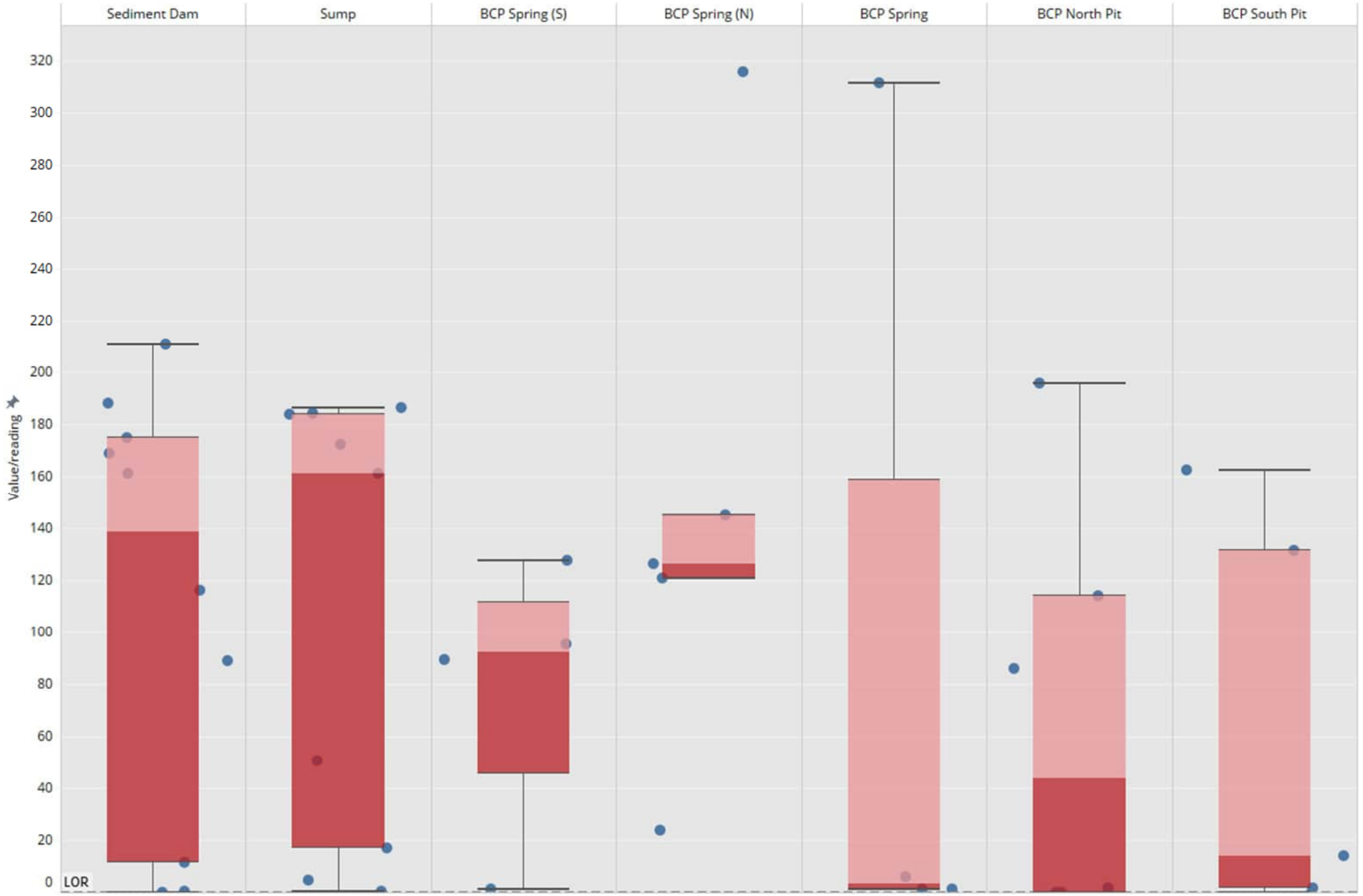

Nickel - dissolved (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.0
0.5
1.0
1.5
2.0
2.5
3.0
2020
2021
2022
2023
2024


Selenium - dissolved (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.0
0.5
1.0
1.5
2.0
2020
2021
2022
2023
2024

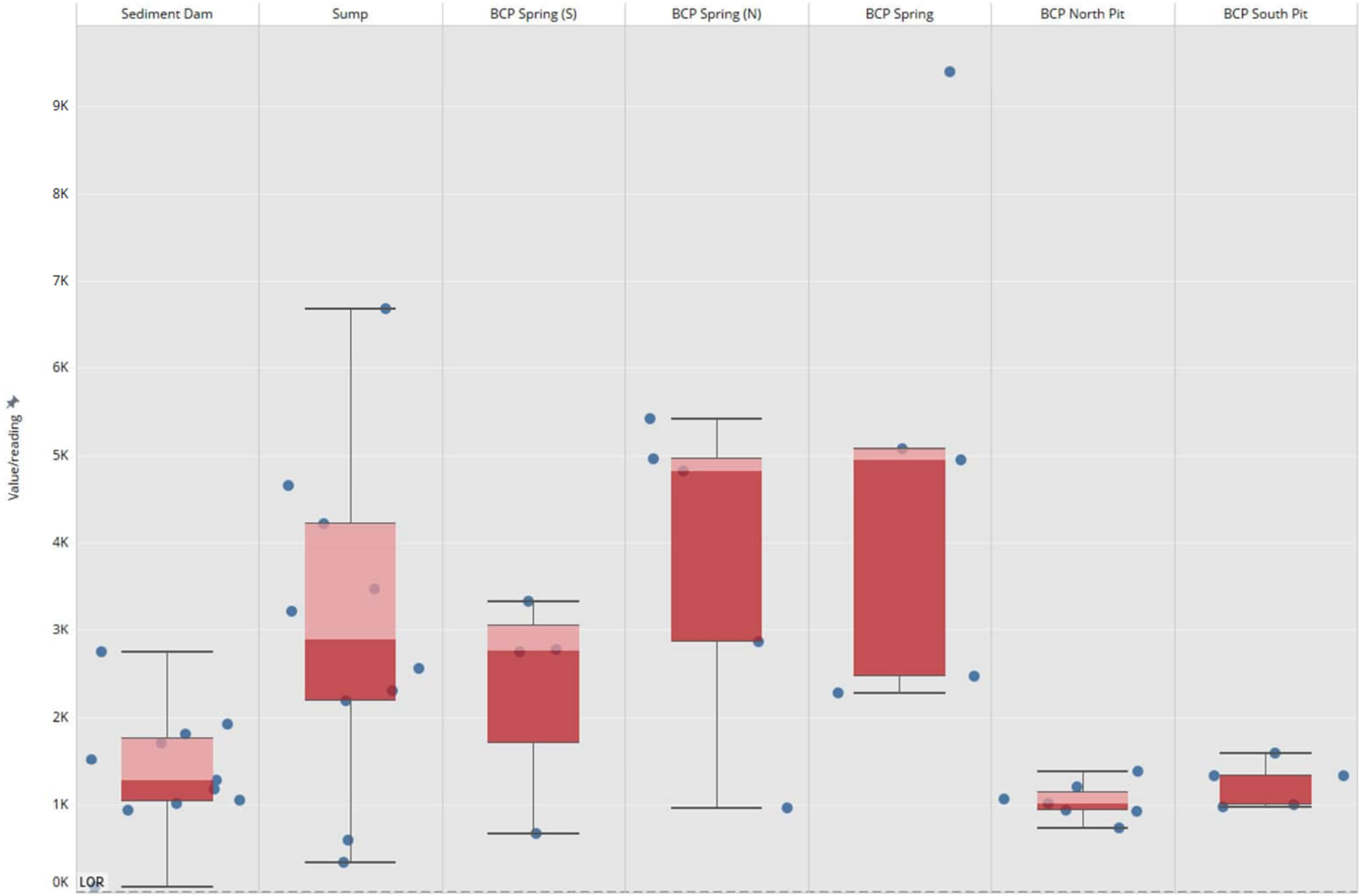

Uranium - dissolved (mg/L)
Rainfall
Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP South Pit
BCP North Pit
Seepage
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
150
100
50
0
50
40
30
20
10
0
2020
2021
2022
2023
2024
Date

F.3 Water quality box & whisker plots

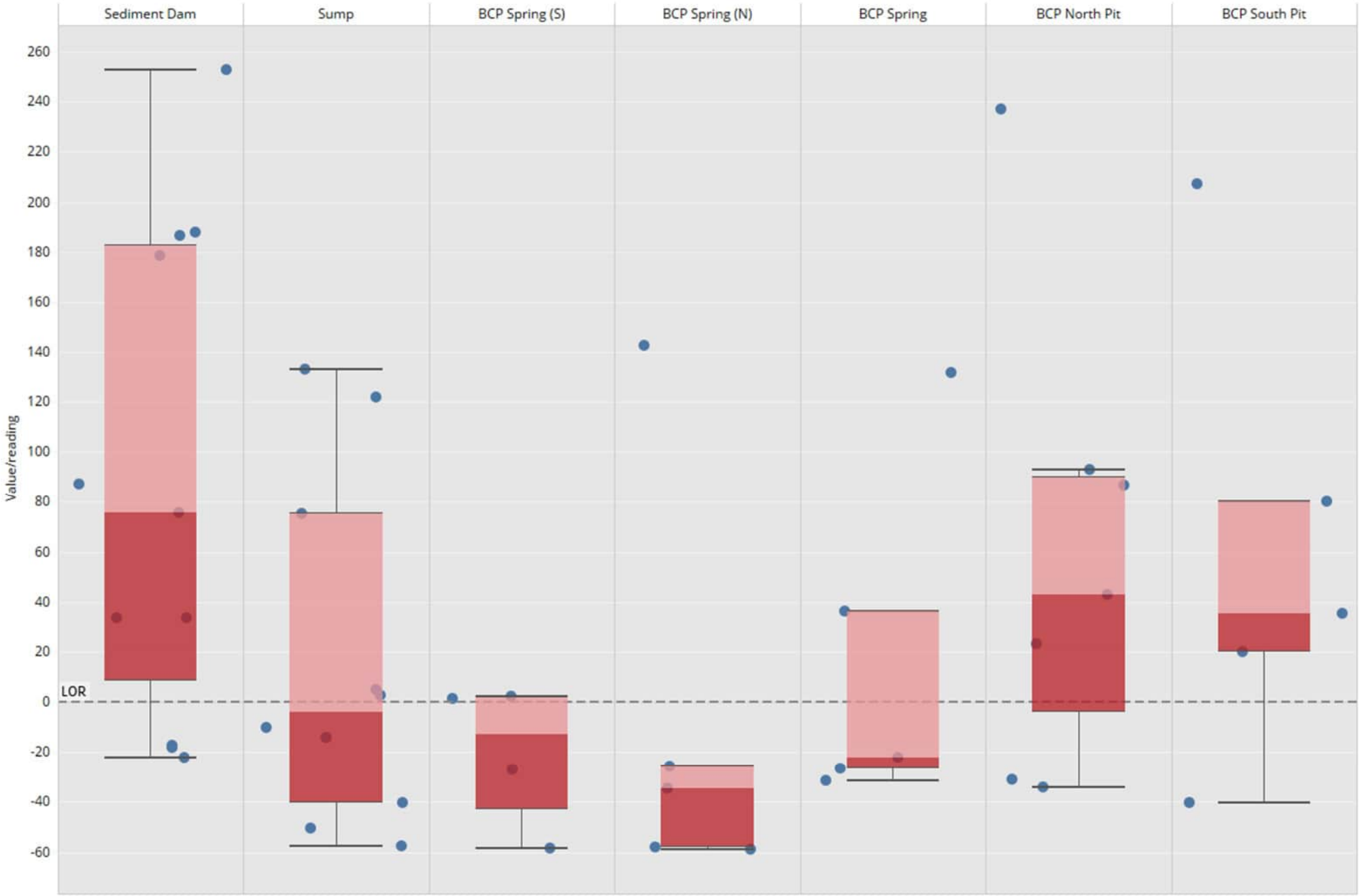
Dissolved Oxygen (field) (% sat)



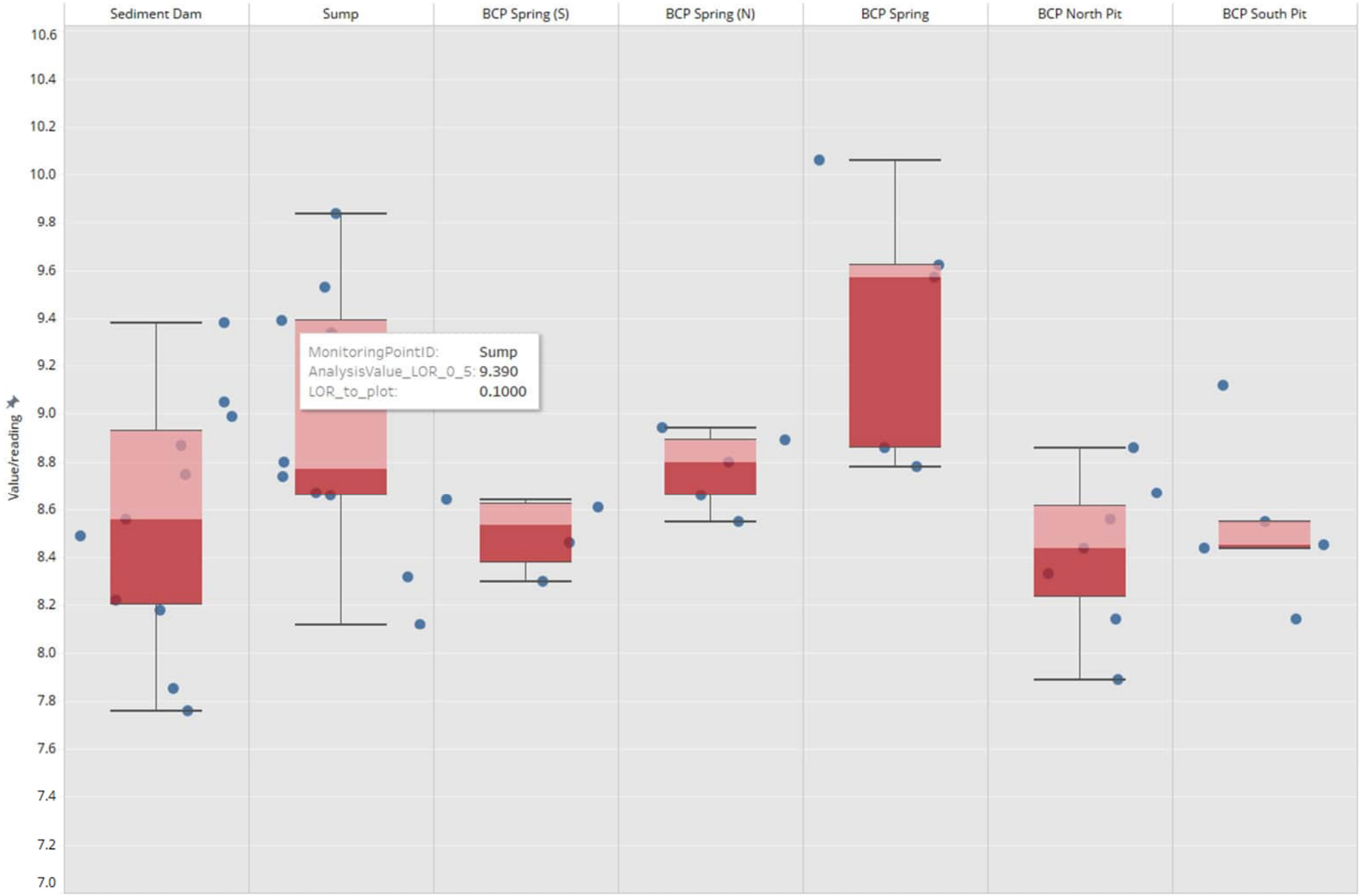
Electrical Conductivity (field) (µS/cm)



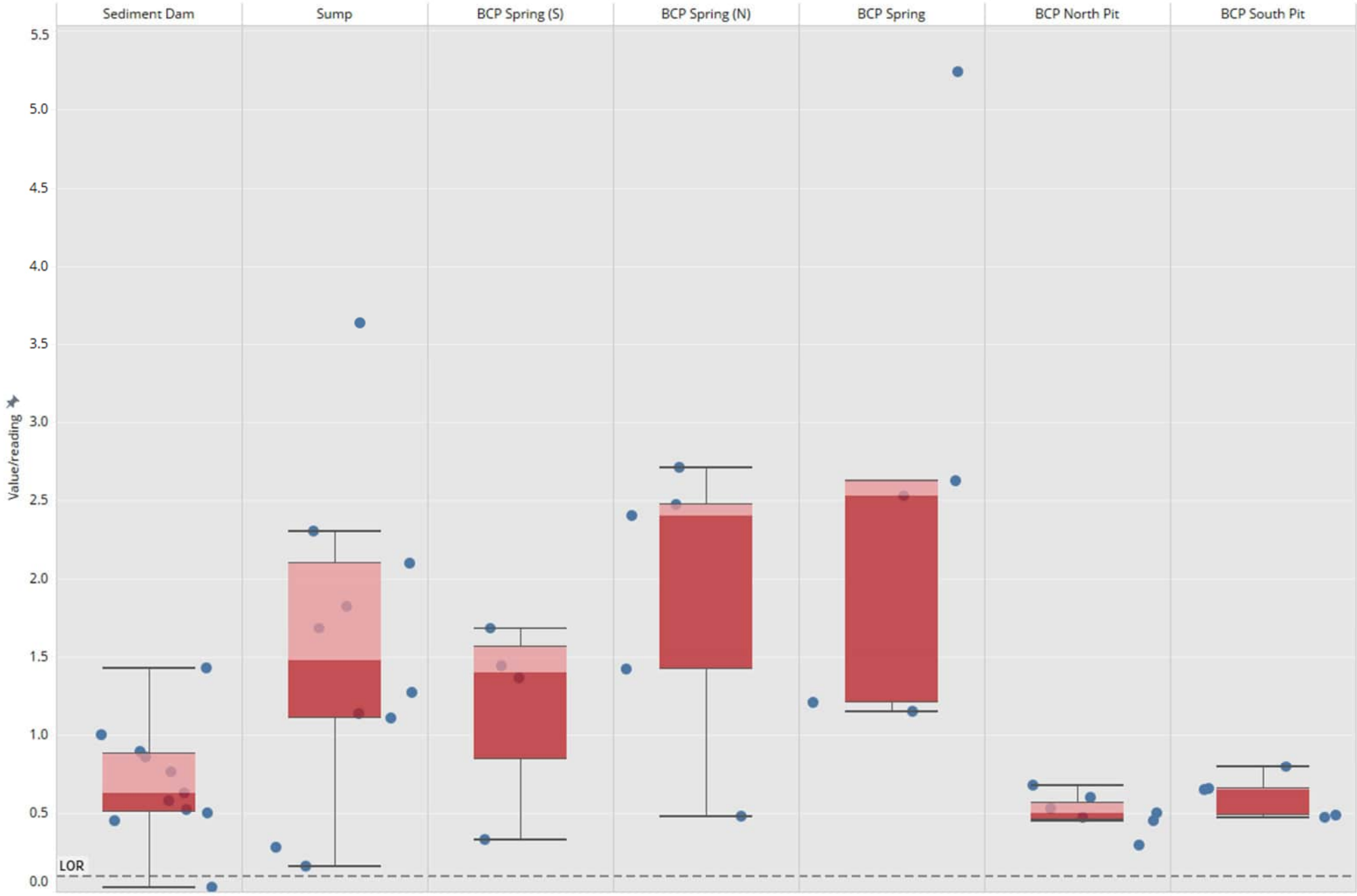
ORP (field) (mV)


Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP North Pit
BCP South Pit
Value/reading
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
LOR

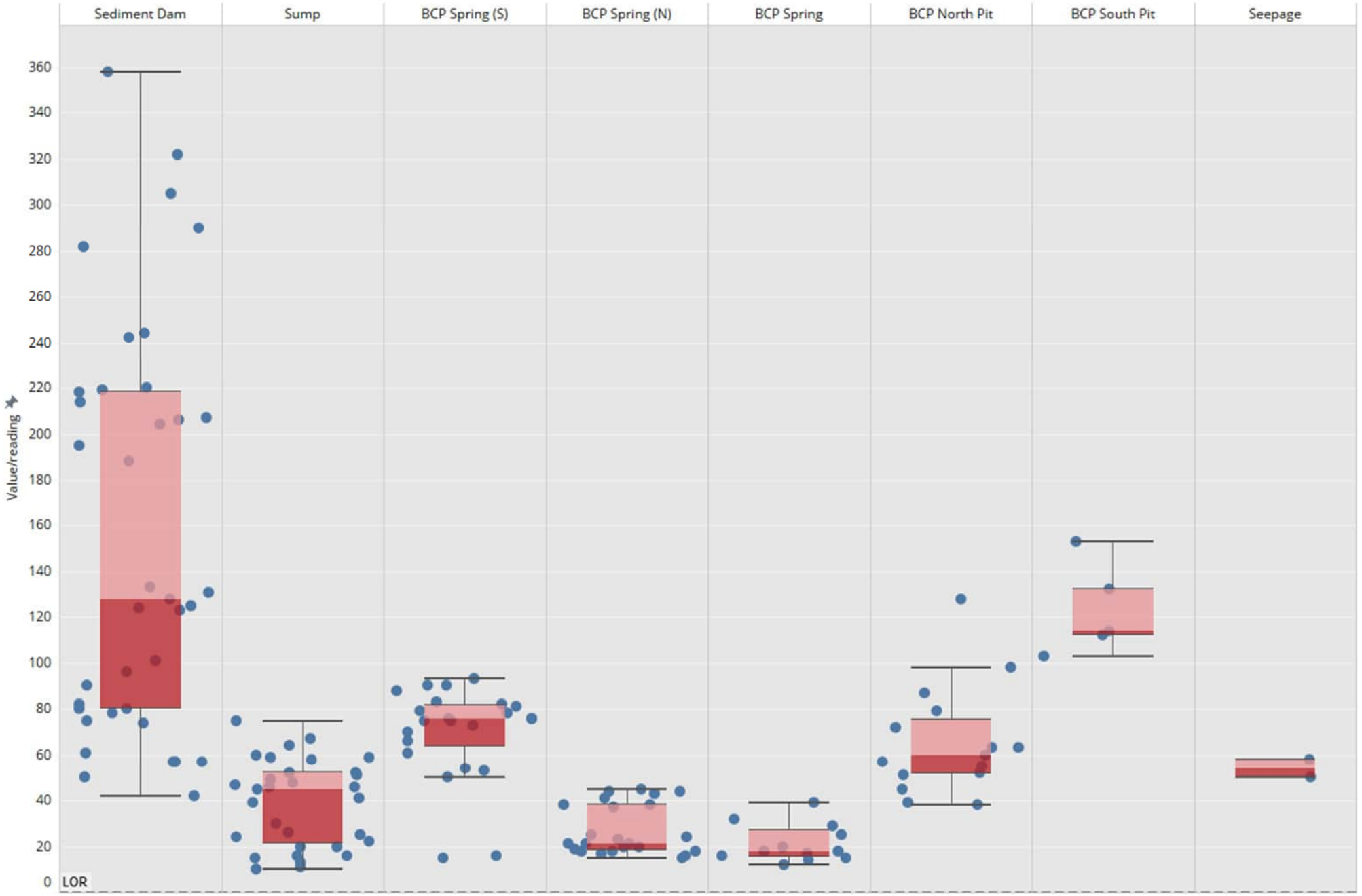
pH (field)


Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP North Pit
BCP South Pit
Value/reading
10.6
10.4
10.2
10.0
9.8
9.6
9.4
9.2
9.0
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0
MonitoringPointID: Sump
AnalysisValue_LOR_0_5: 9.390
LOR_to_plot: 0.1000

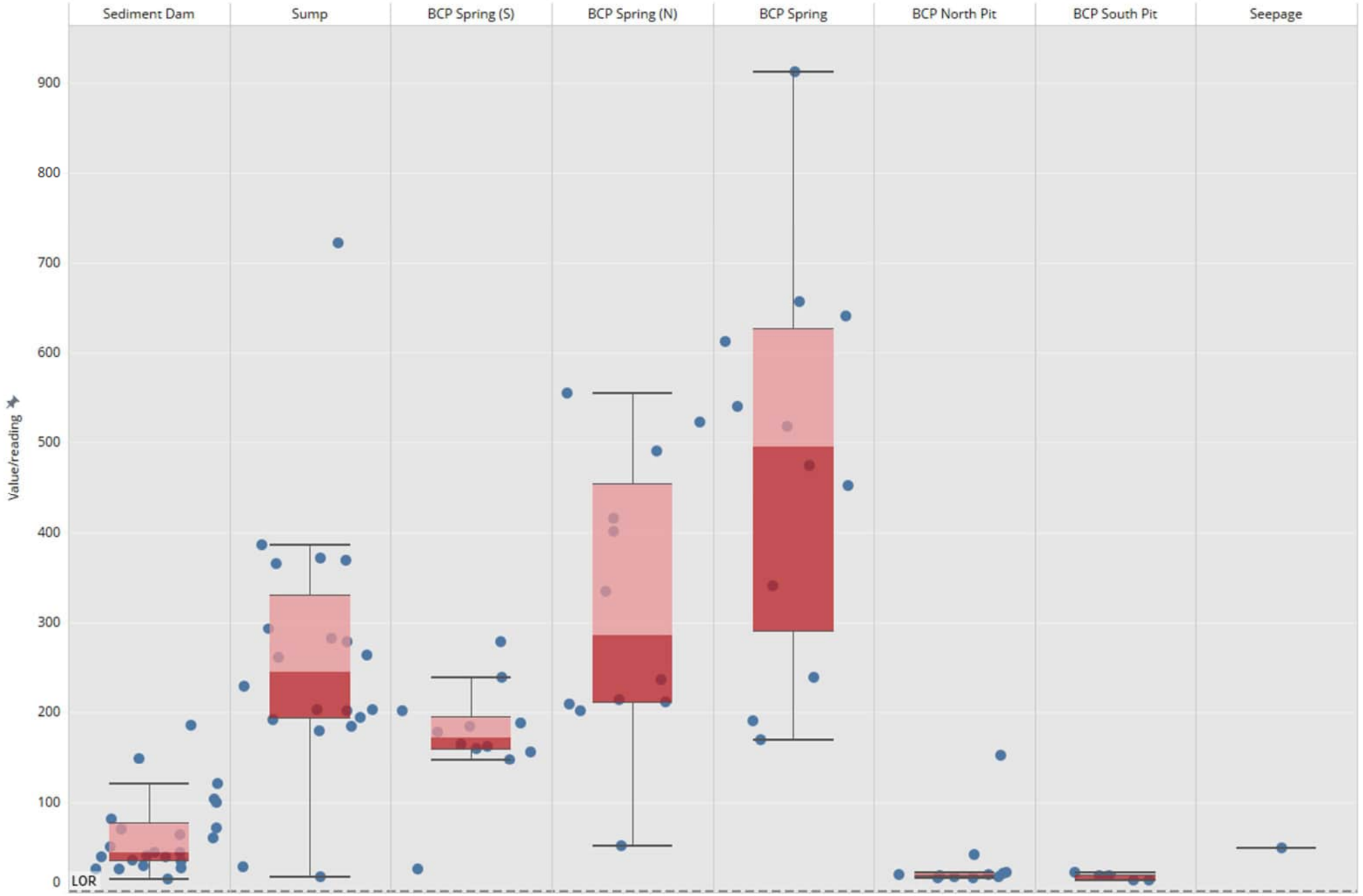
Salinity (field) (PSU)



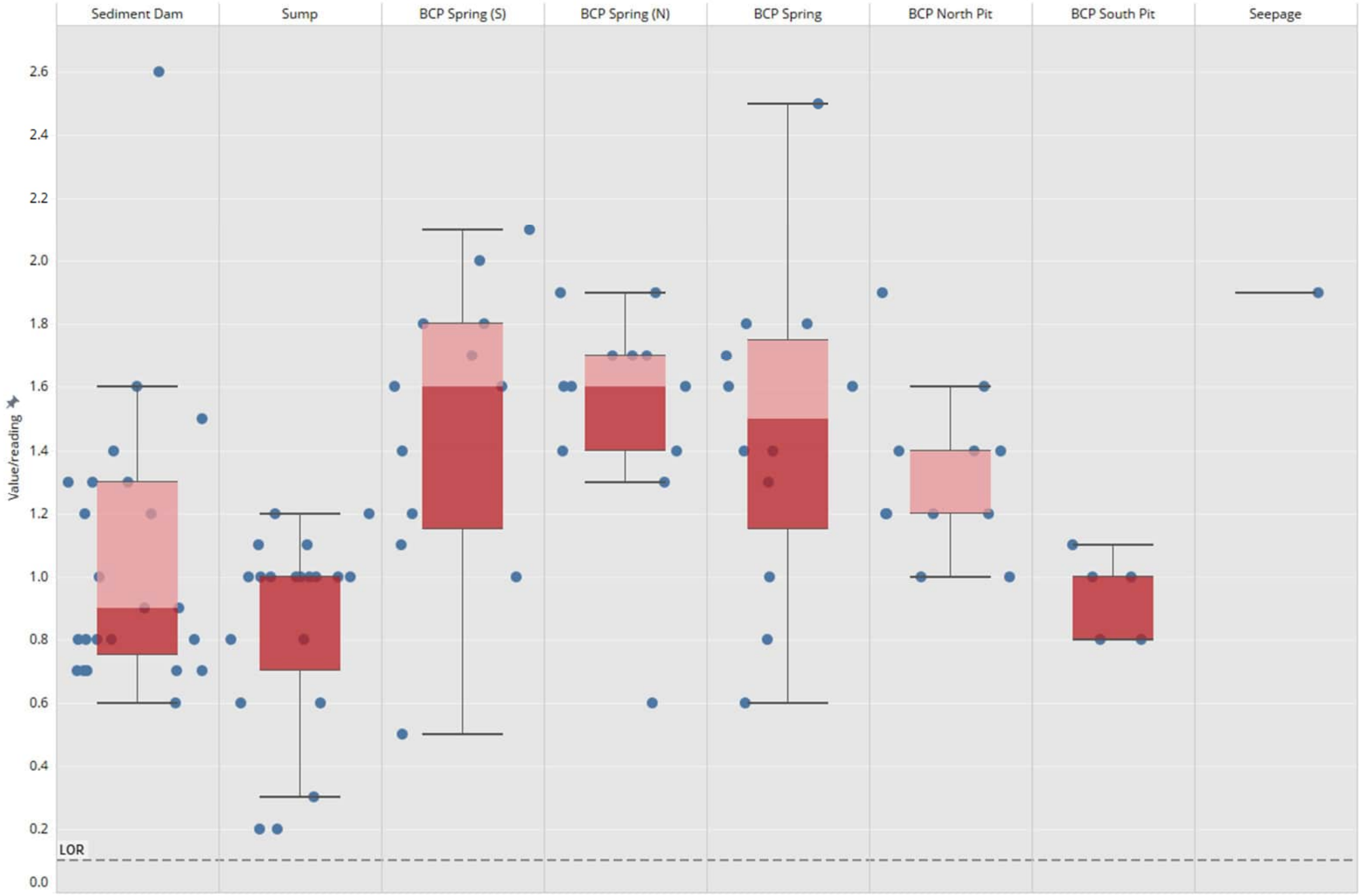
Calcium (mg/L)


Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP North Pit
BCP South Pit
Seepage
Value/reading
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
LOR

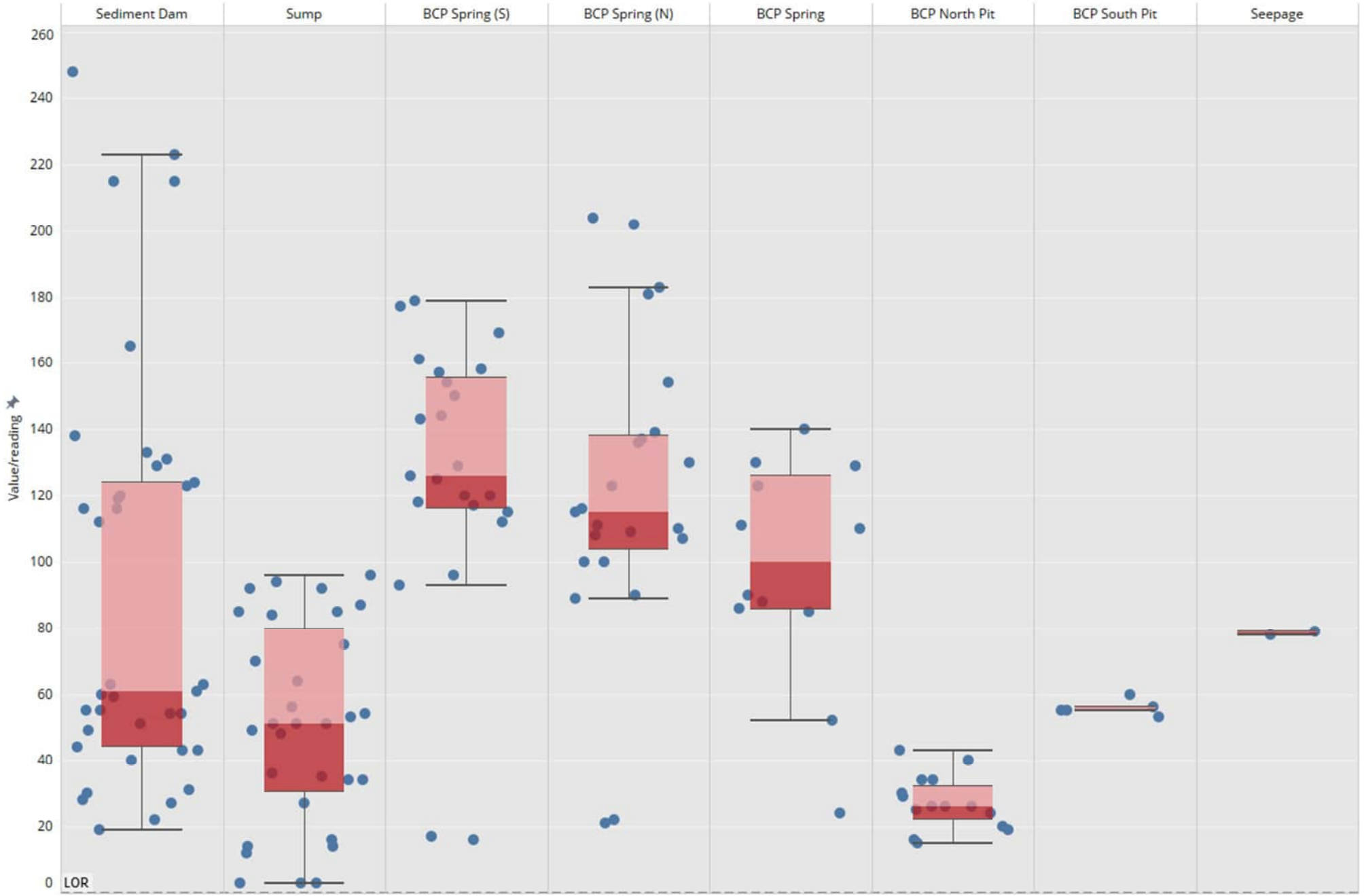
Chloride (mg/L)



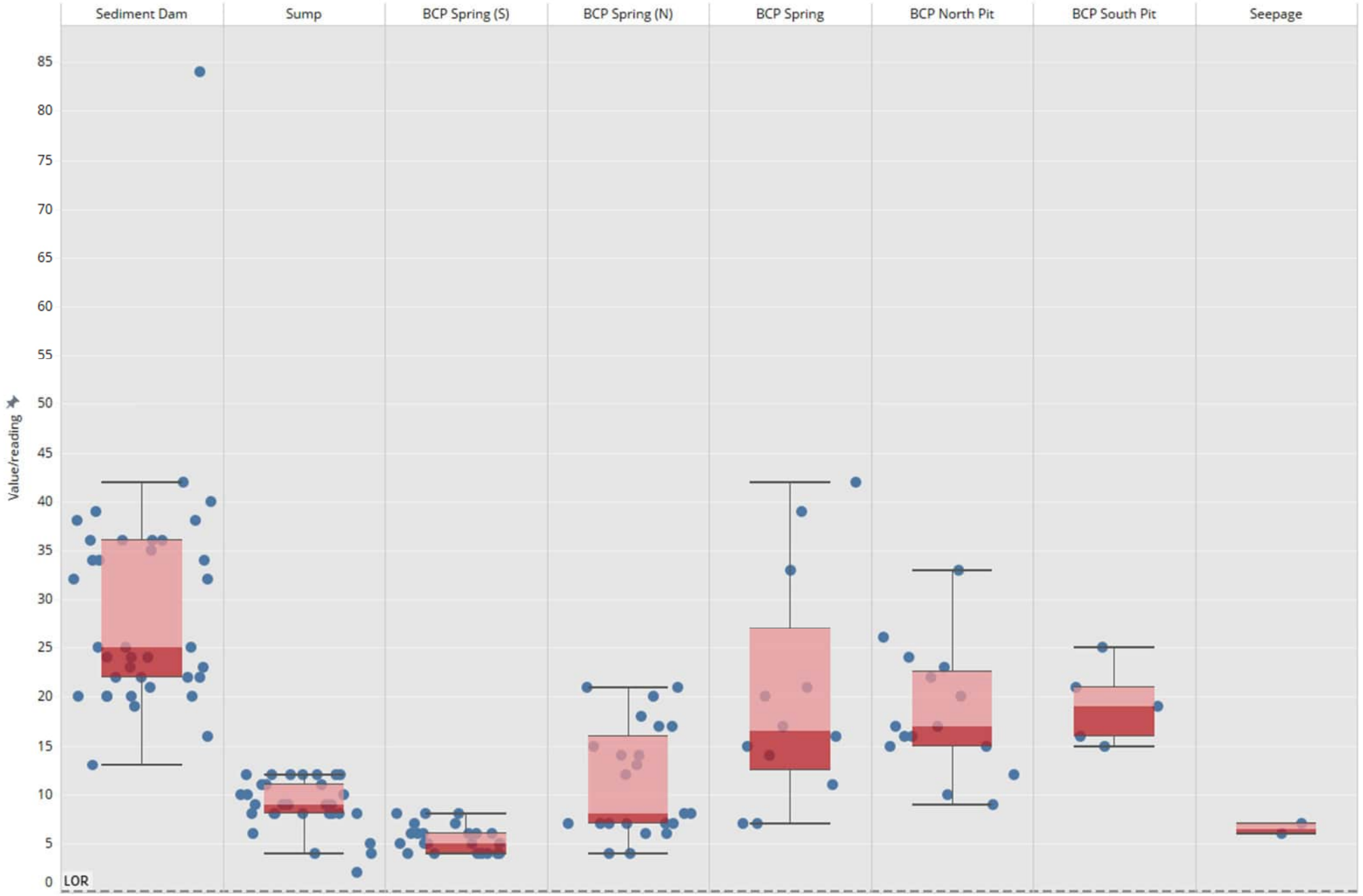
Fluoride (mg/L)



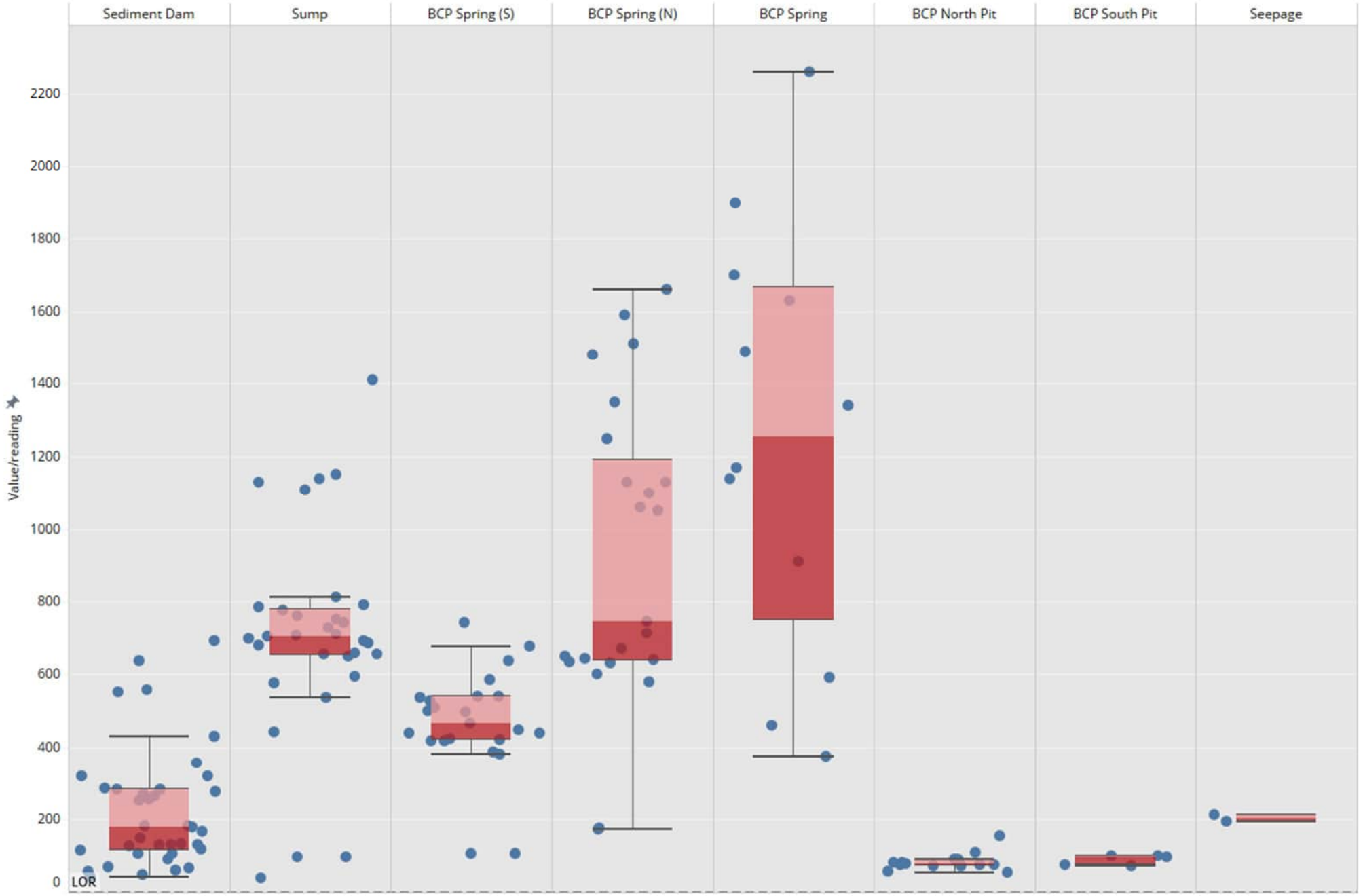
Magnesium (mg/L)



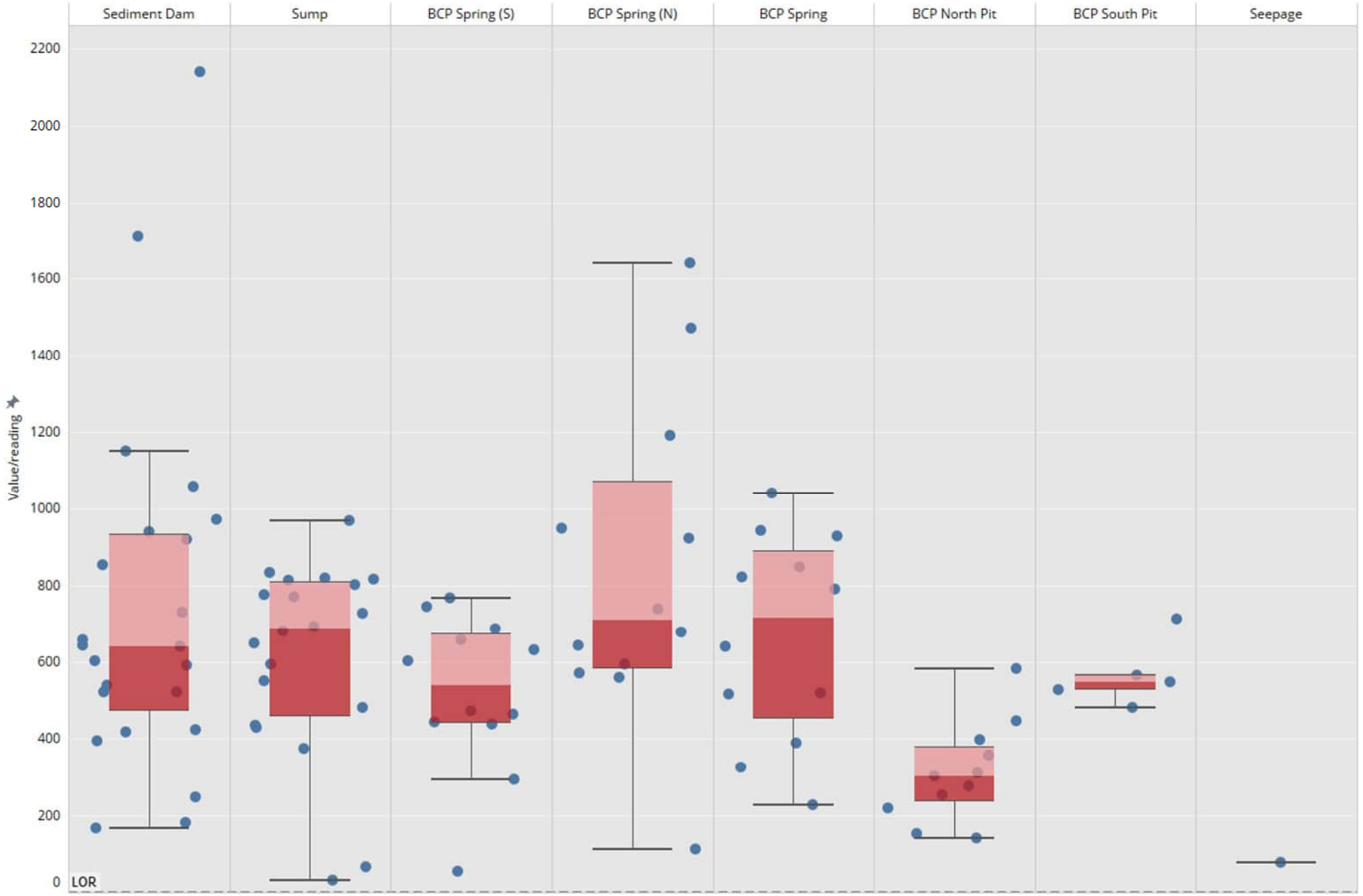
Potassium (mg/L)



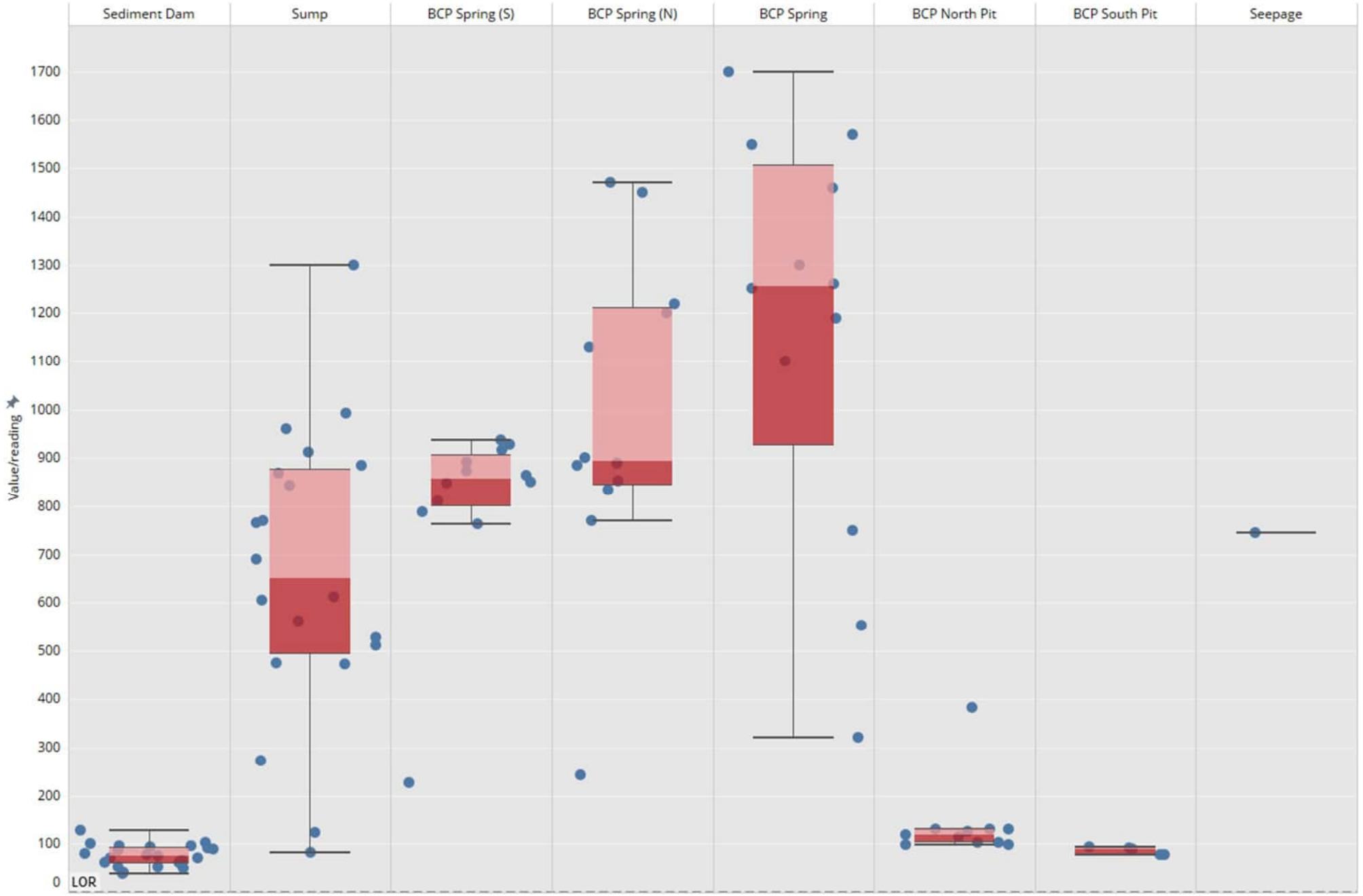
Sodium (mg/L)


Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP North Pit
BCP South Pit
Seepage
Value/reading
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
LOR

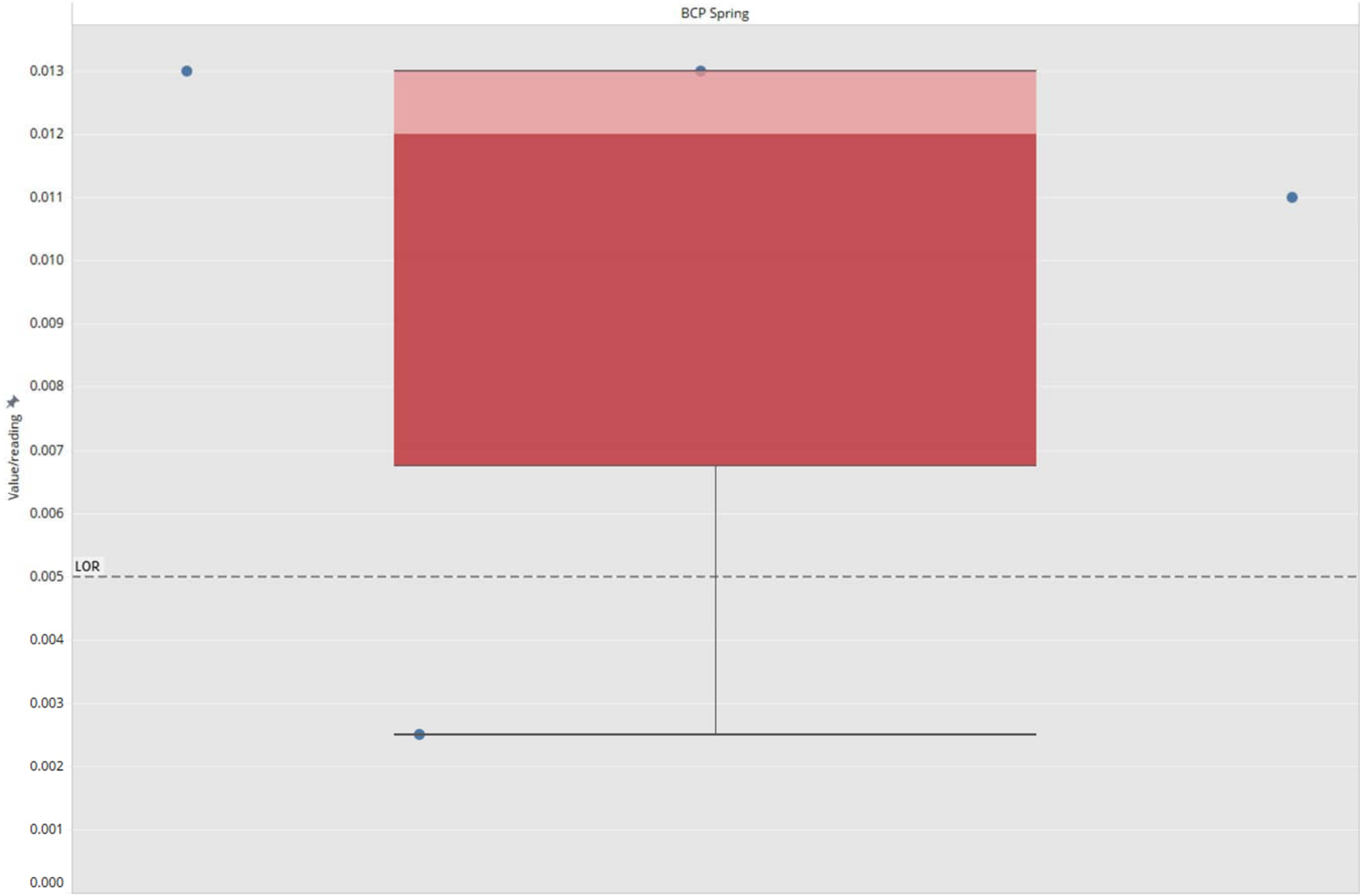
Sulfate (as SO4)



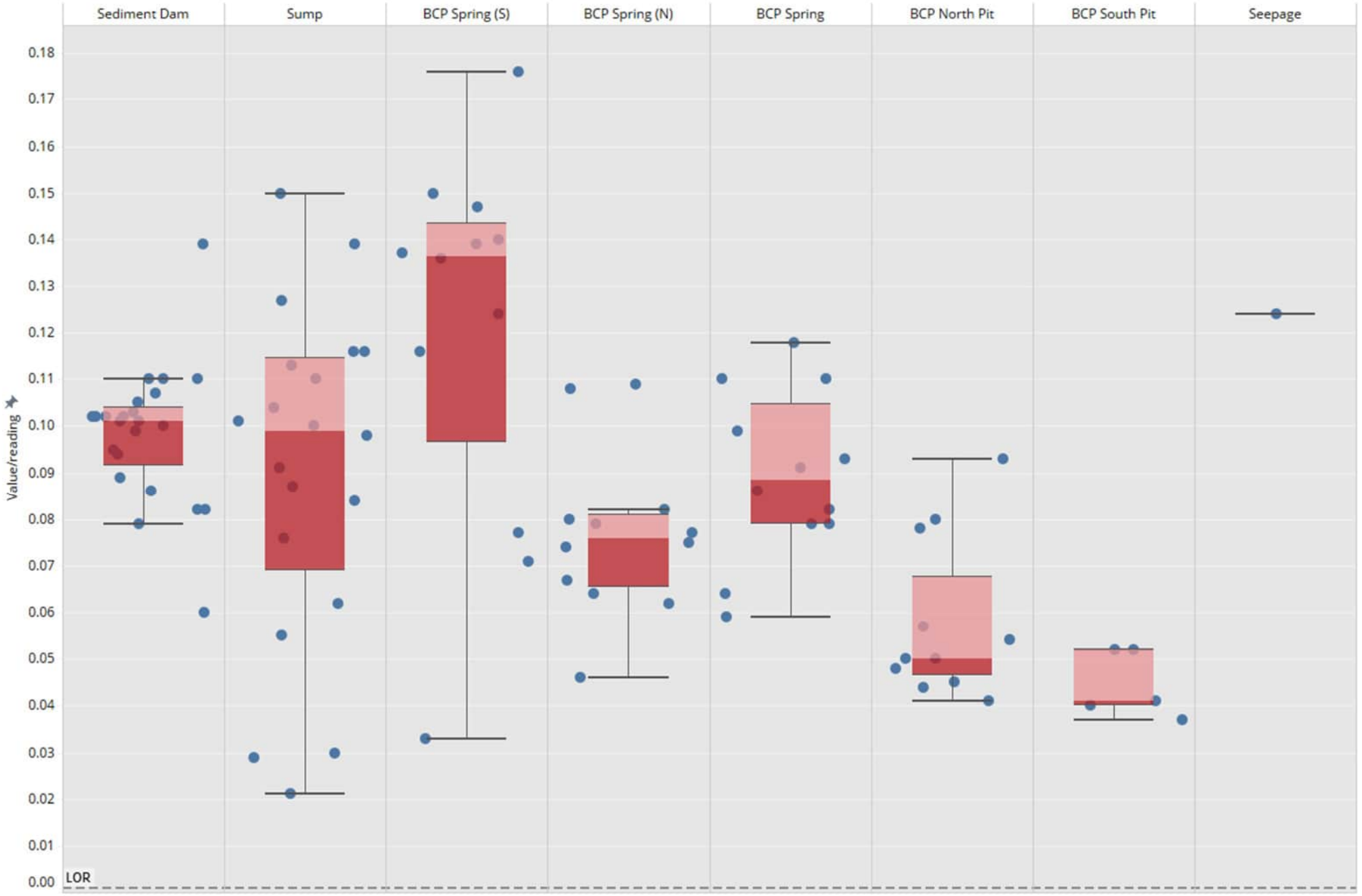
Bicarbonate Alkalinity as CaCO3 (mg/L)



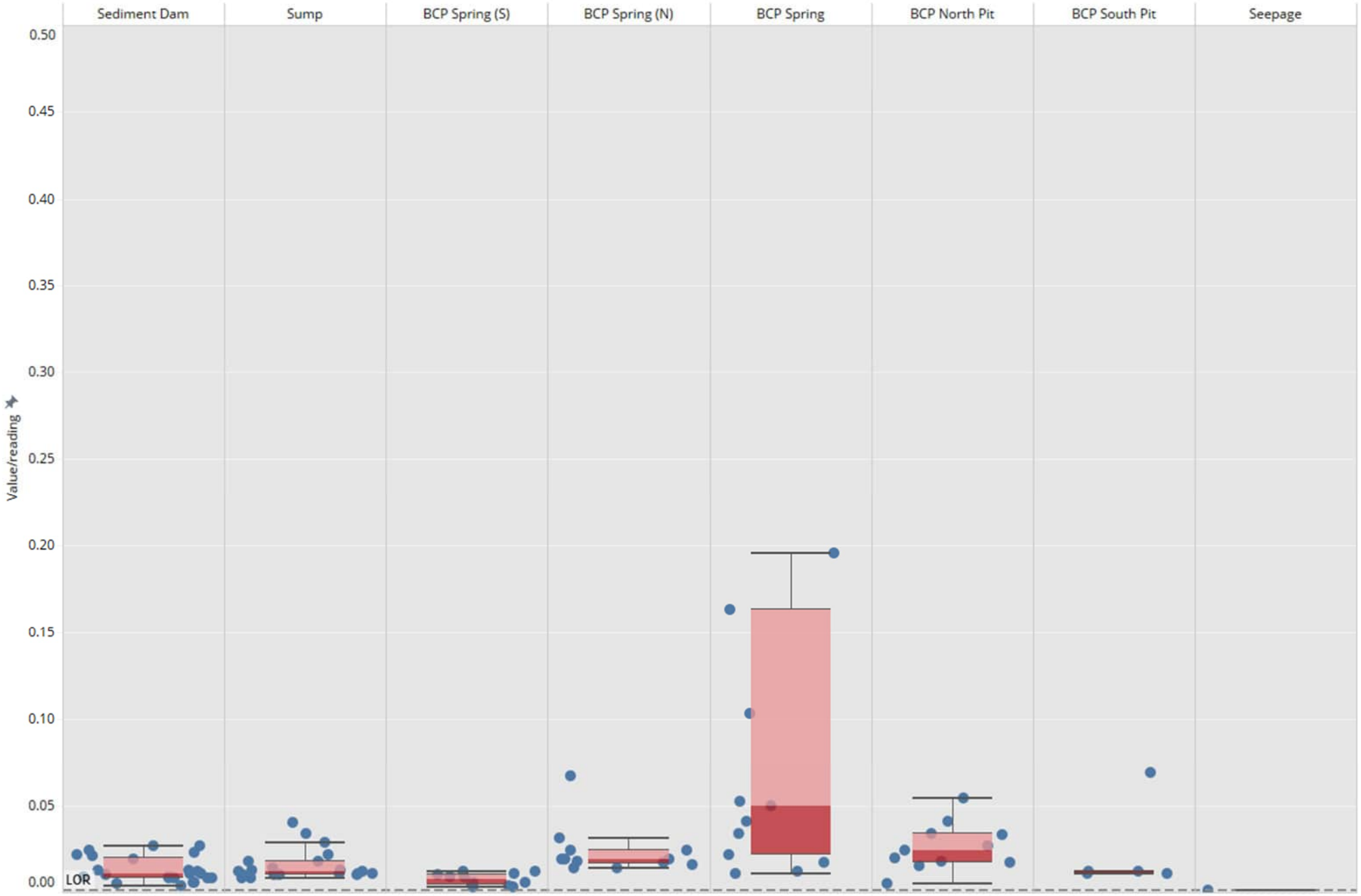
Aluminium - dissolved (mg/L)



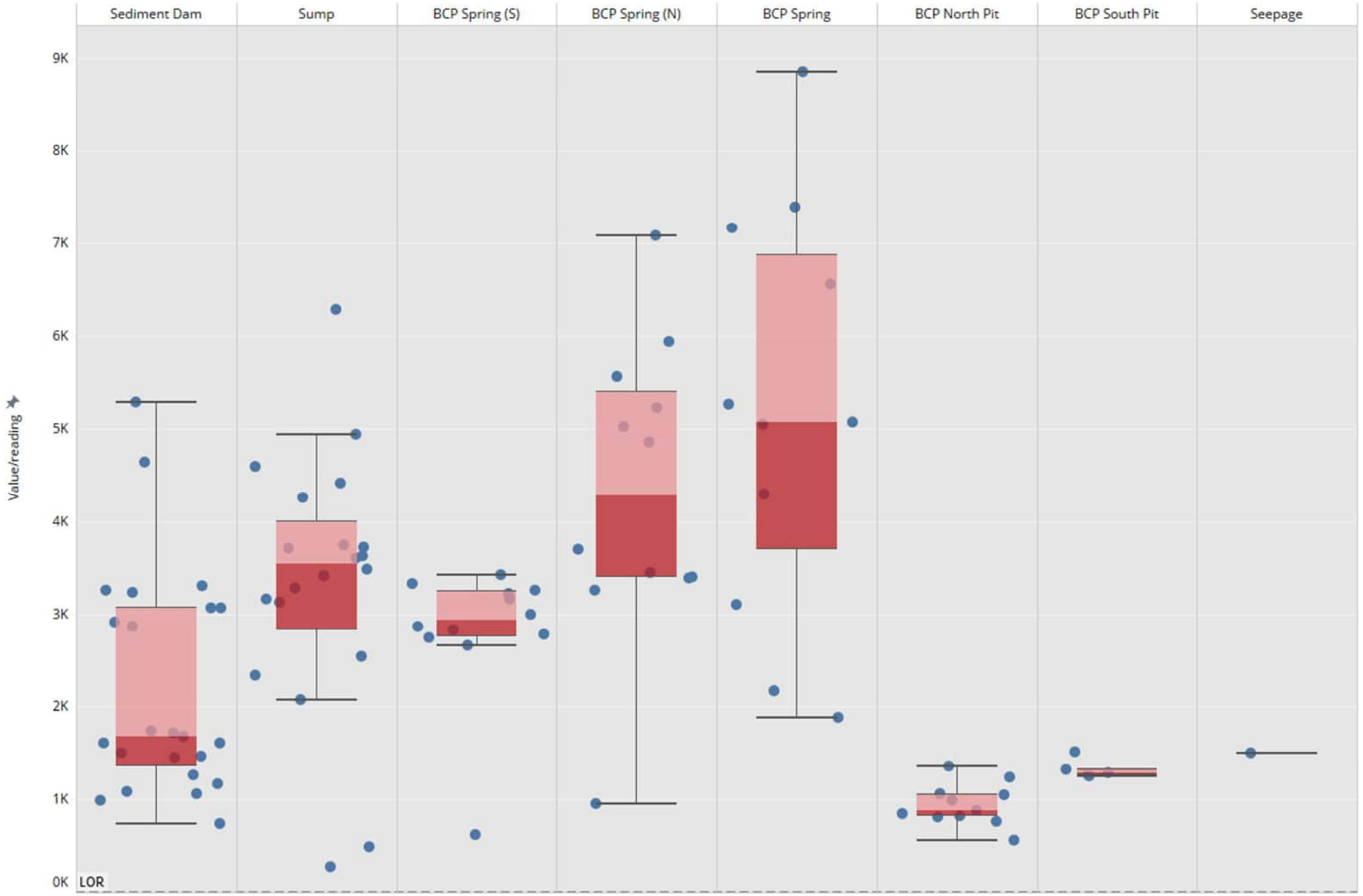
Barium - dissolved (mg/L)



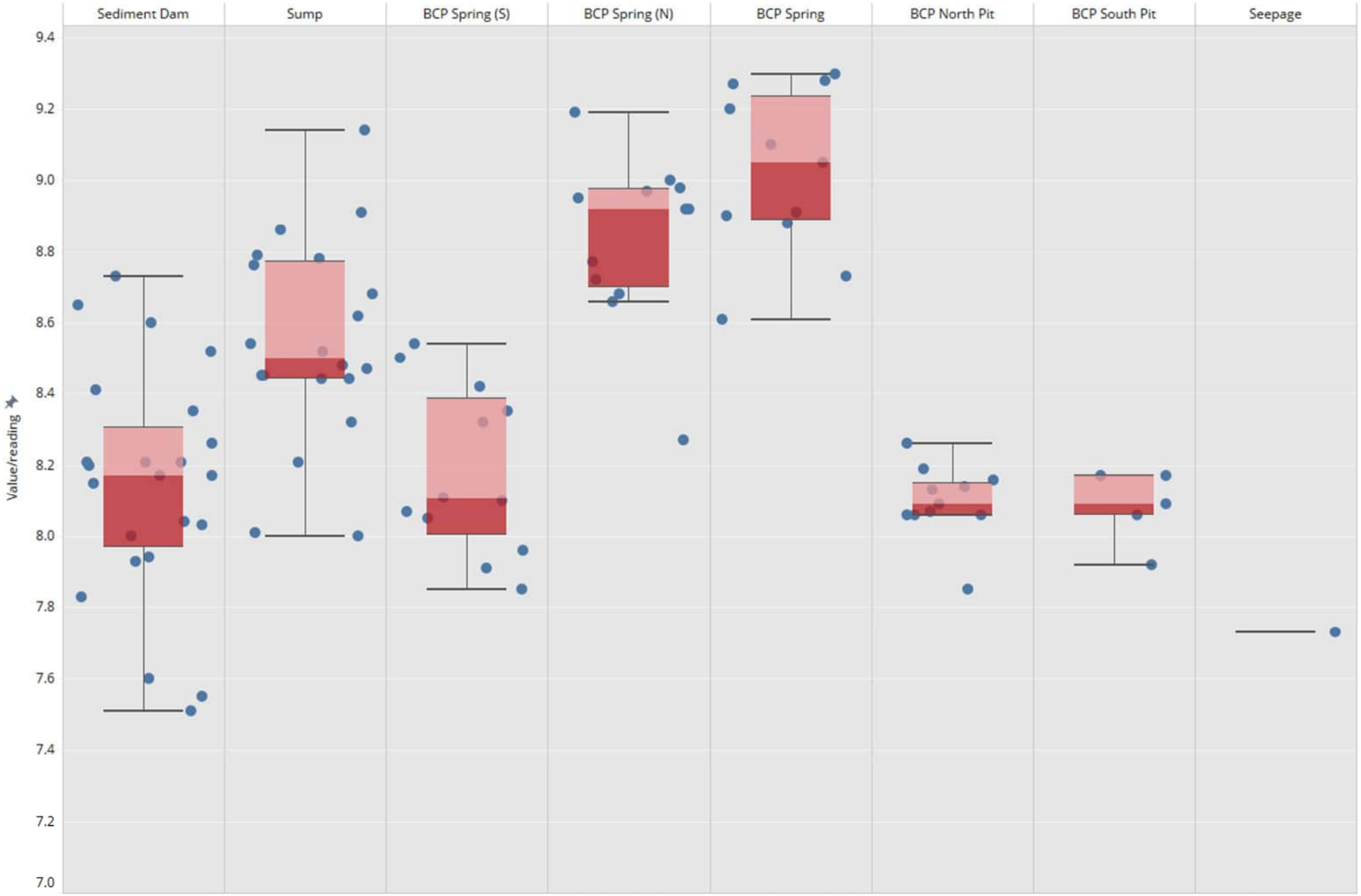
Copper - dissolved (mg/L)



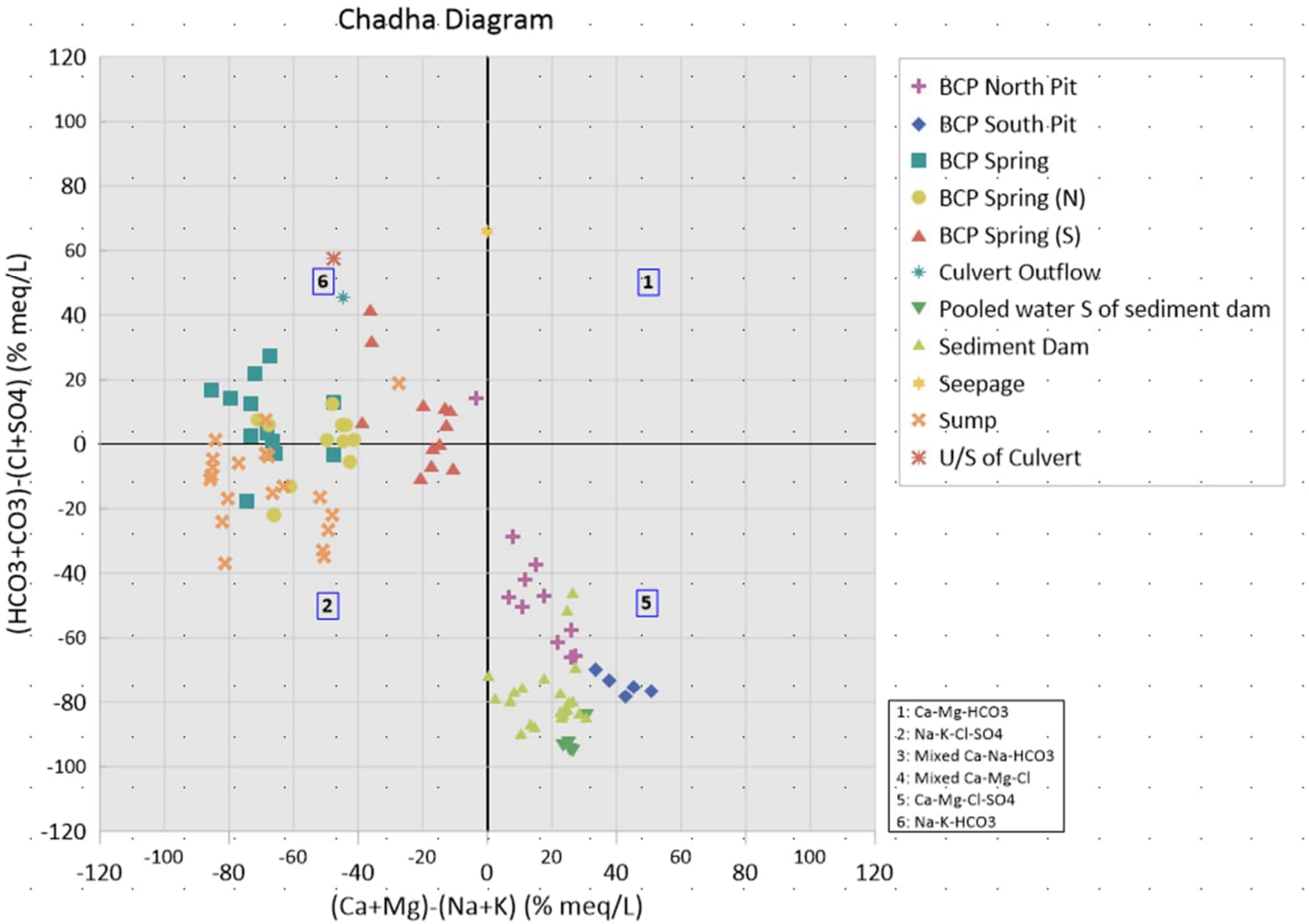
Electrical Conductivity (µS/cm)



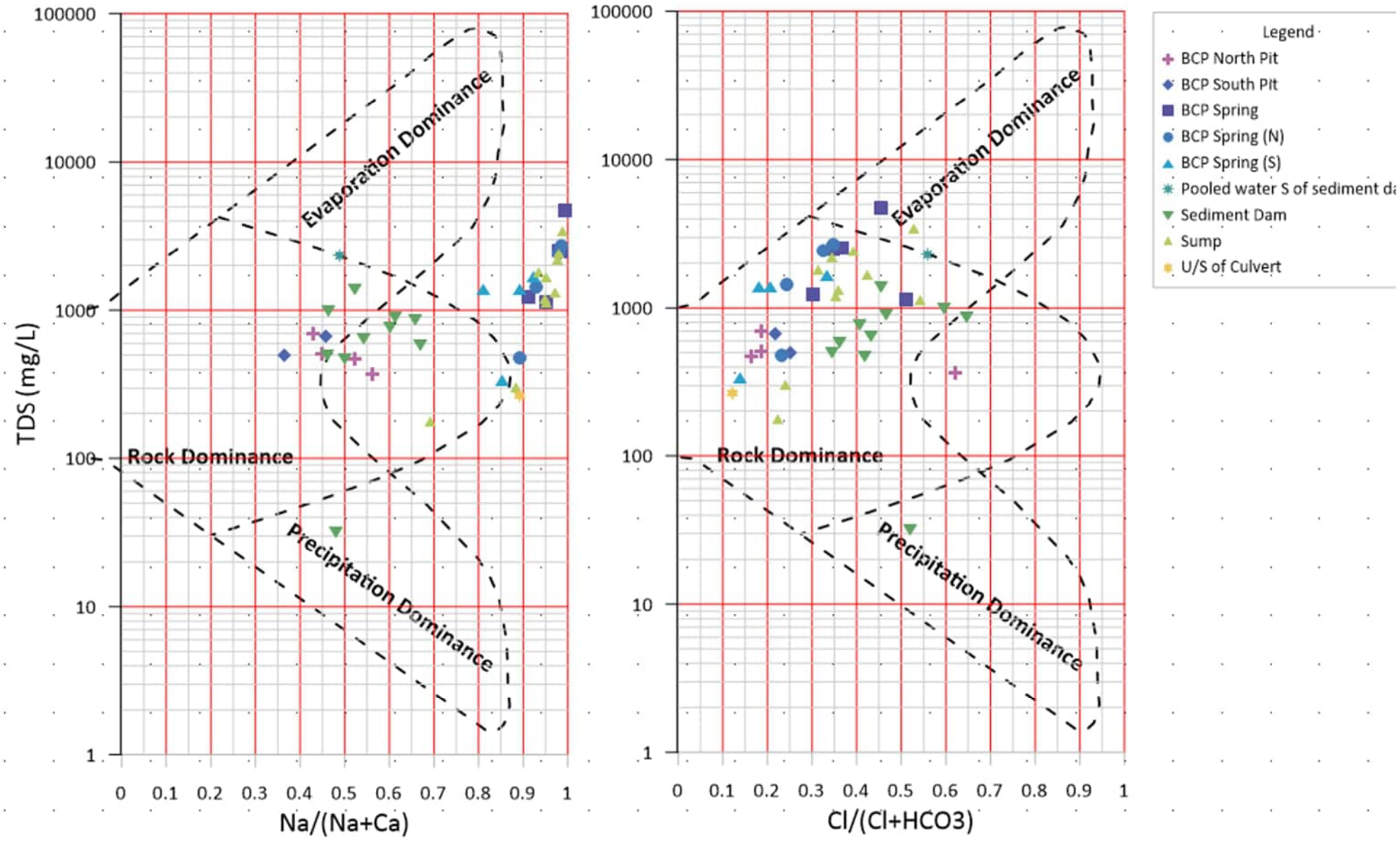
pH (lab)

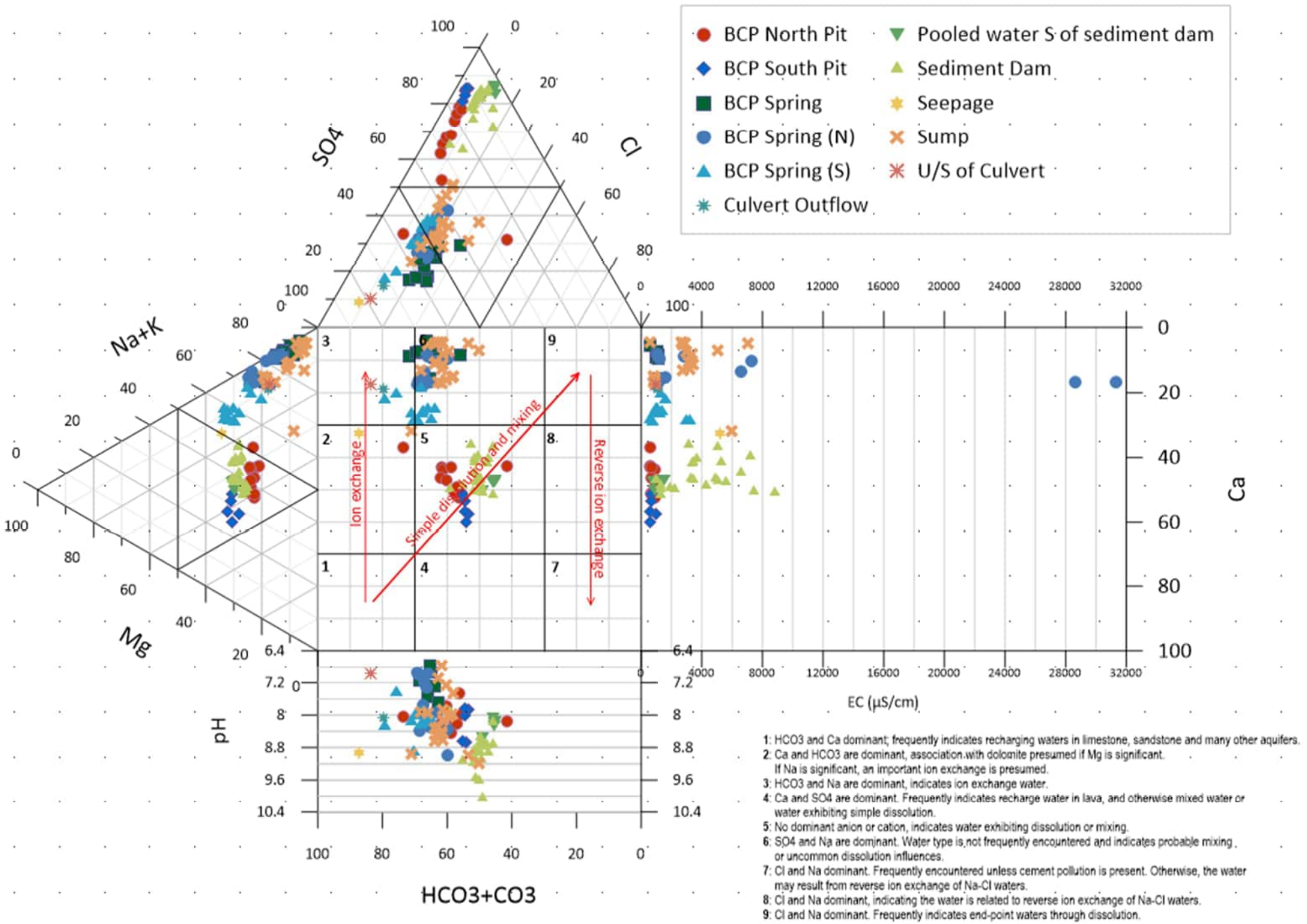

Sediment Dam
Sump
BCP Spring (S)
BCP Spring (N)
BCP Spring
BCP North Pit
BCP South Pit
Seepage
Value/reading
9.4
9.2
9.0
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0

F.4 Hydrogeochemistry plots

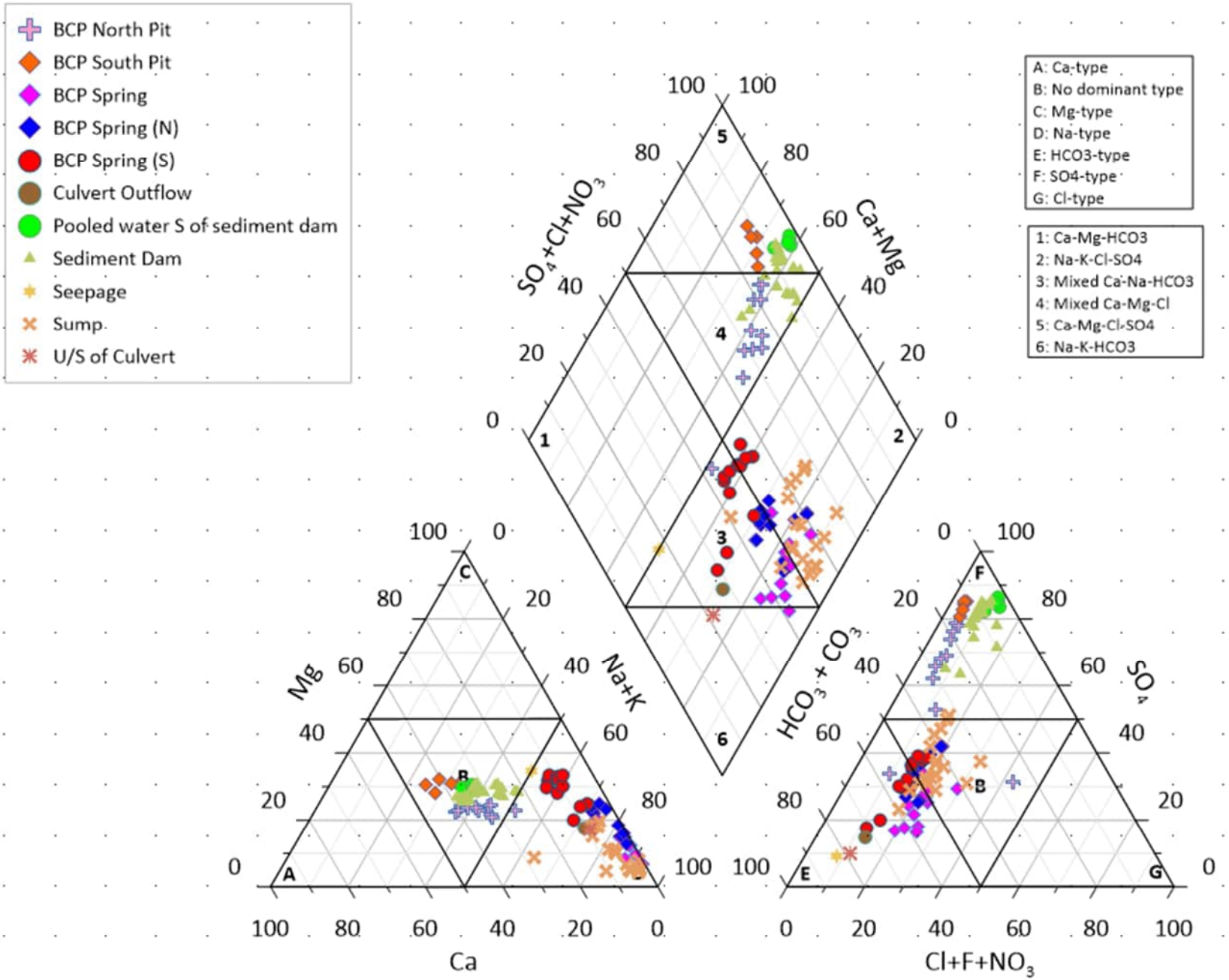

Chadha Diagram
(HCO3+CO3)-(Cl+SO4) (% meq/L)
(Ca+Mg)-(Na+K) (% meq/L)
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-120
-100
-80
-60
-40
-20
0
20
40
60
80
100
120
1
2
5
6
BCP North Pit
BCP South Pit
BCP Spring
BCP Spring (N)
BCP Spring (S)
Culvert Outflow
Pooled water S of sediment dam
Sediment Dam
Seepage
Sump
U/S of Culvert
1: Ca-Mg-HCO3
2: Na-K-Cl-SO4
3: Mixed Ca-Na-HCO3
4: Mixed Ca-Mg-Cl
5: Ca-Mg-Cl-SO4
6: Na-K-HCO3

Gibbs Diagram





1: HCO3 and Ca dominant; frequently indicates recharging waters in limestone, sandstone and many other aquifers.
2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.
3: HCO3 and Na are dominant, indicates ion exchange water.
4: Ca and SO4 are dominant. Frequently indicates recharge water in lava, and otherwise mixed water or water exhibiting simple dissolution.
5: No dominant anion or cation, indicates water exhibiting dissolution or mixing.
6: SO4 and Na are dominant. Water type is not frequently encountered and indicates probable mixing or uncommon dissolution influences.
7: Cl and Na dominant. Frequently encountered unless cement pollution is present. Otherwise, the water may result from reverse ion exchange of Na-Cl waters.
8: Cl and Na dominant, indicating the water is related to reverse ion exchange of Na-Cl waters.
9: Cl and Na dominant. Frequently indicates end-point waters through dissolution.


BCP North Pit
BCP South Pit
BCP Spring
BCP Spring (N)
BCP Spring (S)
Culvert Outflow
Pooled water S of sediment dam
Sediment Dam
Seepage
Sump
U/S of Culvert
A: Ca-type
B: No dominant type
C: Mg-type
D: Na-type
E: HCO3-type
F: SO4-type
G: Cl-type
1: Ca-Mg-HCO3
2: Na-K-Cl-SO4
3: Mixed Ca-Na-HCO3
4: Mixed Ca-Mg-Cl
5: Ca-Mg-Cl-SO4
6: Na-K-HCO3
SO4+Cl+NO3
Ca+Mg
Mg
Na+K
Ca
HCO3+CO3
SO4
Cl+F+NO3

Appendix G Groundwater monitoring data

G.1 Groundwater data tables

Table G.1 Groundwater monitoring events

Year	Month	BARC071	BAWB01	BAWB02	BAWB03	BAWB04	BAWB05	BAWB07	BAWBR01	BAWBR02	BAWBR03	Bore E
2014												
	8		✓	✓		✓		✓				
	9		✓	✓		✓	✓	✓				
	10	✓	✓	✓		✓	✓	✓				
	11	✓	✓	✓		✓	✓	✓				
2015												
	2		✓				✓					
	4		✓	✓		✓	✓	✓				
	11		✓	✓		✓	✓					
2016												
	9		✓	✓		✓	✓				✓	
	11		✓	✓		✓	✓					
2017												
	1		✓	✓	✓	✓	✓					
	4		✓	✓		✓	✓					
	11		✓	✓			✓					
2018												
	1		✓	✓	✓	✓	✓					
	3		✓	✓	✓	✓	✓			✓		
	6		✓	✓	✓	✓	✓	✓	✓	✓		✓
	7		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	8		✓	✓	✓	✓	✓	✓	✓	✓		✓
	9		✓	✓	✓	✓	✓	✓				✓
	11		✓	✓	✓	✓	✓	✓				✓
2019												
	1		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Year	Month	BARC071	BAWB01	BAWB02	BAWB03	BAWB04	BAWB05	BAWB07	BAWBR01	BAWBR02	BAWBR03	Bore E
	2			✓				✓				
	3		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	4		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	5		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	6		✓	✓	✓	✓	✓		✓	✓	✓	✓
	7		✓	✓	✓	✓	✓		✓		✓	✓
	8		✓	✓	✓	✓	✓			✓	✓	✓
	9		✓	✓	✓		✓		✓	✓	✓	✓
	10		✓	✓	✓	✓	✓		✓	✓	✓	✓
	11		✓	✓	✓	✓	✓		✓	✓	✓	✓
2020												
	2		✓	✓	✓	✓	✓		✓	✓	✓	✓
	4		✓	✓	✓	✓	✓		✓	✓	✓	✓
	5		✓	✓	✓	✓	✓		✓	✓	✓	✓
	6		✓	✓	✓	✓	✓		✓	✓	✓	✓
	7		✓	✓	✓	✓	✓		✓	✓	✓	✓
	8		✓		✓		✓		✓	✓	✓	✓
	9		✓	✓	✓	✓	✓		✓	✓	✓	✓
	11		✓	✓	✓	✓	✓		✓	✓	✓	✓
	12		✓	✓	✓	✓	✓		✓	✓	✓	✓
2021												
	1		✓	✓	✓	✓	✓		✓	✓	✓	✓
	2		✓	✓	✓	✓	✓		✓	✓	✓	✓
	3		✓	✓	✓	✓	✓		✓	✓	✓	✓
	4		✓	✓	✓	✓	✓		✓	✓	✓	✓
	5		✓	✓	✓	✓	✓		✓	✓	✓	✓
	6		✓	✓	✓	✓	✓		✓	✓	✓	✓
	7		✓	✓	✓	✓	✓		✓	✓	✓	✓

Year	Month	BARC071	BAWB01	BAWB02	BAWB03	BAWB04	BAWB05	BAWB07	BAWBR01	BAWBR02	BAWBR03	Bore E
	8		✓	✓	✓	✓	✓		✓	✓	✓	✓
	9		✓	✓	✓	✓	✓		✓	✓	✓	✓
	10		✓	✓	✓	✓	✓		✓	✓	✓	✓
	11		✓	✓	✓	✓	✓		✓	✓		✓
	12		✓	✓	✓	✓	✓		✓	✓	✓	✓
2022												
	1						✓		✓	✓	✓	✓
	2		✓	✓	✓	✓	✓		✓	✓	✓	✓
	3		✓	✓	✓	✓	✓		✓	✓	✓	✓
	4		✓	✓	✓	✓	✓		✓	✓	✓	✓
	5		✓	✓	✓	✓	✓		✓	✓	✓	✓
	6		✓	✓	✓	✓	✓		✓	✓	✓	✓
	7		✓	✓	✓	✓	✓		✓	✓	✓	✓
	8		✓	✓	✓	✓	✓		✓	✓	✓	✓
	9		✓	✓	✓	✓	✓		✓	✓	✓	✓
	10		✓	✓	✓	✓	✓		✓	✓	✓	✓
	11		✓	✓	✓	✓	✓		✓	✓	✓	✓
	12		✓	✓	✓	✓	✓		✓	✓	✓	✓
2023												
	1		✓	✓	✓	✓	✓		✓	✓	✓	✓
	2		✓	✓	✓	✓	✓		✓	✓	✓	✓
	3		✓	✓	✓	✓	✓		✓	✓	✓	✓
	4		✓	✓	✓	✓	✓		✓	✓	✓	✓
	5				✓	✓						✓
	7		✓	✓	✓	✓	✓				✓	✓
	10		✓	✓	✓	✓	✓					✓

Table G.2 Descriptive statistics: groundwater monitoring results (all sites)

	NumObs	No. > LOR	No. < LOR	% < LOR	No. distinct values (>LOR)	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	10%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	80%ile	90%ile (> LOR)	95%ile (>LOR)	99%ile (>LOR)
Alkalinity																				
Bicarbonate Alkalinity as CaCO3 (mg/L)	320	320			193	66	465.2281	218.1886	2220	2154	249.95	290	385.8	410.75	453	486	515.6	581.2	643.1	1859.89
Carbonate Alkalinity as CaCO3 (mg/L)	320	6	314	98.1	6	4	17.0000	8.2057	28	24	6.25	8.5	13	13	15.5	24	26	27	27.5	27.9
Hydroxide Alkalinity as CaCO3 (mg/L)	320		320	100.0	1															
Temperature (field) (°C)	320	320			193	66	465.5594	217.9721	2220	2154	249.95	290	386	410.75	453	486	515.6	581.2	643.1	1859.89
Field Measurements																				
Electrical Conductivity (field) (µS/cm)	225	225			192	11.17	1026.1606	519.0249	7385	7373.83	628.6	665	831.8	860	991	1204	1225.2	1274.2	1386.8	1780.88
ORP (field) (mV)	178	178			168	-300.9	-40.9590	91.6788	302.4	603.3	-172.72	-156.8	-113.86	-104.25	-50.35	25.725	38.54	68.52	111.03	211.269
pH (field)	224	224			129	5.91	7.3445	0.5086	8.99	3.08	6.636	6.799	6.96	7	7.305	7.64	7.724	8.01	8.2385	8.6708
Salinity (field) (PSU)	210	210			55	0.06	0.6762	1.6770	17.79	17.73	0.31	0.329	0.4	0.42	0.48	0.6	0.61	0.64	0.7055	3.827
TDS (field) (ppm)	210	210			175	21.99	30.4813	2.0480	35.42	13.43	27.0495	27.825	29.216	29.6275	30.685	31.6775	32.004	32.713	33.4755	34.4703
Total Dissolved Solids (field) (ppm)	178	178			144	14.19	527.2230	277.9189	3692	3677.81	318.85	332	416	431.25	500	605	615.6	658.3	713.6	1004.06
Turbidity (field) (FNU)	128	128			52	0	2.9469	5.5738	35.1	35.1	0	0	0	0	1.15	3.05	3.76	6.4	13.58	29.701
Hardness																				
Total Hardness (mg CaCO3/L)	286	286			160	43	284.6538	134.4622	1300	1257	168.5	185.5	222	233	263	320	334	395	413	1140
Ion Balance																				
Ionic Balance (%)	318	318			247	-3.3	3.1369	4.3282	65.4	68.7	0.21	0.387	0.908	1.175	2.655	4.095	4.418	5.599	8.6415	13.796
Total Anions (meq/L)	320	320			161	1.73	13.8481	27.6105	352	350.27	6.638	7.497	9.244	9.425	11	13.2	13.5	14.42	15.72	84.62
Total Cations (meq/L)	320	320			155	1.66	14.2483	30.7640	397	395.34	6.95	7.567	9.246	9.6175	11.1	13.5	13.8	14.71	15.83	81.507
Major Ions																				
Calcium (mg/L)	491	491			71	9	52.6314	17.2303	184	175	32	36	41	43.5	51	60	62	67	71	125.5
Chloride (mg/L)	321	321			60	5	70.4330	432.8077	5490	5485	12	13	17	19	28	39	41	45	58	776
Fluoride (mg/L)	254	253	1	0.4	20	0.2	0.8830	0.4678	2.4	2.2	0.3	0.4	0.5	0.5	0.8	1.3	1.4	1.6	1.7	1.896
Magnesium (mg/L)	491	491			76	5	38.7637	29.4048	277	272	17	19	23	24	30	47	52	68	72	191.8
Potassium (mg/L)	491	491			33	1	10.5483	4.9726	37	36	5	6	7	7	10	12	13	18	20	22.3
Sodium (mg/L)	491	491			166	16	206.0835	733.9214	8580	8564	66	70	89	95	112	157.5	181	205	220	1543
Sulfate (as SO4)	321	315	6	1.9	120	1	125.4200	585.3403	7360	7359	6	8	37.8	40.5	56	75	93	157	180.6	1212.58
Metals (dissolved)																				
Aluminium - dissolved (mg/L)	11	6	5	45.5	6	0.012	0.0208	0.0085	0.034	0.022	0.012	0.012	0.012	0.01325	0.0185	0.0275	0.03	0.032	0.033	0.0338
Arsenic - dissolved (mg/L)	321	166	155	48.3	12	0.001	0.0023	0.0030	0.018	0.017	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.006	0.018
Barium - dissolved (mg/L)	317	317			184	0.003	0.1726	0.1115	0.493	0.49	0.0558	0.067	0.0902	0.098	0.145	0.191	0.2316	0.3704	0.4304	0.48684
Beryllium - dissolved (mg/L)	49		49	100.0	1															
Bismuth - dissolved (mg/L)	268	1	267	99.6	2	0.00006	0.0001	0.0000	0.00006	0	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006
Boron - dissolved (mg/L)	51	44	7	13.7	27	0.034	0.1373	0.1048	0.35	0.316	0.03915	0.0486	0.0596	0.06	0.0805	0.2625	0.284	0.307	0.32	0.3414
Cadmium - dissolved (mg/L)	55	3	52	94.5	4	0.0001	0.0003	0.0002	0.0005	0.0004	0.00011	0.00012	0.00014	0.00015	0.0002	0.00035	0.00038	0.00044	0.00047	0.000494

	NumObs	No. > LOR	No. < LOR	% < LOR	No. distinct values (>LOR)	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	10%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	80%ile	90%ile (> LOR)	95%ile (>LOR)	99%ile (>LOR)
Chromium - dissolved (mg/L)	321	16	305	95.0	7	0.001	0.0025	0.0018	0.007	0.006	0.001	0.001	0.001	0.001	0.002	0.003	0.003	0.005	0.00625	0.00685
Cobalt - dissolved (mg/L)	321	86	235	73.2	8	0.001	0.0019	0.0020	0.015	0.014	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.004	0.0133
Copper - dissolved (mg/L)	321	139	182	56.7	18	0.001	0.0054	0.0210	0.247	0.246	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.008	0.012	0.0302
Iron - dissolved (mg/L)	5		5	100.0	1															
Lead - dissolved (mg/L)	55	7	48	87.3	4	0.001	0.0026	0.0017	0.006	0.005	0.001	0.001	0.001	0.001	0.003	0.003	0.003	0.0042	0.0051	0.00582
Manganese - dissolved (mg/L)	55	54	1	1.8	51	0.007	1.2328	1.1681	4.06	4.053	0.0688	0.0825	0.2952	0.34175	0.9915	1.375	1.94	3.269	3.735	4.0494
Mercury - dissolved (mg/L)	53		53	100.0	1															
Molybdenum - dissolved (mg/L)	268	262	6	2.2	31	0.001	0.0071	0.0189	0.212	0.211	0.002	0.002	0.002	0.002	0.003	0.004	0.005	0.018	0.022	0.03039
Nickel - dissolved (mg/L)	321	73	248	77.3	10	0.001	0.0030	0.0034	0.025	0.024	0.001	0.001	0.001	0.001	0.002	0.004	0.004	0.005	0.006	0.01852
Selenium - dissolved (mg/L)	317	1	316	99.7	2	0.003	0.0030	0.0000	0.003	0	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Silicon - dissolved (mg/L)	5	5			4	13	17.4000	5.6071	28	15	13	13	13	13	15	18	20	24	26	27.6
Uranium - dissolved (mg/L)	268	265	3	1.1	16	0.001	0.0086	0.0423	0.496	0.495	0.002	0.002	0.002	0.002	0.004	0.005	0.006	0.006	0.007	0.11292
Vanadium - dissolved (mg/L)	49	6	43	87.8	6	0.002	0.0058	0.0032	0.01	0.008	0.00225	0.0025	0.003	0.003	0.0055	0.00875	0.009	0.0095	0.00975	0.00995
Zinc - dissolved (mg/L)	55	37	18	32.7	21	0.005	0.0146	0.0108	0.06	0.055	0.005	0.0066	0.0072	0.008	0.012	0.017	0.0178	0.0234	0.03	0.05496
Metals (total)																				
Aluminium - total (mg/L)	11	11			9	0.02	0.0562	0.0485	0.19	0.17	0.0205	0.021	0.024	0.027	0.039	0.067	0.09	0.09	0.14	0.18
Arsenic - total (mg/L)	321	188	133	41.4	13	0.001	0.0024	0.0028	0.019	0.018	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.006	0.018
Barium - total (mg/L)	317	317			193	0.027	0.1830	0.1173	0.529	0.502	0.0618	0.069	0.0932	0.103	0.152	0.206	0.2526	0.3876	0.4576	0.50884
Beryllium - total (mg/L)	49		49	100.0	1															
Bismuth - total (mg/L)	268	2	266	99.3	3	0.0000 9	0.0001	0.0001	0.0002	0.0001 1	0.000095 5	0.00010 1	0.00011 2	0.000117 5	0.00014 5	0.000172 5	0.00017 8	0.00018 9	0.000194 5	0.000198 9
Boron - total (mg/L)	51	42	9	17.6	26	0.03	0.1384	0.1059	0.35	0.32	0.04005	0.0491	0.06	0.0625	0.0805	0.24	0.286	0.309	0.3395	0.3459
Cadmium - total (mg/L)	55	8	47	85.5	6	0.0001	0.0003	0.0001	0.0005	0.0004	0.0001	0.0001	0.00014	0.000175	0.00025	0.000325	0.00036	0.00043	0.000465	0.000493
Chromium - total (mg/L)	321	58	263	81.9	11	0.001	0.0034	0.0029	0.013	0.012	0.001	0.001	0.001	0.001	0.002	0.004	0.005	0.006	0.01115	0.01243
Cobalt - total (mg/L)	321	107	214	66.7	9	0.001	0.0022	0.0022	0.014	0.013	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.003	0.004	0.01394
Copper - total (mg/L)	321	270	51	15.9	27	0.001	0.0111	0.0609	0.89	0.889	0.001	0.001	0.002	0.002	0.003	0.006	0.0062	0.011	0.019	0.20896
Iron - total (mg/L)	5	5			5	0.071	0.4982	0.5053	1.4	1.329	0.0848	0.0986	0.1262	0.14	0.17	0.71	0.848	1.124	1.262	1.3724
Lead - total (mg/L)	55	22	33	60.0	7	0.001	0.0030	0.0039	0.019	0.018	0.001	0.001	0.001	0.001	0.002	0.002	0.0028	0.0057	0.0079	0.01669
Manganese - total (mg/L)	55	55			48	0.006	1.2809	1.2290	4.35	4.344	0.074	0.0824	0.2752	0.38	1	1.4	1.702	3.604	3.805	4.2906
Mercury - total (mg/L)	53		53	100.0	1															
Molybdenum - total (mg/L)	268	267	1	0.4	28	0.001	0.0076	0.0186	0.216	0.215	0.002	0.002	0.002	0.003	0.004	0.004	0.005	0.0212	0.025	0.03234
Nickel - total (mg/L)	321	88	233	72.6	12	0.001	0.0033	0.0040	0.033	0.032	0.001	0.001	0.001	0.002	0.002	0.004	0.004	0.0063	0.00865	0.01647
Selenium - total (mg/L)	317	1	316	99.7	2	0.003	0.0030	0.0000	0.003	0	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Silicon - total (mg/L)	5	5			5	13	17.8000	5.8447	29	16	13.2	13.4	13.8	14	15	18	20.2	24.6	26.8	28.56
Uranium - total (mg/L)	268	266	2	0.7	17	0.001	0.0093	0.0409	0.459	0.458	0.002	0.002	0.002	0.003	0.005	0.006	0.006	0.007	0.007	0.1365
Vanadium - total (mg/L)	49	7	42	85.7	6	0.001	0.0059	0.0042	0.011	0.01	0.0013	0.0016	0.0022	0.0025	0.003	0.0105	0.0108	0.011	0.011	0.011
Zinc - total (mg/L)	55	47	8	14.5	22	0.006	0.0176	0.0130	0.074	0.068	0.006	0.006	0.008	0.01	0.016	0.021	0.022	0.0262	0.0371	0.06802
Nutrients																				

	NumObs	No. > LOR	No. < LOR	% < LOR	No. distinct values (>LOR)	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	10%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	80%ile	90%ile (> LOR)	95%ile (>LOR)	99%ile (>LOR)
Nitrite + Nitrate as N (mg/L)	17	14	3	17.6	13	0.02	0.5164	0.8398	2.56	2.54	0.02	0.023	0.036	0.04	0.13	0.3625	0.59	1.975	2.482	2.5444
Total Kjeldahl Nitrogen as N (mg/L)	17	16	1	5.9	8	0.1	0.8313	1.2578	3.7	3.6	0.1	0.1	0.1	0.1	0.3	0.4	0.4	3.3	3.475	3.655
Total Nitrogen as N (mg/L)	17	17			11	0.1	1.2000	1.3430	3.7	3.6	0.1	0.16	0.22	0.3	0.4	2.8	2.96	3.32	3.54	3.668
Total Phosphorus as P (mg/L)	17	17			9	0.01	0.0788	0.0859	0.26	0.25	0.018	0.02	0.022	0.03	0.04	0.07	0.078	0.26	0.26	0.26
Physico-Chemical Parameters																				
Electrical Conductivity (µS/cm)	267	267			156	164	1259.880 1	2567.119 2	31300	31136	620.3	658.8	811.4	845.5	977	1180	1210	1274	1378	6824.6
pH (lab)	285	285			111	6.98	7.7323	0.3086	8.66	1.68	7.24	7.32	7.43	7.49	7.74	7.97	8.03	8.13	8.2	8.3916
Total Dissolved Solids (mg/L)	5	5			5	470	640.0000	127.5931	820	350	488	506	542	560	600	750	764	792	806	817.2
Turbidity (NTU)	267	267			109	0.1	6.6228	9.5877	61.4	61.3	0.4	0.6	0.82	1	2.4	8.1	11.16	18.02	24.27	48.786

Table G.3 Descriptive statistics: groundwater monitoring results (by location)

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
BAWB01												
Alkalinity												
Bicarbonate Alkalinity as CaCO3 (mg/L)	53	53		163	568.1132	86.7916	695	436.8	534	570	622	671.4
Carbonate Alkalinity as CaCO3 (mg/L)	53		53									
Hydroxide Alkalinity as CaCO3 (mg/L)	53		53									
Field Measurements												
Dissolved Oxygen (field) (% sat))	29	29		0	28.3103	34.7277	131.5	0	5.8	12.6	40.9	97.38
Electrical Conductivity (field) (µS/cm)	32	32		14.63	1203.0509	239.9184	1529	1130.5	1157.25	1197.5	1287.25	1468.4
ORP (field) (mV)	24	24		-104.5	-0.1125	71.2899	184.8	-84.665	-53.15	-18.25	37.2	124.12
pH (field)	32	32		5.91	6.9794	0.3958	7.98	6.409	6.76	6.945	7.23	7.655
Salinity (field) (PSU)	29	29		0.06	0.5948	0.1163	0.76	0.55	0.57	0.59	0.66	0.726
TDS (field) (ppm)	29	29		27	30.8693	1.9516	35.42	27.498	29.75	30.69	32.02	33.904
Total Dissolved Solids (field) (ppm)	24	24		563	629.5000	59.3317	765	567.9	580	605.5	681	736.1
Temperature (field) (°C)	53	53		163	568.1132	86.7916	695	436.8	534	570	622	671.4
Turbidity (field) (FNU)	18	18		0	4.0167	6.9898	27	0	0	0.65	5.225	17.48
Hardness												
Total Hardness (mg CaCO3/L)	45	45		112	375.1333	56.7719	440	278	369	391	405	424
Ion Balance												
Ionic Balance (%)	53	53		-3.3	2.6019	2.1902	8.64	0.142	1.1	2.59	3.9	6.006
Total Anions (meq/L)	53	53		3.81	13.6434	2.1383	17	10.388	12.7	13.7	14.9	16.4
Total Cations (meq/L)	53	53		3.76	13.8438	2.2025	17.5	9.792	13.1	14	14.8	17.08
Major Ions												
Calcium (mg/L)	79	79		22	44.1139	5.9086	55	33.8	40.5	45	48	51
Chloride (mg/L)	53	53		7	34.9434	9.3676	65	22.2	30	34	38	50.6
Fluoride (mg/L)	38	38		0.3	1.4553	0.3201	1.8	0.7	1.4	1.6	1.675	1.715
Magnesium (mg/L)	79	79		9	64.6456	11.9895	80	44	63	68	71	75

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Potassium (mg/L)	79	79		4	7.2278	1.2180	9.6	4.9	7	7	8	9
Sodium (mg/L)	79	79		32	137.6076	41.4055	242	77.5	117	128	157	221
Sulfate (as SO4)	53	53		17	63.0189	14.4764	104	42	57	62	68	86.4
Metals (dissolved)												
Aluminium - dissolved (mg/L)	2	1	1	0.012	0.0120	0.0000	0.012	0.012	0.012	0.012	0.012	0.012
Arsenic - dissolved (mg/L)	53	45	8	0.001	0.0016	0.0006	0.003	0.001	0.001	0.002	0.002	0.002
Barium - dissolved (mg/L)	52	52		0.03	0.1060	0.0479	0.216	0.0452	0.06475	0.0985	0.14725	0.17645
Beryllium - dissolved (mg/L)	11		11									
Bismuth - dissolved (mg/L)	41		41									
Boron - dissolved (mg/L)	11	11		0.034	0.0773	0.0621	0.26	0.0355	0.0445	0.06	0.07	0.19
Cadmium - dissolved (mg/L)	12		12									
Chromium - dissolved (mg/L)	53	2	51	0.001	0.0015	0.0005	0.002	0.00105	0.00125	0.0015	0.00175	0.00195
Cobalt - dissolved (mg/L)	53	42	11	0.001	0.0017	0.0008	0.005	0.001	0.001	0.002	0.002	0.00295
Copper - dissolved (mg/L)	53	24	29	0.001	0.0030	0.0033	0.018	0.001	0.00175	0.002	0.003	0.005
Iron - dissolved (mg/L)	1		1									
Lead - dissolved (mg/L)	12	2	10	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001
Manganese - dissolved (mg/L)	12	12		0.098	0.8108	0.4485	1.5	0.1486	0.3425	0.9445	1.13	1.3845
Mercury - dissolved (mg/L)	12		12									
Molybdenum - dissolved (mg/L)	41	40	1	0.002	0.0036	0.0012	0.009	0.002	0.003	0.0035	0.004	0.00505
Nickel - dissolved (mg/L)	53	6	47	0.001	0.0022	0.0007	0.003	0.00125	0.002	0.002	0.00275	0.003
Selenium - dissolved (mg/L)	52		52									
Silicon - dissolved (mg/L)	1	1		28	28.0000	0.0000	28	28	28	28	28	28
Uranium - dissolved (mg/L)	41	41		0.001	0.0050	0.0012	0.007	0.003	0.004	0.005	0.006	0.006
Vanadium - dissolved (mg/L)	11	3	8	0.008	0.0090	0.0008	0.01	0.0081	0.0085	0.009	0.0095	0.0099
Zinc - dissolved (mg/L)	12	10	2	0.007	0.0136	0.0041	0.02	0.00745	0.0105	0.014	0.01675	0.0191
Metals (total)												
Aluminium - total (mg/L)	2	2		0.021	0.0255	0.0045	0.03	0.02145	0.02325	0.0255	0.02775	0.02955

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Arsenic - total (mg/L)	53	46	7	0.001	0.0017	0.0005	0.003	0.001	0.001	0.002	0.002	0.002
Barium - total (mg/L)	52	52		0.027	0.1085	0.0481	0.253	0.04785	0.066	0.106	0.14075	0.17695
Beryllium - total (mg/L)	11		11									
Bismuth - total (mg/L)	41		41									
Boron - total (mg/L)	11	9	2	0.03	0.0741	0.0425	0.18	0.0324	0.041	0.07	0.08	0.144
Cadmium - total (mg/L)	12	2	10	0.0001	0.0002	0.0001	0.0002	0.000105	0.000125	0.00015	0.000175	0.000195
Chromium - total (mg/L)	53	5	48	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt - total (mg/L)	53	44	9	0.001	0.0020	0.0010	0.007	0.001	0.001	0.002	0.002	0.003
Copper - total (mg/L)	53	48	5	0.001	0.0041	0.0047	0.034	0.001	0.002	0.003	0.004	0.00765
Iron - total (mg/L)	1	1		0.14	0.1400	0.0000	0.14	0.14	0.14	0.14	0.14	0.14
Lead - total (mg/L)	12	4	8	0.001	0.0020	0.0007	0.003	0.00115	0.00175	0.002	0.00225	0.00285
Manganese - total (mg/L)	12	12		0.12	0.8431	0.4706	1.49	0.164	0.3275	0.9775	1.195	1.4295
Mercury - total (mg/L)	12		12									
Molybdenum - total (mg/L)	41	41		0.001	0.0040	0.0010	0.006	0.002	0.004	0.004	0.004	0.006
Nickel - total (mg/L)	53	5	48	0.001	0.0022	0.0007	0.003	0.0012	0.002	0.002	0.003	0.003
Selenium - total (mg/L)	52		52									
Silicon - total (mg/L)	1	1		29	29.0000	0.0000	29	29	29	29	29	29
Uranium - total (mg/L)	41	41		0.002	0.0056	0.0012	0.007	0.004	0.005	0.006	0.007	0.007
Vanadium - total (mg/L)	11	3	8	0.01	0.0107	0.0005	0.011	0.0101	0.0105	0.011	0.011	0.011
Zinc - total (mg/L)	12	11	1	0.006	0.0142	0.0065	0.024	0.006	0.009	0.013	0.0215	0.023
Nutrients												
Nitrite + Nitrate as N (mg/L)	3	3		0.03	0.1167	0.0634	0.18	0.041	0.085	0.14	0.16	0.176
Total Kjeldahl Nitrogen as N (mg/L)	3	3		0.1	0.1000	#NUM!	0.1	0.1	0.1	0.1	0.1	0.1
Total Nitrogen as N (mg/L)	3	3		0.1	0.2000	0.0816	0.3	0.11	0.15	0.2	0.25	0.29
Total Phosphorus as P (mg/L)	3	3		0.02	0.0400	0.0163	0.06	0.022	0.03	0.04	0.05	0.058
Physico-Chemical Parameters												
Electrical Conductivity (µS/cm)	41	41		389	1187.3415	194.2453	1560	929	1140	1190	1260	1450

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
pH (lab)	45	45		6.98	7.4791	0.2601	8.06	7.134	7.25	7.5	7.7	7.848
Total Dissolved Solids (mg/L)	1	1		750	750.0000	0.0000	750	750	750	750	750	750
Turbidity (NTU)	41	41		0.1	5.5439	6.6446	32.9	0.2	0.9	2.5	8	17
BAWB02												
Alkalinity												
Bicarbonate Alkalinity as CaCO3 (mg/L)	51	51		124	439.5686	61.4058	510	336	440.5	456	468.5	484.5
Carbonate Alkalinity as CaCO3 (mg/L)	51	2	49	13	15.5000	2.5000	18	13.25	14.25	15.5	16.75	17.75
Carbonate Alkalinity as CO3 (mg/L)	1		1									
Hydroxide Alkalinity as CaCO3 (mg/L)	51		51									
Temperature (field) (°C)	51	51		137	440.1765	59.5956	510	341	440.5	456	468.5	484.5
Field Measurements												
Appearance or Colour	23											
Depth of Bore (mbgl)	54	54		104	104.0000	0.0000	104	104	104	104	104	104
Depth to Water (mbRL)	55	55		3.28	6.7382	1.3416	9	3.92	6.135	7.01	7.685	8.278
Depth to Water (mbGL)	19	19		3.28	6.1984	1.4908	8.32	3.343	5.415	6.59	7.21	8.059
Dissolved Oxygen (field) (% sat))	30	30		0	31.8100	80.8807	450.6	0	2.125	9.05	19.85	73.115
Electrical Conductivity (field) (µS/cm)	33	33		13.9	1208.4818	233.7828	1416	1022.4	1218	1251	1270	1372.2
Groundwater Level (mAHD)	53	53		303.21	330.2138	14.2328	370.68	317.288	322.77	325.572	331.25	358.6266
GWL Depth Reference Elevation	54	54		311.33	336.7573	14.2120	378.09	323.92	330.01	332.402	337.569	363.64115
Odour	26											
ORP (field) (mV)	26	26		-200.4	-101.7462	103.8320	302.4	-198	-166.725	-128.05	-69.35	45.525
pH (field)	32	32		6.39	7.5369	0.4188	8.6	6.928	7.29	7.485	7.7925	8.0695
Salinity (field) (PSU)	30	30		0.36	0.6140	0.0536	0.7	0.5945	0.6025	0.62	0.6275	0.681
TDS (field) (ppm)	30	30		24.52	30.5217	2.3072	33.61	25.407	29.8175	30.625	32.105	33.3275
Total Dissolved Solids (field) (ppm)	26	26		378	623.3077	56.5466	713	602.25	610.5	627	641.25	695
Turbidity (field) (FNU)	18	18		0	2.1222	2.9047	11.5	0	0.1	1.5	2.5	8.015
Hardness												

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Total Hardness (mg CaCO3/L)	45	45		77	242.8889	43.2616	320	171.8	240	250	263	278.8
Ion Balance												
Ionic Balance (%)	51	51		-3	3.6888	8.9820	65.4	0.11	0.865	2.58	3.91	6.375
Total Anions (meq/L)	51	51		3.96	13.1755	1.7458	16.2	10.89	13	13.5	13.8	14.5
Total Cations (meq/L)	51	51		2.85	13.3018	2.3596	16.5	9.38	13.25	13.7	14.35	15.15
Major Ions												
Calcium (mg/L)	78	78		16	52.4744	8.9768	75	36.7	50	53	58	65.3
Chloride (mg/L)	52	52		11	40.7885	9.0412	82	28.55	38.75	41	44	48.45
Fluoride (mg/L)	37	37		0.3	0.7243	0.1303	0.9	0.46	0.7	0.8	0.8	0.8
Magnesium (mg/L)	78	78		6	28.3462	4.9790	41	18.7	28	29	30	32
Potassium (mg/L)	78	78		1	10.6795	2.3777	16	6	10	11	12	14
Sodium (mg/L)	78	78		26	187.7179	34.3656	229	113.65	185.5	194	204	216.15
Sulfate (as SO4)	52	52		44	155.4827	27.3018	220	125.8	144.75	153.5	170.25	195
Metals (dissolved)												
Aluminium - dissolved (mg/L)	3	1	2	0.017	0.0170	0.0000	0.017	0.017	0.017	0.017	0.017	0.017
Arsenic - dissolved (mg/L)	52	3	49	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001
Barium - dissolved (mg/L)	51	51		0.083	0.1408	0.0231	0.179	0.1015	0.1255	0.143	0.159	0.175
Beryllium - dissolved (mg/L)	10		10									
Bismuth - dissolved (mg/L)	41		41									
Boron - dissolved (mg/L)	11	11		0.27	0.3064	0.0219	0.35	0.275	0.295	0.3	0.32	0.34
Cadmium - dissolved (mg/L)	12	1	11	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Chromium - dissolved (mg/L)	52	2	50	0.001	0.0025	0.0015	0.004	0.00115	0.00175	0.0025	0.00325	0.00385
Cobalt - dissolved (mg/L)	52	2	50	0.001	0.0015	0.0005	0.002	0.00105	0.00125	0.0015	0.00175	0.00195
Copper - dissolved (mg/L)	52	22	30	0.001	0.0025	0.0023	0.01	0.001	0.001	0.002	0.003	0.00785
Iron - dissolved (mg/L)	1		1									
Lead - dissolved (mg/L)	12	1	11	0.003	0.0030	0.0000	0.003	0.003	0.003	0.003	0.003	0.003
Manganese - dissolved (mg/L)	12	12		0.288	1.0280	0.2666	1.4	0.5685	1.0125	1.065	1.1175	1.345

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Mercury - dissolved (mg/L)	11		11									
Molybdenum - dissolved (mg/L)	41	40	1	0.001	0.0032	0.0011	0.007	0.002	0.00275	0.003	0.004	0.005
Nickel - dissolved (mg/L)	52	8	44	0.001	0.0046	0.0045	0.016	0.00135	0.002	0.003	0.005	0.01215
Selenium - dissolved (mg/L)	51		51									
Silicon - dissolved (mg/L)	1	1		13	13.0000	0.0000	13	13	13	13	13	13
Uranium - dissolved (mg/L)	41	41		0.002	0.0047	0.0010	0.008	0.003	0.004	0.005	0.005	0.006
Vanadium - dissolved (mg/L)	10		10									
Zinc - dissolved (mg/L)	12	6	6	0.005	0.0137	0.0078	0.026	0.005	0.00625	0.013	0.019	0.0245
Metals (total)												
Aluminium - total (mg/L)	3	3		0.024	0.0513	0.0281	0.09	0.0256	0.032	0.04	0.065	0.085
Arsenic - total (mg/L)	52	11	41	0.001	0.0012	0.0004	0.002	0.001	0.001	0.001	0.001	0.002
Barium - total (mg/L)	51	51		0.083	0.1526	0.0250	0.197	0.1155	0.139	0.152	0.1735	0.187
Beryllium - total (mg/L)	10		10									
Bismuth - total (mg/L)	41		41									
Boron - total (mg/L)	11	11		0.26	0.3082	0.0279	0.35	0.265	0.295	0.3	0.335	0.345
Cadmium - total (mg/L)	12	1	11	0.0005	0.0005	0.0000	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Chromium - total (mg/L)	52	5	47	0.002	0.0042	0.0034	0.011	0.002	0.002	0.003	0.003	0.0094
Cobalt - total (mg/L)	52	5	47	0.001	0.0040	0.0050	0.014	0.001	0.001	0.002	0.002	0.0116
Copper - total (mg/L)	52	42	10	0.001	0.0050	0.0084	0.051	0.001	0.002	0.002	0.004	0.016
Iron - total (mg/L)	1	1		0.17	0.1700	0.0000	0.17	0.17	0.17	0.17	0.17	0.17
Lead - total (mg/L)	12	6	6	0.001	0.0028	0.0023	0.008	0.00125	0.002	0.002	0.002	0.0065
Manganese - total (mg/L)	12	12		0.294	1.0882	0.2863	1.4	0.602	1.015	1.125	1.285	1.4
Mercury - total (mg/L)	11		11									
Molybdenum - total (mg/L)	41	41		0.001	0.0034	0.0009	0.005	0.002	0.003	0.004	0.004	0.004
Nickel - total (mg/L)	52	10	42	0.001	0.0031	0.0038	0.014	0.001	0.001	0.002	0.00275	0.0095
Selenium - total (mg/L)	51		51									
Silicon - total (mg/L)	1	1		13	13.0000	0.0000	13	13	13	13	13	13

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Uranium - total (mg/L)	41	41		0.003	0.0050	0.0007	0.006	0.004	0.005	0.005	0.005	0.006
Vanadium - total (mg/L)	10		10									
Zinc - total (mg/L)	12	9	3	0.006	0.0188	0.0077	0.035	0.0084	0.016	0.018	0.022	0.031
Nutrients												
Nitrite + Nitrate as N (mg/L)	3	2	1	0.02	0.0500	0.0300	0.08	0.023	0.035	0.05	0.065	0.077
Total Kjeldahl Nitrogen as N (mg/L)	3	3		3.2	3.4333	0.2055	3.7	3.22	3.3	3.4	3.55	3.67
Total Nitrogen as N (mg/L)	3	3		3.2	3.4667	0.2055	3.7	3.23	3.35	3.5	3.6	3.68
Total Phosphorus as P (mg/L)	3	3		0.26	0.2600	0.0000	0.26	0.26	0.26	0.26	0.26	0.26
Physico-Chemical Parameters												
Electrical Conductivity (µS/cm)	40	40		331	1194.8500	171.9393	1340	897.95	1200	1240	1252.5	1310.5
pH (lab)	44	44		7.56	7.9064	0.2262	8.66	7.603	7.7175	7.9	8.04	8.1895
Total Dissolved Solids (mg/L)	1	1		820	820.0000	0.0000	820	820	820	820	820	820
Turbidity (NTU)	40	40		0.2	3.4250	7.4574	47.8	0.395	0.775	1.55	2.725	8.08
BAWB03												
Alkalinity												
Bicarbonate Alkalinity as CaCO3 (mg/L)	39	39		108	400.4359	83.5819	546	266.9	350	431	457	480.1
Carbonate Alkalinity as CaCO3 (mg/L)	39		39									
Carbonate Alkalinity as CO3 (mg/L)	1		1									
Hydroxide Alkalinity as CaCO3 (mg/L)	39		39									
Temperature (field) (°C)	39	39		108	400.4359	83.5819	546	266.9	350	431	457	480.1
Field Measurements												
Appearance or Colour	19											
Depth of Bore (mbgl)	54	54		104	104.0000	0.0000	104	104	104	104	104	104
Depth to Water (mbRL)	54	54		0.75	10.4609	2.9349	13.81	4.561	9.67	10.855	12.9125	13.621
Depth to Water (mbGL)	20	20		0.75	8.6405	3.0427	12.97	2.2415	7.665	9.27	10.7475	11.925
Dissolved Oxygen (field) (% sat))	30	30		0	36.8333	65.7100	296.3	0	3.1	7	30.4	162.565
Electrical Conductivity (field) (µS/cm)	30	30		665	913.8667	138.1151	1221	688.6	788.75	945.5	1001.5	1125.35

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Groundwater Level (mAHD)	54	54		297.74	328.9926	14.4226	367.98	315.7655	321.3025	323.8495	341.49575	356.73765
GWL Depth Reference Elevation	54	54		311.33	339.4536	14.5363	378.09	325.766	332.092	332.939	353.32	363.64115
Odour	20											
ORP (field) (mV)	25	25		-154.9	-43.3040	71.2425	208.9	-108.22	-88.9	-67.4	-32.9	57.64
pH (field)	30	30		6.12	7.1973	0.3926	8.11	6.67	6.99	7.205	7.3925	7.827
Salinity (field) (PSU)	30	30		0.32	0.4423	0.0708	0.6	0.329	0.38	0.46	0.4875	0.551
TDS (field) (ppm)	30	30		27.11	30.3893	1.7558	33.53	27.207	29.5775	30.4	31.64	32.894
Total Dissolved Solids (field) (ppm)	25	25		352	473.3200	61.6303	610	372.8	457	484	503	567.2
Turbidity (field) (FNU)	21	21		0	1.2190	1.2831	3.8	0	0	0.7	2.6	3.6
Hardness												
Total Hardness (mg CaCO3/L)	39	39		63	226.0769	43.7067	295	167.1	216	233	248	279
Ion Balance												
Ionic Balance (%)	38	38		0.06	3.6474	3.2027	14	0.645	1.495	2.675	4.685	9.6975
Total Anions (meq/L)	39	39		2.65	9.3964	1.8585	12.4	6.67	8.265	10.1	10.8	11.17
Total Cations (meq/L)	39	39		2.62	9.6215	1.8569	12.2	7.056	8.38	10.2	10.9	11.61
Major Ions												
Calcium (mg/L)	63	63		15	60.6032	10.5748	77	45.5	57.5	62	66	73.8
Chloride (mg/L)	39	39		7	15.4103	3.3106	23	11	13	15	17	22.1
Fluoride (mg/L)	36	36		0.3	0.7000	0.3536	2.4	0.3	0.5	0.7	0.8	0.9
Magnesium (mg/L)	63	63		5	19.3016	3.0532	26	16.1	18	19	20	24
Potassium (mg/L)	63	63		4	10.9794	1.9176	14	8	10	11	12	14
Sodium (mg/L)	63	63		29	113.6190	25.5600	150	70.5	96	117	136	145
Sulfate (as SO4)	39	39		14	46.0769	7.3288	56	36	43	48	51	55
Metals (dissolved)												
Aluminium - dissolved (mg/L)	1	1		0.03	0.0300	0.0000	0.03	0.03	0.03	0.03	0.03	0.03
Arsenic - dissolved (mg/L)	39	4	35	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001
Barium - dissolved (mg/L)	39	39		0.057	0.1065	0.0237	0.169	0.0679	0.091	0.108	0.1225	0.1368

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Beryllium - dissolved (mg/L)	1		1									
Bismuth - dissolved (mg/L)	38		38									
Boron - dissolved (mg/L)	1	1		0.15	0.1500	0.0000	0.15	0.15	0.15	0.15	0.15	0.15
Cadmium - dissolved (mg/L)	1		1									
Chromium - dissolved (mg/L)	39		39									
Cobalt - dissolved (mg/L)	39	5	34	0.001	0.0014	0.0005	0.002	0.001	0.001	0.001	0.002	0.002
Copper - dissolved (mg/L)	39	11	28	0.001	0.0032	0.0029	0.012	0.0015	0.002	0.002	0.003	0.008
Iron - dissolved (mg/L)	1		1									
Lead - dissolved (mg/L)	1		1									
Manganese - dissolved (mg/L)	1		1									
Mercury - dissolved (mg/L)	1		1									
Molybdenum - dissolved (mg/L)	38	38		0.001	0.0022	0.0007	0.005	0.00185	0.002	0.002	0.002	0.00315
Nickel - dissolved (mg/L)	39	7	32	0.001	0.0024	0.0012	0.004	0.001	0.0015	0.002	0.0035	0.004
Selenium - dissolved (mg/L)	39		39									
Silicon - dissolved (mg/L)	1	1		15	15.0000	0.0000	15	15	15	15	15	15
Uranium - dissolved (mg/L)	38	38		0.002	0.0053	0.0011	0.008	0.00385	0.005	0.005	0.006	0.007
Vanadium - dissolved (mg/L)	1	1		0.003	0.0030	0.0000	0.003	0.003	0.003	0.003	0.003	0.003
Zinc - dissolved (mg/L)	1	1		0.06	0.0600	0.0000	0.06	0.06	0.06	0.06	0.06	0.06
Metals (total)												
Aluminium - total (mg/L)	1	1		0.09	0.0900	0.0000	0.09	0.09	0.09	0.09	0.09	0.09
Arsenic - total (mg/L)	39	3	36	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001
Barium - total (mg/L)	39	39		0.058	0.1070	0.0280	0.183	0.0627	0.0915	0.104	0.1245	0.144
Beryllium - total (mg/L)	1		1									
Bismuth - total (mg/L)	38		38									
Boron - total (mg/L)	1	1		0.15	0.1500	0.0000	0.15	0.15	0.15	0.15	0.15	0.15
Cadmium - total (mg/L)	1		1									
Chromium - total (mg/L)	39	1	38	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Cobalt - total (mg/L)	39	8	31	0.001	0.0011	0.0003	0.002	0.001	0.001	0.001	0.001	0.00165
Copper - total (mg/L)	39	30	9	0.001	0.0032	0.0023	0.012	0.001	0.002	0.0025	0.00375	0.00765
Iron - total (mg/L)	1	1		0.071	0.0710	0.0000	0.071	0.071	0.071	0.071	0.071	0.071
Lead - total (mg/L)	1		1									
Manganese - total (mg/L)	1	1		0.007	0.0070	0.0000	0.007	0.007	0.007	0.007	0.007	0.007
Mercury - total (mg/L)	1		1									
Molybdenum - total (mg/L)	38	38		0.001	0.0023	0.0006	0.004	0.00185	0.002	0.002	0.003	0.003
Nickel - total (mg/L)	39	3	36	0.001	0.0023	0.0012	0.004	0.0011	0.0015	0.002	0.003	0.0038
Selenium - total (mg/L)	39		39									
Silicon - total (mg/L)	1	1		15	15.0000	0.0000	15	15	15	15	15	15
Uranium - total (mg/L)	38	38		0.003	0.0057	0.0010	0.007	0.004	0.005	0.006	0.006	0.007
Vanadium - total (mg/L)	1	1		0.003	0.0030	0.0000	0.003	0.003	0.003	0.003	0.003	0.003
Zinc - total (mg/L)	1	1		0.074	0.0740	0.0000	0.074	0.074	0.074	0.074	0.074	0.074
Nutrients												
Nitrite + Nitrate as N (mg/L)	3	3		0.89	1.9633	0.7605	2.56	1.045	1.665	2.44	2.5	2.548
Total Kjeldahl Nitrogen as N (mg/L)	3	3		0.1	0.3000	0.1414	0.4	0.13	0.25	0.4	0.4	0.4
Total Nitrogen as N (mg/L)	3	3		1	2.2667	0.8994	3	1.18	1.9	2.8	2.9	2.98
Total Phosphorus as P (mg/L)	3	3		0.02	0.0233	0.0047	0.03	0.02	0.02	0.02	0.025	0.029
Physico-Chemical Parameters												
Electrical Conductivity (µS/cm)	38	38		246	862.2895	168.8863	1130	640.4	740.25	911	993.25	1043
pH (lab)	39	39		7.24	7.6751	0.2665	8.2	7.268	7.415	7.69	7.865	8.101
Total Dissolved Solids (mg/L)	1	1		470	470.0000	0.0000	470	470	470	470	470	470
Turbidity (NTU)	38	38		0.3	2.4368	6.4626	41.4	0.485	0.725	1.15	1.975	3.31
BAWB04												
Alkalinity												
Bicarbonate Alkalinity as CaCO3 (mg/L)	54	54		166	434.6296	67.2743	601	320.95	421	437	463	538.3
Carbonate Alkalinity as CaCO3 (mg/L)	54	1	53	4	4.0000	0.0000	4	4	4	4	4	4

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Carbonate Alkalinity as CO3 (mg/L)	1		1									
Hydroxide Alkalinity as CaCO3 (mg/L)	54		54									
Temperature (field) (°C)	54	54		170	434.7037	66.9800	601	320.95	421	437	463	538.3
Field Measurements												
Appearance or Colour	23											
Depth of Bore (mbgl)	54	54		100	100.2963	1.0476	104	100	100	100	100	104
Depth to Water (mbRL)	55	55		8.04	13.1813	2.0067	15.64	9.32	12.32	14.03	14.515	14.994
Depth to Water (mbGL)	17	17		8.2	11.8818	1.7246	14.03	9.168	10.46	12.44	13.45	13.79
Dissolved Oxygen (field) (% sat))	34	34		0	36.1118	74.3109	422.6	0	3.05	8.3	44.475	107.175
Electrical Conductivity (field) (µS/cm)	37	37		82	845.7568	181.8187	1269	454.6	838	876	903	987
Groundwater Level (mAHD)	53	53		296.47	322.8486	13.7595	363.58	296.746	317	321.74	324.68	343.913
GWL Depth Reference Elevation	54	54		311.33	335.9609	13.6744	378.09	311.33	330.22	332.939	337.486	355.861
Odour	25											
ORP (field) (mV)	29	29		-156.8	-52.1345	72.8763	187.9	-119.14	-90.9	-74.9	-35.6	91.98
pH (field)	37	37		6.17	7.2530	0.3520	8.12	6.786	7.05	7.23	7.49	7.754
Salinity (field) (PSU)	34	34		0.19	0.4132	0.0652	0.63	0.3175	0.41	0.42	0.43	0.4435
TDS (field) (ppm)	34	34		23.25	30.4112	2.4010	35.33	26.591	29.7925	30.705	31.415	34.2855
Total Dissolved Solids (field) (ppm)	29	29		200	426.1724	69.4049	635	302.8	418	438	447	460.8
Turbidity (field) (FNU)	20	20		0	2.1300	2.0691	6.4	0	0.35	1.65	3.25	5.83
Hardness												
Total Hardness (mg CaCO3/L)	47	47		69	246.1064	36.9803	288	182	237.5	254	266.5	283.4
Ion Balance												
Ionic Balance (%)	54	54		-2.6	2.5576	2.1075	9.33	0.3255	1.3625	2.075	3.4	7.148
Total Anions (meq/L)	54	54		3.66	9.4644	1.4230	13	6.948	9.255	9.445	9.9525	11.645
Total Cations (meq/L)	54	54		3.03	9.4957	1.3774	11.4	7.194	9.0725	9.72	10.1	11.3
Major Ions												
Calcium (mg/L)	83	83		11	61.0000	9.4167	79	44.3	57	63	66.5	71

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Chloride (mg/L)	54	54		7	22.0741	7.4133	67	15	19	21	24	28
Fluoride (mg/L)	41	41		0.2	0.4317	0.0839	0.6	0.3	0.4	0.4	0.5	0.6
Magnesium (mg/L)	83	83		10	23.2289	3.1482	31	17	22	24	25	26
Potassium (mg/L)	83	83		2	6.4398	1.4390	11	4	6	6	7	9
Sodium (mg/L)	83	83		37	99.8675	17.1442	168	67.1	95	101	105.5	117.8
Sulfate (as SO4)	54	48	6	1	8.4792	6.7453	39	2	4.75	7	10.25	20.3
Metals (dissolved)												
Aluminium - dissolved (mg/L)	3	1	2	0.012	0.0120	0.0000	0.012	0.012	0.012	0.012	0.012	0.012
Arsenic - dissolved (mg/L)	54	27	27	0.001	0.0013	0.0008	0.004	0.001	0.001	0.001	0.001	0.003
Barium - dissolved (mg/L)	53	53		0.06	0.3703	0.0970	0.493	0.2046	0.315	0.394	0.433	0.487
Beryllium - dissolved (mg/L)	10		10									
Bismuth - dissolved (mg/L)	43		43									
Boron - dissolved (mg/L)	11	11		0.06	0.0895	0.0205	0.13	0.065	0.075	0.084	0.1	0.125
Cadmium - dissolved (mg/L)	12	1	11	0.0002	0.0002	0.0000	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Chromium - dissolved (mg/L)	54	2	52	0.001	0.0015	0.0005	0.002	0.00105	0.00125	0.0015	0.00175	0.00195
Cobalt - dissolved (mg/L)	54	3	51	0.001	0.0023	0.0012	0.004	0.0011	0.0015	0.002	0.003	0.0038
Copper - dissolved (mg/L)	54	26	28	0.001	0.0034	0.0038	0.02	0.001	0.002	0.002	0.003	0.00775
Iron - dissolved (mg/L)	1		1									
Lead - dissolved (mg/L)	12	2	10	0.003	0.0030	0.0000	0.003	0.003	0.003	0.003	0.003	0.003
Manganese - dissolved (mg/L)	12	12		0.684	3.1303	0.8798	4.06	1.7378	2.8625	3.255	3.725	4.049
Mercury - dissolved (mg/L)	11		11									
Molybdenum - dissolved (mg/L)	43	43		0.002	0.0027	0.0007	0.005	0.002	0.002	0.003	0.003	0.0039
Nickel - dissolved (mg/L)	54	9	45	0.001	0.0023	0.0011	0.004	0.001	0.002	0.002	0.003	0.004
Selenium - dissolved (mg/L)	53	1	52	0.003	0.0030	0.0000	0.003	0.003	0.003	0.003	0.003	0.003
Silicon - dissolved (mg/L)	1	1		18	18.0000	0.0000	18	18	18	18	18	18
Uranium - dissolved (mg/L)	43	40	3	0.001	0.0020	0.0004	0.003	0.001	0.002	0.002	0.002	0.003
Vanadium - dissolved (mg/L)	10		10									

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Zinc - dissolved (mg/L)	12	9	3	0.007	0.0144	0.0056	0.024	0.0078	0.011	0.014	0.017	0.0236
Metals (total)												
Aluminium - total (mg/L)	3	3		0.02	0.0297	0.0078	0.039	0.021	0.025	0.03	0.0345	0.0381
Arsenic - total (mg/L)	54	30	24	0.001	0.0017	0.0008	0.004	0.001	0.001	0.0015	0.002	0.00355
Barium - total (mg/L)	53	53		0.068	0.3921	0.0997	0.529	0.2384	0.34	0.413	0.468	0.5094
Beryllium - total (mg/L)	10		10									
Bismuth - total (mg/L)	43		43									
Boron - total (mg/L)	11	10	1	0.06	0.0858	0.0215	0.13	0.0645	0.07	0.0805	0.08925	0.1255
Cadmium - total (mg/L)	12	1	11	0.0003	0.0003	0.0000	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Chromium - total (mg/L)	54	3	51	0.002	0.0037	0.0017	0.006	0.0021	0.0025	0.003	0.0045	0.0057
Cobalt - total (mg/L)	54	4	50	0.002	0.0025	0.0009	0.004	0.002	0.002	0.002	0.0025	0.0037
Copper - total (mg/L)	54	47	7	0.001	0.0170	0.0594	0.369	0.001	0.002	0.004	0.007	0.0175
Iron - total (mg/L)	1	1		1.4	1.4000	0.0000	1.4	1.4	1.4	1.4	1.4	1.4
Lead - total (mg/L)	12	4	8	0.001	0.0018	0.0008	0.003	0.001	0.001	0.0015	0.00225	0.00285
Manganese - total (mg/L)	12	12		0.696	3.2955	0.9454	4.35	1.7157	2.895	3.59	3.7875	4.2895
Mercury - total (mg/L)	11		11									
Molybdenum - total (mg/L)	43	42	1	0.002	0.0030	0.0007	0.005	0.002	0.003	0.003	0.003	0.004
Nickel - total (mg/L)	54	9	45	0.001	0.0021	0.0010	0.004	0.001	0.001	0.002	0.003	0.0036
Selenium - total (mg/L)	53	1	52	0.003	0.0030	0.0000	0.003	0.003	0.003	0.003	0.003	0.003
Silicon - total (mg/L)	1	1		18	18.0000	0.0000	18	18	18	18	18	18
Uranium - total (mg/L)	43	41	2	0.001	0.0020	0.0004	0.003	0.001	0.002	0.002	0.002	0.003
Vanadium - total (mg/L)	10		10									
Zinc - total (mg/L)	12	11	1	0.007	0.0169	0.0086	0.038	0.007	0.0105	0.017	0.0185	0.0315
Nutrients												
Nitrite + Nitrate as N (mg/L)	3	1	2	0.28	0.2800	0.0000	0.28	0.28	0.28	0.28	0.28	0.28
Total Kjeldahl Nitrogen as N (mg/L)	3	3		0.2	0.2333	0.0471	0.3	0.2	0.2	0.2	0.25	0.29
Total Nitrogen as N (mg/L)	3	3		0.2	0.3333	0.1247	0.5	0.21	0.25	0.3	0.4	0.48

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Total Phosphorus as P (mg/L)	3	3		0.03	0.0600	0.0216	0.08	0.034	0.05	0.07	0.075	0.079
Physico-Chemical Parameters												
Electrical Conductivity (µS/cm)	43	43		233	814.8372	117.6562	950	596	813.5	848	868	890.9
pH (lab)	47	47		7.25	7.6762	0.2477	8.33	7.323	7.48	7.68	7.88	8.079
Total Dissolved Solids (mg/L)	1	1		560	560.0000	0.0000	560	560	560	560	560	560
Turbidity (NTU)	43	43		0.4	15.0465	10.4173	50.7	1.83	5.3	16.5	22.75	28.19
BAWB05												
Alkalinity												
Bicarbonate Alkalinity as CaCO3 (mg/L)	50	50		66	342.5800	100.6598	501	230.35	250.5	349	442	470.65
Carbonate Alkalinity as CaCO3 (mg/L)	50	2	48	13	19.5000	6.5000	26	13.65	16.25	19.5	22.75	25.35
Carbonate Alkalinity as CO3 (mg/L)	1		1									
Hydroxide Alkalinity as CaCO3 (mg/L)	50		50									
Temperature (field) (°C)	50	50		66	343.4400	100.7659	501	230.35	250.5	355	442	470.65
Field Measurements												
Appearance or Colour	19											
Depth of Bore (mbgl)	55	55		102	102.0000	0.0000	102	102	102	102	102	102
Depth to Water (mbRL)	56	56		12.86	22.2573	3.3583	25.96	14.8875	21.7075	23.785	24.3375	24.9525
Depth to Water (mbGL)	19	19		12.86	19.6247	3.7342	25.14	13.607	15.99	20.24	22.49	24.915
Dissolved Oxygen (field) (% sat))	30	30		0	20.1000	28.0009	116.1	0	3.1	7.95	23.95	78.615
Electrical Conductivity (field) (µS/cm)	34	34		11.17	749.8579	190.6070	1142	601.2	650.75	713.5	874.25	973.8
Groundwater Level (mAHD)	54	54		287.43	315.3653	13.8797	353.73	299.3225	307.477	310.9645	319.5145	341.10965
GWL Depth Reference Elevation	55	55		311.33	337.4472	14.1016	378.09	323.92	330.22	332.939	335.23	362.5297
Odour	21											
ORP (field) (mV)	26	26		-190.1	-97.1692	76.1229	158.4	-177.925	-154.475	-108.05	-69.4	33.775
pH (field)	34	34		6.99	7.7491	0.4076	8.68	7.1525	7.435	7.655	8.0025	8.51
Salinity (field) (PSU)	31	31		0.3	0.3771	0.0723	0.56	0.3	0.31	0.35	0.43	0.48
TDS (field) (ppm)	31	31		21.99	30.6306	1.9696	33.47	28.615	29.93	31.05	31.515	32.775

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Total Dissolved Solids (field) (ppm)	26	26		312	377.5000	68.5286	571	315	327.25	345.5	428.5	489
Turbidity (field) (FNU)	20	20		0	1.9350	2.1178	8.7	0	0	1.8	2.5	4.9
Hardness												
Total Hardness (mg CaCO3/L)	43	43		43	228.3721	59.5268	327	170.1	184	214	279	319.6
Ion Balance												
Ionic Balance (%)	49	49		-2	3.3308	2.7853	14.3	0.278	1.42	2.96	4.46	9.172
Total Anions (meq/L)	50	50		1.73	8.5838	2.0640	11.6	6.238	6.84	9.02	10.45	11.11
Total Cations (meq/L)	50	50		1.66	8.6134	1.9111	11.8	6.647	7.0925	8.93	9.9425	11.31
Major Ions												
Calcium (mg/L)	74	74		9	38.6081	7.0420	58	31	34	37	43	49.35
Chloride (mg/L)	50	50		5	17.0800	5.3994	28	11.45	12	17	21.75	26
Fluoride (mg/L)	36	35	1	0.2	0.5343	0.1194	0.8	0.27	0.5	0.6	0.6	0.63
Magnesium (mg/L)	74	74		5	32.1486	9.4378	53	23	24	28.5	40.75	47
Potassium (mg/L)	74	74		4	18.5270	2.5797	25	16	18	19	20	22
Sodium (mg/L)	74	74		16	77.5405	15.6552	118	62.65	68	72	89	102.75
Sulfate (as SO4)	50	50		13	59.6840	14.7785	84	36.15	49.5	63.6	69.75	77.65
Metals (dissolved)												
Aluminium - dissolved (mg/L)	2	2		0.02	0.0270	0.0070	0.034	0.0207	0.0235	0.027	0.0305	0.0333
Arsenic - dissolved (mg/L)	50	25	25	0.001	0.0014	0.0005	0.002	0.001	0.001	0.001	0.002	0.002
Barium - dissolved (mg/L)	49	49		0.071	0.1777	0.0669	0.374	0.0984	0.141	0.159	0.205	0.3144
Beryllium - dissolved (mg/L)	10		10									
Bismuth - dissolved (mg/L)	39		39									
Boron - dissolved (mg/L)	10	5	5	0.04	0.0594	0.0144	0.08	0.0416	0.048	0.059	0.07	0.078
Cadmium - dissolved (mg/L)	11	1	10	0.0005	0.0005	0.0000	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Chromium - dissolved (mg/L)	50	1	49	0.002	0.0020	0.0000	0.002	0.002	0.002	0.002	0.002	0.002
Cobalt - dissolved (mg/L)	50		50									
Copper - dissolved (mg/L)	50	18	32	0.001	0.0041	0.0053	0.024	0.001	0.002	0.002	0.00375	0.0104

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Iron - dissolved (mg/L)	1		1									
Lead - dissolved (mg/L)	11		11									
Manganese - dissolved (mg/L)	11	11		0.3	0.5906	0.3265	1.4	0.312	0.3695	0.461	0.6305	1.225
Mercury - dissolved (mg/L)	11		11									
Molybdenum - dissolved (mg/L)	39	39		0.005	0.0191	0.0057	0.031	0.0098	0.015	0.02	0.023	0.0273
Nickel - dissolved (mg/L)	50	9	41	0.001	0.0018	0.0012	0.005	0.001	0.001	0.001	0.002	0.0038
Selenium - dissolved (mg/L)	49		49									
Silicon - dissolved (mg/L)	1	1		13	13.0000	0.0000	13	13	13	13	13	13
Uranium - dissolved (mg/L)	39	39		0.001	0.0025	0.0012	0.006	0.001	0.002	0.002	0.003	0.005
Vanadium - dissolved (mg/L)	10	1	9	0.002	0.0020	0.0000	0.002	0.002	0.002	0.002	0.002	0.002
Zinc - dissolved (mg/L)	11	5	6	0.007	0.0108	0.0030	0.015	0.0072	0.008	0.011	0.013	0.0146
Metals (total)												
Aluminium - total (mg/L)	2	2		0.044	0.1170	0.0730	0.19	0.0513	0.0805	0.117	0.1535	0.1827
Arsenic - total (mg/L)	50	33	17	0.001	0.0017	0.0009	0.005	0.001	0.001	0.002	0.002	0.003
Barium - total (mg/L)	49	49		0.088	0.1952	0.0812	0.399	0.1016	0.153	0.167	0.247	0.3662
Beryllium - total (mg/L)	10		10									
Bismuth - total (mg/L)	39		39									
Boron - total (mg/L)	10	6	4	0.04	0.0563	0.0095	0.07	0.04225	0.0515	0.0595	0.06	0.0675
Cadmium - total (mg/L)	11	2	9	0.0003	0.0004	0.0001	0.0004	0.000305	0.000325	0.00035	0.000375	0.000395
Chromium - total (mg/L)	50	6	44	0.001	0.0018	0.0011	0.004	0.001	0.001	0.0015	0.002	0.0035
Cobalt - total (mg/L)	50	4	46	0.001	0.0015	0.0005	0.002	0.001	0.001	0.0015	0.002	0.002
Copper - total (mg/L)	50	48	2	0.001	0.0047	0.0032	0.019	0.00135	0.003	0.004	0.006	0.00965
Iron - total (mg/L)	1	1		0.71	0.7100	0.0000	0.71	0.71	0.71	0.71	0.71	0.71
Lead - total (mg/L)	11	5	6	0.001	0.0024	0.0019	0.006	0.001	0.001	0.002	0.002	0.0052
Manganese - total (mg/L)	11	11		0.346	0.6552	0.3198	1.4	0.368	0.4175	0.54	0.747	1.265
Mercury - total (mg/L)	11		11									
Molybdenum - total (mg/L)	39	39		0.007	0.0217	0.0062	0.033	0.0128	0.0155	0.024	0.026	0.0311

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Nickel - total (mg/L)	50	13	37	0.001	0.0029	0.0033	0.014	0.001	0.002	0.002	0.002	0.0086
Selenium - total (mg/L)	49		49									
Silicon - total (mg/L)	1	1		14	14.0000	0.0000	14	14	14	14	14	14
Uranium - total (mg/L)	39	39		0.002	0.0028	0.0012	0.006	0.002	0.002	0.002	0.003	0.006
Vanadium - total (mg/L)	10	2	8	0.001	0.0015	0.0005	0.002	0.00105	0.00125	0.0015	0.00175	0.00195
Zinc - total (mg/L)	11	10	1	0.006	0.0101	0.0041	0.02	0.006	0.00625	0.0105	0.011	0.01685
Nutrients												
Nitrite + Nitrate as N (mg/L)	3	3		0.02	0.0333	0.0094	0.04	0.022	0.03	0.04	0.04	0.04
Total Kjeldahl Nitrogen as N (mg/L)	3	3		0.3	0.3333	0.0471	0.4	0.3	0.3	0.3	0.35	0.39
Total Nitrogen as N (mg/L)	3	3		0.3	0.3333	0.0471	0.4	0.3	0.3	0.3	0.35	0.39
Total Phosphorus as P (mg/L)	3	3		0.03	0.0467	0.0125	0.06	0.032	0.04	0.05	0.055	0.059
Physico-Chemical Parameters												
Electrical Conductivity (µS/cm)	39	39		164	738.7436	170.8824	996	604.2	621.5	662	895.5	978.9
pH (lab)	43	43		7.1	7.9895	0.2410	8.4	7.649	7.83	8.05	8.17	8.289
Total Dissolved Solids (mg/L)	1	1		600	600.0000	0.0000	600	600	600	600	600	600
Turbidity (NTU)	39	39		0.3	4.6564	4.8768	18.5	0.49	1.8	2.6	5.65	17.6
BAWB07												
Alkalinity												
Bicarbonate Alkalinity as CaCO3 (mg/L)	17	17		419	485.5294	36.3401	554	443	462	476	497	548.4
Carbonate Alkalinity as CaCO3 (mg/L)	17		17									
Hydroxide Alkalinity as CaCO3 (mg/L)	17		17									
Temperature (field) (°C)	17	17		419	485.5294	36.3401	554	443	462	476	497	548.4
Field Measurements												
Appearance or Colour	1											
Depth of Bore (mbgl)	8	8		146	146.0000	0.0000	146	146	146	146	146	146
Depth to Water (mbRL)	9	9		10.04	14.3811	2.2769	16.93	10.404	13.59	14.96	15.96	16.71
Depth to Water (mbGL)	5	5		10.04	13.2080	2.2937	15.74	10.222	10.95	14.12	15.19	15.63

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Depth to Water Comments	1											
Dissolved Oxygen (field) (% sat))	7	7		2.4	9.5714	7.2691	25.2	3.06	5.1	5.6	11.8	21.78
Electrical Conductivity (field) (µS/cm)	10	10		998	1100.7000	72.5811	1264	1006.55	1070	1087	1115.75	1225.75
Groundwater Level (mAHD)	7	7		307.96	317.5799	4.4072	322.052	310.4776	317.052	317.832	320.5555	322.0331
GWL Depth Reference Elevation	8	8		323.92	331.3934	2.8452	332.939	326.7368	332.061	332.402	332.712	332.85955
Odour	1											
ORP (field) (mV)	3	3		-77.3	1.6333	55.8611	43.9	-65.74	-19.5	38.3	41.1	43.34
pH (field)	10	10		6.62	7.0330	0.3803	8.01	6.6245	6.82	6.965	7.0975	7.686
Salinity (field) (PSU)	7	7		0.5	0.5386	0.0236	0.58	0.506	0.525	0.54	0.55	0.571
TDS (field) (ppm)	7	7		24.79	29.4014	2.1045	31.68	26.005	28.975	29.75	30.82	31.425
Total Dissolved Solids (field) (ppm)	3	3		541	561.6667	20.7257	590	542.3	547.5	554	572	586.4
Turbidity (field) (FNU)	7	7		0	2.8714	6.4322	18.6	0	0	0	0.75	13.35
Hardness												
Total Hardness (mg CaCO3/L)	11	11		236	265.6364	19.1751	307	236	258.5	264	272	296
Ion Balance												
Ionic Balance (%)	17	17		0.38	2.9853	2.2451	8.8	0.588	1.38	2.42	3.64	7.744
Total Anions (meq/L)	17	17		11	12.0941	0.5936	13.1	11.32	11.6	12	12.6	13.1
Total Cations (meq/L)	17	17		9.55	12.1676	0.9002	13.7	10.79	12	12.2	12.6	13.14
Major Ions												
Calcium (mg/L)	17	17		44	52.8824	4.4043	62	44	50	53	55	58.8
Chloride (mg/L)	17	17		36	41.7647	3.9931	49	36	39	42	44	47.4
Fluoride (mg/L)	11	11		0.8	1.4545	0.3173	1.7	0.8	1.5	1.6	1.65	1.7
Magnesium (mg/L)	17	17		26	32.4706	3.1271	37	26.8	32	33	34	37
Potassium (mg/L)	17	17		5	7.4118	1.0878	10	5.8	7	8	8	8.4
Sodium (mg/L)	17	17		117	153.4118	12.9254	173	134.6	150	153	161	170.6
Sulfate (as SO4)	17	17		39	58.2353	10.9627	75	42.2	47	61	66	71
Metals (dissolved)												

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Arsenic - dissolved (mg/L)	17	17		0.002	0.0079	0.0063	0.018	0.002	0.003	0.004	0.015	0.018
Barium - dissolved (mg/L)	17	17		0.054	0.0884	0.0242	0.152	0.0548	0.073	0.084	0.1	0.128
Beryllium - dissolved (mg/L)	6		6									
Bismuth - dissolved (mg/L)	11		11									
Boron - dissolved (mg/L)	6	4	2	0.05	0.0675	0.0109	0.08	0.053	0.065	0.07	0.0725	0.0785
Cadmium - dissolved (mg/L)	6		6									
Chromium - dissolved (mg/L)	17	2	15	0.001	0.0015	0.0005	0.002	0.00105	0.00125	0.0015	0.00175	0.00195
Cobalt - dissolved (mg/L)	17	1	16	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001
Copper - dissolved (mg/L)	17	11	6	0.001	0.0043	0.0049	0.015	0.001	0.001	0.002	0.0055	0.0135
Lead - dissolved (mg/L)	6	2	4	0.001	0.0035	0.0025	0.006	0.00125	0.00225	0.0035	0.00475	0.00575
Manganese - dissolved (mg/L)	6	6		0.058	0.0733	0.0105	0.086	0.05875	0.064	0.077	0.081	0.08475
Mercury - dissolved (mg/L)	6		6									
Molybdenum - dissolved (mg/L)	11	11		0.003	0.0039	0.0007	0.005	0.003	0.0035	0.004	0.004	0.005
Nickel - dissolved (mg/L)	17	4	13	0.001	0.0025	0.0015	0.004	0.001	0.001	0.0025	0.004	0.004
Selenium - dissolved (mg/L)	17		17									
Uranium - dissolved (mg/L)	11	11		0.004	0.0042	0.0004	0.005	0.004	0.004	0.004	0.004	0.005
Vanadium - dissolved (mg/L)	6		6									
Zinc - dissolved (mg/L)	6	5	1	0.005	0.0068	0.0012	0.008	0.0052	0.006	0.007	0.008	0.008
Metals (total)												
Arsenic - total (mg/L)	17	17		0.002	0.0081	0.0063	0.019	0.002	0.003	0.005	0.014	0.0182
Barium - total (mg/L)	17	17		0.066	0.0885	0.0111	0.105	0.074	0.08	0.086	0.098	0.1042
Beryllium - total (mg/L)	6		6									
Bismuth - total (mg/L)	11		11									
Boron - total (mg/L)	6	4	2	0.05	0.0725	0.0148	0.09	0.053	0.065	0.075	0.0825	0.0885
Cadmium - total (mg/L)	6	1	5	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Chromium - total (mg/L)	17	3	14	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt - total (mg/L)	17		17									

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Copper - total (mg/L)	17	15	2	0.002	0.0093	0.0082	0.029	0.0027	0.0035	0.006	0.0125	0.0241
Lead - total (mg/L)	6	3	3	0.001	0.0073	0.0083	0.019	0.0011	0.0015	0.002	0.0105	0.0173
Manganese - total (mg/L)	6	6		0.074	0.0850	0.0145	0.116	0.074	0.0755	0.08	0.0845	0.1085
Mercury - total (mg/L)	6		6									
Molybdenum - total (mg/L)	11	11		0.003	0.0040	0.0006	0.005	0.003	0.004	0.004	0.004	0.005
Nickel - total (mg/L)	17	7	10	0.001	0.0014	0.0005	0.002	0.001	0.001	0.001	0.002	0.002
Selenium - total (mg/L)	17		17									
Uranium - total (mg/L)	11	11		0.003	0.0039	0.0005	0.005	0.003	0.004	0.004	0.004	0.0045
Vanadium - total (mg/L)	6		6									
Zinc - total (mg/L)	6	4	2	0.011	0.0203	0.0061	0.028	0.0125	0.0185	0.021	0.02275	0.02695
Nutrients												
Nitrite + Nitrate as N (mg/L)	1	1		0.39	0.3900	0.0000	0.39	0.39	0.39	0.39	0.39	0.39
Total Kjeldahl Nitrogen as N (mg/L)	1	1		0.1	0.1000	0.0000	0.1	0.1	0.1	0.1	0.1	0.1
Total Nitrogen as N (mg/L)	1	1		0.5	0.5000	0.0000	0.5	0.5	0.5	0.5	0.5	0.5
Total Phosphorus as P (mg/L)	1	1		0.04	0.0400	0.0000	0.04	0.04	0.04	0.04	0.04	0.04
Physico-Chemical Parameters												
Electrical Conductivity (µS/cm)	11	11		951	1077.3636	51.8429	1130	995.5	1050	1100	1120	1130
pH (lab)	11	11		7.31	7.4382	0.1372	7.71	7.31	7.33	7.43	7.45	7.705
Turbidity (NTU)	11	11		0.3	5.0182	5.6307	16.2	0.55	1.05	1.7	6	16.2
BAWBR01												
Alkalinity												
Bicarbonate Alkalinity as CaCO3 (mg/L)	2	2		2120	2170.0000	50.0000	2220	2125	2145	2170	2195	2215
Carbonate Alkalinity as CaCO3 (mg/L)	2		2									
Hydroxide Alkalinity as CaCO3 (mg/L)	2		2									
Temperature (field) (°C)	2	2		2120	2170.0000	50.0000	2220	2125	2145	2170	2195	2215
Field Measurements												
Appearance or Colour	2											

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Depth of Bore (mbgl)	51	51		3.5	5.9627	0.3581	6.6	6	6	6	6	6
Depth to Water (mbRL)	24	24		1.22	5.0142	1.7549	6.9	1.533	3.37	5.795	6.1075	6.77
Depth to Water (mbGL)	12	12		3.34	5.5517	1.0583	6.9	3.362	5.6975	5.775	5.87	6.845
Depth to Water Comments	39											
Dissolved Oxygen (field) (% sat))	3	3		6	79.2333	84.9327	198.3	8.74	19.7	33.4	115.85	181.81
Dry?	39											
Electrical Conductivity (field) (µS/cm)	3	3		28.4	240.8100	299.9477	665	28.463	28.715	29.03	347.015	601.403
Groundwater Level (mAHD)	24	24		318.16	329.8427	9.1451	349.971	318.653	325.3355	326.6705	331.93425	349.56885
GWL Depth Reference Elevation	51	51		323.92	338.2382	13.2926	378.09	325.34	331.094	332.939	337.237	366.9755
Odour	2											
ORP (field) (mV)	3	3		-118.7	-40.0667	59.9494	26.7	-109.65	-73.45	-28.2	-0.75	21.21
pH (field)	3	3		7.67	8.1200	0.3195	8.38	7.734	7.99	8.31	8.345	8.373
Salinity (field) (PSU)	3	3		0.32	11.7967	8.1179	17.79	2.016	8.8	17.28	17.535	17.739
TDS (field) (ppm)	3	3		30.6	31.7333	1.2532	33.48	30.652	30.86	31.12	32.3	33.244
Total Dissolved Solids (field) (ppm)	3	3		14.19	120.2333	149.7417	332	14.222	14.35	14.51	173.255	300.251
Turbidity (field) (FNU)	1	1		4.6	4.6000	0.0000	4.6	4.6	4.6	4.6	4.6	4.6
Hardness												
Total Hardness (mg CaCO3/L)	2	2		1140	1140.0000	0.0000	1140	1140	1140	1140	1140	1140
Ion Balance												
Ionic Balance (%)	2	2		4.44	5.6800	1.2400	6.92	4.564	5.06	5.68	6.3	6.796
Total Anions (meq/L)	2	2		346	349.0000	3.0000	352	346.3	347.5	349	350.5	351.7
Total Cations (meq/L)	2	2		385	391.0000	6.0000	397	385.6	388	391	394	396.4
Major Ions												
Calcium (mg/L)	4	4		125	132.7500	6.2199	142	125.75	128.75	132	136	140.8
Chloride (mg/L)	2	2		5420	5455.0000	35.0000	5490	5423.5	5437.5	5455	5472.5	5486.5
Fluoride (mg/L)	2	2		2	2.2000	0.2000	2.4	2.02	2.1	2.2	2.3	2.38
Magnesium (mg/L)	4	4		173	187.0000	9.4868	199	174.8	182	188	193	197.8

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Potassium (mg/L)	4	4		35	35.7500	0.8292	37	35	35	35.5	36.25	36.85
Sodium (mg/L)	4	4		7790	8150.0000	313.4486	8580	7809.5	7887.5	8115	8377.5	8539.5
Sulfate (as SO4)	2	2		7220	7290.0000	70.0000	7360	7227	7255	7290	7325	7353
Metals (dissolved)												
Arsenic - dissolved (mg/L)	2	2		0.006	0.0060	0.0000	0.006	0.006	0.006	0.006	0.006	0.006
Barium - dissolved (mg/L)	2	2		0.091	0.0935	0.0025	0.096	0.09125	0.09225	0.0935	0.09475	0.09575
Bismuth - dissolved (mg/L)	2		2									
Chromium - dissolved (mg/L)	2		2									
Cobalt - dissolved (mg/L)	2	2		0.013	0.0140	0.0010	0.015	0.0131	0.0135	0.014	0.0145	0.0149
Copper - dissolved (mg/L)	2	1	1	0.007	0.0070	0.0000	0.007	0.007	0.007	0.007	0.007	0.007
Molybdenum - dissolved (mg/L)	2	2		0.209	0.2105	0.0015	0.212	0.20915	0.20975	0.2105	0.21125	0.21185
Nickel - dissolved (mg/L)	2		2									
Selenium - dissolved (mg/L)	2		2									
Uranium - dissolved (mg/L)	2	2		0.461	0.4785	0.0175	0.496	0.46275	0.46975	0.4785	0.48725	0.49425
Metals (total)												
Arsenic - total (mg/L)	2	2		0.006	0.0065	0.0005	0.007	0.00605	0.00625	0.0065	0.00675	0.00695
Barium - total (mg/L)	2	2		0.076	0.0860	0.0100	0.096	0.077	0.081	0.086	0.091	0.095
Bismuth - total (mg/L)	2		2									
Chromium - total (mg/L)	2		2									
Cobalt - total (mg/L)	2	2		0.013	0.0135	0.0005	0.014	0.01305	0.01325	0.0135	0.01375	0.01395
Copper - total (mg/L)	2	1	1	0.009	0.0090	0.0000	0.009	0.009	0.009	0.009	0.009	0.009
Molybdenum - total (mg/L)	2	2		0.195	0.2055	0.0105	0.216	0.19605	0.20025	0.2055	0.21075	0.21495
Nickel - total (mg/L)	2		2									
Selenium - total (mg/L)	2		2									
Uranium - total (mg/L)	2	2		0.448	0.4535	0.0055	0.459	0.44855	0.45075	0.4535	0.45625	0.45845
Physico-Chemical Parameters												
Electrical Conductivity (µS/cm)	2	2		28600	29950.0000	1350.0000	31300	28735	29275	29950	30625	31165

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
pH (lab)	2	2		8.07	8.0800	0.0100	8.09	8.071	8.075	8.08	8.085	8.089
Turbidity (NTU)	2	2		9.6	13.1000	3.5000	16.6	9.95	11.35	13.1	14.85	16.25
BAWBR02												
Alkalinity												
Bicarbonate Alkalinity as CaCO3 (mg/L)	6	6		290	1033.6667	816.5747	2200	305.5	381.25	610	1792.75	2185
Carbonate Alkalinity as CaCO3 (mg/L)	6		6									
Hydroxide Alkalinity as CaCO3 (mg/L)	6		6									
Temperature (field) (°C)	6	6		290	1033.6667	816.5747	2200	305.5	381.25	610	1792.75	2185
Field Measurements												
Appearance or Colour	5											
Depth of Bore (mbgl)	53	53		3	3.0336	0.1176	3.45	3	3	3	3	3.44
Depth to Water (mbRL)	35	35		0.98	2.5114	0.7307	3.4	1.094	2.23	2.5	3.34	3.39
Depth to Water (mbGL)	13	13		1.35	2.9692	0.5944	3.39	2.028	2.5	3.36	3.37	3.384
Depth to Water Comments	30											
Dissolved Oxygen (field) (% sat))	7	7		0	45.5000	68.9561	208.5	0.9	6.9	14.9	40.65	163.56
Dry?	30											
Electrical Conductivity (field) (µS/cm)	7	7		557	2274.5714	2186.7162	7385	662	916.5	1676	2235.5	5966.6
Groundwater Level (mAHD)	35	35		309.11	330.9629	10.3460	354.551	320.55	327.36	328.588	330.81	353.714
GWL Depth Reference Elevation	53	53		311.33	335.9972	14.6118	378.09	318.884	329.94	332.092	337.237	364.7526
Odour	5											
ORP (field) (mV)	7	7		-300.9	-24.9857	128.5353	104.9	-232.89	-62.4	4.9	70.5	99.05
pH (field)	7	7		7.05	7.9329	0.6247	8.99	7.092	7.475	7.98	8.28	8.798
Salinity (field) (PSU)	7	7		0.26	1.1929	1.2245	4.07	0.314	0.445	0.85	1.14	3.26
TDS (field) (ppm)	7	7		23.81	29.6229	2.7849	31.97	24.974	28.495	31.32	31.635	31.958
Total Dissolved Solids (field) (ppm)	7	7		279	1138.2857	1092.9212	3692	331.2	458	845	1118	2983.1
Turbidity (field) (FNU)	2	2		0.6	1.0500	0.4500	1.5	0.645	0.825	1.05	1.275	1.455
Hardness												

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Total Hardness (mg CaCO3/L)	6	6		80	529.0000	540.2481	1300	89.75	128.5	197.5	1019.5	1295
Ion Balance												
Ionic Balance (%)	6	6		0.45	2.7367	2.3514	7.32	0.6	1.085	1.8	3.6025	6.49
Total Anions (meq/L)	6	6		9.1	43.4500	37.9807	96.4	9.95	13.525	23.15	79.725	96.4
Total Cations (meq/L)	6	6		9.85	42.3083	36.5460	94.4	10.0875	12.35	23.45	76.4	93.775
Major Ions												
Calcium (mg/L)	12	12		17	63.9167	54.9643	184	18.65	23.75	41.5	78	176.85
Chloride (mg/L)	6	6		58	396.8333	381.0680	950	65.75	98.75	188	743	939.5
Fluoride (mg/L)	6	6		0.3	0.6333	0.2625	1	0.3	0.375	0.7	0.8	0.95
Magnesium (mg/L)	12	12		9	96.5833	112.7818	277	9	14.75	23.5	224	273.7
Potassium (mg/L)	12	12		2	8.0000	6.0690	20	2.55	4	5	12.25	19.45
Sodium (mg/L)	12	12		170	703.0000	570.8289	1570	172.75	208	431.5	1355	1553.5
Sulfate (as SO4)	6	6		80	557.8333	525.1001	1290	95.75	151.25	272	1059.5	1290
Metals (dissolved)												
Arsenic - dissolved (mg/L)	6	5	1	0.001	0.0034	0.0034	0.01	0.001	0.001	0.002	0.003	0.0086
Barium - dissolved (mg/L)	6	6		0.003	0.0670	0.0510	0.162	0.00975	0.036	0.0555	0.08625	0.1455
Bismuth - dissolved (mg/L)	6	1	5	0.00006	0.0001	0.0000	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006
Chromium - dissolved (mg/L)	6	2	4	0.001	0.0040	0.0030	0.007	0.0013	0.0025	0.004	0.0055	0.0067
Cobalt - dissolved (mg/L)	6	2	4	0.002	0.0035	0.0015	0.005	0.00215	0.00275	0.0035	0.00425	0.00485
Copper - dissolved (mg/L)	6	5	1	0.005	0.0600	0.0941	0.247	0.0052	0.006	0.008	0.034	0.2044
Molybdenum - dissolved (mg/L)	6	4	2	0.002	0.0068	0.0065	0.018	0.00215	0.00275	0.0035	0.0075	0.0159
Nickel - dissolved (mg/L)	6	4	2	0.002	0.0088	0.0095	0.025	0.002	0.002	0.004	0.01075	0.02215
Selenium - dissolved (mg/L)	6		6									
Uranium - dissolved (mg/L)	6	6		0.003	0.0317	0.0502	0.143	0.003	0.00425	0.01	0.01875	0.1125
Metals (total)												
Arsenic - total (mg/L)	6	6		0.001	0.0042	0.0034	0.011	0.00125	0.002	0.0025	0.00525	0.00975
Barium - total (mg/L)	6	6		0.067	0.1112	0.0395	0.182	0.0675	0.077	0.1075	0.129	0.17

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Bismuth - total (mg/L)	6	2	4	0.00009	0.0001	0.0001	0.0002	0.0000955	0.0001175	0.000145	0.0001725	0.0001945
Chromium - total (mg/L)	6	4	2	0.001	0.0043	0.0051	0.013	0.001	0.001	0.0015	0.00475	0.01135
Cobalt - total (mg/L)	6	4	2	0.001	0.0038	0.0031	0.009	0.00115	0.00175	0.0025	0.0045	0.0081
Copper - total (mg/L)	6	6		0.009	0.1965	0.3190	0.89	0.0095	0.012	0.0245	0.1735	0.7225
Molybdenum - total (mg/L)	6	6		0.001	0.0077	0.0063	0.017	0.00175	0.004	0.004	0.013	0.01675
Nickel - total (mg/L)	6	6		0.001	0.0092	0.0109	0.033	0.00125	0.0025	0.0055	0.00775	0.02675
Selenium - total (mg/L)	6		6									
Uranium - total (mg/L)	6	6		0.004	0.0563	0.0611	0.156	0.00475	0.0085	0.0225	0.1025	0.1485
Physico-Chemical Parameters												
Electrical Conductivity (µS/cm)	6	6		883	3393.8333	2582.8299	7280	959.75	1292.5	2210	5647.5	7107.5
pH (lab)	6	6		7.46	7.9350	0.2375	8.24	7.575	7.9275	7.96	8.045	8.1975
Turbidity (NTU)	6	6		1.9	6.9500	6.1592	20	2.2	3.225	4.25	7.375	17.05
BAWBR03												
Alkalinity												
Bicarbonate Alkalinity as CaCO3 (mg/L)	6	6		255	486.3333	152.0523	662	271.25	369.75	519	612	657.25
Carbonate Alkalinity as CaCO3 (mg/L)	6		6									
Hydroxide Alkalinity as CaCO3 (mg/L)	6		6									
Temperature (field) (°C)	6	6		255	486.3333	152.0523	662	271.25	369.75	519	612	657.25
Field Measurements												
Appearance or Colour	2											
Depth of Bore (mbgl)	49	49		3.61	3.9982	0.0703	4.3	4	4	4	4	4
Depth to Water (mbRL)	16	16		1.72	3.3306	0.6833	4.3	1.735	3.335	3.62	3.6325	3.805
Depth to Water (mbGL)	14	14		2.61	3.5064	0.2708	3.64	3.052	3.5725	3.62	3.63	3.64
Depth to Water Comments	43											
Dissolved Oxygen (field) (% sat))	4	4		0	20.3750	29.8818	72	0.525	2.625	4.75	22.5	62.1
Dry?	43											
Electrical Conductivity (field) (µS/cm)	4	4		665	1251.0000	358.6698	1621	758	1130	1359	1480	1592.8

	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Groundwater Level (mAHD)	16	16		308.04	328.0186	5.5376	333.617	320.79	328.3985	328.54	329.35975	333.52175
GWL Depth Reference Elevation	49	49		311.33	337.9139	15.3164	378.09	317.502	331.968	332.939	337.237	378.09
Odour	3											
ORP (field) (mV)	4	4		-156.8	-71.0000	76.0383	43.6	-151.085	-128.225	-85.4	-28.175	29.245
pH (field)	4	4		7.4	8.0400	0.5601	8.86	7.4405	7.6025	7.95	8.3875	8.7655
Salinity (field) (PSU)	4	4		0.32	0.6175	0.1832	0.81	0.3665	0.5525	0.67	0.735	0.795
TDS (field) (ppm)	4	4		28.84	30.3875	1.3851	32.28	28.9105	29.1925	30.215	31.41	32.106
Total Dissolved Solids (field) (ppm)	4	4		332	625.5000	179.4861	810	378.65	565.25	680	740.25	796.05
Turbidity (field) (FNU)	2	2		4.6	12.1500	7.5500	19.7	5.355	8.375	12.15	15.925	18.945
Hardness												
Total Hardness (mg CaCO3/L)	6	6		114	300.6667	160.9986	517	114	138	313	428.75	496
Ion Balance												
Ionic Balance (%)	6	6		-2.3	1.5717	2.2585	4.29	-1.59	0.54	1.52	3.52	4.1825
Total Anions (meq/L)	6	6		7.93	19.3883	9.6909	34.4	9.3225	13.5	14.9	27.1	33.475
Total Cations (meq/L)	6	6		7.57	20.2617	10.7520	37.2	9.0275	13.4	15.55	28.65	35.975
Major Ions												
Calcium (mg/L)	9	9		26	83.2222	35.8043	118	26	54	97	112	118
Chloride (mg/L)	6	6		16	95.5000	79.2817	220	22.75	43	51.5	158.25	212.75
Fluoride (mg/L)	5	5		0.2	0.5600	0.3666	1	0.2	0.2	0.4	1	1
Magnesium (mg/L)	9	9		12	35.7778	16.2739	54	12	17	44	47	53.6
Potassium (mg/L)	9	9		5	7.4444	2.1140	12	5	6	8	8	10.8
Sodium (mg/L)	9	9		72	367.7778	194.6226	627	125.2	228	252	546	621
Sulfate (as SO4)	6	6		47	334.3333	269.7497	737	58.5	93	274	549.5	698
Metals (dissolved)												
Arsenic - dissolved (mg/L)	6	5	1	0.002	0.0022	0.0004	0.003	0.002	0.002	0.002	0.002	0.0028
Barium - dissolved (mg/L)	6	6		0.031	0.0468	0.0111	0.068	0.034	0.043	0.045	0.0485	0.06325
Beryllium - dissolved (mg/L)	1		1									

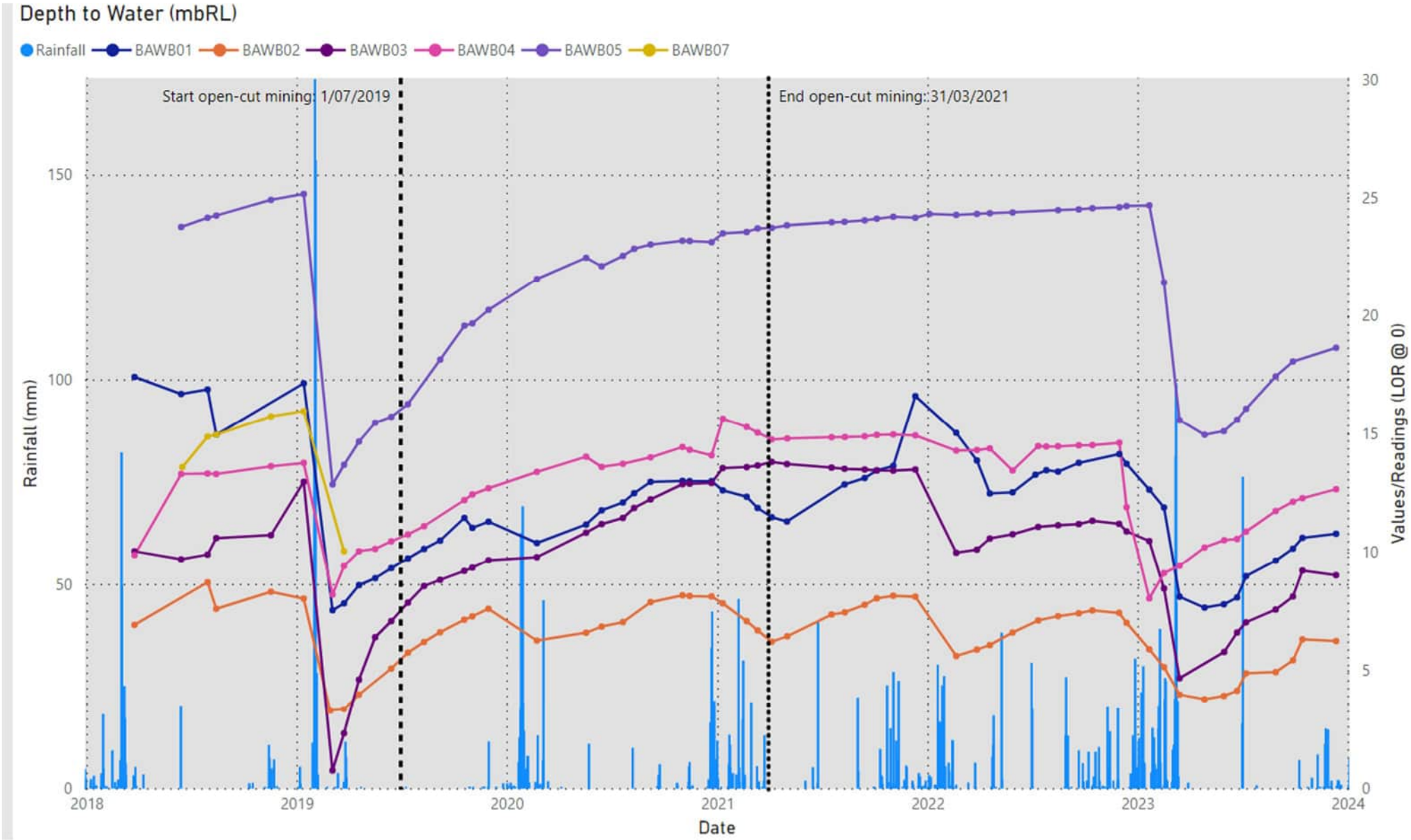
	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Bismuth - dissolved (mg/L)	5		5									
Boron - dissolved (mg/L)	1	1		0.12	0.1200	0.0000	0.12	0.12	0.12	0.12	0.12	0.12
Cadmium - dissolved (mg/L)	1		1									
Chromium - dissolved (mg/L)	6	5	1	0.001	0.0032	0.0016	0.006	0.0014	0.003	0.003	0.003	0.0054
Cobalt - dissolved (mg/L)	6	2	4	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001
Copper - dissolved (mg/L)	6	6		0.002	0.0055	0.0021	0.008	0.0025	0.00425	0.006	0.007	0.00775
Lead - dissolved (mg/L)	1		1									
Manganese - dissolved (mg/L)	1	1		0.007	0.0070	0.0000	0.007	0.007	0.007	0.007	0.007	0.007
Mercury - dissolved (mg/L)	1		1									
Molybdenum - dissolved (mg/L)	5	5		0.003	0.0066	0.0026	0.011	0.0036	0.006	0.006	0.007	0.0102
Nickel - dissolved (mg/L)	6		6									
Selenium - dissolved (mg/L)	6		6									
Uranium - dissolved (mg/L)	5	5		0.002	0.0244	0.0363	0.096	0.002	0.002	0.004	0.018	0.0804
Vanadium - dissolved (mg/L)	1	1		0.003	0.0030	0.0000	0.003	0.003	0.003	0.003	0.003	0.003
Zinc - dissolved (mg/L)	1	1		0.046	0.0460	0.0000	0.046	0.046	0.046	0.046	0.046	0.046
Metals (total)												
Arsenic - total (mg/L)	6	5	1	0.002	0.0022	0.0004	0.003	0.002	0.002	0.002	0.002	0.0028
Barium - total (mg/L)	6	6		0.031	0.0553	0.0140	0.068	0.035	0.04775	0.059	0.068	0.068
Beryllium - total (mg/L)	1		1									
Bismuth - total (mg/L)	5		5									
Boron - total (mg/L)	1	1		0.12	0.1200	0.0000	0.12	0.12	0.12	0.12	0.12	0.12
Cadmium - total (mg/L)	1	1		0.0002	0.0002	0.0000	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Chromium - total (mg/L)	6	5	1	0.002	0.0044	0.0016	0.006	0.0022	0.003	0.005	0.006	0.006
Cobalt - total (mg/L)	6	4	2	0.002	0.0020	0.0000	0.002	0.002	0.002	0.002	0.002	0.002
Copper - total (mg/L)	6	6		0.004	0.0123	0.0072	0.022	0.0045	0.00675	0.01	0.01925	0.022
Lead - total (mg/L)	1		1									
Manganese - total (mg/L)	1	1		0.006	0.0060	0.0000	0.006	0.006	0.006	0.006	0.006	0.006

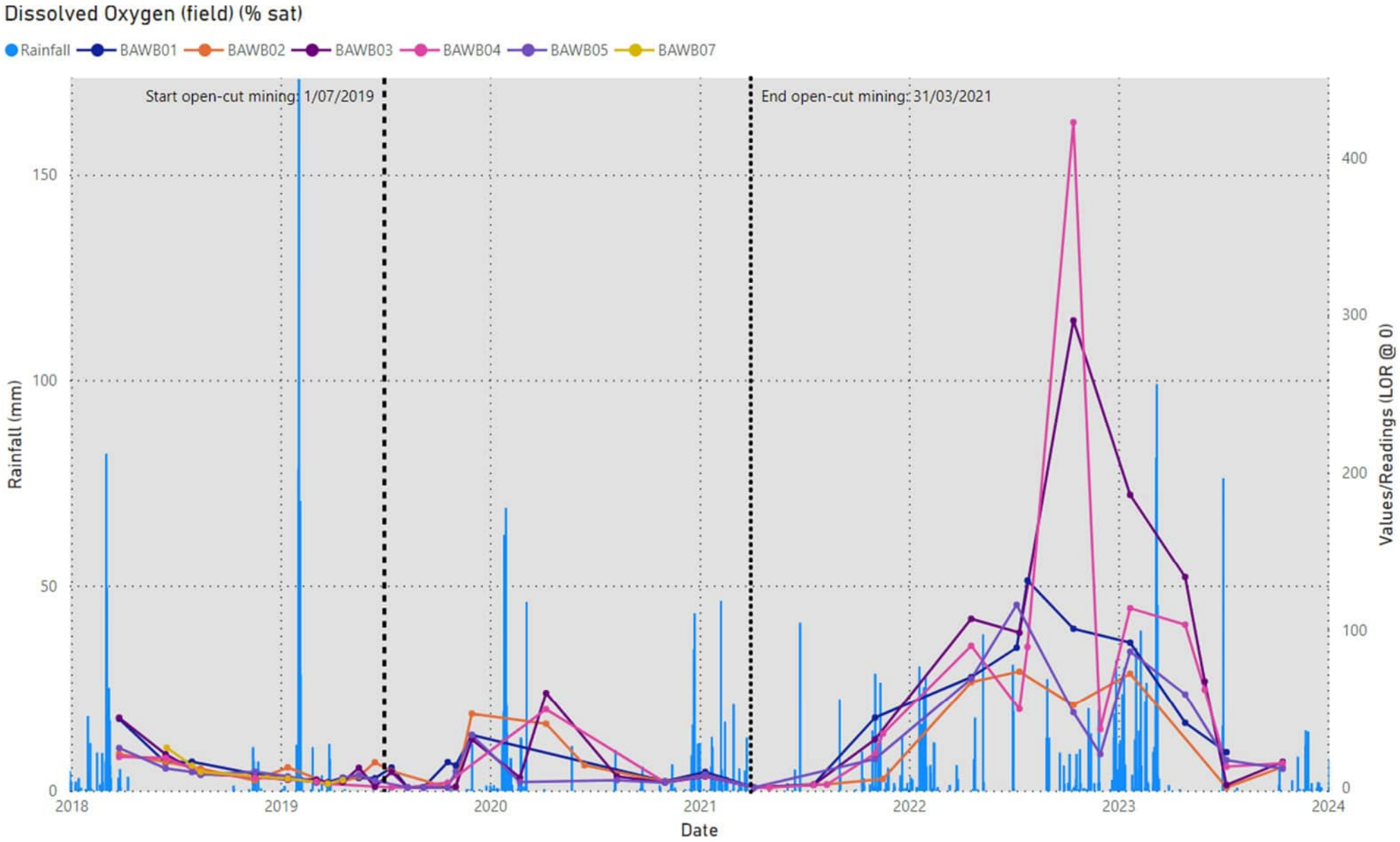
	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Mercury - total (mg/L)	1		1									
Molybdenum - total (mg/L)	5	5		0.004	0.0066	0.0026	0.011	0.004	0.004	0.007	0.007	0.0102
Nickel - total (mg/L)	6	3	3	0.001	0.0017	0.0005	0.002	0.0011	0.0015	0.002	0.002	0.002
Selenium - total (mg/L)	6		6									
Uranium - total (mg/L)	5	5		0.003	0.0260	0.0375	0.1	0.003	0.003	0.005	0.019	0.0838
Vanadium - total (mg/L)	1	1		0.003	0.0030	0.0000	0.003	0.003	0.003	0.003	0.003	0.003
Zinc - total (mg/L)	1	1		0.061	0.0610	0.0000	0.061	0.061	0.061	0.061	0.061	0.061
Physico-Chemical Parameters												
Electrical Conductivity (µS/cm)	5	5		1250	2062.0000	856.3037	3190	1250	1250	1620	3000	3152
pH (lab)	6	6		7.71	7.9383	0.1781	8.2	7.71	7.775	7.975	8.04	8.165
Turbidity (NTU)	5	5		0.6	7.2400	7.2456	16.1	0.8	1.6	1.8	16.1	16.1
Bore E												
Alkalinity												
Bicarbonate Alkalinity as CaCO3 (mg/L)	42	42		261	438.4524	48.8014	515	351.15	420.5	447.5	468	495.6
Carbonate Alkalinity as CaCO3 (mg/L)	42	1	41	28	28.0000	0.0000	28	28	28	28	28	28
Hydroxide Alkalinity as CaCO3 (mg/L)	42		42									
Temperature (field) (°C)	42	42		261	439.1190	47.7828	515	355.25	420.5	447.5	468	495.6
Field Measurements												
Appearance or Colour	25											
Depth of Bore (mbgl)	56	56		83	83.0000	0.0000	83	83	83	83	83	83
Depth to Water (mbRL)	54	54		5.97	10.0202	1.2795	12.21	7.3025	9.89	10.32	10.81	11.31
Depth to Water (mbGL)	20	20		0	8.8615	2.5872	12.21	5.6715	7.9225	9.63	10.2425	12.1245
Depth to Water Comments	1											
Dissolved Oxygen (field) (% sat))	34	34		0	28.6912	48.5231	171.1	0	2.45	8.8	22.05	152.965
Dry?	1											
Electrical Conductivity (field) (µS/cm)	35	35		844	1018.5429	97.1518	1226	864.8	951	1018	1095	1190.5
Groundwater Level (mAHD)	54	54		300.52	324.5317	14.7531	367.62	301.1855	319.3825	323.7395	326.754	353.50865

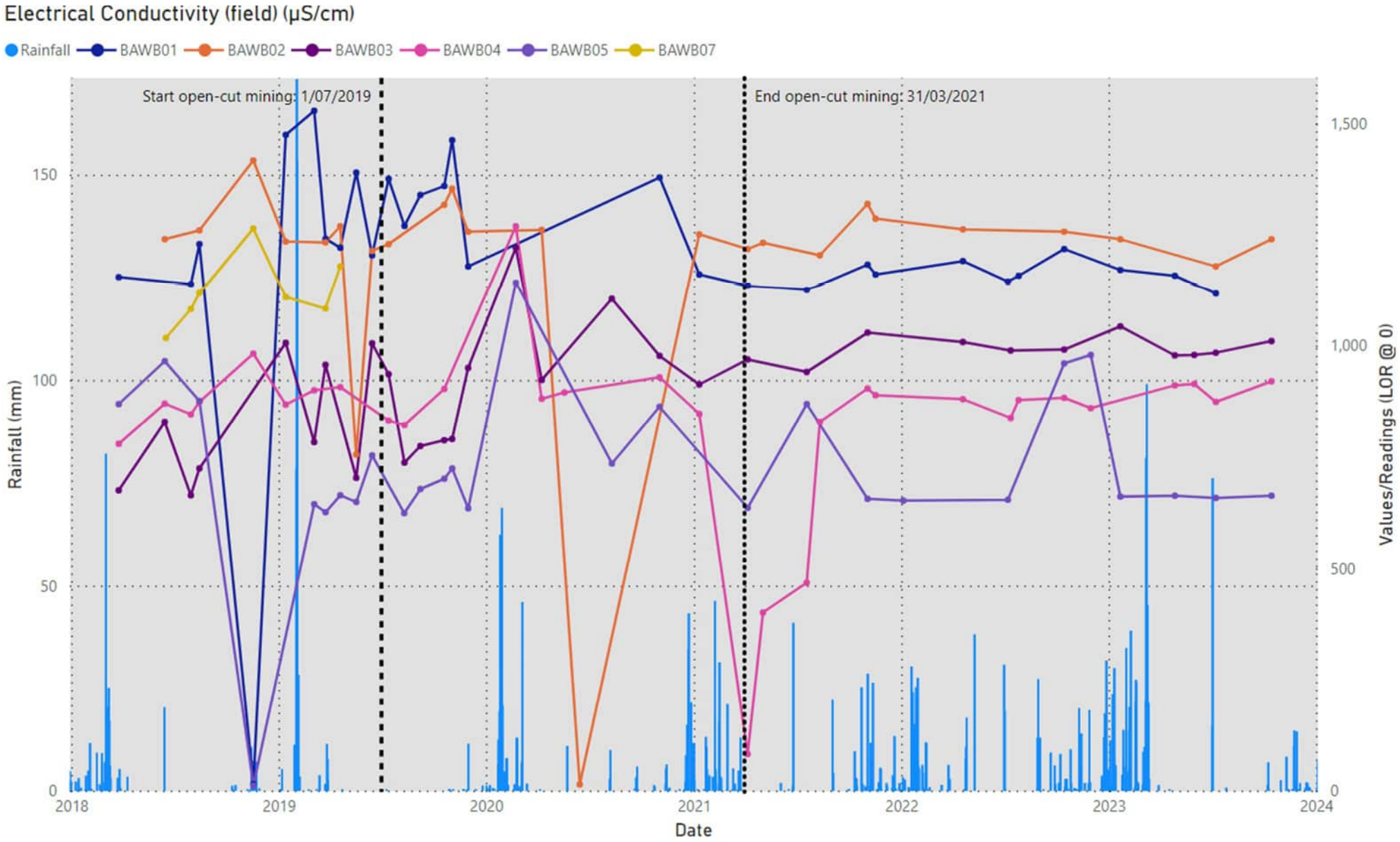
	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
GWL Depth Reference Elevation	56	56		311.33	334.5120	14.5995	378.09	311.33	329.94	332.712	337.237	361.41825
Odour	23											
ORP (field) (mV)	31	31		-71.1	33.9516	55.7929	219.2	-38.55	-7.9	28.4	64	117.95
pH (field)	35	35		6.09	7.1574	0.4269	8.51	6.573	6.985	7.17	7.345	7.691
Salinity (field) (PSU)	35	35		0.41	0.4957	0.0513	0.6	0.42	0.455	0.5	0.54	0.586
TDS (field) (ppm)	35	35		27.47	30.4311	1.5170	33.55	27.795	29.445	30.41	31.32	33.13
Total Dissolved Solids (field) (ppm)	31	31		431	516.4194	46.2042	613	448.5	483	512	550.5	600
Turbidity (field) (FNU)	19	19		0	5.7211	9.9379	35.1	0	0	1.5	4.3	31.14
Hardness												
Total Hardness (mg CaCO3/L)	42	42		194	314.6667	45.8152	405	248.4	280	322	342.75	380.9
Ion Balance												
Ionic Balance (%)	42	42		0.23	3.4200	2.8166	14	0.468	1.465	3	4.29	9.229
Total Anions (meq/L)	42	42		6.56	10.6902	1.2195	13.4	9.1135	10.325	10.75	11.3	12.2
Total Cations (meq/L)	42	42		7.08	11.0569	1.3736	14.3	9.17	10.1	11.25	11.8	13.195
Major Ions												
Calcium (mg/L)	72	72		30	49.7222	7.4893	63	36.55	45.75	51	55	59.45
Chloride (mg/L)	42	42		22	33.6905	11.0507	77	23	28	31	35.75	51.6
Fluoride (mg/L)	42	42		0.5	1.2548	0.2352	1.6	1	1.1	1.3	1.4	1.595
Magnesium (mg/L)	72	72		24	47.3750	8.3988	76	36	42	47	52	61
Potassium (mg/L)	72	72		6	10.3611	2.0770	14	7	9	11	12	13
Sodium (mg/L)	72	72		70	104.6528	11.9979	137	82.2	99	104	111.25	123.45
Sulfate (as SO4)	42	42		28	46.9286	11.3838	74	28.15	38	47.5	52	69.75
Metals (dissolved)												
Arsenic - dissolved (mg/L)	42	33	9	0.001	0.0017	0.0006	0.003	0.001	0.001	0.002	0.002	0.0024
Barium - dissolved (mg/L)	42	42		0.06	0.1707	0.0705	0.474	0.064	0.12925	0.1755	0.199	0.25065
Bismuth - dissolved (mg/L)	42		42									
Chromium - dissolved (mg/L)	42		42									

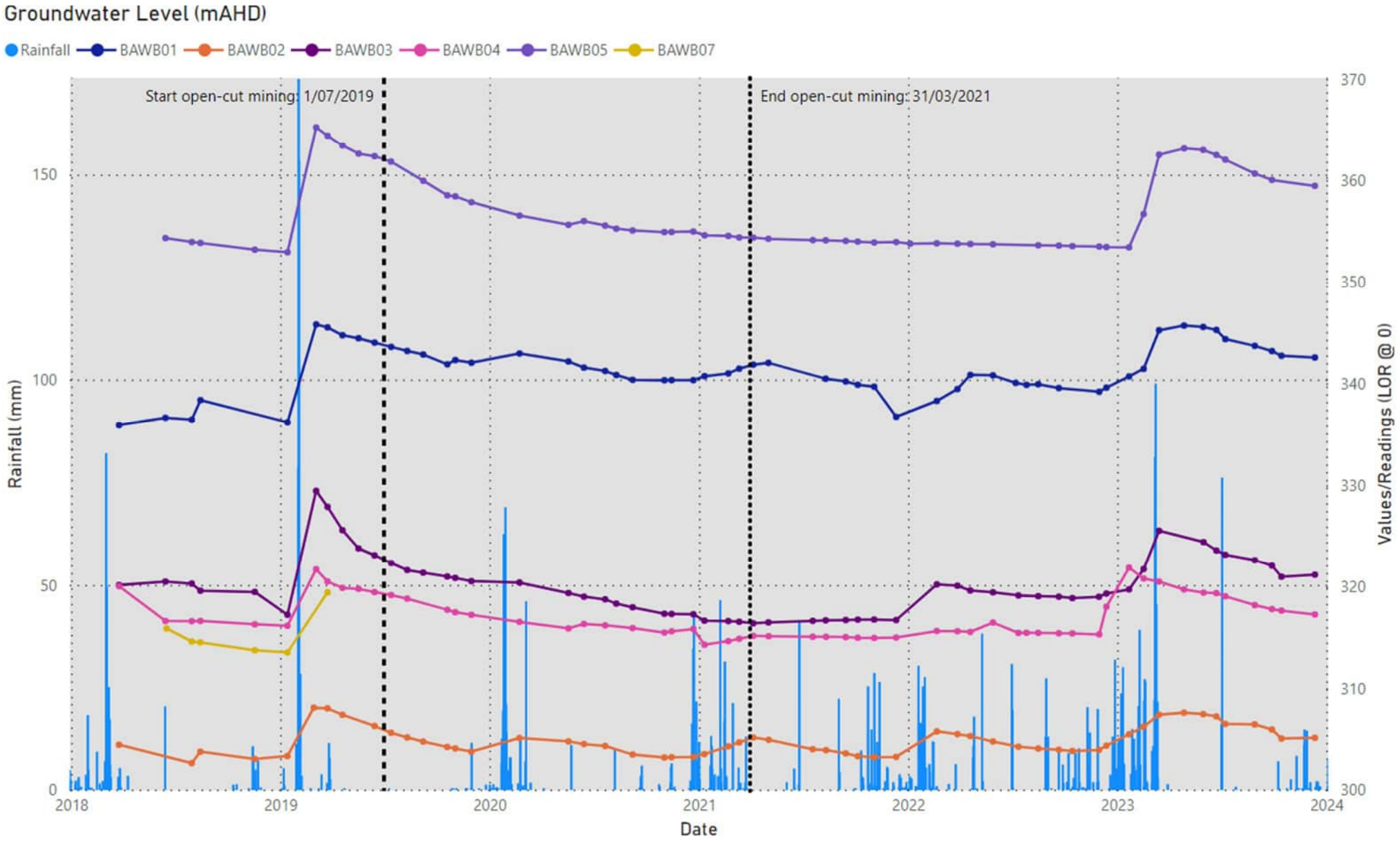
	NumObs	No. > LOR	No. < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Cobalt - dissolved (mg/L)	42	27	15	0.001	0.0014	0.0005	0.002	0.001	0.001	0.001	0.002	0.002
Copper - dissolved (mg/L)	42	15	27	0.001	0.0023	0.0017	0.008	0.001	0.001	0.002	0.002	0.0052
Molybdenum - dissolved (mg/L)	42	40	2	0.001	0.0030	0.0013	0.008	0.002	0.002	0.003	0.003	0.0051
Nickel - dissolved (mg/L)	42	26	16	0.001	0.0027	0.0017	0.007	0.001	0.00125	0.002	0.00375	0.006
Selenium - dissolved (mg/L)	42		42									
Uranium - dissolved (mg/L)	42	42		0.001	0.0043	0.0015	0.007	0.002	0.003	0.005	0.005	0.006
Metals (total)												
Arsenic - total (mg/L)	42	35	7	0.001	0.0017	0.0007	0.004	0.001	0.001	0.002	0.002	0.003
Barium - total (mg/L)	42	42		0.06	0.1757	0.0554	0.258	0.06125	0.153	0.1815	0.21775	0.251
Bismuth - total (mg/L)	42		42									
Chromium - total (mg/L)	42	26	16	0.001	0.0040	0.0027	0.012	0.00125	0.002	0.0035	0.005	0.01075
Cobalt - total (mg/L)	42	32	10	0.001	0.0018	0.0004	0.002	0.001	0.00175	0.002	0.002	0.002
Copper - total (mg/L)	42	27	15	0.001	0.0021	0.0009	0.005	0.001	0.002	0.002	0.002	0.003
Molybdenum - total (mg/L)	42	42		0.002	0.0032	0.0013	0.008	0.002	0.002	0.003	0.003	0.00595
Nickel - total (mg/L)	42	32	10	0.001	0.0037	0.0021	0.009	0.00155	0.002	0.003	0.004	0.00845
Selenium - total (mg/L)	42		42									
Uranium - total (mg/L)	42	42		0.002	0.0049	0.0015	0.008	0.002	0.004	0.005	0.006	0.007
Nutrients												
Nitrite + Nitrate as N (mg/L)	1	1		0.12	0.1200	0.0000	0.12	0.12	0.12	0.12	0.12	0.12
Total Kjeldahl Nitrogen as N (mg/L)	1		1									
Total Nitrogen as N (mg/L)	1	1		0.1	0.1000	0.0000	0.1	0.1	0.1	0.1	0.1	0.1
Total Phosphorus as P (mg/L)	1	1		0.01	0.0100	0.0000	0.01	0.01	0.01	0.01	0.01	0.01
Physico-Chemical Parameters												
Electrical Conductivity (µS/cm)	42	42		653	973.1667	113.1575	1280	835.75	879	992	1040	1119.5
pH (lab)	42	42		7.01	7.6757	0.3007	8.39	7.2425	7.425	7.695	7.92	8.155
Turbidity (NTU)	42	42		0.2	7.7024	13.7808	61.4	0.305	1	2.2	6.275	29.1

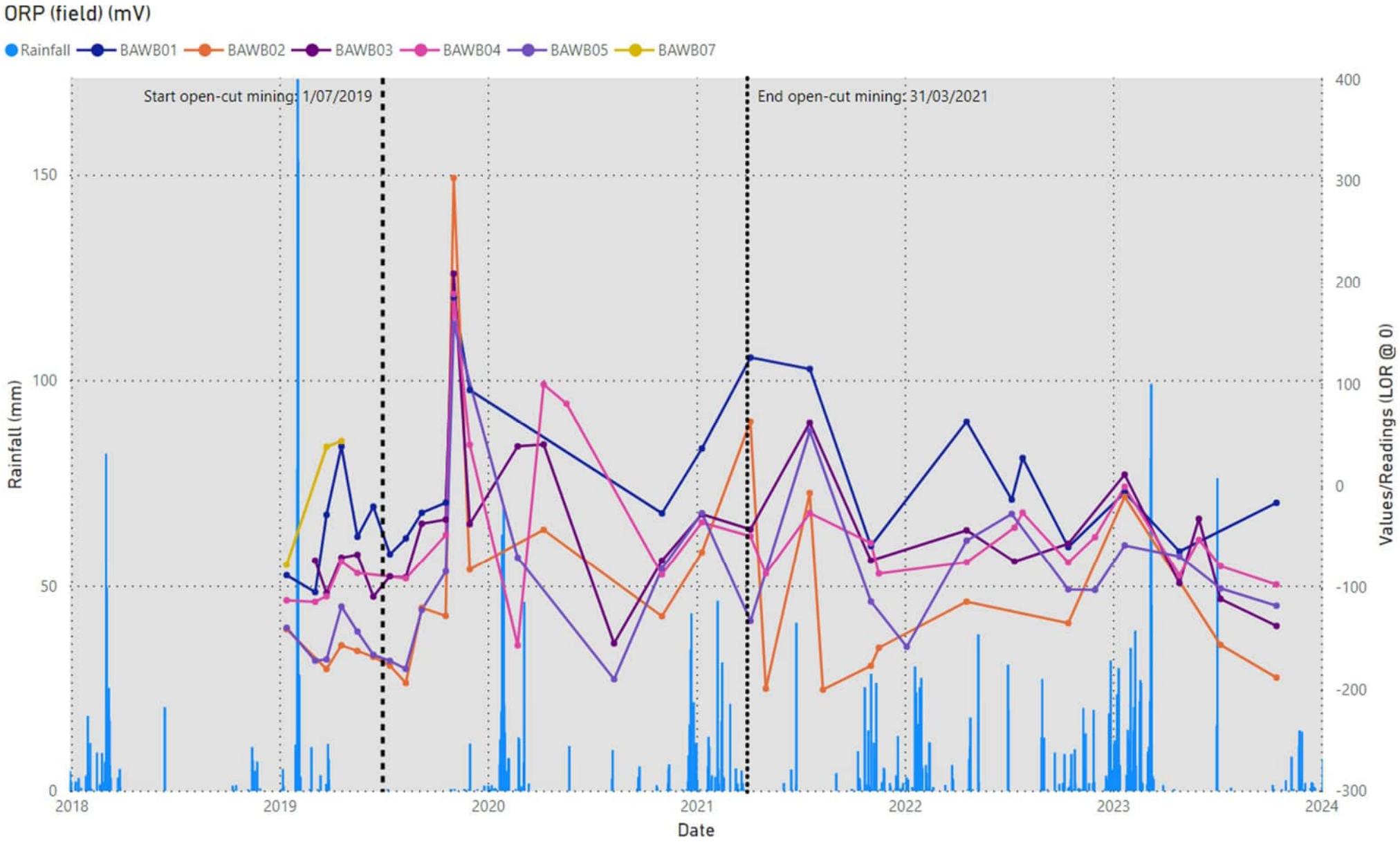
G.2 Water quality time series

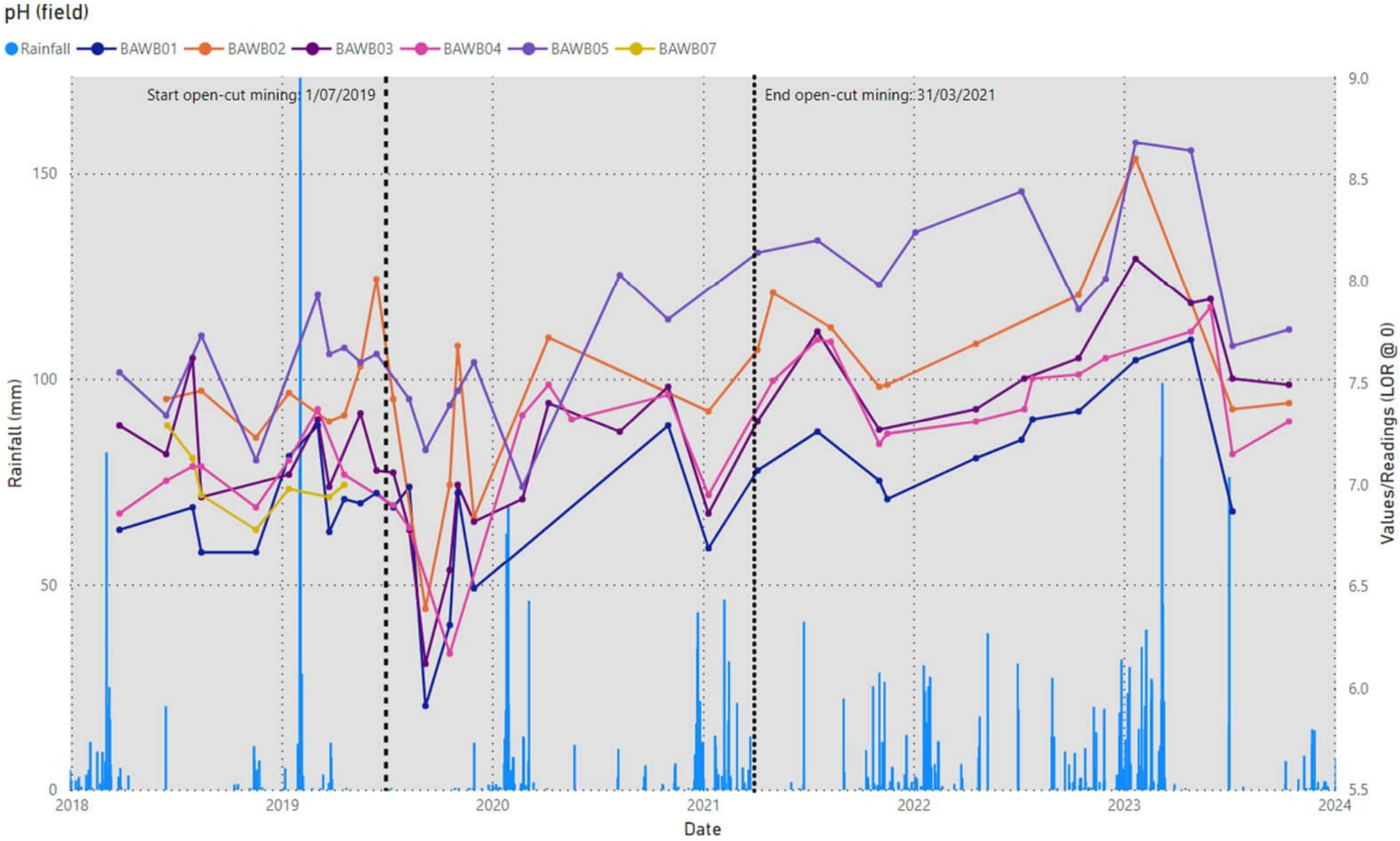

Depth to Water (mbRL)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining:: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
5
10
15
20
25
30
2018
2019
2020
2021
2022
2023
2024

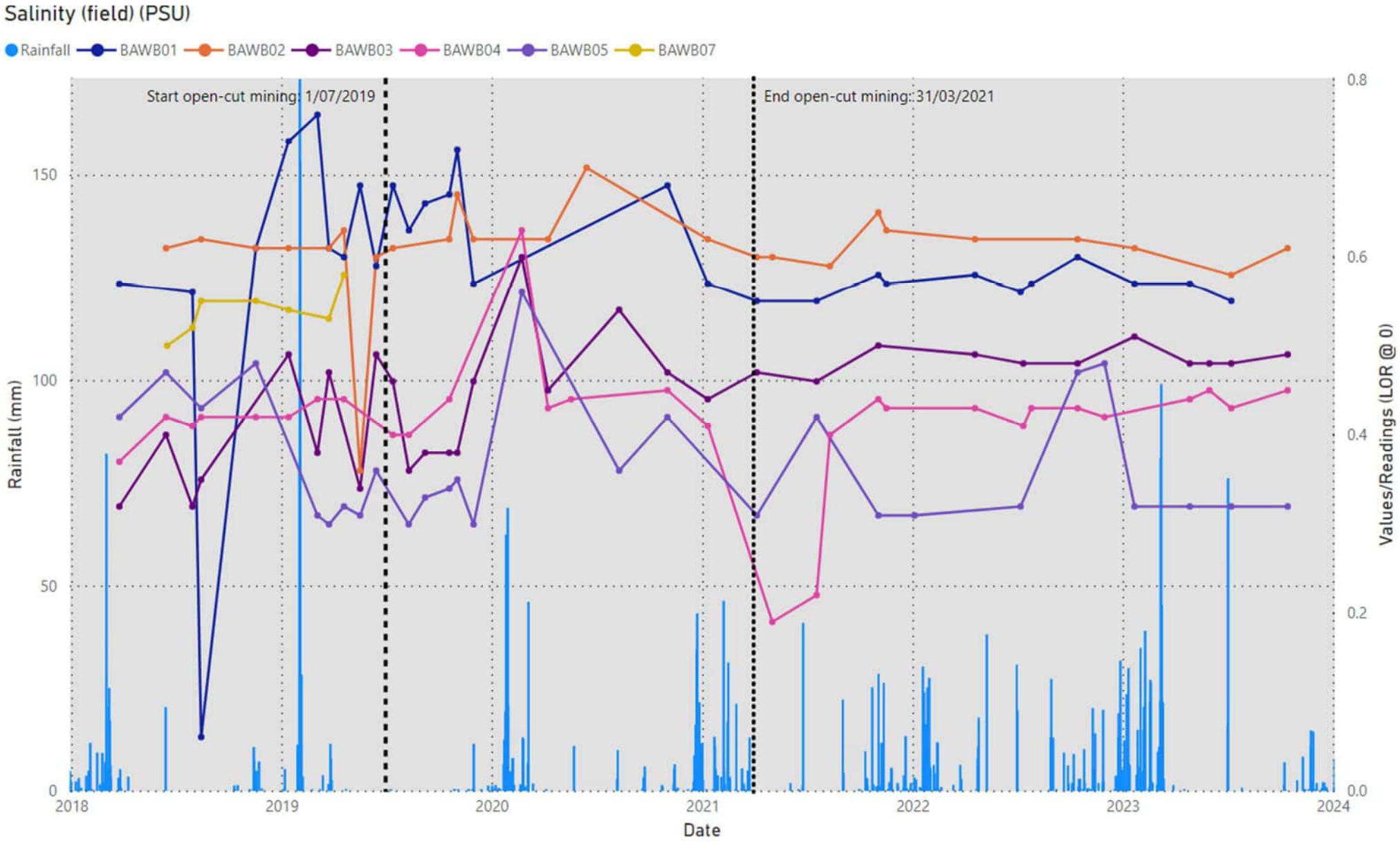

Dissolved Oxygen (field) (% sat)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
100
200
300
400
2018
2019
2020
2021
2022
2023
2024

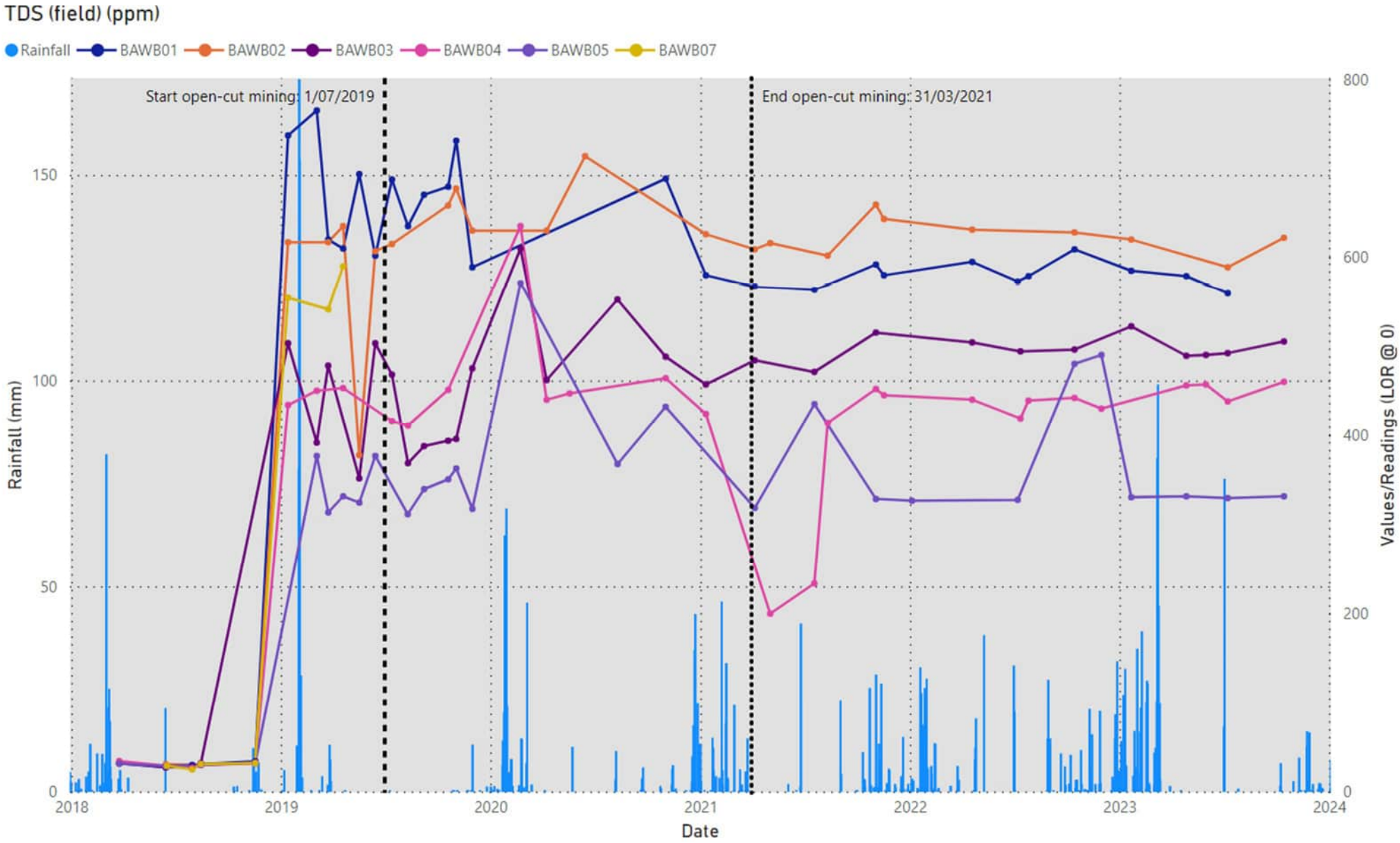

Electrical Conductivity (field) (µS/cm)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
500
1,000
1,500
2018
2019
2020
2021
2022
2023
2024

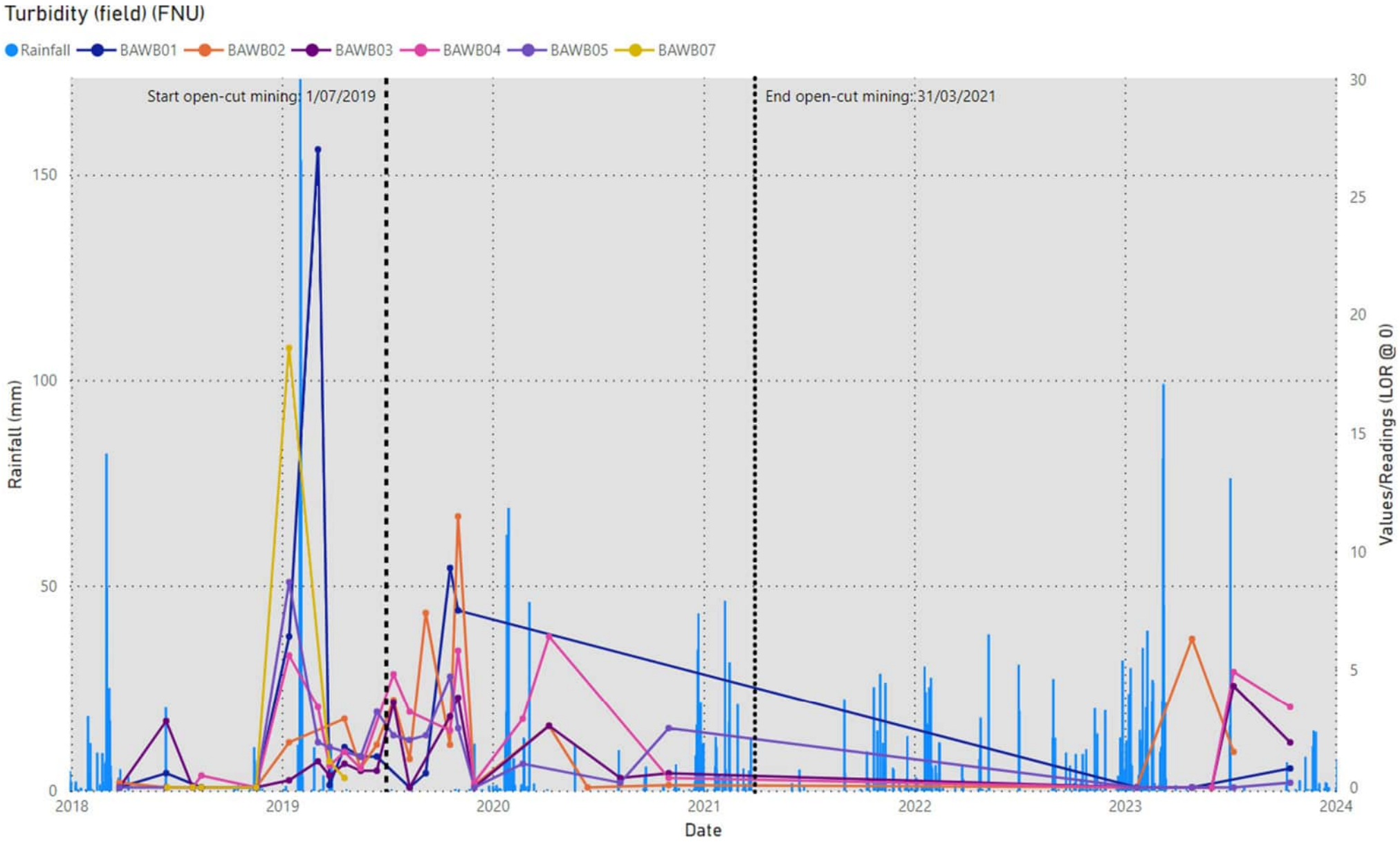

Groundwater Level (mAHD)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
300
310
320
330
340
350
360
370
2018
2019
2020
2021
2022
2023
2024


ORP (field) (mV)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
400
300
200
100
0
-100
-200
-300
2018
2019
2020
2021
2022
2023
2024

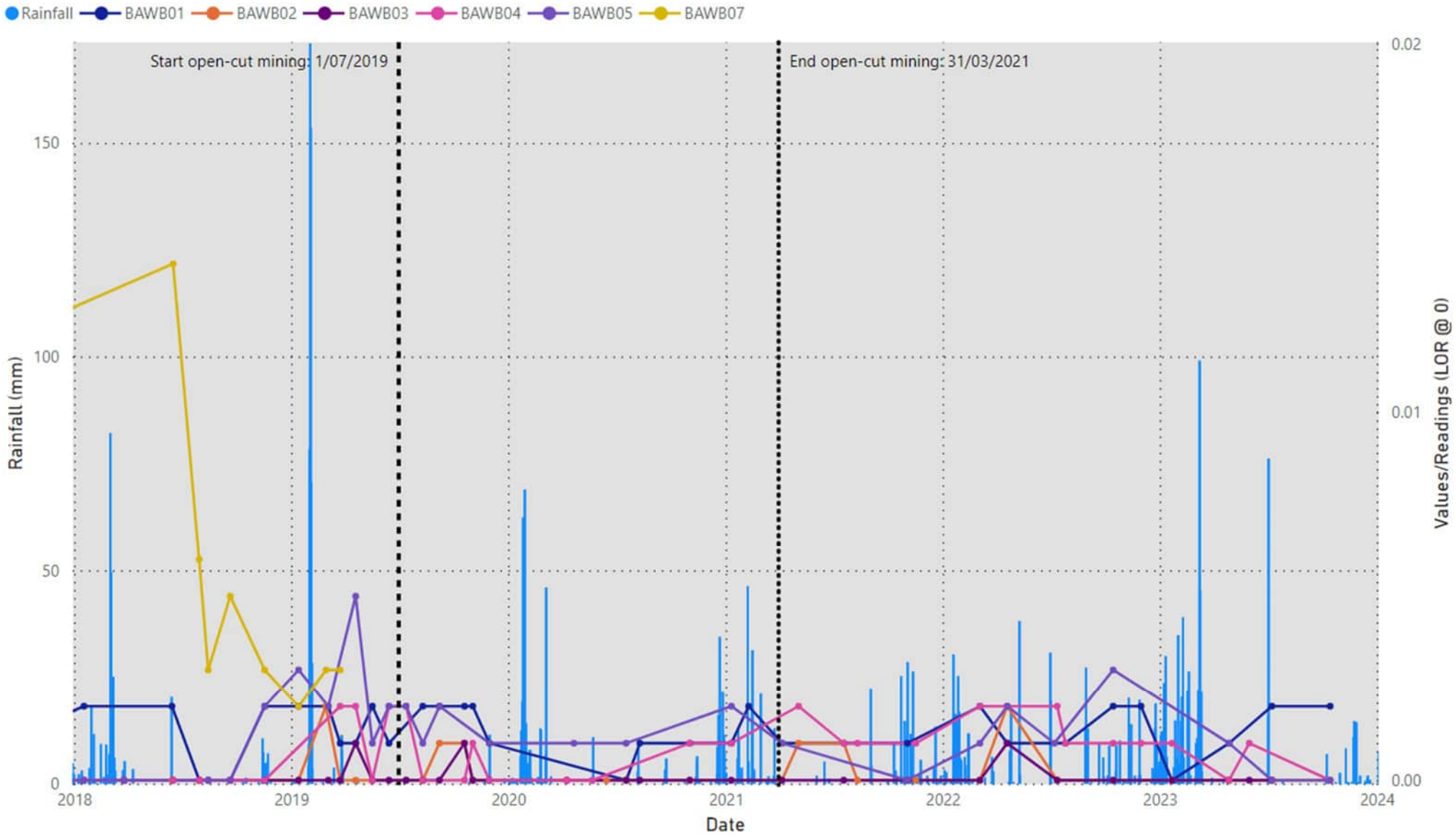

pH (field)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
2018
2019
2020
2021
2022
2023
2024

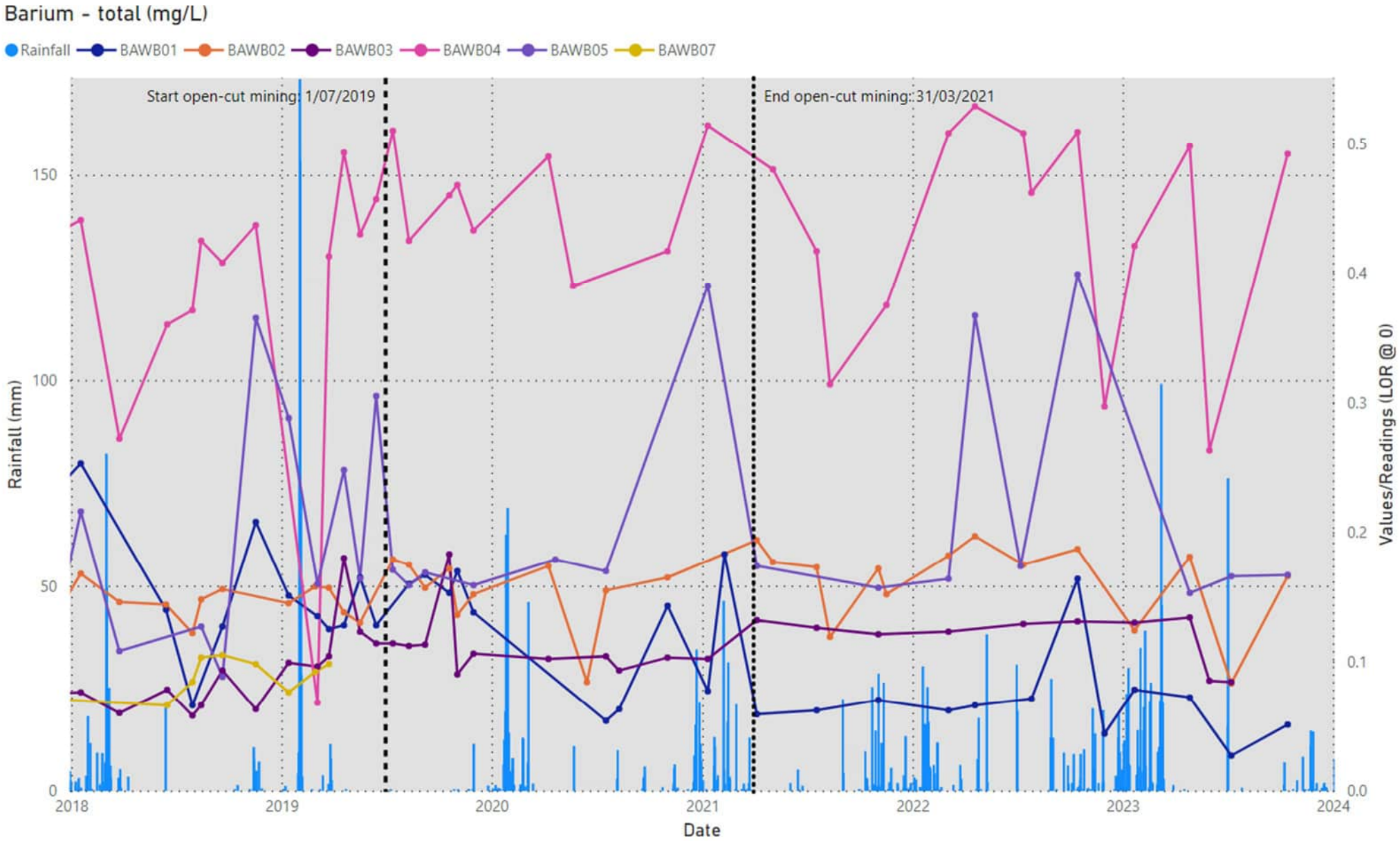

Salinity (field) (PSU)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.0
0.2
0.4
0.6
0.8
2018
2019
2020
2021
2022
2023
2024

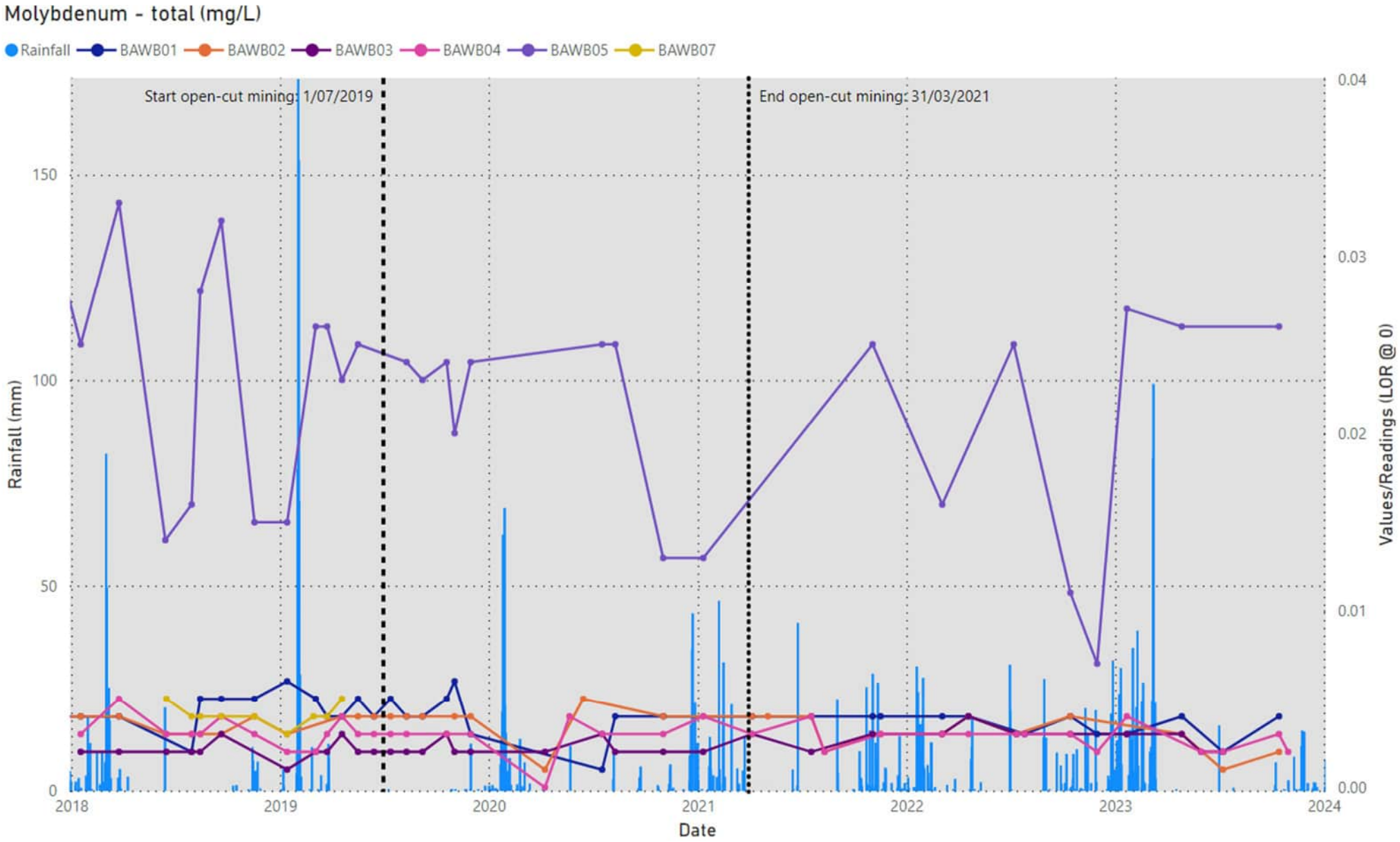

TDS (field) (ppm)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
200
400
600
800
2018
2019
2020
2021
2022
2023
2024

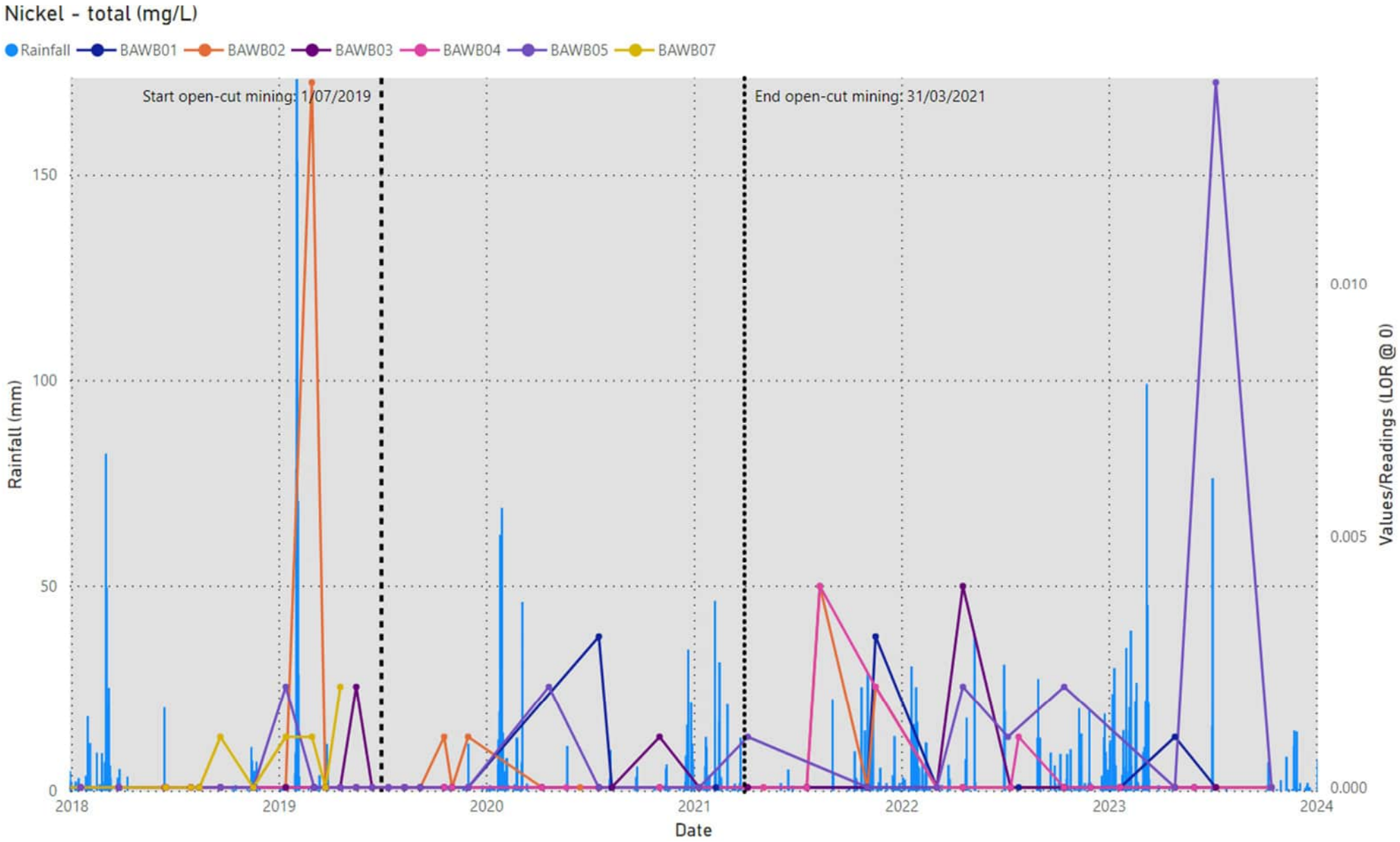

Turbidity (field) (FNU)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
5
10
15
20
25
30
2018
2019
2020
2021
2022
2023
2024

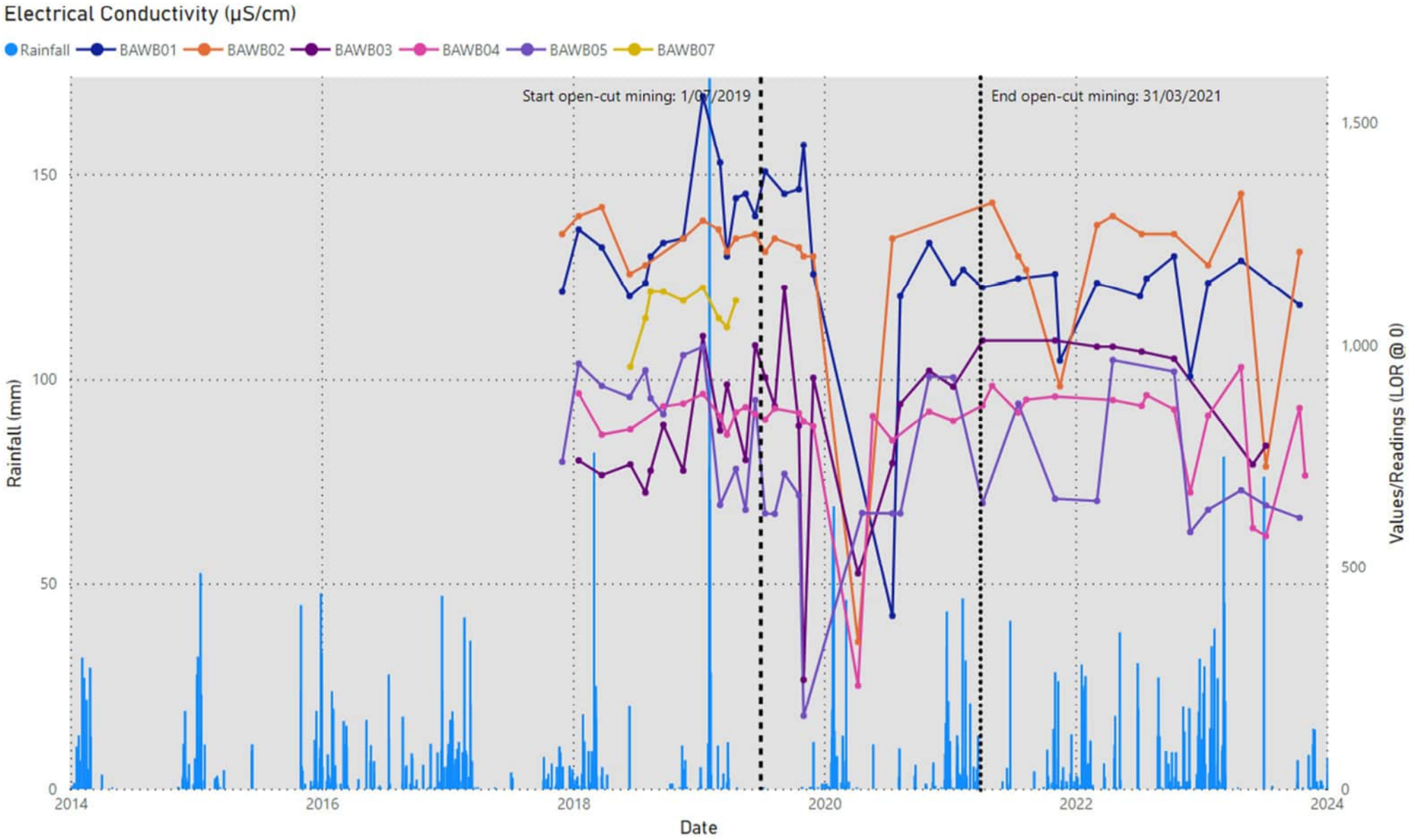
Arsenic - total (mg/L)

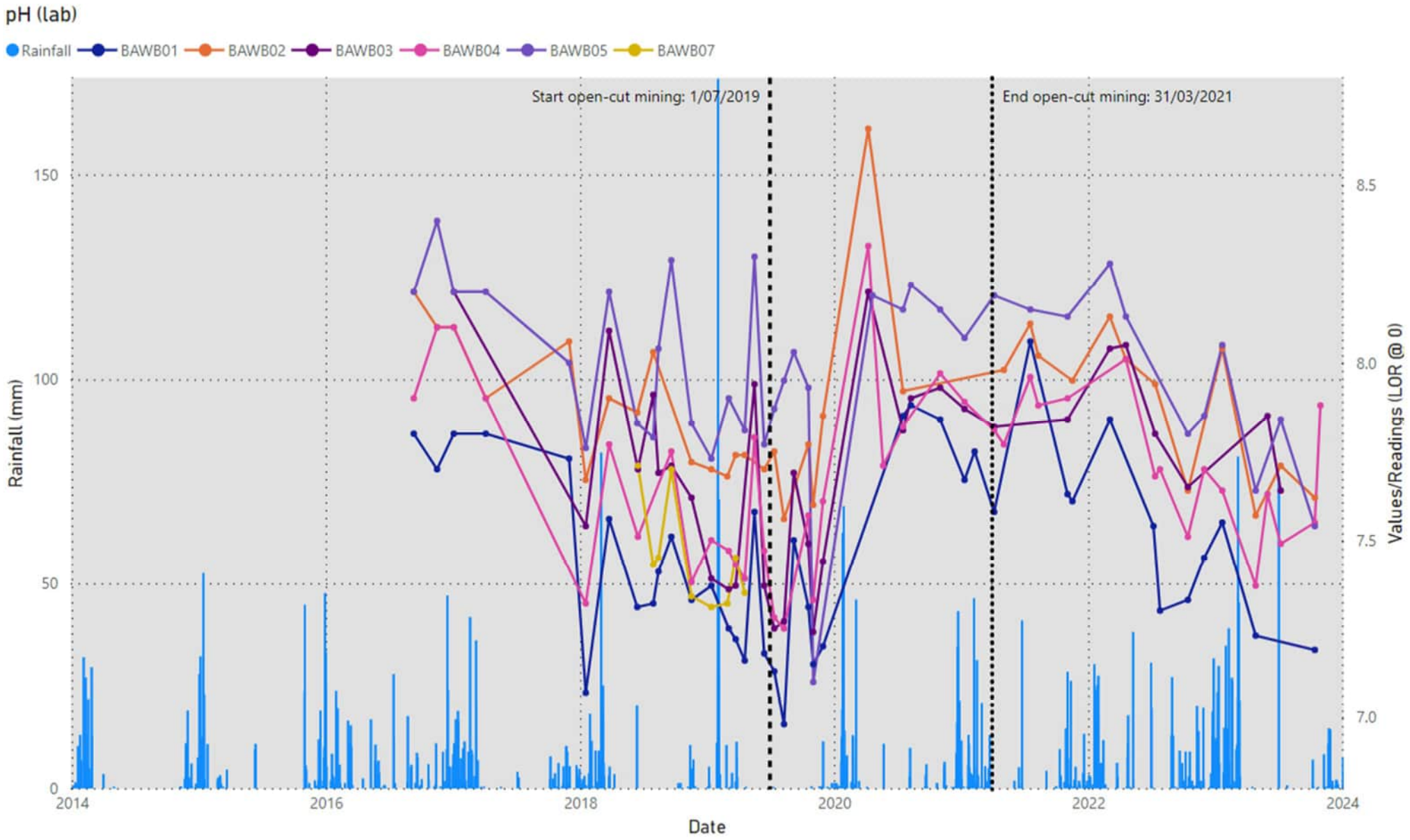


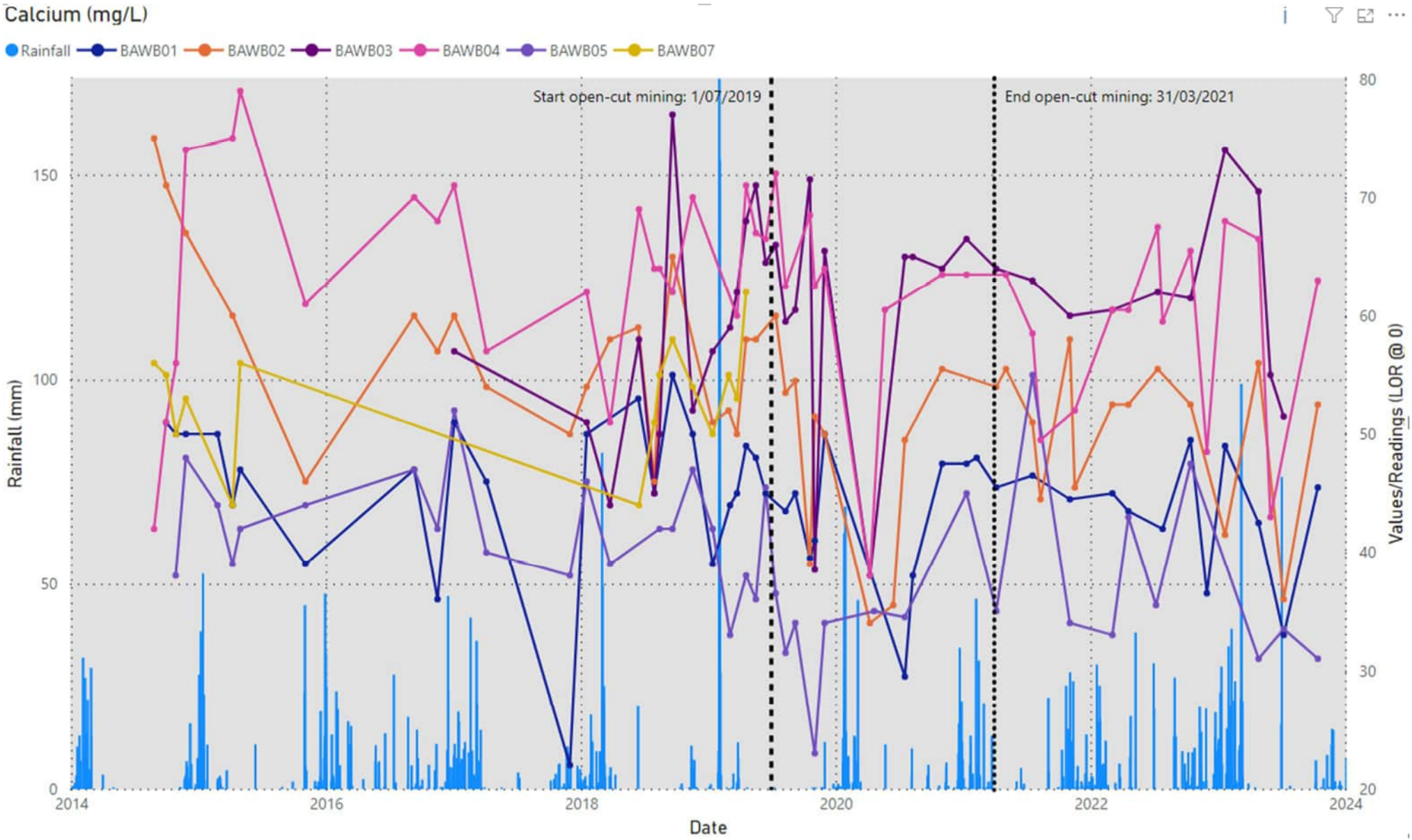

Barium - total (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.0
0.1
0.2
0.3
0.4
0.5
2018
2019
2020
2021
2022
2023
2024

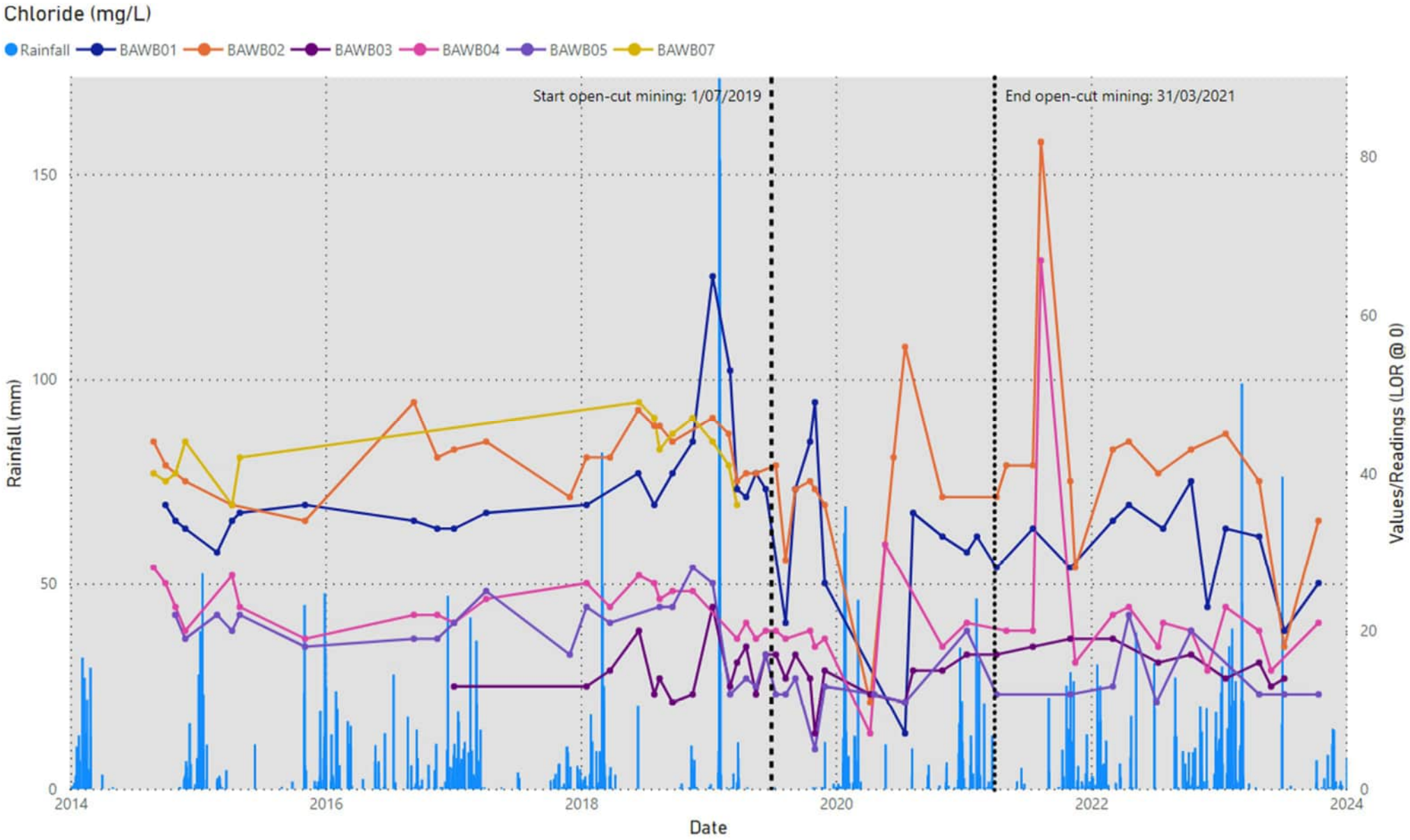

Molybdenum - total (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.01
0.02
0.03
0.04
2018
2019
2020
2021
2022
2023
2024

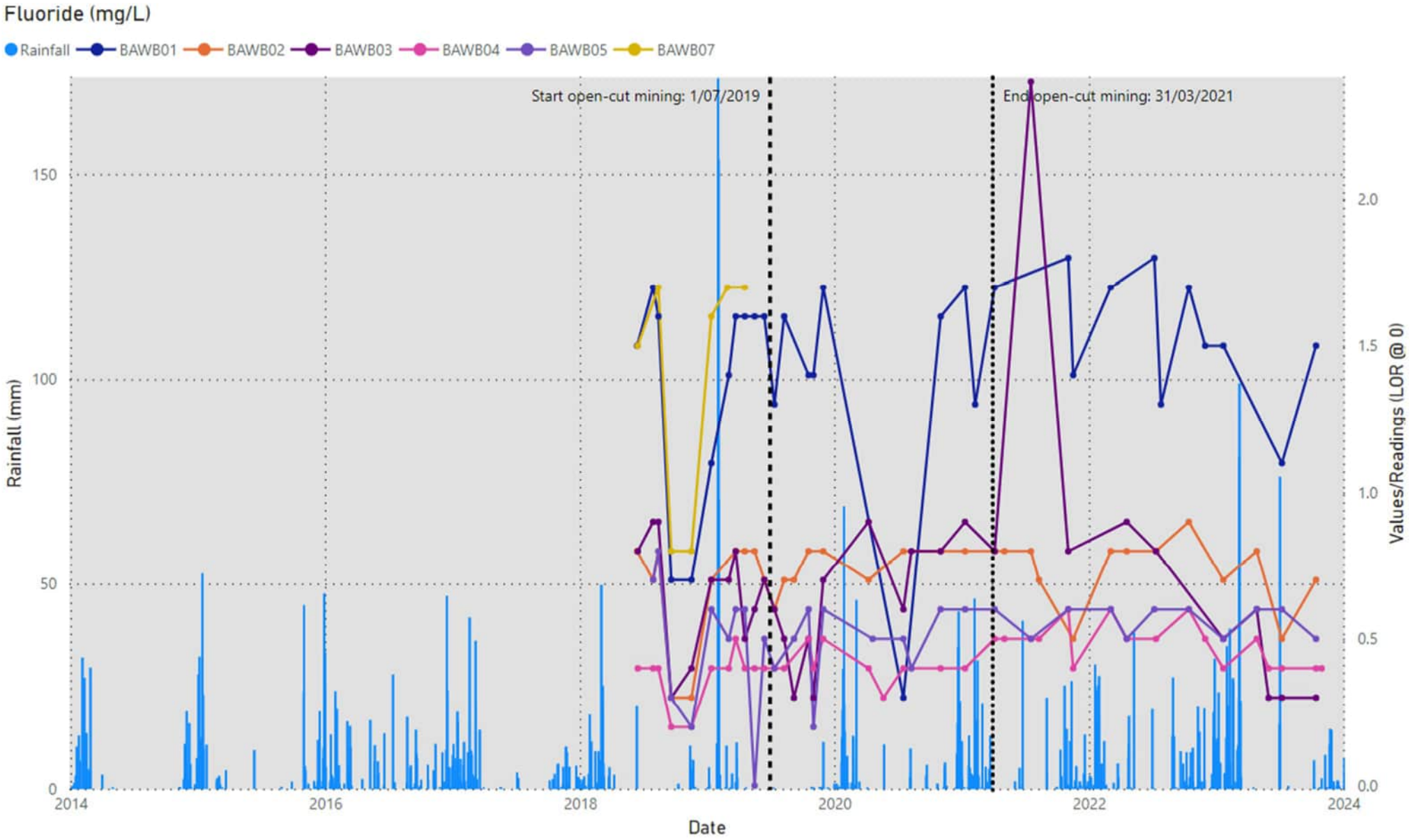

Nickel - total (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
0.010
0.005
0.000
Values/Readings (LOR @ 0)
2018
2019
2020
2021
2022
2023
2024
Date

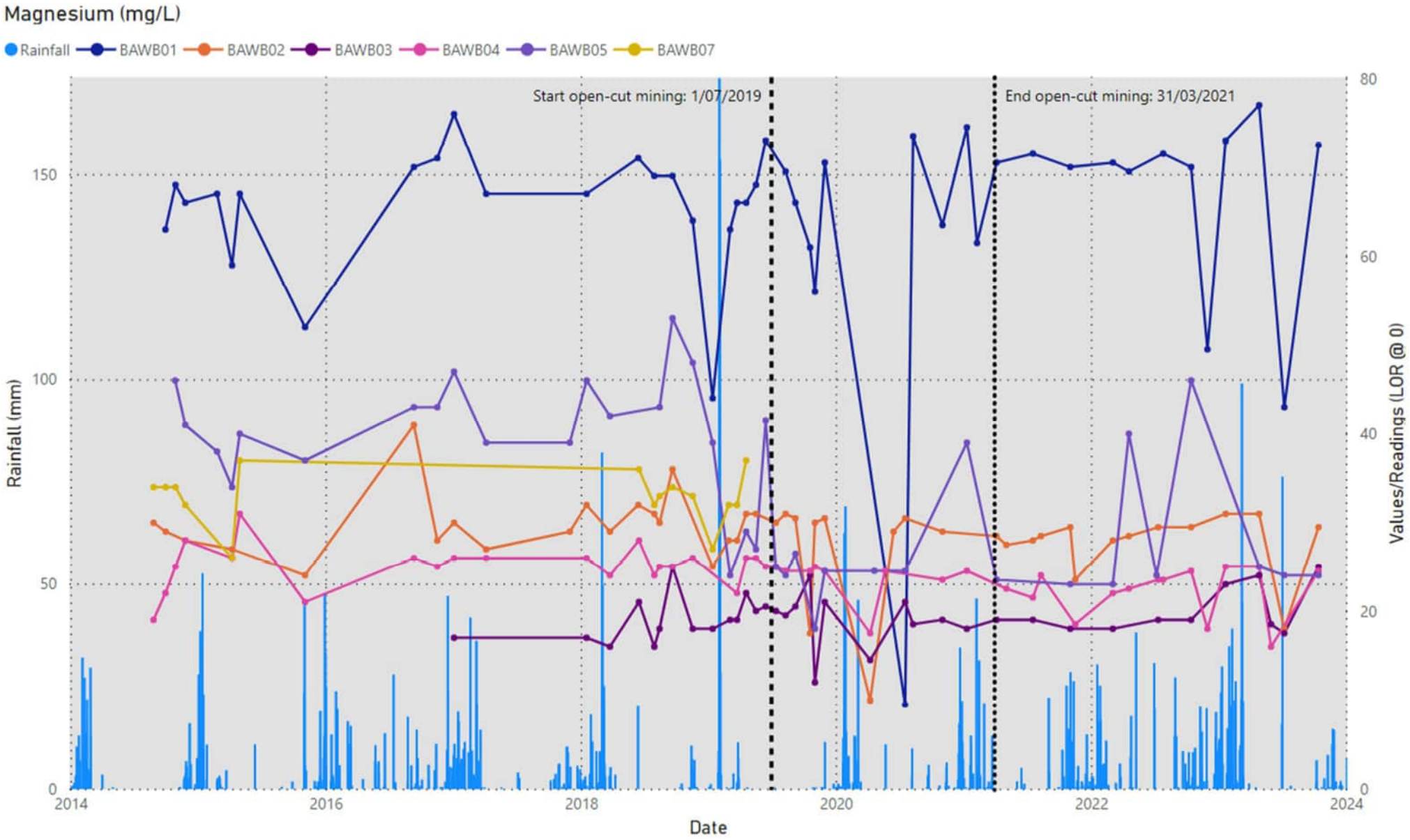

Electrical Conductivity (µS/cm)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
500
1,000
1,500
2014
2016
2018
2020
2022
2024

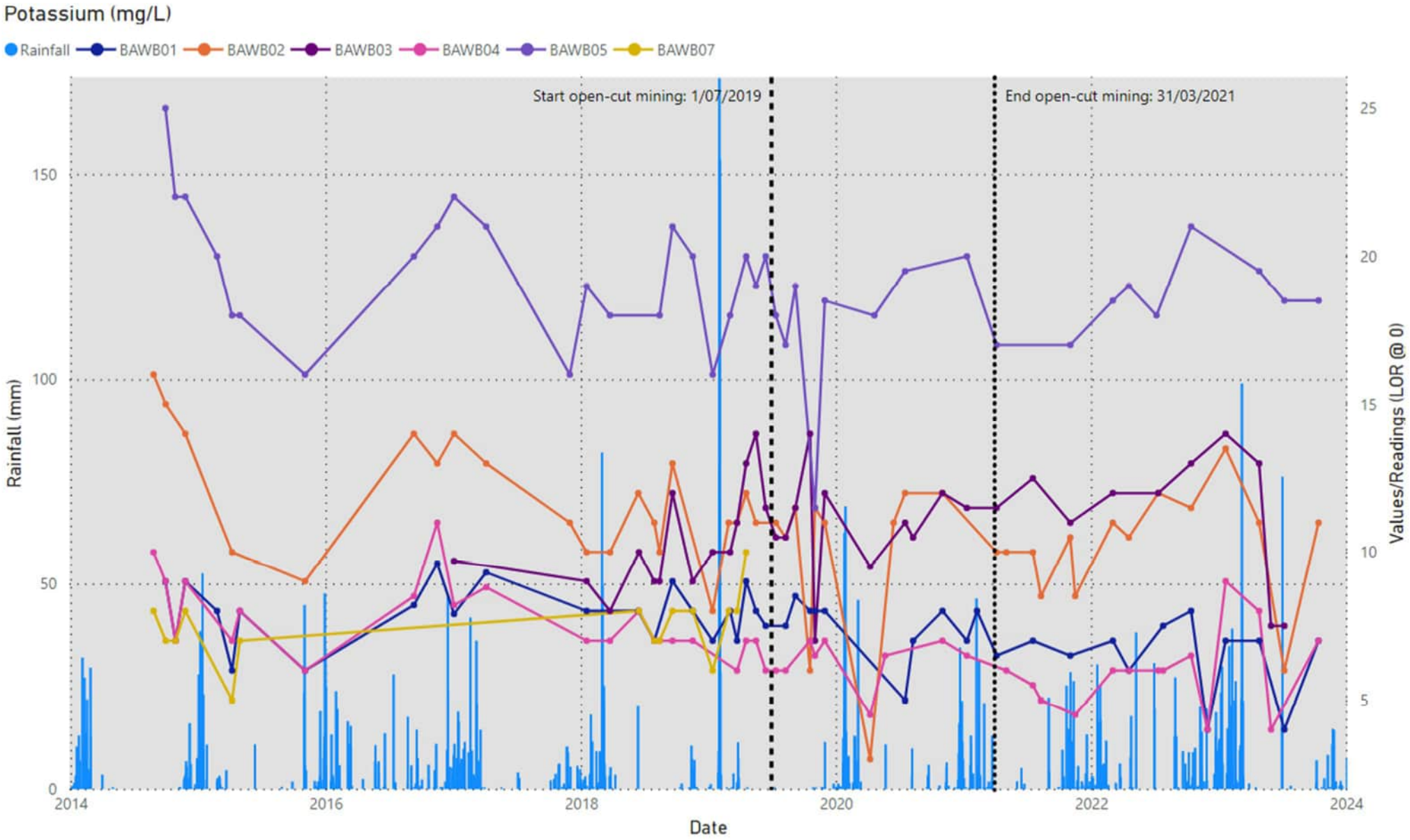

pH (lab)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
7.0
7.5
8.0
8.5
2014
2016
2018
2020
2022
2024

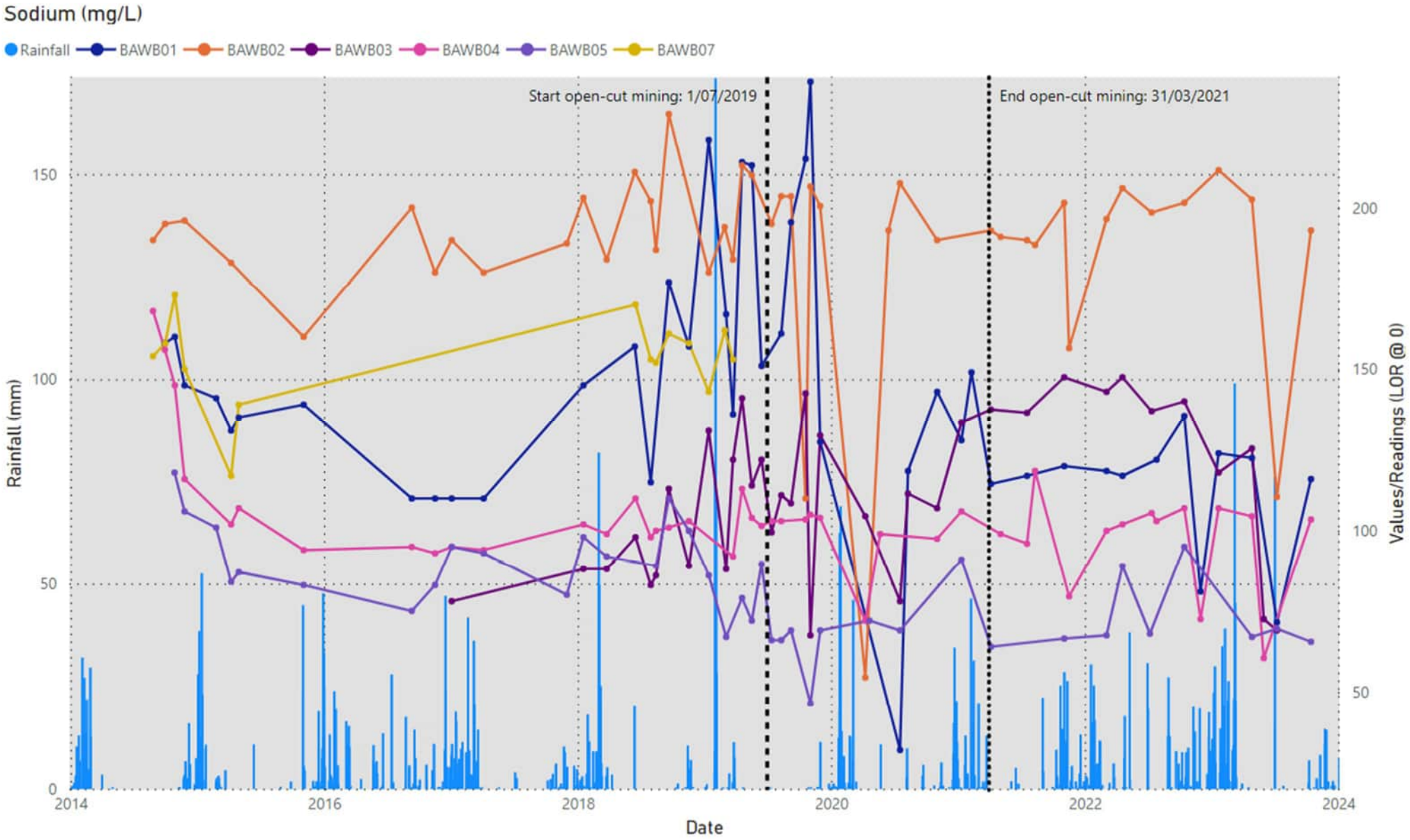

Calcium (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
20
30
40
50
60
70
80
2014
2016
2018
2020
2022
2024

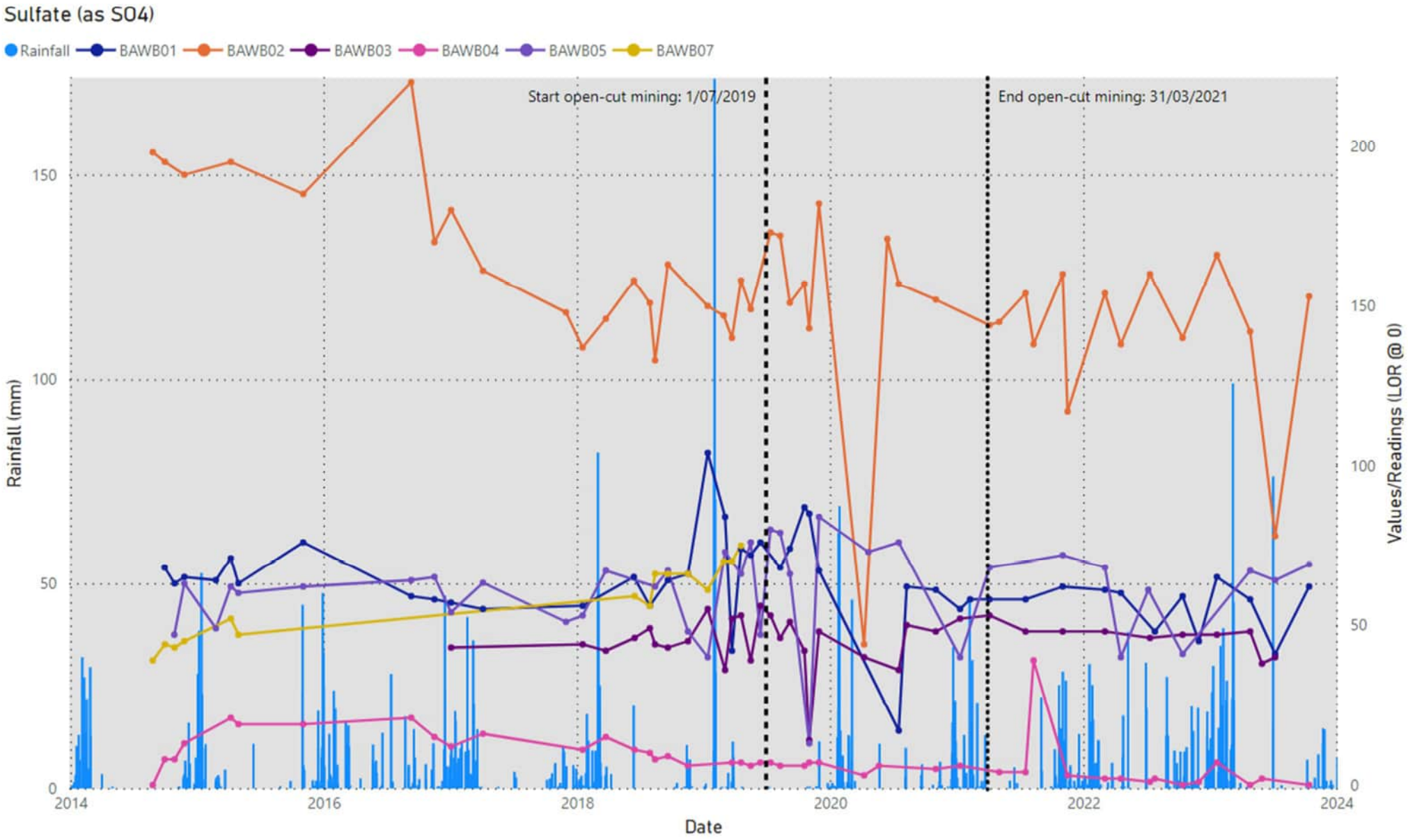

Chloride (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
20
40
60
80
2014
2016
2018
2020
2022
2024

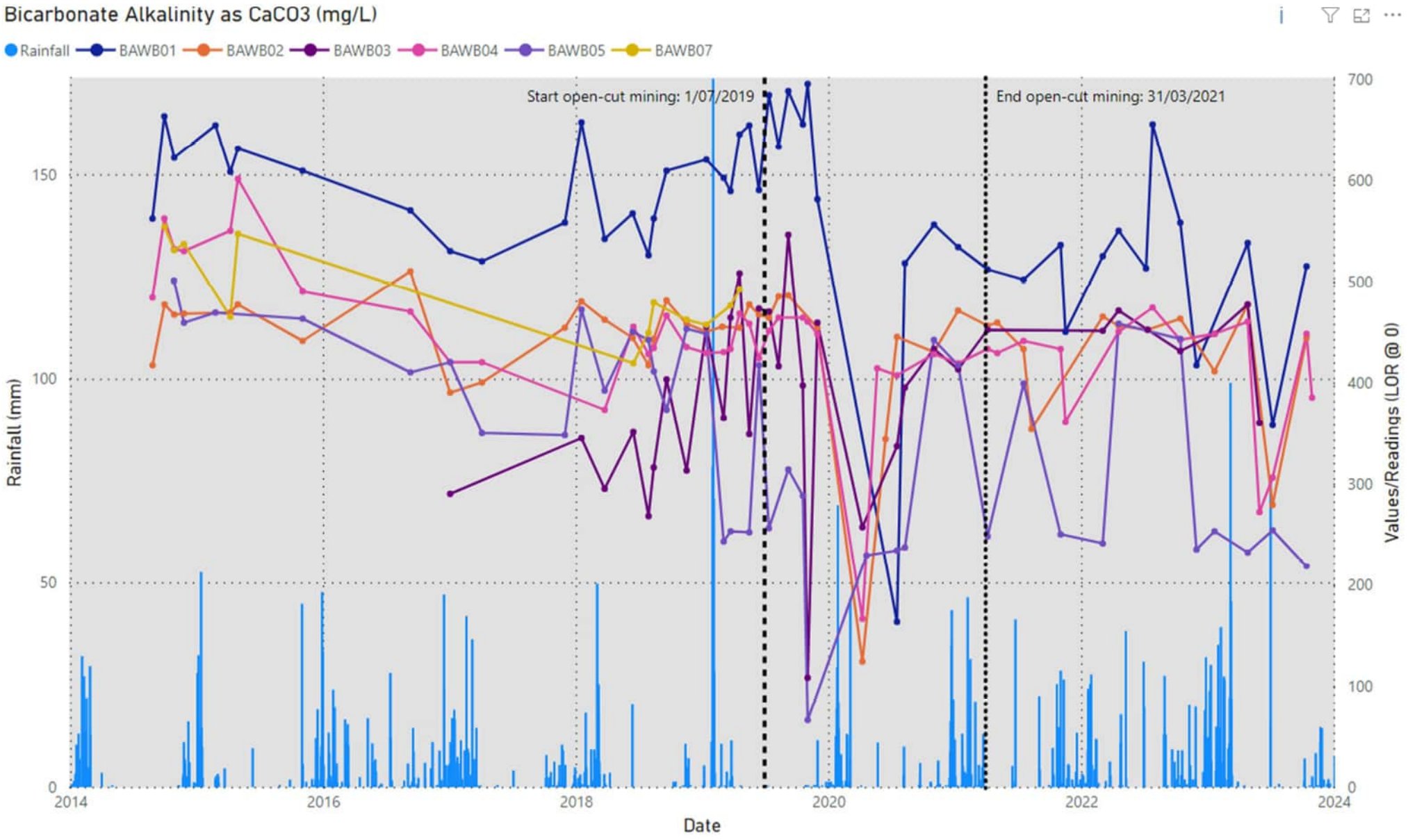

Fluoride (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.0
0.5
1.0
1.5
2.0
2014
2016
2018
2020
2022
2024

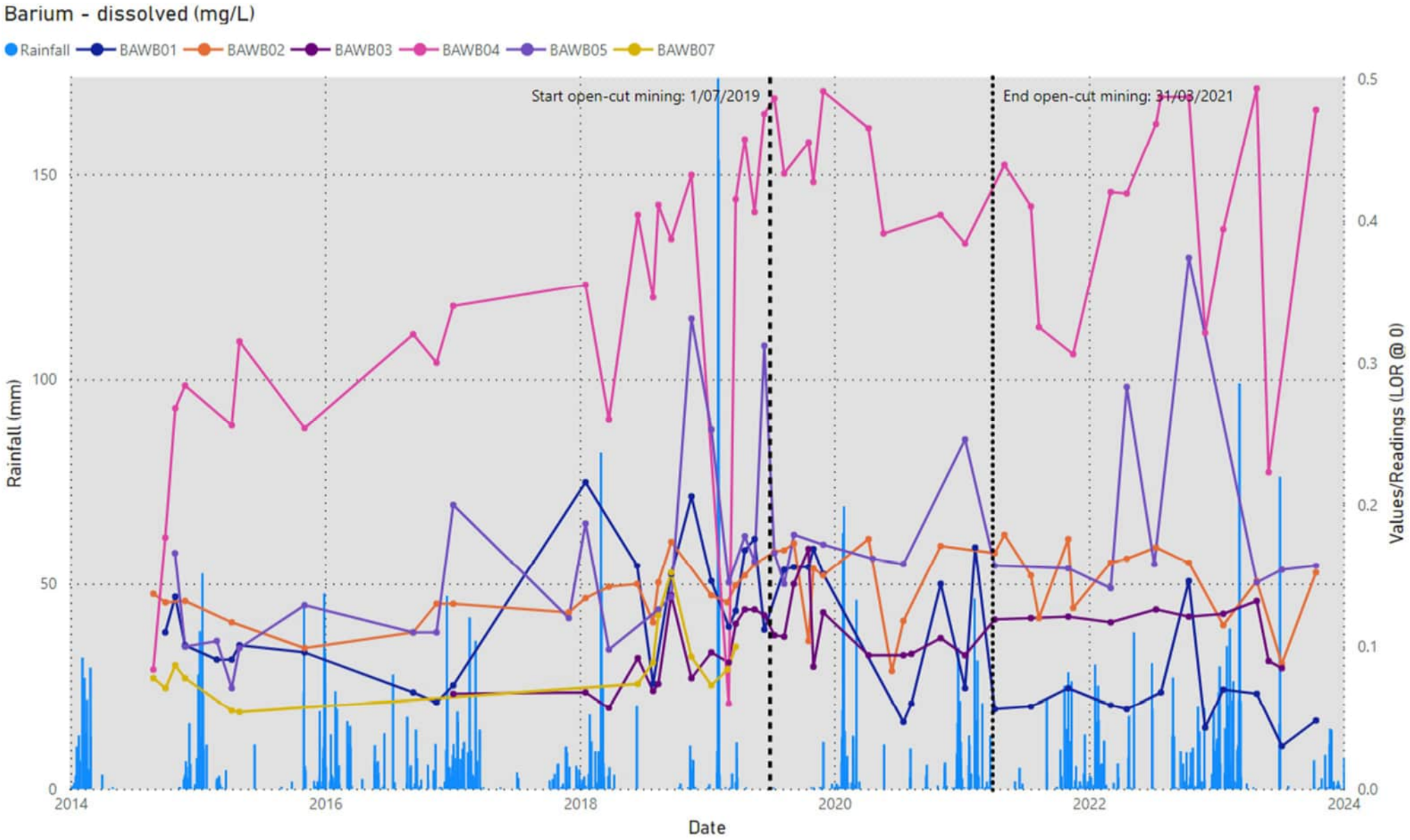

Magnesium (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
20
40
60
80
2014
2016
2018
2020
2022
2024

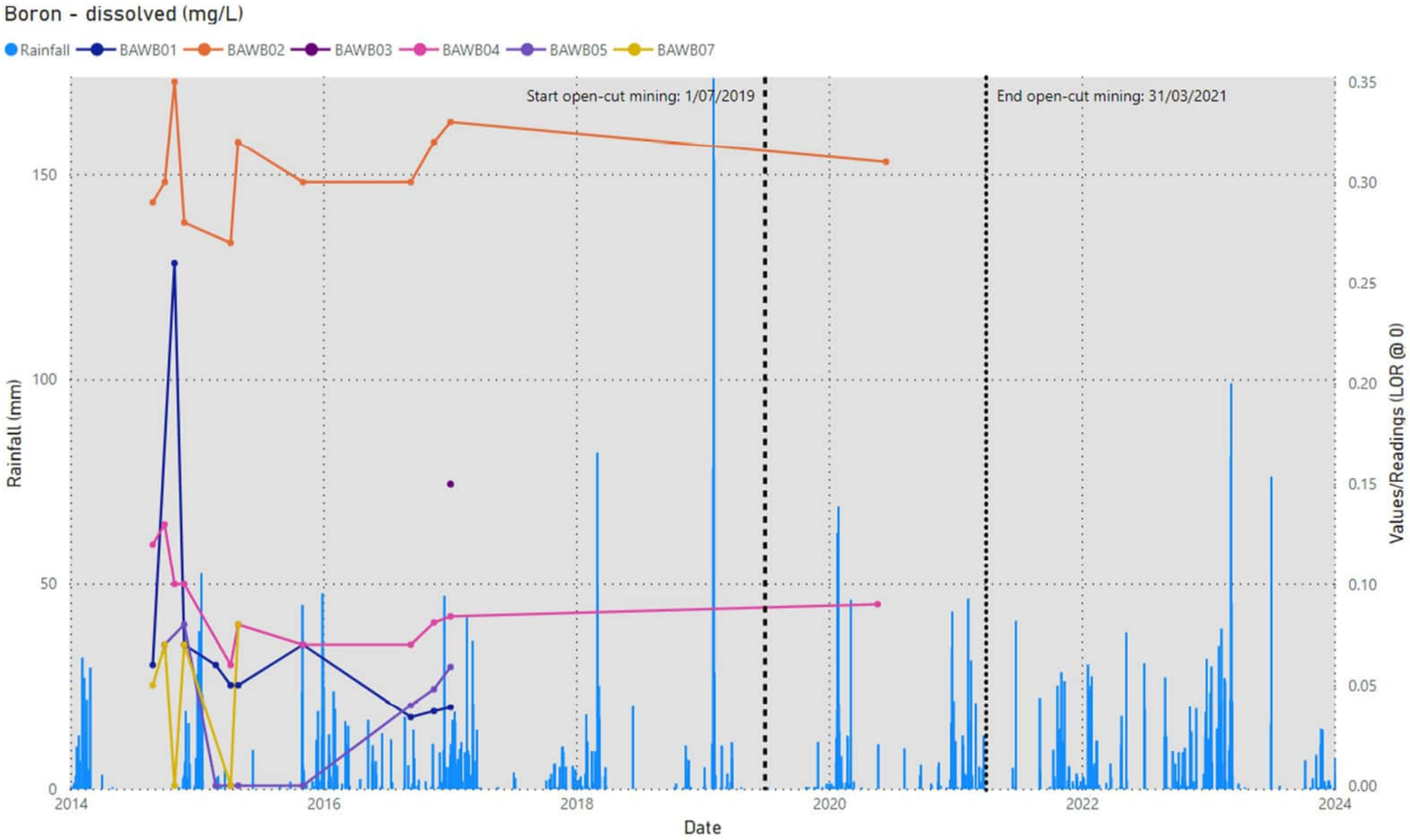

Potassium (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
5
10
15
20
25
2014
2016
2018
2020
2022
2024

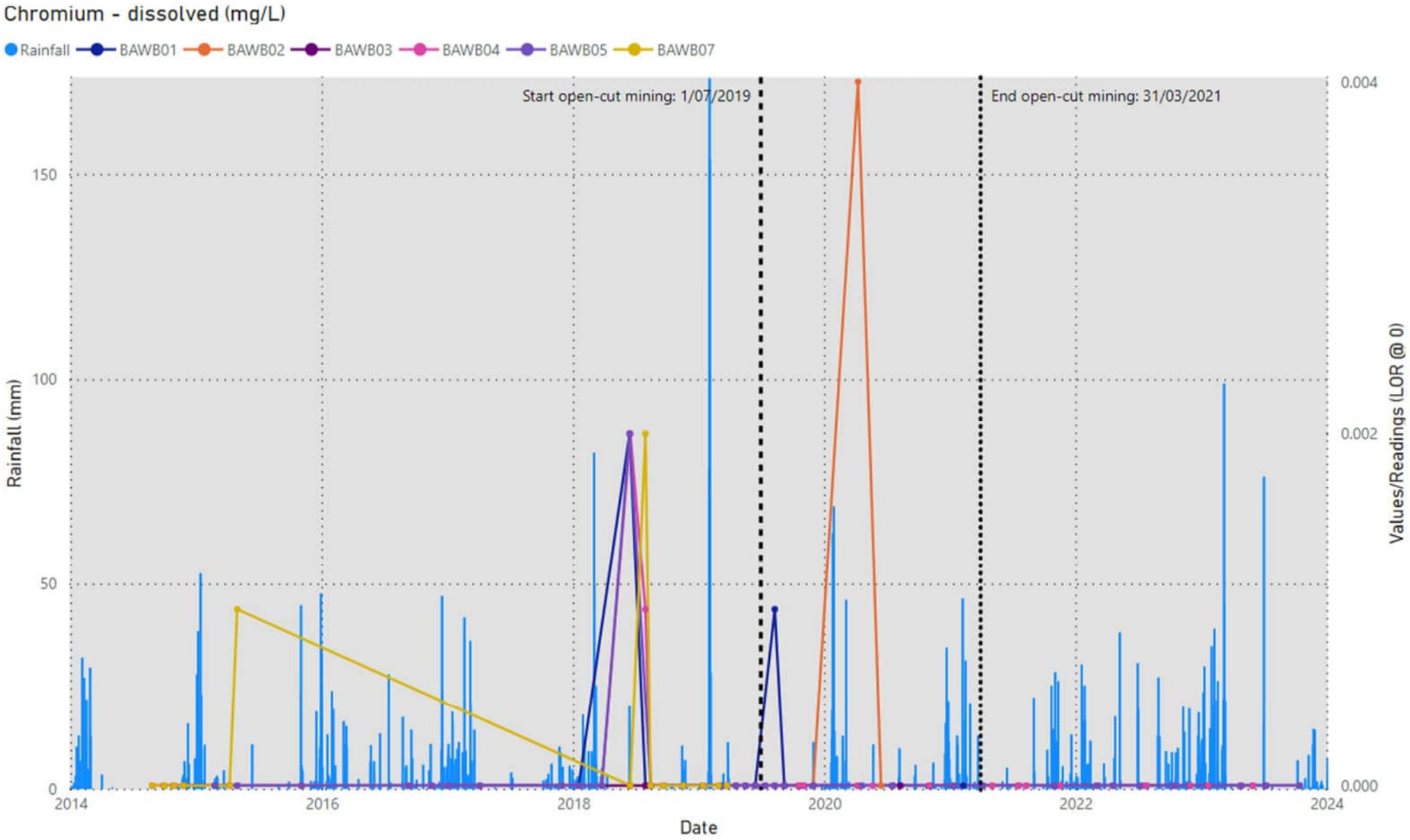

Sodium (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
200
2014
2016
2018
2020
2022
2024

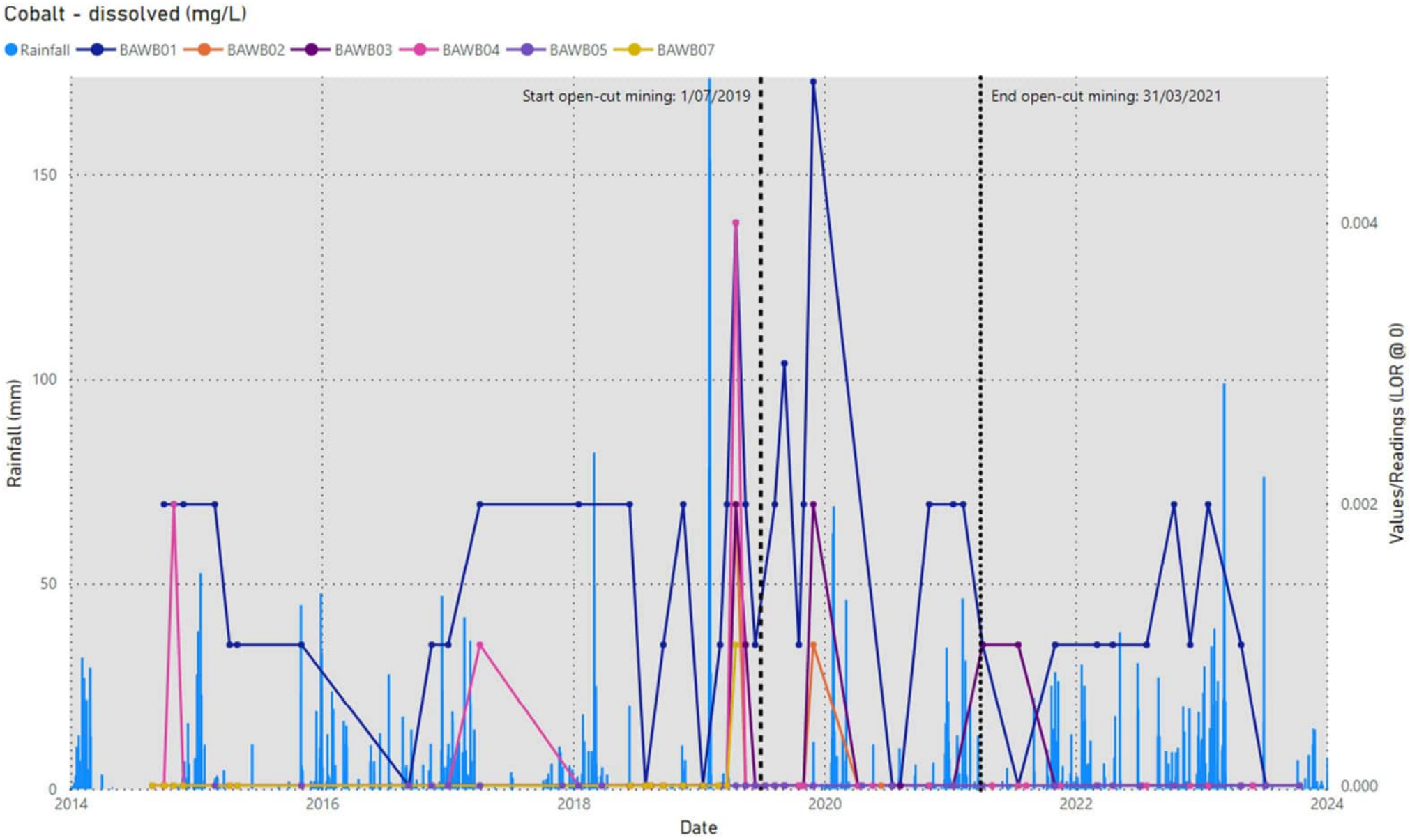

Sulfate (as SO4)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
200
2014
2016
2018
2020
2022
2024

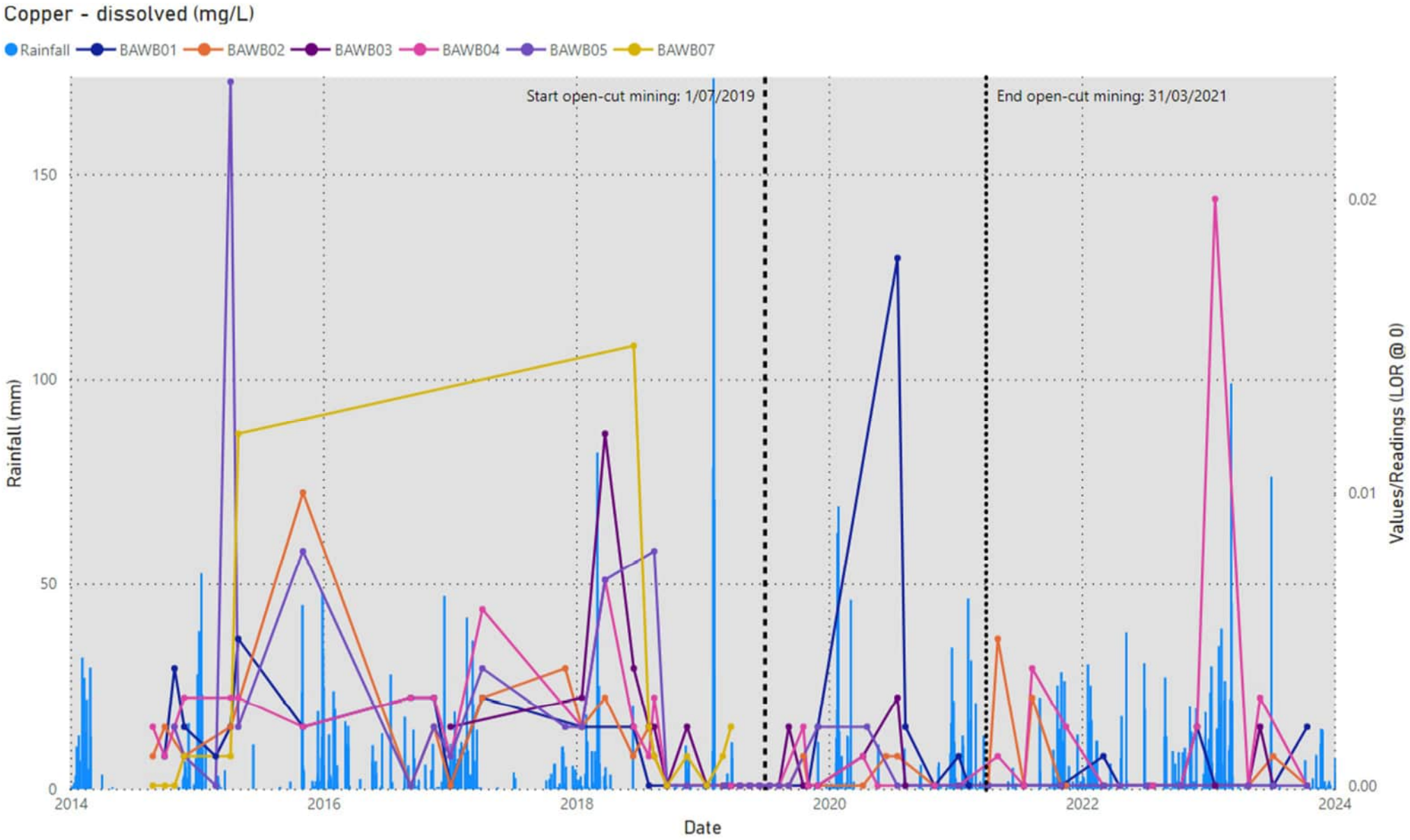

Bicarbonate Alkalinity as CaCO3 (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
100
200
300
400
500
600
700
2014
2016
2018
2020
2022
2024

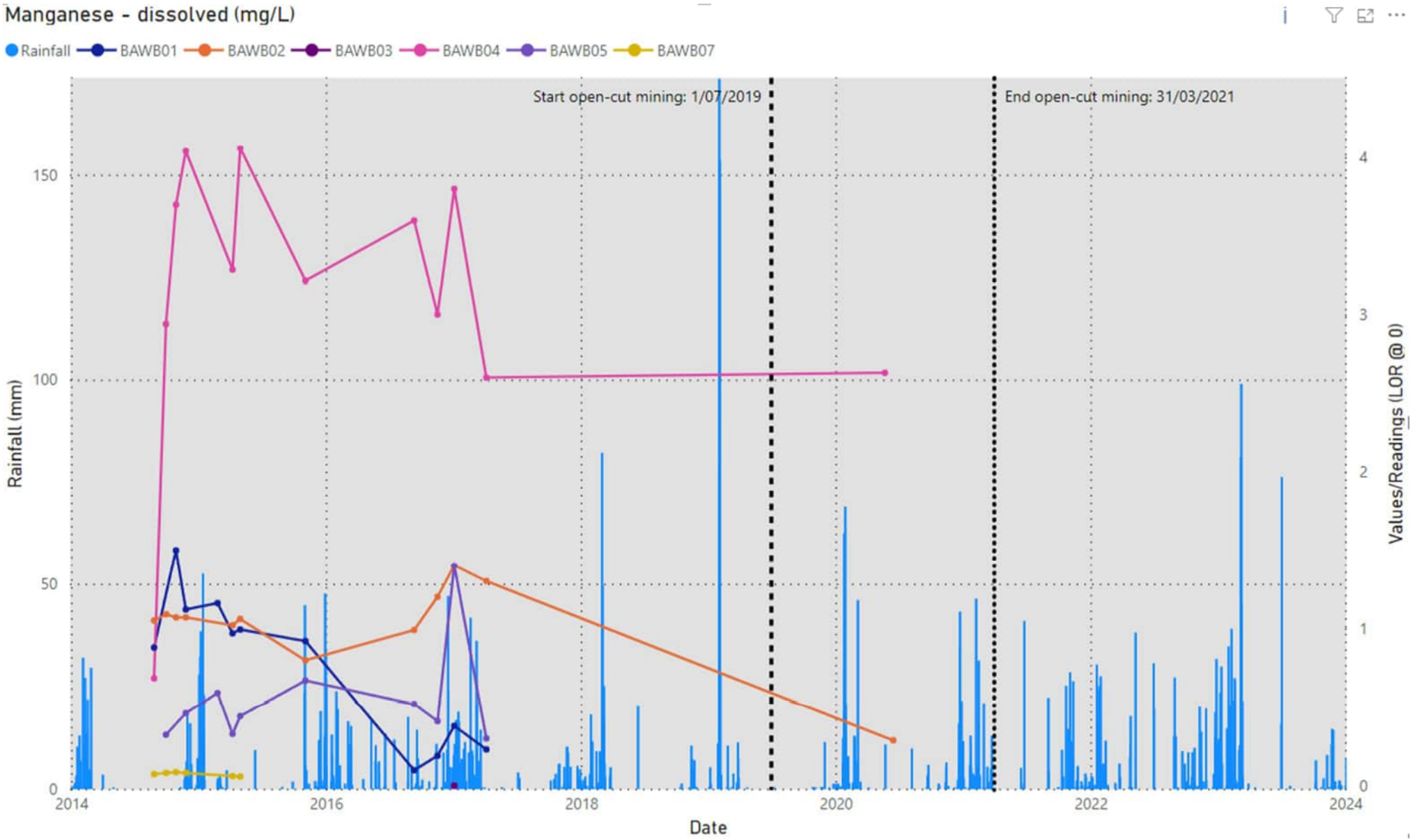

Barium - dissolved (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.0
0.1
0.2
0.3
0.4
0.5
2014
2016
2018
2020
2022
2024

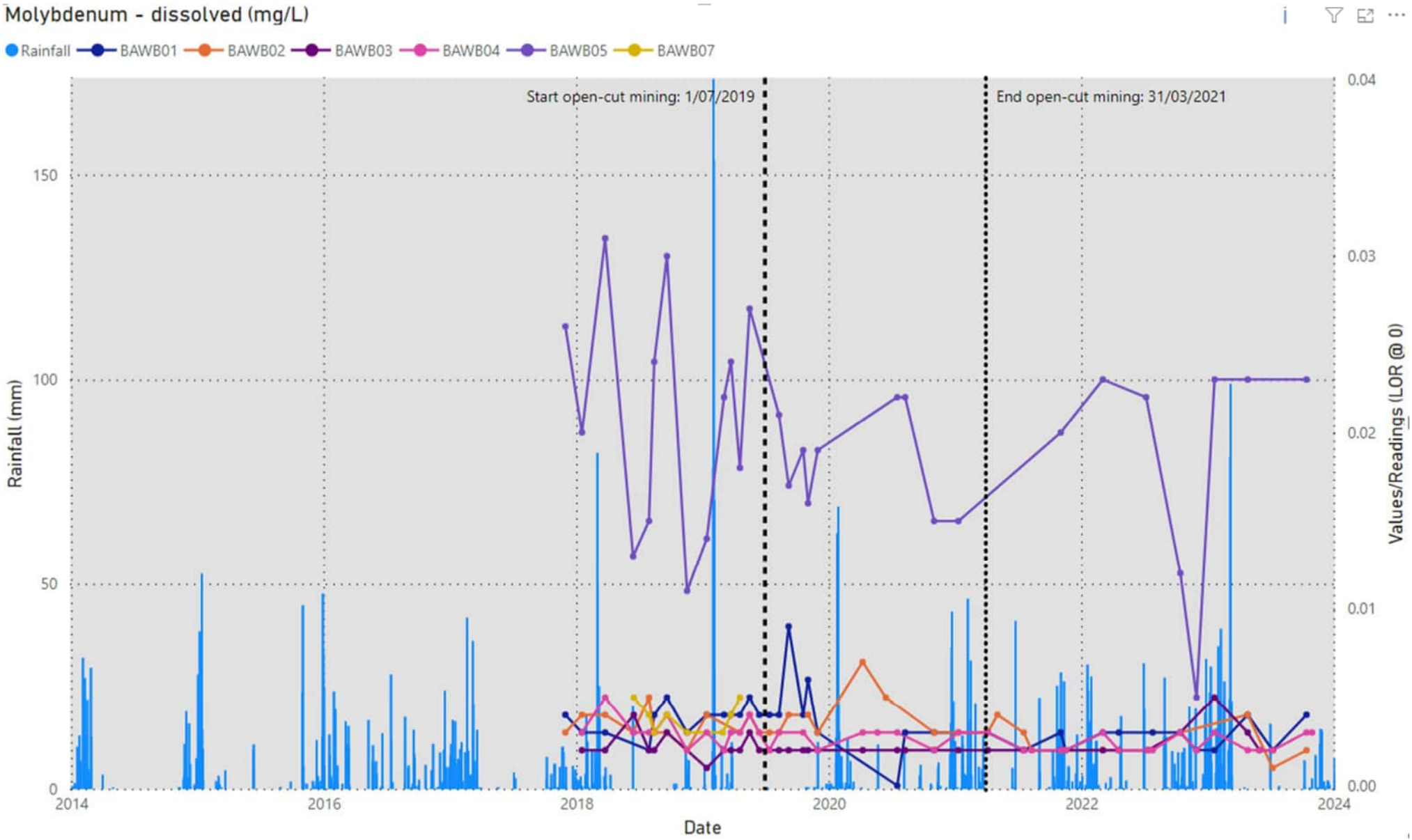

Boron - dissolved (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
2014
2016
2018
2020
2022
2024

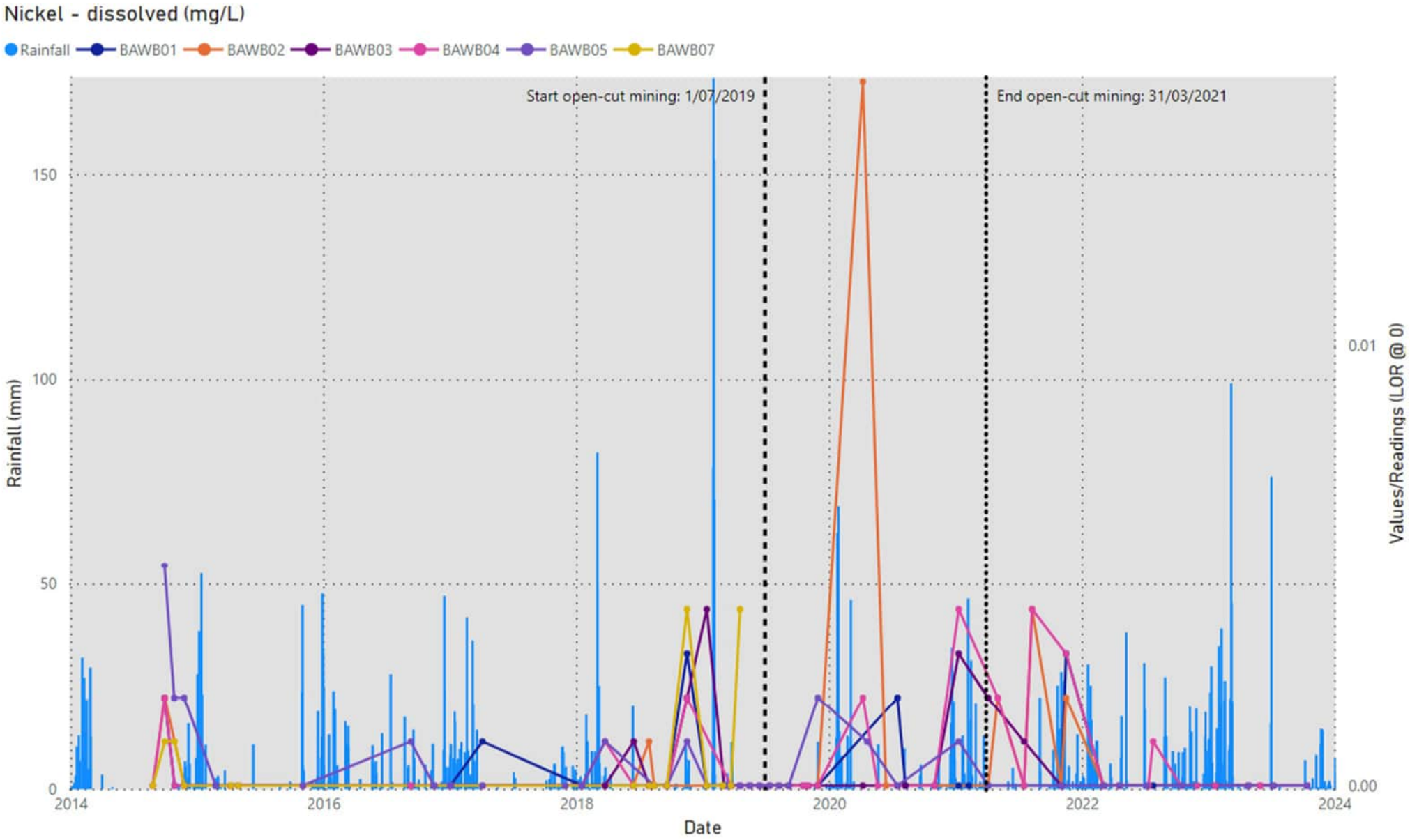

Chromium - dissolved (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.000
0.002
0.004
2014
2016
2018
2020
2022
2024

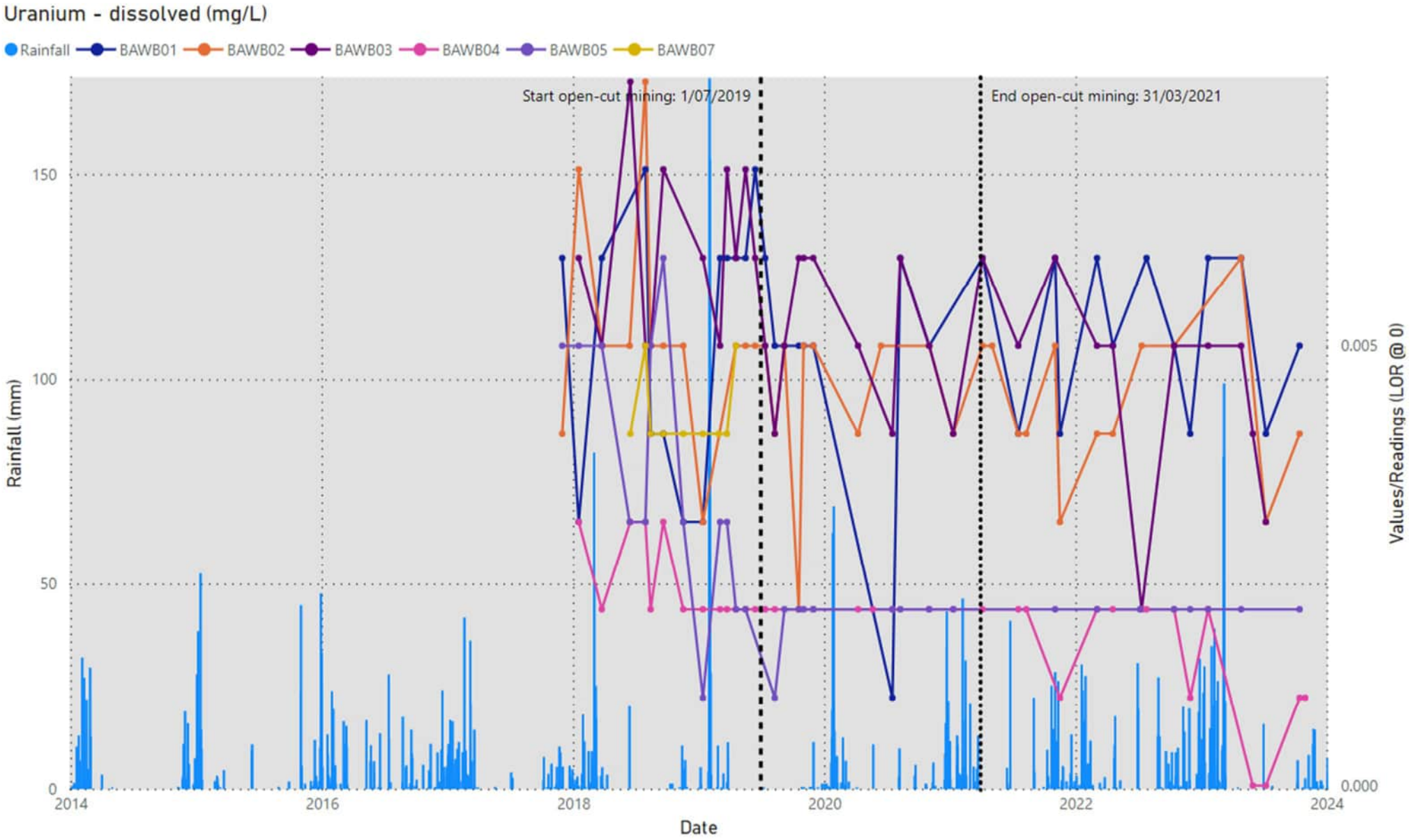

Cobalt - dissolved (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
0.004
0.002
0.000
Values/Readings (LOR @ 0)
2014
2016
2018
2020
2022
2024
Date

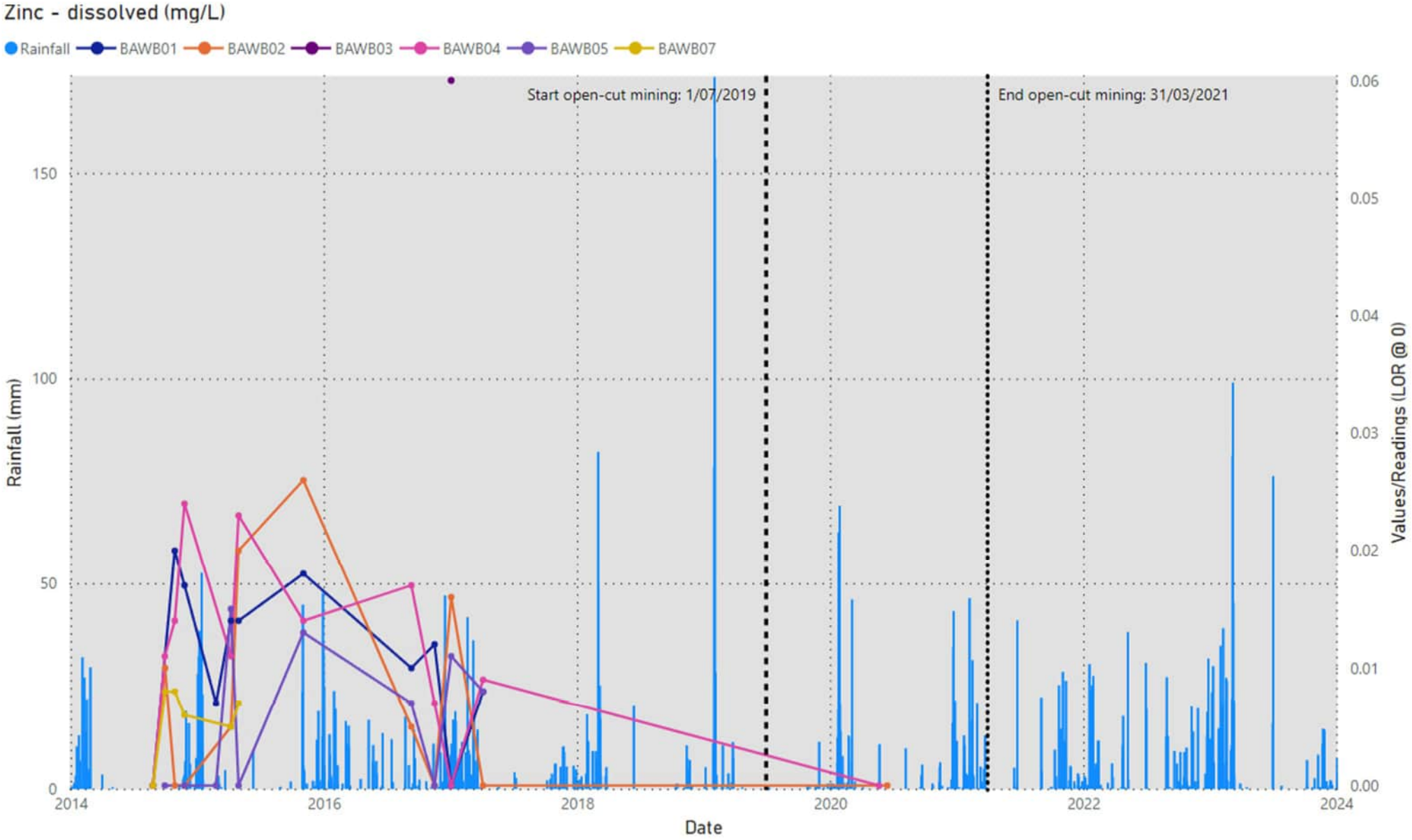

Copper - dissolved (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
0.02
0.01
0.00
Values/Readings (LOR @ 0)
2014
2016
2018
2020
2022
2024
Date

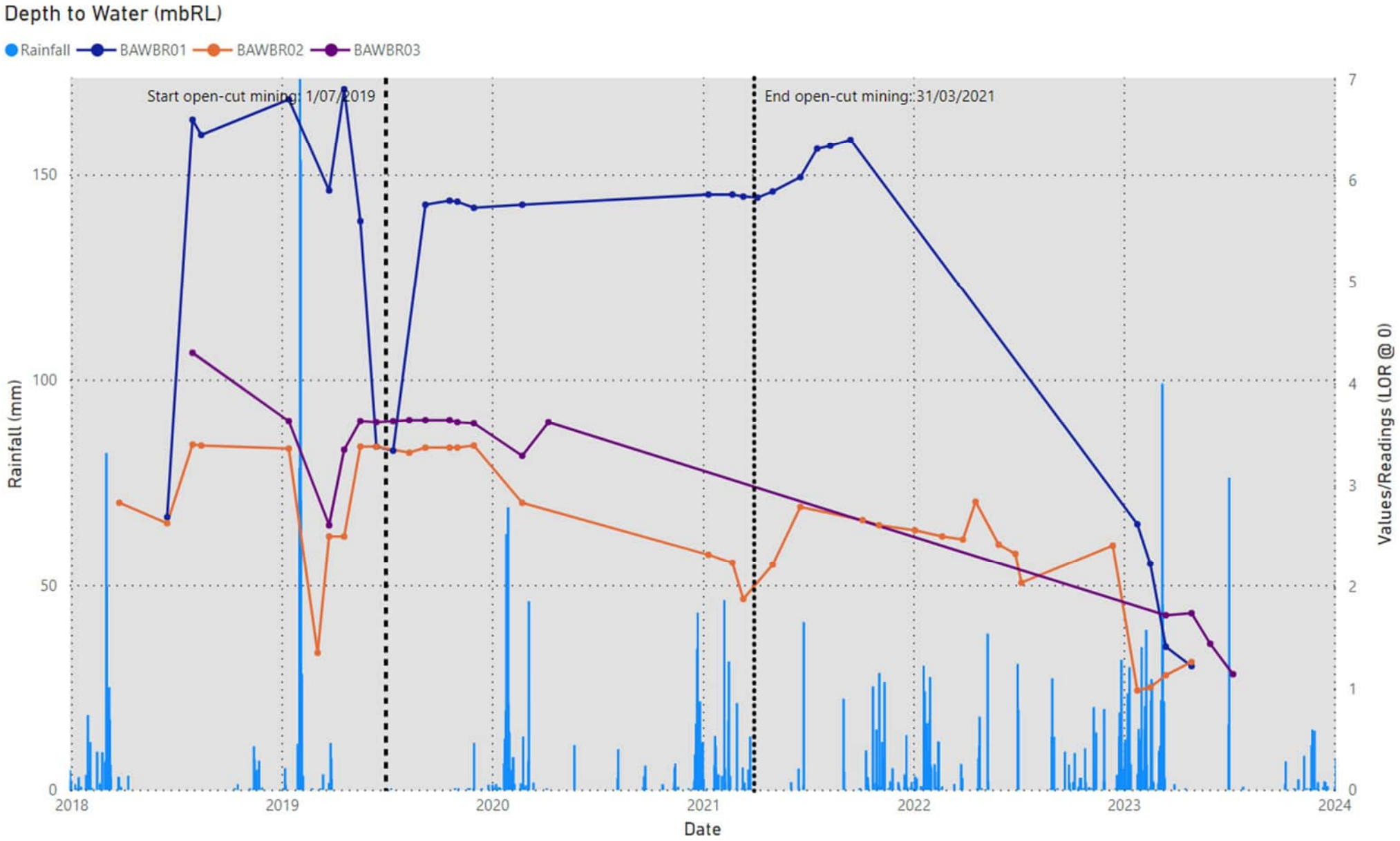

Manganese - dissolved (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
1
2
3
4
2014
2016
2018
2020
2022
2024

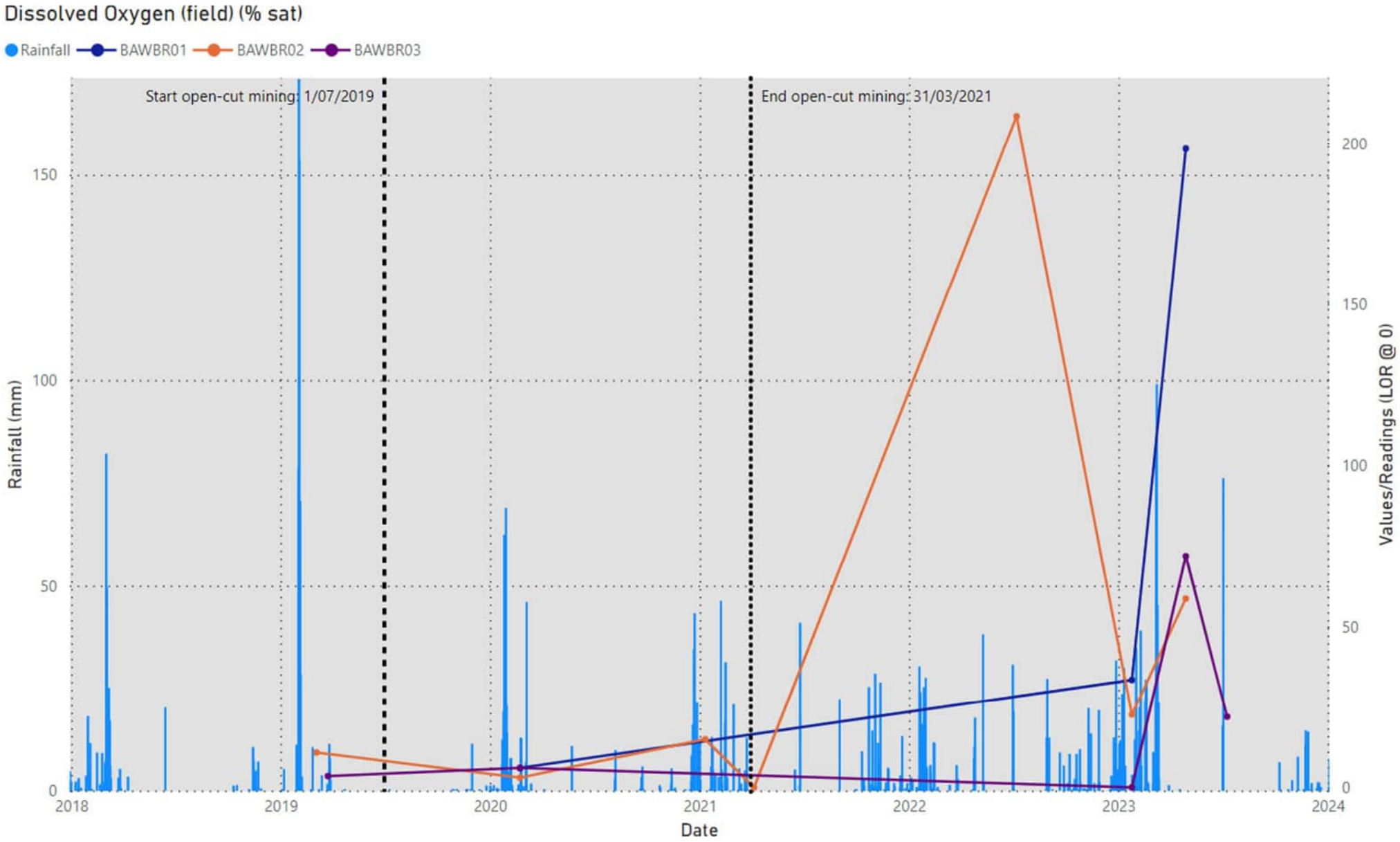

Molybdenum - dissolved (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.01
0.02
0.03
0.04
2014
2016
2018
2020
2022
2024

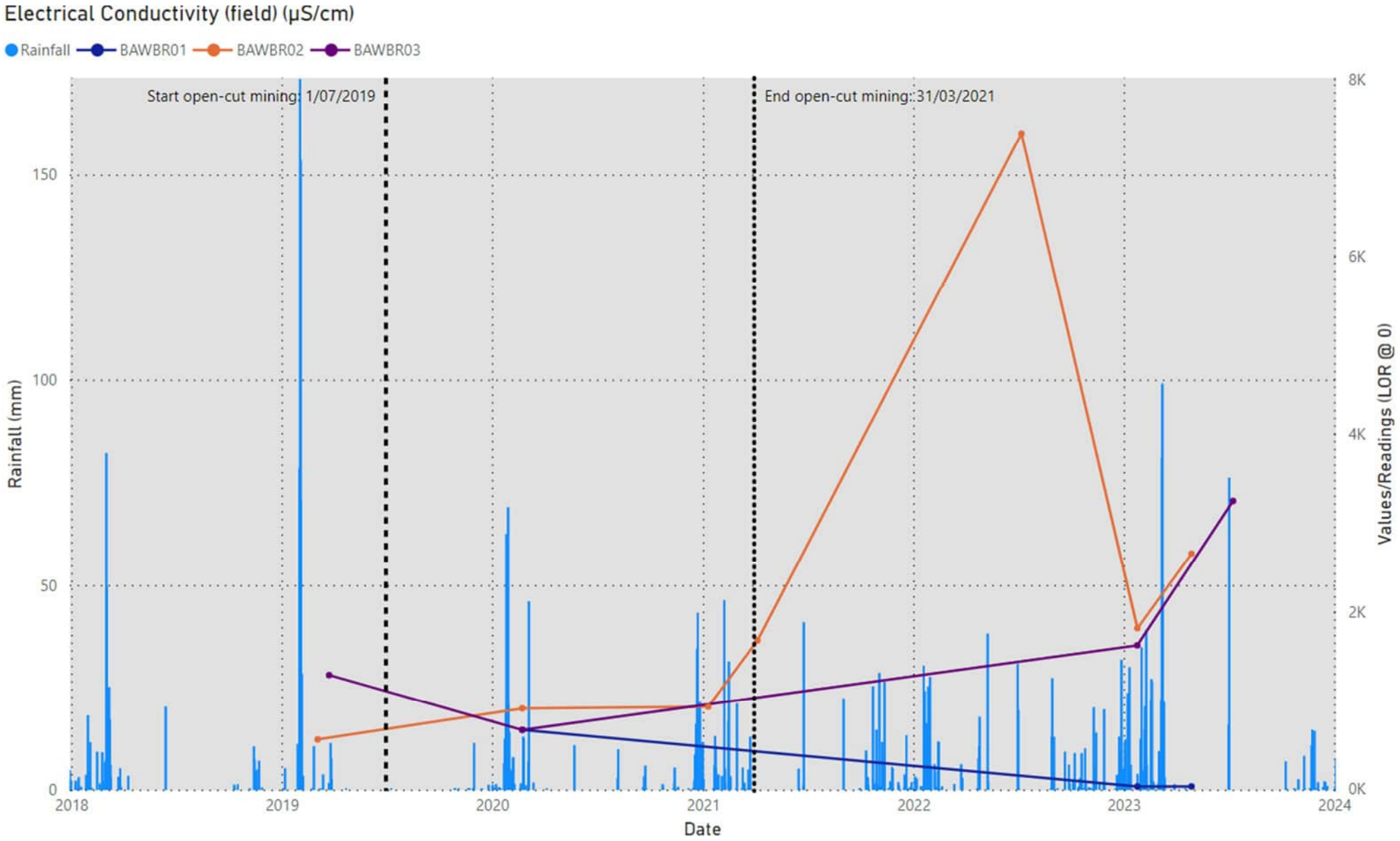

Nickel - dissolved (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
150
100
50
0
Rainfall (mm)
0.01
0.00
Values/Readings (LOR @ 0)
2014
2016
2018
2020
2022
2024
Date

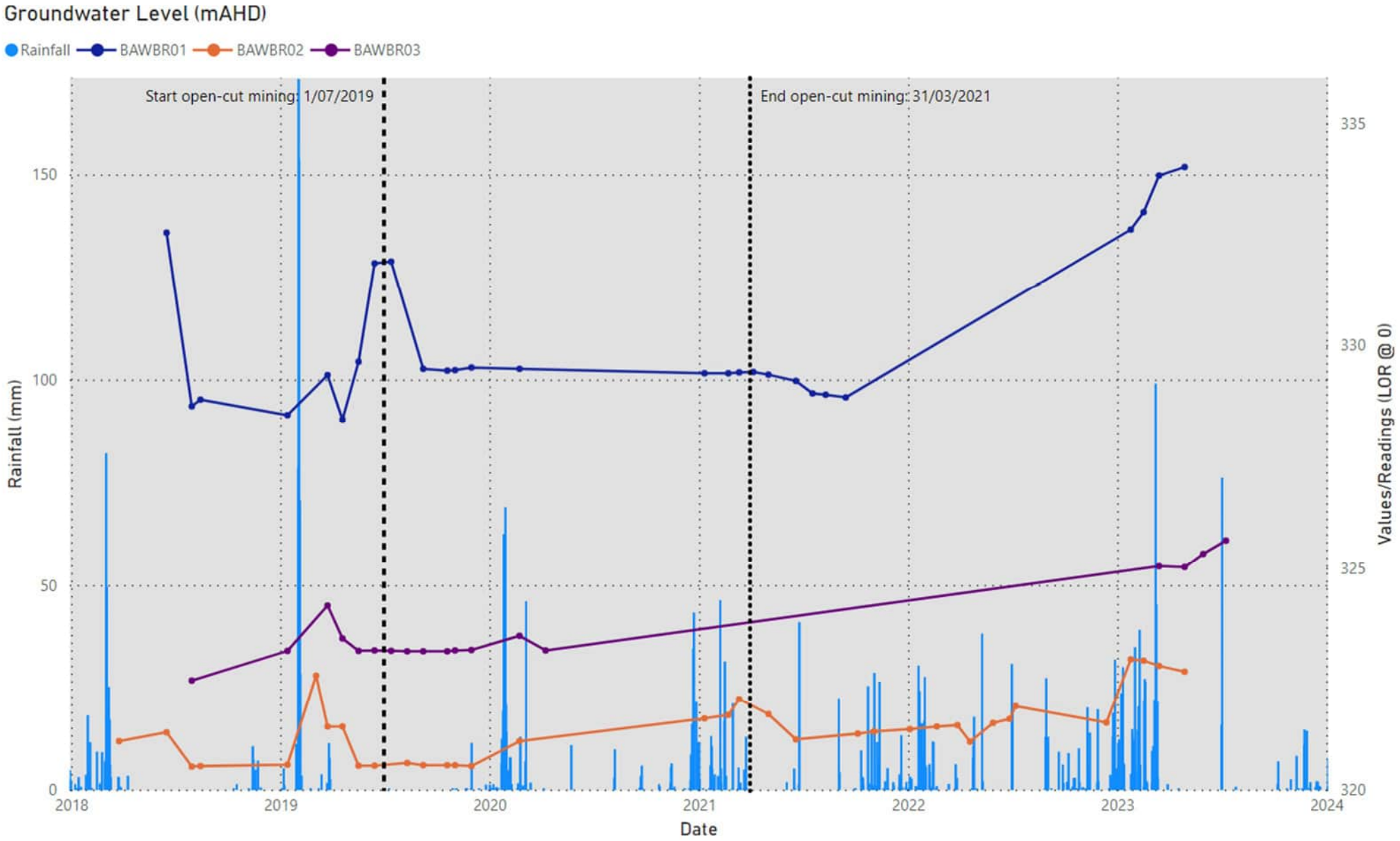

Uranium - dissolved (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
2014
2016
2018
2020
2022
2024
Date
0.005
0.000
Values/Readings (LOR @ 0)

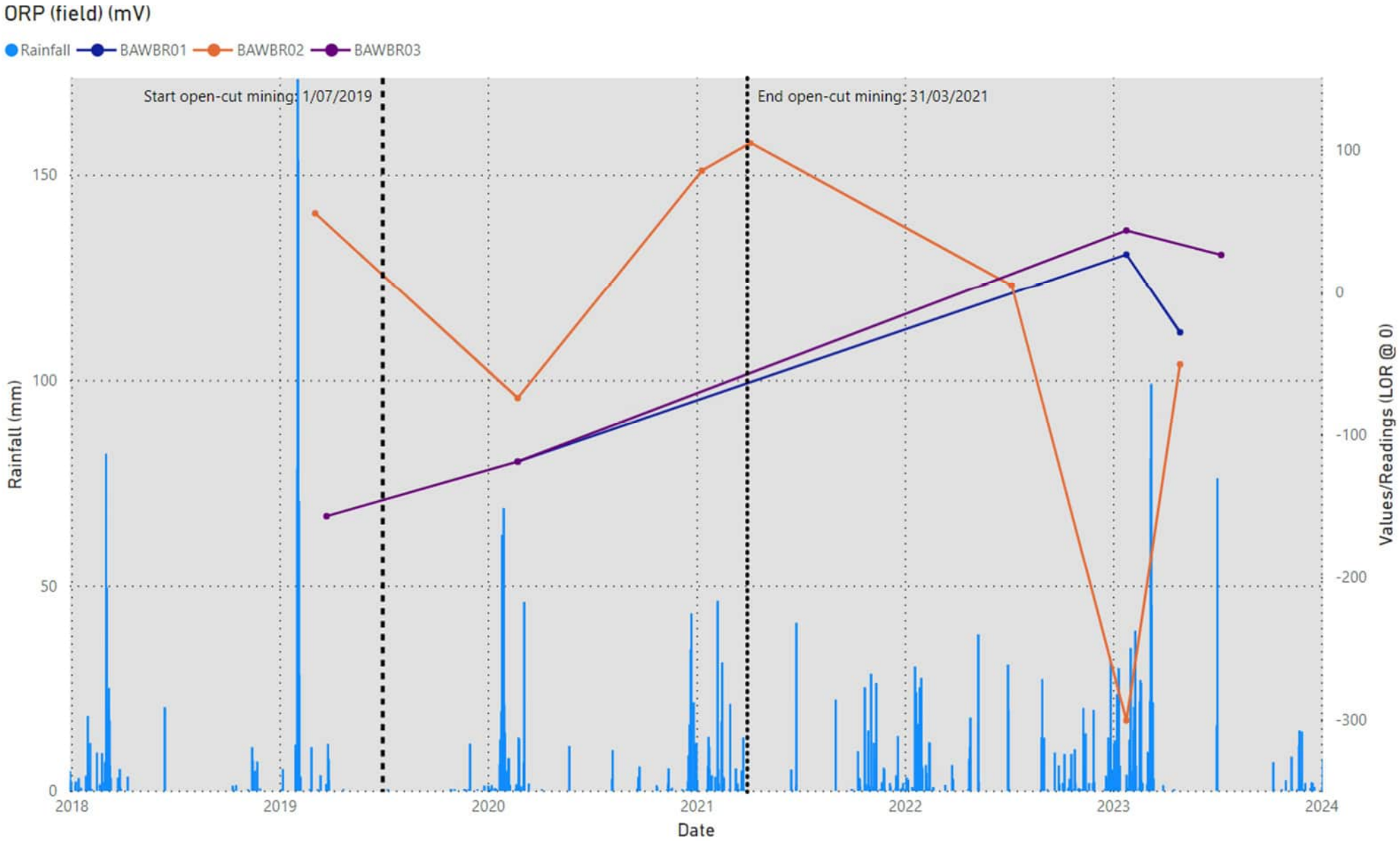

Zinc - dissolved (mg/L)
Rainfall
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.01
0.02
0.03
0.04
0.05
0.06
2014
2016
2018
2020
2022
2024

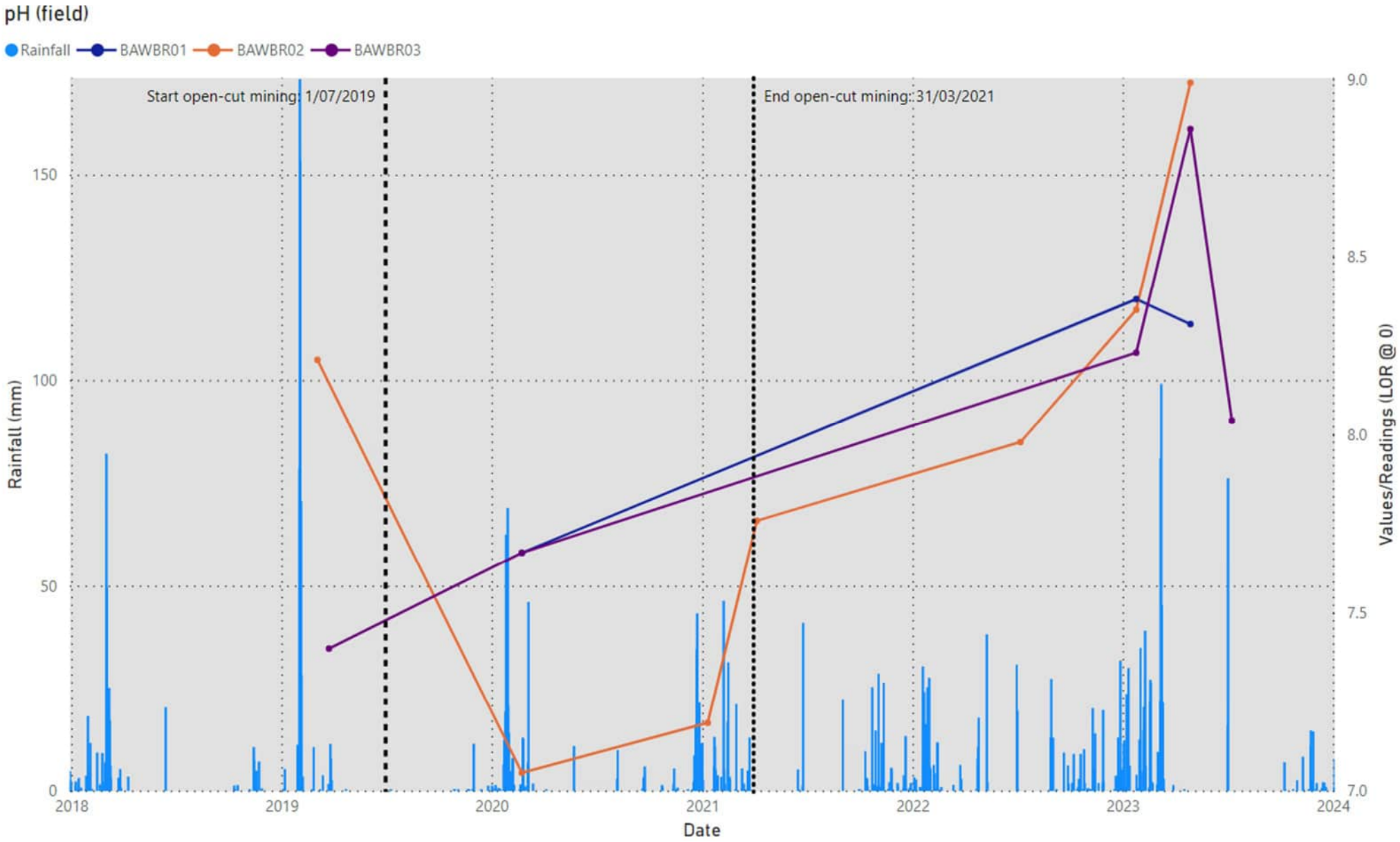

Depth to Water (mbRL)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
1
2
3
4
5
6
7
2018
2019
2020
2021
2022
2023
2024


Dissolved Oxygen (field) (% sat)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
0
50
100
150
200
2018
2019
2020
2021
2022
2023
2024
Date

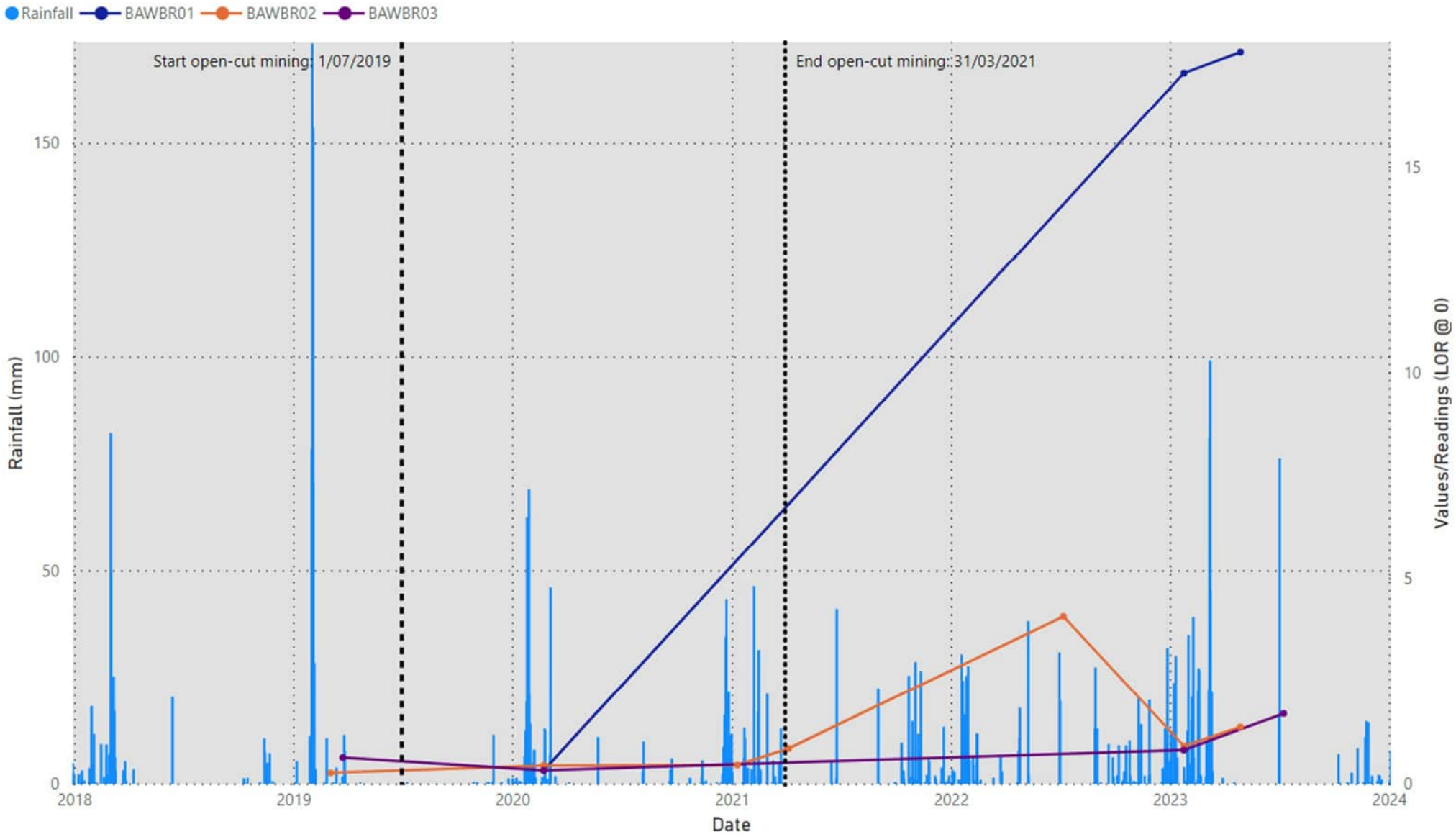

Electrical Conductivity (field) (µS/cm)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
0
50
100
150
0K
2K
4K
6K
8K
2018
2019
2020
2021
2022
2023
2024
Date

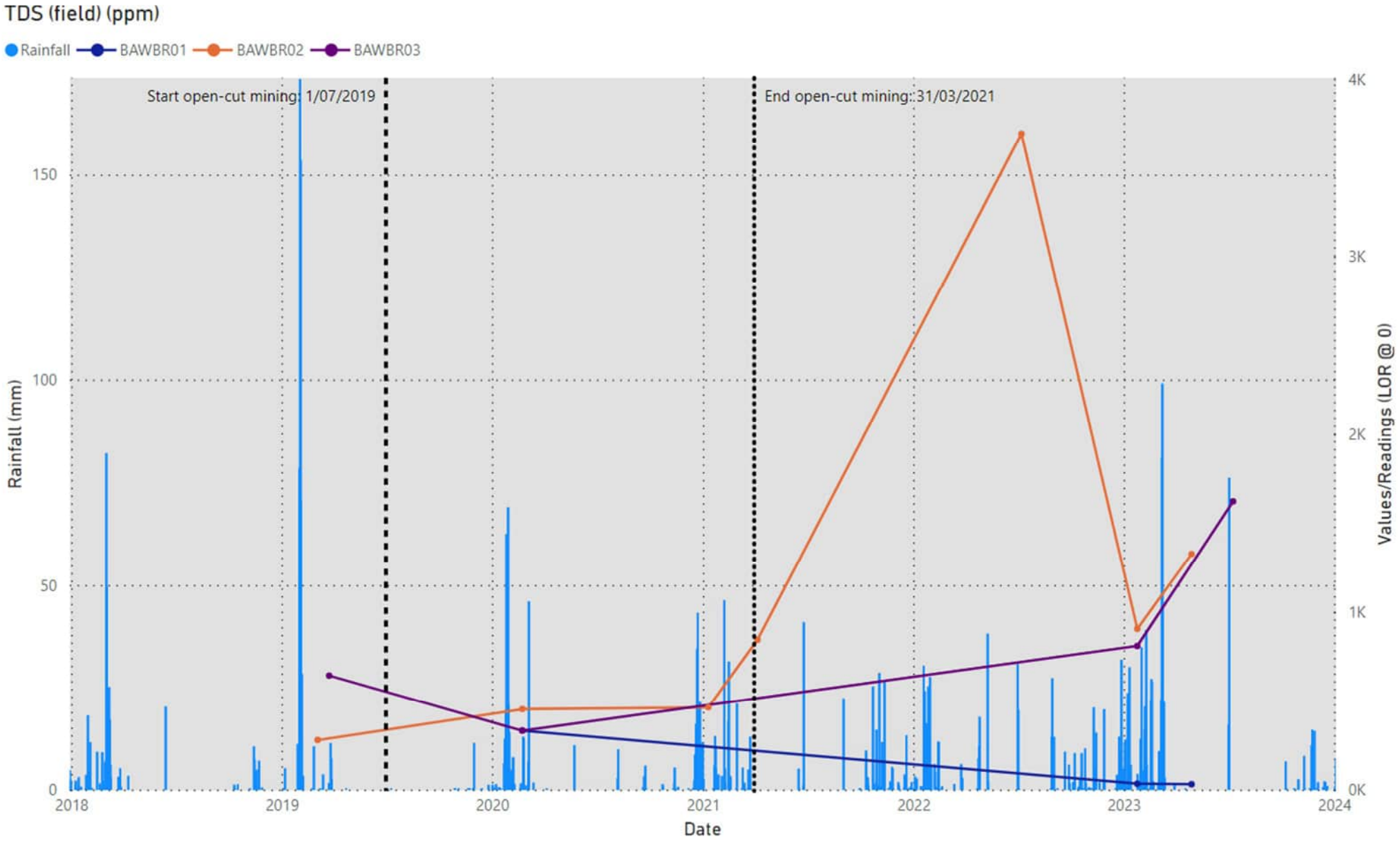

Groundwater Level (mAHD)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
320
325
330
335
2018
2019
2020
2021
2022
2023
2024

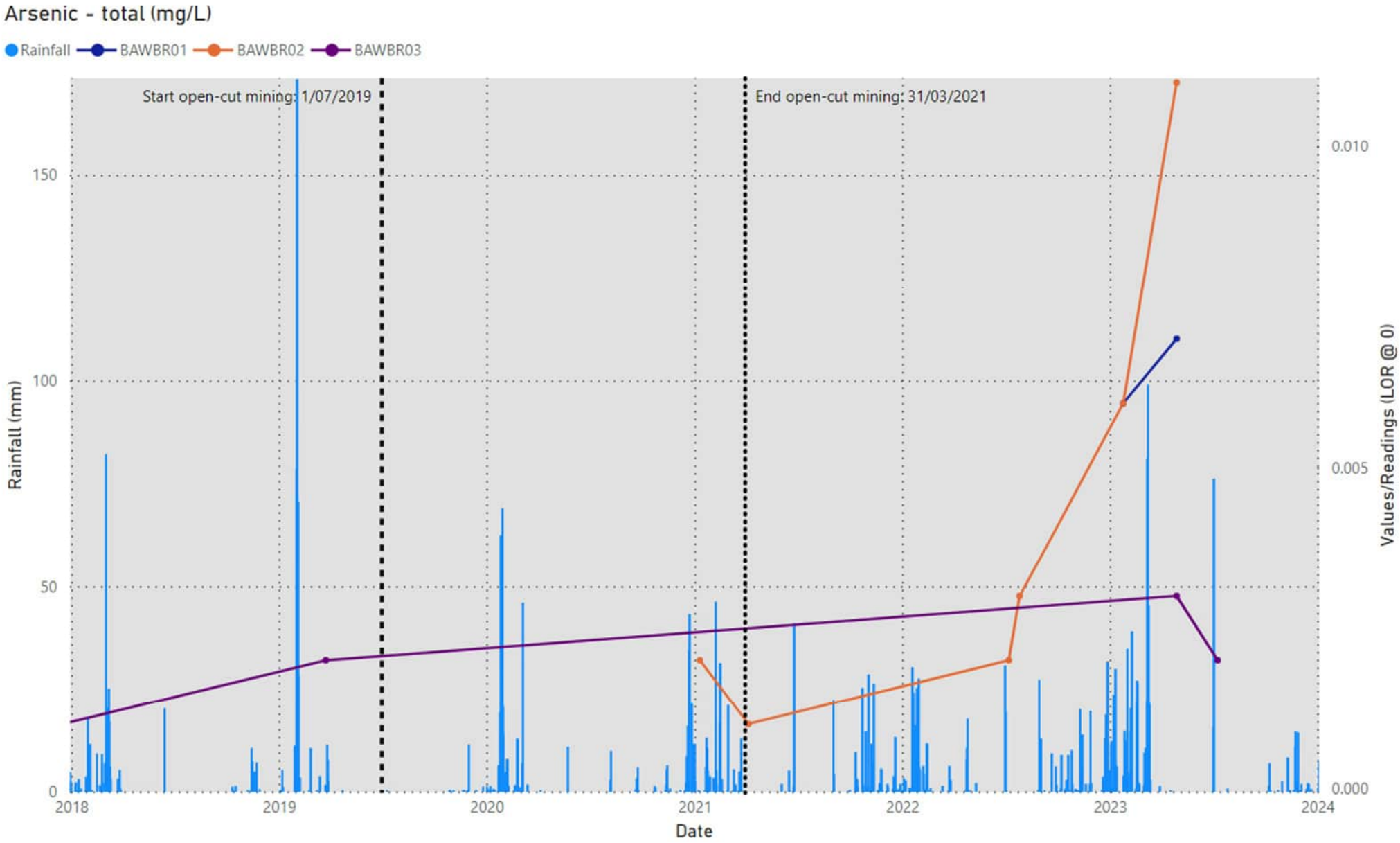

ORP (field) (mV)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
100
0
-100
-200
-300
2018
2019
2020
2021
2022
2023
2024

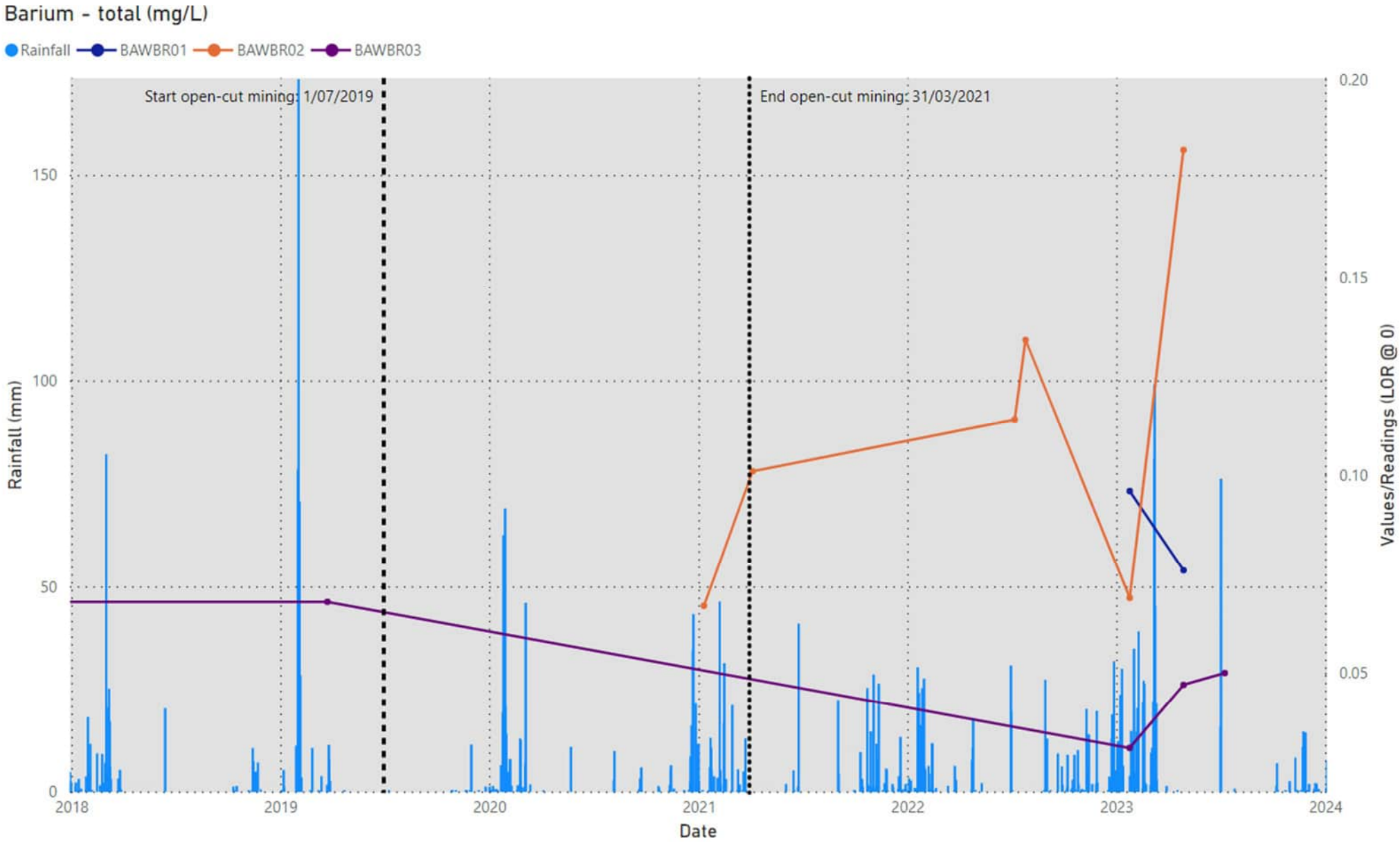

pH (field)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
7.0
7.5
8.0
8.5
9.0
2018
2019
2020
2021
2022
2023
2024

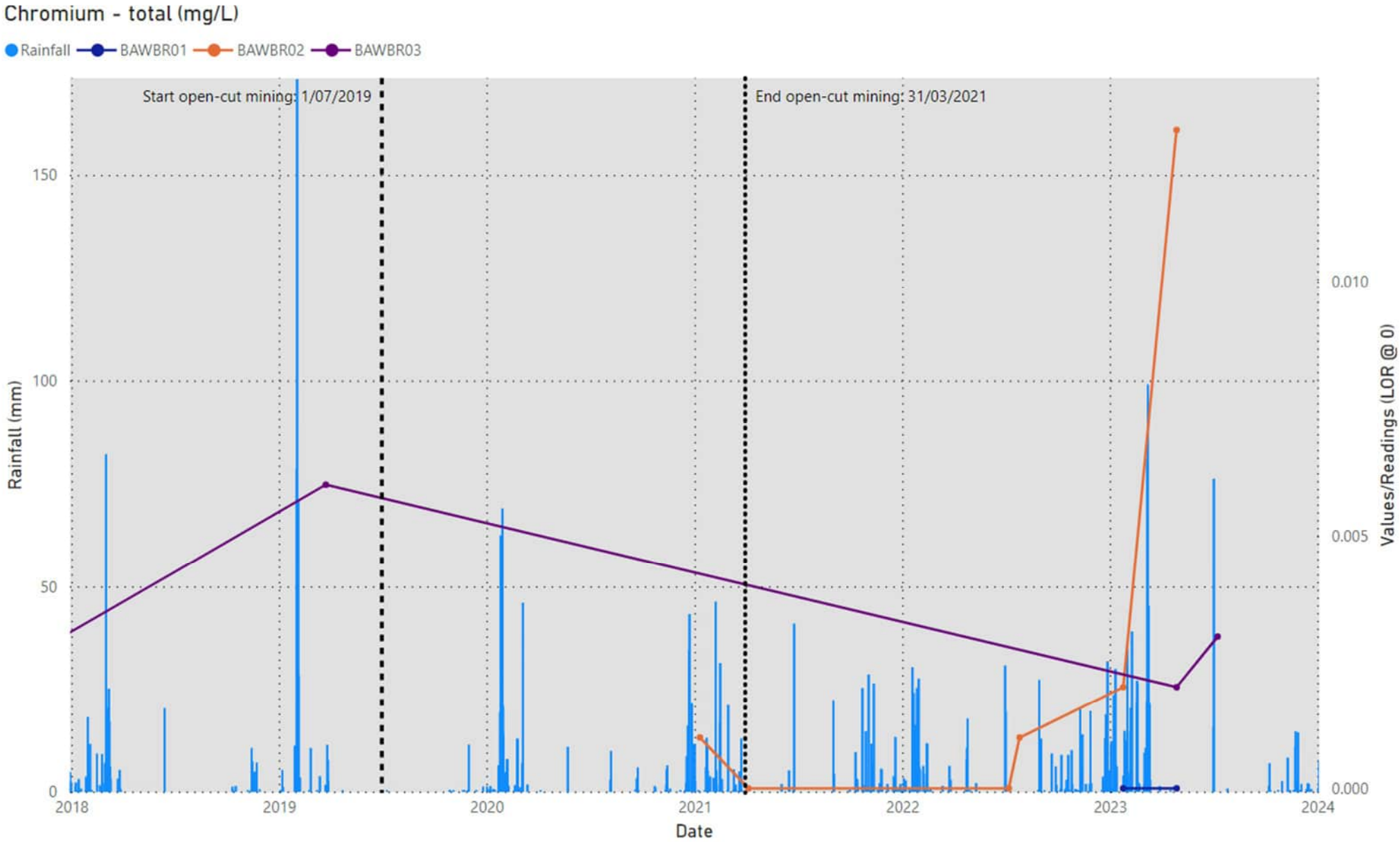
Salinity (field) (PSU)



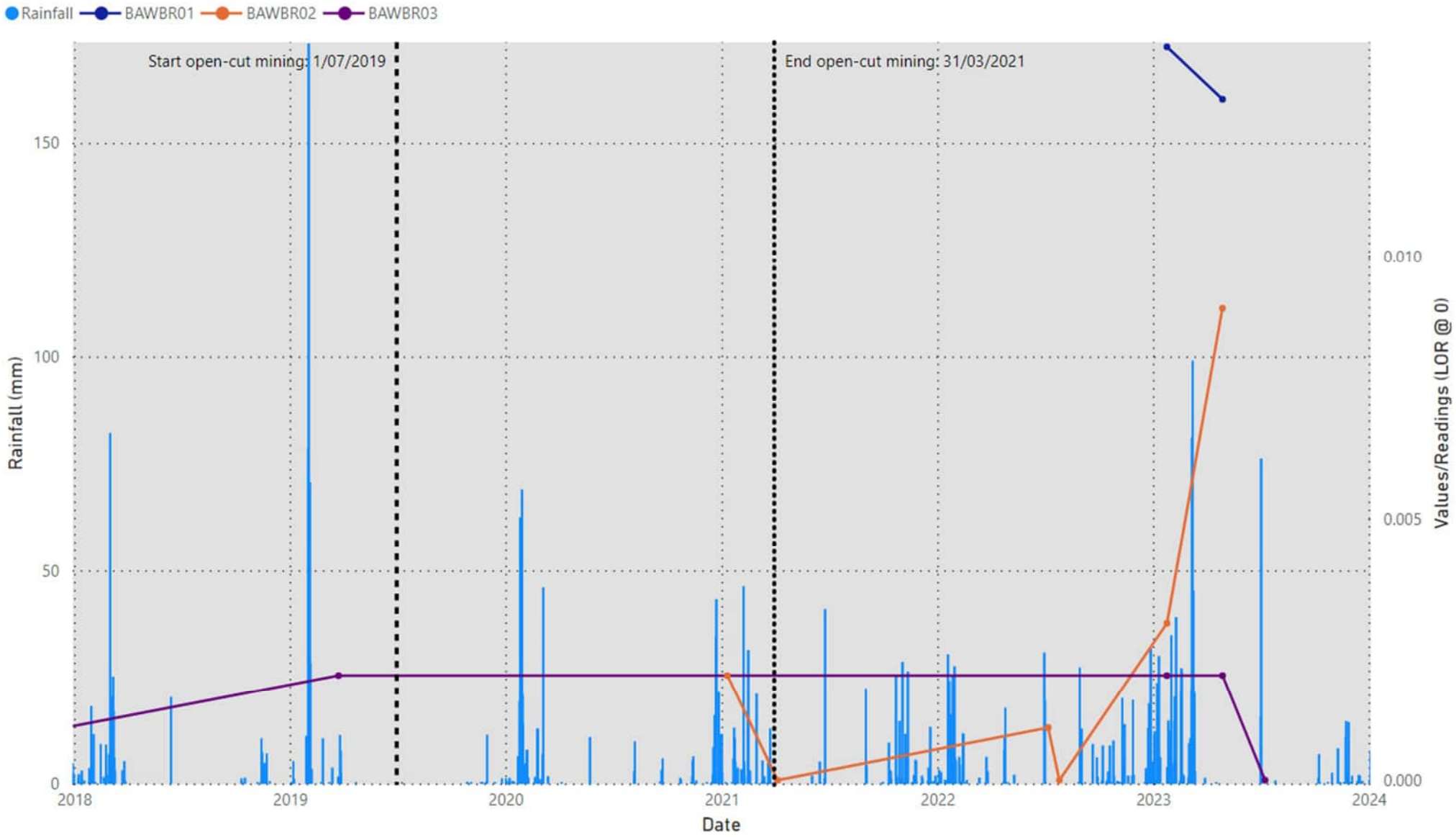

TDS (field) (ppm)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
150
100
50
0
4K
3K
2K
1K
0K
2018
2019
2020
2021
2022
2023
2024
Date

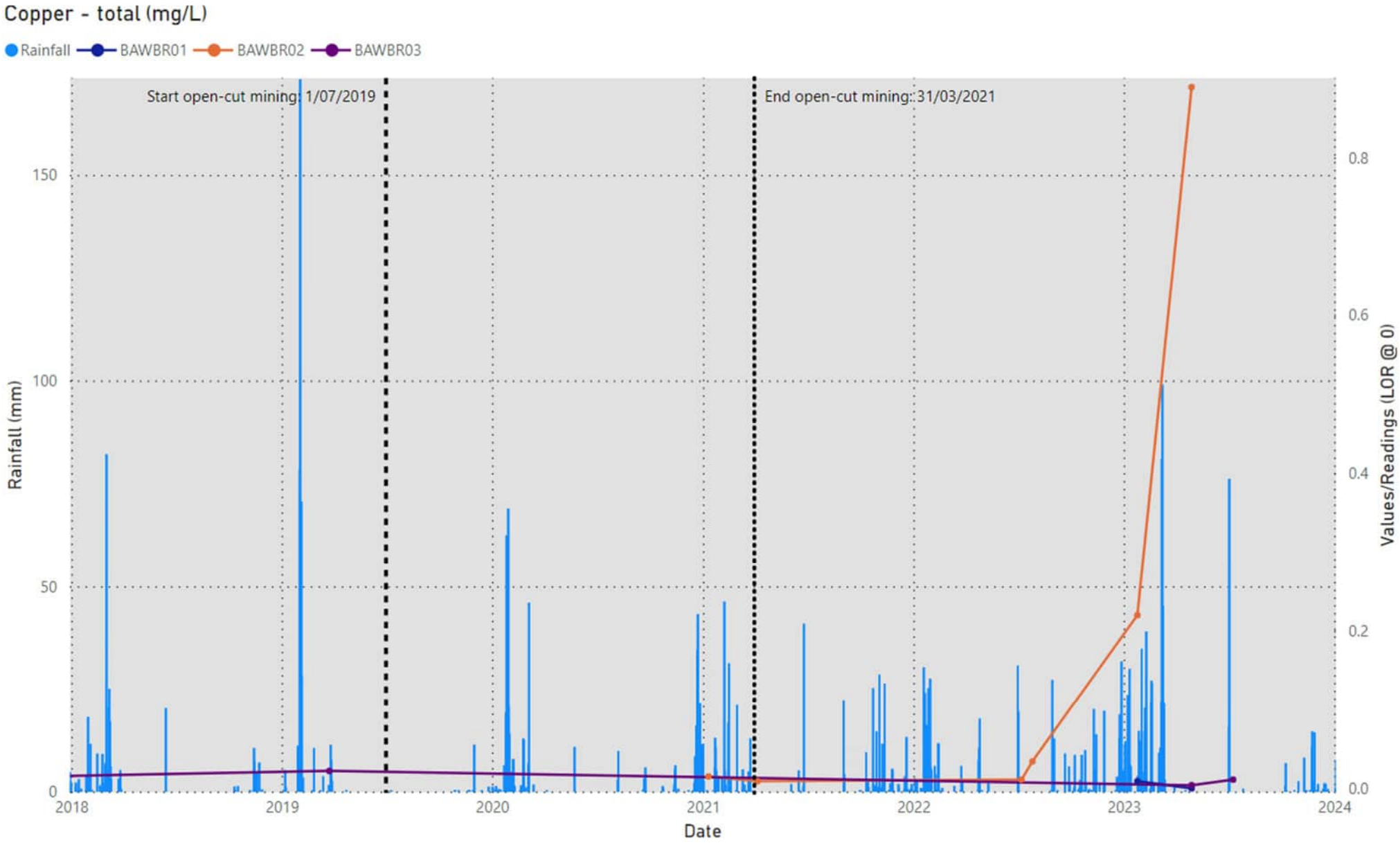

Arsenic - total (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
0
50
100
150
0.000
0.005
0.010
2018
2019
2020
2021
2022
2023
2024
Date


Barium - total (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
0
50
100
150
0.05
0.10
0.15
0.20
2018
2019
2020
2021
2022
2023
2024
Date

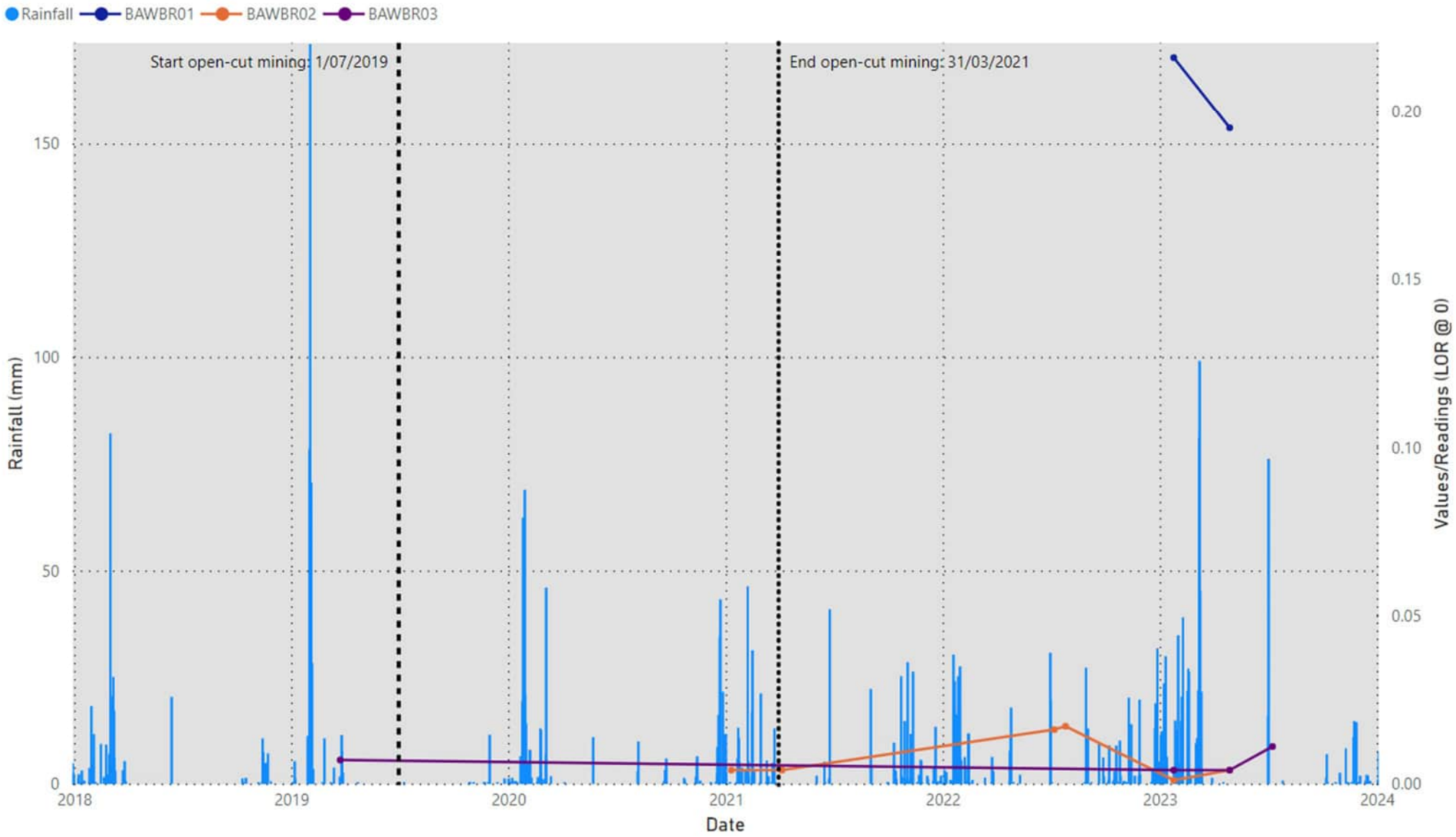

Chromium - total (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
0.010
0.005
0.000
Values/Readings (LOR @ 0)
2018
2019
2020
2021
2022
2023
2024
Date

Cobalt - total (mg/L)

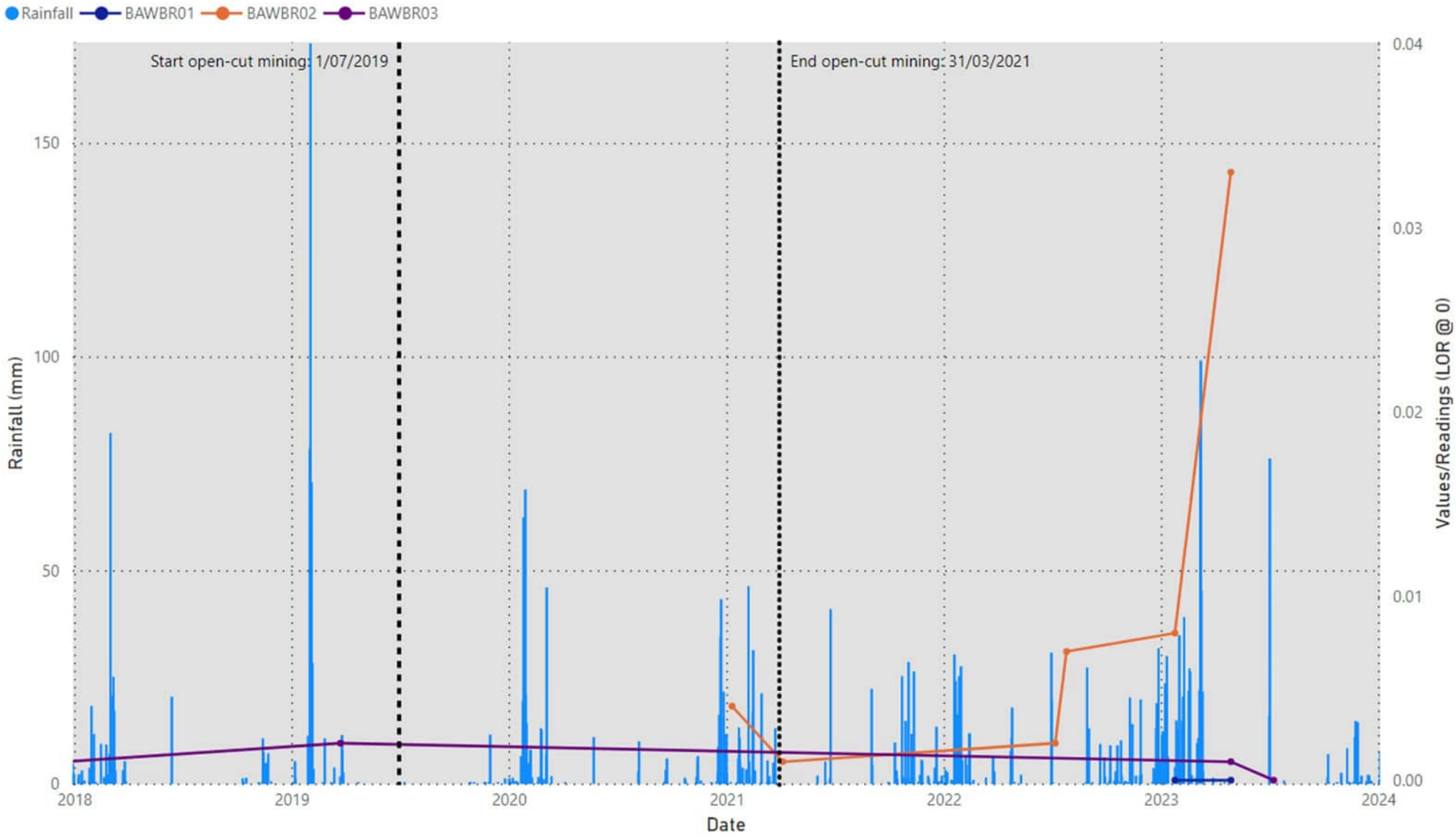


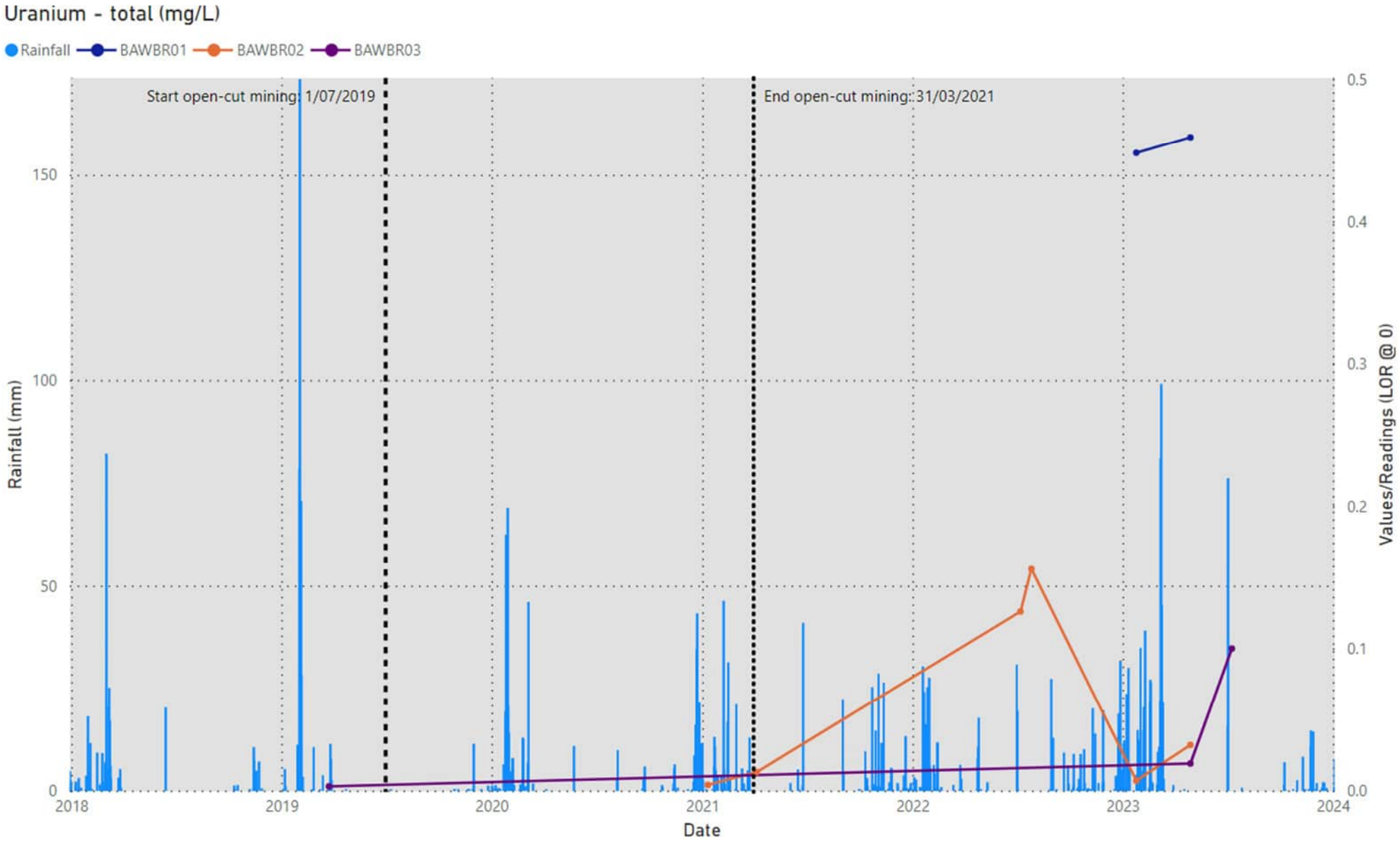

Copper - total (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.0
0.2
0.4
0.6
0.8
2018
2019
2020
2021
2022
2023
2024

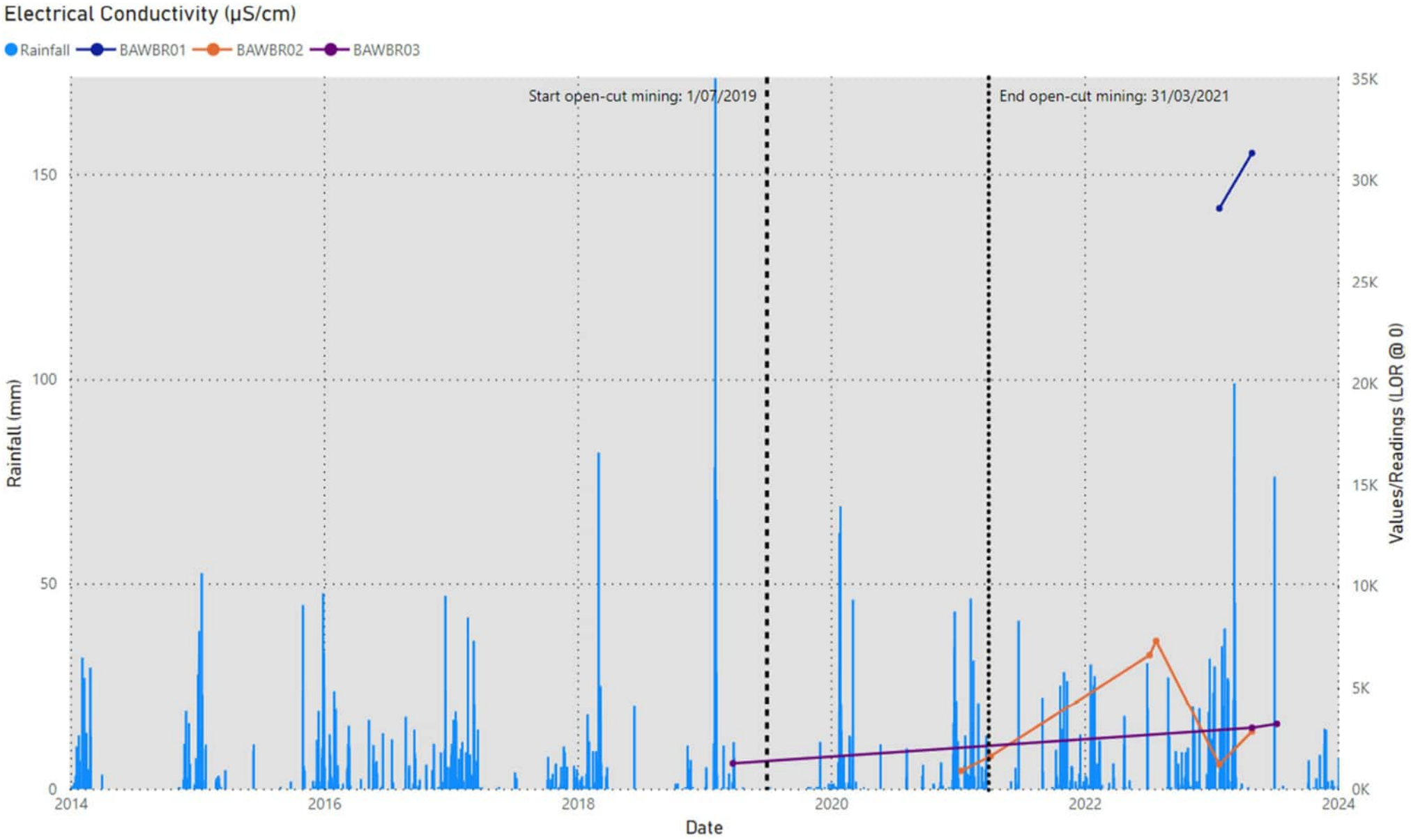
Molybdenum - total (mg/L)

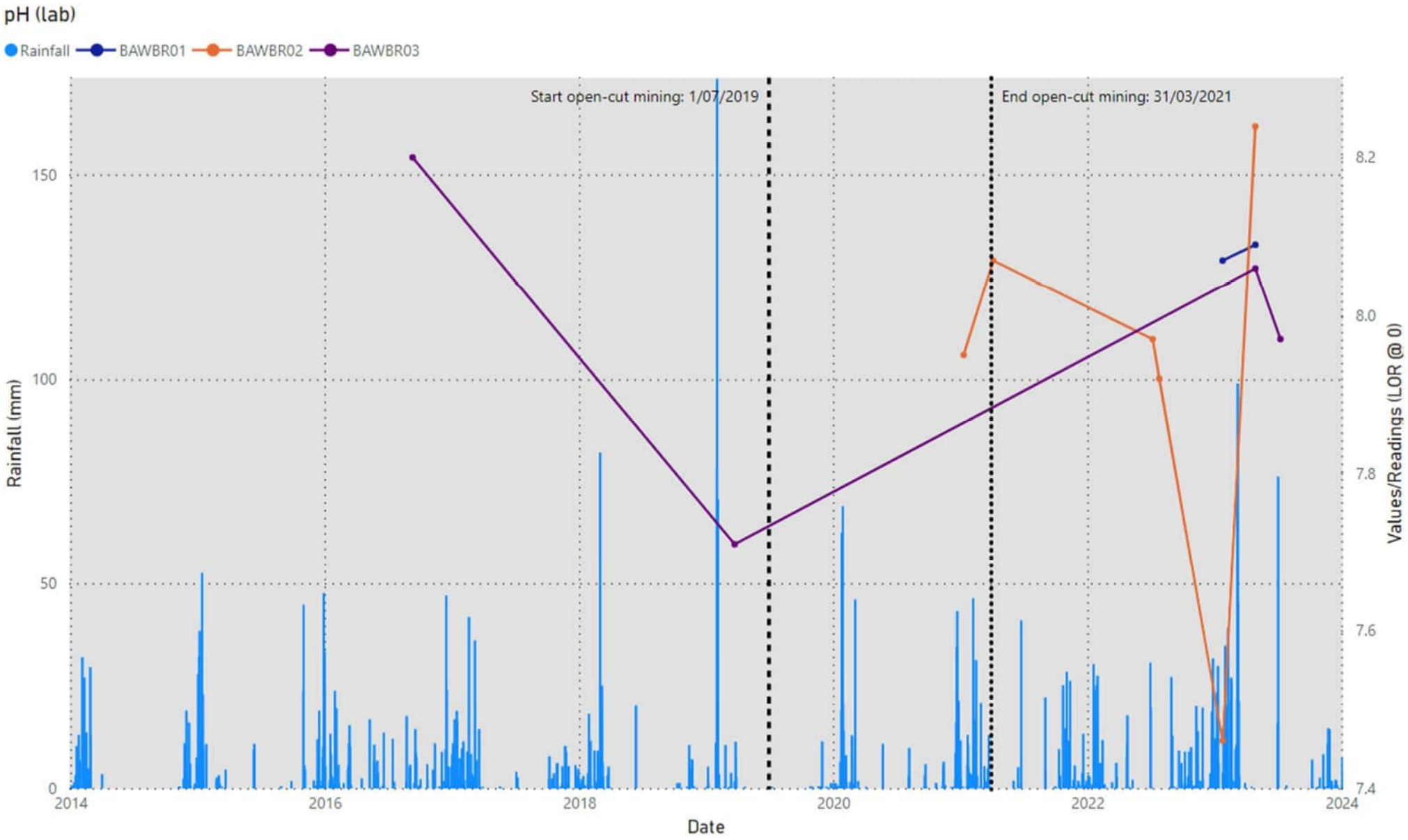


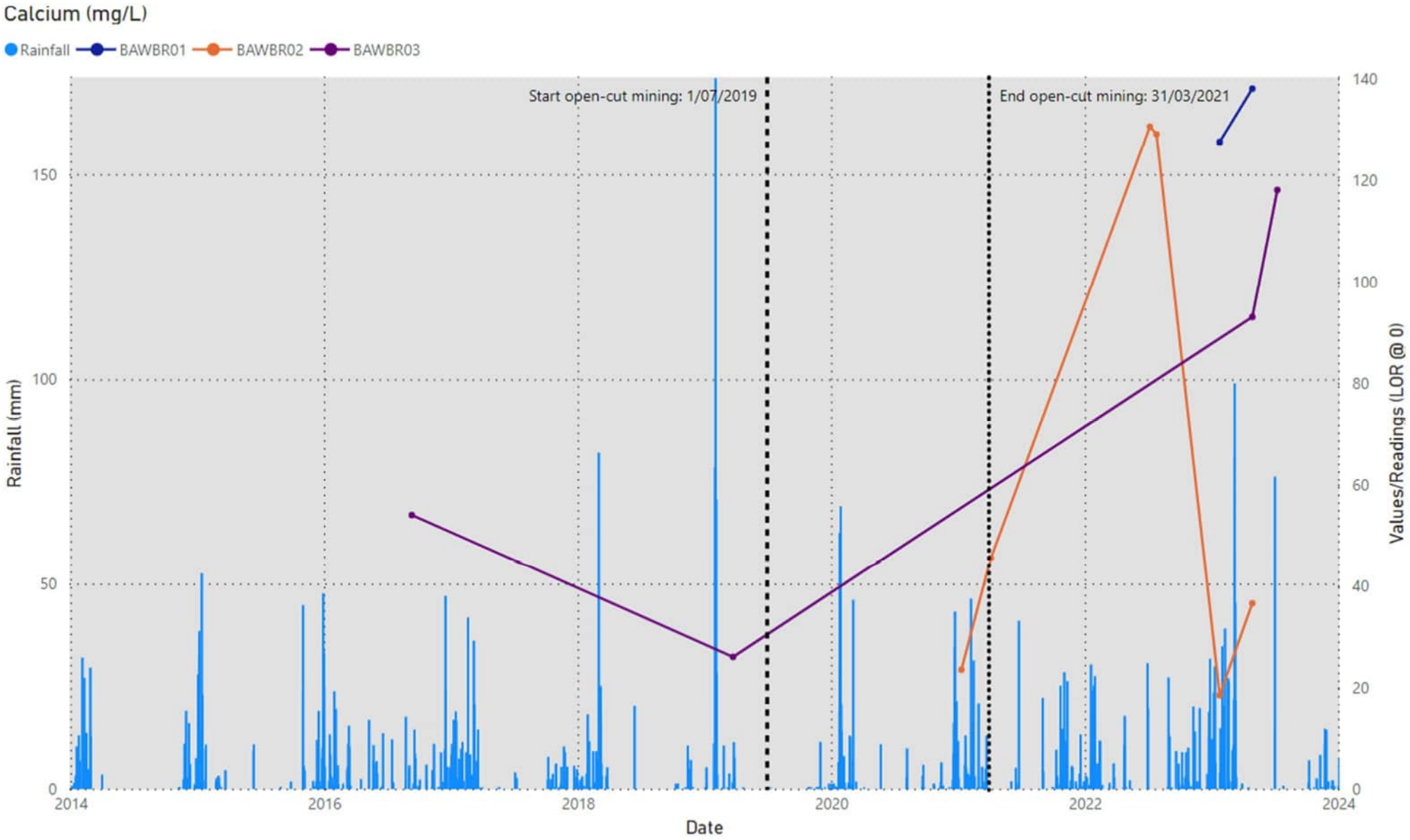
Nickel - total (mg/L)

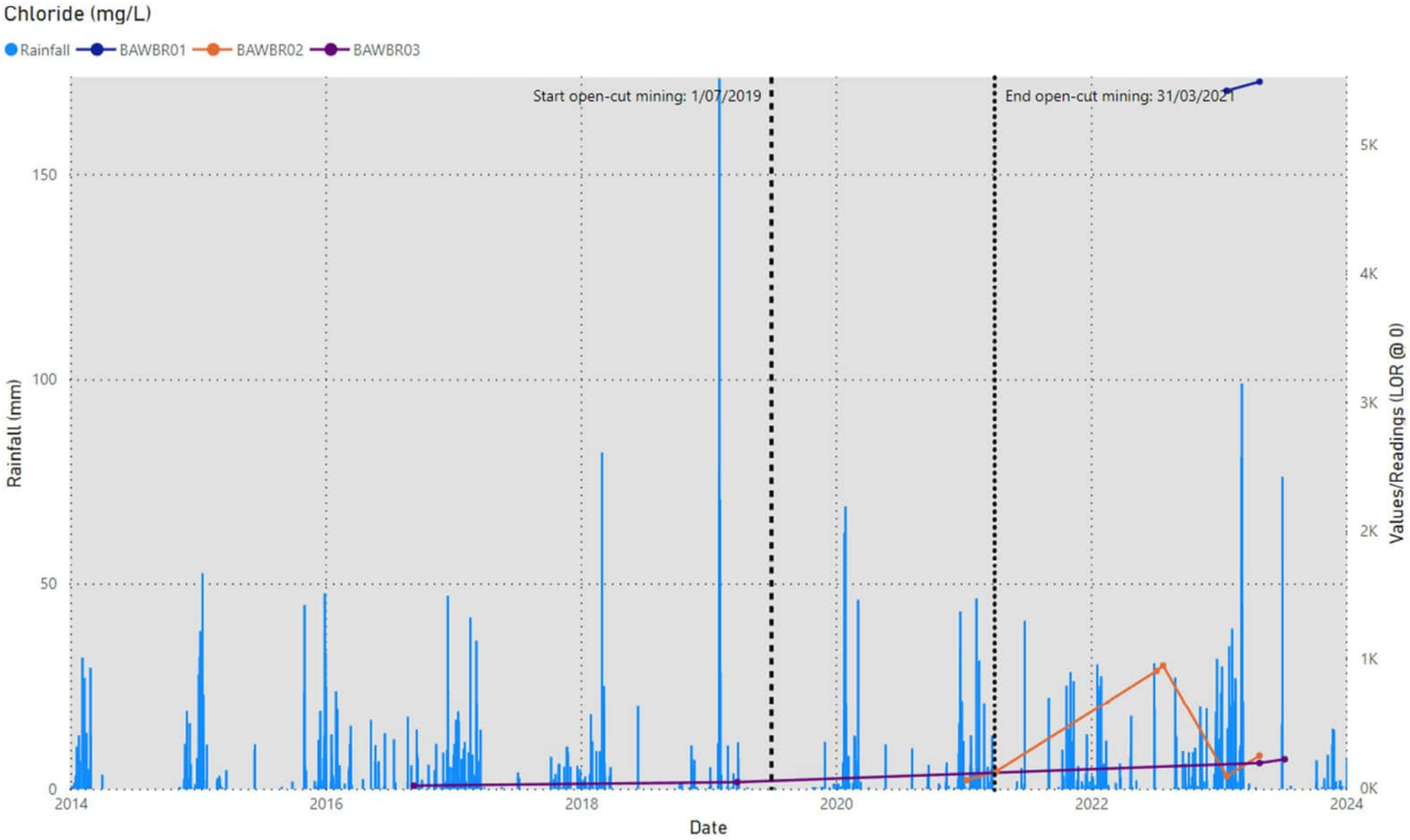


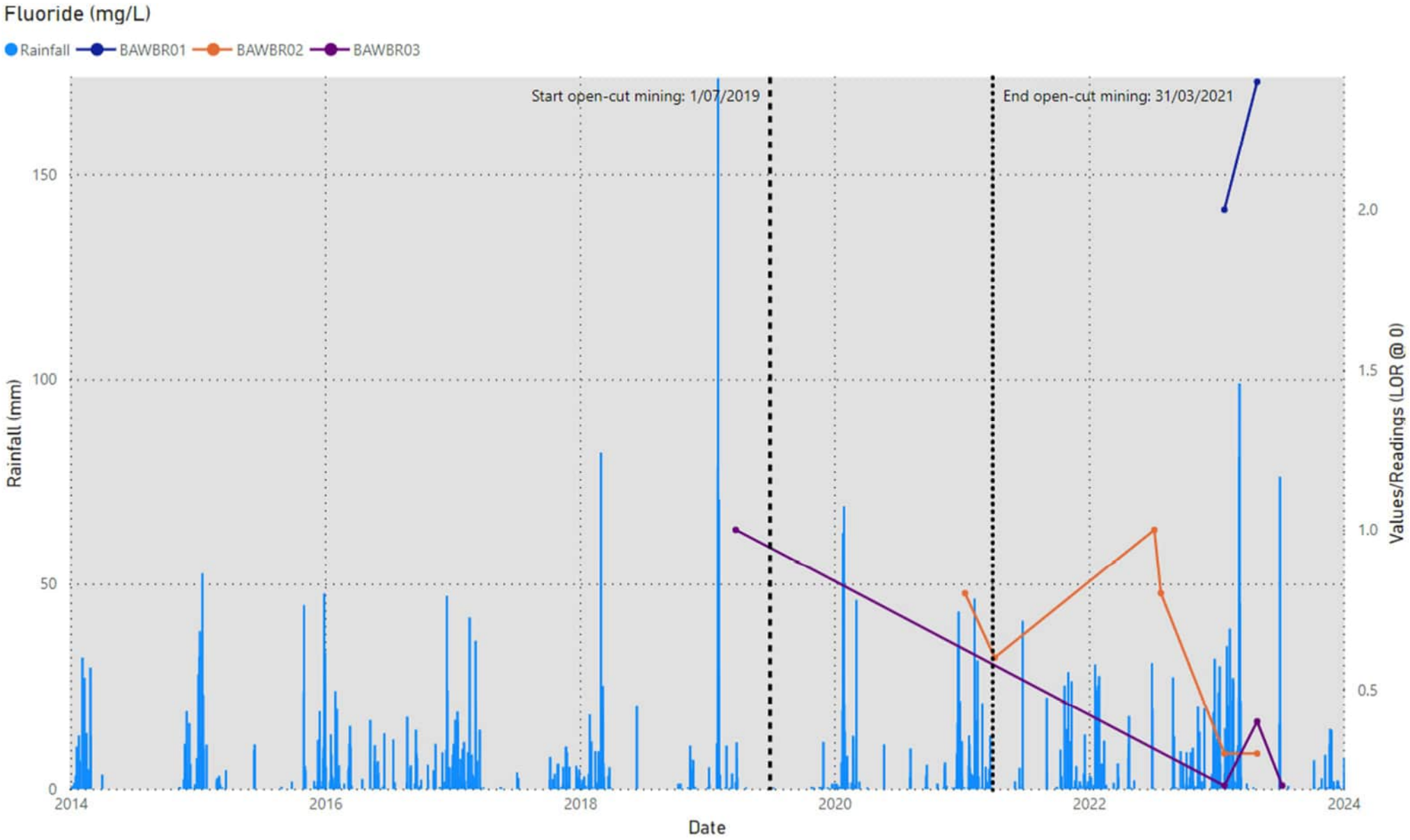

Uranium - total (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.0
0.1
0.2
0.3
0.4
0.5
2018
2019
2020
2021
2022
2023
2024

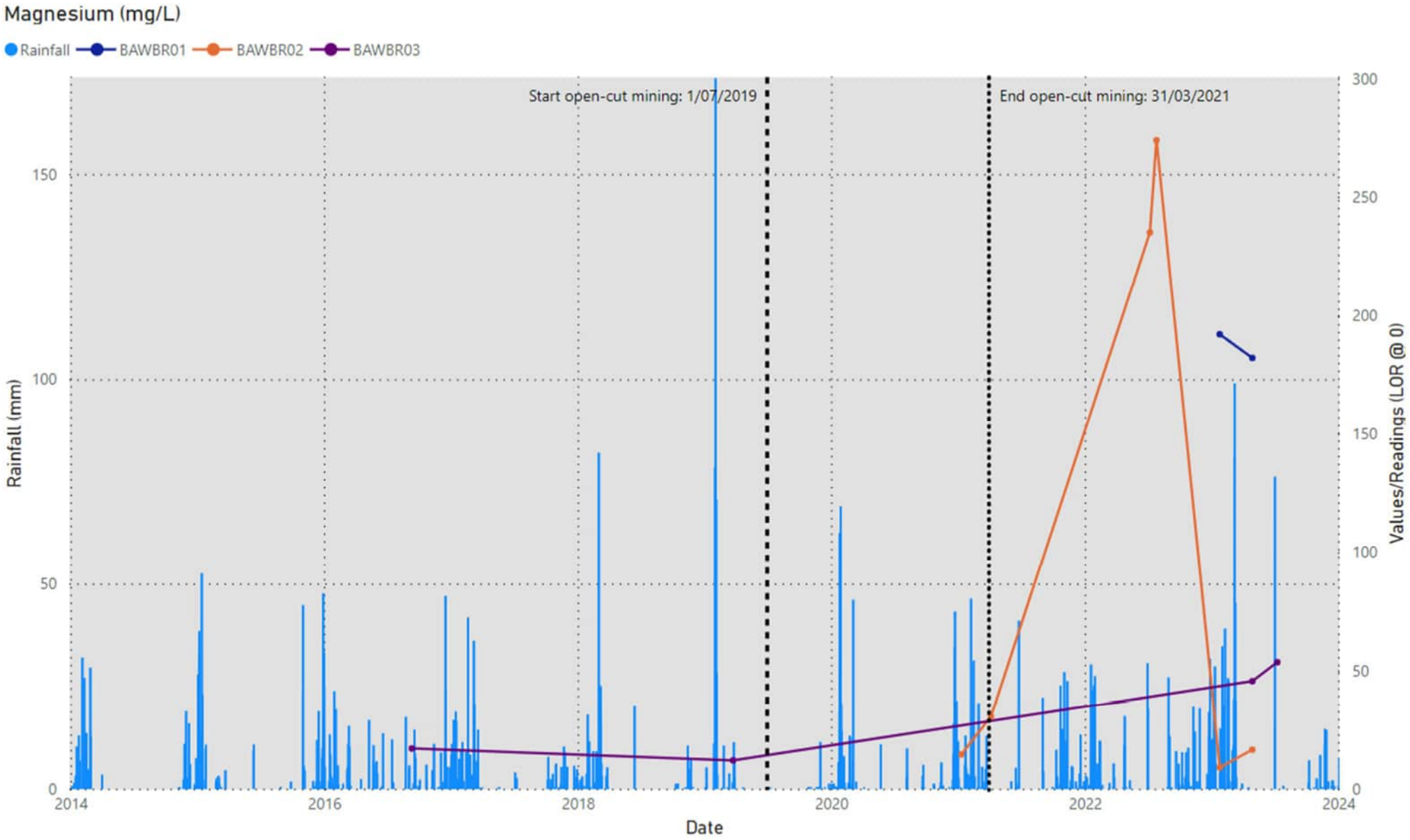

Electrical Conductivity (µS/cm)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0K
5K
10K
15K
20K
25K
30K
35K
2014
2016
2018
2020
2022
2024

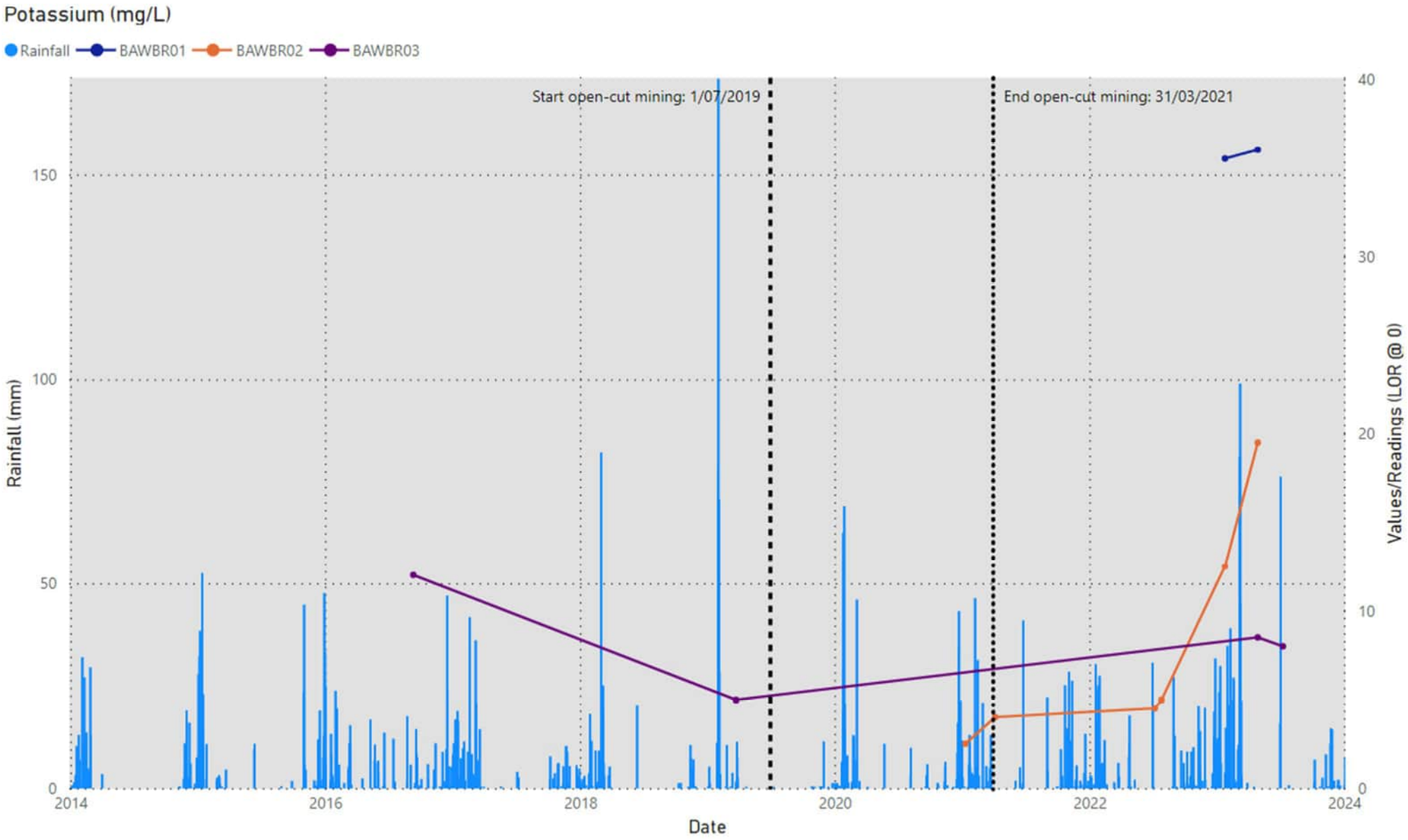

pH (lab)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
7.4
7.6
7.8
8.0
8.2
2014
2016
2018
2020
2022
2024


Calcium (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
20
40
60
80
100
120
140
2014
2016
2018
2020
2022
2024

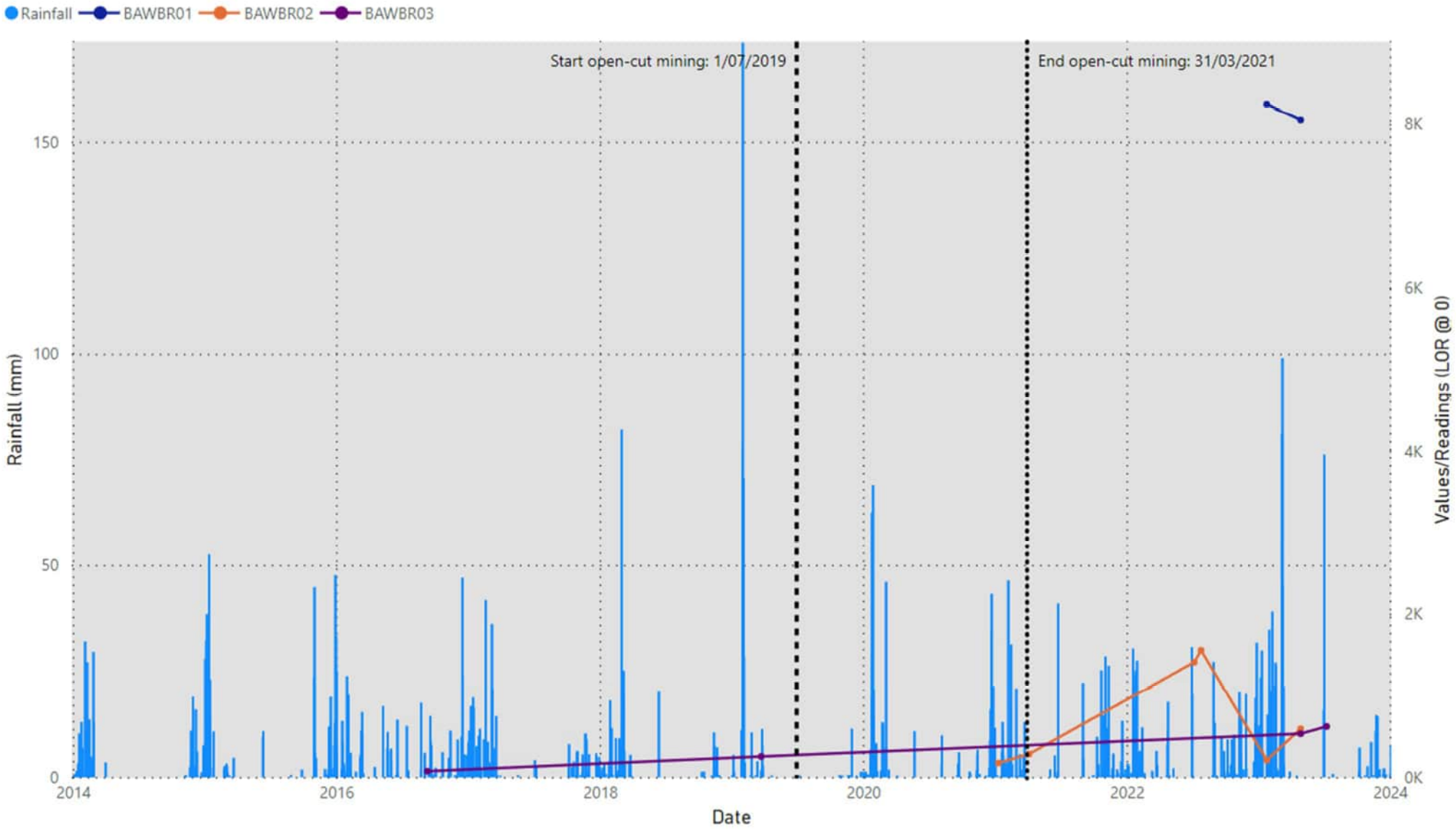

Chloride (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
5K
4K
3K
2K
1K
0K
Values/Readings (LOR @ 0)
2014
2016
2018
2020
2022
2024
Date


Fluoride (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.5
1.0
1.5
2.0
2014
2016
2018
2020
2022
2024

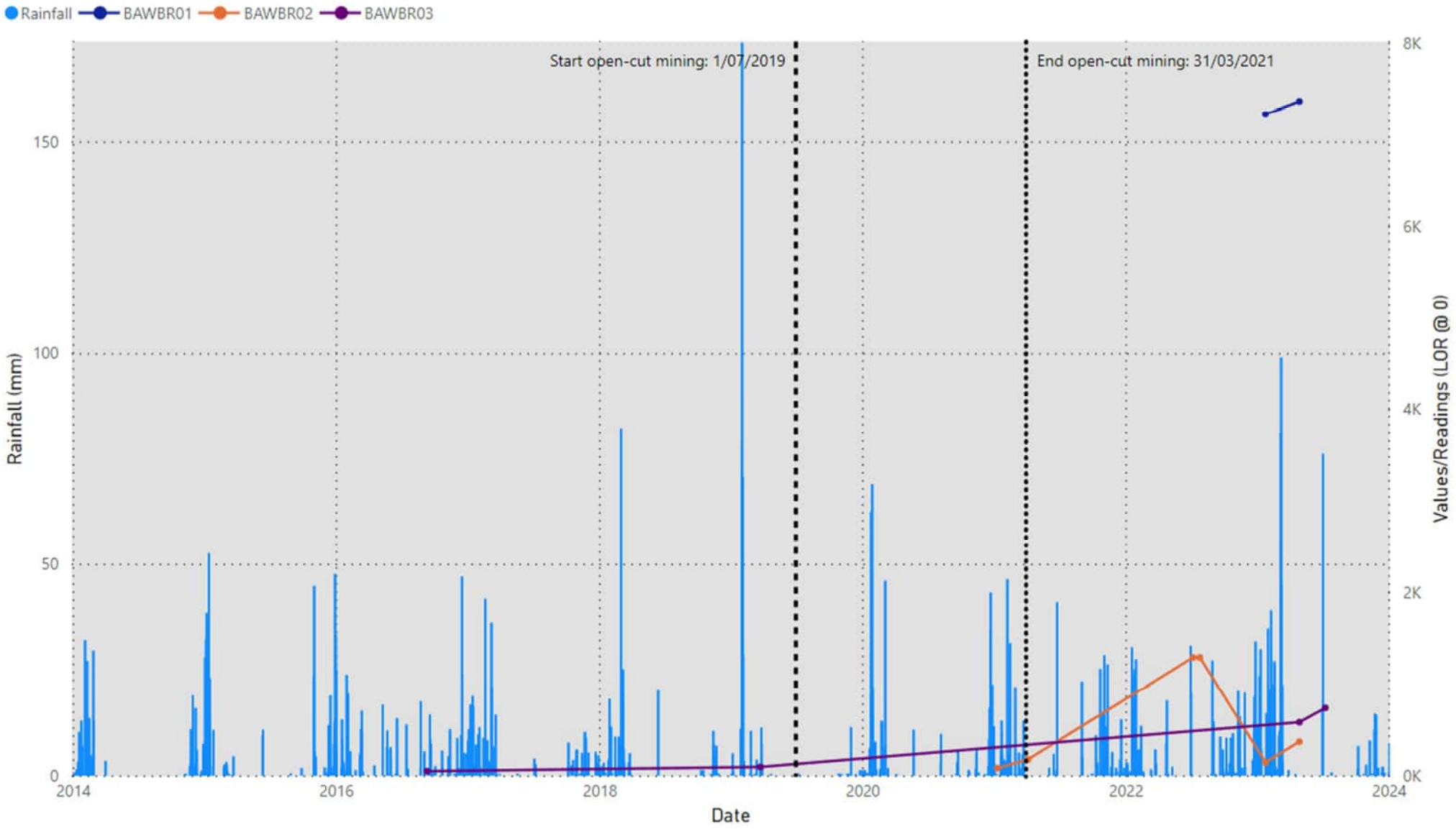

Magnesium (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
200
250
300
2014
2016
2018
2020
2022
2024


Potassium (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
10
20
30
40
2014
2016
2018
2020
2022
2024

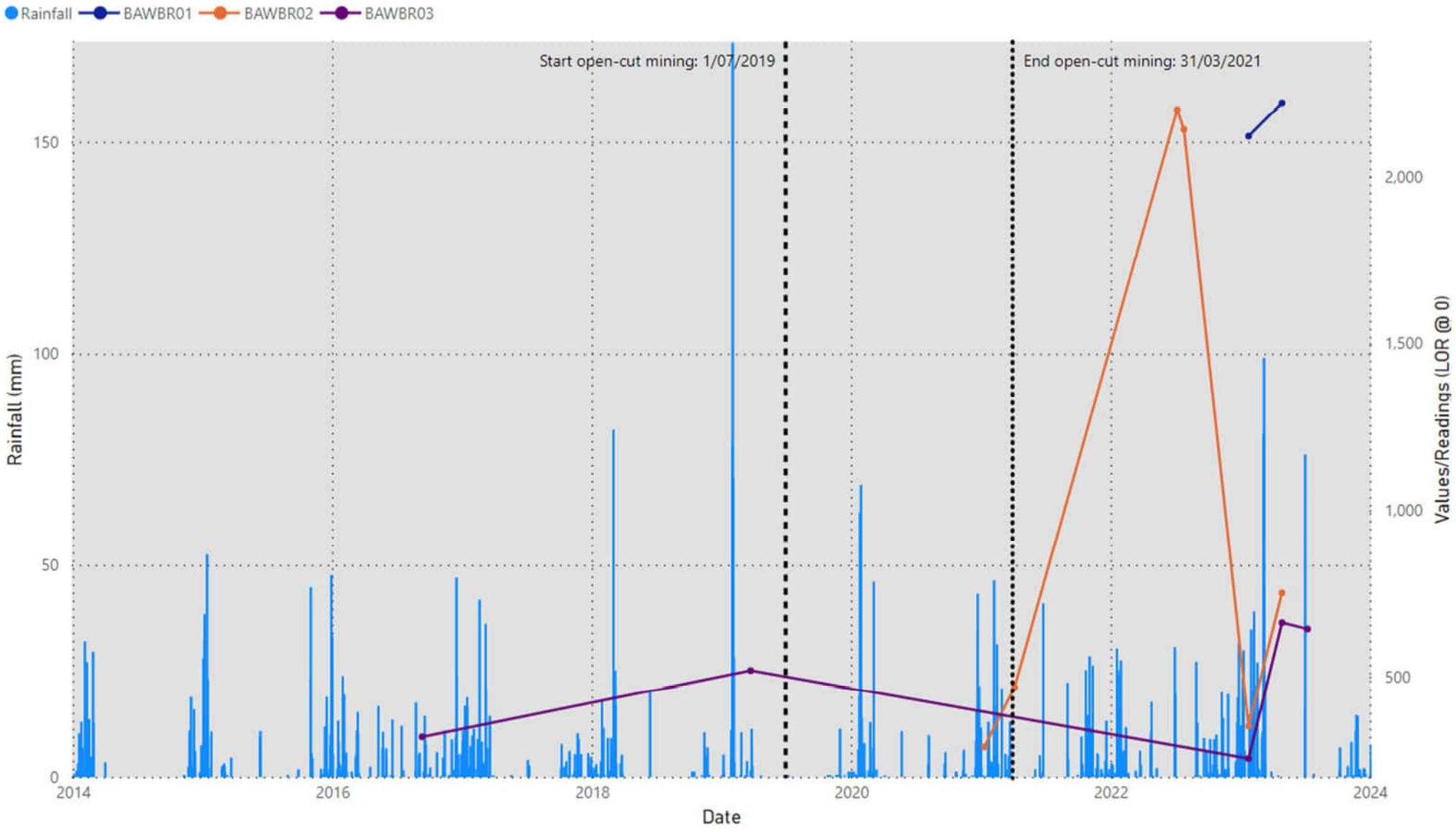
Sodium (mg/L)

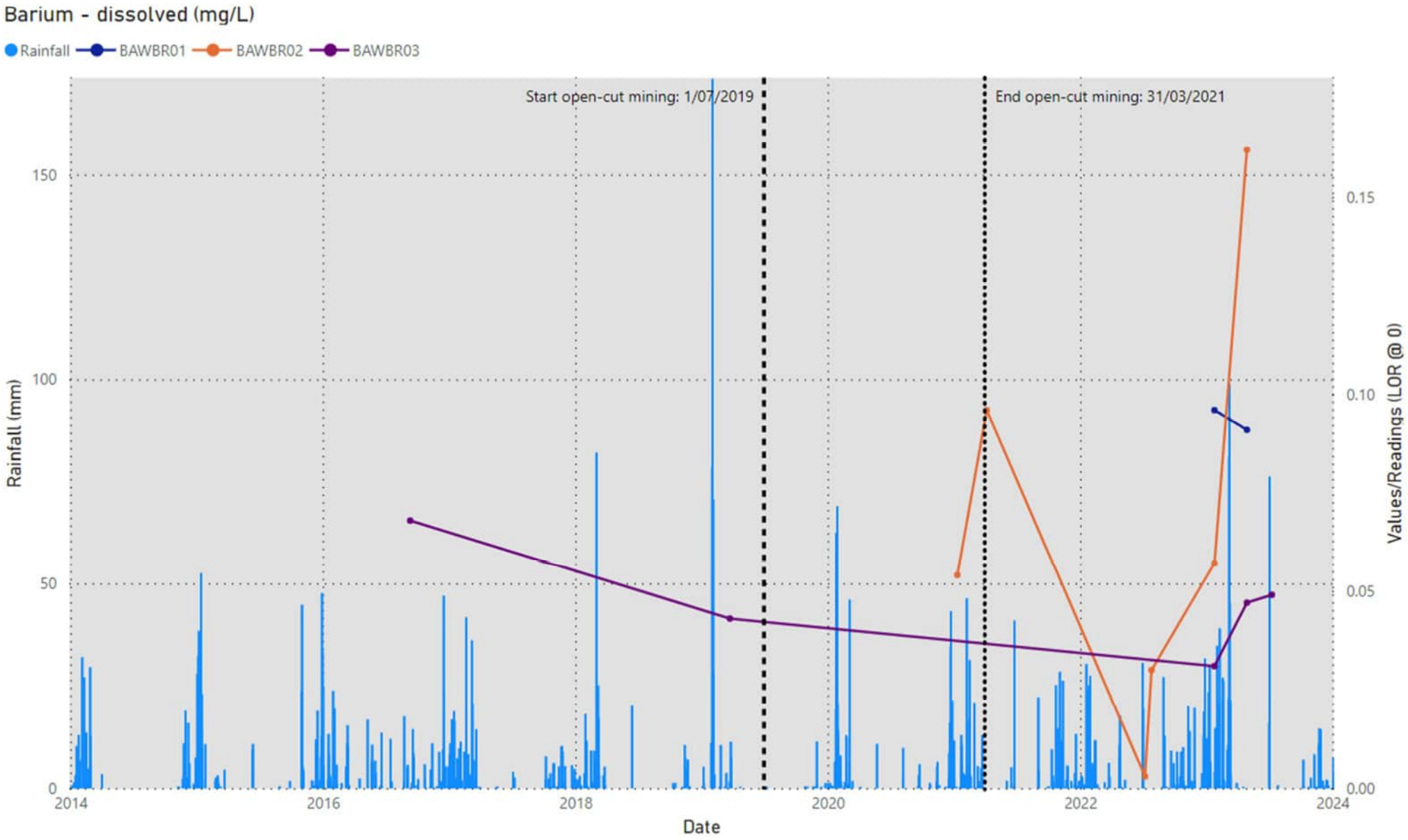

Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
Values/Readings (LOR @ 0)
8K
6K
4K
2K
0K
2014
2016
2018
2020
2022
2024
Date

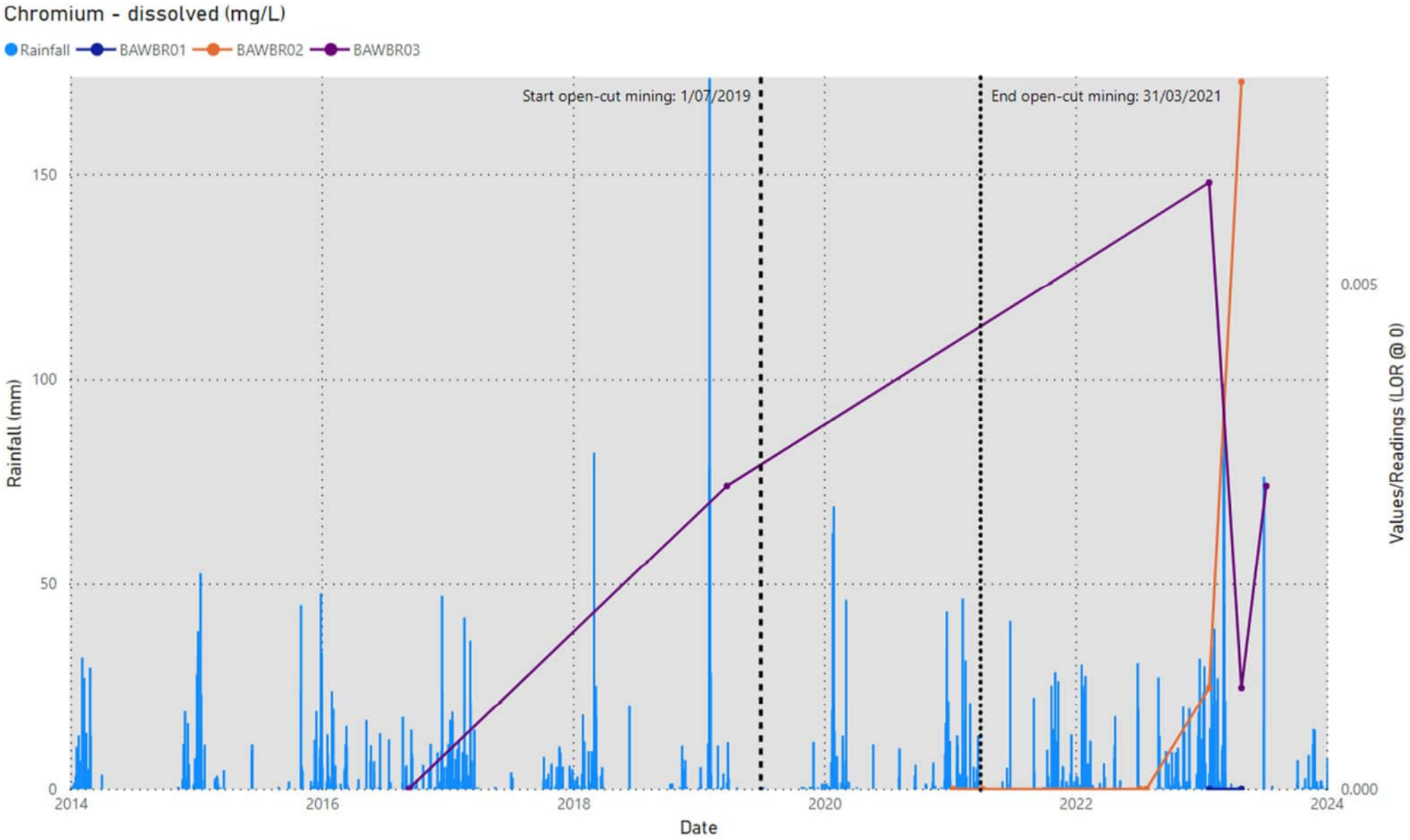
Sulfate (as SO4)



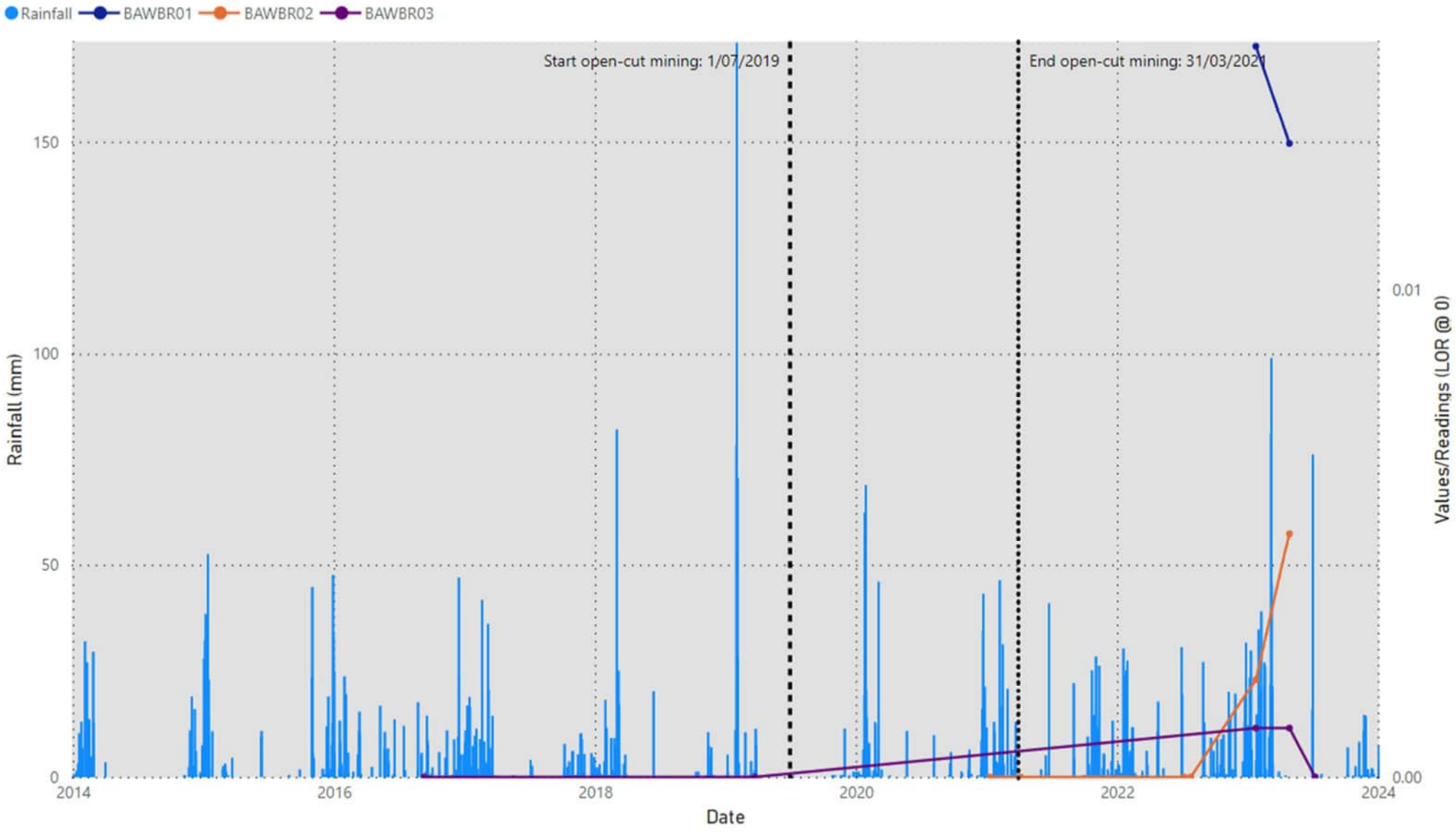
Bicarbonate Alkalinity as CaCO3 (mg/L)

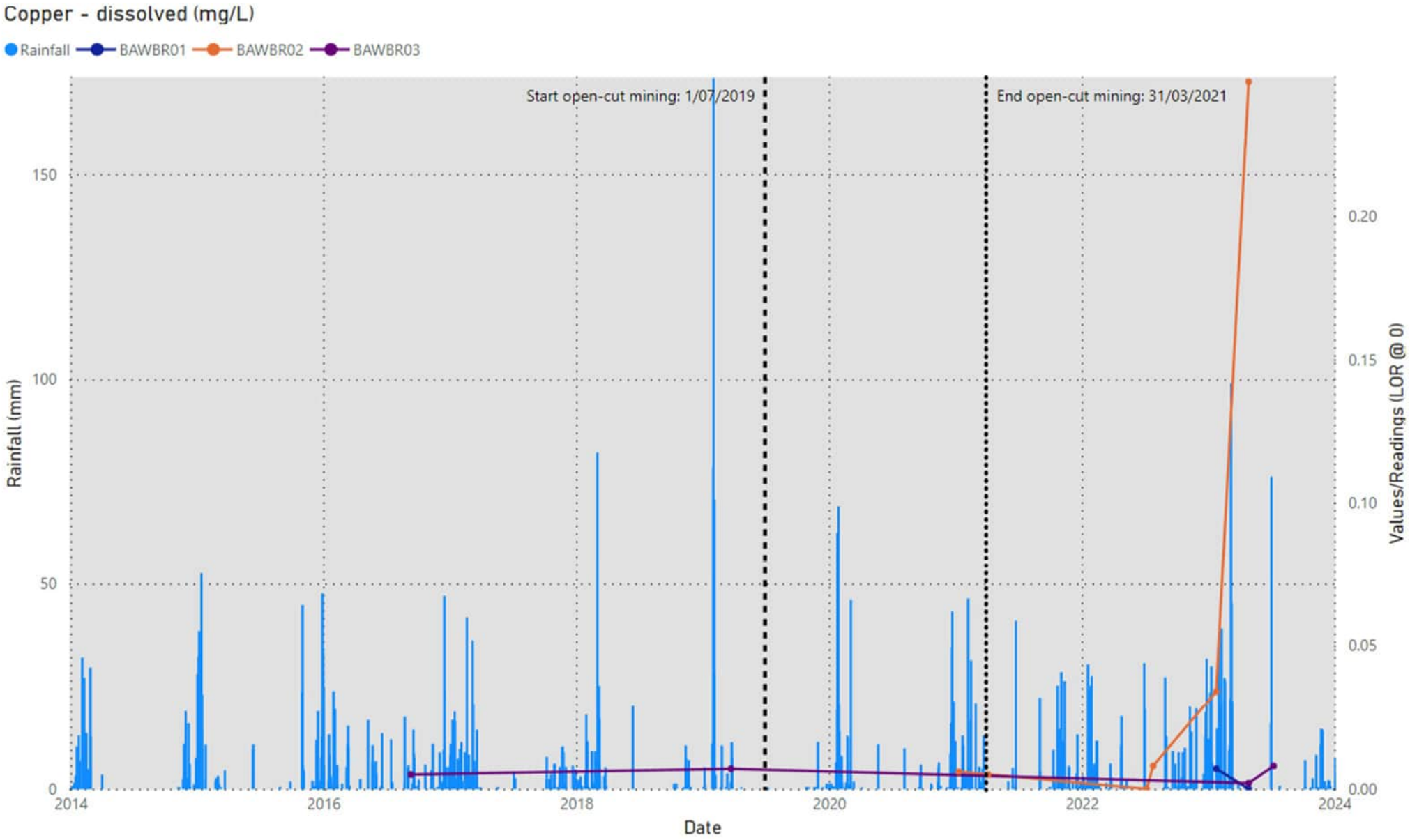


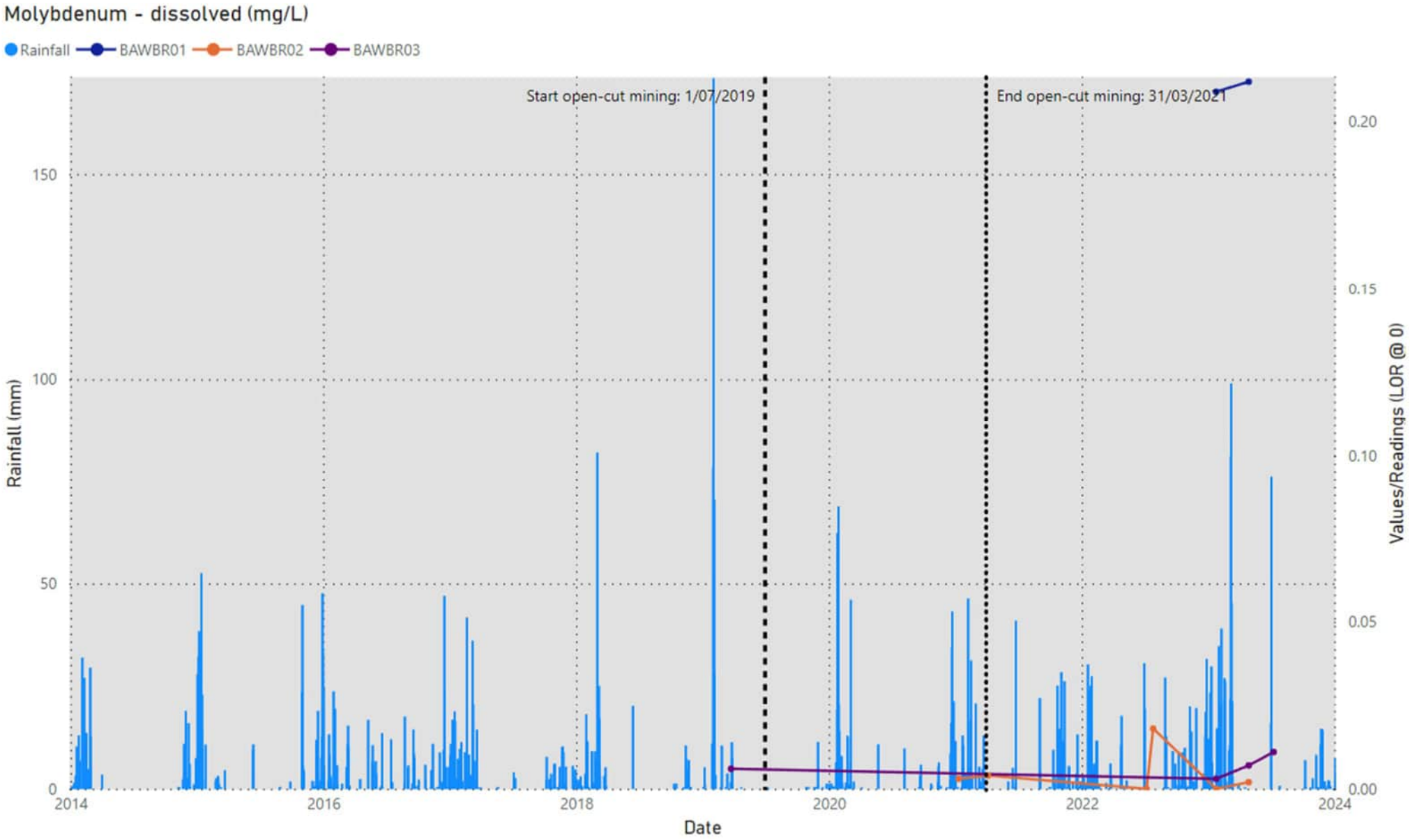

Barium - dissolved (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.05
0.10
0.15
2014
2016
2018
2020
2022
2024

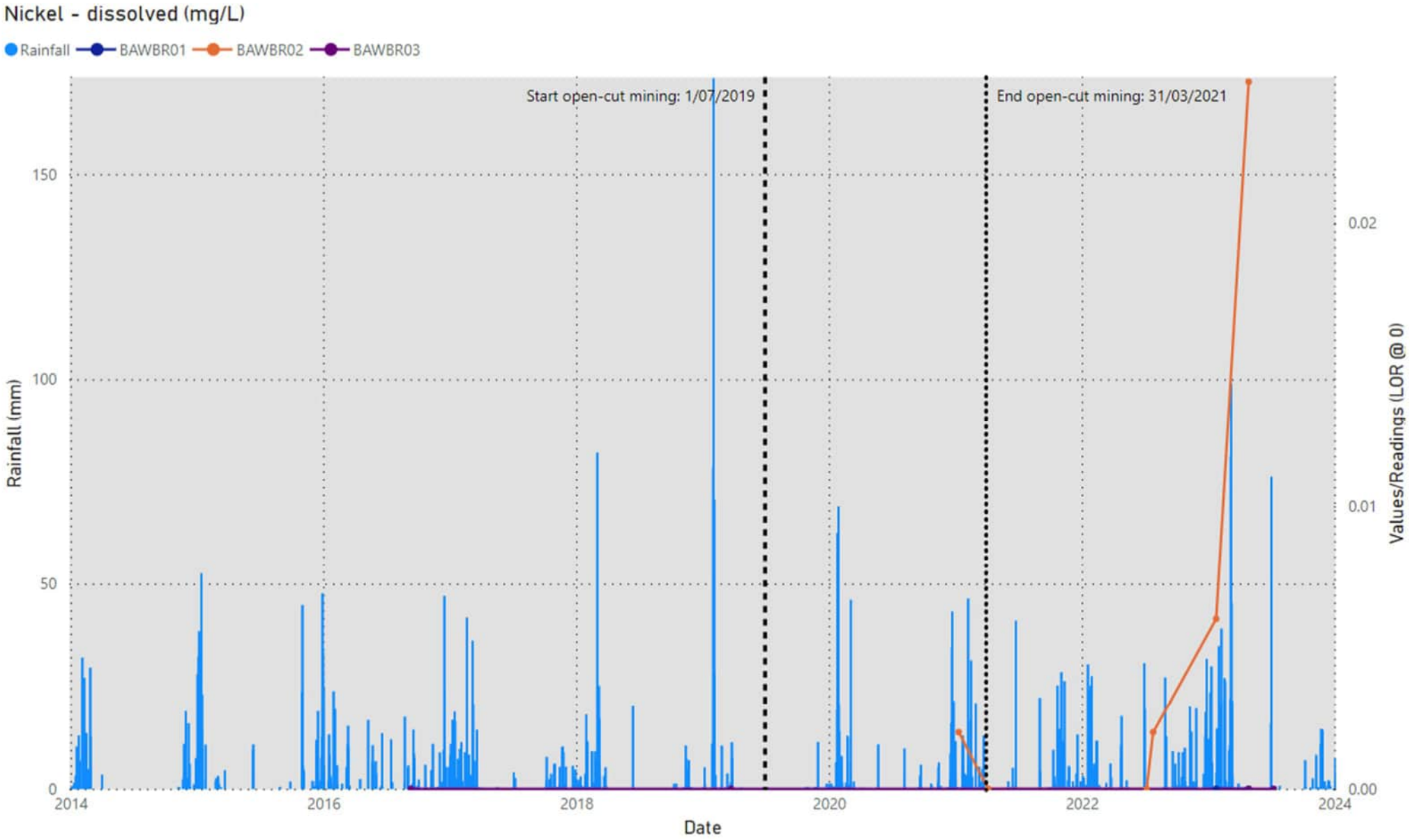

Chromium - dissolved (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
150
100
50
0
Rainfall (mm)
0.005
0.000
Values/Readings (LOR @ 0)
2014
2016
2018
2020
2022
2024
Date

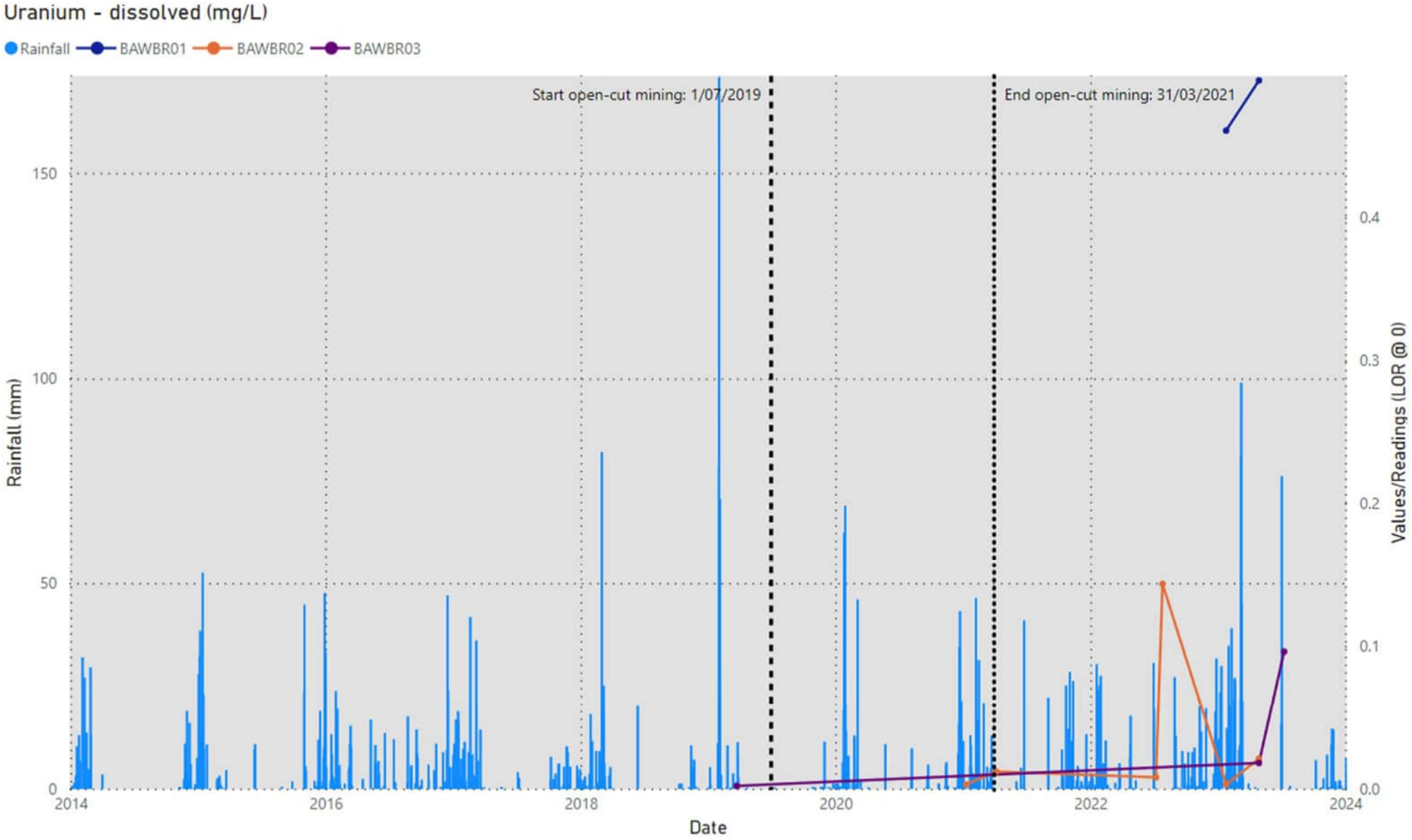
Cobalt - dissolved (mg/L)

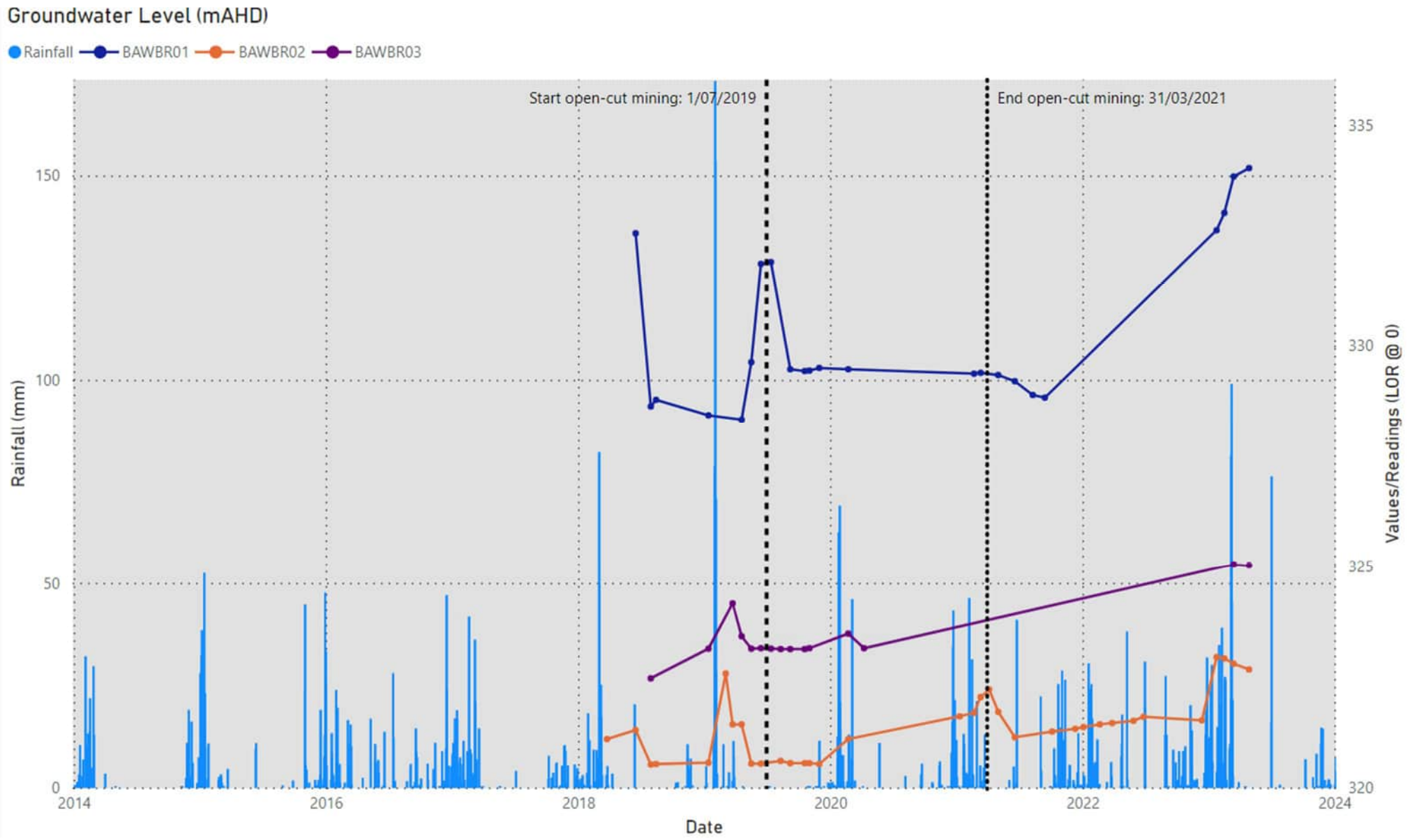



Copper - dissolved (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.05
0.10
0.15
0.20
2014
2016
2018
2020
2022
2024


Molybdenum - dissolved (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.05
0.10
0.15
0.20
2014
2016
2018
2020
2022
2024

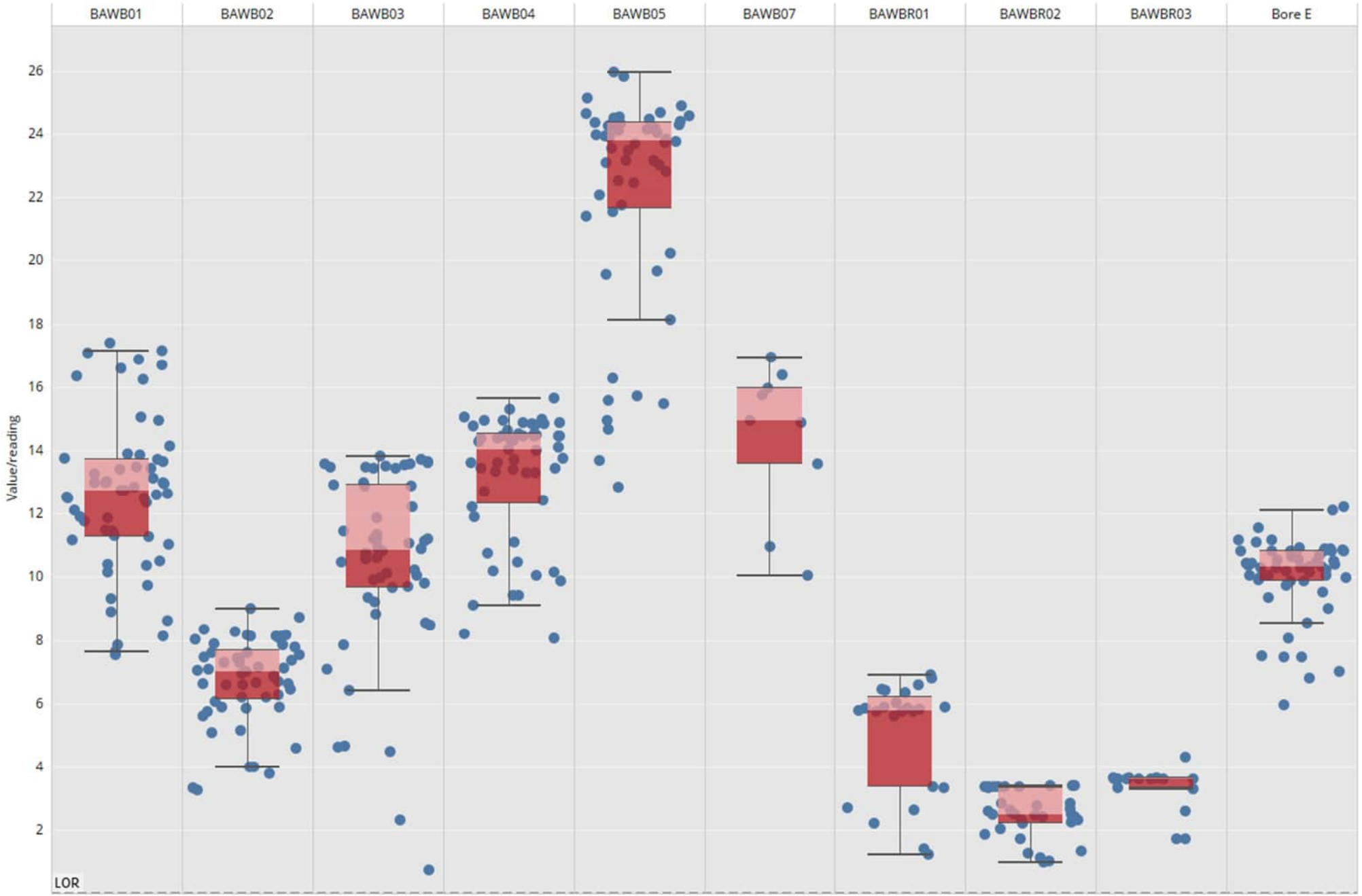

Nickel - dissolved (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.01
0.02
2014
2016
2018
2020
2022
2024


Uranium - dissolved (mg/L)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.0
0.1
0.2
0.3
0.4
2014
2016
2018
2020
2022
2024

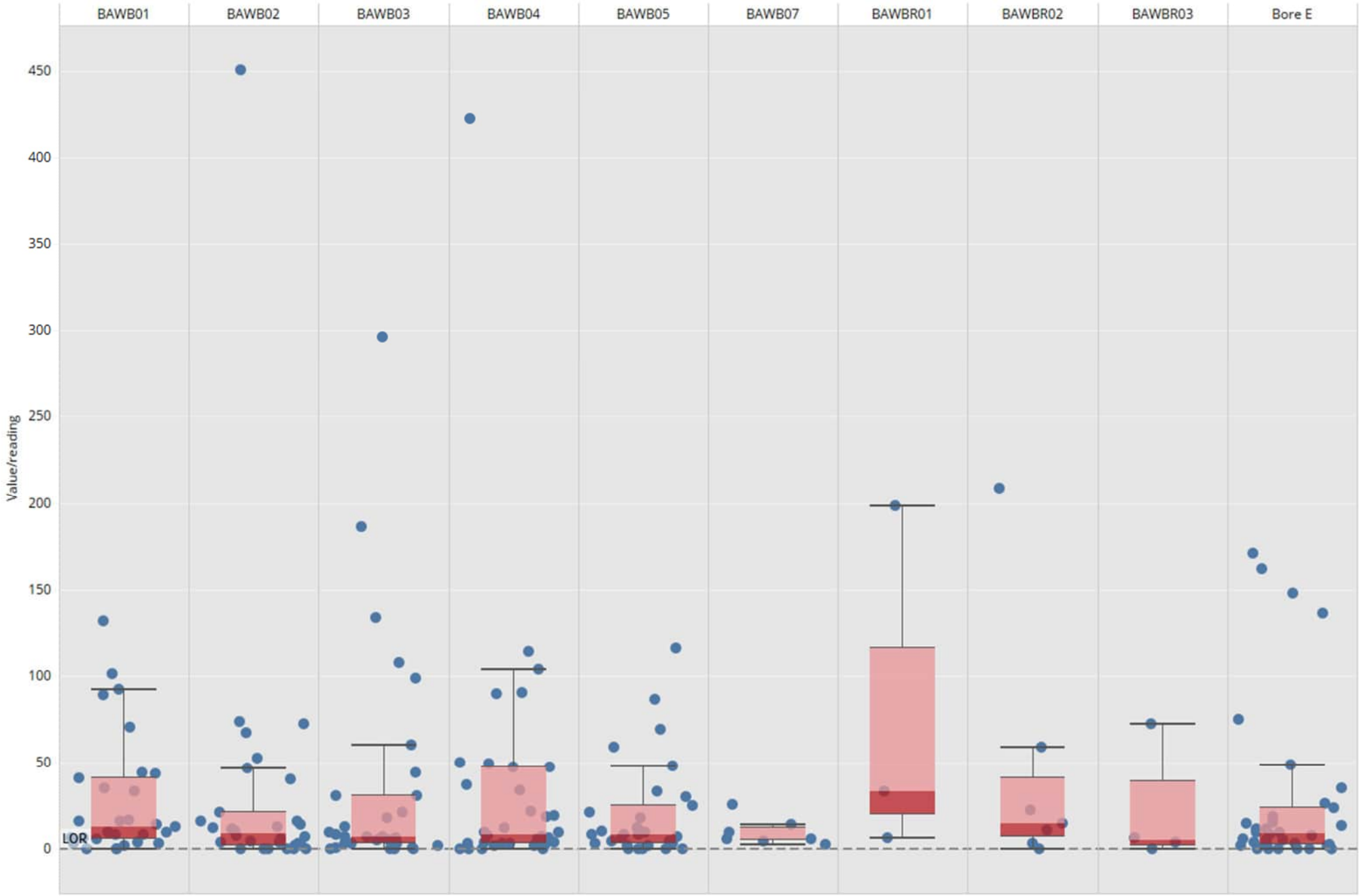

Groundwater Level (mAHD)
Rainfall
BAWBR01
BAWBR02
BAWBR03
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
335
330
325
320
Values/Readings (LOR @ 0)
2014
2016
2018
2020
2022
2024
Date

G.3 Water quality box & whisker plots

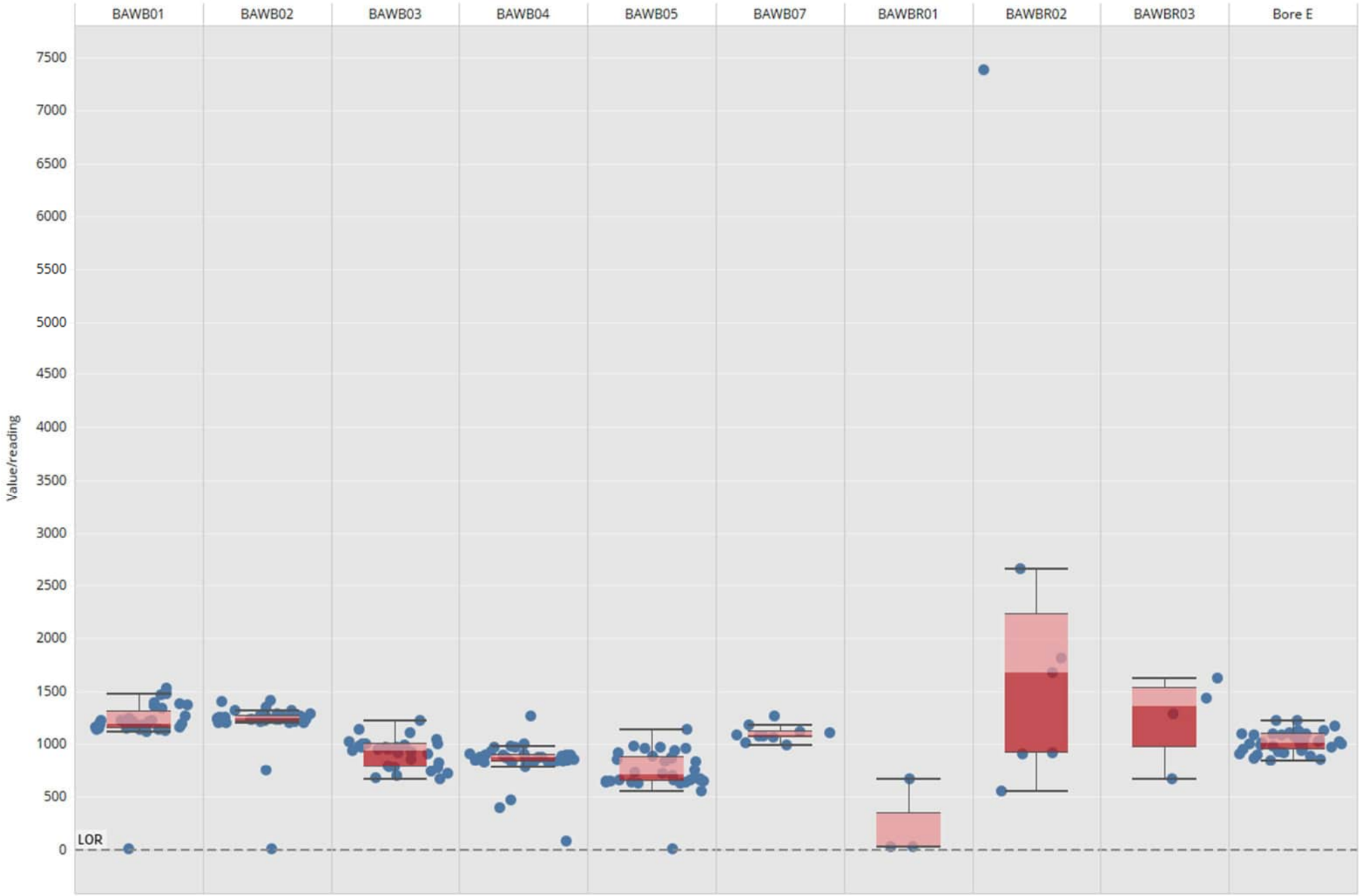
Depth to Water (mbRL)



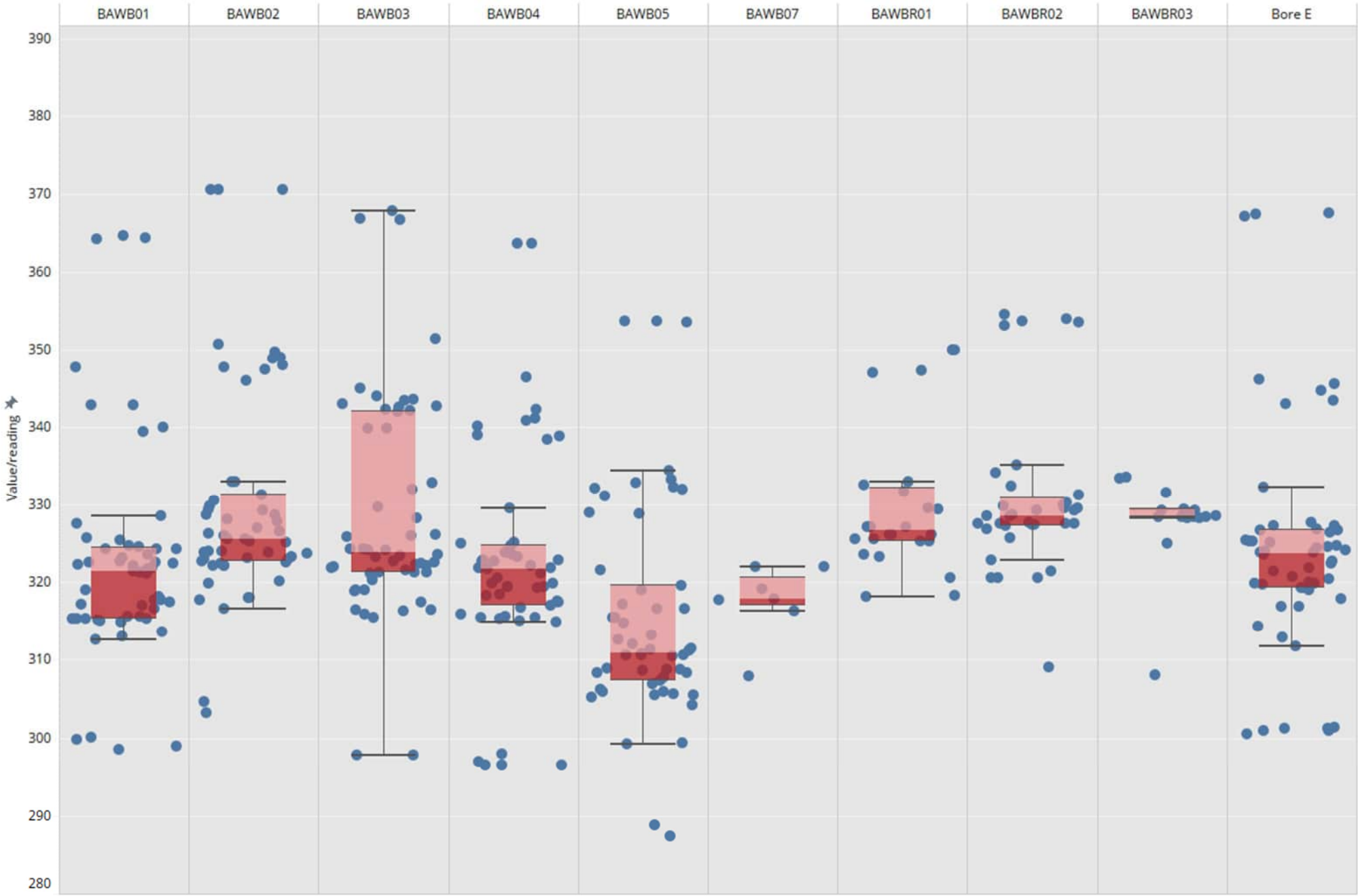
Dissolved Oxygen (field) (% sat)



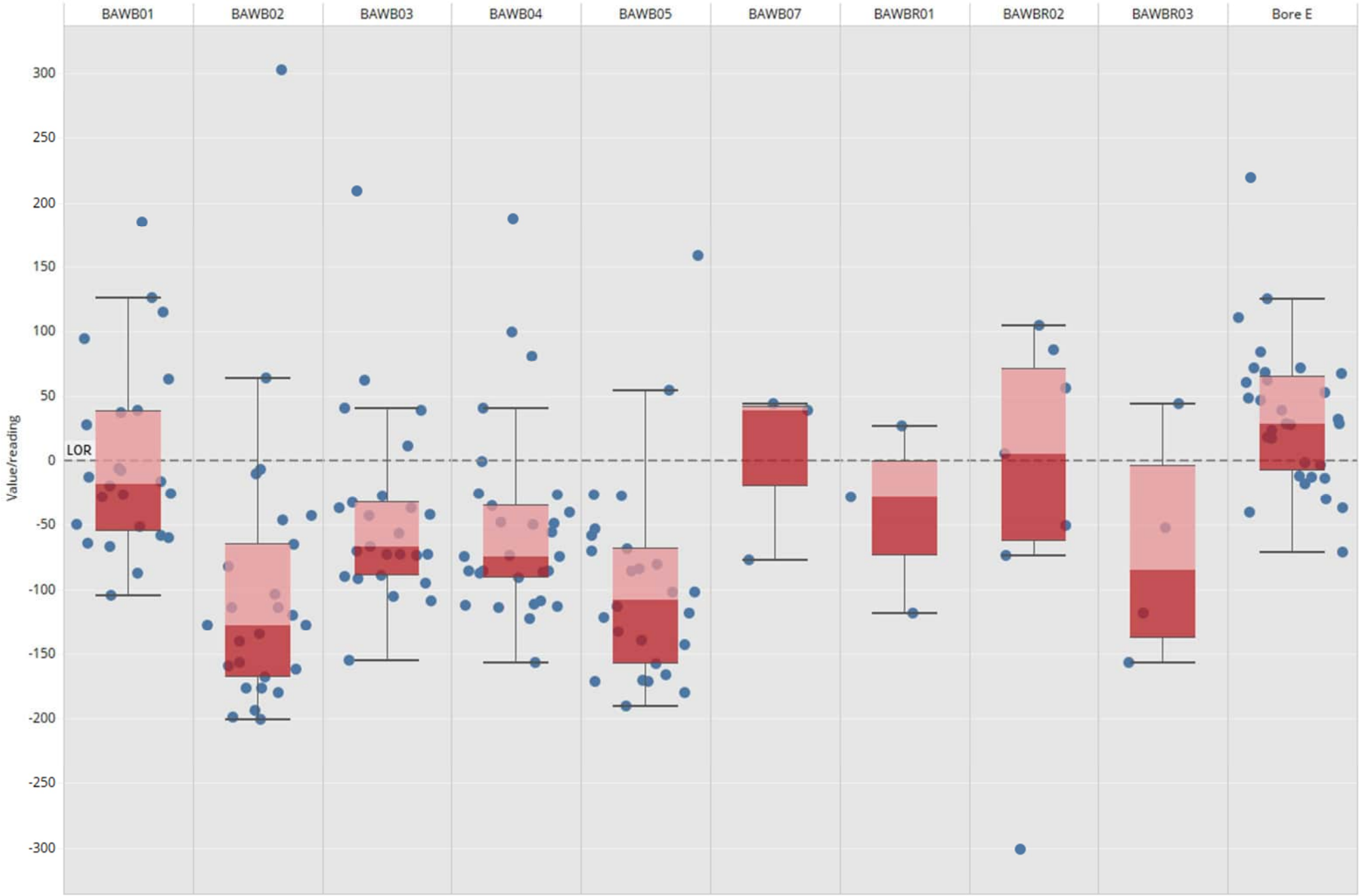
Electrical Conductivity (field) (µS/cm)



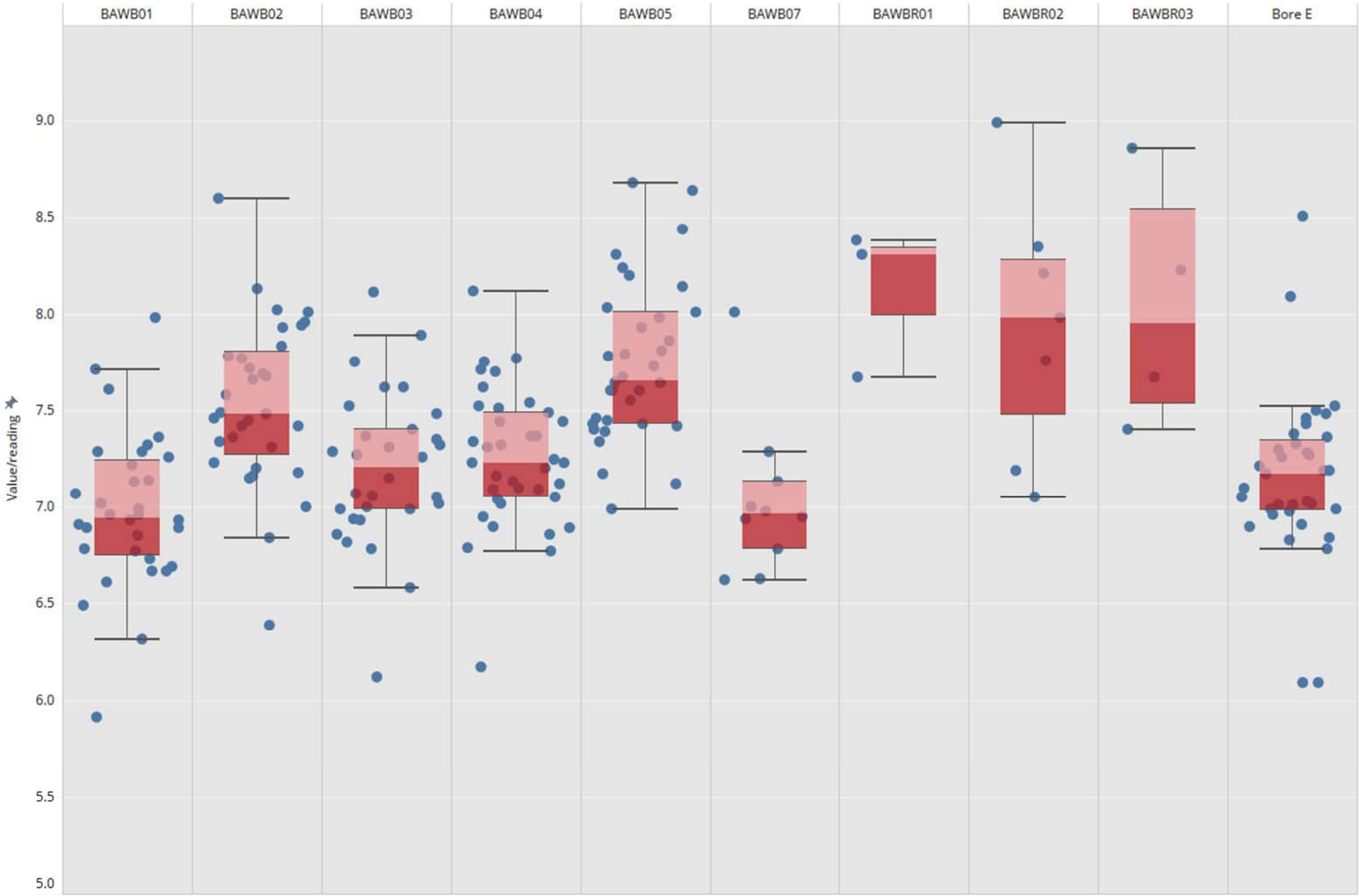
Groundwater Level (mAHD)



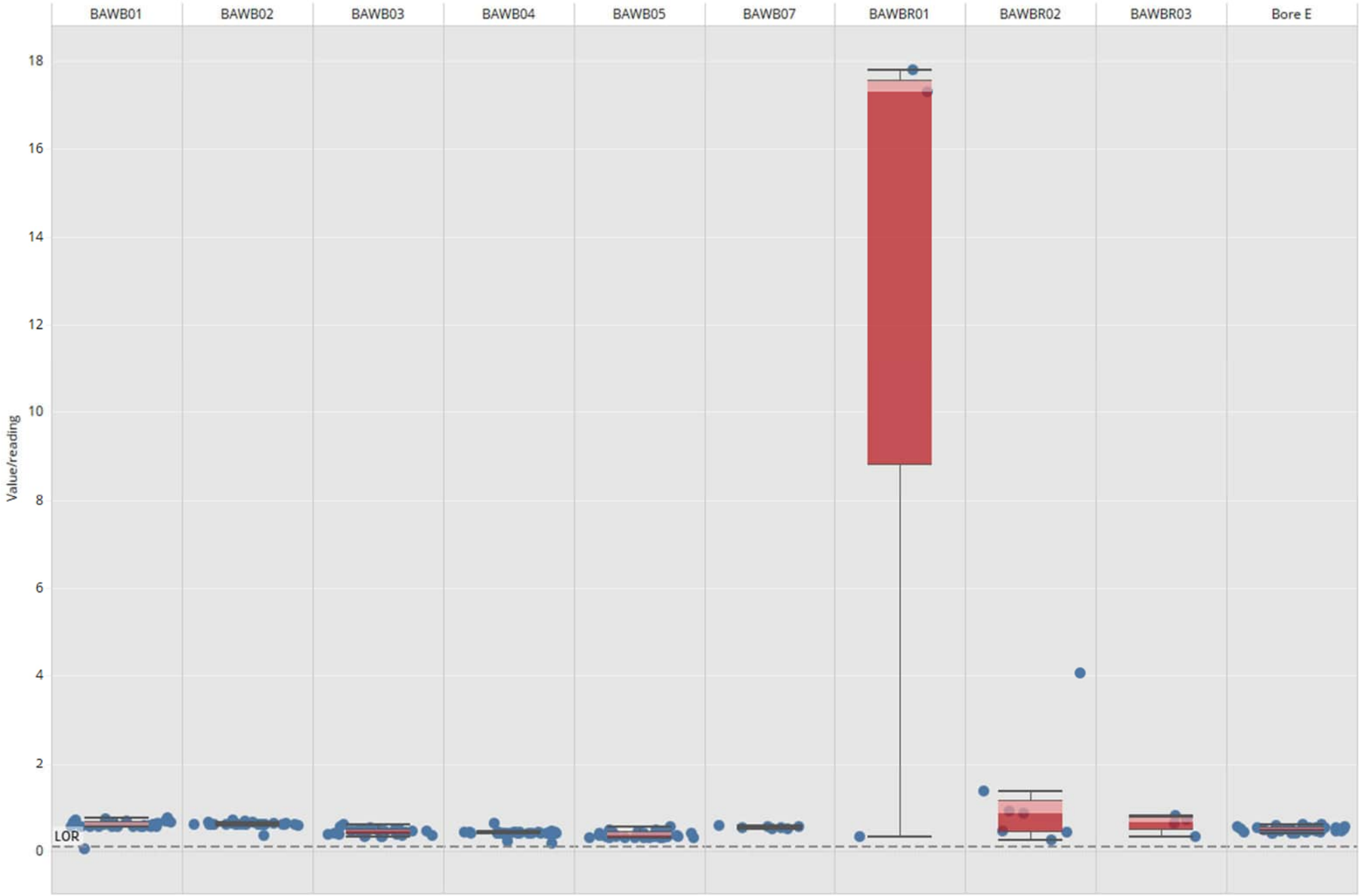
ORP (field) (mV)


BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
BAWBR01
BAWBR02
BAWBR03
Bore E
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
LOR
Value/reading

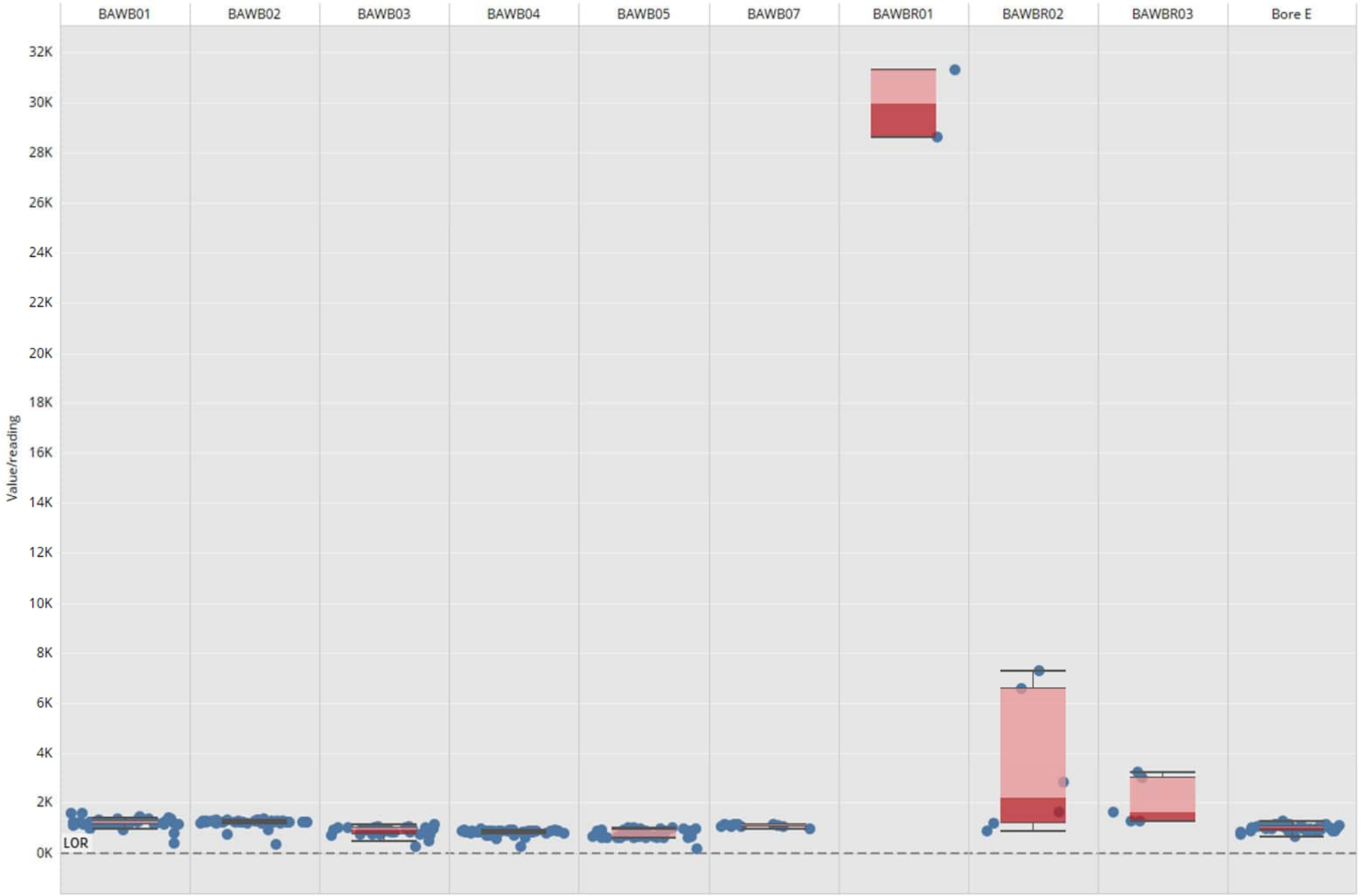
pH (field)


BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
BAWBR01
BAWBR02
BAWBR03
Bore E
Value/reading
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0

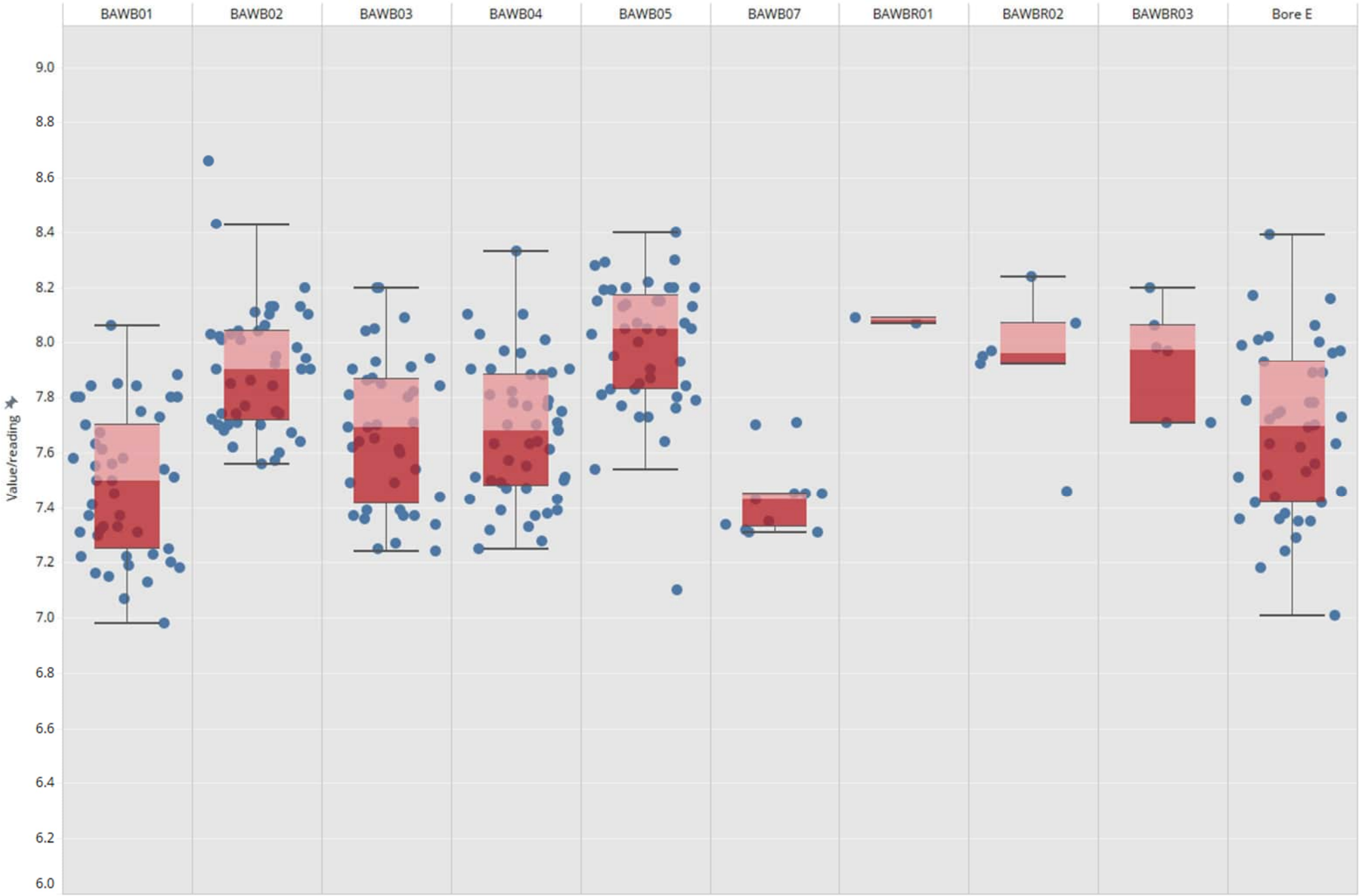
Salinity (field) (PSU)



Electrical Conductivity (µS/cm)



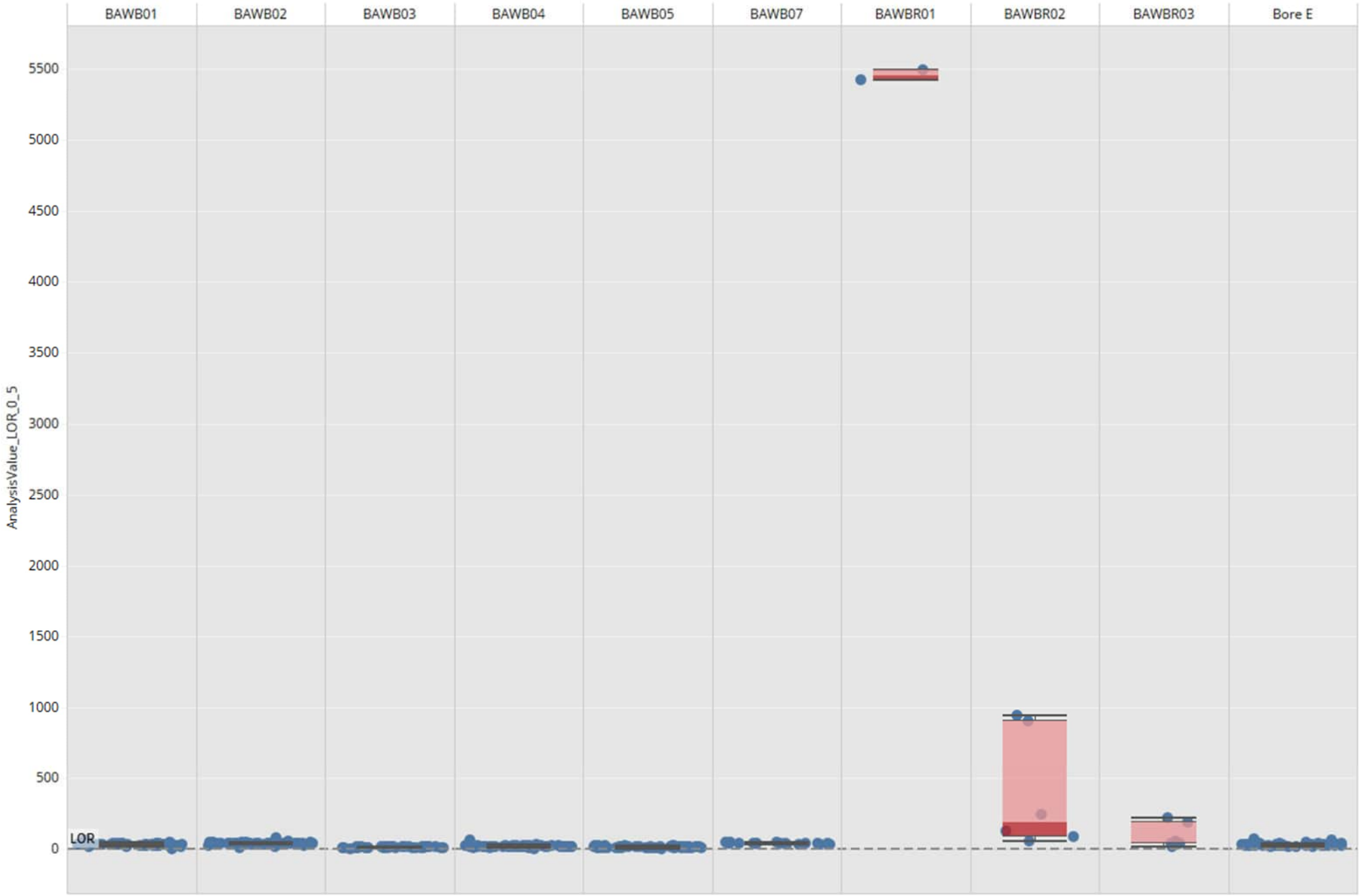
pH (lab)


BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
BAWBR01
BAWBR02
BAWBR03
Bore E
Value/reading
9.0
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
7.2
7.0
6.8
6.6
6.4
6.2
6.0

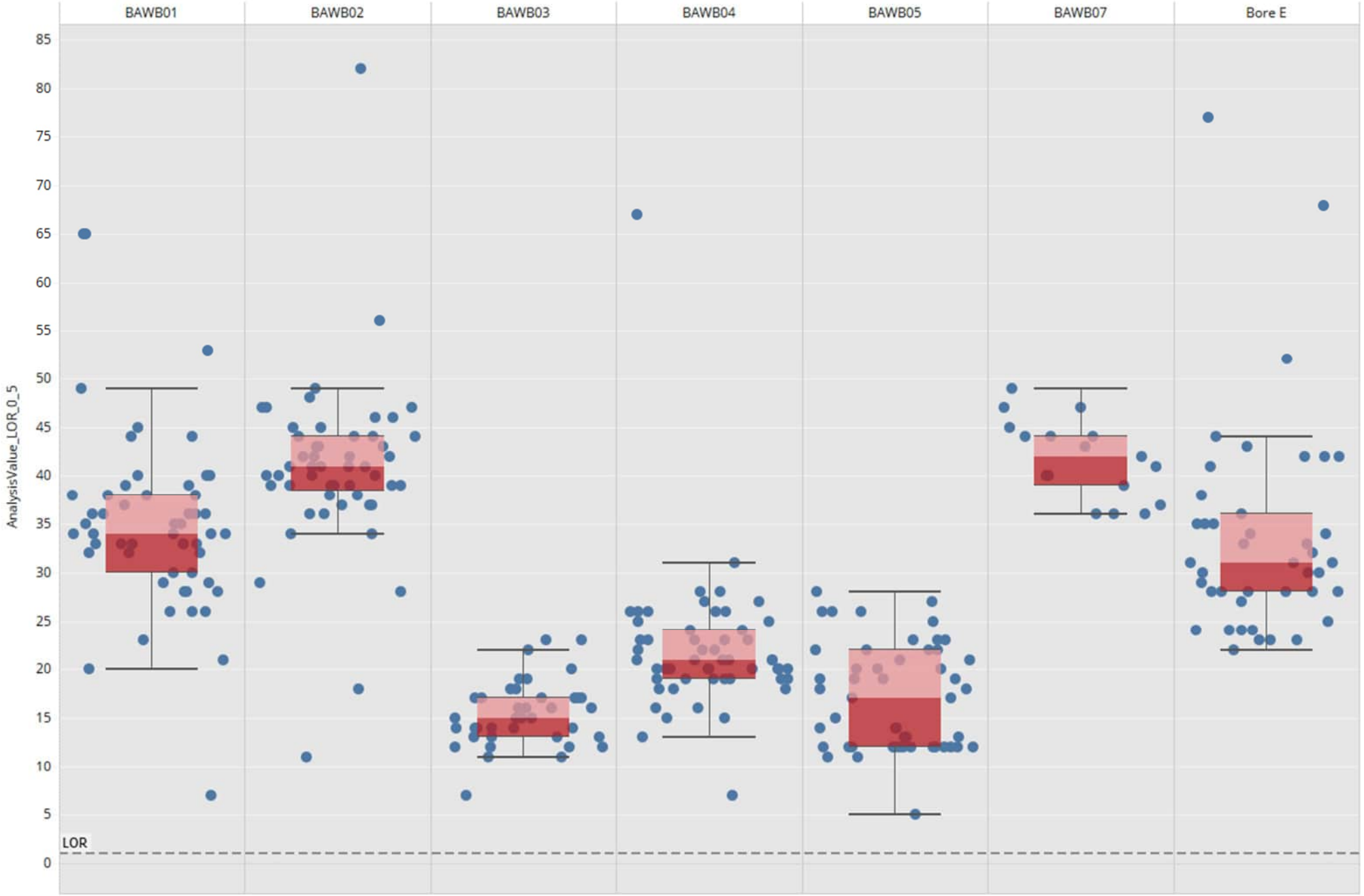
Calcium (mg/L)

BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
BAWBR01
BAWBR02
BAWBR03
Bore E
AnalysisValue_LOR_0_5
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
LOR

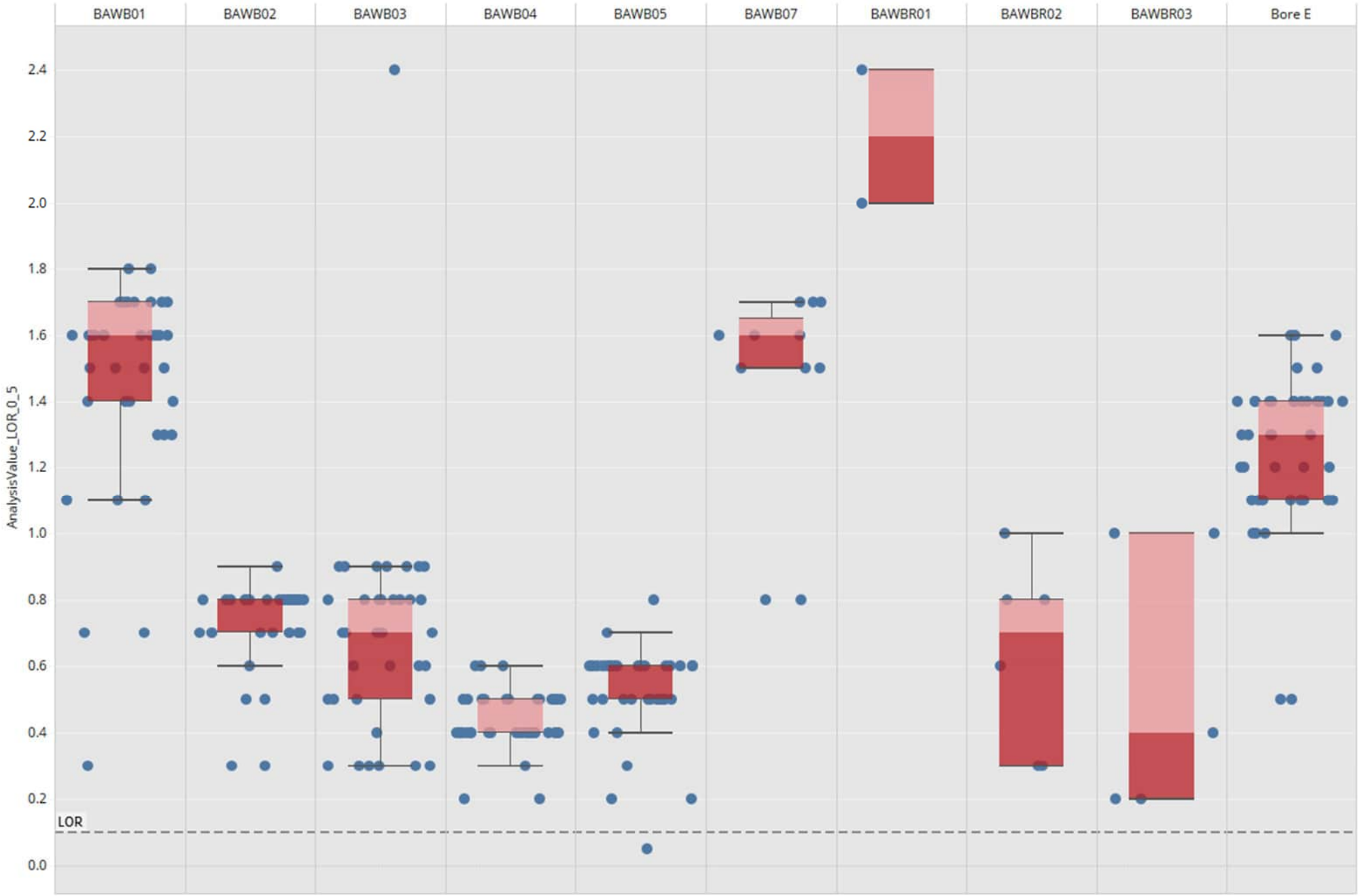
Chloride (mg/L)



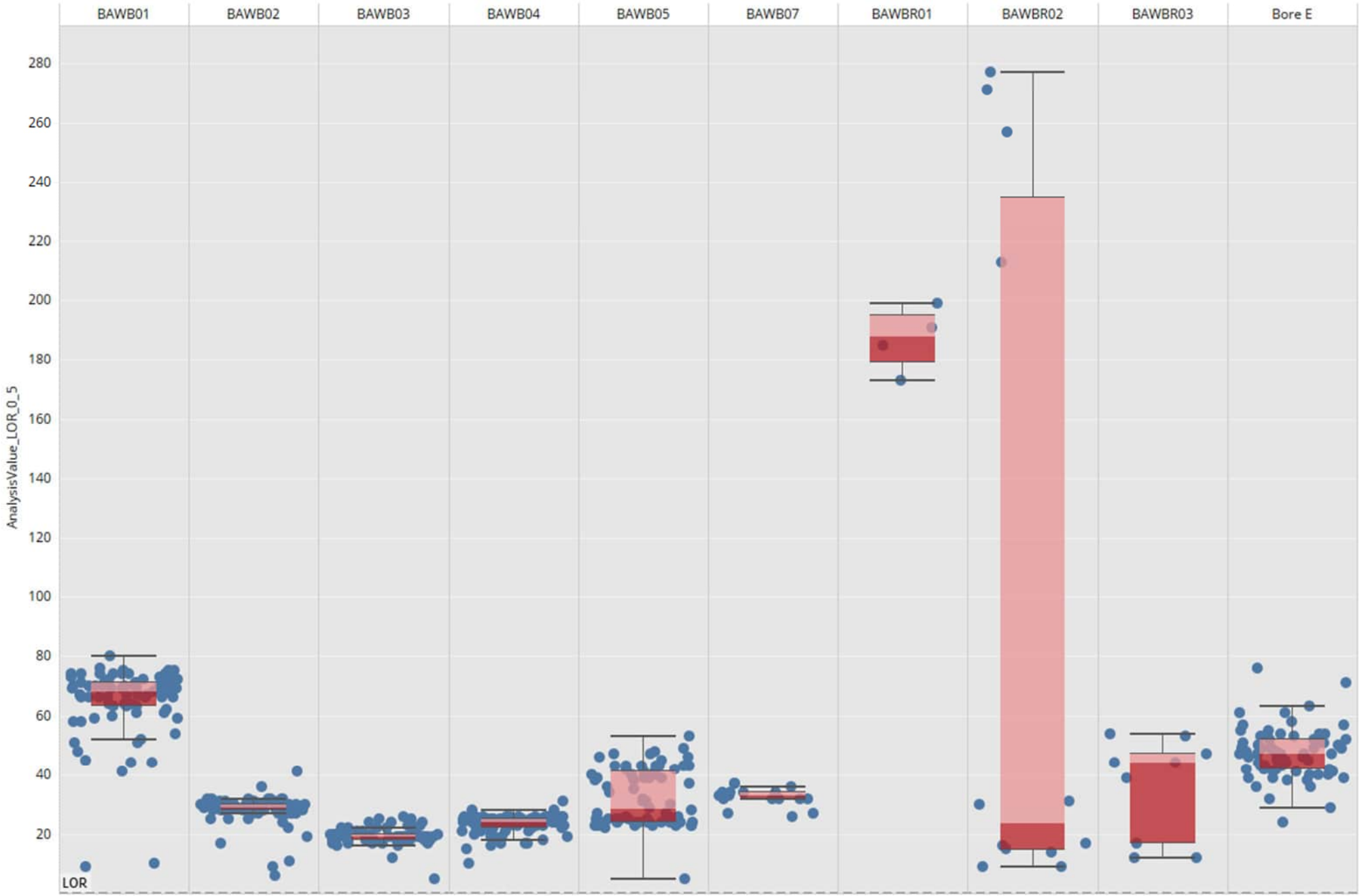
Chloride (mg/L)



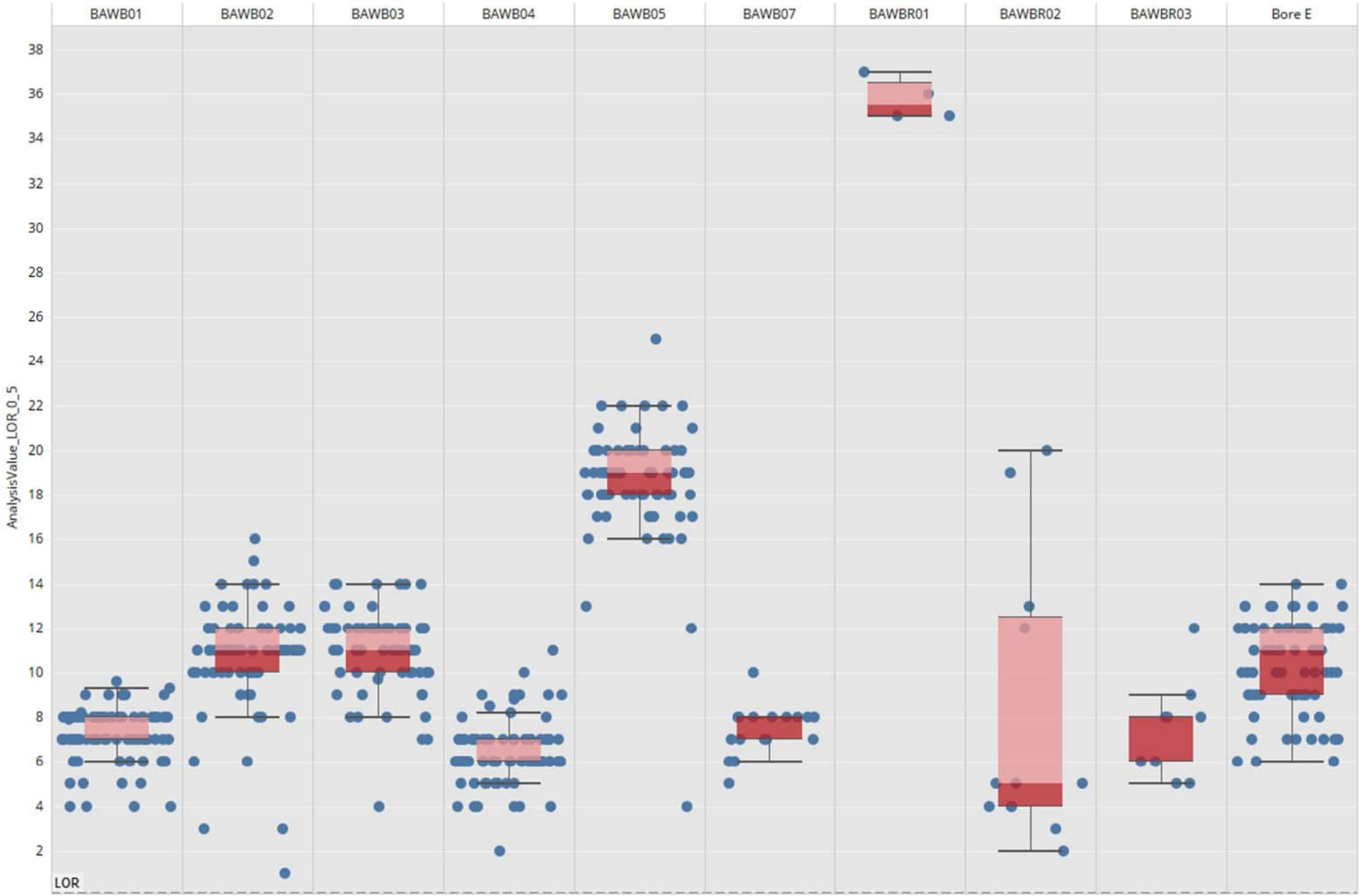
Fluoride (mg/L)



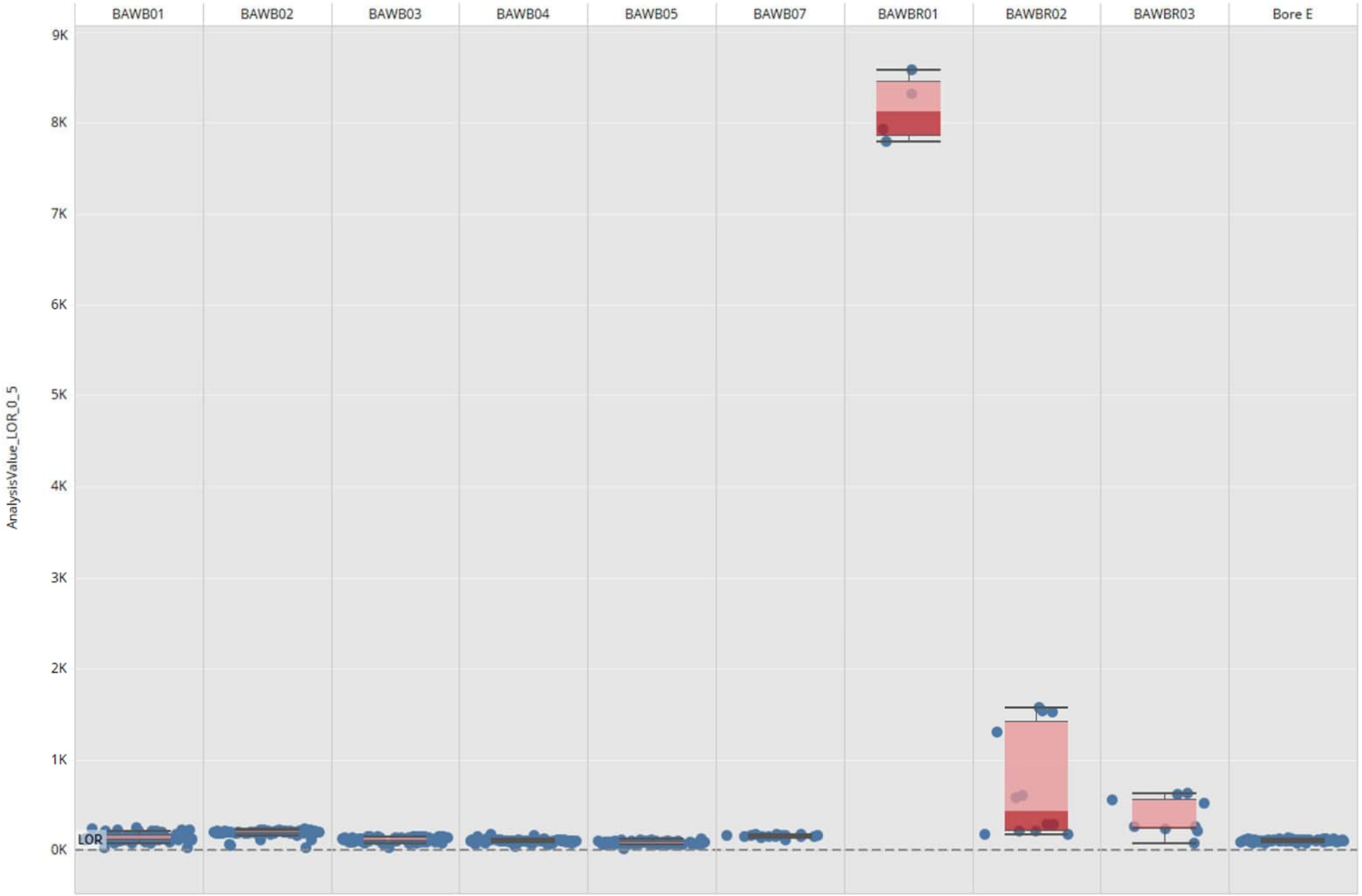
Magnesium (mg/L)



Potassium (mg/L)



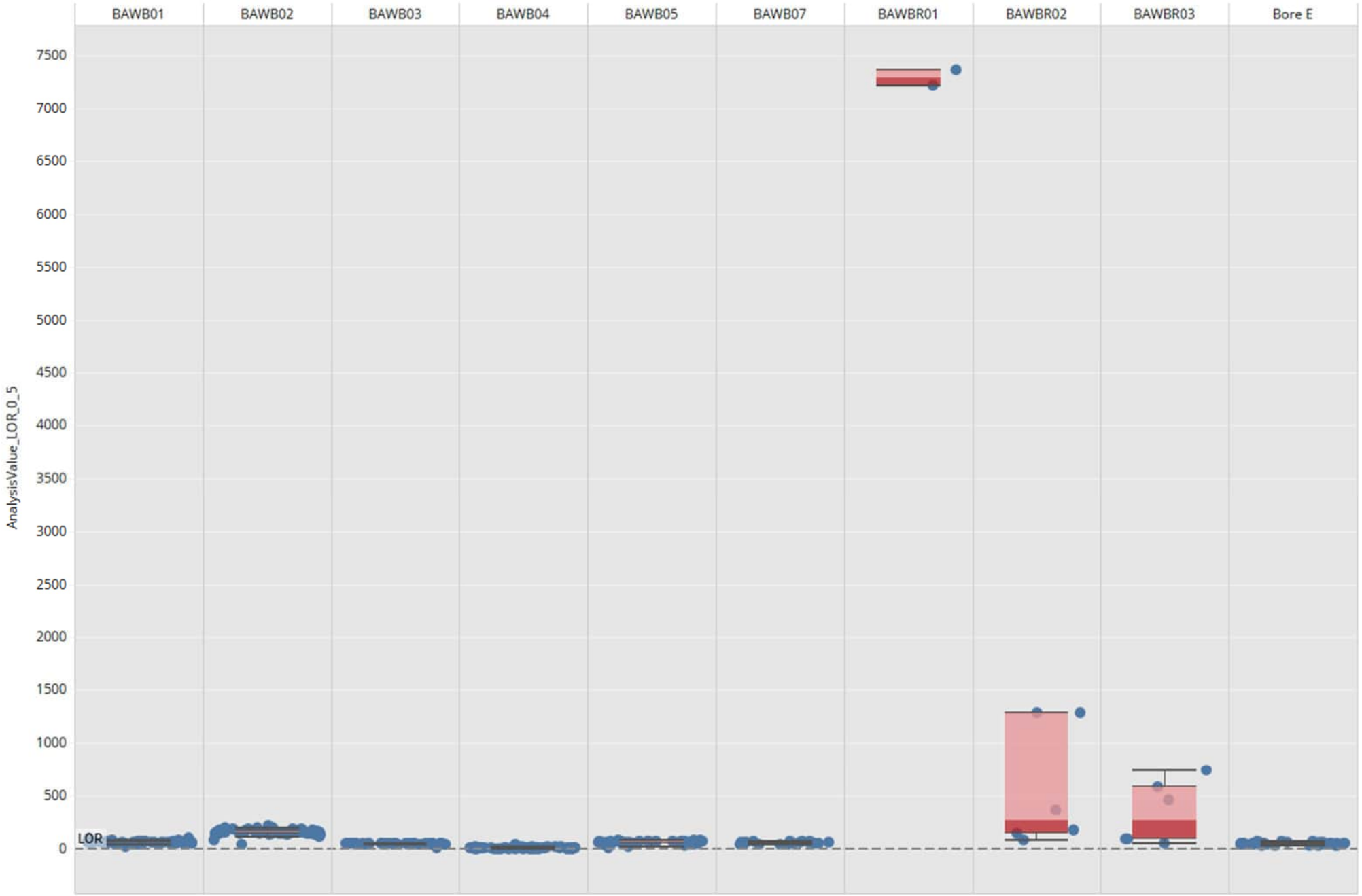
Sodium (mg/L)


BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
BAWBR01
BAWBR02
BAWBR03
Bore E
9K
8K
7K
6K
5K
4K
3K
2K
1K
0K
AnalysisValue_LOR_0_5
LOR

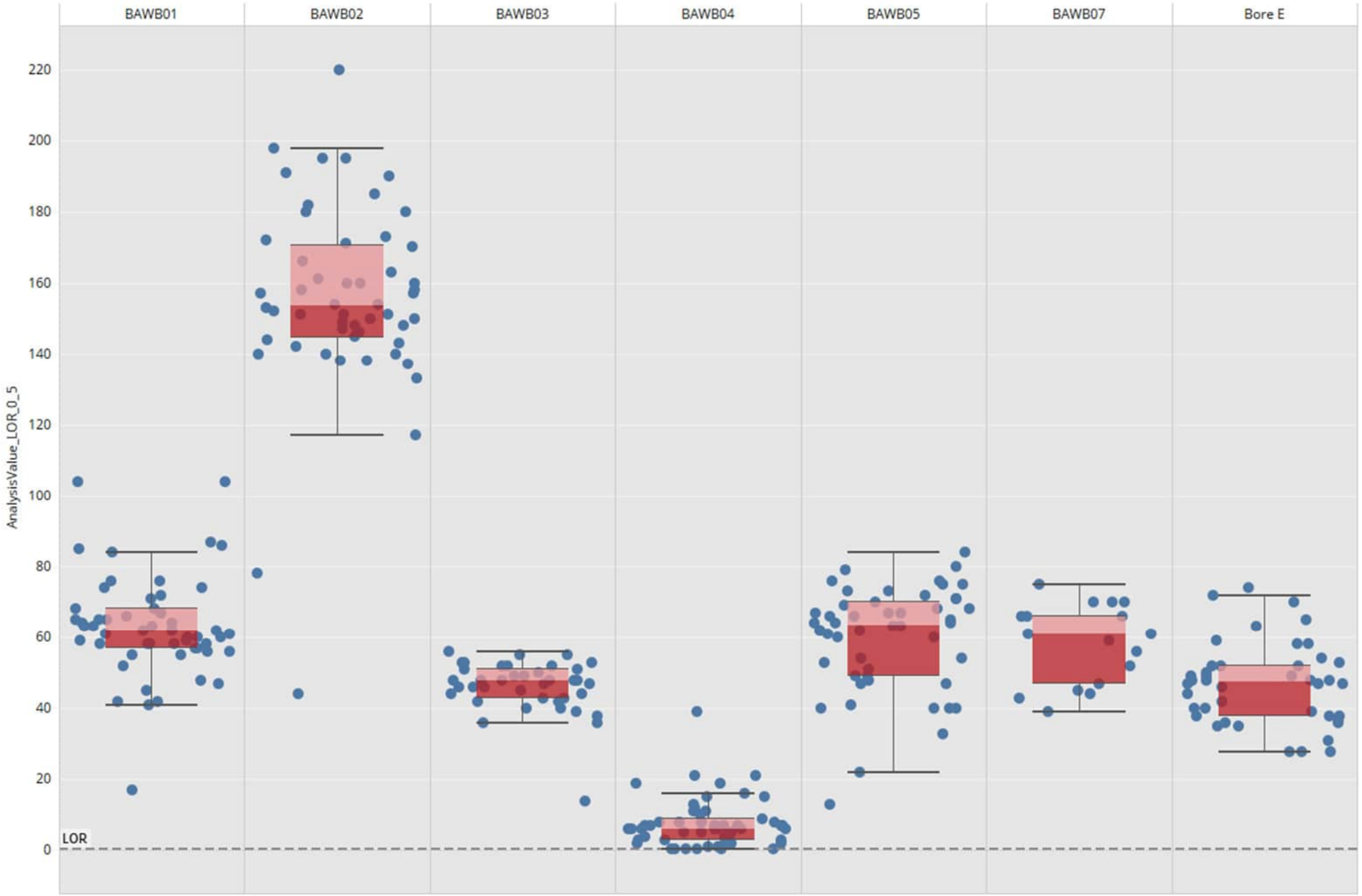
Sodium (mg/L)

BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
Bore E
AnalysisValue_LOR_0_5
240
220
200
180
160
140
120
100
80
60
40
20
LOR

Sulfate (as SO4)

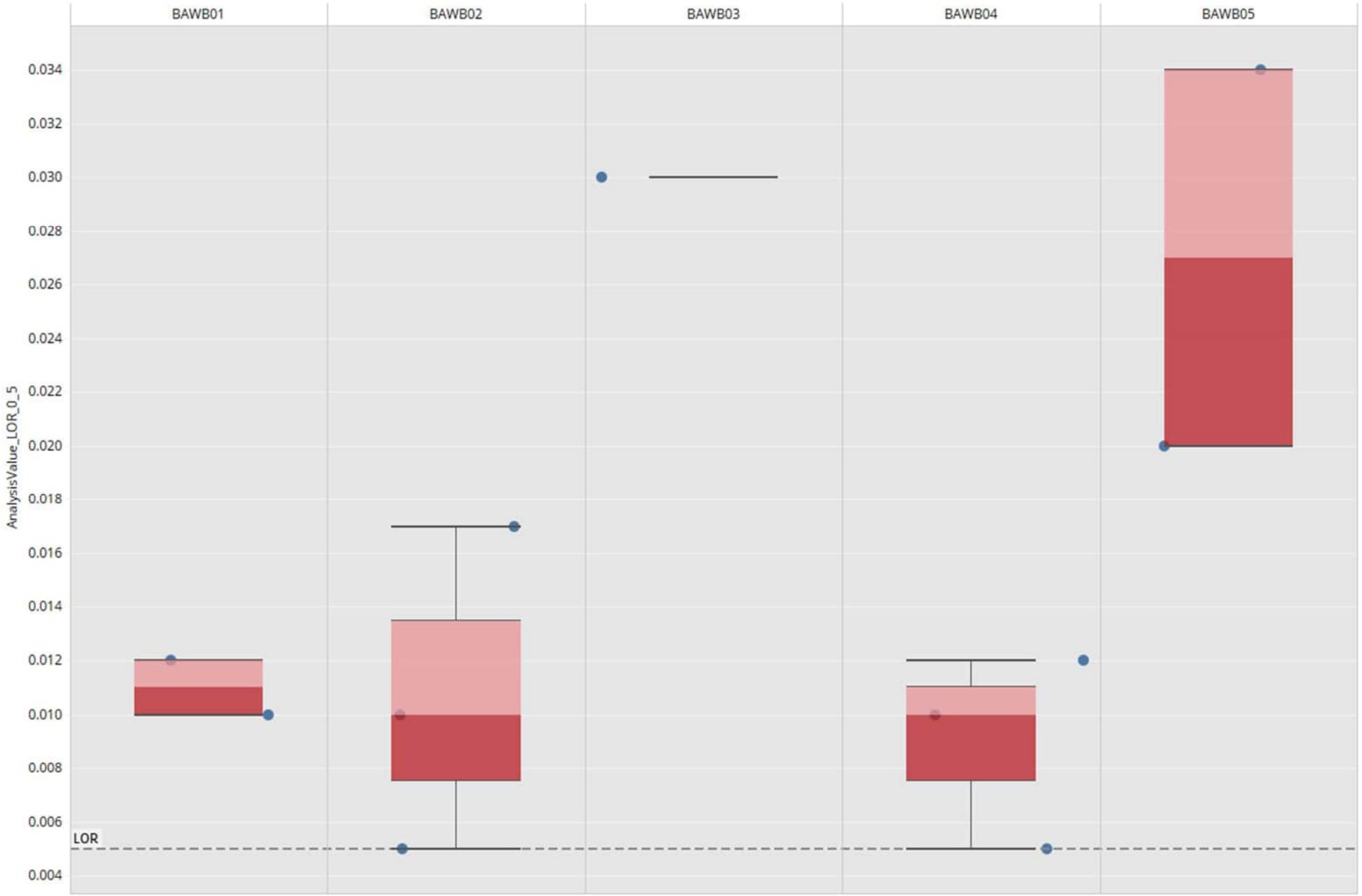


Sulfate (as SO4)

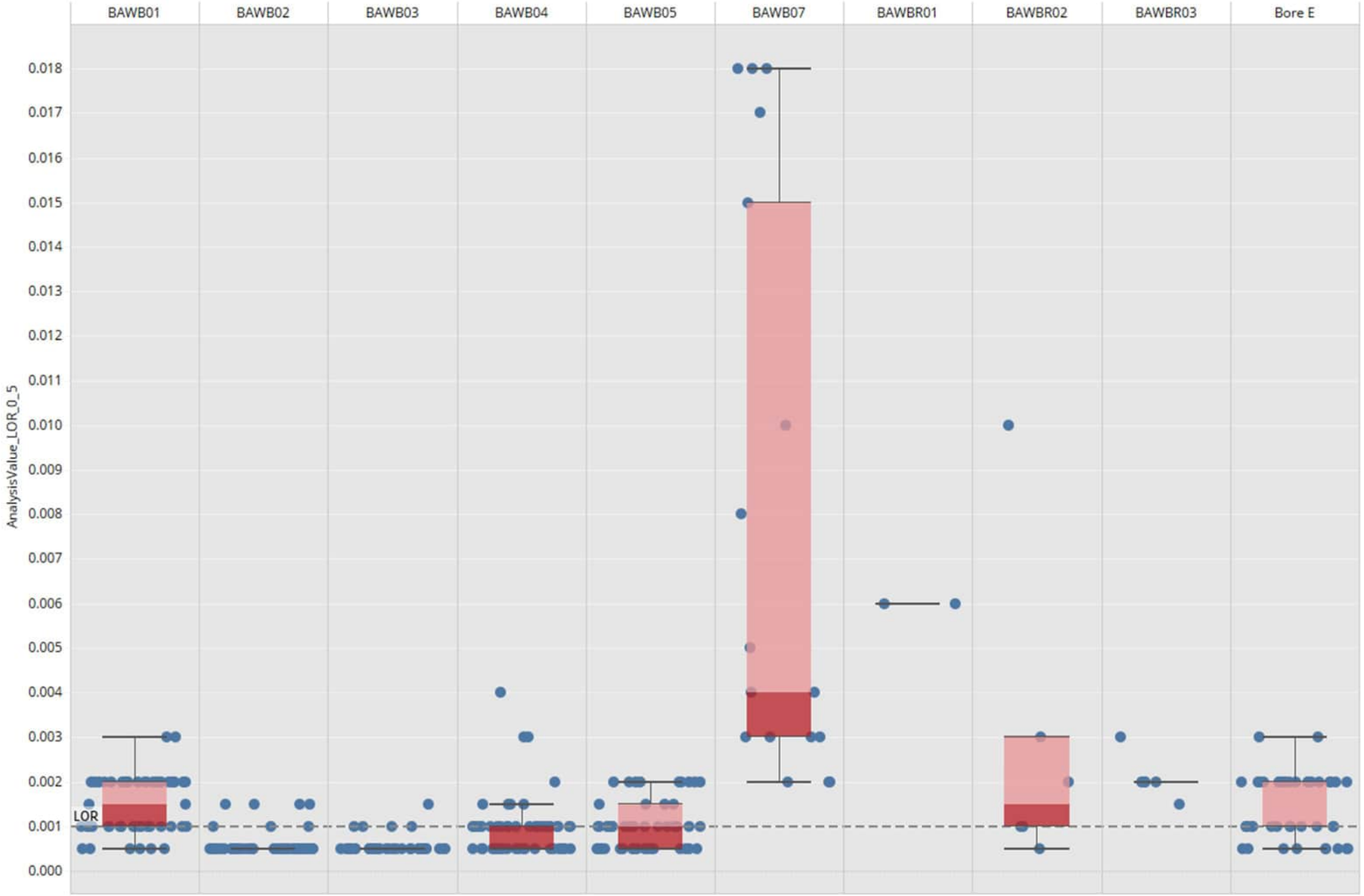


Bicarbonate Alkalinity as CaCO3 (mg/L)

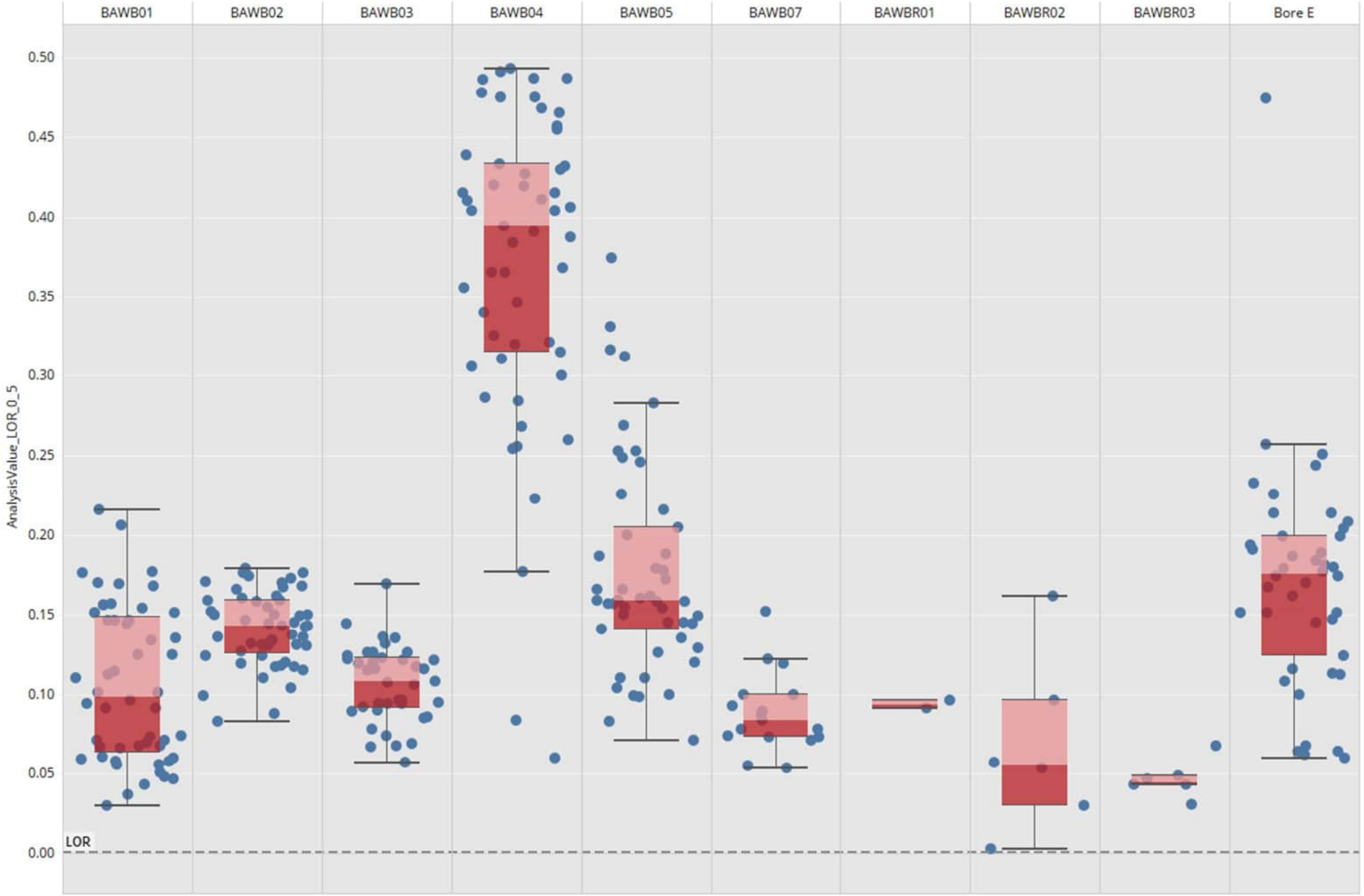
Aluminium - dissolved (mg/L)



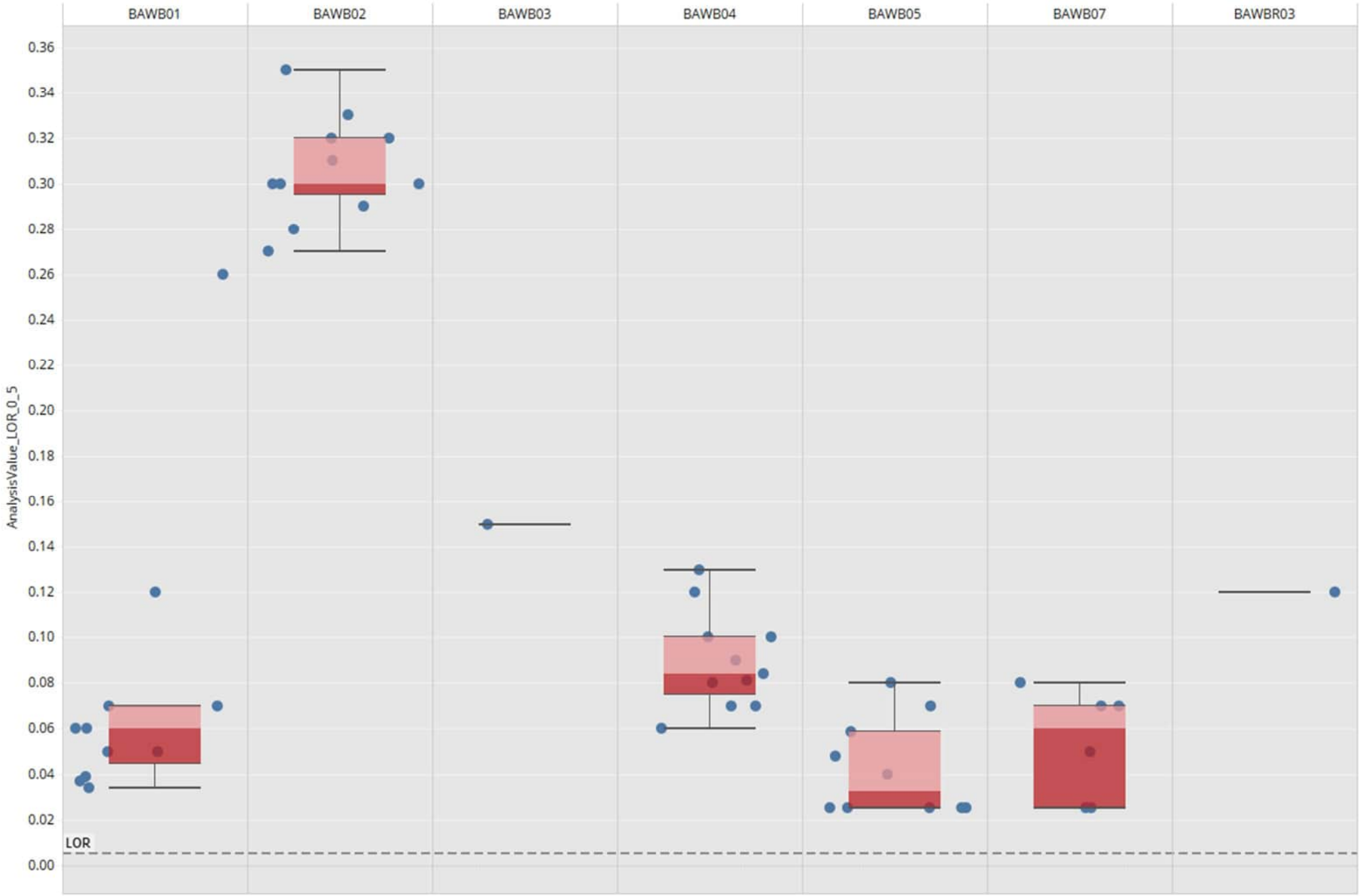
Arsenic - dissolved (mg/L)



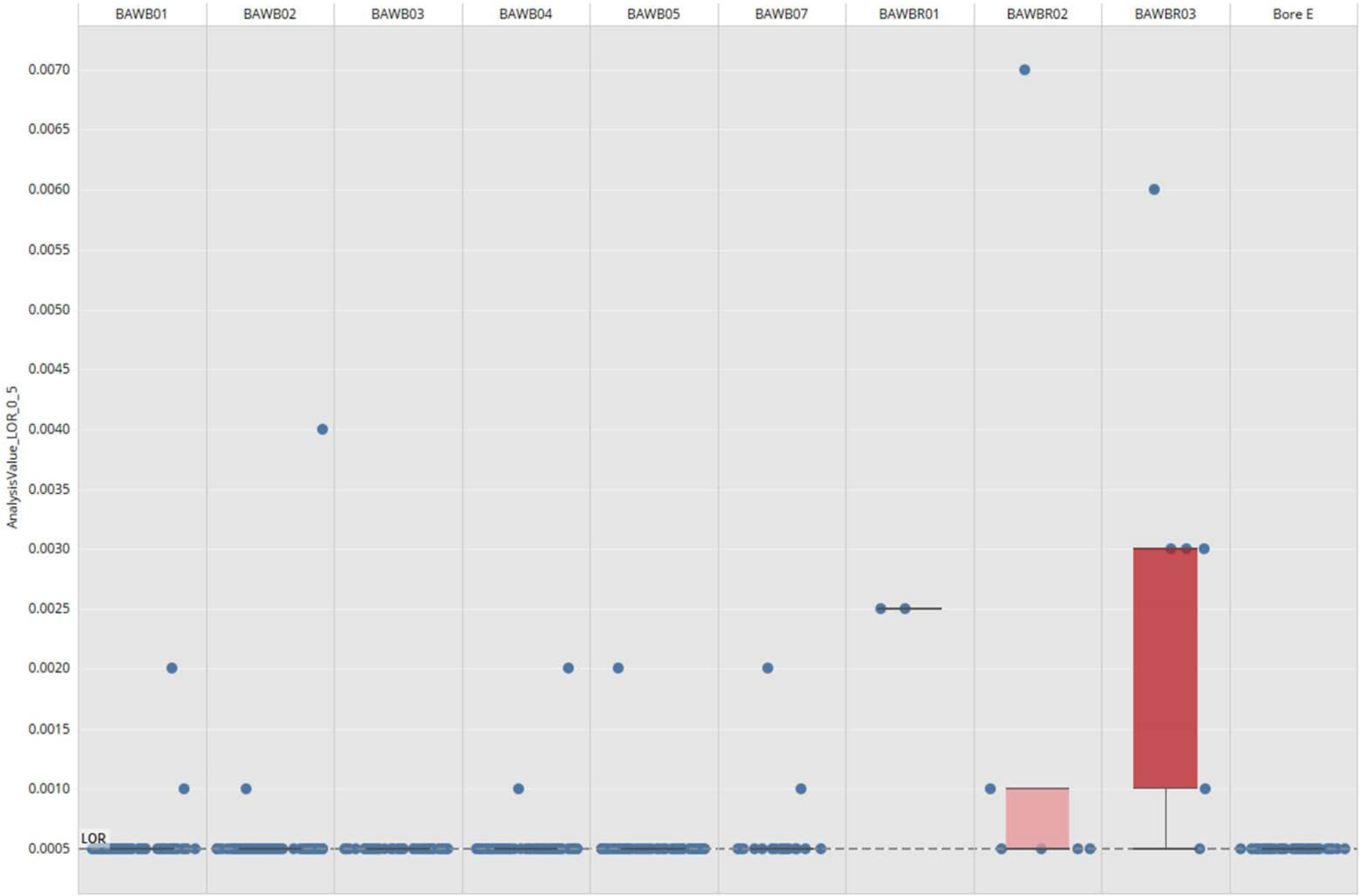
Barium - dissolved (mg/L)



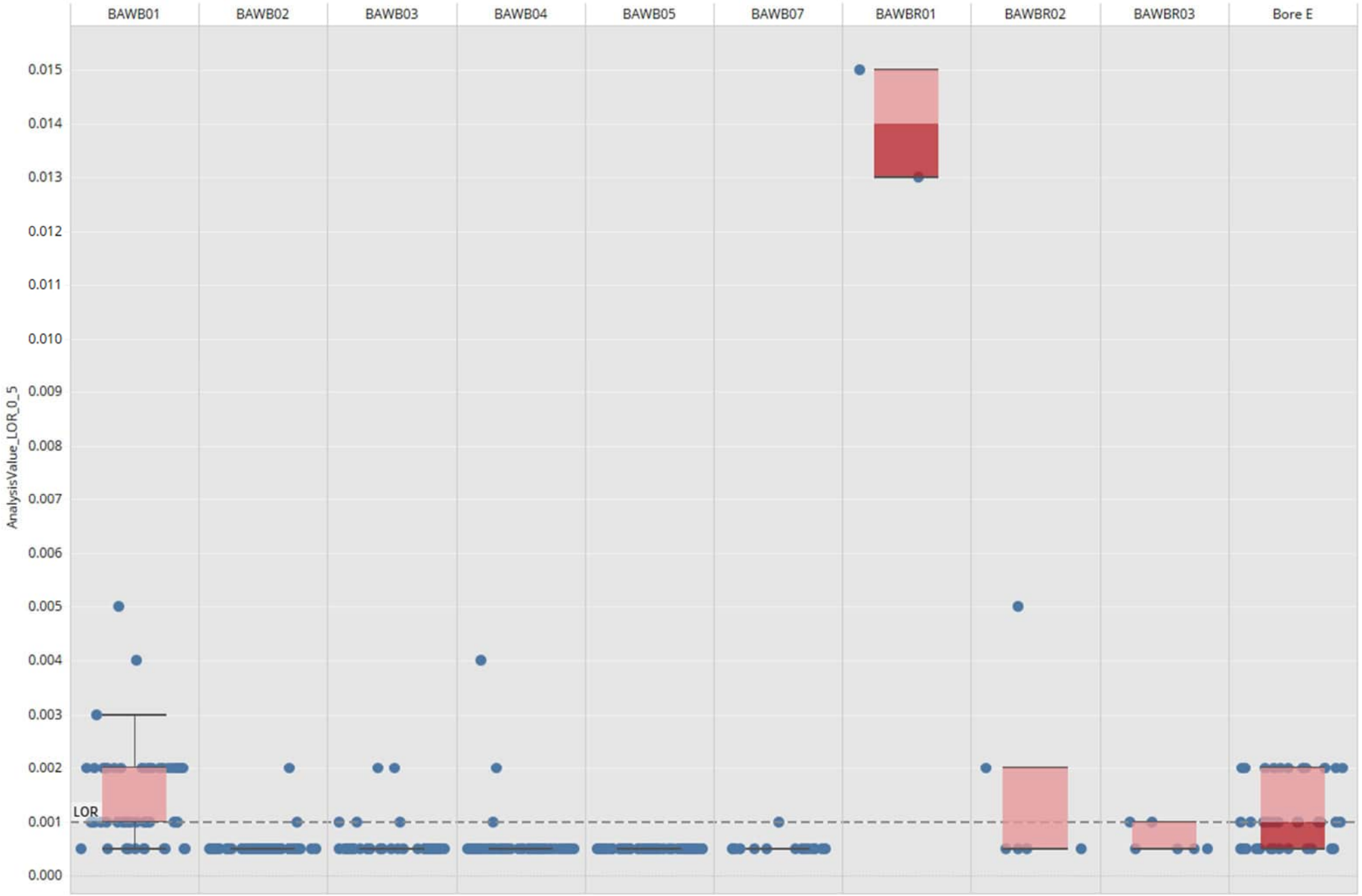
Boron - dissolved (mg/L)



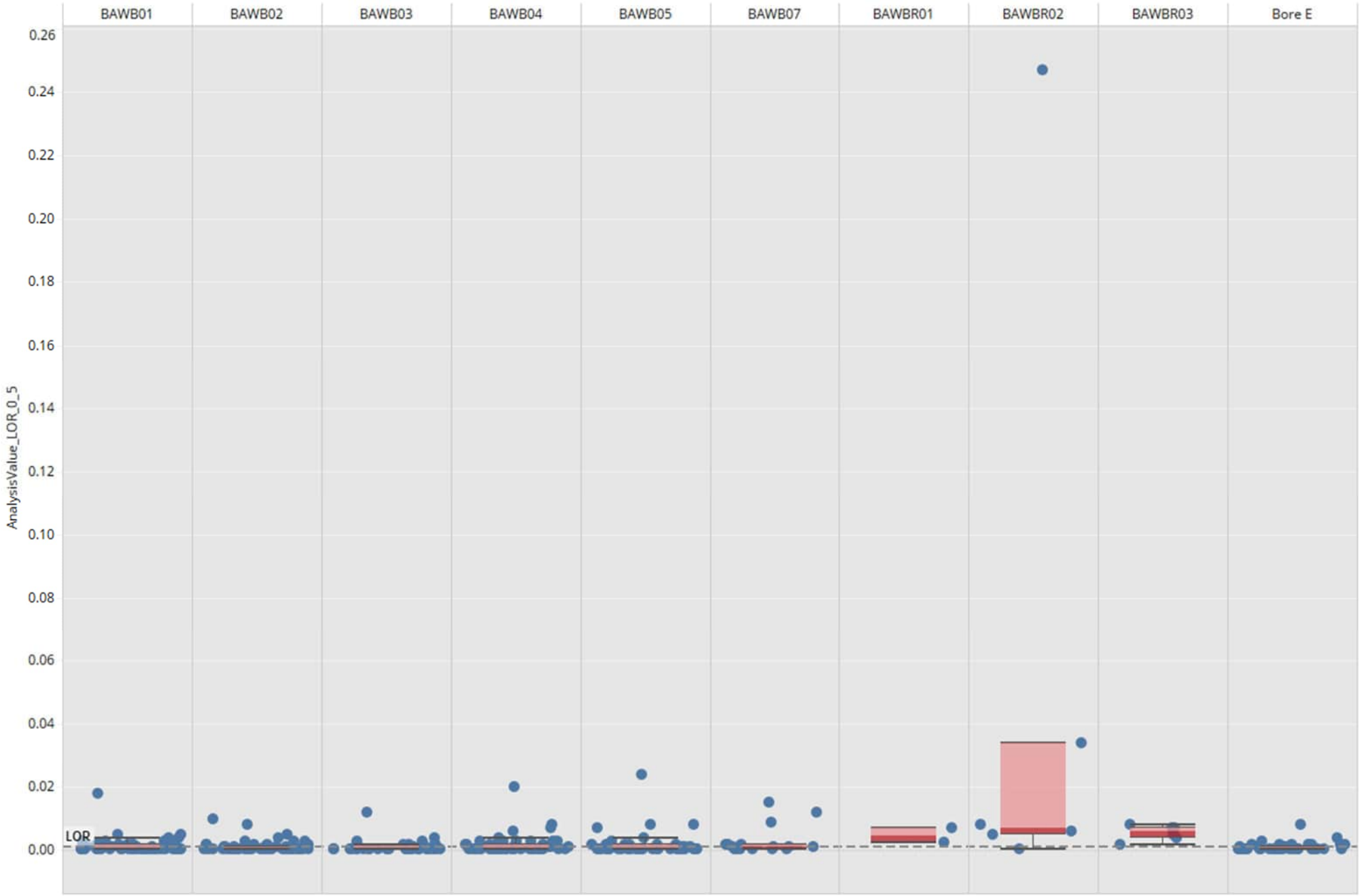
Chromium - dissolved (mg/L)



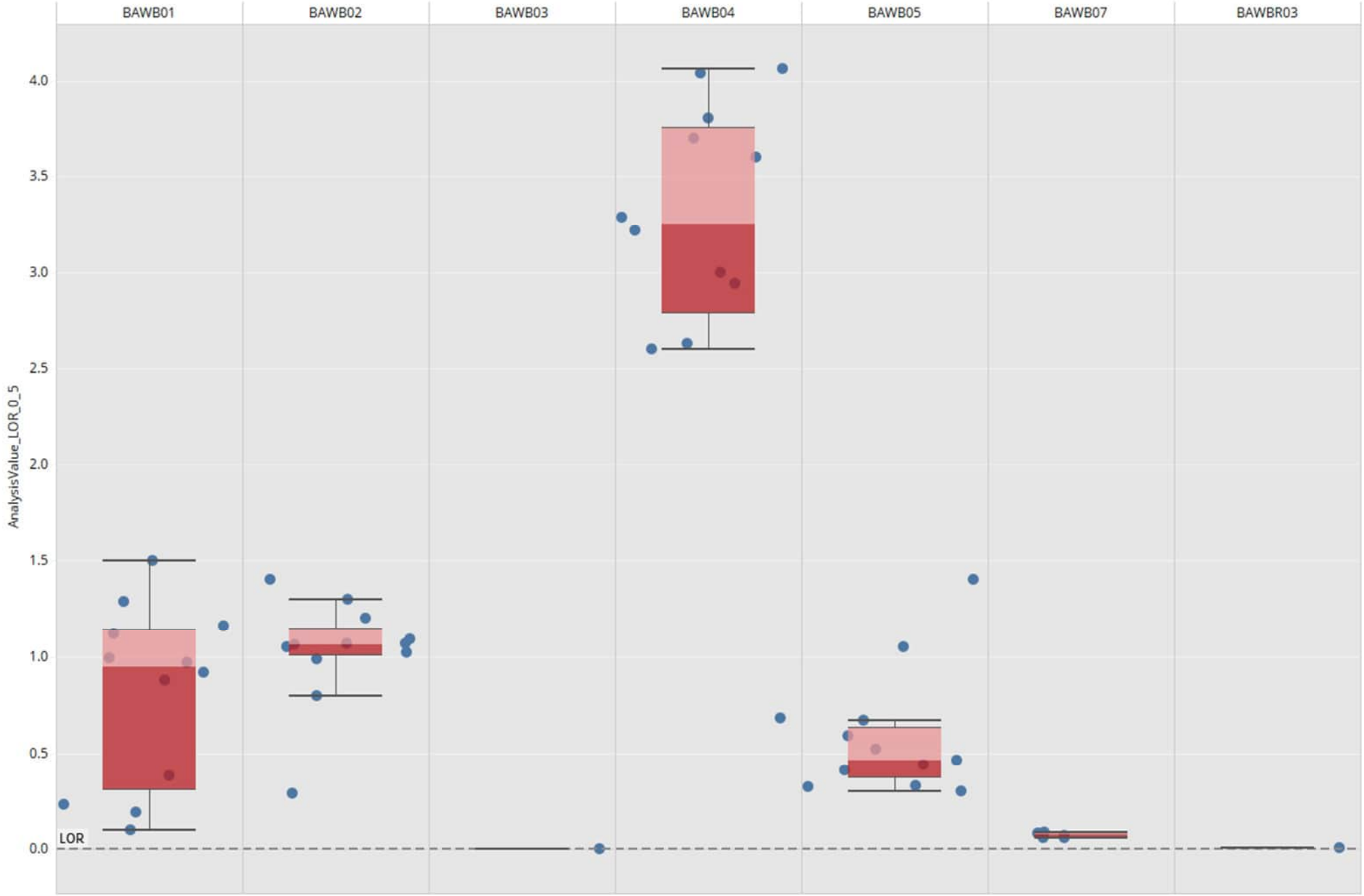
Cobalt - dissolved (mg/L)



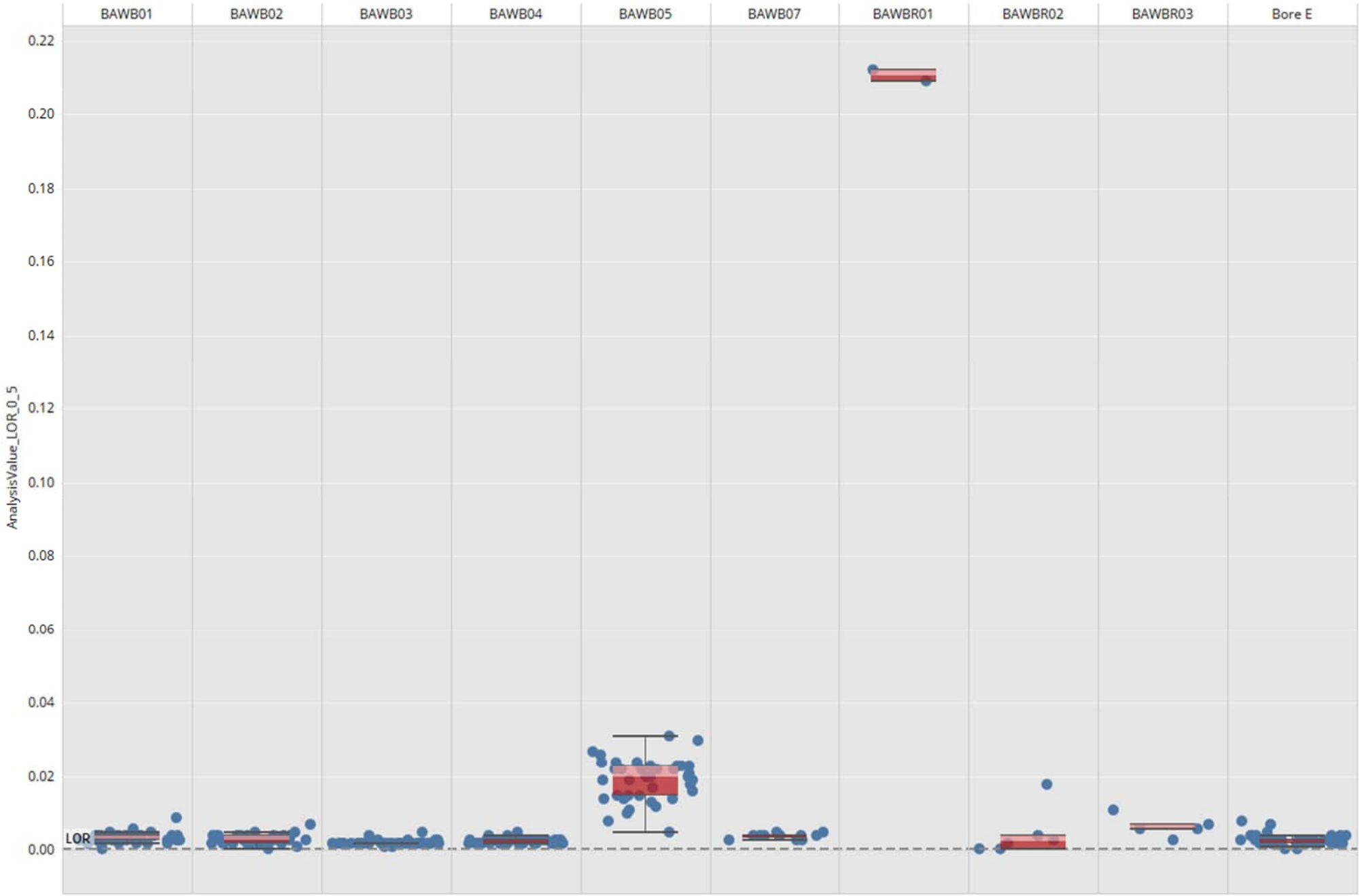
Copper - dissolved (mg/L)



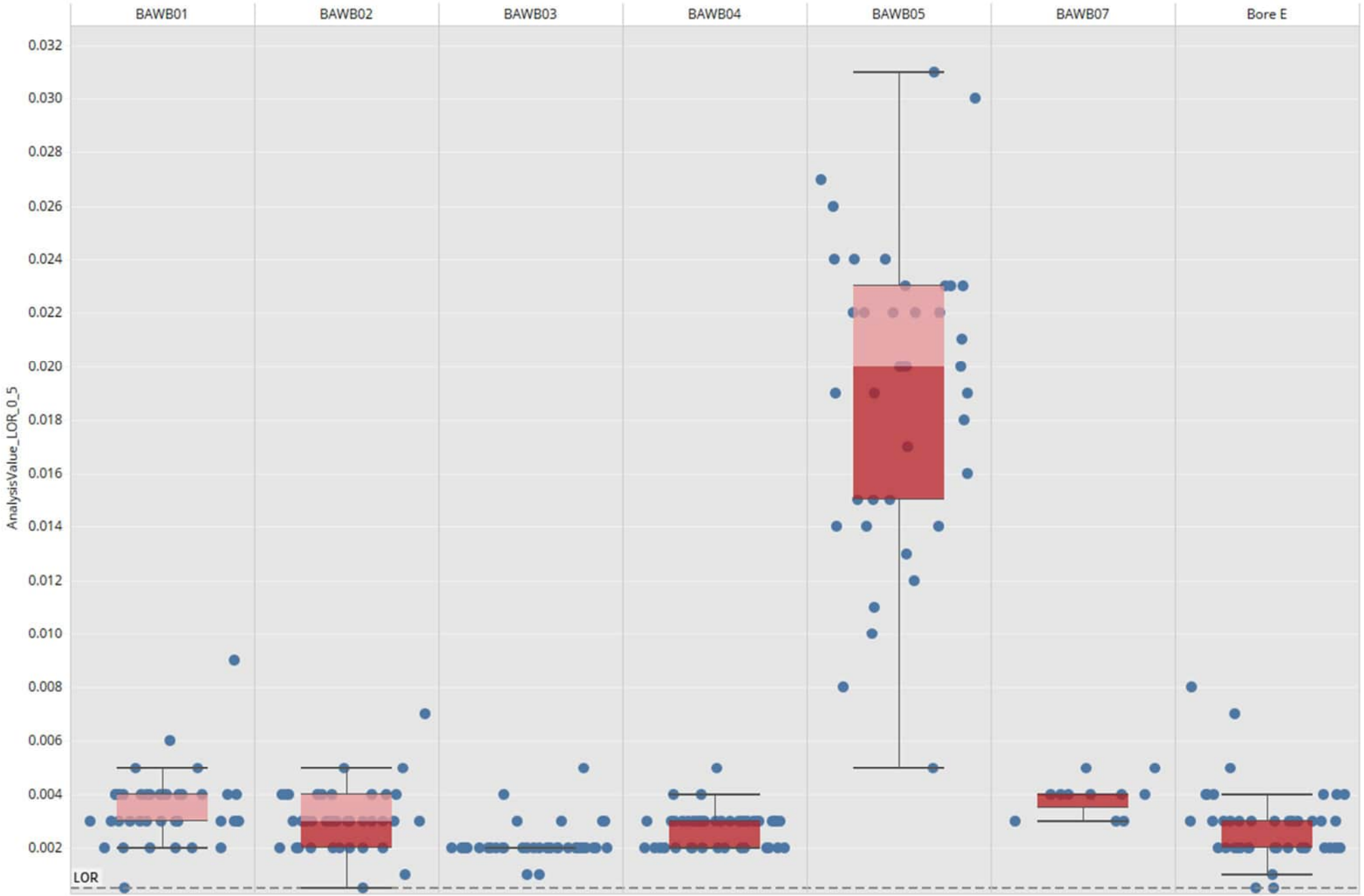
Manganese - dissolved (mg/L)



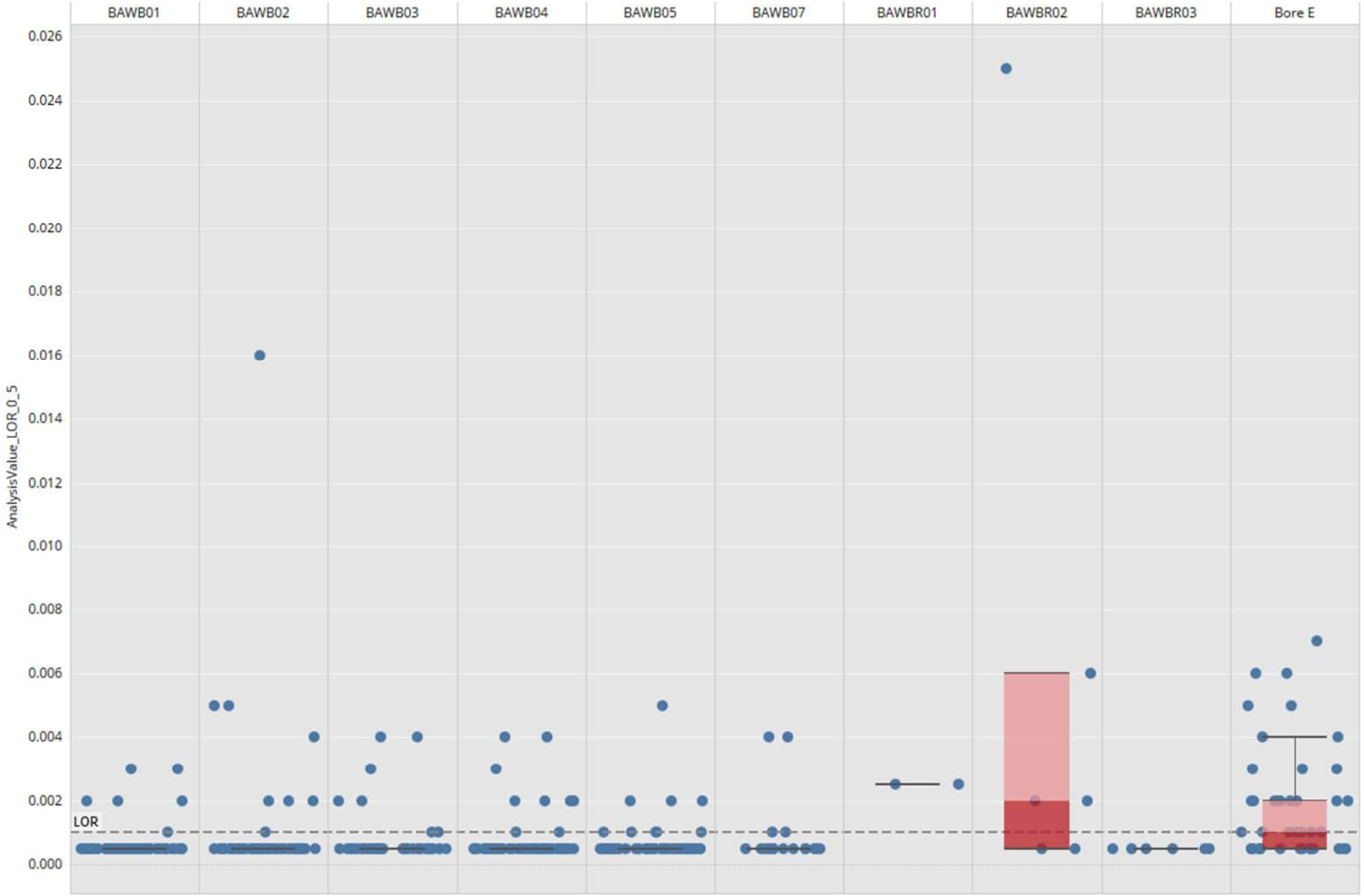
Molybdenum - dissolved (mg/L)



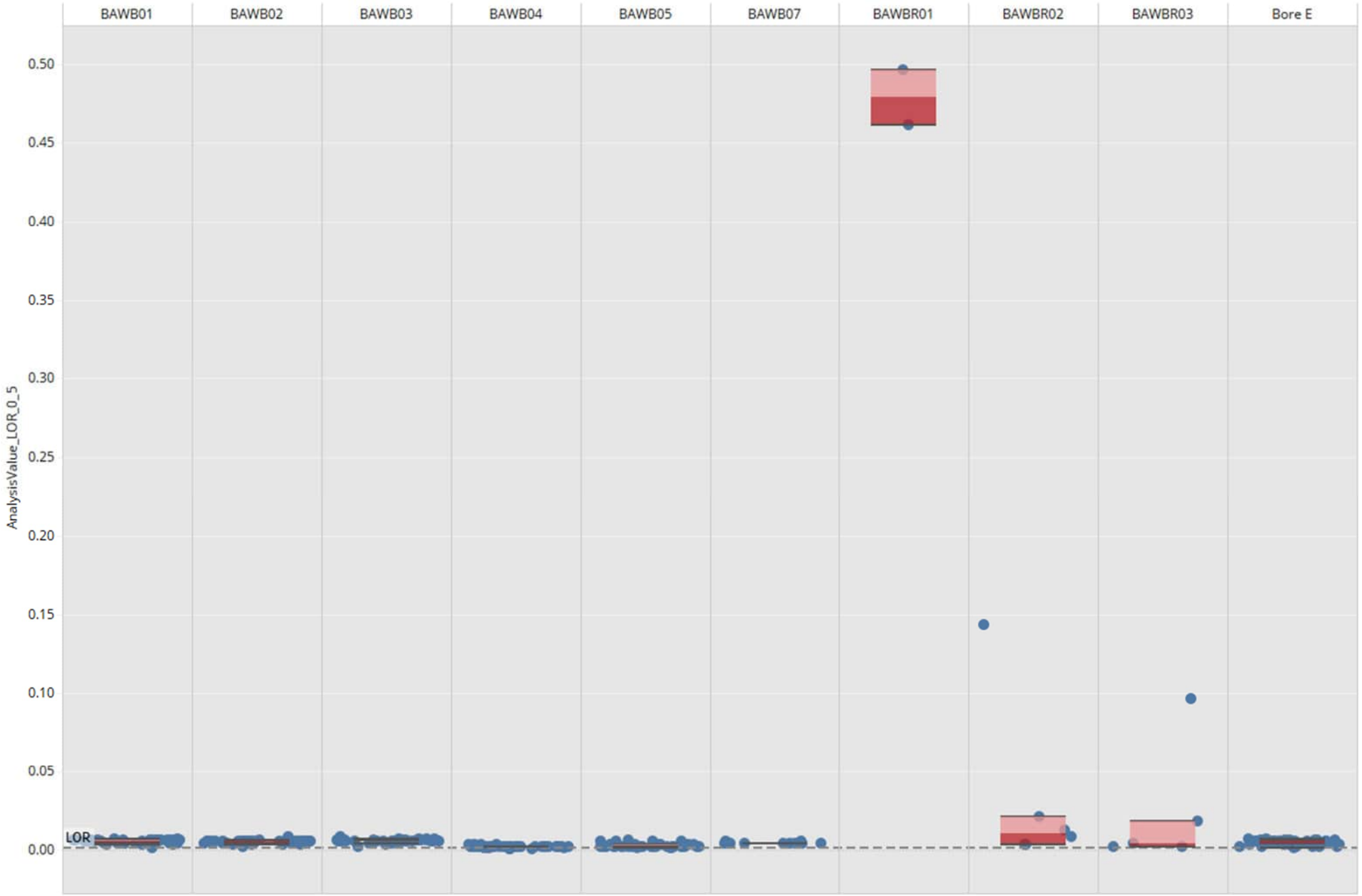
Molybdenum - dissolved (mg/L)



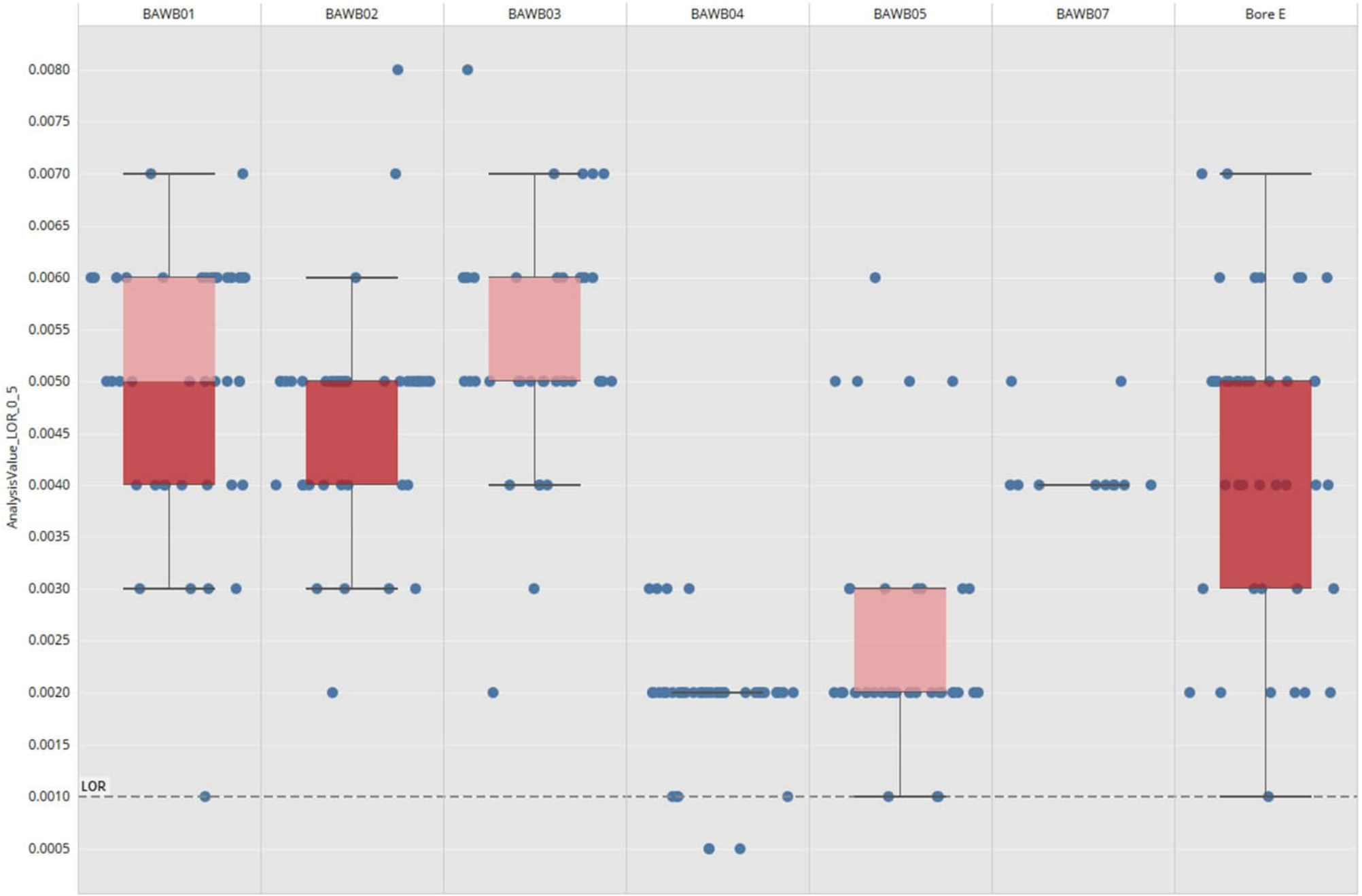
Nickel - dissolved (mg/L)



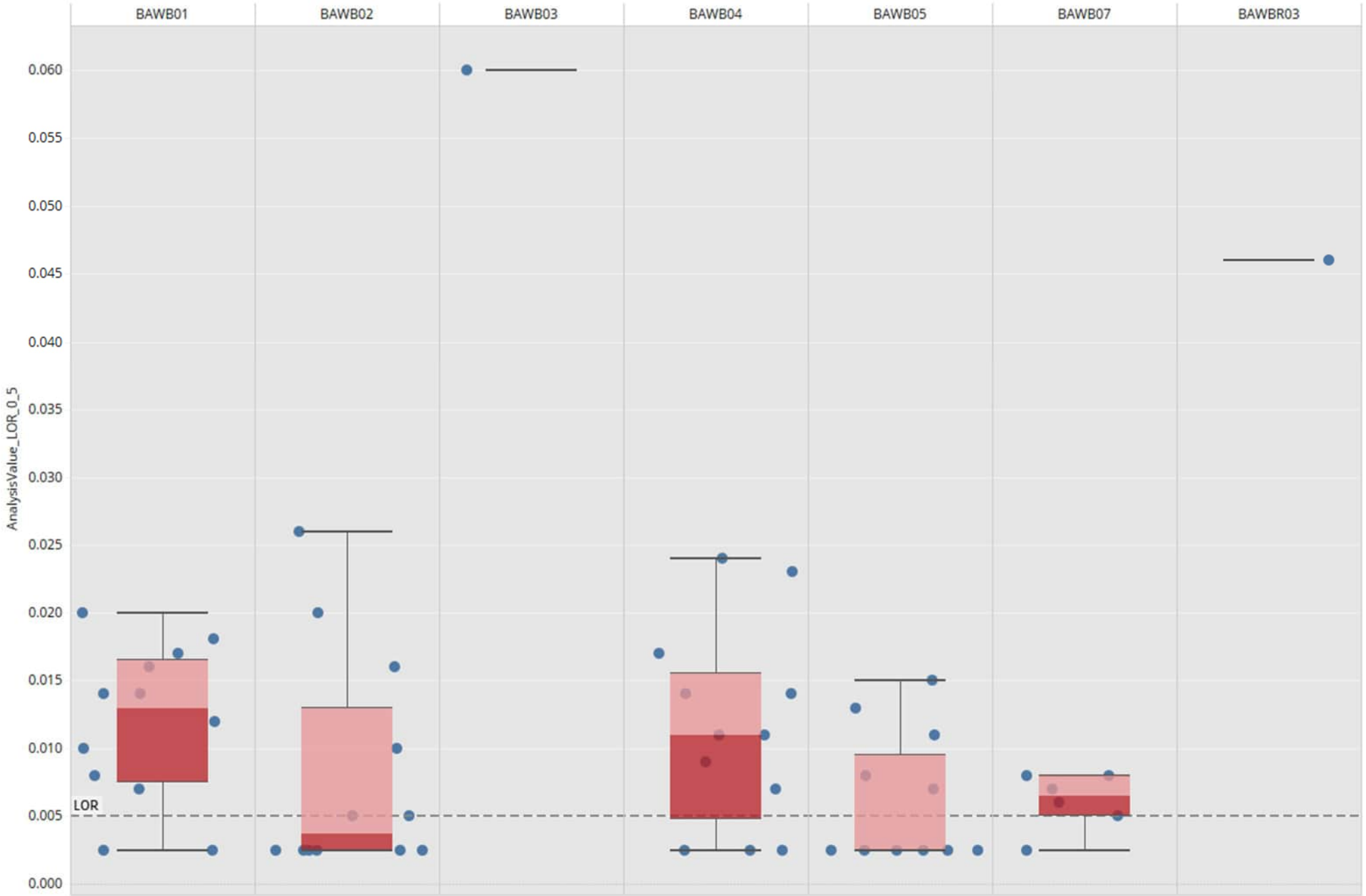
Uranium - dissolved (mg/L)



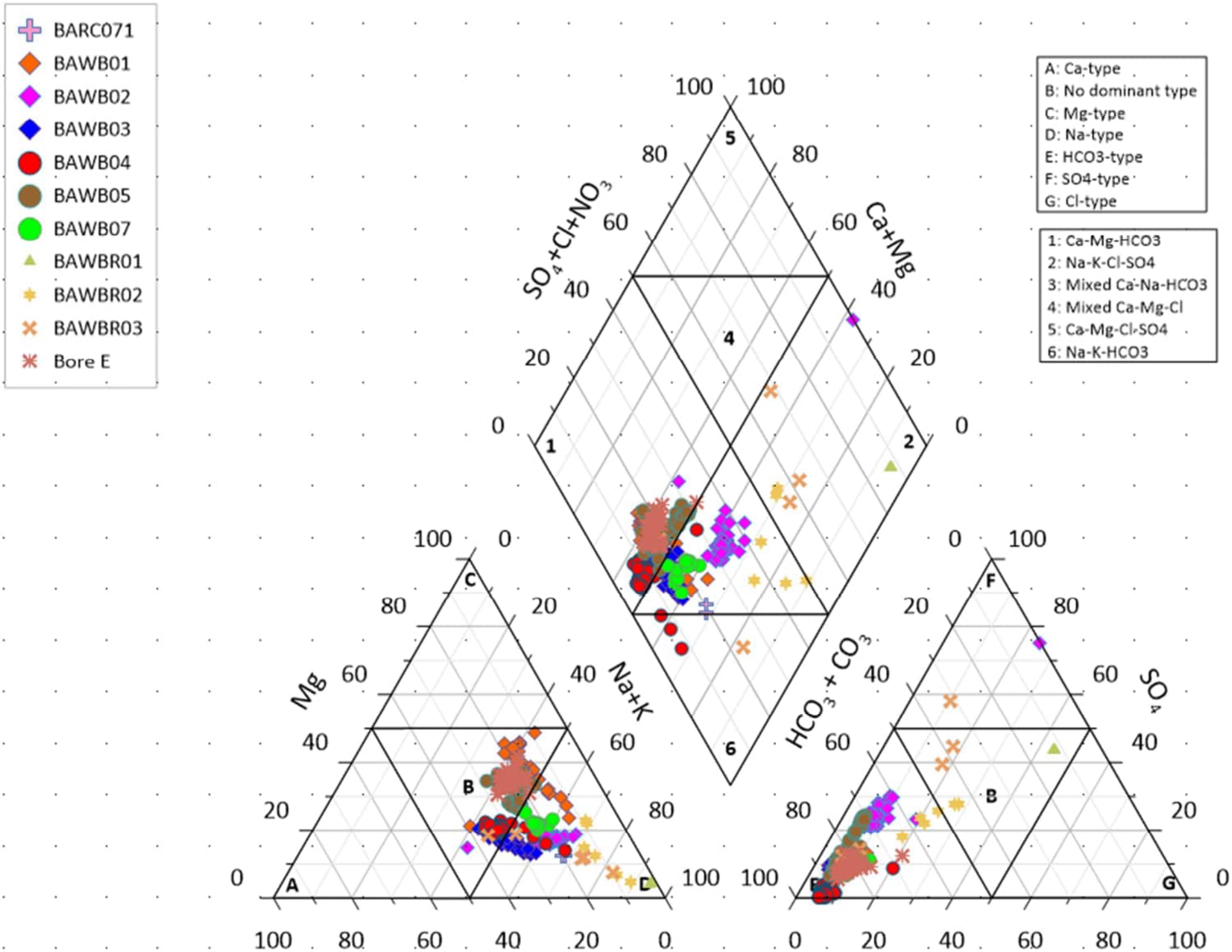
Uranium - dissolved (mg/L)

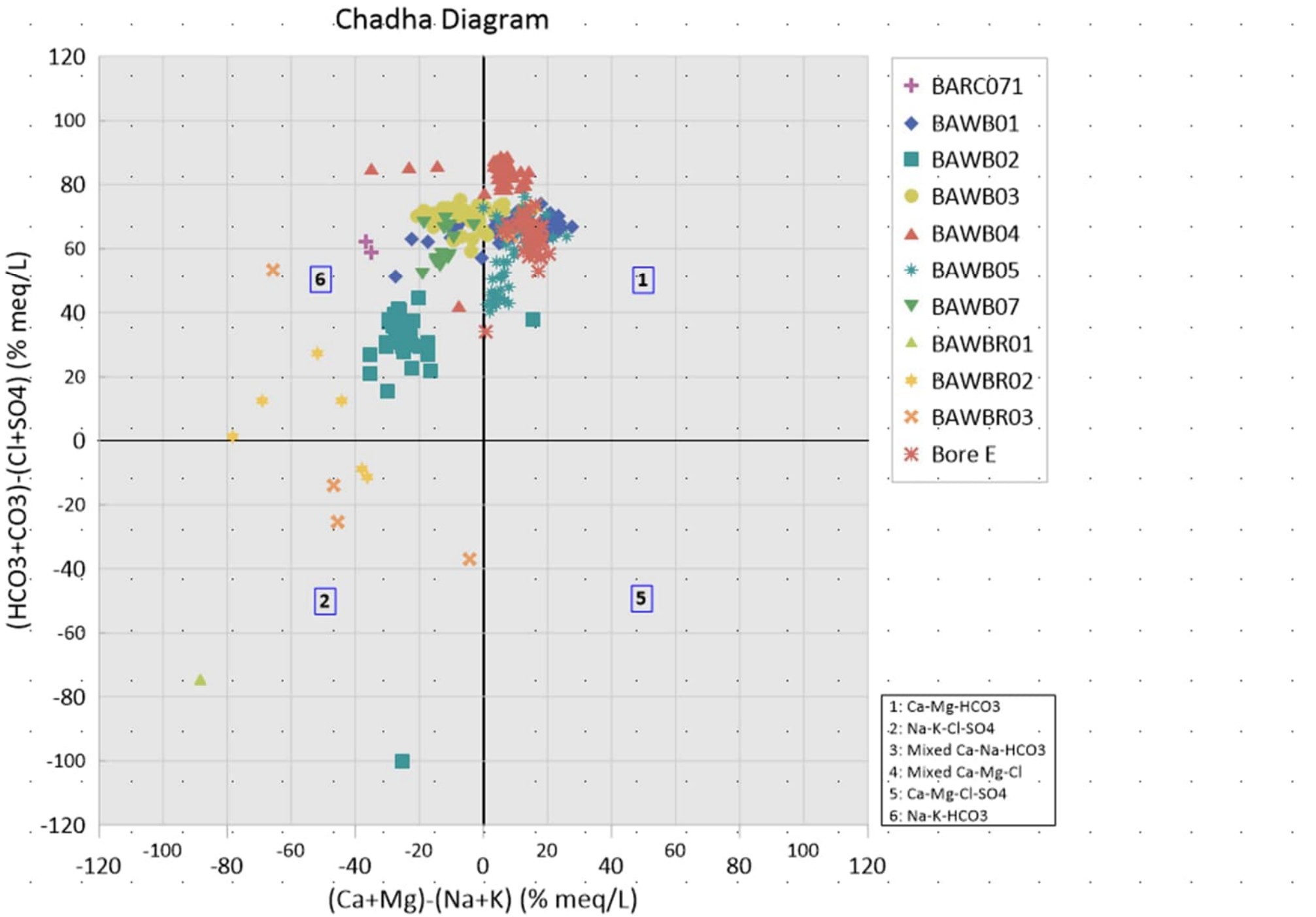


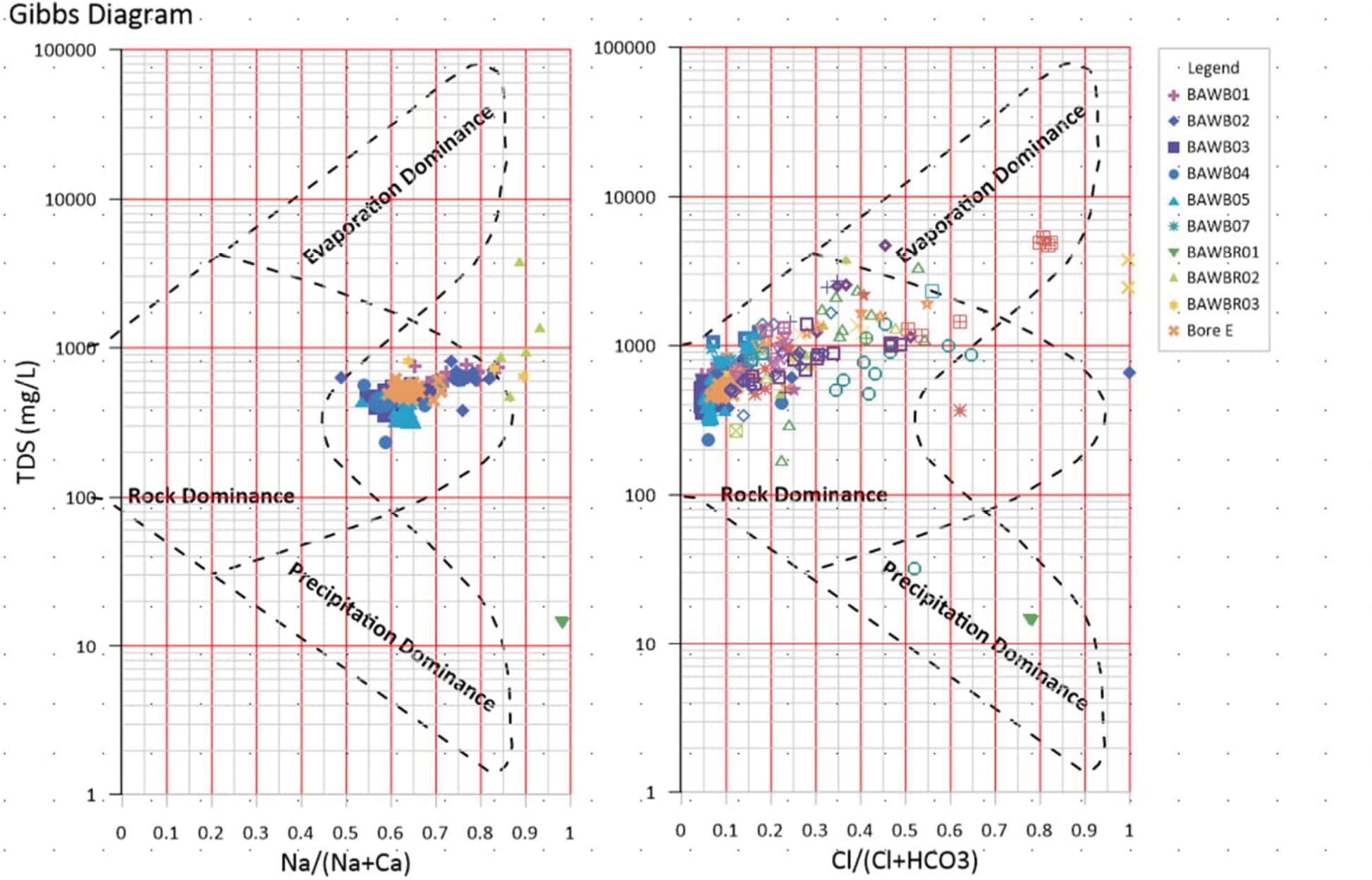
Zinc - dissolved (mg/L)

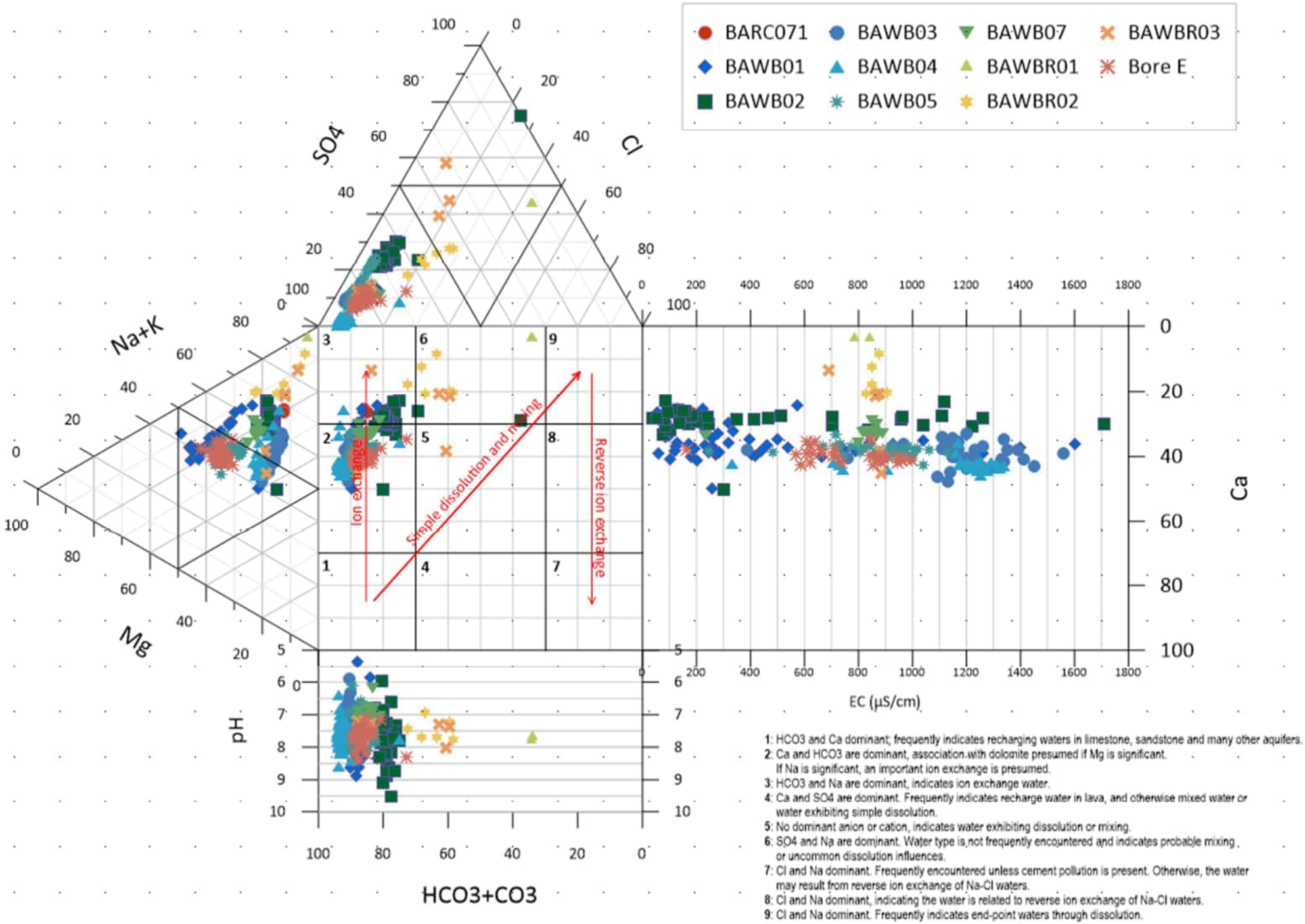


G.4 Hydrogeochemistry plots


BARC071
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
BAWBR01
BAWBR02
BAWBR03
Bore E
A: Ca-type
B: No dominant type
C: Mg-type
D: Na-type
E: HCO3-type
F: SO4-type
G: Cl-type
1: Ca-Mg-HCO3
2: Na-K-Cl-SO4
3: Mixed Ca-Na-HCO3
4: Mixed Ca-Mg-Cl
5: Ca-Mg-Cl-SO4
6: Na-K-HCO3
SO4+Cl+NO3
Ca+Mg
HCO3+CO3
SO4
Mg
Na+K


Chadha Diagram
(HCO3+CO3)-(Cl+SO4) (% meq/L)
(Ca+Mg)-(Na+K) (% meq/L)
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-120
-100
-80
-60
-40
-20
0
20
40
60
80
100
120
6
1
2
5
BARC071
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
BAWBR01
BAWBR02
BAWBR03
Bore E
1: Ca-Mg-HCO3
2: Na-K-Cl-SO4
3: Mixed Ca-Na-HCO3
4: Mixed Ca-Mg-Cl
5: Ca-Mg-Cl-SO4
6: Na-K-HCO3


Gibbs Diagram
TDS (mg/L)
100000
10000
1000
100
10
1
Evaporation Dominance
Rock Dominance
Precipitation Dominance
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Na/(Na+Ca)
Cl/(Cl+HCO3)
Legend
BAWB01
BAWB02
BAWB03
BAWB04
BAWB05
BAWB07
BAWBR01
BAWBR02
BAWBR03
Bore E



1: HCO3 and Ca dominant; frequently indicates recharging waters in limestone, sandstone and many other aquifers.
2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.
3: HCO3 and Na are dominant, indicates ion exchange water.
4: Ca and SO4 are dominant. Frequently indicates recharge water in lava, and otherwise mixed water or water exhibiting simple dissolution.
5: No dominant anion or cation, indicates water exhibiting dissolution or mixing.
6: SO4 and Na are dominant. Water type is not frequently encountered and indicates probable mixing, or uncommon dissolution influences.
7: Cl and Na dominant. Frequently encountered unless cement pollution is present. Otherwise, the water may result from reverse ion exchange of Na-Cl waters.
8: Cl and Na dominant, indicating the water is related to reverse ion exchange of Na-Cl waters.
9: Cl and Na dominant. Frequently indicates end-point waters through dissolution.

Appendix H Seepage monitoring bore results

H.1 Seepage monitoring bores data tables

Table H.1 Seepage monitoring bore sampling events

Year/ Moth	Seepage Bore 1a	Seepage Bore 1b	Seepage Bore 2a	Seepage Bore 2b	Seepage Bore 3a	Seepage Bore 3b	Seepage Bore 4a	Seepage Bore 4b	Seepage Bore 5a	Seepage Bore 5b	Seepage Bore 6a	Seepage Bore 6b	Seepage Bore 7a	Seepage Bore 8a	Seepage Bore 9a
2019															
9	✓	✓	✓	✓	✓	✓	✓	✓							
10	✓	✓	✓	✓	✓	✓	✓	✓							
11	✓	✓	✓	✓	✓	✓	✓	✓							
2020															
2	✓	✓	✓	✓	✓	✓	✓	✓							
4	✓	✓	✓	✓	✓	✓	✓	✓							
5	✓	✓	✓	✓	✓	✓	✓	✓							
6	✓	✓	✓	✓	✓	✓	✓	✓							
7	✓	✓	✓	✓	✓	✓	✓	✓							
8	✓	✓	✓	✓	✓	✓		✓							
9	✓	✓	✓	✓	✓	✓	✓	✓							
11	✓	✓	✓	✓	✓	✓	✓	✓							
12	✓	✓	✓	✓	✓	✓	✓	✓							
2021															
1	✓	✓	✓	✓	✓	✓	✓	✓							
2	✓	✓	✓	✓	✓	✓	✓	✓							
3	✓	✓	✓	✓	✓	✓	✓	✓							
4	✓	✓	✓	✓	✓	✓	✓	✓							
5	✓	✓	✓	✓	✓	✓	✓	✓							
6	✓	✓	✓	✓	✓	✓	✓	✓							
7	✓	✓	✓	✓	✓	✓	✓	✓							

Year/ Moth	Seepage Bore 1a	Seepage Bore 1b	Seepage Bore 2a	Seepage Bore 2b	Seepage Bore 3a	Seepage Bore 3b	Seepage Bore 4a	Seepage Bore 4b	Seepage Bore 5a	Seepage Bore 5b	Seepage Bore 6a	Seepage Bore 6b	Seepage Bore 7a	Seepage Bore 8a	Seepage Bore 9a
8	✓	✓	✓	✓	✓	✓	✓	✓							
9	✓	✓	✓	✓	✓	✓	✓	✓							
10	✓	✓	✓	✓	✓	✓	✓	✓							
11	✓	✓	✓	✓	✓	✓	✓	✓							
12	✓	✓	✓	✓	✓	✓	✓	✓							
2022															
1	✓	✓	✓	✓	✓	✓	✓	✓							
2	✓	✓	✓	✓	✓	✓	✓	✓							
3	✓	✓	✓	✓	✓	✓	✓	✓							
4	✓	✓	✓	✓	✓	✓	✓	✓							
5	✓	✓	✓	✓	✓	✓	✓	✓							
6	✓	✓	✓	✓	✓	✓	✓	✓							
7	✓	✓	✓	✓	✓	✓	✓	✓							
8	✓	✓	✓	✓	✓	✓	✓	✓							
9	✓	✓	✓	✓	✓	✓	✓	✓							
10	✓	✓	✓	✓	✓	✓	✓	✓							
11	✓	✓	✓	✓	✓	✓	✓	✓							
12	✓	✓	✓	✓	✓	✓	✓	✓							
2023															
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	✓	✓	✓	✓	✓	✓	✓	✓							
3	✓	✓	✓	✓	✓	✓	✓	✓							
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Year/ Moth	Seepage Bore 1a	Seepage Bore 1b	Seepage Bore 2a	Seepage Bore 2b	Seepage Bore 3a	Seepage Bore 3b	Seepage Bore 4a	Seepage Bore 4b	Seepage Bore 5a	Seepage Bore 5b	Seepage Bore 6a	Seepage Bore 6b	Seepage Bore 7a	Seepage Bore 8a	Seepage Bore 9a
5									✓	✓	✓	✓	✓	✓	✓
6									✓	✓	✓	✓	✓	✓	✓
7	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
8					✓				✓	✓	✓	✓	✓	✓	✓
9									✓	✓	✓	✓	✓	✓	✓
10	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
11									✓	✓	✓	✓	✓	✓	✓
12									✓	✓	✓	✓	✓	✓	✓

Table H.2 Descriptive statistics: seepage monitoring results (all sites)

R	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	10%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	80%ile	90%ile (> LOR)	95%ile (>LOR)	99%ile (>LOR)
Alkalinity																			
Bicarbonate Alkalinity as CaCO3 (mg/L)	193	183	10	5.2%	38	542.7760	249.5573	1200	1162	127.1	143.4	340	429	538	709.5	800.4	848.8	936.3	1104.4
Carbonate Alkalinity as CaCO3 (mg/L)	193	16	177	91.7%	8	198.0625	170.6764	659	651	8	8	13	29.5	190	239.25	282	391.5	473.75	621.95
Hydroxide Alkalinity as CaCO3 (mg/L)	193	10	183	94.8%	371	551.7000	124.5536	819	448	389.45	407.9	437.6	453.5	567	608.75	617.2	659.7	739.35	803.07
Field Measurements																			
Dissolved Oxygen (field) (% sat))	108	108			0	52.4278	76.2069	468	468	0	0	1.84	2	24	76.3	88.18	134	192.945	337.64
Electrical Conductivity (field) (µS/cm)	108	108			10.58	2128.1535	1552.4815	9912	9901.42	1027.3	1197.3	1345.4	1453	1775	2227.75	2400.2	2734.8	4124.4	9872.54
ORP (field) (mV)	108	108			-162.8	48.9500	82.4488	231.4	394.2	-63.985	-58.62	-26.06	-20.375	51.6	101	113.48	148.54	210.575	230.517
pH (field)	108	108			5.95	7.4281	1.0170	12.8	6.85	6.128	6.283	6.778	6.925	7.27	7.7925	8.014	8.272	8.8815	12.4013
Salinity (field) (PSU)	108	108			0.47	2.0795	9.7098	102	101.53	0.517	0.59	0.668	0.72	0.895	1.1525	1.236	1.513	3.5685	5.9227
TDS (field) (ppm)	108	108			24.67	30.6013	2.4089	36.26	11.59	26.527	27.438	28.494	29.0625	30.635	32.05	32.768	33.509	34.755	35.679
Temperature (field) (°C)	193	193			50	559.6632	255.7568	1480	1430	127.6	150.6	393.2	432	543	754	803	848.8	941	1172.4
Total Dissolved Solids (field) (ppm)	108	108			486	1111.6204	869.1024	5293	4807	533.35	603.7	679.6	729	893	1123.25	1199.8	1393.1	2335.6	4955.72
Turbidity (field) (FNU)	37	37			0	5.8514	6.9829	33.7	33.7	0.24	0.7	1.24	1.7	3.1	7.7	9.3	15.92	18.76	28.696
Hardness																			
Total Hardness (mg CaCO3/L)	193	193			40	591.1192	385.8419	2500	2460	308	320.4	363.8	378	514	631	677.2	888.2	1364	2348
Ion Balance																			
Ionic Balance (%)	191	191			0.06	4.7971	4.6460	24	23.94	0.45	0.75	1.28	1.665	3.46	6.19	7.83	10.9	15.85	19.95
Total Anions (meq/L)	193	193			1.36	26.5007	17.5837	109	107.64	11	13.1	16.44	18.1	22.5	28.6	29.82	38.12	47	104
Total Cations (meq/L)	193	193			1.27	28.8345	19.7506	119	117.73	11.8	13.8	17.54	18.8	24.2	30.4	31.98	44.68	64.8	110.32
Major Ions																			
Calcium (mg/L)	386	386			4	129.6865	95.6918	483	479	32	54	64	72	106	146	161	244.5	369.75	470
Chloride (mg/L)	193	193			6	203.0363	374.0589	2170	2164	36.8	48.8	64	69	116	161	181	276	408.8	2031.6
Fluoride (mg/L)	193	193			0.2	1.6119	1.1312	5.8	5.6	0.2	0.52	1	1	1.4	1.9	2.06	2.6	4.34	5.432
Magnesium (mg/L)	386	367	19	4.9%	3	71.6076	47.9622	316	313	27.3	32	42	46	58	86	92	113.2	161.5	296.34
Potassium (mg/L)	386	383	3	0.8%	1	9.7363	15.1308	120	119	2	2	4	4	6	8	9	15.8	45.1	79.08
Sodium (mg/L)	386	386			11	389.5181	411.2366	2500	2489	118.25	146.5	186	196	302.5	421	437	510.5	765.75	2337.5
Sulfate (as SO4)	193	193			9	460.9482	437.1279	1910	1901	48.6	67.2	91	110	311	650	701.4	1118	1568	1732.8
Metals (dissolved)																			
Arsenic - dissolved (mg/L)	194	119	75	38.7%	0.001	0.0027	0.0016	0.008	0.007	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.005	0.006	0.007
Barium - dissolved (mg/L)	194	194			0.042	0.1382	0.0587	0.329	0.287	0.06265	0.0773	0.089	0.09225	0.1245	0.17875	0.192	0.2187	0.24285	0.29821
Bismuth - dissolved (mg/L)	194		194	100.0%															
Chromium - dissolved (mg/L)	194	15	179	92.3%	0.001	0.0150	0.0122	0.05	0.049	0.0017	0.002	0.0028	0.004	0.015	0.021	0.022	0.0226	0.0311	0.04622
Cobalt - dissolved (mg/L)	194	119	75	38.7%	0.001	0.0022	0.0014	0.009	0.008	0.001	0.001	0.001	0.001	0.002	0.003	0.003	0.004	0.005	0.006
Copper - dissolved (mg/L)	194	117	77	39.7%	0.001	0.0062	0.0088	0.04	0.039	0.001	0.001	0.001	0.001	0.002	0.007	0.0088	0.0124	0.0302	0.03484
Molybdenum - dissolved (mg/L)	194	188	6	3.1%	0.001	0.0279	0.0705	0.612	0.611	0.002	0.002	0.003	0.003	0.005	0.01525	0.0186	0.0663	0.1871	0.28234
Nickel - dissolved (mg/L)	194	87	107	55.2%	0.001	0.0041	0.0046	0.015	0.014	0.001	0.001	0.001	0.001	0.002	0.004	0.004	0.014	0.015	0.015
Selenium - dissolved (mg/L)	194	55	139	71.6%	0.01	0.0584	0.0668	0.3	0.29	0.02	0.02	0.02	0.02	0.03	0.06	0.07	0.12	0.243	0.2946
Uranium - dissolved (mg/L)	194	179	15	7.7%	0.001	0.0263	0.0558	0.328	0.327	0.003	0.004	0.006	0.008	0.013	0.018	0.0204	0.0264	0.1829	0.29328

R	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	Range (>LOR)	5%ile (>LOR)	10%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	80%ile	90%ile (> LOR)	95%ile (>LOR)	99%ile (>LOR)
Metals (total)																			
Arsenic - total (mg/L)	194	127	67	34.5%	0.001	0.0030	0.0019	0.01	0.009	0.001	0.001	0.001	0.002	0.002	0.004	0.004	0.006	0.008	0.00874
Barium - total (mg/L)	194	194			0.048	0.1479	0.0628	0.362	0.314	0.06495	0.0863	0.0958	0.101	0.13	0.19375	0.202	0.233	0.2667	0.31017
Bismuth - total (mg/L)	194	1	193	99.5%	0.00014	0.0001	0.0000	0.00014	0	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014
Chromium - total (mg/L)	194	27	167	86.1%	0.001	0.0133	0.0247	0.132	0.131	0.001	0.001	0.002	0.002	0.003	0.018	0.0206	0.023	0.0237	0.10392
Cobalt - total (mg/L)	194	155	39	20.1%	0.001	0.0027	0.0018	0.016	0.015	0.001	0.001	0.001	0.002	0.002	0.003	0.004	0.005	0.006	0.00838
Copper - total (mg/L)	194	177	17	8.8%	0.001	0.0079	0.0102	0.073	0.072	0.001	0.002	0.002	0.003	0.004	0.009	0.01	0.0148	0.032	0.04644
Molybdenum - total (mg/L)	194	190	4	2.1%	0.001	0.0303	0.0757	0.66	0.659	0.002	0.003	0.003	0.004	0.006	0.01775	0.02	0.0744	0.17595	0.32288
Nickel - total (mg/L)	194	101	93	47.9%	0.001	0.0056	0.0143	0.142	0.141	0.001	0.001	0.001	0.002	0.002	0.004	0.004	0.014	0.016	0.016
Selenium - total (mg/L)	194	55	139	71.6%	0.01	0.0607	0.0663	0.29	0.28	0.02	0.02	0.02	0.02	0.03	0.06	0.09	0.126	0.239	0.2846
Uranium - total (mg/L)	194	180	14	7.2%	0.001	0.0280	0.0567	0.325	0.324	0.004	0.005	0.007	0.008	0.014	0.02	0.0222	0.0291	0.1909	0.29352
Physico-Chemical Parameters																			
Electrical Conductivity (µS/cm)	193	193			109	2637.8756	1868.4069	11200	11091	1020	1198	1544	1650	2090	2750	3128	4550	5462	10200
pH (lab)	193	193			6.65	7.9548	0.9851	12.1	5.45	7.2	7.32	7.504	7.56	7.78	7.99	8.056	8.22	9.972	12
Turbidity (NTU)	193	192	1	0.5%	0.1	8.6417	35.7670	477	476.9	0.3	0.5	0.6	0.8	2.4	5.65	6.6	14.51	38.7	62.424

Table H.3 Descriptive statistics: seepage monitoring results (by location)

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Seepage Bore 1a														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	10	10			446	508.0000	37.9368	578	456.35	473	477	510.5	535.75	562.25
Carbonate Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Hydroxide Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Temperature (field) (°C)	10	10			446	508.0000	37.9368	578	456.35	473	477	510.5	535.75	562.25
Field Measurements														
Appearance or Colour	6													
Depth of Bore (mbgl)	42	42			6	6.0000	0.0000	6	6	6	6	6	6	6
Depth to Water (mbRL)	34	34			3.17	4.9118	0.8504	6.43	3.766	4.412	4.4475	4.72	5.145	6.417
Depth to Water (mbGL)	3	3			6.17	6.2833	0.0865	6.38	6.183	6.222	6.235	6.3	6.34	6.372
Depth to Water Comments	11													
Dissolved Oxygen (field) (% sat))	6	6			0	64.4000	52.4729	136.1	0.5	2	13.575	65.9	108.25	131.2
Dry?	11													
Electrical Conductivity (field) (µS/cm)	6	6			1241	2196.6667	538.6259	2730	1364	1733	1894.25	2387	2625.5	2723
Groundwater Level (mAHD)	34	34			306.61	332.5229	17.3126	373.54	306.9665	320.22	321.0875	329.67	344.45675	373.4085
GWL Depth Reference Elevation	42	42			311.33	338.7630	16.2100	378.09	311.9595	326.76	327.555	335.23	353.32	376.97855
Odour	6													

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
ORP (field) (mV)	6	6			-63.4	20.2167	59.1466	100.8	-53.6	-24.2	-23.2	19.8	66.325	92.725
pH (field)	6	6			7.1	7.5417	0.3051	7.9	7.115	7.16	7.275	7.645	7.7675	7.875
Salinity (field) (PSU)	6	6			0.61	1.1150	0.2868	1.39	0.6725	0.86	0.9475	1.22	1.35	1.39
TDS (field) (ppm)	6	6			26.91	30.2550	1.9055	32.68	27.42	28.95	29.2325	30.655	31.5675	32.43
Total Dissolved Solids (field) (ppm)	6	6			620	1097.0000	270.7520	1365	679.5	858	941	1194	1312.75	1361.5
Hardness														
Total Hardness (mg CaCO3/L)	10	10			616	875.6000	153.3905	1180	654.25	769.8	801.75	869.5	929.75	1121.5
Ion Balance														
Ionic Balance (%)	10	10			0.11	3.2520	1.6259	5.53	0.722	1.862	2.13	3.74	4	5.476
Total Anions (meq/L)	10	10			14.4	27.0600	5.9126	34.2	16.02	24.32	26.3	29	30.425	33.345
Total Cations (meq/L)	10	10			14.4	27.0800	6.2483	34.2	15.39	24.68	26.775	28.7	31.3	33.435
Major Ions														
Calcium (mg/L)	20	20			207	284.3500	59.8576	415	213.65	242.4	243.75	264	308.25	404.55
Chloride (mg/L)	10	10			65	192.6000	63.0955	301	101	148.2	153.5	192	235.75	278.05
Fluoride (mg/L)	10	10			0.2	0.4500	0.2500	0.9	0.2	0.2	0.225	0.35	0.65	0.855
Magnesium (mg/L)	20	20			24	44.8000	19.0594	89	24	30.8	31.75	36.5	58.25	83.3
Potassium (mg/L)	20	20			1	2.5000	1.1180	4	1	1.8	2	2	4	4
Sodium (mg/L)	20	20			46	220.2000	97.9043	353	46.95	155.2	180.25	229.5	300.25	347.3
Sulfate (as SO4)	10	10			116	551.7000	199.5059	747	170.9	496.4	562	603	685	738.45
Metals (dissolved)														
Arsenic - dissolved (mg/L)	10		10	100.0										
Barium - dissolved (mg/L)	10	10			0.084	0.1407	0.0846	0.329	0.084	0.084	0.08575	0.103	0.13125	0.30785

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Bismuth - dissolved (mg/L)	10		10	100.0										
Chromium - dissolved (mg/L)	10		10	100.0										
Cobalt - dissolved (mg/L)	10	8	2	20.0	0.001	0.0028	0.0025	0.009	0.001	0.001	0.001	0.002	0.0025	0.00725
Copper - dissolved (mg/L)	10	4	6	60.0	0.001	0.0020	0.0007	0.003	0.00115	0.0016	0.00175	0.002	0.00225	0.00285
Molybdenum - dissolved (mg/L)	10	9	1	10.0	0.001	0.0019	0.0009	0.003	0.001	0.001	0.001	0.002	0.003	0.003
Nickel - dissolved (mg/L)	10	4	6	60.0	0.001	0.0018	0.0004	0.002	0.00115	0.0016	0.00175	0.002	0.002	0.002
Selenium - dissolved (mg/L)	10	1	9	90.0	0.02	0.0200	0.0000	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Uranium - dissolved (mg/L)	10	10			0.012	0.0139	0.0015	0.016	0.012	0.0128	0.013	0.0135	0.0155	0.016
Metals (total)														
Arsenic - total (mg/L)	10	1	9	90.0	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Barium - total (mg/L)	10	10			0.086	0.1558	0.0989	0.362	0.0878	0.0956	0.09725	0.109	0.14	0.35165
Bismuth - total (mg/L)	10		10	100.0										
Chromium - total (mg/L)	10		10	100.0										
Cobalt - total (mg/L)	10	9	1	10.0	0.001	0.0037	0.0024	0.01	0.0014	0.0026	0.003	0.003	0.003	0.008
Copper - total (mg/L)	10	10			0.001	0.0042	0.0026	0.01	0.00145	0.002	0.00225	0.0035	0.005	0.00865
Molybdenum - total (mg/L)	10	9	1	10.0	0.001	0.0021	0.0006	0.003	0.0014	0.002	0.002	0.002	0.002	0.003
Nickel - total (mg/L)	10	5	5	50.0	0.001	0.0020	0.0006	0.003	0.0012	0.0018	0.002	0.002	0.002	0.0028
Selenium - total (mg/L)	10	1	9	90.0	0.02	0.0200	0.0000	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Uranium - total (mg/L)	10	10			0.012	0.0150	0.0018	0.019	0.0129	0.014	0.014	0.0145	0.01575	0.0181
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	10	10			1320	2357.0000	518.2866	2880	1414.5	2050	2205	2540	2742.5	2857.5

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
pH (lab)	10	10			7.27	7.6160	0.2141	7.9	7.3105	7.368	7.4175	7.635	7.7875	7.882
Turbidity (NTU)	10	10			0.4	3.1200	2.6095	8.9	0.445	0.9	1.1	2.05	4.95	7.19
Seepage Bore 1b														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	18	18			135	527.3889	110.9140	697	401.05	494.4	506.5	540.5	568.25	639.2
Carbonate Alkalinity as CaCO3 (mg/L)	18	1	17	94.4	8	8.0000	0.0000	8	8	8	8	8	8	8
Hydroxide Alkalinity as CaCO3 (mg/L)	18		18	100.0										
Temperature (field) (°C)	18	18			143	527.8333	109.3457	697	402.25	494.4	506.5	540.5	568.25	639.2
Field Measurements														
Appearance or Colour	12													
Depth of Bore (mbgl)	42	42			16	16.0000	0.0000	16	16	16	16	16	16	16
Depth to Water (mbRL)	42	42			3.09	5.6521	1.4948	9.17	4.0065	4.512	4.5525	5.045	6.965	8.3105
Depth to Water (mbGL)	6	6			6.27	6.8533	0.3318	7.22	6.3525	6.6	6.665	6.93	7.1275	7.2075
Dissolved Oxygen (field) (% sat))	15	15			0	46.6333	59.7785	193.4	0	1.52	2.4	15.2	68.6	169.88

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Electrical Conductivity (field) (µS/cm)	15	15			1232	2114.1333	759.7664	3789	1308.3	1436.8	1458	1908	2533	3425.7
Groundwater Level (mAHD)	42	42			306.41	334.3304	15.3054	373.38	316.8895	324.3588	324.84825	329.6285	348.23825	372.20455
GWL Depth Reference Elevation	42	42			311.33	339.9825	14.9648	378.09	324.062	329.94	330.22	335.23	353.32	376.97855
Odour	12													
ORP (field) (mV)	15	15			-64.3	60.0000	89.1381	231	-64.3	-15.7	-2.15	77	114.7	207.06
pH (field)	15	15			6.1	7.1253	0.5840	8.03	6.1	6.542	6.795	7.27	7.55	7.904
Salinity (field) (PSU)	15	15			0.6	1.0720	0.4078	1.98	0.642	0.708	0.72	0.96	1.29	1.777
TDS (field) (ppm)	15	15			25.11	31.1307	2.6510	35.7	25.971	29.754	30.02	31.64	33.09	34.181
Total Dissolved Solids (field) (ppm)	15	15			616	1057.1333	379.8327	1894	654.5	718.4	729	954	1266	1712.7
Turbidity (field) (FNU)	8	8			0.7	8.4375	7.3043	18.5	0.7	1.1	1.45	6.6	15.275	18.5
Hardness														
Total Hardness (mg CaCO3/L)	18	18			90	609.1667	289.8753	1340	300.8	380.8	417.5	558	724.75	1076.5
Ion Balance														
Ionic Balance (%)	18	18			0.68	4.0339	2.9762	10.9	0.714	1.292	1.38	3.245	5.9	9.1235
Total Anions (meq/L)	18	18			3.81	23.4283	9.5342	44.6	12.1315	15.94	16.5	23.7	26.8	39.16
Total Cations (meq/L)	18	18			3.2	24.8667	10.1932	46.7	12.72	16.3	17.075	24.9	30.5	40.41
Major Ions														
Calcium (mg/L)	36	36			18	123.8611	55.1040	280	69	85	87.5	109.5	139.5	226.25
Chloride (mg/L)	18	18			11	136.8889	95.4969	410	49.25	68.4	71	108.5	159.5	296.1
Fluoride (mg/L)	18	18			1	1.5056	0.2818	2	1	1.34	1.4	1.5	1.6	1.915
Magnesium (mg/L)	36	36			11	76.7222	35.1699	166	32.75	48	50	70.5	92.25	139.75

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Potassium (mg/L)	36	35	1	2.8	4	5.9429	0.9840	8	5	5	5	6	6	8
Sodium (mg/L)	36	36			32	293.1111	97.7269	453	167.75	197	201.25	319.5	365.25	432.5
Sulfate (as SO4)	18	18			31	433.3333	325.0398	1130	53.95	81.2	104.75	463	614.5	950.65
Metals (dissolved)														
Arsenic - dissolved (mg/L)	19	19			0.001	0.0029	0.0009	0.004	0.0019	0.002	0.002	0.003	0.0035	0.004
Barium - dissolved (mg/L)	19	19			0.06	0.1119	0.0568	0.274	0.0618	0.0642	0.0725	0.096	0.1195	0.2182
Bismuth - dissolved (mg/L)	19		19	100.0										
Chromium - dissolved (mg/L)	19		19	100.0										
Cobalt - dissolved (mg/L)	19	15	4	21.1	0.001	0.0020	0.0013	0.006	0.001	0.001	0.001	0.002	0.002	0.0039
Copper - dissolved (mg/L)	19	15	4	21.1	0.001	0.0014	0.0006	0.003	0.001	0.001	0.001	0.001	0.002	0.0023
Molybdenum - dissolved (mg/L)	19	19			0.003	0.0039	0.0011	0.007	0.003	0.003	0.003	0.004	0.004	0.0061
Nickel - dissolved (mg/L)	19	1	18	94.7	0.003	0.0030	0.0000	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Selenium - dissolved (mg/L)	19	2	17	89.5	0.02	0.0250	0.0050	0.03	0.0205	0.022	0.0225	0.025	0.0275	0.0295
Uranium - dissolved (mg/L)	19	19			0.005	0.0128	0.0056	0.026	0.005	0.0076	0.0085	0.014	0.015	0.0224
Metals (total)														
Arsenic - total (mg/L)	19	18	1	5.3	0.002	0.0031	0.0008	0.004	0.002	0.002	0.00225	0.003	0.004	0.004
Barium - total (mg/L)	19	19			0.063	0.1178	0.0552	0.27	0.063	0.081	0.087	0.102	0.124	0.225
Bismuth - total (mg/L)	19		19	100.0										
Chromium - total (mg/L)	19		19	100.0										
Cobalt - total (mg/L)	19	14	5	26.3	0.001	0.0026	0.0013	0.007	0.00165	0.002	0.002	0.002	0.003	0.0044
Copper - total (mg/L)	19	19			0.001	0.0038	0.0024	0.01	0.001	0.002	0.002	0.003	0.005	0.0091

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Molybdenum - total (mg/L)	19	19			0.003	0.0045	0.0011	0.008	0.003	0.004	0.004	0.004	0.005	0.0062
Nickel - total (mg/L)	19	4	15	78.9	0.001	0.0013	0.0004	0.002	0.001	0.001	0.001	0.001	0.00125	0.00185
Selenium - total (mg/L)	19	2	17	89.5	0.02	0.0250	0.0050	0.03	0.0205	0.022	0.0225	0.025	0.0275	0.0295
Uranium - total (mg/L)	19	19			0.005	0.0146	0.0055	0.026	0.0059	0.0106	0.0115	0.015	0.016	0.0251
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	18	18			267	2115.9444	847.3263	3910	1043.05	1400	1460	2100	2707.5	3315
pH (lab)	18	18			7.16	7.7428	0.2876	8.42	7.3045	7.548	7.59	7.73	7.8875	8.114
Turbidity (NTU)	18	18			0.2	7.0500	13.6646	48.4	0.2	0.74	0.85	1.15	4.225	42.62
Seepage Bore 2a														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	13	13			286	511.3846	149.6244	690	292	342.8	353	582	649	684.6
Carbonate Alkalinity as CaCO3 (mg/L)	13		13	100.0										
Hydroxide Alkalinity as CaCO3 (mg/L)	13		13	100.0										
Temperature (field) (°C)	13	13			286	511.3846	149.6244	690	292	342.8	353	582	649	684.6
Field Measurements														
Appearance or Colour	7													
Depth of Bore (mbgl)	42	42			6	6.0333	0.1491	6.7	6	6	6	6	6	6
Depth to Water (mbRL)	41	41			0.67	4.1100	2.0912	7.12	0.85	1.67	1.86	5.13	5.58	6.8
Depth to Water (mbGL)	6	6			5.43	5.5883	0.1336	5.82	5.445	5.49	5.495	5.545	5.67	5.79
Depth to Water Comments	4													
Dissolved Oxygen (field) (% sat))	7	7			2	69.5143	42.4591	110.6	2.69	21.38	47	90.7	94.65	105.95

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Dry?	4													
Electrical Conductivity (field) (µS/cm)	7	7			10.58	5298.6543	3973.8157	9912	695.906	2350.8	2434.5	2879	9710	9908.1
Groundwater Level (mAHD)	41	41			306.2	336.2881	18.0595	377.3	306.6	323.1	324.97	331.867	350.351	376.23
GWL Depth Reference Elevation	42	42			311.33	339.7060	17.7596	378.09	311.33	327.396	330.01	335.005	355.18825	376.97855
Odour	7													
ORP (field) (mV)	7	7			-78.5	45.3714	78.7164	199.5	-58.52	-2.78	10.9	45.9	64.45	161.4
pH (field)	7	7			7.75	8.3186	0.3979	8.92	7.822	8.004	8.025	8.3	8.605	8.887
Salinity (field) (PSU)	7	7			1.17	3.7557	2.1186	5.95	1.212	1.344	1.395	5.29	5.545	5.833
TDS (field) (ppm)	7	7			26.52	29.7500	1.7122	31.86	27.072	28.55	28.835	30.24	30.98	31.701
Total Dissolved Solids (field) (ppm)	7	7			1148	3405.2857	1837.8282	5293	1189.7	1317.6	1363.5	4761	4954	5191.9
Turbidity (field) (FNU)	1	1			19.8	19.8000	0.0000	19.8	19.8	19.8	19.8	19.8	19.8	19.8
Hardness														
Total Hardness (mg CaCO3/L)	13	13			329	466.1538	78.3845	578	339.2	383.2	436	483	520	563
Ion Balance														
Ionic Balance (%)	13	13			0.28	2.5208	2.2004	6.68	0.304	0.396	0.48	2.08	2.99	6.578
Total Anions (meq/L)	13	13			26	72.2846	35.6054	109	26.24	26.94	27.3	96	100	106
Total Cations (meq/L)	13	13			25.5	76.4385	39.4531	119	25.62	26.98	27.4	101	110	116
Major Ions														
Calcium (mg/L)	26	26			86	111.5000	17.8525	150	86.75	96	97.5	113.5	124.75	144.25
Chloride (mg/L)	13	13			276	1329.9231	800.4024	2170	284.4	318.6	342	1860	1950	2098
Fluoride (mg/L)	13	13			1	3.7077	2.0660	5.8	1.06	1.14	1.2	5.1	5.4	5.8

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Magnesium (mg/L)	26	26			23	46.8077	16.1508	64	23.25	25	29.25	55.5	60	63.75
Potassium (mg/L)	26	26			9	13.6923	2.3496	16	10	10	13	14.5	16	16
Sodium (mg/L)	26	26			414	1537.5385	881.9129	2500	421.5	427	436	2085	2247.5	2427.5
Sulfate (as SO4)	13	13			515	1180.9231	490.4217	1630	522.2	555.6	564	1490	1600	1624
Metals (dissolved)														
Arsenic - dissolved (mg/L)	13	13			0.001	0.0025	0.0012	0.004	0.001	0.001	0.001	0.003	0.003	0.004
Barium - dissolved (mg/L)	13	13			0.06	0.0853	0.0166	0.121	0.0618	0.0696	0.075	0.085	0.091	0.112
Bismuth - dissolved (mg/L)	13		13	100.0										
Chromium - dissolved (mg/L)	13		13	100.0										
Cobalt - dissolved (mg/L)	13	8	5	38.5	0.001	0.0011	0.0003	0.002	0.001	0.001	0.001	0.001	0.001	0.00165
Copper - dissolved (mg/L)	13	13			0.002	0.0069	0.0028	0.01	0.0026	0.0034	0.004	0.008	0.009	0.01
Molybdenum - dissolved (mg/L)	13	13			0.014	0.0307	0.0130	0.05	0.014	0.0154	0.016	0.032	0.038	0.0494
Nickel - dissolved (mg/L)	13	12	1	7.7	0.001	0.0018	0.0009	0.004	0.001	0.001	0.001	0.002	0.002	0.00345
Selenium - dissolved (mg/L)	13	8	5	38.5	0.05	0.0538	0.0048	0.06	0.05	0.05	0.05	0.05	0.06	0.06
Uranium - dissolved (mg/L)	13	13			0.014	0.1653	0.1212	0.328	0.0152	0.0196	0.022	0.204	0.254	0.3184
Metals (total)														
Arsenic - total (mg/L)	13	13			0.001	0.0029	0.0014	0.005	0.001	0.0014	0.002	0.003	0.004	0.005
Barium - total (mg/L)	13	13			0.063	0.0911	0.0200	0.131	0.0666	0.0734	0.074	0.09	0.1	0.1274
Bismuth - total (mg/L)	13		13	100.0										
Chromium - total (mg/L)	13	2	11	84.6	0.002	0.0020	0.0000	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Cobalt - total (mg/L)	13	9	4	30.8	0.001	0.0022	0.0010	0.005	0.0014	0.002	0.002	0.002	0.002	0.0038

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Copper - total (mg/L)	13	13			0.003	0.0106	0.0046	0.02	0.0048	0.007	0.007	0.01	0.012	0.0194
Molybdenum - total (mg/L)	13	13			0.018	0.0358	0.0130	0.054	0.018	0.0206	0.023	0.038	0.044	0.0528
Nickel - total (mg/L)	13	13			0.001	0.0032	0.0023	0.01	0.001	0.0014	0.002	0.002	0.004	0.007
Selenium - total (mg/L)	13	8	5	38.5	0.05	0.0563	0.0048	0.06	0.05	0.05	0.05	0.06	0.06	0.06
Uranium - total (mg/L)	13	13			0.014	0.1705	0.1220	0.325	0.0164	0.0212	0.023	0.23	0.261	0.3118
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	13	13			2340	7036.1538	3601.7806	11200	2418	2550	2640	9230	10100	10600
pH (lab)	13	13			7.99	8.1323	0.0782	8.25	8.002	8.074	8.08	8.15	8.2	8.232
Turbidity (NTU)	13	13			0.4	2.8462	2.6590	9.4	0.58	0.7	0.7	1.8	3.9	8.08
Seepage Bore 2b														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	19	19			160	574.8421	115.3682	694	468.7	528.8	537	603	660	681.4
Carbonate Alkalinity as CaCO3 (mg/L)	19	1	18	94.7	8	8.0000	0.0000	8	8	8	8	8	8	8
Hydroxide Alkalinity as CaCO3 (mg/L)	19		19	100.0										
Temperature (field) (°C)	19	19			168	575.2632	113.8581	694	469.5	528.8	537	603	660	681.4
Field Measurements														
Appearance or Colour	11													
Depth of Bore (mbgl)	42	42			16	16.0000	0.0000	16	16	16	16	16	16	16
Depth to Water (mbRL)	42	42			0.05	1.5783	0.9540	3.63	0.2735	0.932	0.9825	1.18	2.465	3.4155
Depth to Water (mbGL)	5	5			2.17	2.3720	0.1197	2.49	2.2	2.29	2.32	2.39	2.49	2.49
Dissolved Oxygen (field) (% sat))	15	15			0	52.8067	79.1845	252.5	0	0	0.95	9.1	62.85	210.22

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Electrical Conductivity (field) (µS/cm)	15	15			1206	1611.8000	368.9174	2554	1209.5	1229	1306.5	1546	1887.5	2172.5
Groundwater Level (mAHD)	42	42			308.59	337.6785	18.4241	377.11	310.2955	328.488	328.704	332.609	352.24	377.087
GWL Depth Reference Elevation	42	42			311.33	339.2569	18.2684	378.09	311.33	329.94	330.22	333.746	353.32	378.09
Odour	10													
ORP (field) (mV)	15	15			-43.4	93.1133	66.3781	216.7	1.05	48.04	52.3	100.8	118.5	212.78
pH (field)	15	15			6.02	7.0687	0.6131	8.1	6.02	6.62	6.775	7.18	7.525	7.883
Salinity (field) (PSU)	15	15			0.59	0.7940	0.1708	1.15	0.59	0.6	0.645	0.77	0.95	1.052
TDS (field) (ppm)	15	15			27.83	31.1840	2.4788	36.26	27.935	28.014	29.22	31.28	32.25	35.49
Total Dissolved Solids (field) (ppm)	15	15			603	795.8667	161.1975	1127	605.1	614	653	774	943.5	1040.9
Turbidity (field) (FNU)	7	7			1.1	7.7000	10.6796	33.7	1.7	3.1	3.1	3.4	4.75	25.18
Hardness														
Total Hardness (mg CaCO3/L)	19	19			81	457.3684	143.0735	702	285.3	354.2	363.5	440	530.5	682.2
Ion Balance														
Ionic Balance (%)	19	19			0.24	2.6937	2.4545	10.7	0.528	0.984	1.145	1.89	2.755	6.56
Total Anions (meq/L)	19	19			3.99	17.6626	4.7968	23.4	12.189	13.76	14.55	17.1	21.35	23.04
Total Cations (meq/L)	19	19			3.21	18.1058	5.2559	26	12.021	14.16	15.2	17.5	21.5	25.19
Major Ions														
Calcium (mg/L)	38	38			16	104.2632	28.5571	160	72.4	79.4	81.25	106.5	122	152.3
Chloride (mg/L)	19	19			12	102.4737	40.5805	154	48.9	59.2	61	106	142	145
Fluoride (mg/L)	19	19			1	1.2842	0.1843	1.6	1	1.1	1.15	1.3	1.4	1.6
Magnesium (mg/L)	38	38			10	50.7632	14.8225	79	32.7	36	38	49	59	74.45
Potassium (mg/L)	38	38			1	6.6579	1.1760	8	5	6	6	7	7	8
Sodium (mg/L)	38	38			36	205.8158	48.6220	272	148.75	169.4	172.25	200	245	266.75
Sulfate (as SO4)	19	19			14	157.2632	90.6693	361	55.4	68.2	73.5	138	201	314.2

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Metals (dissolved)														
Arsenic - dissolved (mg/L)	19	4	15	78.9	0.001	0.0013	0.0004	0.002	0.001	0.001	0.001	0.001	0.00125	0.00185
Barium - dissolved (mg/L)	19	19			0.106	0.2053	0.0276	0.239	0.1816	0.1936	0.1945	0.208	0.222	0.2309
Bismuth - dissolved (mg/L)	19		19	100.0										
Chromium - dissolved (mg/L)	19		19	100.0										
Cobalt - dissolved (mg/L)	19	2	17	89.5	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper - dissolved (mg/L)	19	11	8	42.1	0.001	0.0017	0.0009	0.004	0.001	0.001	0.001	0.002	0.002	0.003
Molybdenum - dissolved (mg/L)	19	19			0.003	0.0041	0.0010	0.006	0.003	0.003	0.003	0.004	0.005	0.006
Nickel - dissolved (mg/L)	19	7	12	63.2	0.001	0.0011	0.0003	0.002	0.001	0.001	0.001	0.001	0.001	0.0017
Selenium - dissolved (mg/L)	19		19	100.0										
Uranium - dissolved (mg/L)	19	19			0.005	0.0142	0.0056	0.021	0.0059	0.008	0.008	0.016	0.0195	0.021
Metals (total)														
Arsenic - total (mg/L)	19	6	13	68.4	0.001	0.0013	0.0005	0.002	0.001	0.001	0.001	0.001	0.00175	0.002
Barium - total (mg/L)	19	19			0.111	0.2178	0.0323	0.266	0.174	0.2012	0.2055	0.224	0.2345	0.2534
Bismuth - total (mg/L)	19	1	18	94.7	0.00014	0.0001	0.0000	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014	0.00014
Chromium - total (mg/L)	19	2	17	89.5	0.001	0.0020	0.0010	0.003	0.0011	0.0014	0.0015	0.002	0.0025	0.0029
Cobalt - total (mg/L)	19	12	7	36.8	0.001	0.0019	0.0011	0.005	0.001	0.001	0.001	0.002	0.002	0.0039
Copper - total (mg/L)	19	19			0.002	0.0083	0.0149	0.07	0.002	0.003	0.003	0.003	0.007	0.0178
Molybdenum - total (mg/L)	19	19			0.003	0.0046	0.0011	0.007	0.003	0.004	0.004	0.004	0.0055	0.0061
Nickel - total (mg/L)	19	9	10	52.6	0.001	0.0019	0.0010	0.004	0.001	0.001	0.001	0.002	0.002	0.0036
Selenium - total (mg/L)	19		19	100.0										

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Uranium - total (mg/L)	19	19			0.006	0.0157	0.0060	0.024	0.0069	0.008	0.0085	0.018	0.0205	0.0231
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	19	19			248	1561.4737	450.8181	2210	1068.8	1190	1245	1550	1865	2147
pH (lab)	19	19			7.28	7.7558	0.2684	8.45	7.361	7.516	7.595	7.76	7.915	8.09
Turbidity (NTU)	19	19			0.2	9.5579	18.1888	74.8	0.47	1.08	1.35	3.1	5.7	45.91
Seepage Bore 3a														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	20	20			38	510.6500	212.0121	1060	400.9	429.6	430.75	454	494.5	965
Carbonate Alkalinity as CaCO3 (mg/L)	20	1	19	95.0	13	13.0000	0.0000	13	13	13	13	13	13	13
Hydroxide Alkalinity as CaCO3 (mg/L)	20		20	100.0										
Temperature (field) (°C)	20	20			50	511.2500	210.6865	1060	401.5	429.6	430.75	454	494.5	965
Field Measurements														
Appearance or Colour	12													
Depth of Bore (mbgl)	42	42			6	6.0000	0.0000	6	6	6	6	6	6	6
Depth to Water (mbRL)	42	42			1.34	2.3983	0.5270	3.6	1.567	2.094	2.135	2.245	2.77	3.488
Depth to Water (mbGL)	6	6			2.58	2.7300	0.0879	2.83	2.5975	2.65	2.6725	2.76	2.795	2.8225
Dissolved Oxygen (field) (% sat))	16	16			0	42.8563	81.7536	343.1	0	0	1.35	7.7	47.125	142.775
Electrical Conductivity (field) (µS/cm)	16	16			1093	1714.5625	423.5285	2746	1156	1229	1335.5	1720	2034	2230.75
Groundwater Level (mAHD)	42	42			308.53	335.6640	17.9143	375.89	309.331	324.228	325.375	330.649	351.1375	375.798
GWL Depth Reference Elevation	42	42			311.33	338.0624	17.8890	378.09	311.33	326.76	326.76	333.436	353.32	378.09
Odour	11													

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
ORP (field) (mV)	16	16			-63.3	71.1875	73.6103	223.9	-36.3	30.8	34.775	64.5	102.575	213.175
pH (field)	16	16			6.33	6.9913	0.3921	7.75	6.33	6.63	6.7275	7.075	7.2375	7.525
Salinity (field) (PSU)	16	16			0.53	7.1694	24.4861	102	0.5675	0.61	0.6625	0.86	1.03	26.5575
TDS (field) (ppm)	16	16			25.84	30.8113	2.8376	35.19	25.9825	28.45	28.9675	30.515	33.59	34.5225
Total Dissolved Solids (field) (ppm)	16	16			547	857.3125	211.7583	1373	577.75	615	667.5	860	1017	1114.25
Turbidity (field) (FNU)	7	7			0	5.1143	3.6795	9.9	0.66	2.36	2.6	3.2	8.75	9.9
Hardness														
Total Hardness (mg CaCO3/L)	20	20			40	482.8500	172.5599	787	278.45	315	331	506	559.25	744.25
Ion Balance														
Ionic Balance (%)	19	19			0.22	3.3884	2.6865	12.3	0.553	1.46	1.77	3.06	4.07	7.404
Total Anions (meq/L)	20	20			1.36	18.8880	7.3967	33.6	10.613	12.4	14.475	18.9	22.125	32.365
Total Cations (meq/L)	20	20			1.27	19.3735	7.7406	36.6	11.2735	12.62	13.15	19.05	23.5	32.04
Major Ions														
Calcium (mg/L)	40	40			11	114.3000	35.7402	170	71.2	75.8	77	117.5	143.5	160.1
Chloride (mg/L)	20	20			6	157.3500	82.0386	294	49.7	78.4	107	155	208.25	276.9
Fluoride (mg/L)	20	20			0.5	1.1950	0.2765	1.6	0.69	1	1	1.3	1.4	1.505
Magnesium (mg/L)	40	40			3	49.7250	19.8834	92	26.3	32.4	35.75	46.5	58.25	82.3
Potassium (mg/L)	40	39	1	2.5	3	6.4359	1.9585	10	4	5	5	6	6.5	10
Sodium (mg/L)	40	40			11	222.5500	102.9424	498	121.1	146.8	149.5	189.5	275	389.5
Sulfate (as SO4)	20	20			9	203.6000	104.9030	376	50.8	84.8	121.25	222	278.25	342.75
Metals (dissolved)														
Arsenic - dissolved (mg/L)	20	5	15	75.0	0.001	0.0014	0.0005	0.002	0.001	0.001	0.001	0.001	0.002	0.002
Barium - dissolved (mg/L)	20	20			0.123	0.1699	0.0362	0.25	0.1249	0.1362	0.143	0.1675	0.195	0.23195
Bismuth - dissolved (mg/L)	20		20	100.0										

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Chromium - dissolved (mg/L)	20	1	19	95.0	0.002	0.0020	0.0000	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Cobalt - dissolved (mg/L)	20	8	12	60.0	0.001	0.0029	0.0019	0.005	0.001	0.001	0.001	0.0025	0.005	0.005
Copper - dissolved (mg/L)	20	8	12	60.0	0.001	0.0021	0.0020	0.007	0.001	0.001	0.001	0.001	0.00225	0.0056
Molybdenum - dissolved (mg/L)	20	20			0.002	0.0061	0.0039	0.014	0.002	0.0038	0.004	0.0045	0.006	0.01305
Nickel - dissolved (mg/L)	20	8	12	60.0	0.001	0.0039	0.0036	0.013	0.001	0.0014	0.00175	0.003	0.004	0.00985
Selenium - dissolved (mg/L)	20		20	100.0										
Uranium - dissolved (mg/L)	20	20			0.003	0.0341	0.0630	0.244	0.0049	0.007	0.00775	0.011	0.012	0.18415
Metals (total)														
Arsenic - total (mg/L)	20	6	14	70.0	0.001	0.0017	0.0005	0.002	0.001	0.001	0.00125	0.002	0.002	0.002
Barium - total (mg/L)	20	20			0.13	0.1850	0.0360	0.258	0.1357	0.1524	0.15625	0.1825	0.204	0.2466
Bismuth - total (mg/L)	20		20	100.0										
Chromium - total (mg/L)	20	1	19	95.0	0.003	0.0030	0.0000	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Cobalt - total (mg/L)	20	17	3	15.0	0.001	0.0029	0.0017	0.006	0.001	0.0012	0.002	0.002	0.005	0.0052
Copper - total (mg/L)	20	13	7	35.0	0.001	0.0035	0.0033	0.013	0.001	0.002	0.002	0.002	0.003	0.0106
Molybdenum - total (mg/L)	20	20			0.003	0.0066	0.0045	0.016	0.003	0.004	0.004	0.0045	0.006	0.016
Nickel - total (mg/L)	20	11	9	45.0	0.001	0.0025	0.0013	0.004	0.001	0.001	0.001	0.002	0.004	0.004
Selenium - total (mg/L)	20		20	100.0										
Uranium - total (mg/L)	20	20			0.005	0.0360	0.0647	0.247	0.00595	0.008	0.008	0.0115	0.013	0.1919
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	20	20			109	1710.4500	649.1339	2940	993.45	1198	1327.5	1685	2025	2902
pH (lab)	20	20			7.14	7.7310	0.3760	8.82	7.216	7.4	7.4725	7.655	7.9225	8.174

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Turbidity (NTU)	20	20			0.2	3.7000	7.7545	36.2	0.295	0.54	0.6	0.95	3.825	8.65
Seepage Bore 3b														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	19	19			99	450.9474	91.8858	543	381.6	428	432	462	498	538.5
Carbonate Alkalinity as CaCO3 (mg/L)	19	1	18	94.7	8	8.0000	0.0000	8	8	8	8	8	8	8
Hydroxide Alkalinity as CaCO3 (mg/L)	19		19	100.0										
Temperature (field) (°C)	19	19			107	451.3684	90.2763	543	382.4	428	432	462	498	538.5
Field Measurements														
Appearance or Colour	11													
Depth of Bore (mbgl)	42	42			16	16.0000	0.0000	16	16	16	16	16	16	16
Depth to Water (mbRL)	42	42			0.05	1.2914	1.0368	3.23	0.1	0.45	0.515	0.805	2.4125	3.195
Depth to Water (mbGL)	6	6			2.06	2.3567	0.1350	2.45	2.14	2.38	2.3825	2.405	2.435	2.4475
Dissolved Oxygen (field) (% sat))	16	16			0	48.0188	110.3114	468	0	2.8	5.725	13.45	41.775	172.275
Electrical Conductivity (field) (µS/cm)	16	16			974	1349.6875	340.4487	1804	975.5	1014	1014	1199	1731	1798.75
Groundwater Level (mAHD)	42	42			308.74	337.4589	15.8527	377.48	311.32	329.008	329.327	334.7335	348.39675	376.25855
GWL Depth Reference Elevation	42	42			311.33	338.7503	15.5816	378.09	311.9595	329.94	329.94	335.23	349.38225	376.97605
Odour	10													
ORP (field) (mV)	16	16			-59.9	90.1375	70.6897	231.4	-8.3	51.8	55.325	86.65	122.9	225.925
pH (field)	16	16			5.95	6.8869	0.4636	7.66	6.145	6.62	6.6425	6.98	7.165	7.63
Salinity (field) (PSU)	16	16			0.47	0.6700	0.1784	0.91	0.47	0.5	0.5	0.59	0.875	0.9025

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
TDS (field) (ppm)	16	16			24.67	30.9531	2.7324	35.4	26.5	29.7	29.8125	30.7	32.8625	35.1
Total Dissolved Solids (field) (ppm)	16	16			486	674.8750	170.3467	902	487.5	507	507	599.5	865.75	899.75
Turbidity (field) (FNU)	7	7			0	1.2571	0.8398	2.2	0.09	0.42	0.6	1.2	2.1	2.17
Hardness														
Total Hardness (mg CaCO3/L)	19	19			86	450.1579	169.7764	817	259.7	314	316.5	490	570	654.1
Ion Balance														
Ionic Balance (%)	18	18			1.1	3.8300	2.4736	10.2	1.355	1.796	1.9825	3.045	4.6225	8.8315
Total Anions (meq/L)	19	19			2.57	14.6826	4.8537	22.2	9.707	10.86	10.95	15.8	18.85	20.4
Total Cations (meq/L)	19	19			3.07	15.7405	5.4791	27.2	9.847	11.56	11.6	16.6	19.8	22.7
Major Ions														
Calcium (mg/L)	38	38			18	104.4211	36.1333	182	64.85	72.4	73	114	132.25	151.4
Chloride (mg/L)	19	19			8	84.1053	46.7692	162	35	40.8	44	77	125	151.2
Fluoride (mg/L)	19	19			0.9	1.1579	0.0990	1.3	0.99	1.1	1.1	1.2	1.2	1.3
Magnesium (mg/L)	38	38			10	47.8684	17.1636	88	29	32	33	51	60	69.3
Potassium (mg/L)	38	37	1	2.6	4	5.3784	0.6304	7	4.8	5	5	5	6	6
Sodium (mg/L)	38	38			31	154.2632	43.0781	246	111.85	117.4	119.25	153.5	184.5	221.35
Sulfate (as SO4)	19	19			10	158.2632	116.9336	441	39.7	47.2	48	157	246.5	324
Metals (dissolved)														
Arsenic - dissolved (mg/L)	19	4	15	78.9	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Barium - dissolved (mg/L)	19	19			0.089	0.1516	0.0460	0.274	0.0971	0.1054	0.1105	0.154	0.1795	0.2155
Bismuth - dissolved (mg/L)	19		19	100.0										
Chromium - dissolved (mg/L)	19		19	100.0										
Cobalt - dissolved (mg/L)	19	5	14	73.7	0.001	0.0012	0.0004	0.002	0.001	0.001	0.001	0.001	0.001	0.0018

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Copper - dissolved (mg/L)	19	1	18	94.7	0.002	0.0020	0.0000	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Molybdenum - dissolved (mg/L)	19	19			0.001	0.0025	0.0009	0.005	0.0019	0.002	0.002	0.002	0.003	0.0041
Nickel - dissolved (mg/L)	19		19	100.0										
Selenium - dissolved (mg/L)	19	1	18	94.7	0.02	0.0200	0.0000	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Uranium - dissolved (mg/L)	19	19			0.003	0.0090	0.0048	0.018	0.0039	0.0046	0.005	0.008	0.012	0.0171
Metals (total)														
Arsenic - total (mg/L)	19	5	14	73.7	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Barium - total (mg/L)	19	19			0.101	0.1608	0.0484	0.288	0.1046	0.112	0.116	0.163	0.1945	0.2205
Bismuth - total (mg/L)	19		19	100.0										
Chromium - total (mg/L)	19	1	18	94.7	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt - total (mg/L)	19	13	6	31.6	0.001	0.0016	0.0008	0.003	0.001	0.001	0.001	0.001	0.002	0.003
Copper - total (mg/L)	19	11	8	42.1	0.001	0.0048	0.0072	0.027	0.001	0.002	0.002	0.002	0.003	0.017
Molybdenum - total (mg/L)	19	19			0.002	0.0030	0.0010	0.005	0.002	0.002	0.002	0.003	0.003	0.005
Nickel - total (mg/L)	19	1	18	94.7	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Selenium - total (mg/L)	19	1	18	94.7	0.02	0.0200	0.0000	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Uranium - total (mg/L)	19	19			0.005	0.0100	0.0049	0.02	0.005	0.0056	0.006	0.008	0.0125	0.0182
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	19	19			192	1360.8421	478.4407	2200	869.7	968.2	989.5	1430	1750	1939
pH (lab)	19	19			7.13	7.6184	0.3095	8.47	7.166	7.352	7.4	7.62	7.785	7.993
Turbidity (NTU)	19	18	1	5.3	0.1	4.7611	11.7446	51.2	0.27	0.3	0.35	1.25	1.6	20.515
Seepage Bore 4a														
Alkalinity														

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Bicarbonate Alkalinity as CaCO3 (mg/L)	7	7			346	941.0000	267.6229	1200	503.2	885.4	908.5	964	1130	1191
Carbonate Alkalinity as CaCO3 (mg/L)	7	1	6	85.7	412	412.0000	0.0000	412	412	412	412	412	412	412
Hydroxide Alkalinity as CaCO3 (mg/L)	7		7	100.0										
Temperature (field) (°C)	7	7			758	999.8571	149.5559	1200	791.6	885.4	908.5	964	1130	1191
Field Measurements														
Appearance or Colour	4													
Depth of Bore (mbgl)	41	41			6	6.0000	0.0000	6	6	6	6	6	6	6
Depth to Water (mbRL)	20	20			3.91	5.2365	0.8929	6.49	4.0715	4.402	4.5075	4.955	5.935	6.49
Depth to Water (mbGL)	2	2			4.25	4.6400	0.3900	5.03	4.289	4.406	4.445	4.64	4.835	4.991
Depth to Water Comments	24													
Dissolved Oxygen (field) (% sat))	4	4			0	24.7000	26.5333	68.3	1.095	4.38	5.475	15.25	34.475	61.535
Dry?	24													
Electrical Conductivity (field) (µS/cm)	4	4			1508	2062.7500	342.9208	2436	1596.05	1860.2	1948.25	2153.5	2268	2402.4
Groundwater Level (mAHD)	20	20			305.32	328.2914	13.5573	351.301	305.4435	321.318	322.4425	326.222	331.67975	351.168
GWL Depth Reference Elevation	41	41			311.33	338.4755	16.5203	378.09	311.33	329.94	330.22	334.78	337.569	378.09
Odour	4													
ORP (field) (mV)	4	4			-81.1	-43.3500	24.2828	-20.9	-76.165	-61.36	-56.425	-35.7	-22.625	-21.245
pH (field)	4	4			7.16	7.7650	0.3806	8.1	7.244	7.496	7.58	7.9	8.085	8.097
Salinity (field) (PSU)	4	4			0.75	1.0425	0.1809	1.24	0.7965	0.936	0.9825	1.09	1.15	1.222
TDS (field) (ppm)	4	4			29.36	31.1150	1.3197	33.08	29.6015	30.326	30.5675	31.01	31.5575	32.7755

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Total Dissolved Solids (field) (ppm)	4	4			754	1031.0000	171.1768	1217	797.95	929.8	973.75	1076.5	1133.75	1200.35
Hardness														
Total Hardness (mg CaCO3/L)	7	7			340	436.0000	63.6014	526	345.4	371.8	392.5	431	485	514.3
Ion Balance														
Ionic Balance (%)	7	7			0.06	2.4657	2.0532	6.13	0.168	0.514	0.655	2.51	3.625	5.584
Total Anions (meq/L)	7	7			19.2	24.2286	3.2358	28.1	19.62	21.04	21.7	24.5	27.2	27.89
Total Cations (meq/L)	7	7			19.4	24.5714	3.2261	28.4	19.85	21.56	22.55	24.2	27.45	28.34
Major Ions														
Calcium (mg/L)	14	14			4	18.7857	20.3862	70	4.65	6	6	6	24.25	63.5
Chloride (mg/L)	7	7			62	89.7143	33.5632	161	62.6	65.2	67	70	100.5	146.9
Fluoride (mg/L)	7	7			1.4	1.8571	0.2195	2.1	1.49	1.74	1.8	1.9	2	2.07
Magnesium (mg/L)	14	14			74	97.5714	14.5784	122	77.25	82.8	84.75	100.5	108	118.75
Potassium (mg/L)	14	14			6	8.5714	1.1157	10	6.65	8	8	9	9	10
Sodium (mg/L)	14	14			220	363.2143	69.1894	440	220.65	315	326.25	397	412.75	429.6
Sulfate (as SO4)	7	7			69	83.0000	9.2428	99	71.7	78	78	79	89	96.6
Metals (dissolved)														
Arsenic - dissolved (mg/L)	7	7			0.002	0.0056	0.0017	0.008	0.0029	0.0052	0.0055	0.006	0.006	0.0074
Barium - dissolved (mg/L)	7	7			0.085	0.1503	0.0382	0.202	0.0961	0.1256	0.131	0.14	0.1815	0.1996
Bismuth - dissolved (mg/L)	7		7	100.0										
Chromium - dissolved (mg/L)	7	1	6	85.7	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt - dissolved (mg/L)	7	5	2	28.6	0.001	0.0014	0.0005	0.002	0.001	0.001	0.001	0.001	0.002	0.002
Copper - dissolved (mg/L)	7	2	5	71.4	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Molybdenum - dissolved (mg/L)	7	7			0.011	0.0140	0.0027	0.019	0.0113	0.012	0.012	0.013	0.0155	0.0184

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Nickel - dissolved (mg/L)	7	2	5	71.4	0.002	0.0045	0.0025	0.007	0.00225	0.003	0.00325	0.0045	0.00575	0.00675
Selenium - dissolved (mg/L)	7		7	100.0										
Uranium - dissolved (mg/L)	7	7			0.009	0.0124	0.0028	0.016	0.009	0.0092	0.0095	0.013	0.015	0.0157
Metals (total)														
Arsenic - total (mg/L)	7	7			0.003	0.0057	0.0016	0.008	0.0033	0.0044	0.005	0.006	0.0065	0.0077
Barium - total (mg/L)	7	7			0.109	0.1656	0.0366	0.22	0.1129	0.1296	0.141	0.168	0.19	0.2128
Bismuth - total (mg/L)	7		7	100.0										
Chromium - total (mg/L)	7	2	5	71.4	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cobalt - total (mg/L)	7	6	1	14.3	0.001	0.0023	0.0014	0.005	0.001	0.001	0.00125	0.002	0.00275	0.0045
Copper - total (mg/L)	7	5	2	28.6	0.001	0.0044	0.0031	0.01	0.0012	0.0018	0.002	0.004	0.005	0.009
Molybdenum - total (mg/L)	7	7			0.013	0.0163	0.0025	0.021	0.0133	0.0142	0.0145	0.016	0.0175	0.0201
Nickel - total (mg/L)	7	3	4	57.1	0.001	0.0013	0.0005	0.002	0.001	0.001	0.001	0.001	0.0015	0.0019
Selenium - total (mg/L)	7		7	100.0										
Uranium - total (mg/L)	7	7			0.01	0.0146	0.0032	0.019	0.0106	0.0122	0.0125	0.014	0.017	0.019
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	7	7			1690	2067.1429	268.4726	2550	1723	1836	1890	2070	2190	2472
pH (lab)	7	7			7.81	8.0500	0.1918	8.34	7.825	7.862	7.865	8.11	8.18	8.313
Turbidity (NTU)	7	7			0.4	3.7000	2.0633	6.9	0.85	2	2.15	4.4	4.95	6.39
Seepage Bore 4b														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	17	17			645	822.0000	77.9796	1020	706.6	780.4	798	821	859	928.8

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Carbonate Alkalinity as CaCO3 (mg/L)	17	1	16	94.1	35	35.0000	0.0000	35	35	35	35	35	35	35
Hydroxide Alkalinity as CaCO3 (mg/L)	17		17	100.0										
Temperature (field) (°C)	17	17			680	824.0588	73.6194	1020	713.6	780.4	798	821	859	928.8
Field Measurements														
Appearance or Colour	11													
Depth of Bore (mbgl)	42	42			16	16.0000	0.0000	16	16	16	16	16	16	16
Depth to Water (mbRL)	41	41			3.98	5.6566	0.9769	7.56	4.14	4.66	4.88	5.89	6.4	7.1
Depth to Water (mbGL)	4	4			4.28	4.7050	0.3841	5.21	4.2965	4.346	4.3625	4.665	5.0075	5.1695
Depth to Water Comments	1													
Dissolved Oxygen (field) (% sat))	16	16			0	29.5250	41.1348	133.1	0	0	0.375	7.1	40.45	114.8
Dry?	1													
Electrical Conductivity (field) (µS/cm)	16	16			1514	1802.6875	227.9141	2286	1555.25	1582	1592.5	1787.5	1916	2238.75
Groundwater Level (mAHD)	41	41			305.05	330.9974	16.8173	372.82	306.67	319.94	322.38	325.152	346.22	370.99
GWL Depth Reference Elevation	42	42			311.33	336.6679	16.7673	378.09	311.33	324.488	327.445	331.968	349.38225	376.97605
Odour	11													
ORP (field) (mV)	16	16			-66.8	33.8875	66.0963	193.9	-54.65	-24.1	-23.275	39.55	66.2	132.775
pH (field)	16	16			6.18	7.1688	0.5650	8.03	6.18	6.79	6.895	7.315	7.5225	7.955
Salinity (field) (PSU)	16	16			0.75	0.9025	0.1217	1.16	0.7725	0.78	0.7875	0.895	0.96	1.1375
TDS (field) (ppm)	16	16			26.92	30.7931	1.7998	34	28.15	29.1	29.4225	30.935	32.05	33.295
Total Dissolved Solids (field) (ppm)	16	16			757	901.3750	113.8787	1143	778	790	796	894	957.5	1119.75
Turbidity (field) (FNU)	7	7			1.4	4.3857	2.4098	7.7	1.61	2.24	2.45	3.5	6.6	7.7

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Hardness														
Total Hardness (mg CaCO3/L)	17	17			315	479.5294	87.7115	632	319	416.4	434	496	538	615.2
Ion Balance														
Ionic Balance (%)	17	17			1.05	2.9118	2.1468	9.67	1.106	1.3	1.38	2.16	3.68	6.91
Total Anions (meq/L)	17	17			16.2	20.5824	2.0495	23.4	16.44	19.06	19.3	20.8	22.3	22.84
Total Cations (meq/L)	17	17			17.4	21.0235	2.2399	24.4	17.64	18.56	18.8	21.5	23	23.6
Major Ions														
Calcium (mg/L)	34	34			31	56.7647	13.7863	85	32	48	49.25	56.5	65	77.35
Chloride (mg/L)	17	17			44	84.0000	25.3168	122	50.4	54.2	59	89	108	115.6
Fluoride (mg/L)	17	17			1.9	2.3176	0.4656	4	1.98	2.02	2.1	2.2	2.3	2.88
Magnesium (mg/L)	34	34			56	83.8824	13.4093	108	58.3	73.4	76	87	92	103.45
Potassium (mg/L)	34	34			5	6.2647	0.5588	7	5.65	6	6	6	7	7
Sodium (mg/L)	34	34			212	262.7353	29.1520	312	216.95	234.6	244	259.5	286.5	310.35
Sulfate (as SO4)	17	17			42	84.0000	17.4996	110	50.8	71.6	74	89	95	106
Metals (dissolved)														
Arsenic - dissolved (mg/L)	17	17			0.002	0.0031	0.0010	0.005	0.002	0.002	0.002	0.003	0.004	0.0042
Barium - dissolved (mg/L)	17	17			0.068	0.1062	0.0188	0.131	0.076	0.0862	0.091	0.115	0.119	0.1294
Bismuth - dissolved (mg/L)	17		17	100.0										
Chromium - dissolved (mg/L)	17		17	100.0										
Cobalt - dissolved (mg/L)	17	8	9	52.9	0.001	0.0015	0.0007	0.003	0.001	0.001	0.001	0.001	0.002	0.00265
Copper - dissolved (mg/L)	17	12	5	29.4	0.001	0.0018	0.0006	0.003	0.001	0.0012	0.00175	0.002	0.002	0.00245
Molybdenum - dissolved (mg/L)	17	17			0.009	0.0132	0.0021	0.017	0.009	0.012	0.012	0.013	0.015	0.0162

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Nickel - dissolved (mg/L)	17		17	100.0										
Selenium - dissolved (mg/L)	17		17	100.0										
Uranium - dissolved (mg/L)	17	17			0.006	0.0115	0.0026	0.017	0.0084	0.0092	0.01	0.011	0.013	0.0154
Metals (total)														
Arsenic - total (mg/L)	17	17			0.002	0.0033	0.0008	0.005	0.002	0.003	0.003	0.003	0.004	0.0042
Barium - total (mg/L)	17	17			0.07	0.1136	0.0170	0.138	0.0844	0.1024	0.108	0.116	0.126	0.1316
Bismuth - total (mg/L)	17		17	100.0										
Chromium - total (mg/L)	17		17	100.0										
Cobalt - total (mg/L)	17	12	5	29.4	0.001	0.0018	0.0008	0.004	0.001	0.001	0.001	0.002	0.002	0.0029
Copper - total (mg/L)	17	17			0.001	0.0038	0.0020	0.008	0.001	0.002	0.002	0.004	0.005	0.0064
Molybdenum - total (mg/L)	17	17			0.012	0.0161	0.0019	0.021	0.0136	0.015	0.015	0.016	0.017	0.0186
Nickel - total (mg/L)	17	1	16	94.1	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Selenium - total (mg/L)	17		17	100.0										
Uranium - total (mg/L)	17	17			0.007	0.0136	0.0024	0.017	0.0102	0.012	0.012	0.014	0.015	0.017
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	17	17			1440	1771.1765	170.9793	2080	1512	1602	1610	1820	1870	1992
pH (lab)	17	17			7.41	7.8147	0.2771	8.36	7.426	7.526	7.59	7.78	8.01	8.192
Turbidity (NTU)	17	17			0.4	3.1353	2.7585	8.6	0.4	0.62	0.7	2.4	6.1	7.64
Seepage Bore 5a														
Alkalinity														

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Bicarbonate Alkalinity as CaCO3 (mg/L)	10	10			176	223.8000	37.2177	301	183.65	197	199.25	213	236.75	290.65
Carbonate Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Hydroxide Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Temperature (field) (°C)	10	10			176	223.8000	37.2177	301	183.65	197	199.25	213	236.75	290.65
Field Measurements														
Appearance or Colour	2													
Depth to Water (mbRL)	2	2			3.13	3.1800	0.0500	3.23	3.135	3.15	3.155	3.18	3.205	3.225
Dissolved Oxygen (field) (% sat))	2	2			28.7	37.9000	9.2000	47.1	29.62	32.38	33.3	37.9	42.5	46.18
Electrical Conductivity (field) (µS/cm)	2	2			1595	1686.0000	91.0000	1777	1604.1	1631.4	1640.5	1686	1731.5	1767.9
Groundwater Level (mAHD)	2	2			323.53	323.5800	0.0500	323.63	323.535	323.55	323.555	323.58	323.605	323.625
GWL Depth Reference Elevation	2	2			326.76	326.7600	0.0000	326.76	326.76	326.76	326.76	326.76	326.76	326.76
Odour	2													
ORP (field) (mV)	2	2			-54.4	-49.3500	5.0500	-44.3	-53.895	-52.38	-51.875	-49.35	-46.825	-44.805
pH (field)	2	2			9.08	9.1550	0.0750	9.23	9.0875	9.11	9.1175	9.155	9.1925	9.2225
Salinity (field) (PSU)	2	2			0.8	0.8450	0.0450	0.89	0.8045	0.818	0.8225	0.845	0.8675	0.8855
TDS (field) (ppm)	2	2			28.08	28.7900	0.7100	29.5	28.151	28.364	28.435	28.79	29.145	29.429
Total Dissolved Solids (field) (ppm)	2	2			797	843.0000	46.0000	889	801.6	815.4	820	843	866	884.4
Hardness														
Total Hardness (mg CaCO3/L)	10	10			448	1291.8000	615.4362	2060	467.35	511	622.75	1410	1892.5	2028.5
Ion Balance														
Ionic Balance (%)	10	10			3.8	14.4150	4.9748	20.4	6.2525	10.73	11.675	15.35	18.35	20.175

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Total Anions (meq/L)	10	10			12.9	30.0800	10.9523	43	13.935	15.68	19.275	33	39.05	42.91
Total Cations (meq/L)	10	10			17.1	41.3100	17.4151	62.9	17.91	18.98	22.275	44.65	58.35	62.045
Major Ions														
Calcium (mg/L)	20	20			110	312.4500	141.3448	483	110	125.6	130.25	350.5	445.5	470.65
Chloride (mg/L)	10	10			23	109.0000	52.9415	171	26.6	43.8	62.75	124.5	155.25	166.95
Fluoride (mg/L)	10	10			0.5	0.7100	0.1972	1	0.5	0.58	0.6	0.6	0.925	1
Magnesium (mg/L)	20	20			41	135.8500	65.4884	211	41.95	49.8	50.75	149	204	209.1
Potassium (mg/L)	20	20			7	13.5000	3.9937	19	7	8.8	9	15.5	17	18.05
Sodium (mg/L)	20	20			183	355.8000	117.4915	494	183.95	199.2	203.75	383.5	462.5	490.2
Sulfate (as SO4)	10	10			418	1082.5000	434.1404	1660	453.1	500	643.25	1195	1397.5	1615
Metals (dissolved)														
Arsenic - dissolved (mg/L)	10	3	7	70.0	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Barium - dissolved (mg/L)	10	10			0.083	0.0982	0.0112	0.125	0.08615	0.0908	0.0915	0.095	0.1025	0.11735
Bismuth - dissolved (mg/L)	10		10	100.0										
Chromium - dissolved (mg/L)	10		10	100.0										
Cobalt - dissolved (mg/L)	10	8	2	20.0	0.001	0.0030	0.0011	0.004	0.00135	0.002	0.002	0.0035	0.004	0.004
Copper - dissolved (mg/L)	10	10			0.002	0.0097	0.0071	0.029	0.0029	0.004	0.005	0.009	0.01	0.02135
Molybdenum - dissolved (mg/L)	10	10			0.007	0.0141	0.0042	0.02	0.00835	0.0108	0.01125	0.013	0.018	0.01955
Nickel - dissolved (mg/L)	10	6	4	40.0	0.001	0.0015	0.0008	0.003	0.001	0.001	0.001	0.001	0.00175	0.00275
Selenium - dissolved (mg/L)	10	10			0.02	0.0810	0.0448	0.14	0.02	0.02	0.03	0.095	0.12	0.131
Uranium - dissolved (mg/L)	10	10			0.009	0.0166	0.0074	0.032	0.00945	0.01	0.0105	0.015	0.01825	0.0302
Metals (total)														

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Arsenic - total (mg/L)	10	4	6	60.0	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Barium - total (mg/L)	10	10			0.08	0.1045	0.0116	0.126	0.0881	0.098	0.0985	0.104	0.11225	0.1206
Bismuth - total (mg/L)	10		10	100.0										
Chromium - total (mg/L)	10	2	8	80.0	0.003	0.0040	0.0010	0.005	0.0031	0.0034	0.0035	0.004	0.0045	0.0049
Cobalt - total (mg/L)	10	9	1	10.0	0.001	0.0037	0.0018	0.006	0.001	0.0022	0.003	0.004	0.005	0.006
Copper - total (mg/L)	10	10			0.003	0.0098	0.0046	0.02	0.00345	0.0056	0.007	0.01	0.01175	0.0164
Molybdenum - total (mg/L)	10	10			0.009	0.0148	0.0044	0.021	0.009	0.0114	0.012	0.014	0.019	0.021
Nickel - total (mg/L)	10	6	4	40.0	0.001	0.0022	0.0011	0.004	0.001	0.001	0.00125	0.002	0.00275	0.00375
Selenium - total (mg/L)	10	10			0.02	0.0850	0.0457	0.15	0.02	0.02	0.0375	0.095	0.12	0.1365
Uranium - total (mg/L)	10	10			0.009	0.0180	0.0069	0.032	0.0099	0.011	0.012	0.017	0.0215	0.0293
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	10	10			1570	3794.0000	1449.3944	5510	1646.5	1860	2387.5	4050	5007.5	5442.5
pH (lab)	10	10			7.5	7.7330	0.1736	8.09	7.509	7.576	7.6075	7.705	7.8375	8
Turbidity (NTU)	10	10			0.3	4.1400	7.6216	25.8	0.345	0.56	0.625	0.8	1.725	18.195
Seepage Bore 5b														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	10	10			124	136.6000	9.9418	158	125.35	127.8	129.25	134.5	140.5	153.95
Carbonate Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Hydroxide Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Temperature (field) (°C)	10	10			124	136.6000	9.9418	158	125.35	127.8	129.25	134.5	140.5	153.95
Field Measurements														

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Appearance or Colour	1													
Depth to Water (mbRL)	2	2			3.09	3.1600	0.0700	3.23	3.097	3.118	3.125	3.16	3.195	3.223
Dissolved Oxygen (field) (% sat))	1	1			56.9	56.9000	0.0000	56.9	56.9	56.9	56.9	56.9	56.9	56.9
Electrical Conductivity (field) (µS/cm)	1	1			2242	2242.0000	0.0000	2242	2242	2242	2242	2242	2242	2242
Groundwater Level (mAHD)	2	2			323.67	338.1255	14.4555	352.581	325.11555	329.4522	330.89775	338.1255	345.35325	351.13545
GWL Depth Reference Elevation	2	2			326.76	341.2855	14.5255	355.811	328.21255	332.5702	334.02275	341.2855	348.54825	354.35845
Odour	1													
ORP (field) (mV)	1	1			-59.1	-59.1000	0.0000	-59.1	-59.1	-59.1	-59.1	-59.1	-59.1	-59.1
pH (field)	1	1			9.06	9.0600	0.0000	9.06	9.06	9.06	9.06	9.06	9.06	9.06
Salinity (field) (PSU)	1	1			1.14	1.1400	0.0000	1.14	1.14	1.14	1.14	1.14	1.14	1.14
TDS (field) (ppm)	1	1			28.67	28.6700	0.0000	28.67	28.67	28.67	28.67	28.67	28.67	28.67
Total Dissolved Solids (field) (ppm)	1	1			1122	1122.0000	0.0000	1122	1122	1122	1122	1122	1122	1122
Hardness														
Total Hardness (mg CaCO3/L)	10	10			405	550.8000	76.9919	632	419.85	490.8	509	577	617.75	632
Ion Balance														
Ionic Balance (%)	10	10			4.66	8.6050	2.3265	13	5.335	6.928	7.125	8.915	9.515	12.235
Total Anions (meq/L)	10	10			17.3	20.9000	1.5710	23.6	18.29	20.06	20.375	21.3	21.65	22.745
Total Cations (meq/L)	10	10			20.6	24.8700	2.2181	27.7	21.41	23.12	23.325	25.5	26.625	27.475
Major Ions														
Calcium (mg/L)	20	20			91	128.6000	19.9685	161	92.9	111.6	115.25	132.5	142.75	154.35
Chloride (mg/L)	10	10			52	66.5000	7.1589	82	56.5	63.6	64.25	66.5	67.75	77.5

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Fluoride (mg/L)	10	10			1.2	1.3700	0.1269	1.5	1.2	1.2	1.225	1.4	1.5	1.5
Magnesium (mg/L)	20	20			39	57.3000	7.7143	71	41.85	53.4	54.75	58	64	65.3
Potassium (mg/L)	20	20			2	3.8000	0.5099	4	2.95	4	4	4	4	4
Sodium (mg/L)	20	20			287	320.5500	18.1590	353	288.9	309.4	312.5	320.5	333.25	348.25
Sulfate (as SO4)	10	10			626	783.0000	65.4034	879	672.35	756.2	763.5	804.5	812.75	858.75
Metals (dissolved)														
Arsenic - dissolved (mg/L)	10	10			0.001	0.0017	0.0005	0.002	0.001	0.001	0.00125	0.002	0.002	0.002
Barium - dissolved (mg/L)	10	10			0.098	0.1244	0.0140	0.15	0.10205	0.1158	0.1195	0.126	0.12825	0.1455
Bismuth - dissolved (mg/L)	10		10	100.0										
Chromium - dissolved (mg/L)	10	1	9	90.0	0.005	0.0050	0.0000	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Cobalt - dissolved (mg/L)	10	10			0.002	0.0026	0.0007	0.004	0.002	0.002	0.002	0.0025	0.003	0.00355
Copper - dissolved (mg/L)	10	10			0.003	0.0074	0.0030	0.013	0.0039	0.005	0.00525	0.007	0.0085	0.01255
Molybdenum - dissolved (mg/L)	10	10			0.066	0.0787	0.0102	0.1	0.06645	0.0686	0.06975	0.078	0.0855	0.09415
Nickel - dissolved (mg/L)	10	10			0.004	0.0042	0.0006	0.006	0.004	0.004	0.004	0.004	0.004	0.0051
Selenium - dissolved (mg/L)	10	10			0.01	0.0230	0.0064	0.03	0.0145	0.02	0.02	0.02	0.03	0.03
Uranium - dissolved (mg/L)	10	10			0.002	0.0029	0.0007	0.004	0.002	0.002	0.00225	0.003	0.003	0.004
Metals (total)														
Arsenic - total (mg/L)	10	10			0.002	0.0020	#NUM!	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Barium - total (mg/L)	10	10			0.094	0.1302	0.0137	0.148	0.1066	0.1268	0.12925	0.133	0.13575	0.1444
Bismuth - total (mg/L)	10		10	100.0										
Chromium - total (mg/L)	10	1	9	90.0	0.006	0.0060	0.0000	0.006	0.006	0.006	0.006	0.006	0.006	0.006
Cobalt - total (mg/L)	10	10			0.002	0.0029	0.0009	0.004	0.002	0.002	0.002	0.0025	0.004	0.004
Copper - total (mg/L)	10	10			0.006	0.0093	0.0023	0.014	0.00645	0.0078	0.008	0.009	0.0105	0.0131

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Molybdenum - total (mg/L)	10	10			0.074	0.0876	0.0095	0.105	0.0758	0.0812	0.08225	0.085	0.0925	0.10365
Nickel - total (mg/L)	10	10			0.004	0.0042	0.0004	0.005	0.004	0.004	0.004	0.004	0.004	0.005
Selenium - total (mg/L)	10	10			0.01	0.0250	0.0081	0.04	0.0145	0.02	0.02	0.025	0.03	0.0355
Uranium - total (mg/L)	10	10			0.003	0.0037	0.0006	0.005	0.003	0.003	0.003	0.004	0.004	0.00455
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	10	10			1770	2291.0000	218.8812	2600	1900.5	2180	2245	2350	2390	2528
pH (lab)	10	10			7.55	7.8140	0.1472	8.05	7.5905	7.68	7.7175	7.825	7.895	8.0275
Turbidity (NTU)	10	10			0.5	1.3300	1.2442	4.2	0.5	0.5	0.525	0.6	1.4	3.75
Seepage Bore 6a														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	10	10			78	125.8000	25.0152	172	91.95	112.2	113.5	122	138	165.25
Carbonate Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Hydroxide Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Temperature (field) (°C)	10	10			78	125.8000	25.0152	172	91.95	112.2	113.5	122	138	165.25
Field Measurements														
Appearance or Colour	2													
Depth to Water (mbRL)	2	2			2.15	2.9200	0.7700	3.69	2.227	2.458	2.535	2.92	3.305	3.613
Dissolved Oxygen (field) (% sat))	2	2			68.5	80.5500	12.0500	92.6	69.705	73.32	74.525	80.55	86.575	91.395
Electrical Conductivity (field) (µS/cm)	2	2			1208	1894.5000	686.5000	2581	1276.65	1482.6	1551.25	1894.5	2237.75	2512.35
Groundwater Level (mAHD)	2	2			331.54	332.3100	0.7700	333.08	331.617	331.848	331.925	332.31	332.695	333.003
GWL Depth Reference Elevation	2	2			335.23	335.2300	0.0000	335.23	335.23	335.23	335.23	335.23	335.23	335.23

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Odour	2													
ORP (field) (mV)	2	2			-56.1	-20.6000	35.5000	14.9	-52.55	-41.9	-38.35	-20.6	-2.85	11.35
pH (field)	2	2			7.52	7.8900	0.3700	8.26	7.557	7.668	7.705	7.89	8.075	8.223
Salinity (field) (PSU)	2	2			0.6	0.9650	0.3650	1.33	0.6365	0.746	0.7825	0.965	1.1475	1.2935
TDS (field) (ppm)	2	2			27.2	27.3700	0.1700	27.54	27.217	27.268	27.285	27.37	27.455	27.523
Total Dissolved Solids (field) (ppm)	2	2			604	947.5000	343.5000	1291	638.35	741.4	775.75	947.5	1119.25	1256.65
Hardness														
Total Hardness (mg CaCO3/L)	10	10			448	1328.5000	841.4824	2500	454.3	506.8	575	885.5	2270	2473
Ion Balance														
Ionic Balance (%)	10	10			3.53	13.9550	6.0042	24	4.0655	9.584	11.25	14.95	18.025	21.525
Total Anions (meq/L)	10	10			10.1	27.3200	13.8388	46.2	11.27	12.86	13.925	24.2	41.475	45.57
Total Cations (meq/L)	10	10			13	37.3900	22.3248	69.1	13.36	15.4	17.5	26.5	61.625	68.11
Major Ions														
Calcium (mg/L)	20	20			102	272.7500	149.3629	481	104.85	122.2	125.5	189.5	439.5	479.1
Chloride (mg/L)	10	10			13	63.6000	41.8645	118	14.35	16	20.75	56.5	108.25	114.4
Fluoride (mg/L)	10	10			0.2	0.2100	0.0300	0.3	0.2	0.2	0.2	0.2	0.2	0.255
Magnesium (mg/L)	20	20			35	163.1000	110.1794	316	36.9	55.6	56.75	108	278	316
Potassium (mg/L)	20	20			4	8.1000	3.6729	16	4	4.8	5	8	9	15.05
Sodium (mg/L)	20	20			83	248.2000	125.2692	442	83.95	123.8	127.75	196	372	435.35
Sulfate (as SO4)	10	10			392	1105.3000	589.7756	1910	429.8	476.8	522.75	979	1685	1896.5
Metals (dissolved)														
Arsenic - dissolved (mg/L)	10		10	100.0										

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Barium - dissolved (mg/L)	10	10			0.046	0.0672	0.0228	0.102	0.0469	0.0488	0.049	0.0555	0.0915	0.10155
Bismuth - dissolved (mg/L)	10		10	100.0										
Chromium - dissolved (mg/L)	10		10	100.0										
Cobalt - dissolved (mg/L)	10	10			0.001	0.0034	0.0016	0.006	0.00145	0.002	0.002	0.003	0.005	0.00555
Copper - dissolved (mg/L)	10	9	1	10.0	0.002	0.0031	0.0010	0.005	0.002	0.002	0.002	0.003	0.004	0.0046
Molybdenum - dissolved (mg/L)	10	6	4	40.0	0.001	0.0027	0.0012	0.004	0.001	0.001	0.0015	0.003	0.00375	0.004
Nickel - dissolved (mg/L)	10	9	1	10.0	0.001	0.0067	0.0059	0.015	0.001	0.001	0.001	0.003	0.012	0.015
Selenium - dissolved (mg/L)	10	9	1	10.0	0.02	0.1456	0.1136	0.3	0.024	0.036	0.04	0.07	0.25	0.296
Uranium - dissolved (mg/L)	10	5	5	50.0	0.001	0.0028	0.0017	0.006	0.0012	0.0018	0.002	0.002	0.003	0.0054
Metals (total)														
Arsenic - total (mg/L)	10		10	100.0										
Barium - total (mg/L)	10	10			0.048	0.0676	0.0211	0.107	0.04845	0.0506	0.051	0.058	0.08275	0.1034
Bismuth - total (mg/L)	10		10	100.0										
Chromium - total (mg/L)	10		10	100.0										
Cobalt - total (mg/L)	10	10			0.001	0.0039	0.0019	0.006	0.001	0.0026	0.003	0.004	0.00575	0.006
Copper - total (mg/L)	10	10			0.002	0.0048	0.0019	0.009	0.00245	0.003	0.00325	0.005	0.00575	0.00765
Molybdenum - total (mg/L)	10	7	3	30.0	0.001	0.0026	0.0013	0.005	0.001	0.0012	0.0015	0.003	0.003	0.0044
Nickel - total (mg/L)	10	7	3	30.0	0.002	0.0273	0.0471	0.142	0.0023	0.0034	0.004	0.011	0.014	0.1042
Selenium - total (mg/L)	10	9	1	10.0	0.03	0.1511	0.1068	0.29	0.03	0.036	0.04	0.13	0.26	0.286
Uranium - total (mg/L)	10	5	5	50.0	0.001	0.0030	0.0018	0.006	0.0012	0.0018	0.002	0.002	0.004	0.0056
Physico-Chemical Parameters														

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Electrical Conductivity (µS/cm)	10	10			1170	3297.0000	1753.2544	5430	1219.5	1312	1500	3120	5082.5	5389.5
pH (lab)	10	10			6.65	7.1110	0.2777	7.68	6.722	6.922	6.965	7.07	7.2675	7.527
Turbidity (NTU)	10	10			0.5	2.2100	2.3132	7.3	0.5	0.5	0.5	0.9	2.9	6.535
Seepage Bore 6b														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Carbonate Alkalinity as CaCO3 (mg/L)	10	10			175	268.5000	141.9488	659	179.05	188.8	190	204.5	267.75	529.4
Hydroxide Alkalinity as CaCO3 (mg/L)	10	10			371	551.7000	124.5536	819	389.45	437.6	453.5	567	608.75	739.35
Temperature (field) (°C)	10	10			601	820.4000	229.6159	1480	630.7	714.2	730	773	814.25	1182.55
Field Measurements														
Appearance or Colour	2													
Depth to Water (mbRL)	2	2			4.24	4.5750	0.3350	4.91	4.2735	4.374	4.4075	4.575	4.7425	4.8765
Dissolved Oxygen (field) (% sat))	2	2			26.2	28.5000	2.3000	30.8	26.43	27.12	27.35	28.5	29.65	30.57
Electrical Conductivity (field) (µS/cm)	2	2			4872	6165.5000	1293.5000	7459	5001.35	5389.4	5518.75	6165.5	6812.25	7329.65
Groundwater Level (mAHD)	2	2			319.01	320.7650	1.7550	322.52	319.1855	319.712	319.8875	320.765	321.6425	322.3445
GWL Depth Reference Elevation	2	2			323.92	325.3400	1.4200	326.76	324.062	324.488	324.63	325.34	326.05	326.618
Odour	2													
ORP (field) (mV)	2	2			-162.8	-12.0500	150.7500	138.7	-147.725	-102.5	-87.425	-12.05	63.325	123.625
pH (field)	2	2			12.64	12.7200	0.0800	12.8	12.648	12.672	12.68	12.72	12.76	12.792
Salinity (field) (PSU)	2	2			2.6	3.3450	0.7450	4.09	2.6745	2.898	2.9725	3.345	3.7175	4.0155
TDS (field) (ppm)	2	2			26.54	27.3050	0.7650	28.07	26.6165	26.846	26.9225	27.305	27.6875	27.9935

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Total Dissolved Solids (field) (ppm)	2	2			2435	3082.5000	647.5000	3730	2499.75	2694	2758.75	3082.5	3406.25	3665.25
Hardness														
Total Hardness (mg CaCO3/L)	10	10			372	470.0000	88.2100	692	385.5	403.6	406.5	443	505.25	617.75
Ion Balance														
Ionic Balance (%)	10	10			2.25	8.1850	3.3690	15.8	3.1185	7.1	7.8375	7.99	9.3475	12.938
Total Anions (meq/L)	10	10			21.8	27.2800	7.1634	48.2	22.025	24.14	24.7	25.55	26.375	38.795
Total Cations (meq/L)	10	10			26.7	31.8400	6.3380	50.4	27.42	29.42	29.725	30.1	30.8	42.165
Major Ions														
Calcium (mg/L)	20	20			149	196.0000	41.5307	316	152.8	161.8	165	188	210.25	278.95
Chloride (mg/L)	10	10			76	87.9000	9.8939	116	79.6	84	84.25	86	87	103.4
Fluoride (mg/L)	10	10			1.4	1.5500	0.2335	2.2	1.4	1.4	1.4	1.45	1.6	1.93
Magnesium (mg/L)	20	1	19	95.0	13	13.0000	0.0000	13	13	13	13	13	13	13
Potassium (mg/L)	20	20			48	69.5000	19.2964	120	53.7	55.8	56	61.5	75.75	119.05
Sodium (mg/L)	20	20			382	480.6500	106.1448	794	401.95	420.6	423.25	446	486.5	772.15
Sulfate (as SO4)	10	10			327	404.1000	115.0447	738	334.2	344.6	347.25	358.5	406.25	595.8
Metals (dissolved)														
Arsenic - dissolved (mg/L)	10	10			0.001	0.0022	0.0006	0.003	0.00145	0.002	0.002	0.002	0.00275	0.003
Barium - dissolved (mg/L)	10	10			0.178	0.2423	0.0481	0.301	0.18205	0.1878	0.19425	0.238	0.2925	0.29965
Bismuth - dissolved (mg/L)	10		10	100.0										
Chromium - dissolved (mg/L)	10	10			0.012	0.0212	0.0103	0.05	0.01245	0.0146	0.01525	0.0195	0.022	0.03785
Cobalt - dissolved (mg/L)	10	10			0.002	0.0020	#NUM!	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Copper - dissolved (mg/L)	10	10			0.027	0.0321	0.0034	0.04	0.02835	0.03	0.03	0.031	0.03375	0.03775
Molybdenum - dissolved (mg/L)	10	10			0.234	0.2960	0.1071	0.612	0.2367	0.2416	0.2425	0.2675	0.27875	0.4707

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Nickel - dissolved (mg/L)	10	10			0.012	0.0142	0.0010	0.015	0.01245	0.0138	0.014	0.0145	0.015	0.015
Selenium - dissolved (mg/L)	10	10			0.02	0.0270	0.0078	0.04	0.02	0.02	0.02	0.025	0.03	0.04
Uranium - dissolved (mg/L)	10		10	100.0										
Metals (total)														
Arsenic - total (mg/L)	10	10			0.002	0.0028	0.0006	0.004	0.002	0.002	0.00225	0.003	0.003	0.00355
Barium - total (mg/L)	10	10			0.178	0.2537	0.0486	0.308	0.1888	0.2044	0.2065	0.266	0.29925	0.3071
Bismuth - total (mg/L)	10		10	100.0										
Chromium - total (mg/L)	10	10			0.012	0.0298	0.0343	0.132	0.01245	0.0146	0.0155	0.02	0.02275	0.0834
Cobalt - total (mg/L)	10	10			0.002	0.0023	0.0009	0.005	0.002	0.002	0.002	0.002	0.002	0.00365
Copper - total (mg/L)	10	10			0.031	0.0380	0.0120	0.073	0.03145	0.032	0.032	0.0335	0.0375	0.0577
Molybdenum - total (mg/L)	10	10			0.234	0.3184	0.1173	0.66	0.2439	0.256	0.2585	0.2815	0.31575	0.5115
Nickel - total (mg/L)	10	10			0.014	0.0153	0.0008	0.016	0.014	0.0148	0.015	0.0155	0.016	0.016
Selenium - total (mg/L)	10	10			0.02	0.0270	0.0064	0.04	0.02	0.02	0.02	0.03	0.03	0.0355
Uranium - total (mg/L)	10	1	9	90.0	0.002	0.0020	0.0000	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	10	10			3660	4553.0000	1127.4578	7640	3669	3712	3792.5	4230	4580	6542
pH (lab)	10	10			11.7	11.9400	0.1114	12.1	11.745	11.88	11.9	12	12	12.055
Turbidity (NTU)	10	10			3.1	8.9800	11.3287	42.6	3.235	3.56	3.725	5.65	6.55	27.345
Seepage Bore 7a														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	10	10			670	832.4000	75.4854	951	720.85	787	795.5	829	870.5	941.55

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Carbonate Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Hydroxide Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Temperature (field) (°C)	10	10			670	832.4000	75.4854	951	720.85	787	795.5	829	870.5	941.55
Field Measurements														
Appearance or Colour	2													
Depth to Water (mbRL)	2	2			2.44	2.6900	0.2500	2.94	2.465	2.54	2.565	2.69	2.815	2.915
Dissolved Oxygen (field) (% sat))	2	2			118.2	191.6500	73.4500	265.1	125.545	147.58	154.925	191.65	228.375	257.755
Electrical Conductivity (field) (µS/cm)	2	2			1979	2245.5000	266.5000	2512	2005.65	2085.6	2112.25	2245.5	2378.75	2485.35
Groundwater Level (mAHD)	2	2			324.32	338.5955	14.2755	352.871	325.74755	330.0302	331.45775	338.5955	345.73325	351.44345
GWL Depth Reference Elevation	2	2			326.76	341.2855	14.5255	355.811	328.21255	332.5702	334.02275	341.2855	348.54825	354.35845
Odour	2													
ORP (field) (mV)	2	2			-58.5	-32.0000	26.5000	-5.5	-55.85	-47.9	-45.25	-32	-18.75	-8.15
pH (field)	2	2			8.21	8.2650	0.0550	8.32	8.2155	8.232	8.2375	8.265	8.2925	8.3145
Salinity (field) (PSU)	2	2			1	1.1400	0.1400	1.28	1.014	1.056	1.07	1.14	1.21	1.266
TDS (field) (ppm)	2	2			30.01	30.3100	0.3000	30.61	30.04	30.13	30.16	30.31	30.46	30.58
Total Dissolved Solids (field) (ppm)	2	2			990	1123.0000	133.0000	1256	1003.3	1043.2	1056.5	1123	1189.5	1242.7
Hardness														
Total Hardness (mg CaCO3/L)	10	10			227	353.3000	43.1603	380	281	355.8	359.25	365.5	374.75	379.1
Ion Balance														
Ionic Balance (%)	10	10			0.72	2.1850	1.1675	3.83	0.792	0.92	0.9475	2.43	3.2225	3.7625

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Total Anions (meq/L)	10	10			21	26.0300	1.9804	28.6	22.845	25.18	25.35	26.4	26.95	28.33
Total Cations (meq/L)	10	10			22.7	26.8200	2.1917	30.6	23.285	25.76	26.225	26.6	28.4	29.79
Major Ions														
Calcium (mg/L)	20	20			35	56.3000	7.7466	66	35	55.6	56	58	60	64.1
Chloride (mg/L)	10	10			97	141.4000	15.5512	155	116.35	140	140.25	145.5	149.75	153.2
Fluoride (mg/L)	10	10			3.3	3.9400	0.5748	5.2	3.345	3.48	3.5	3.8	4.275	4.84
Magnesium (mg/L)	20	20			34	53.2500	6.8401	59	34	52.8	53	56	56.25	58.05
Potassium (mg/L)	20	20			2	4.1500	0.8529	5	2	4	4	4	5	5
Sodium (mg/L)	20	20			390	458.0500	33.4835	526	414.7	432.4	435.25	456	479	518.4
Sulfate (as SO4)	10	10			235	260.0000	12.6412	286	241.75	250.8	252.5	262	265.75	277
Metals (dissolved)														
Arsenic - dissolved (mg/L)	10	10			0.003	0.0052	0.0015	0.007	0.003	0.0038	0.004	0.0055	0.00675	0.007
Barium - dissolved (mg/L)	10	10			0.075	0.0855	0.0062	0.093	0.0759	0.0794	0.081	0.0865	0.091	0.093
Bismuth - dissolved (mg/L)	10		10	100.0										
Chromium - dissolved (mg/L)	10	1	9	90.0	0.002	0.0020	0.0000	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Cobalt - dissolved (mg/L)	10	8	2	20.0	0.001	0.0014	0.0005	0.002	0.001	0.001	0.001	0.001	0.002	0.002
Copper - dissolved (mg/L)	10	4	6	60.0	0.001	0.0023	0.0011	0.004	0.00115	0.0016	0.00175	0.002	0.0025	0.0037
Molybdenum - dissolved (mg/L)	10	10			0.015	0.0198	0.0037	0.027	0.0159	0.017	0.01725	0.019	0.0205	0.02655
Nickel - dissolved (mg/L)	10	9	1	10.0	0.001	0.0018	0.0006	0.003	0.001	0.001	0.001	0.002	0.002	0.0026
Selenium - dissolved (mg/L)	10		10	100.0										
Uranium - dissolved (mg/L)	10	10			0.018	0.0250	0.0035	0.03	0.01935	0.0226	0.023	0.026	0.0275	0.02955
Metals (total)														
Arsenic - total (mg/L)	10	10			0.003	0.0074	0.0019	0.01	0.00435	0.006	0.0065	0.008	0.008	0.00955

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Barium - total (mg/L)	10	10			0.087	0.0969	0.0067	0.107	0.0879	0.0906	0.09125	0.0975	0.10175	0.1061
Bismuth - total (mg/L)	10		10	100.0										
Chromium - total (mg/L)	10	3	7	70.0	0.002	0.0020	0.0000	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Cobalt - total (mg/L)	10	10			0.001	0.0022	0.0009	0.004	0.001	0.0018	0.002	0.002	0.00275	0.00355
Copper - total (mg/L)	10	10			0.002	0.0083	0.0053	0.019	0.00245	0.0038	0.00425	0.007	0.01	0.01765
Molybdenum - total (mg/L)	10	10			0.016	0.0199	0.0027	0.026	0.01645	0.017	0.01775	0.02	0.02075	0.0242
Nickel - total (mg/L)	10	9	1	10.0	0.002	0.0031	0.0007	0.004	0.002	0.0026	0.003	0.003	0.004	0.004
Selenium - total (mg/L)	10		10	100.0										
Uranium - total (mg/L)	10	10			0.017	0.0272	0.0047	0.034	0.0197	0.0238	0.02425	0.0285	0.03	0.0331
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	10	10			1960	2331.0000	223.4032	2660	2005	2108	2137.5	2375	2517.5	2606
pH (lab)	10	10			7.59	7.8510	0.1723	8.23	7.6305	7.696	7.7225	7.85	7.94	8.1175
Turbidity (NTU)	10	10			4.7	28.1000	16.8588	61.2	7.67	14.02	15.75	22.75	39.9	54.765
Seepage Bore 8a														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	10	10			570	799.4000	87.8353	937	655.95	794.6	803.25	808.5	828	896.95
Carbonate Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Hydroxide Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Temperature (field) (°C)	10	10			570	799.4000	87.8353	937	655.95	794.6	803.25	808.5	828	896.95
Field Measurements														

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Appearance or Colour	2													
Depth to Water (mbRL)	2	2			1.47	1.5550	0.0850	1.64	1.4785	1.504	1.5125	1.555	1.5975	1.6315
Dissolved Oxygen (field) (% sat))	2	2			77.2	161.9500	84.7500	246.7	85.675	111.1	119.575	161.95	204.325	238.225
Electrical Conductivity (field) (µS/cm)	2	2			1905	3105.0000	1200.0000	4305	2025	2385	2505	3105	3705	4185
Groundwater Level (mAHD)	2	2			325.12	339.7305	14.6105	354.341	326.58105	330.9642	332.42525	339.7305	347.03575	352.87995
GWL Depth Reference Elevation	2	2			326.76	341.2855	14.5255	355.811	328.21255	332.5702	334.02275	341.2855	348.54825	354.35845
Odour	2													
ORP (field) (mV)	2	2			-49.6	-29.3000	20.3000	-9	-47.57	-41.48	-39.45	-29.3	-19.15	-11.03
pH (field)	2	2			8.18	8.3700	0.1900	8.56	8.199	8.256	8.275	8.37	8.465	8.541
Salinity (field) (PSU)	2	2			0.96	1.6150	0.6550	2.27	1.0255	1.222	1.2875	1.615	1.9425	2.2045
TDS (field) (ppm)	2	2			28.8	29.2650	0.4650	29.73	28.8465	28.986	29.0325	29.265	29.4975	29.6835
Total Dissolved Solids (field) (ppm)	2	2			952	1551.5000	599.5000	2151	1011.95	1191.8	1251.75	1551.5	1851.25	2091.05
Hardness														
Total Hardness (mg CaCO3/L)	10	10			118	353.4000	100.0822	529	208	321.2	324.75	353.5	381.25	494.35
Ion Balance														
Ionic Balance (%)	10	10			0.15	1.7840	1.3363	3.96	0.258	0.462	0.525	1.625	2.9625	3.744
Total Anions (meq/L)	10	10			20	36.7500	6.8993	50.1	27.11	36.12	36.275	36.8	37.575	45.825
Total Cations (meq/L)	10	10			20.5	36.4400	6.7216	49.7	26.71	34.78	35.175	36.55	38.575	44.795
Major Ions														
Calcium (mg/L)	20	20			21	57.9000	17.7874	94	22.9	50.4	51.75	56.5	62	90.2
Chloride (mg/L)	10	10			127	261.0000	81.9902	453	166.6	215	215.5	243	285.75	395.85

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Fluoride (mg/L)	10	10			0.8	0.9900	0.2071	1.4	0.8	0.8	0.8	0.9	1.175	1.31
Magnesium (mg/L)	20	20			16	52.9500	17.0190	100	17.9	47.6	49.5	51.5	56	75.3
Potassium (mg/L)	20	20			2	2.9000	1.9468	11	2	2	2	2	3	4.35
Sodium (mg/L)	20	20			394	681.5500	116.2624	916	414.9	651.4	668	681	717.5	898.9
Sulfate (as SO4)	10	10			243	644.8000	158.1150	895	376.2	627	650.75	669	703.5	819.85
Metals (dissolved)														
Arsenic - dissolved (mg/L)	10	7	3	30.0	0.001	0.0011	0.0003	0.002	0.001	0.001	0.001	0.001	0.001	0.0017
Barium - dissolved (mg/L)	10	10			0.042	0.1300	0.0354	0.178	0.0726	0.114	0.118	0.135	0.14975	0.17125
Bismuth - dissolved (mg/L)	10		10	100.0										
Chromium - dissolved (mg/L)	10	1	9	90.0	0.003	0.0030	0.0000	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Cobalt - dissolved (mg/L)	10	4	6	60.0	0.001	0.0013	0.0004	0.002	0.001	0.001	0.001	0.001	0.00125	0.00185
Copper - dissolved (mg/L)	10	4	6	60.0	0.001	0.0020	0.0012	0.004	0.001	0.001	0.001	0.0015	0.0025	0.0037
Molybdenum - dissolved (mg/L)	10	9	1	10.0	0.003	0.0048	0.0017	0.008	0.003	0.003	0.003	0.004	0.006	0.0076
Nickel - dissolved (mg/L)	10	3	7	70.0	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Selenium - dissolved (mg/L)	10		10	100.0										
Uranium - dissolved (mg/L)	10	10			0.008	0.0222	0.0072	0.038	0.0125	0.0188	0.0195	0.022	0.023	0.0335
Metals (total)														
Arsenic - total (mg/L)	10	10			0.001	0.0014	0.0009	0.004	0.001	0.001	0.001	0.001	0.001	0.0031
Barium - total (mg/L)	10	10			0.049	0.1459	0.0534	0.268	0.08095	0.1224	0.1235	0.1355	0.157	0.23335
Bismuth - total (mg/L)	10		10	100.0										
Chromium - total (mg/L)	10	1	9	90.0	0.023	0.0230	0.0000	0.023	0.023	0.023	0.023	0.023	0.023	0.023
Cobalt - total (mg/L)	10	4	6	60.0	0.001	0.0050	0.0064	0.016	0.001	0.001	0.001	0.0015	0.0055	0.0139

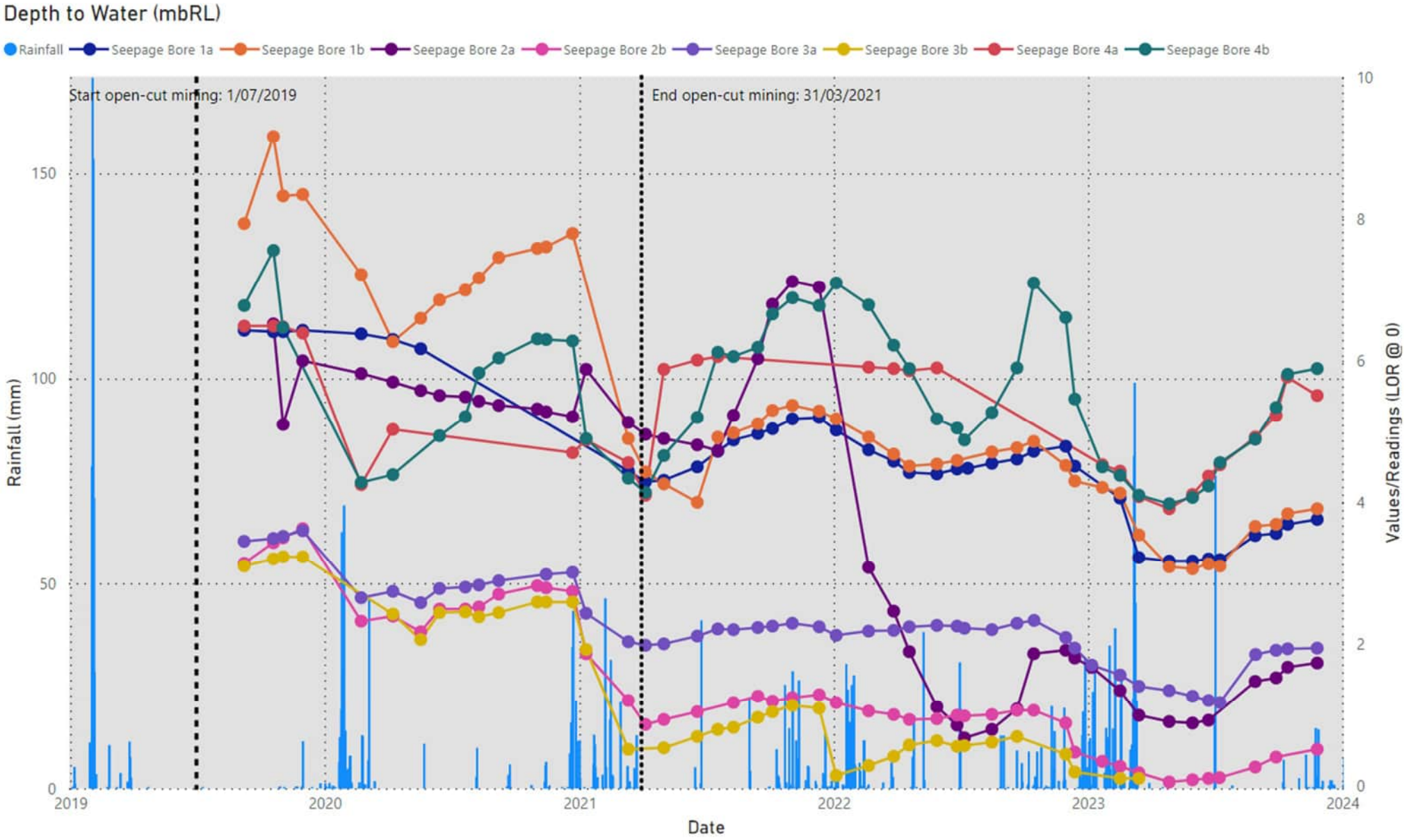
	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Copper - total (mg/L)	10	10			0.001	0.0038	0.0038	0.014	0.001	0.0018	0.002	0.0025	0.003	0.01085
Molybdenum - total (mg/L)	10	10			0.003	0.0048	0.0021	0.01	0.003	0.003	0.00325	0.004	0.005	0.00865
Nickel - total (mg/L)	10	4	6	60.0	0.001	0.0035	0.0038	0.01	0.001	0.001	0.001	0.0015	0.004	0.0088
Selenium - total (mg/L)	10		10	100.0										
Uranium - total (mg/L)	10	10			0.01	0.0244	0.0087	0.046	0.01405	0.0206	0.02125	0.023	0.0255	0.0388
Physico-Chemical Parameters														
Electrical Conductivity (µS/cm)	10	10			2040	3279.0000	570.9720	4430	2494.5	3098	3117.5	3260	3377.5	4151
pH (lab)	10	10			7.31	7.6220	0.2697	8.2	7.3145	7.336	7.395	7.625	7.6375	8.0965
Turbidity (NTU)	10	10			1	52.8600	141.4153	477	1.36	2.36	3.175	6.4	9.4	267.345
Seepage Bore 9a														
Alkalinity														
Bicarbonate Alkalinity as CaCO3 (mg/L)	10	10			550	666.3000	87.7315	846	558.55	584.2	597.25	650.5	726.5	803.7
Carbonate Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Hydroxide Alkalinity as CaCO3 (mg/L)	10		10	100.0										
Temperature (field) (°C)	10	10			550	666.3000	87.7315	846	558.55	584.2	597.25	650.5	726.5	803.7
Field Measurements														
Appearance or Colour	2													
Depth to Water (mbRL)	2	2			0.49	1.2500	0.7600	2.01	0.566	0.794	0.87	1.25	1.63	1.934
Dissolved Oxygen (field) (% sat))	2	2			58.8	107.2000	48.4000	155.6	63.64	78.16	83	107.2	131.4	150.76
Electrical Conductivity (field) (µS/cm)	2	2			2525	2562.0000	37.0000	2599	2528.7	2539.8	2543.5	2562	2580.5	2595.3

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Groundwater Level (mAHD)	2	2			323.43	324.0900	0.6600	324.75	323.496	323.694	323.76	324.09	324.42	324.684
GWL Depth Reference Elevation	2	2			323.92	325.3400	1.4200	326.76	324.062	324.488	324.63	325.34	326.05	326.618
Odour	2													
ORP (field) (mV)	2	2			-54.7	-26.6500	28.0500	1.4	-51.895	-43.48	-40.675	-26.65	-12.625	-1.405
pH (field)	2	2			8.03	8.0850	0.0550	8.14	8.0355	8.052	8.0575	8.085	8.1125	8.1345
Salinity (field) (PSU)	2	2			1.29	1.3100	0.0200	1.33	1.292	1.298	1.3	1.31	1.32	1.328
TDS (field) (ppm)	2	2			29.71	30.1550	0.4450	30.6	29.7545	29.888	29.9325	30.155	30.3775	30.5555
Total Dissolved Solids (field) (ppm)	2	2			1263	1281.5000	18.5000	1300	1264.85	1270.4	1272.25	1281.5	1290.75	1298.15
Hardness														
Total Hardness (mg CaCO3/L)	10	10			577	672.3000	57.2853	765	600.85	630.8	634.75	653.5	716.75	760.95
Ion Balance														
Ionic Balance (%)	10	10			0.85	3.5790	2.4715	7.81	0.904	1.25	1.4975	2.8	5.515	7.531
Total Anions (meq/L)	10	10			27.5	28.7200	0.8518	30.2	27.635	27.88	28	28.7	29.25	30.065
Total Cations (meq/L)	10	10			29.4	30.6300	1.0734	32.6	29.445	29.5	29.525	30.8	31	32.375
Major Ions														
Calcium (mg/L)	20	20			74	91.9500	8.5234	106	75.9	84	87.75	93	99.25	102.2
Chloride (mg/L)	10	10			129	146.5000	15.1542	185	129.9	136.6	138.25	144	149.75	171.95
Fluoride (mg/L)	10	10			1.7	2.0900	0.1758	2.4	1.835	2	2	2.1	2.2	2.31
Magnesium (mg/L)	20	20			88	109.4000	10.0717	125	93.7	101.4	102.75	109	116.5	124.05
Potassium (mg/L)	20	20			2	2.0000	0.0000	2	2	2	2	2	2	2
Sodium (mg/L)	20	20			368	396.1500	23.3865	447	368.95	377.8	378	388.5	402.25	445.1
Sulfate (as SO4)	10	10			382	542.1000	77.6382	650	416.2	488.4	503	547	597.5	640.55
Metals (dissolved)														
Arsenic - dissolved (mg/L)	10	10			0.002	0.0021	0.0003	0.003	0.002	0.002	0.002	0.002	0.002	0.00255

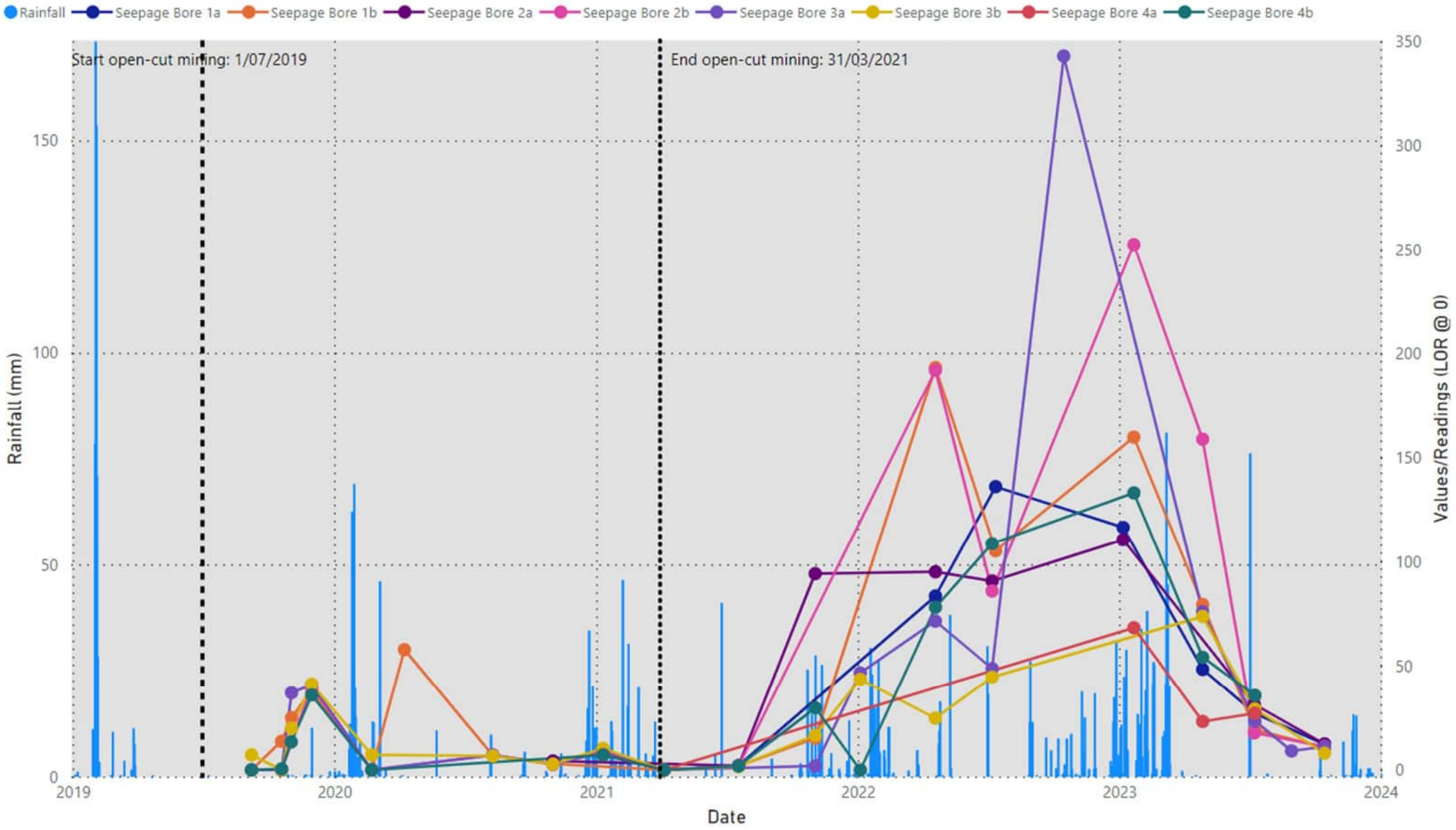
	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Barium - dissolved (mg/L)	10	10			0.146	0.1651	0.0138	0.192	0.1469	0.1504	0.15325	0.1665	0.172	0.18615
Bismuth - dissolved (mg/L)	10		10	100.0										
Chromium - dissolved (mg/L)	10		10	100.0										
Cobalt - dissolved (mg/L)	10	10			0.002	0.0027	0.0005	0.003	0.002	0.002	0.00225	0.003	0.003	0.003
Copper - dissolved (mg/L)	10	4	6	60.0	0.001	0.0013	0.0004	0.002	0.001	0.001	0.001	0.001	0.00125	0.00185
Molybdenum - dissolved (mg/L)	10	10			0.003	0.0050	0.0010	0.006	0.00345	0.004	0.00425	0.005	0.006	0.006
Nickel - dissolved (mg/L)	10	6	4	40.0	0.001	0.0010	0.0000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Selenium - dissolved (mg/L)	10	4	6	60.0	0.01	0.0175	0.0043	0.02	0.0115	0.016	0.0175	0.02	0.02	0.02
Uranium - dissolved (mg/L)	10	10			0.006	0.0097	0.0038	0.016	0.006	0.006	0.006	0.0085	0.013	0.0151
Metals (total)														
Arsenic - total (mg/L)	10	10			0.002	0.0022	0.0004	0.003	0.002	0.002	0.002	0.002	0.002	0.003
Barium - total (mg/L)	10	10			0.148	0.1735	0.0153	0.196	0.1498	0.1552	0.16	0.1785	0.184	0.1915
Bismuth - total (mg/L)	10		10	100.0										
Chromium - total (mg/L)	10	2	8	80.0	0.002	0.0020	0.0000	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Cobalt - total (mg/L)	10	10			0.003	0.0033	0.0005	0.004	0.003	0.003	0.003	0.003	0.00375	0.004
Copper - total (mg/L)	10	10			0.003	0.0056	0.0040	0.016	0.003	0.003	0.00325	0.004	0.00475	0.0133
Molybdenum - total (mg/L)	10	10			0.004	0.0056	0.0008	0.007	0.00445	0.005	0.005	0.006	0.006	0.00655
Nickel - total (mg/L)	10	8	2	20.0	0.001	0.0018	0.0004	0.002	0.001	0.0014	0.00175	0.002	0.002	0.002
Selenium - total (mg/L)	10	4	6	60.0	0.01	0.0175	0.0043	0.02	0.0115	0.016	0.0175	0.02	0.02	0.02
Uranium - total (mg/L)	10	10			0.006	0.0109	0.0049	0.022	0.00645	0.007	0.007	0.0095	0.0135	0.01885
Physico-Chemical Parameters														

	NumObs	No. > LOR	No. < LOR	% < LOR	Min > LOR	Average > LOR	STDev > LOR	Max >LOR	5%ile (>LOR)	20%ile (>LOR)	25%ile (Q1) (> LOR)	50%ile (Q2) (> LOR)	75%ile (Q3) (> LOR)	95%ile (>LOR)
Electrical Conductivity (µS/cm)	10	10			2520	2622.0000	93.2523	2840	2520	2552	2565	2605	2635	2790.5
pH (lab)	10	10			7.49	7.7390	0.1685	8.09	7.508	7.618	7.6425	7.73	7.8425	7.9955
Turbidity (NTU)	10	10			1.5	6.7400	6.6000	24.5	1.995	3.08	3.275	4.3	5.425	19.235

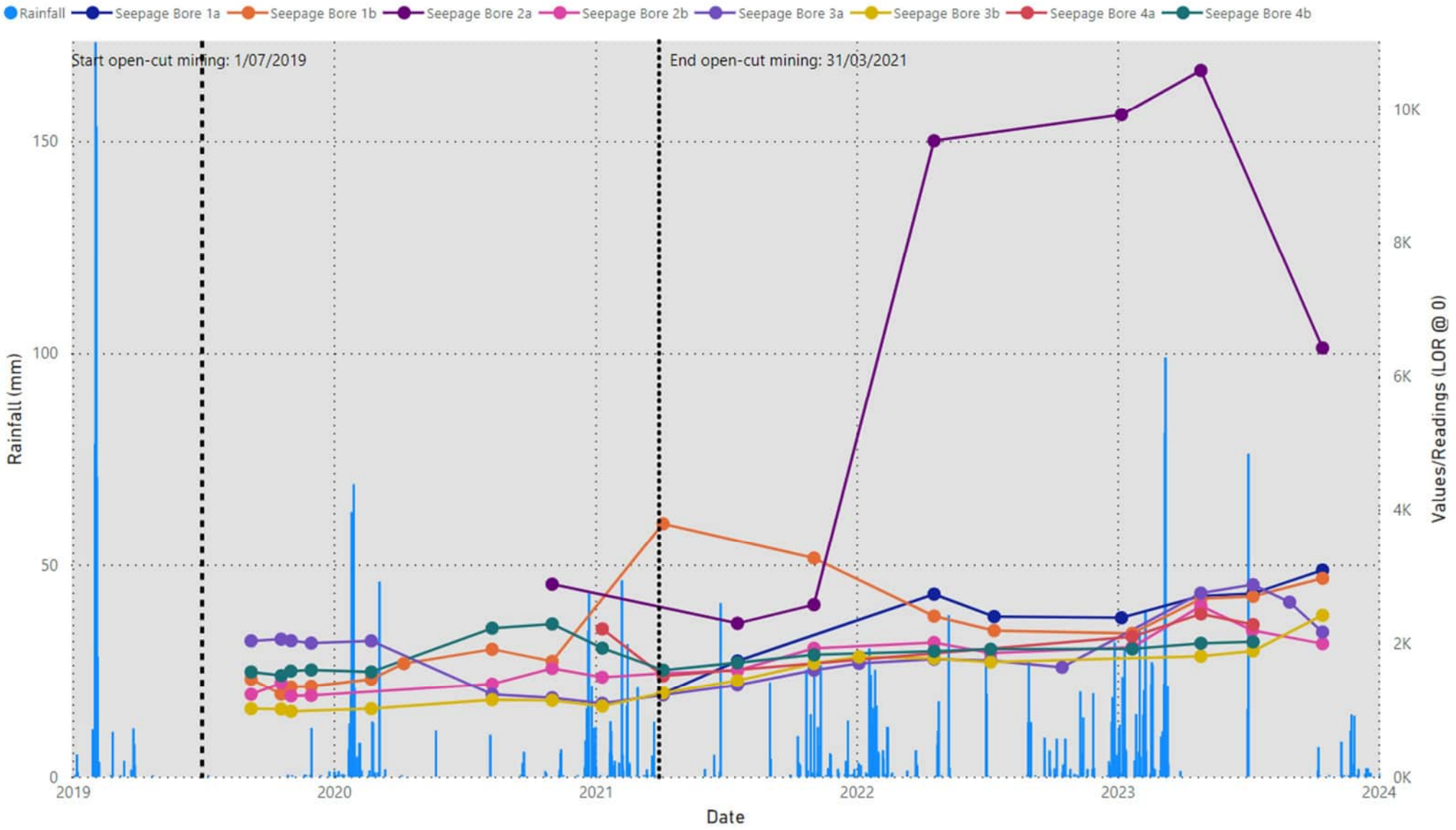
H.2 Water quality time series

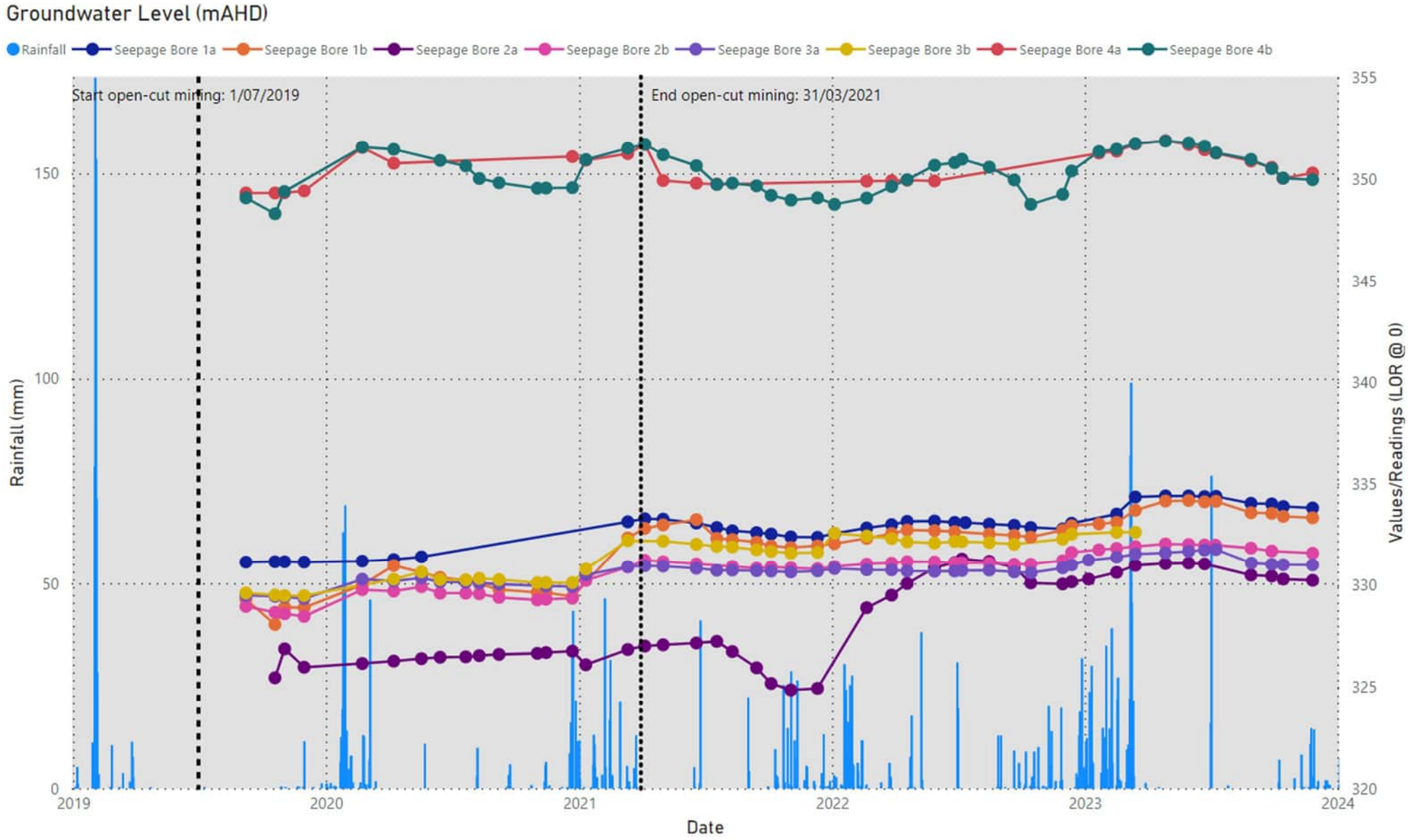

Depth to Water (mbRL)
Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
2
4
6
8
10
2019
2020
2021
2022
2023
2024

Dissolved Oxygen (field) (% sat)

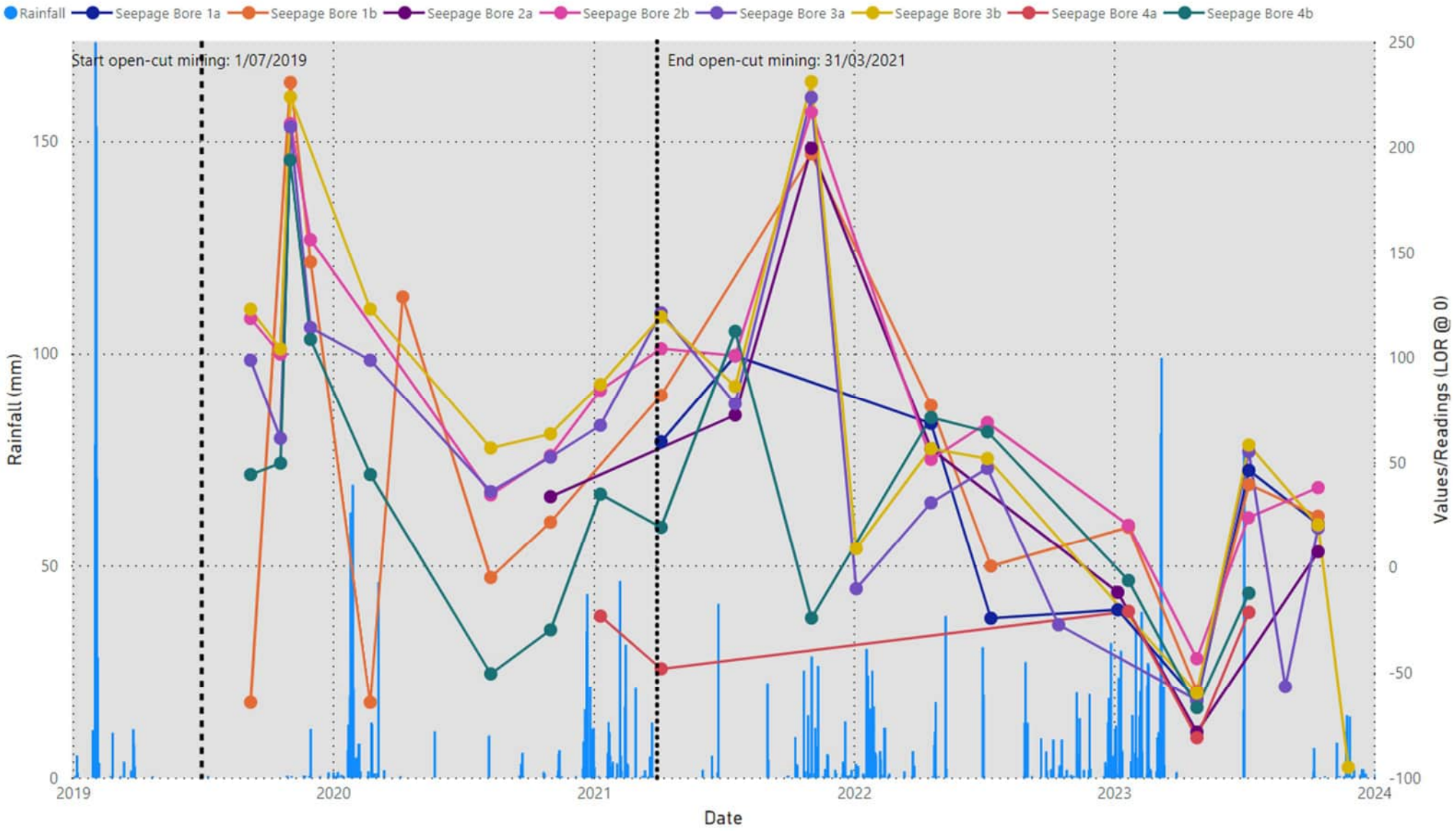


Electrical Conductivity (field) (µS/cm)

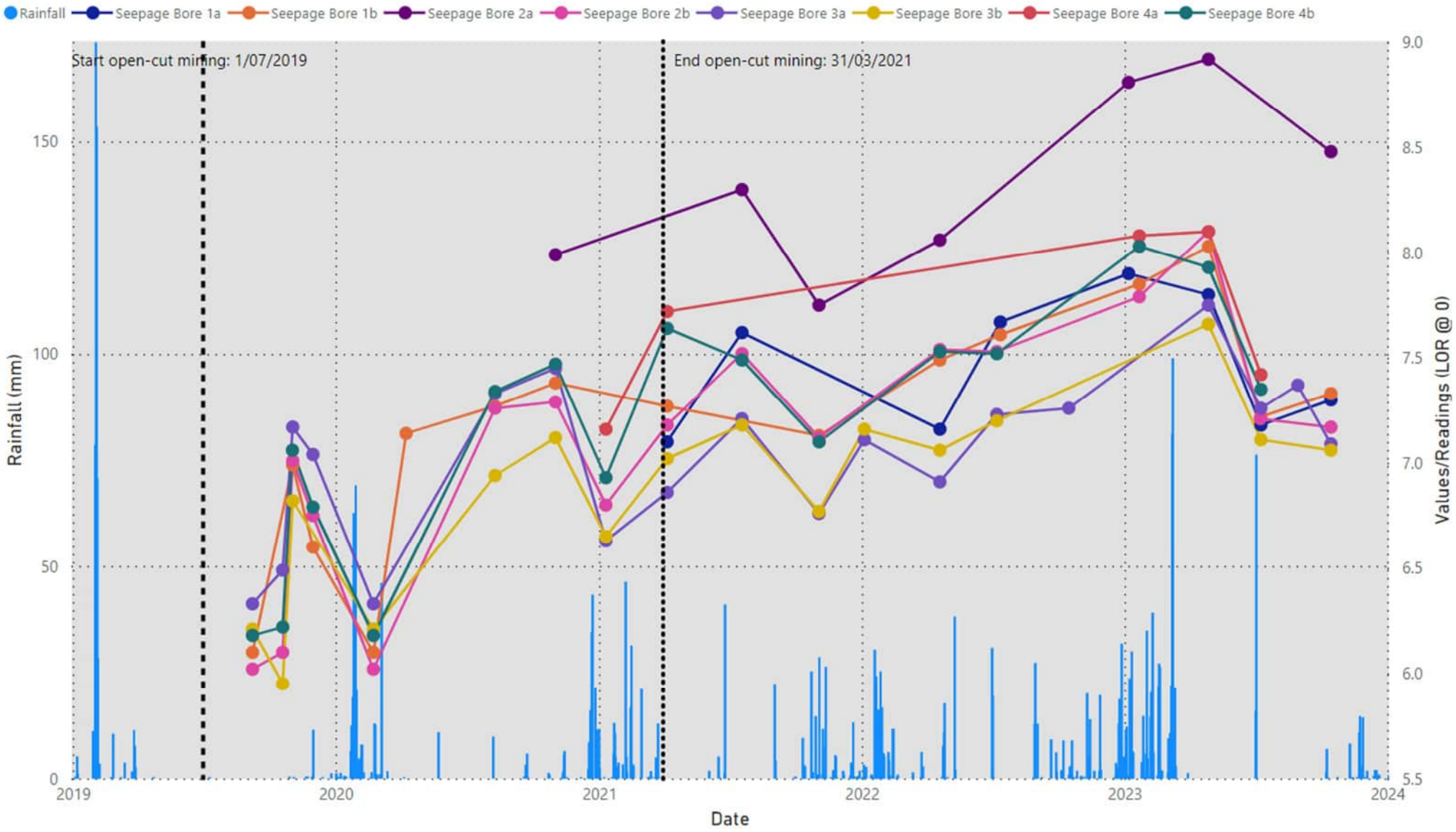


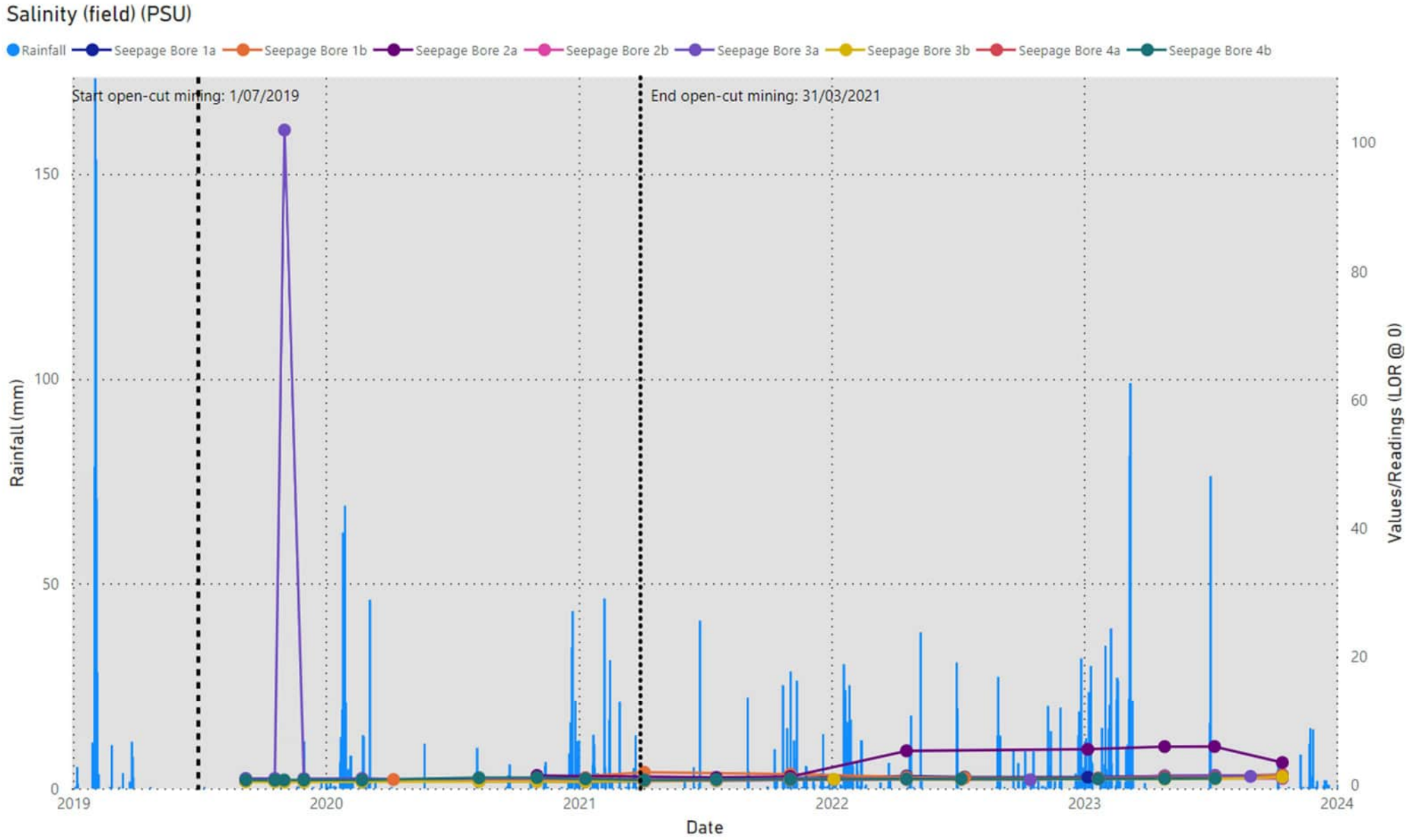

Groundwater Level (mAHD)
Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
320
325
330
335
340
345
350
355
2019
2020
2021
2022
2023
2024

ORP (field) (mV)

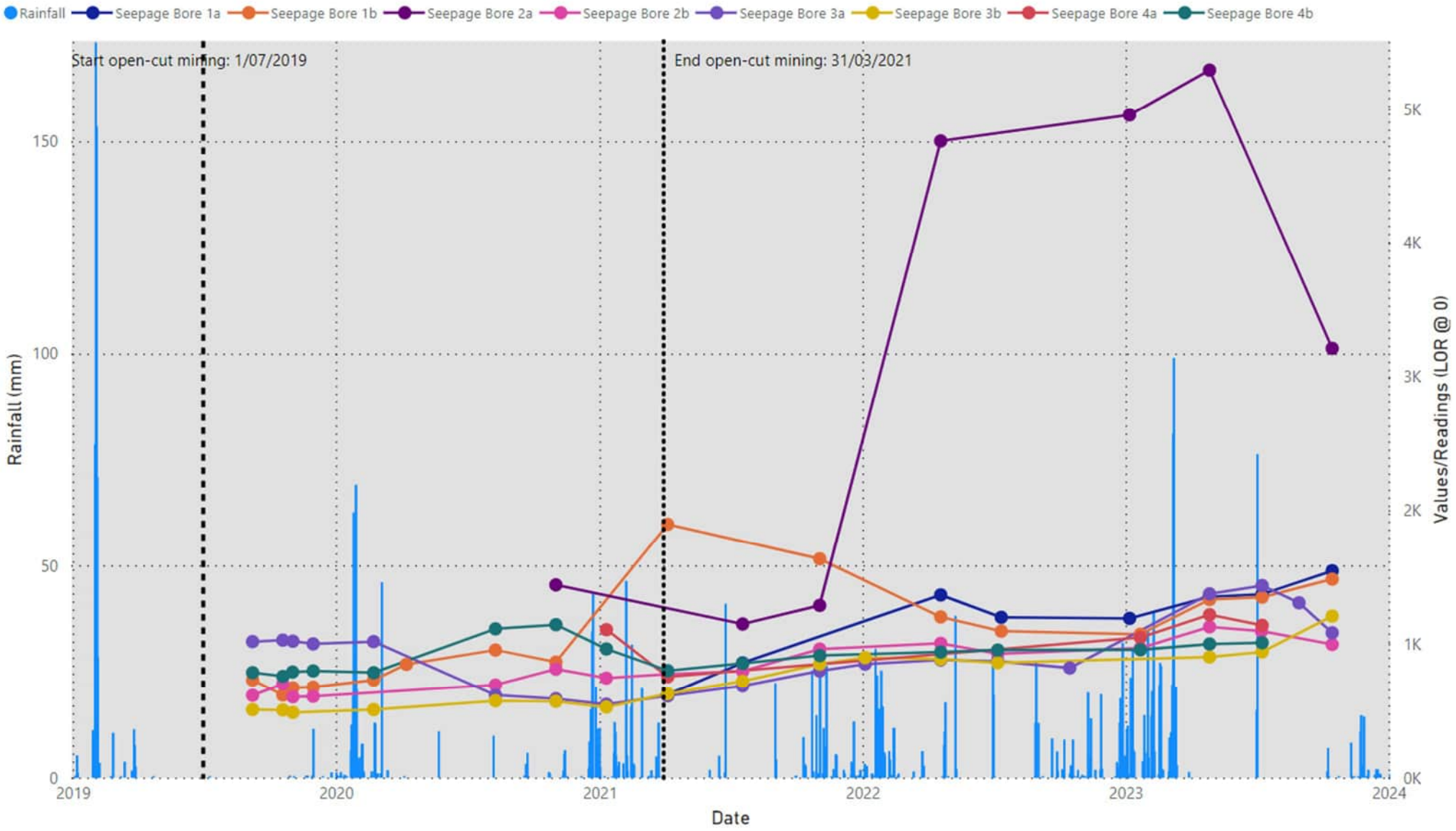

Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
250
200
150
100
50
0
-50
-100
2019
2020
2021
2022
2023
2024

pH (field)

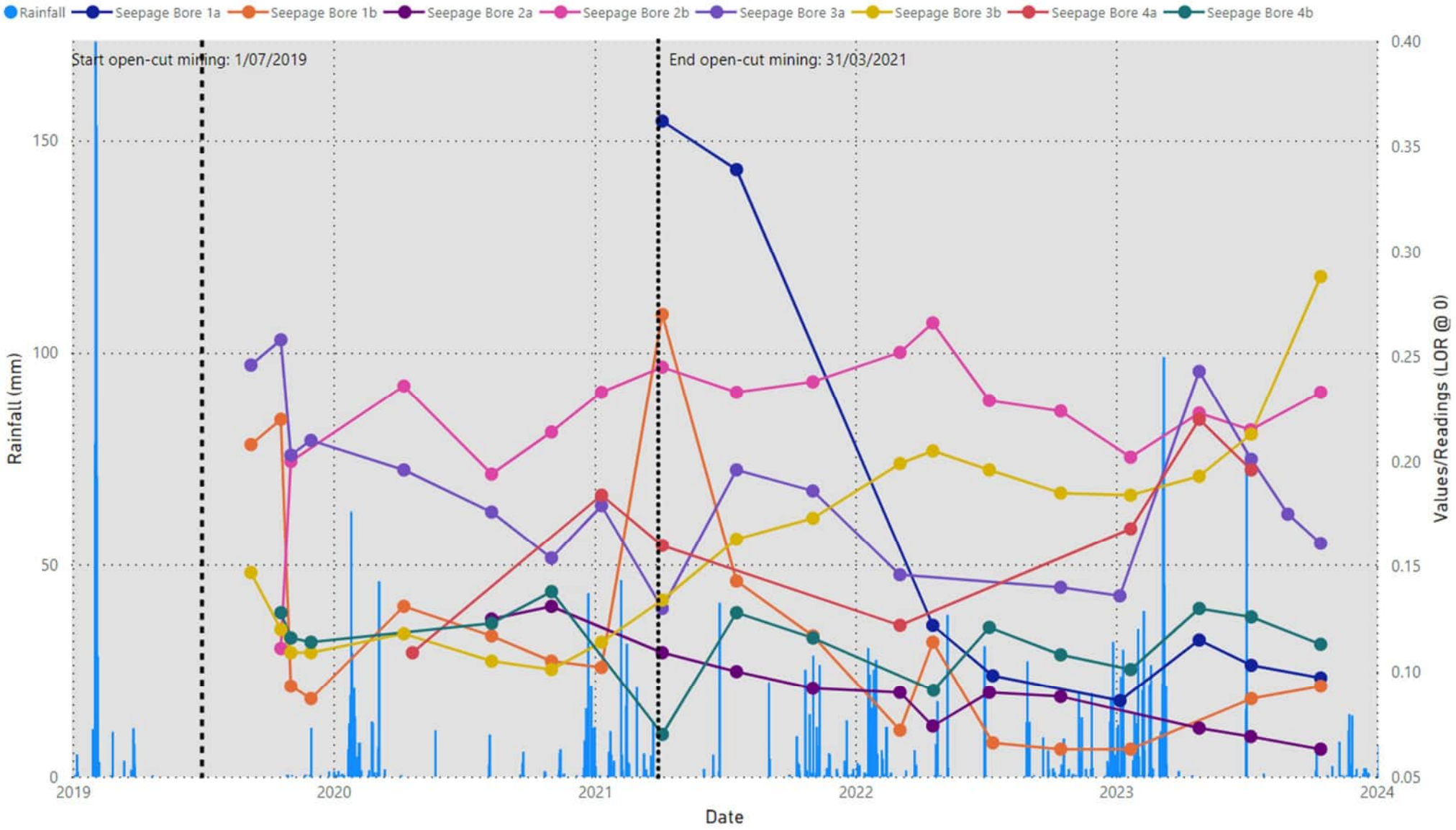

Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
2019
2020
2021
2022
2023
2024

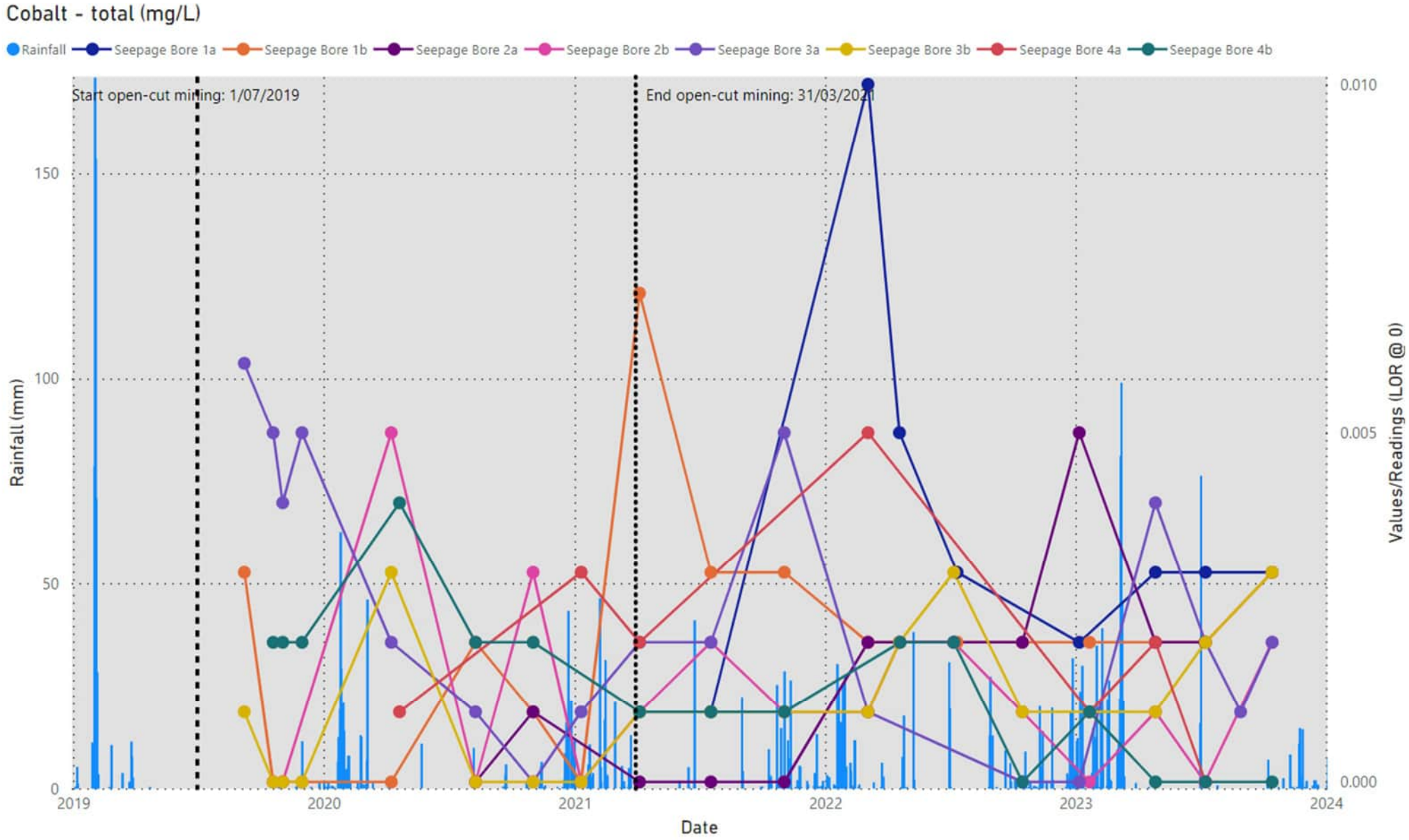

Salinity (field) (PSU)
Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
20
40
60
80
100
2019
2020
2021
2022
2023
2024

TDS (field) (ppm)

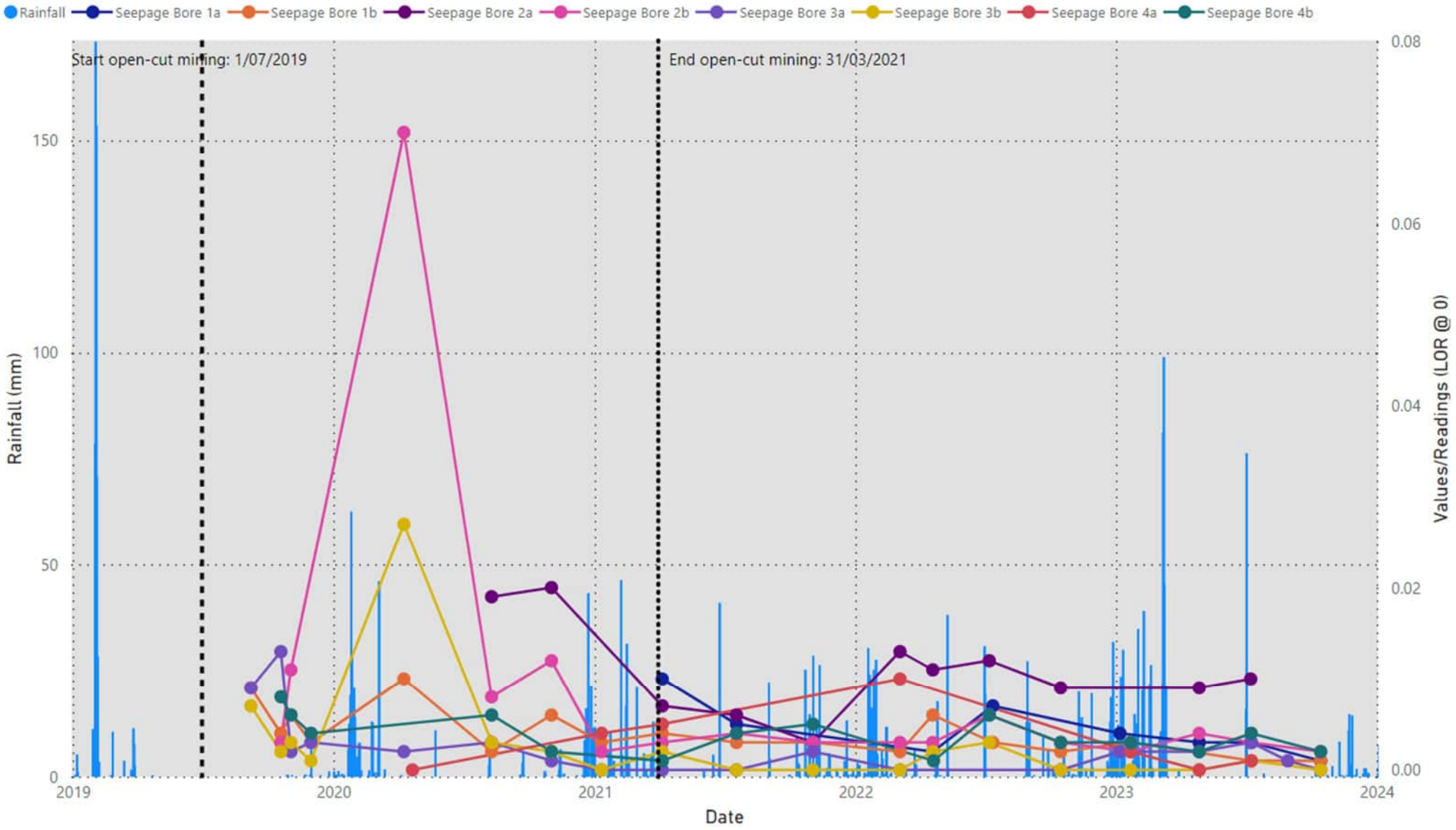


Barium - total (mg/L)

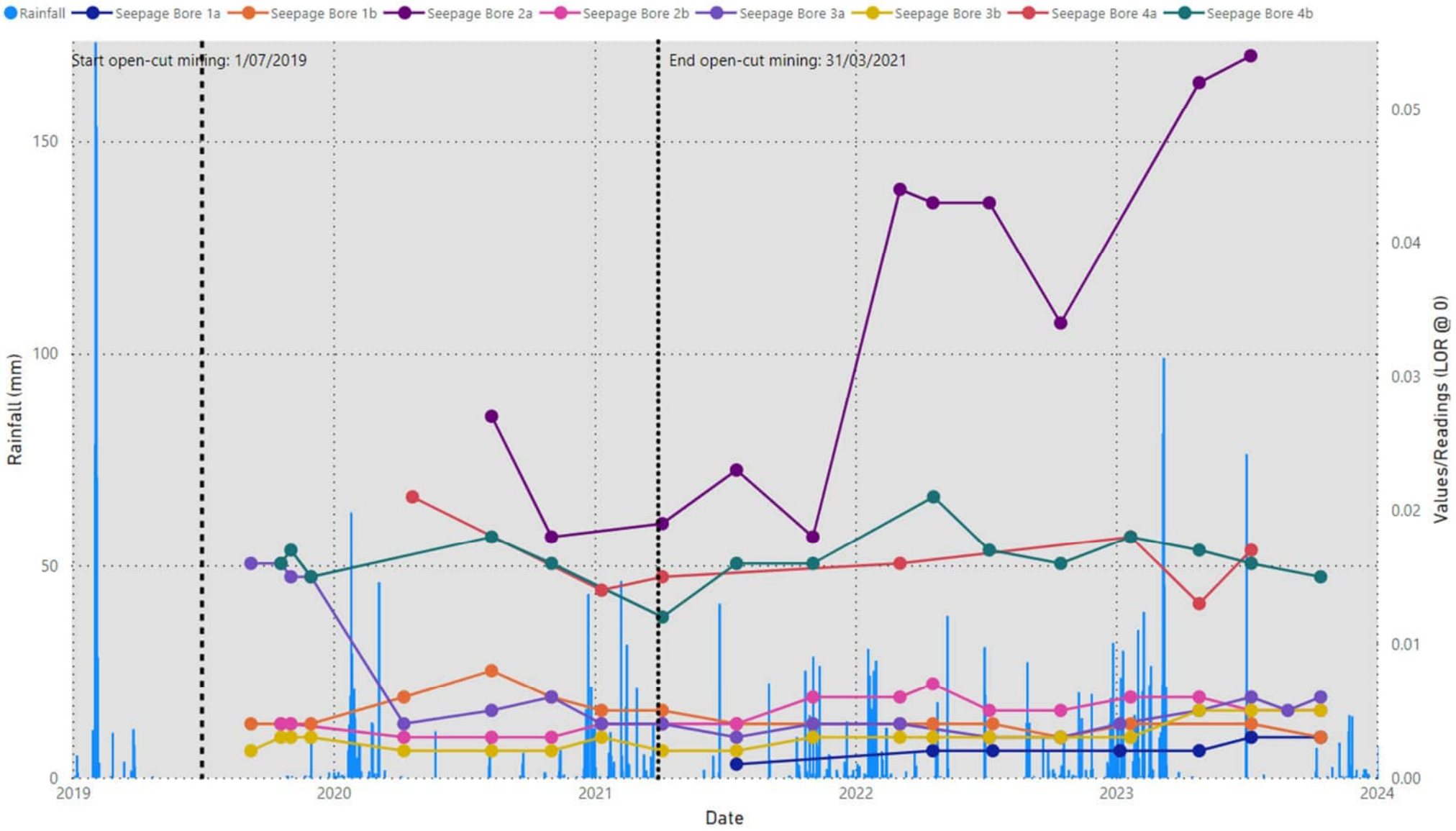



Cobalt - total (mg/L)
Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.000
0.005
0.010
2019
2020
2021
2022
2023
2024

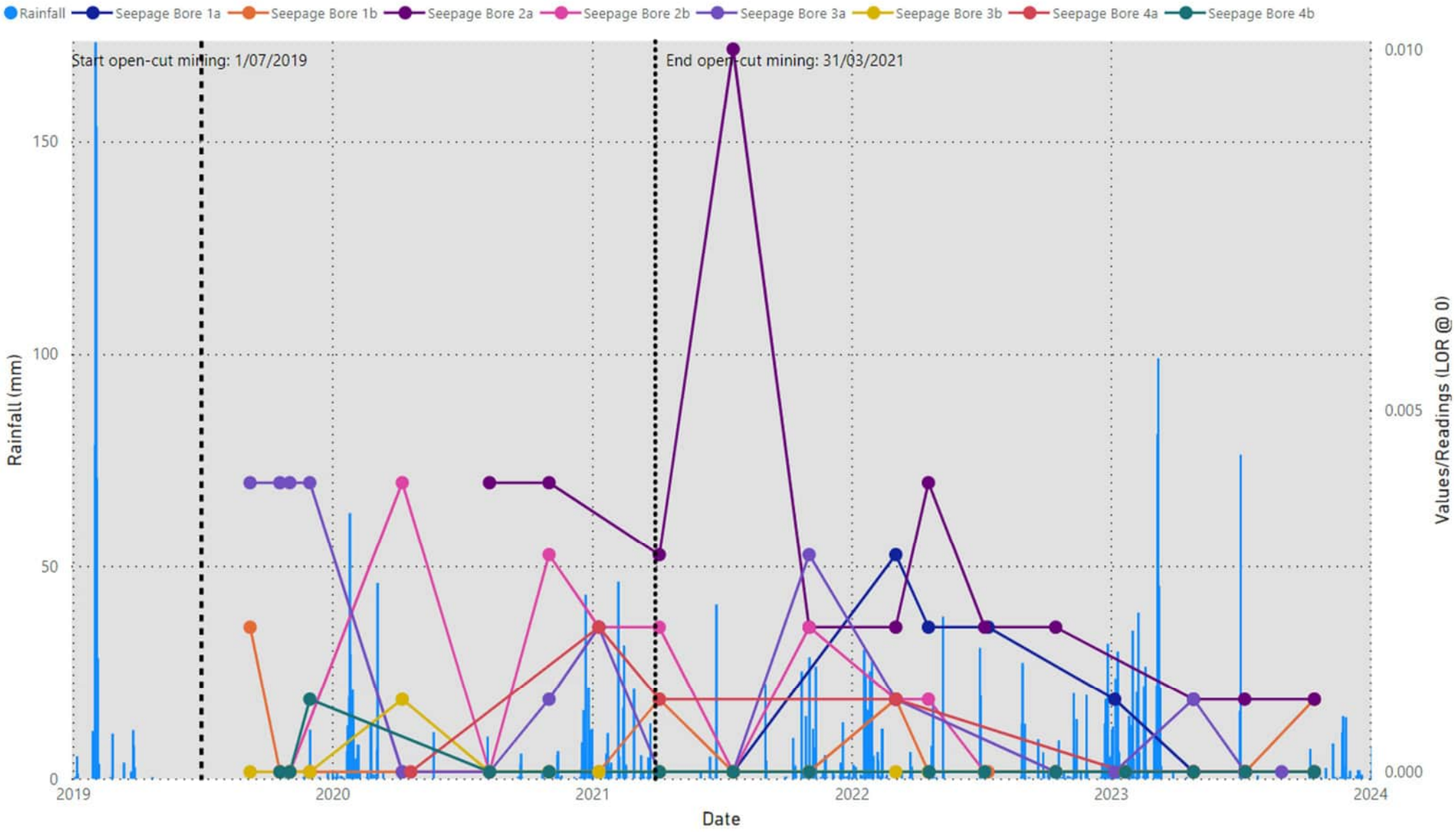
Copper - total (mg/L)



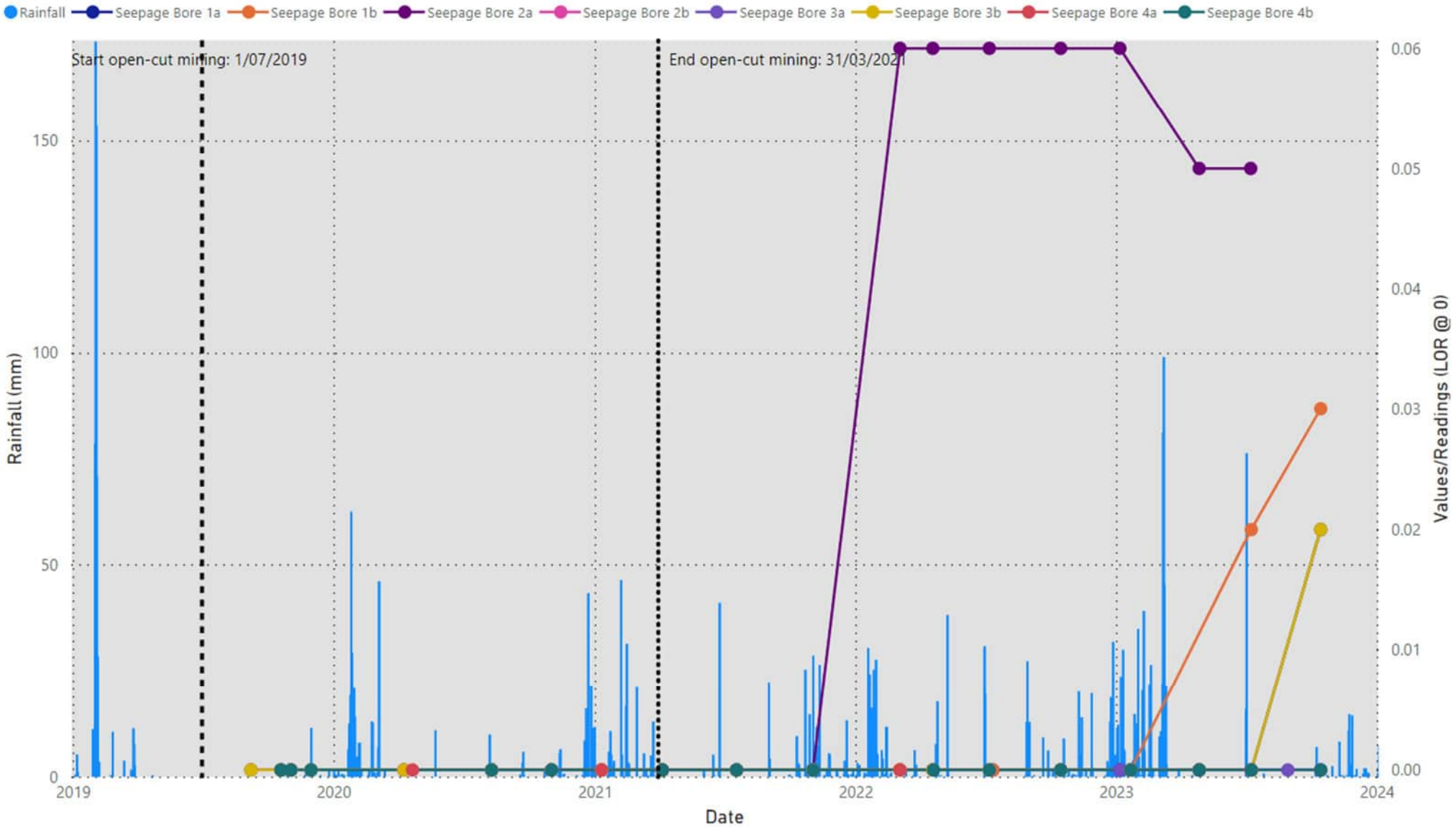
Molybdenum - total (mg/L)



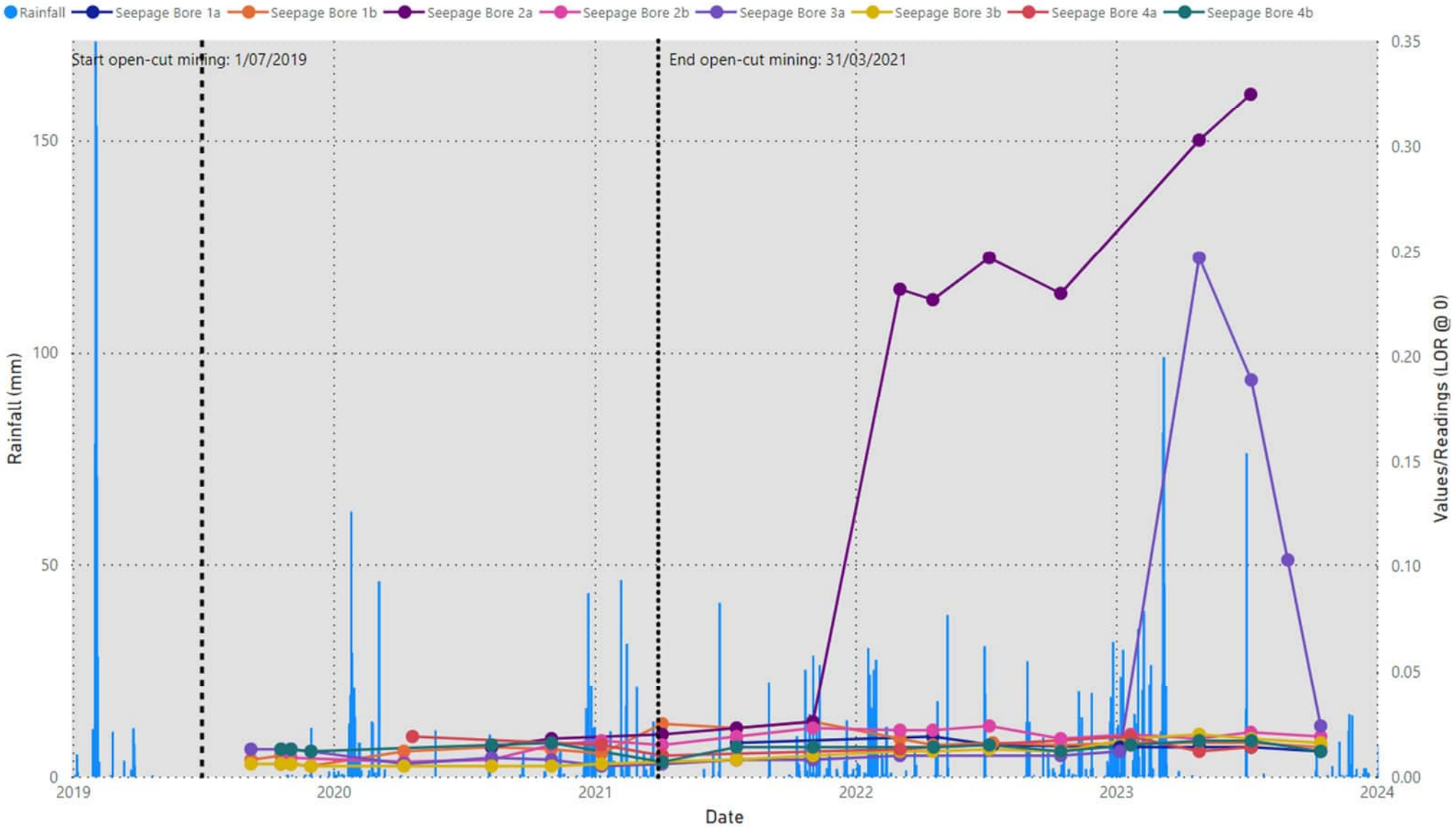
Nickel - total (mg/L)

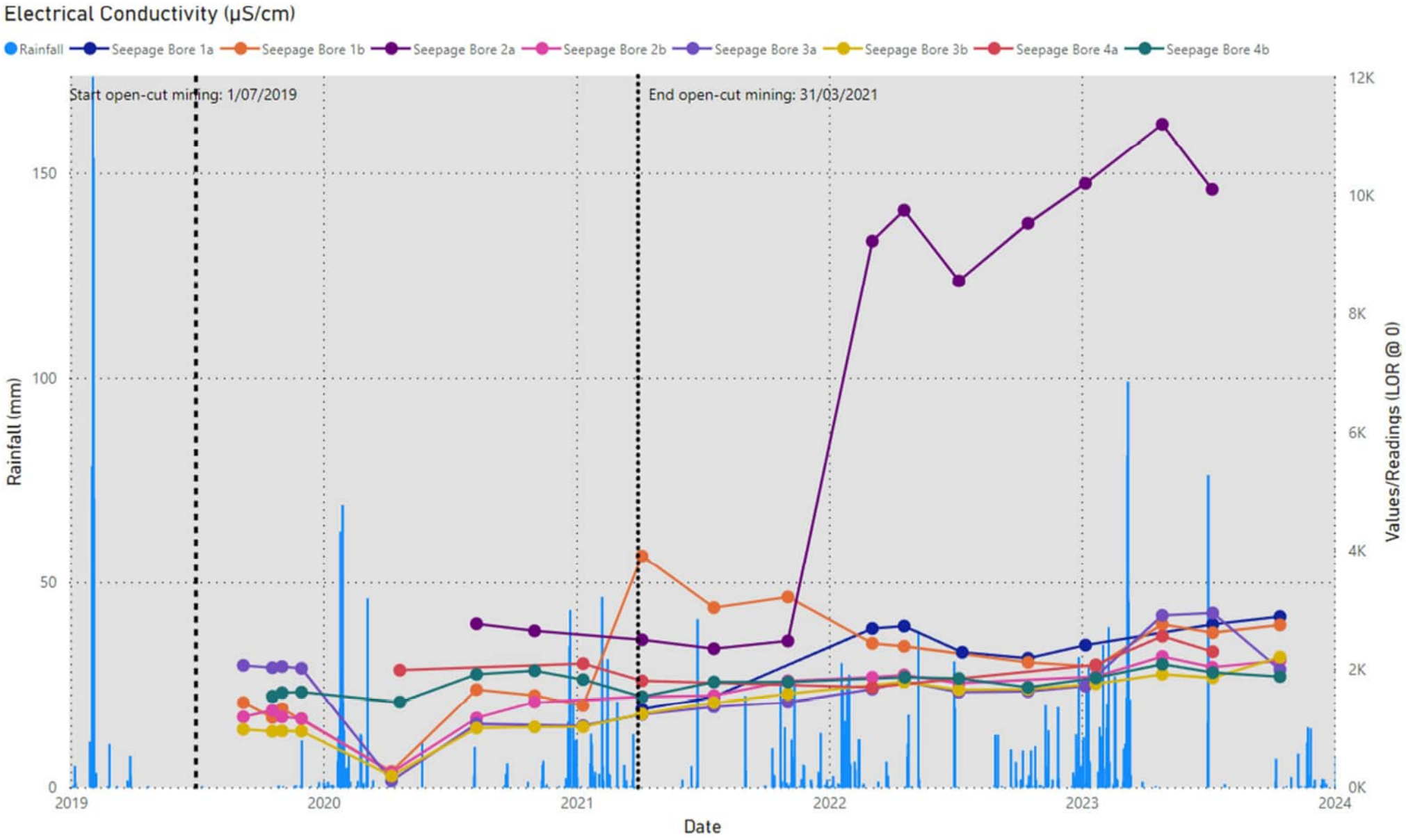


Selenium - total (mg/L)

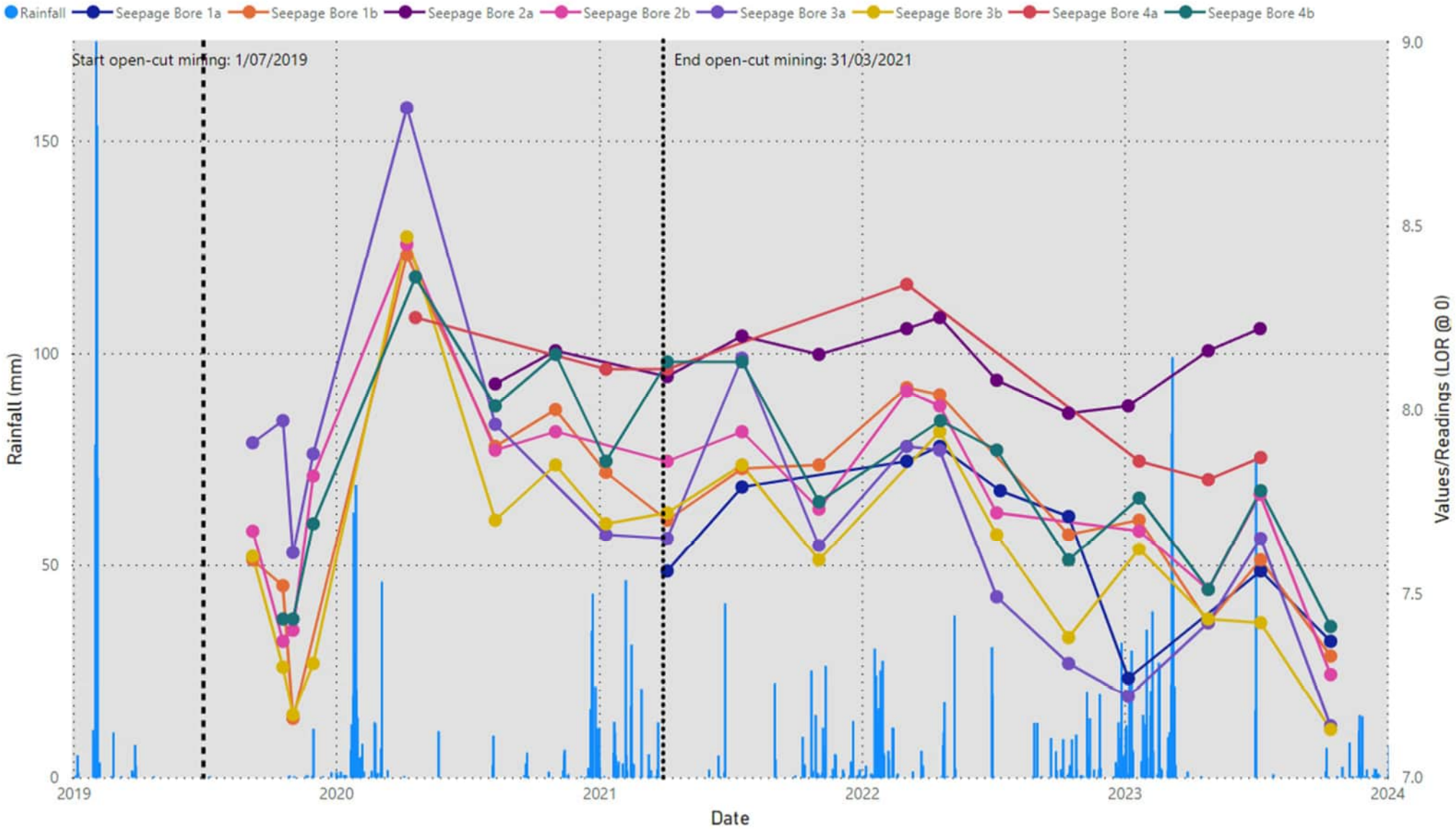


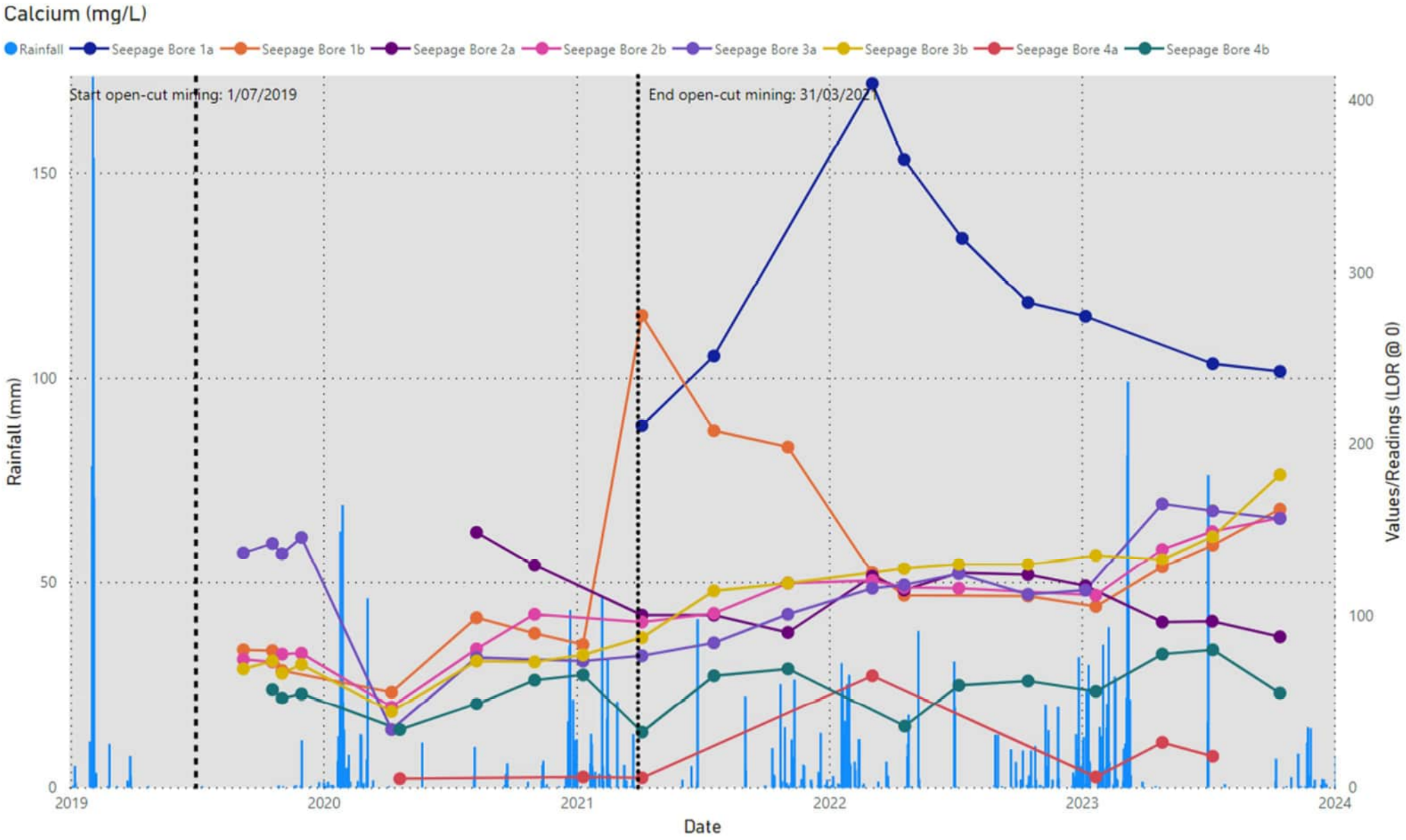
Uranium - total (mg/L)

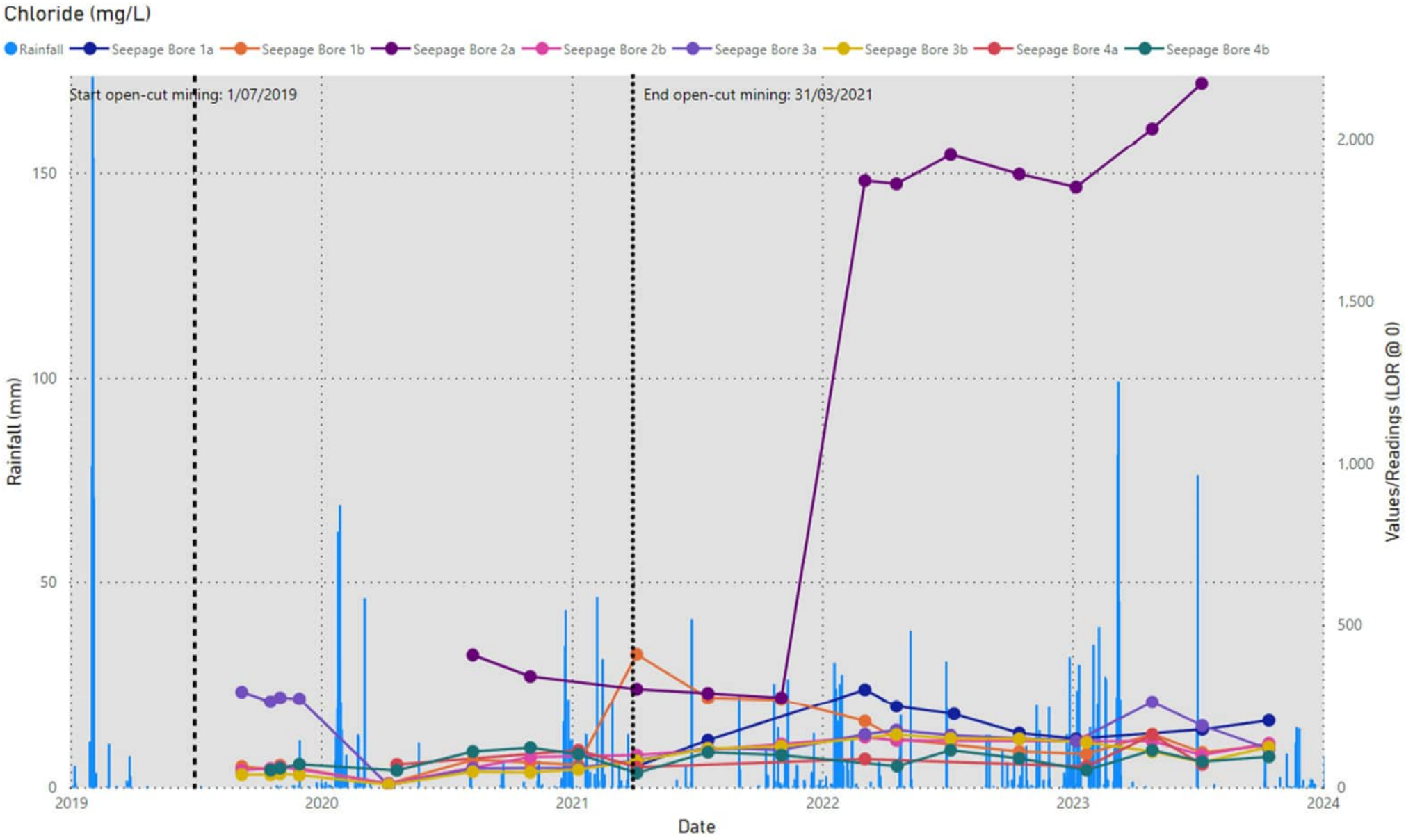



Electrical Conductivity (µS/cm)
Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0K
2K
4K
6K
8K
10K
12K
2019
2020
2021
2022
2023
2024

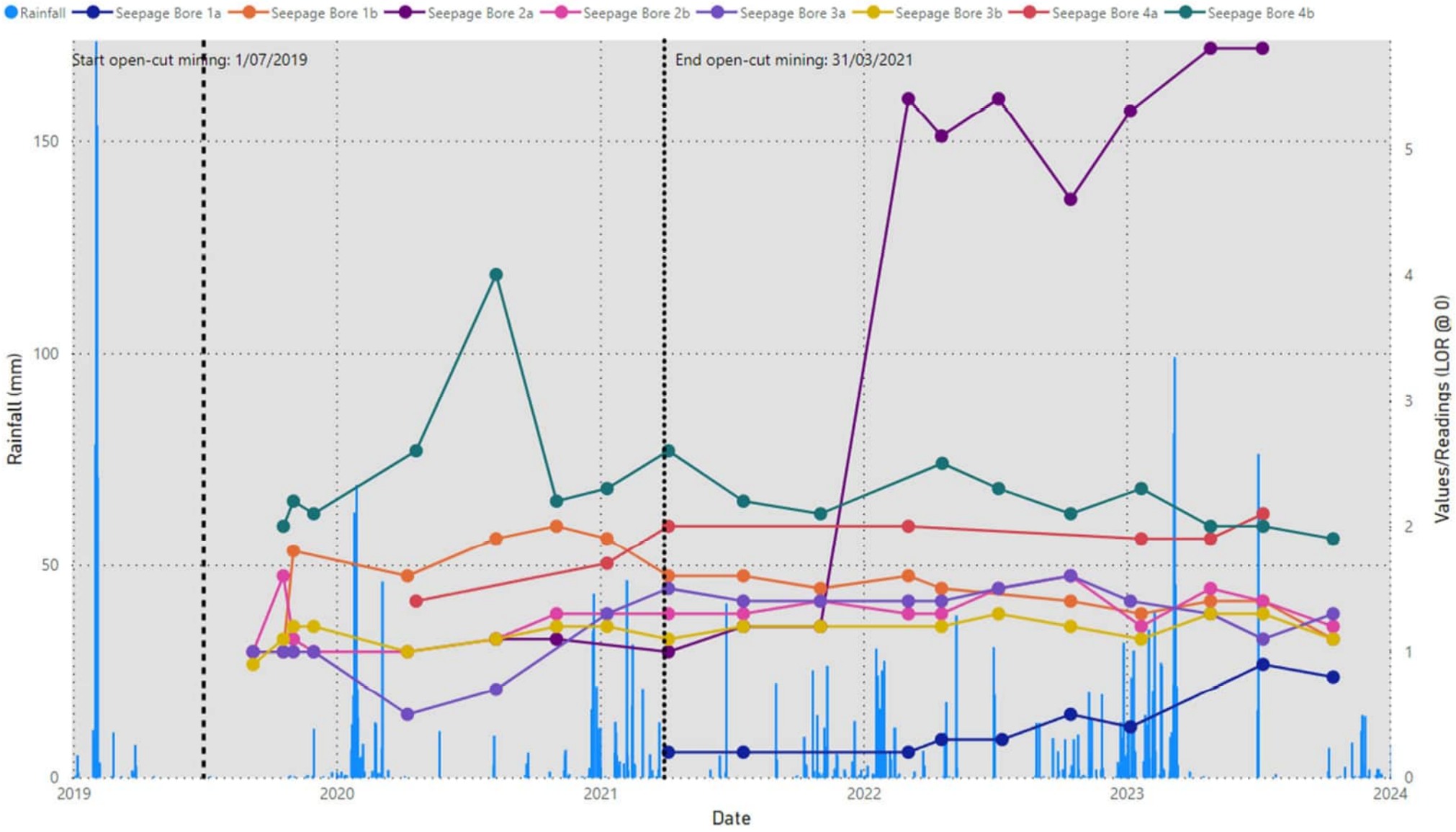
pH (lab)


Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
7.0
7.5
8.0
8.5
9.0
2019
2020
2021
2022
2023
2024

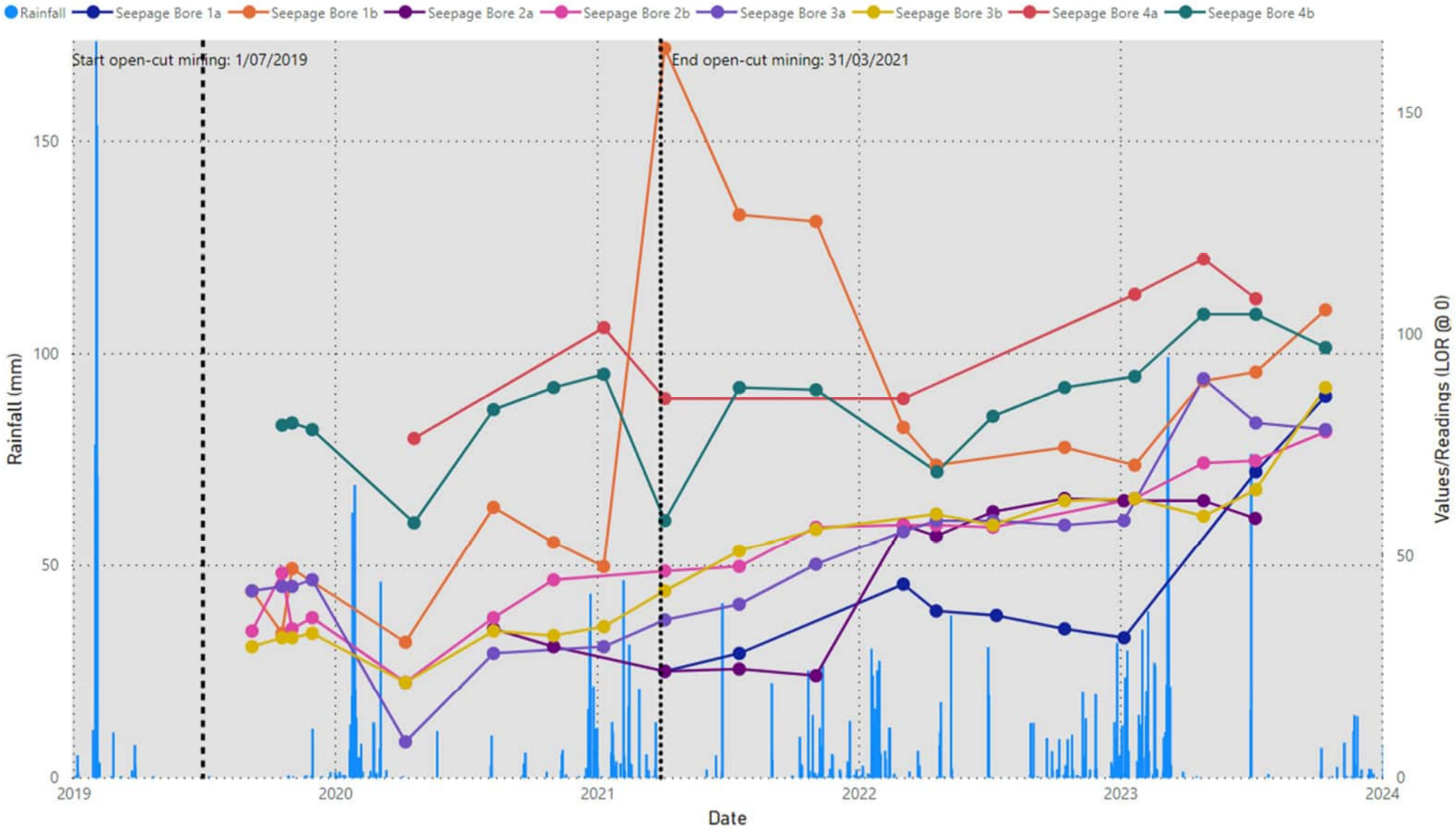

Calcium (mg/L)
Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
200
300
400
2019
2020
2021
2022
2023
2024


Chloride (mg/L)
Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0
500
1,000
1,500
2,000
2019
2020
2021
2022
2023
2024

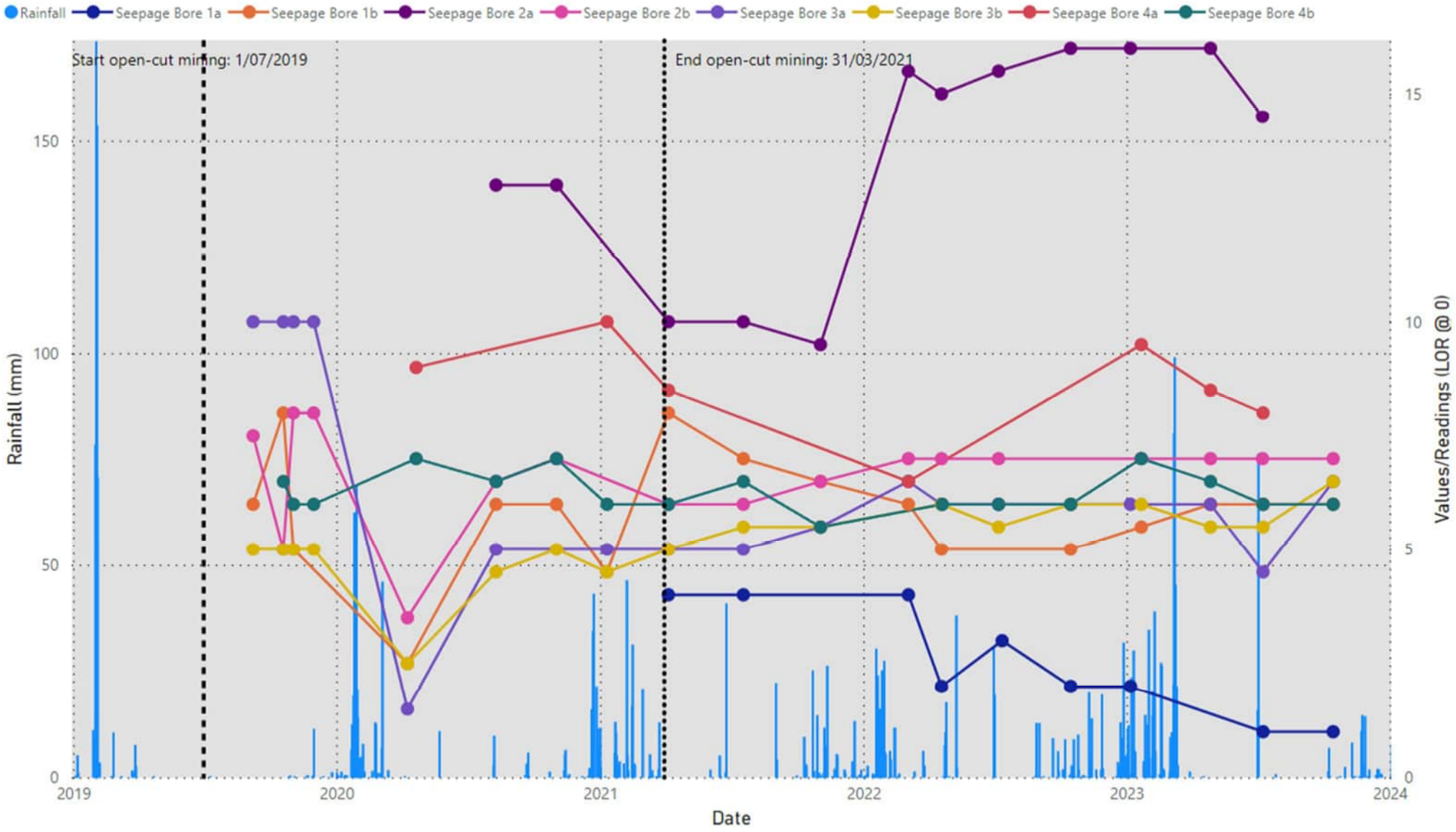
Fluoride (mg/L)



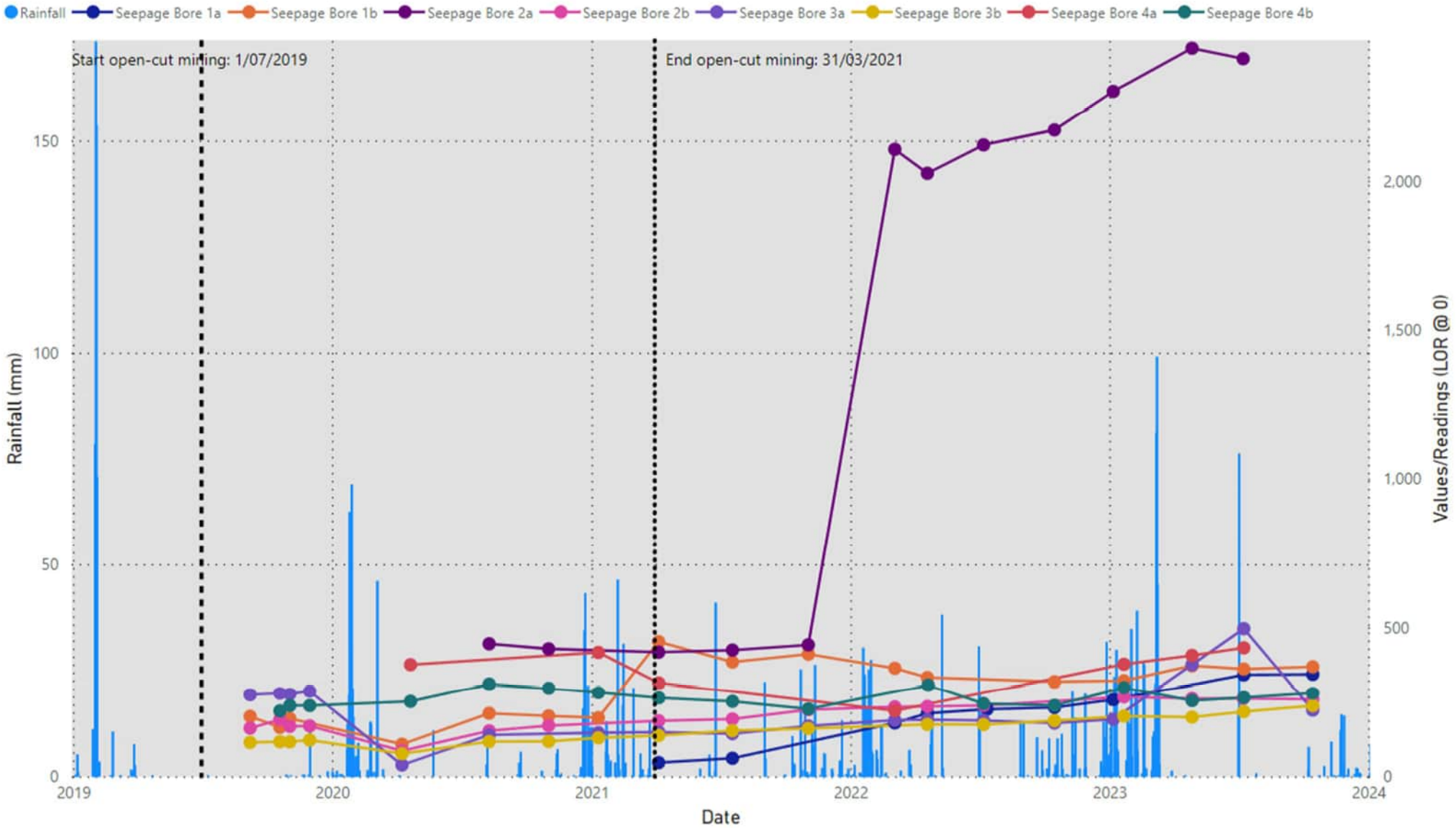
Magnesium (mg/L)



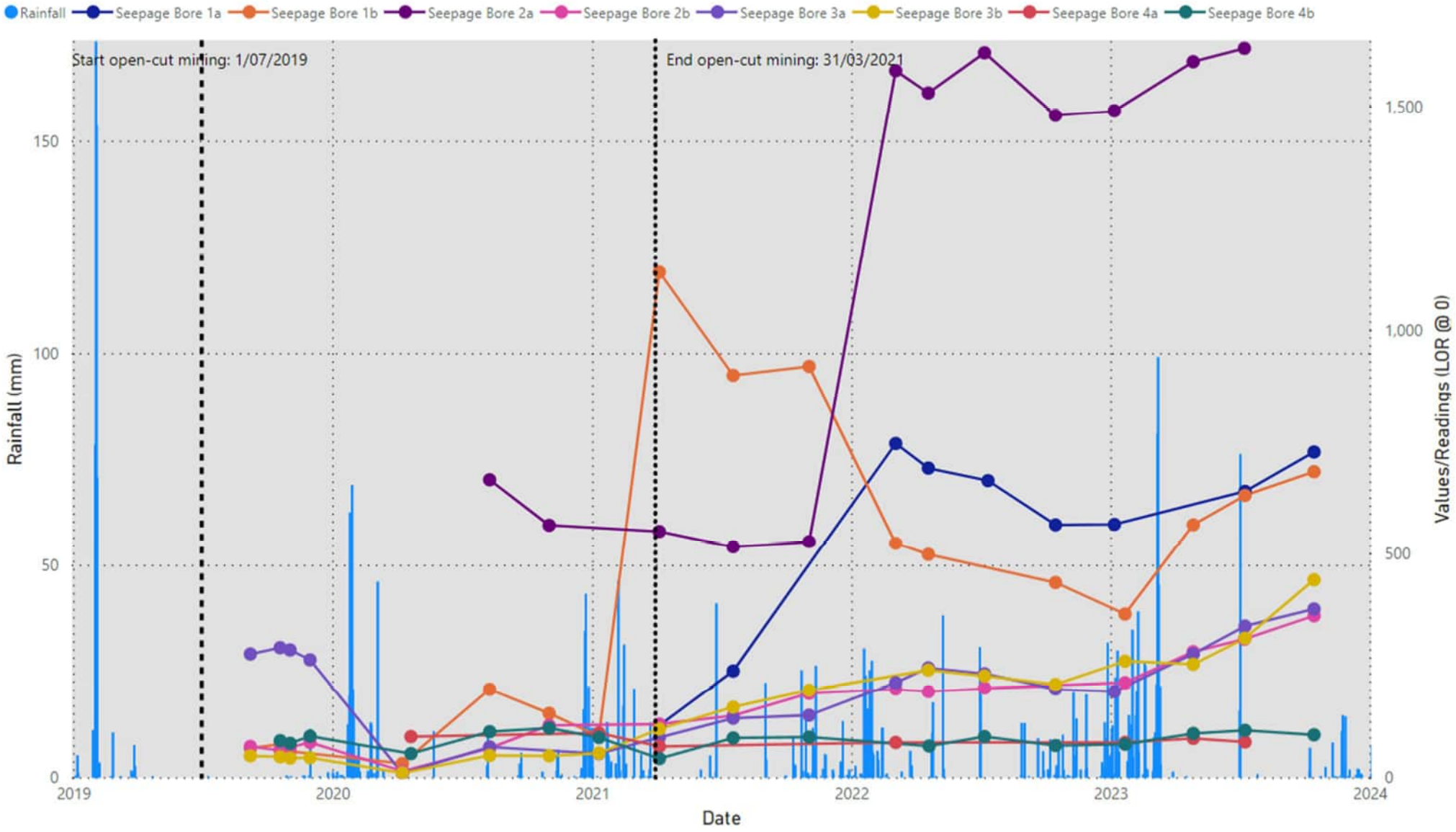
Potassium (mg/L)



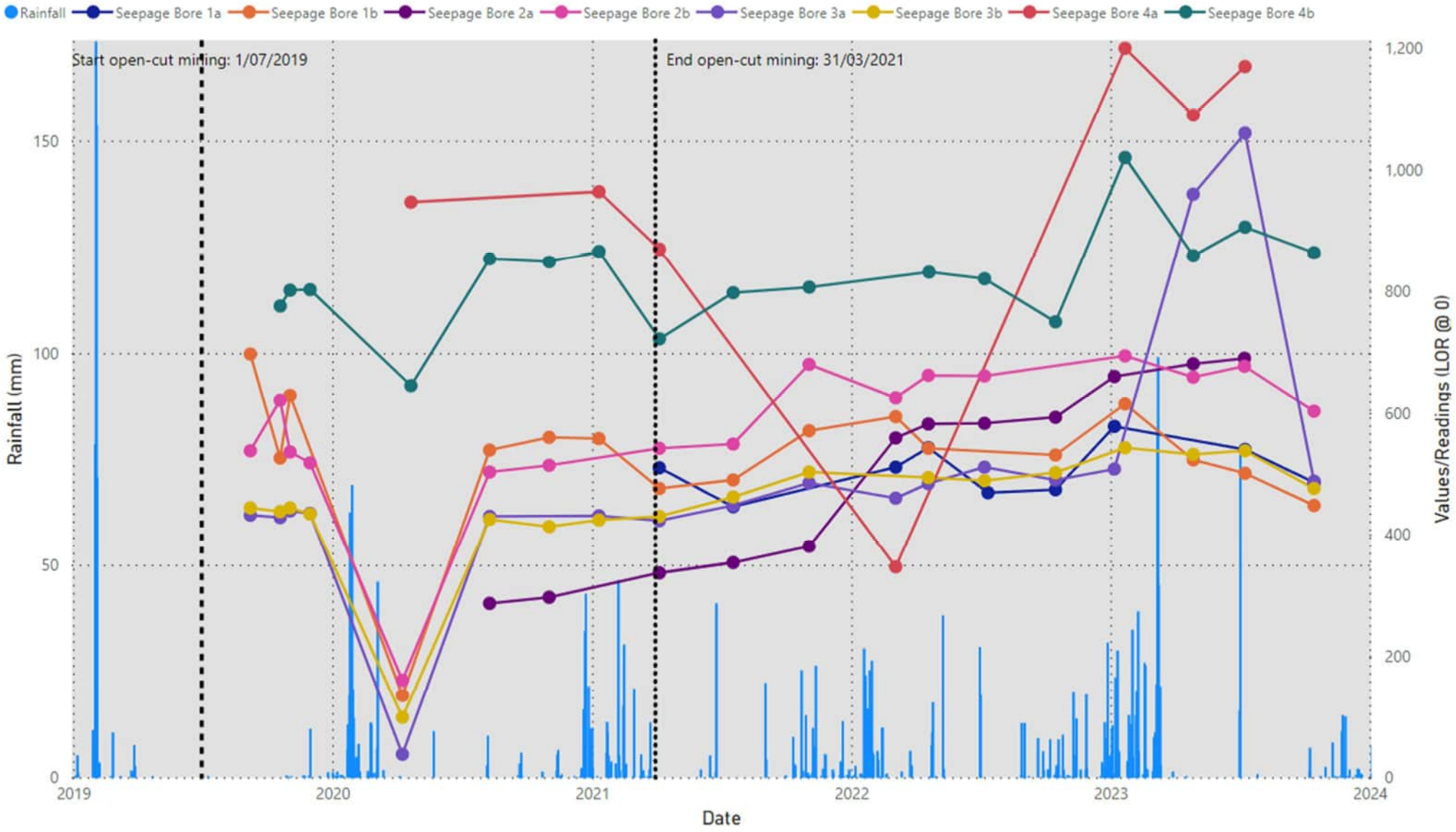
Sodium (mg/L)

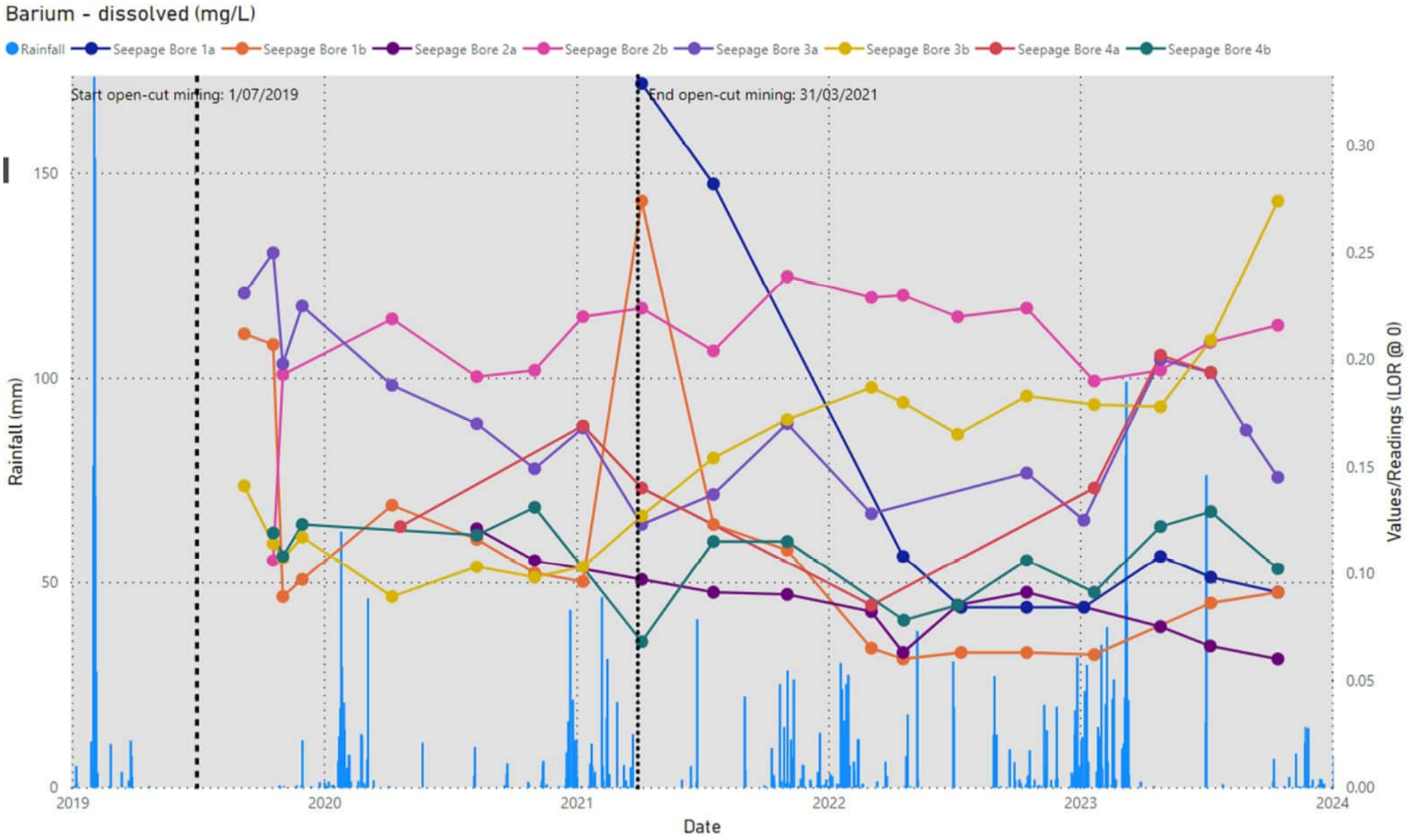

Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
500
1,000
1,500
2,000
2019
2020
2021
2022
2023
2024

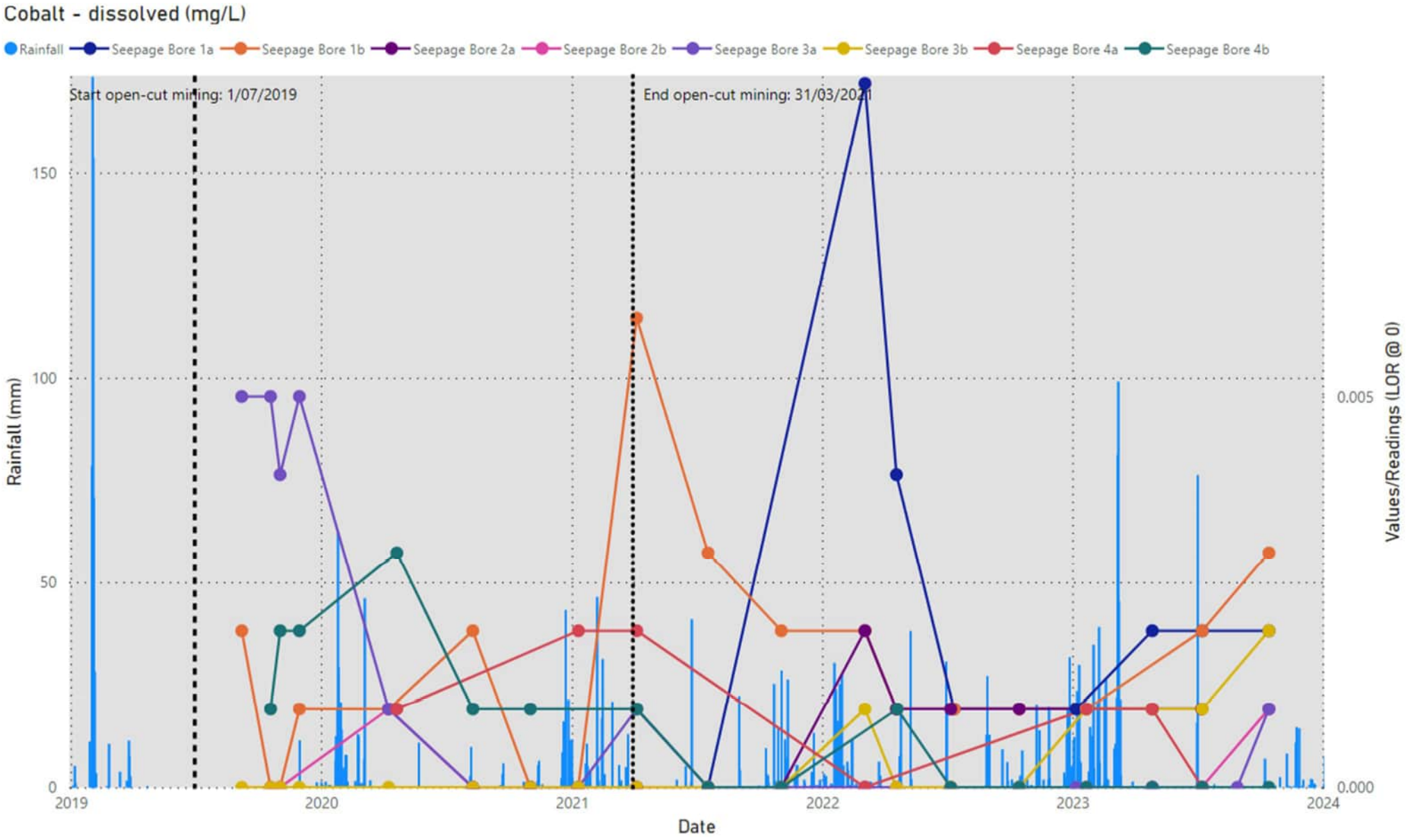
Sulfate (as SO4)



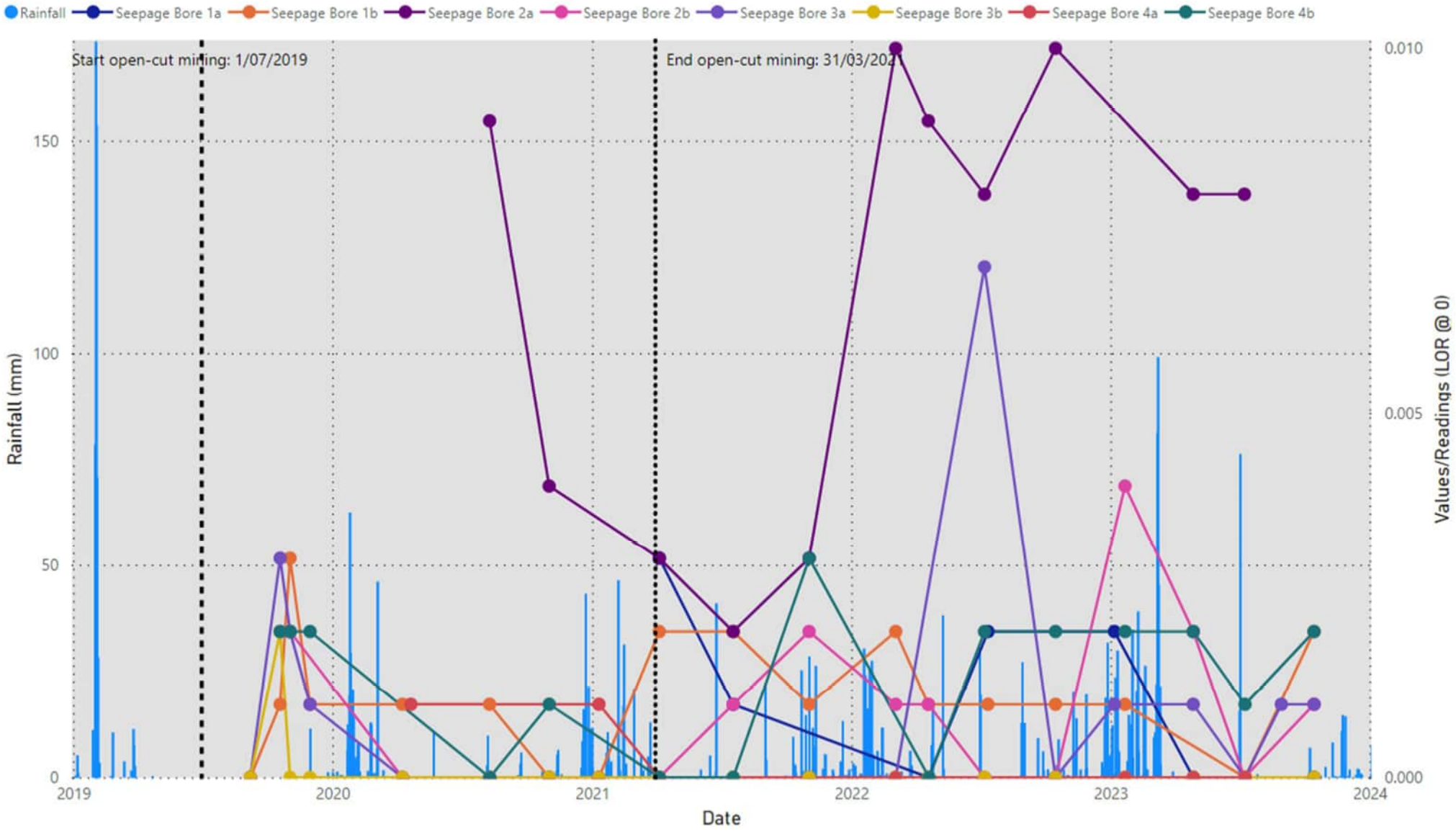
Bicarbonate Alkalinity as CaCO3 (mg/L)

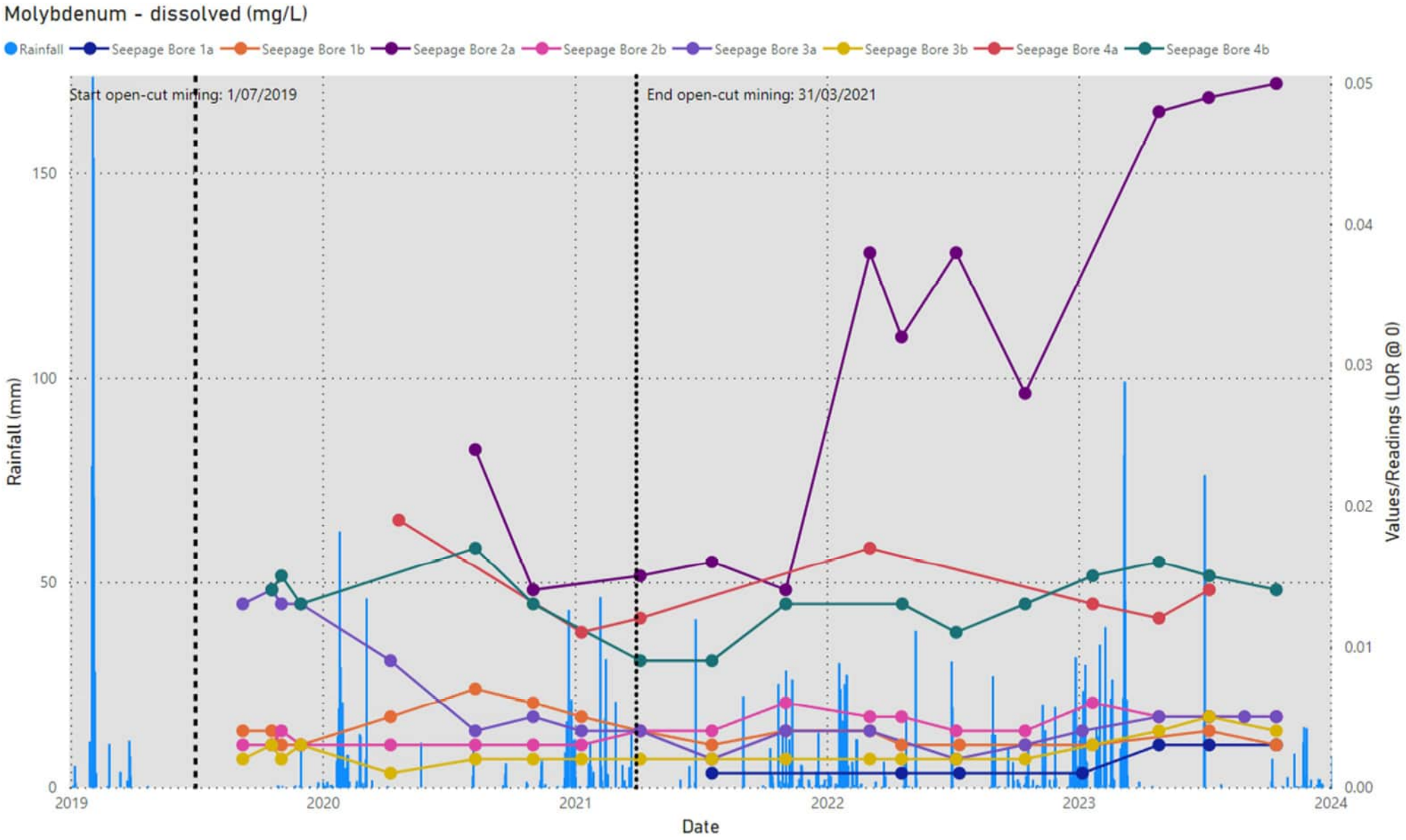


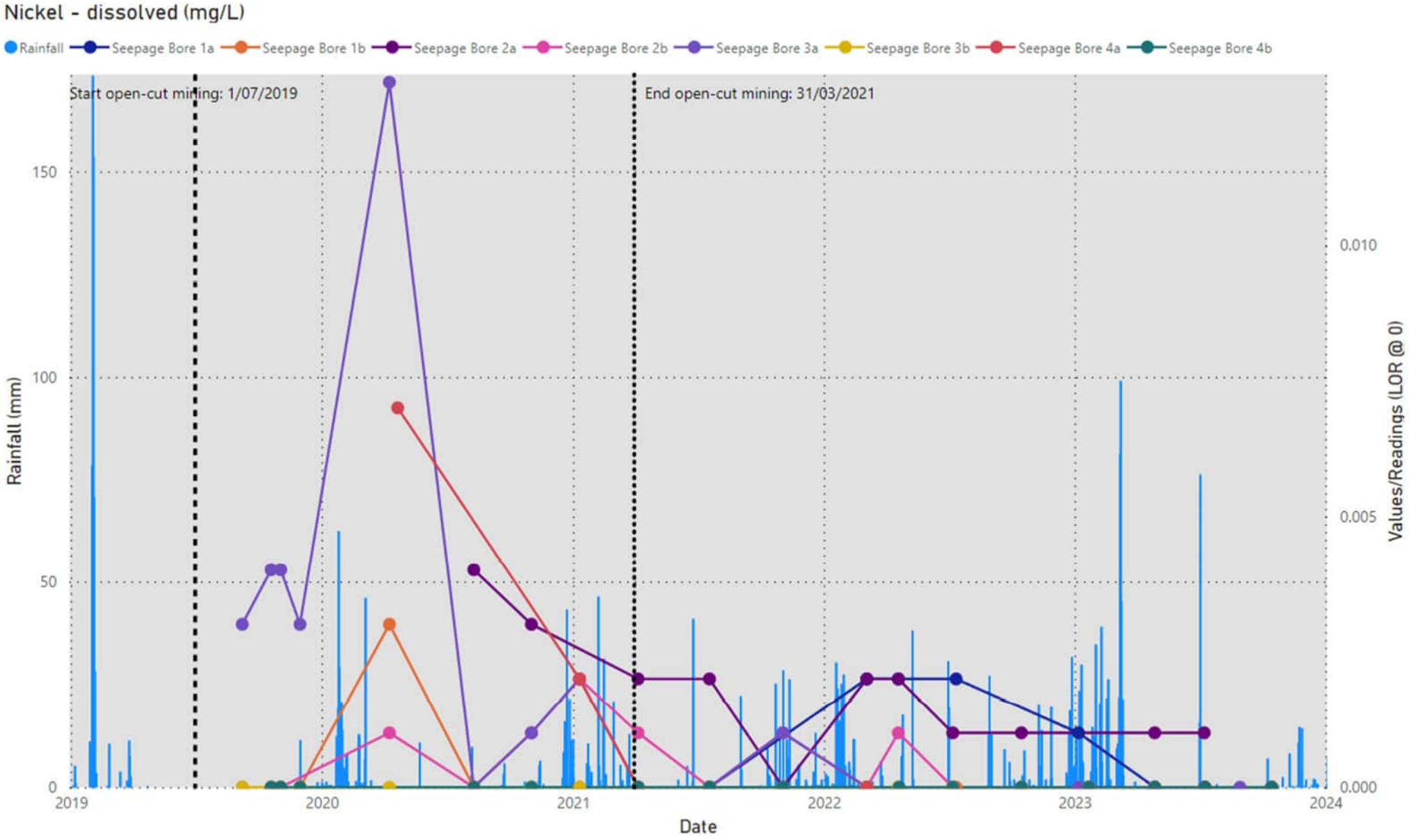

Barium - dissolved (mg/L)
Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
Values/Readings (LOR @ 0)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2019
2020
2021
2022
2023
2024
Date

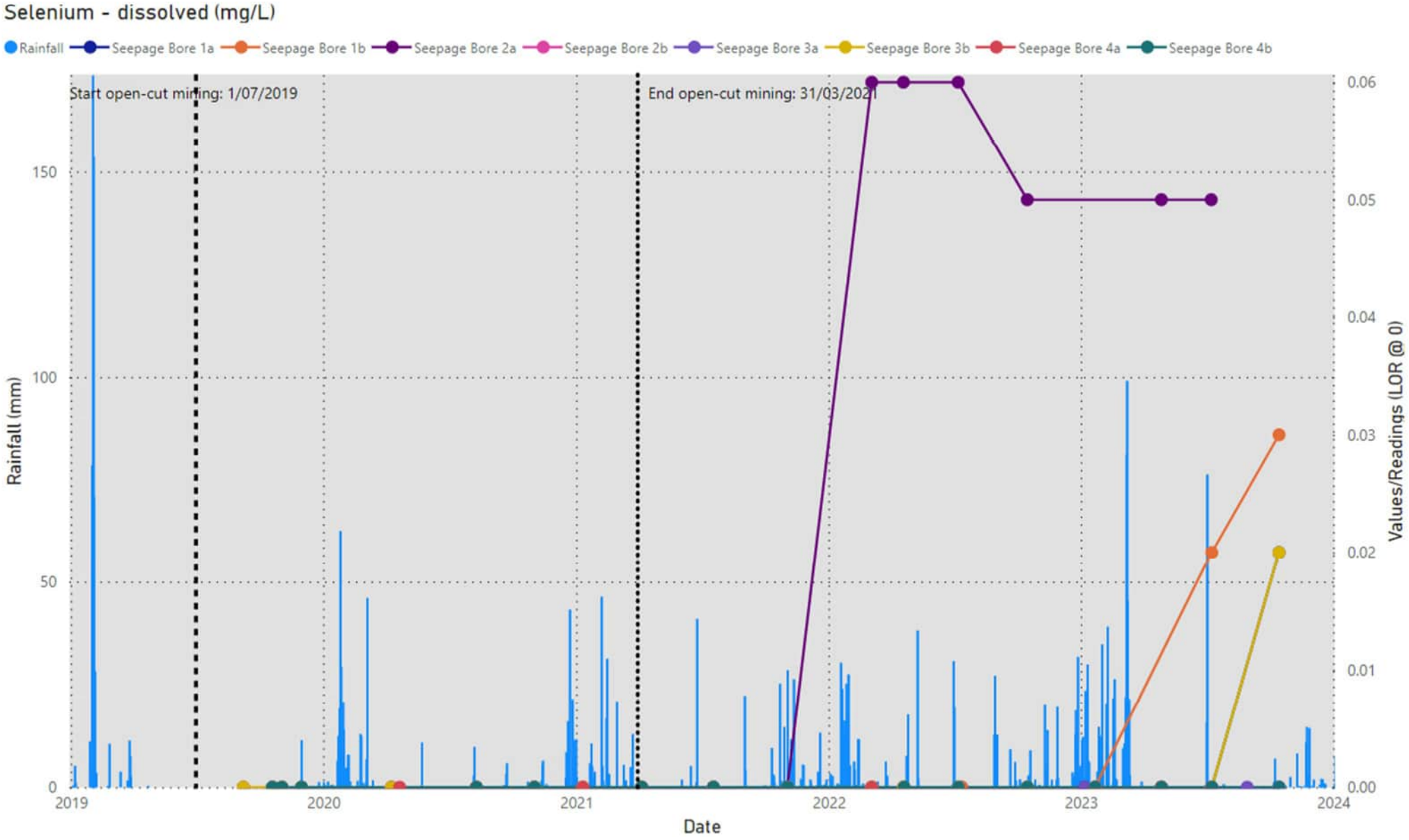

Cobalt - dissolved (mg/L)
Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
150
100
50
0
0.005
0.000
Values/Readings (LOR @ 0)
2019
2020
2021
2022
2023
2024
Date

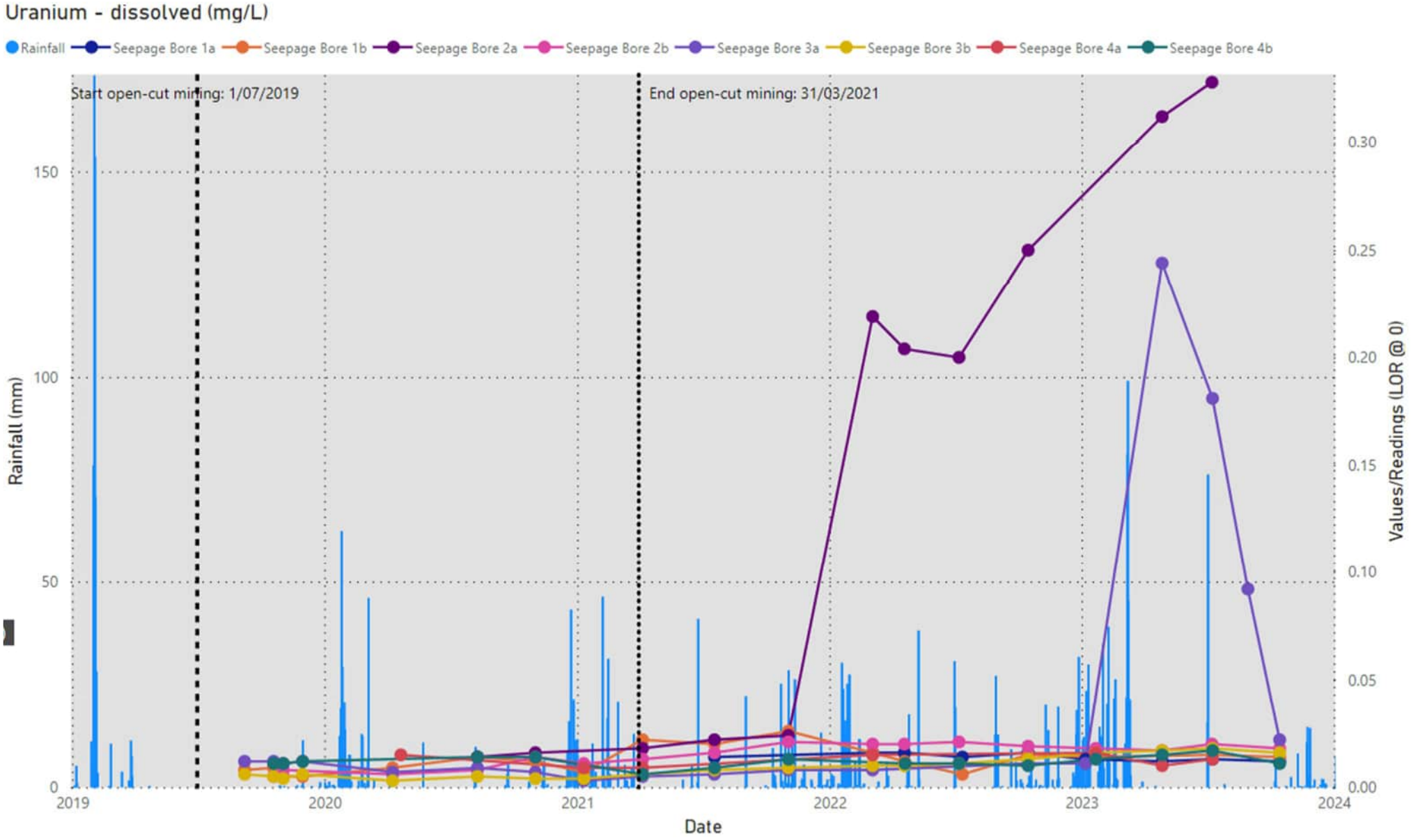
Copper - dissolved (mg/L)



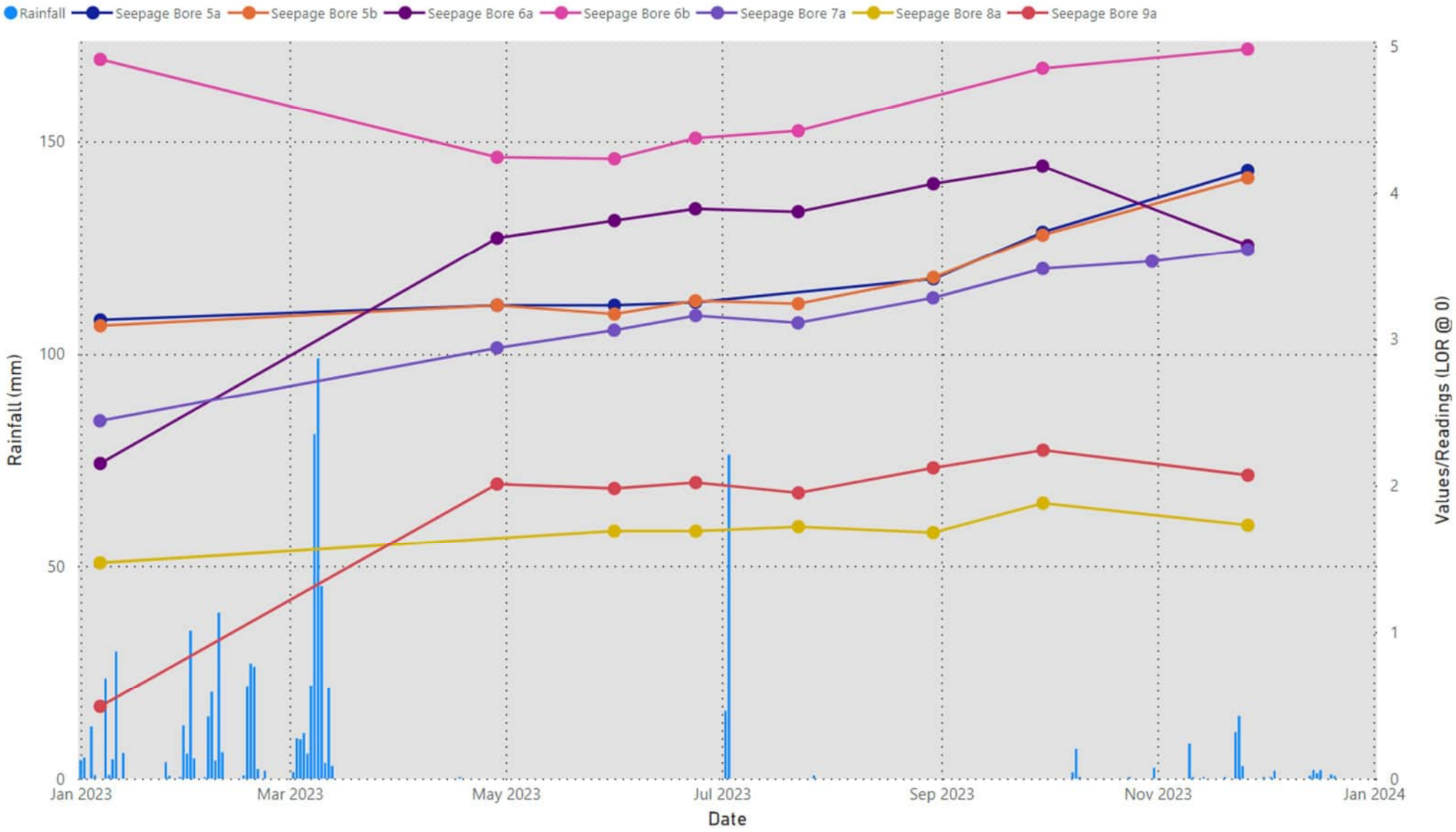

Molybdenum - dissolved (mg/L)
Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.01
0.02
0.03
0.04
0.05
2019
2020
2021
2022
2023
2024


Nickel - dissolved (mg/L)
Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.000
0.005
0.010
2019
2020
2021
2022
2023
2024

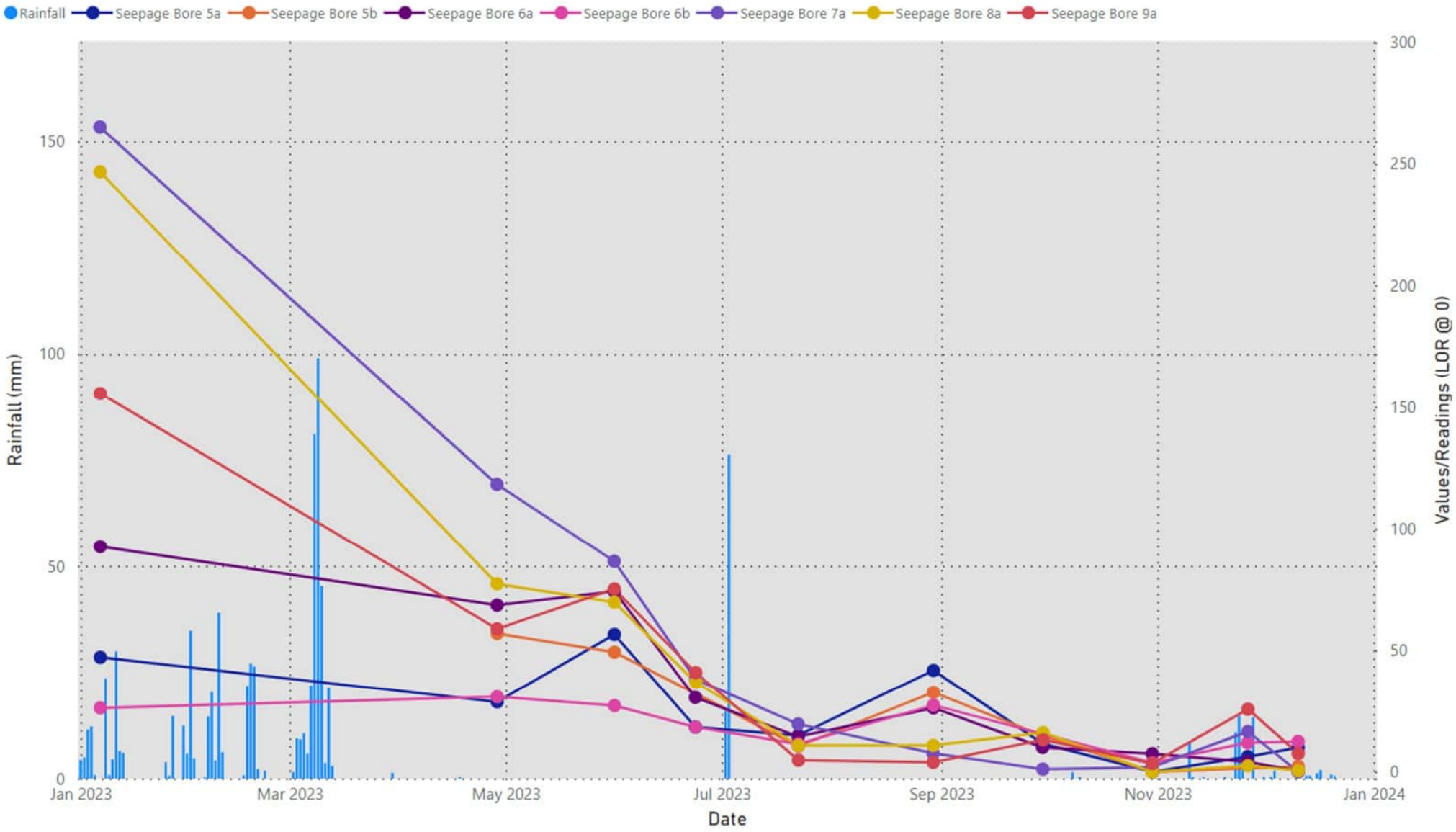

Selenium - dissolved (mg/L)
Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.01
0.02
0.03
0.04
0.05
0.06
2019
2020
2021
2022
2023
2024


Uranium - dissolved (mg/L)
Rainfall
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Start open-cut mining: 1/07/2019
End open-cut mining: 31/03/2021
Rainfall (mm)
Values/Readings (LOR @ 0)
Date
0
50
100
150
0.00
0.05
0.10
0.15
0.20
0.25
0.30
2019
2020
2021
2022
2023
2024

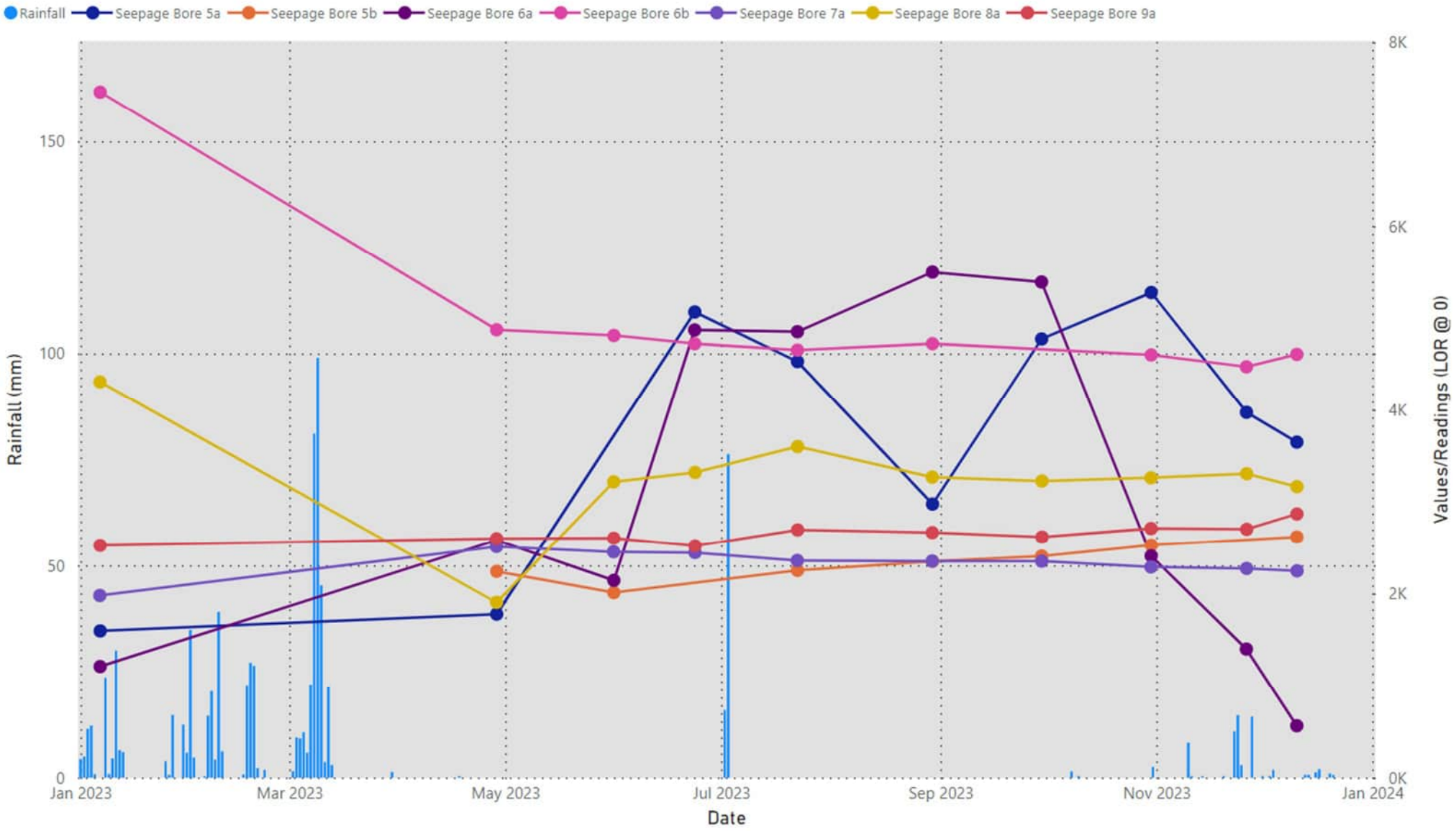
Depth to Water (mbRL)



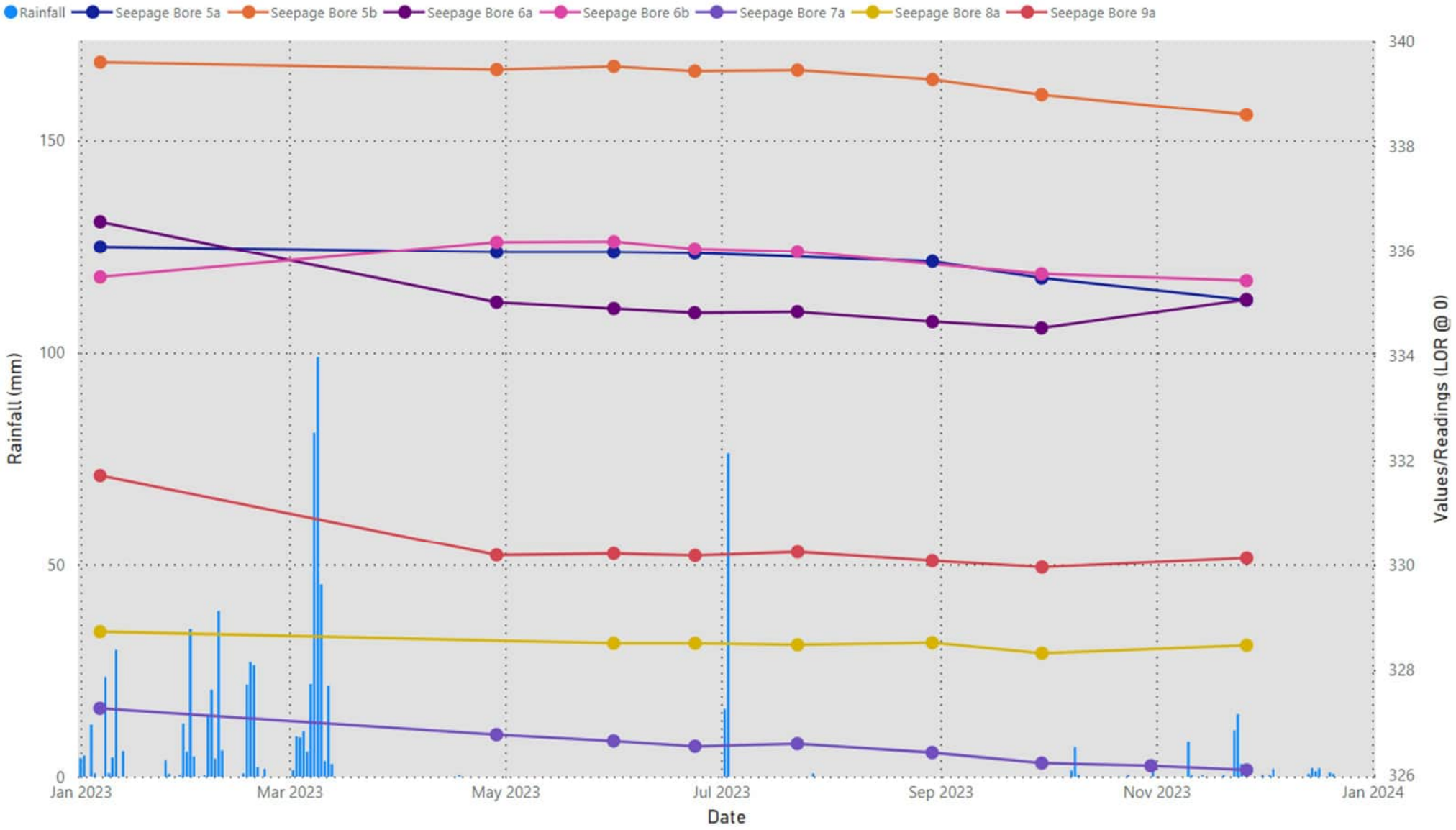
Dissolved Oxygen (field) (% sat)

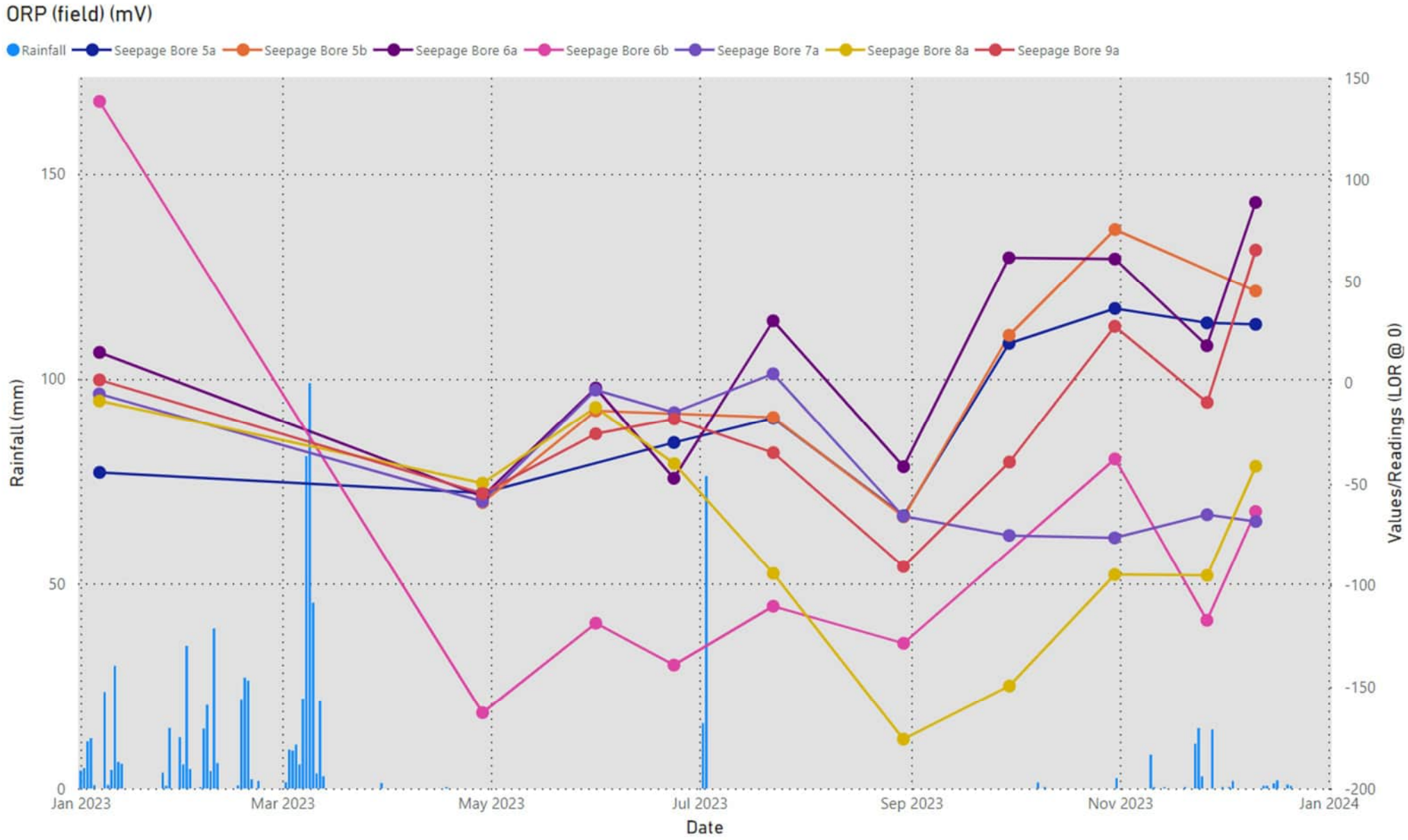


Electrical Conductivity (field) (µS/cm)

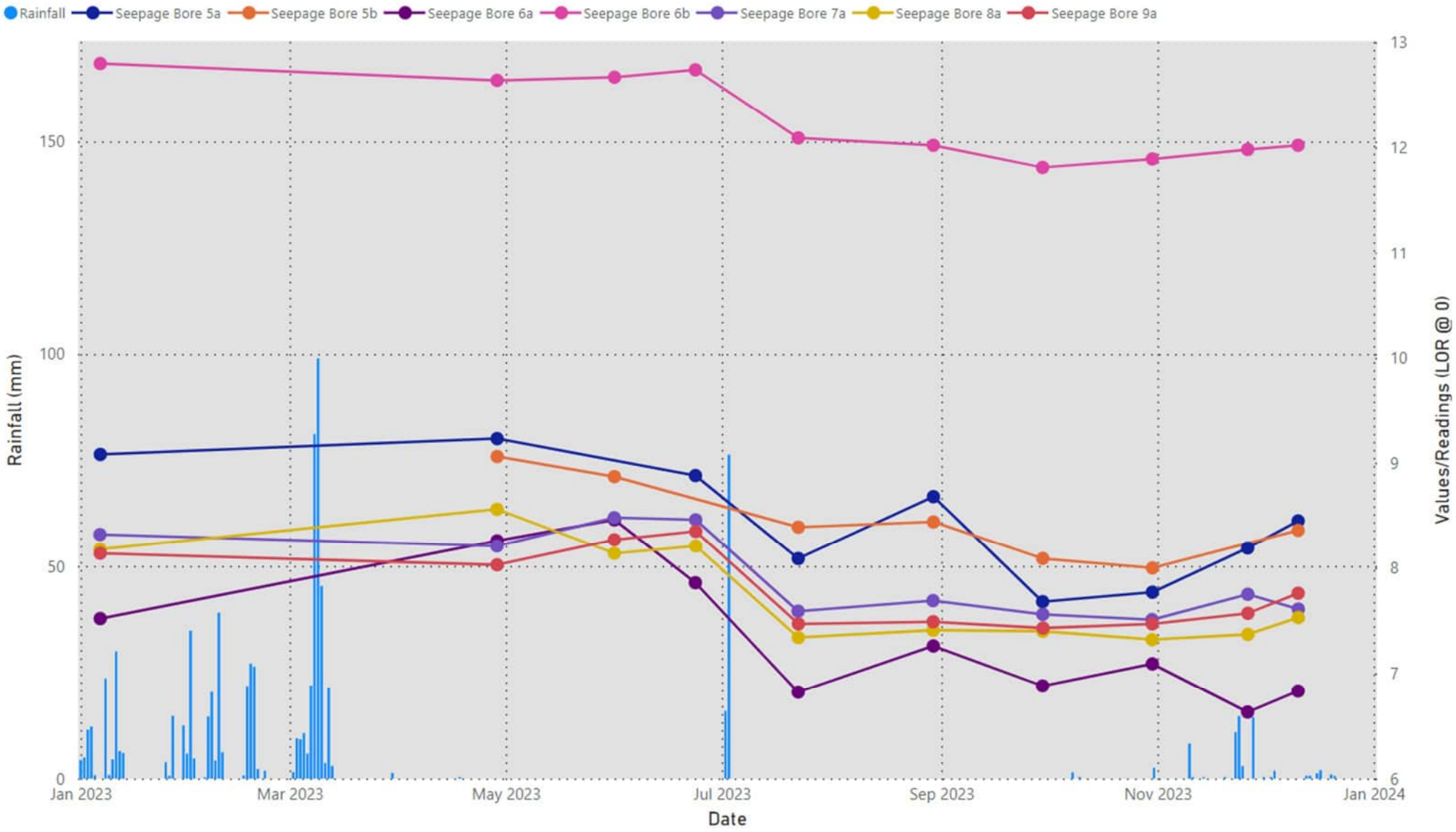


Groundwater Level (mAHD)

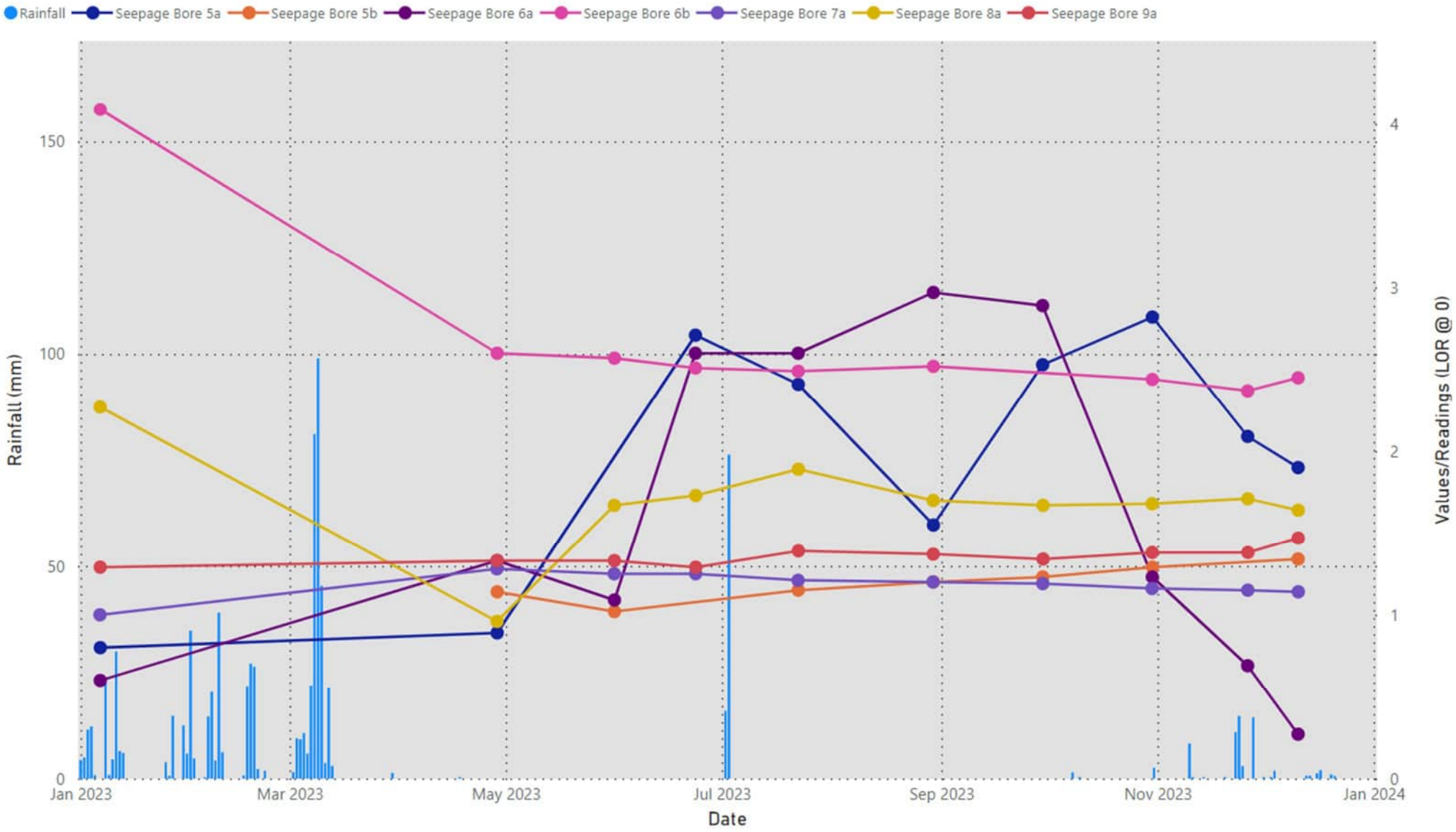



ORP (field) (mV)
Rainfall
Seepage Bore 5a
Seepage Bore 5b
Seepage Bore 6a
Seepage Bore 6b
Seepage Bore 7a
Seepage Bore 8a
Seepage Bore 9a
Rainfall (mm)
Values/Readings (LOR @ 0)
150
100
50
0
-50
-100
-150
-200
Jan 2023
Mar 2023
May 2023
Jul 2023
Sep 2023
Nov 2023
Jan 2024
Date

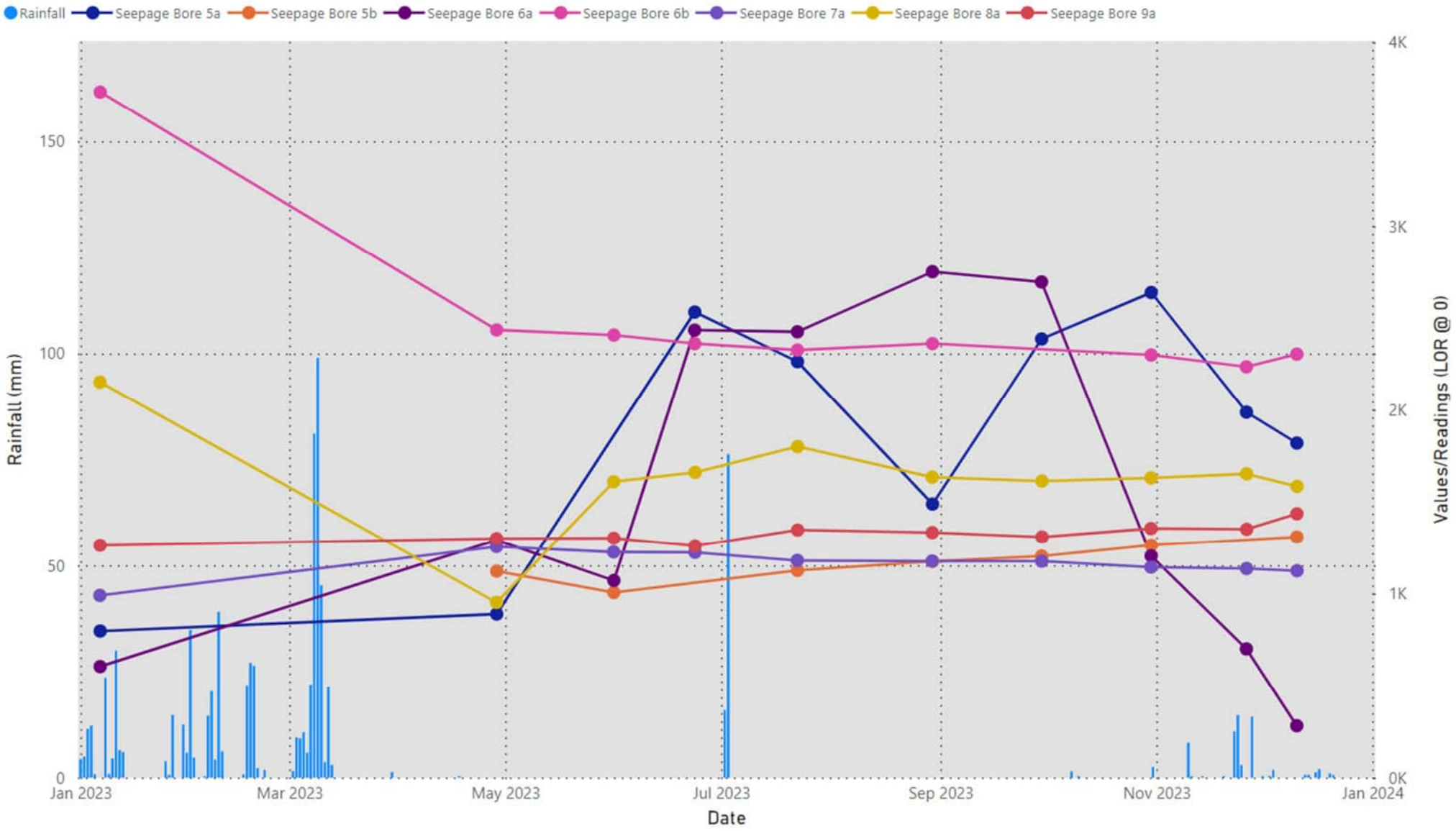
pH (field)


Rainfall
Seepage Bore 5a
Seepage Bore 5b
Seepage Bore 6a
Seepage Bore 6b
Seepage Bore 7a
Seepage Bore 8a
Seepage Bore 9a
Rainfall (mm)
0
50
100
150
Values/Readings (LOR @ 0)
6
7
8
9
10
11
12
13
Jan 2023
Mar 2023
May 2023
Jul 2023
Sep 2023
Nov 2023
Jan 2024
Date

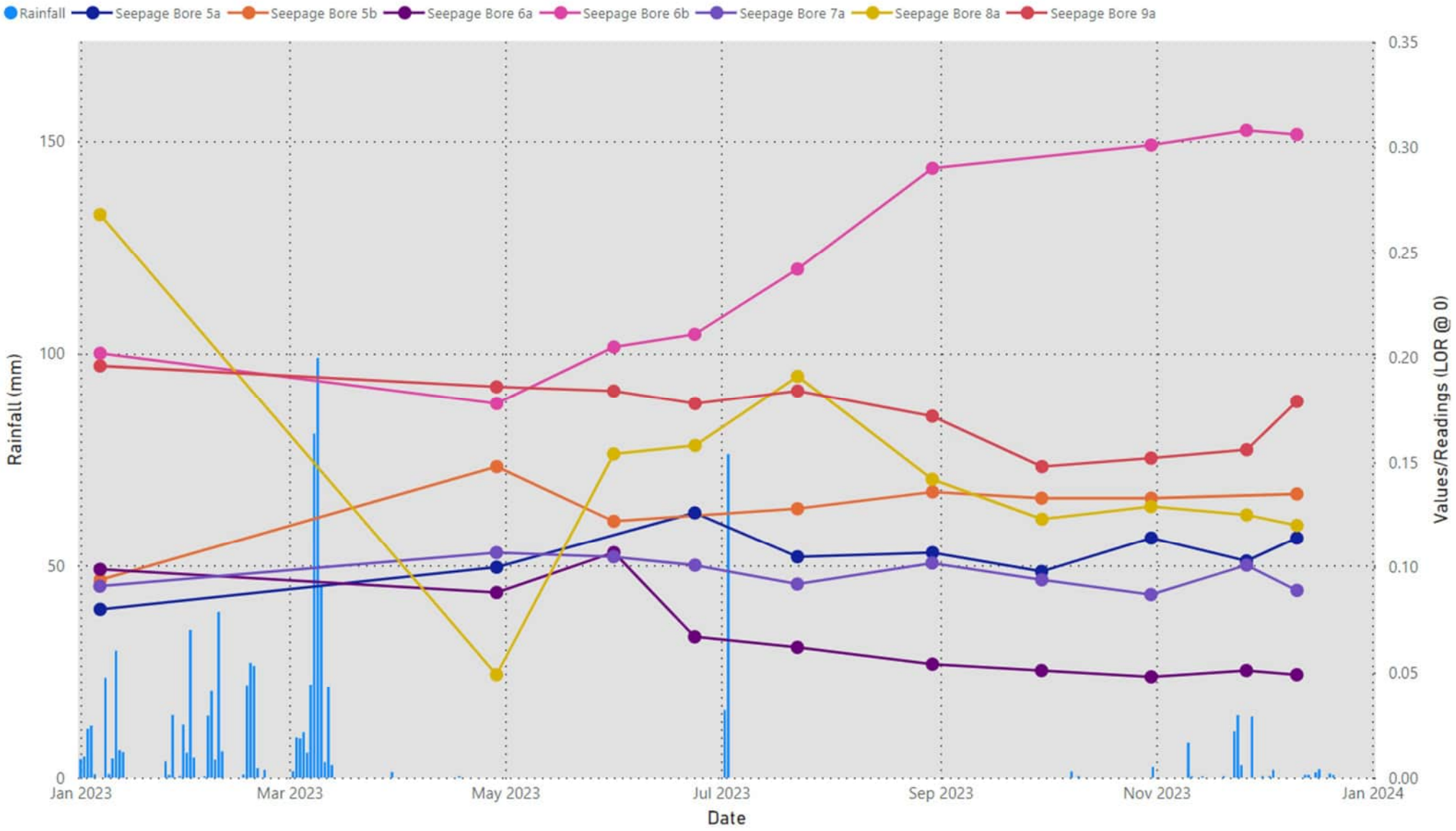
Salinity (field) (PSU)



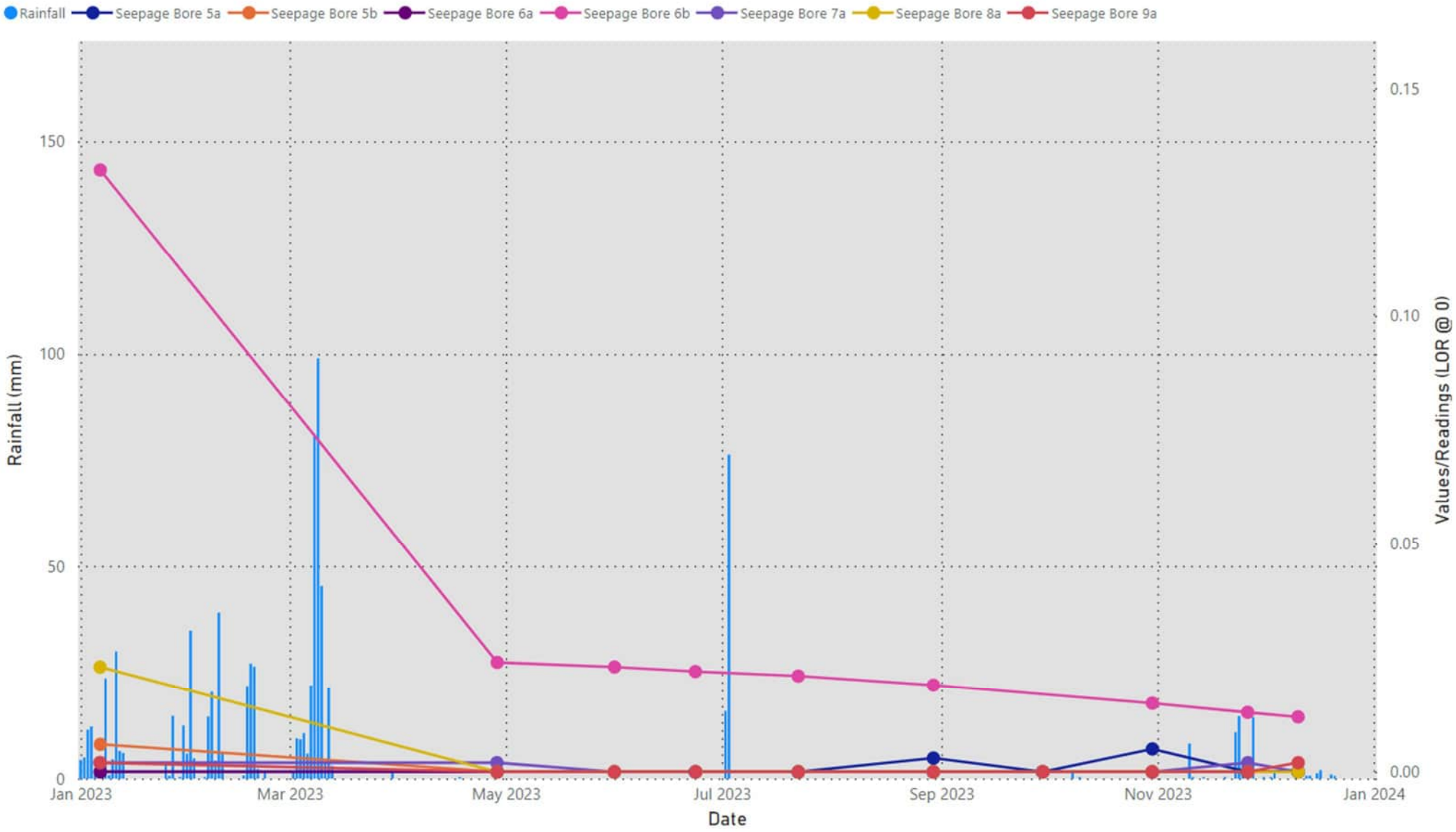
TDS (field) (ppm)



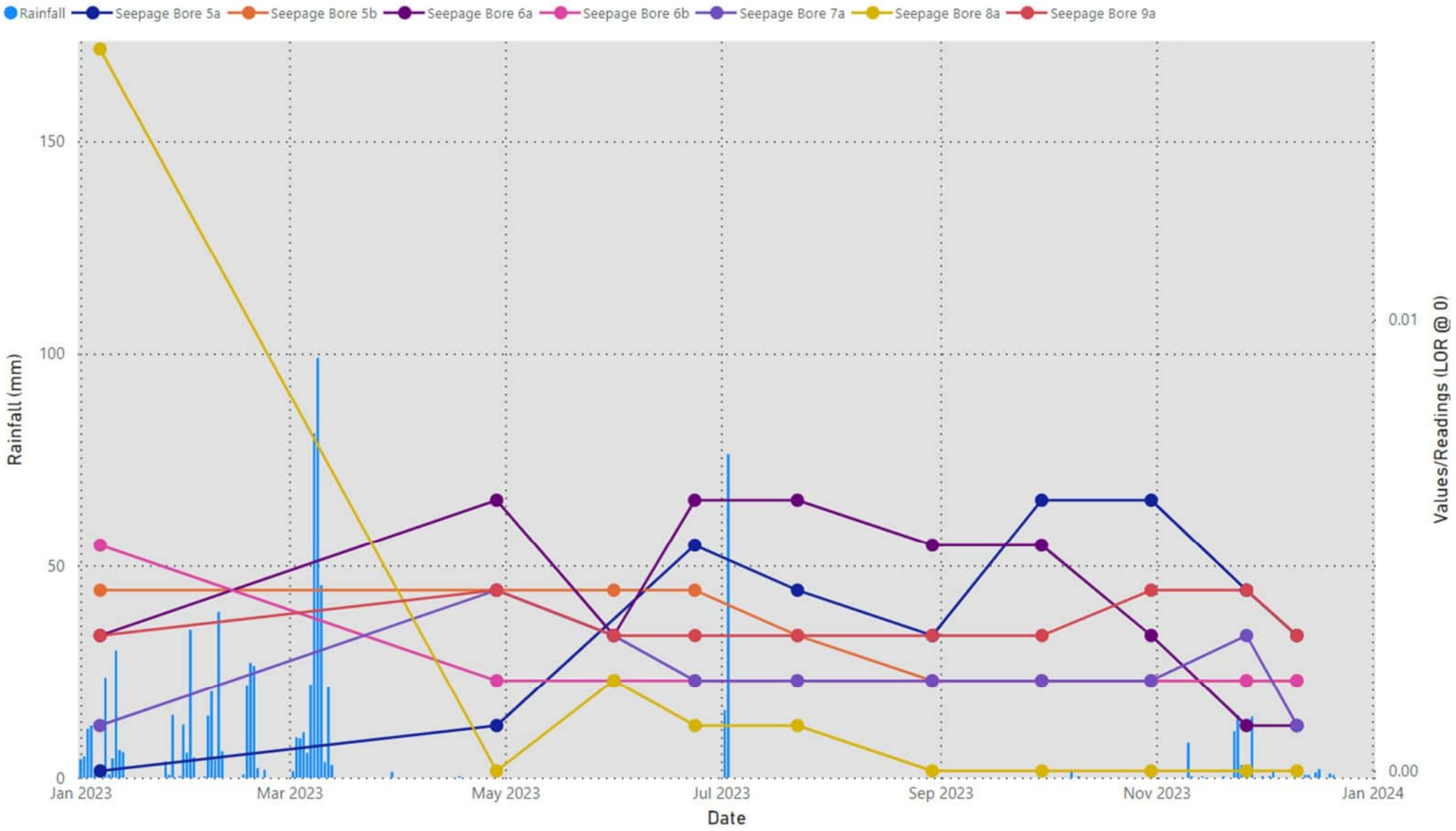
Barium - total (mg/L)



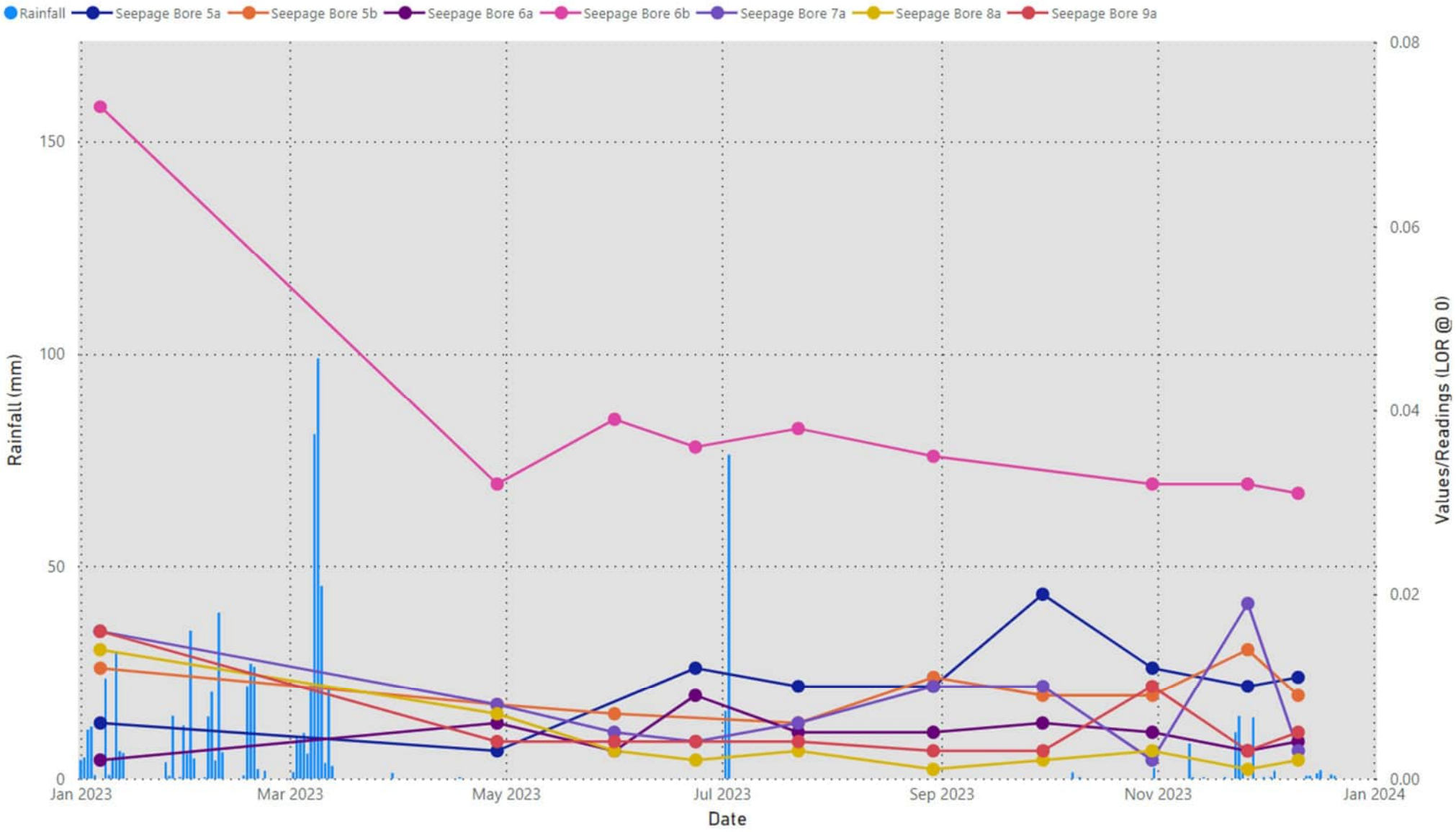
Chromium - total (mg/L)



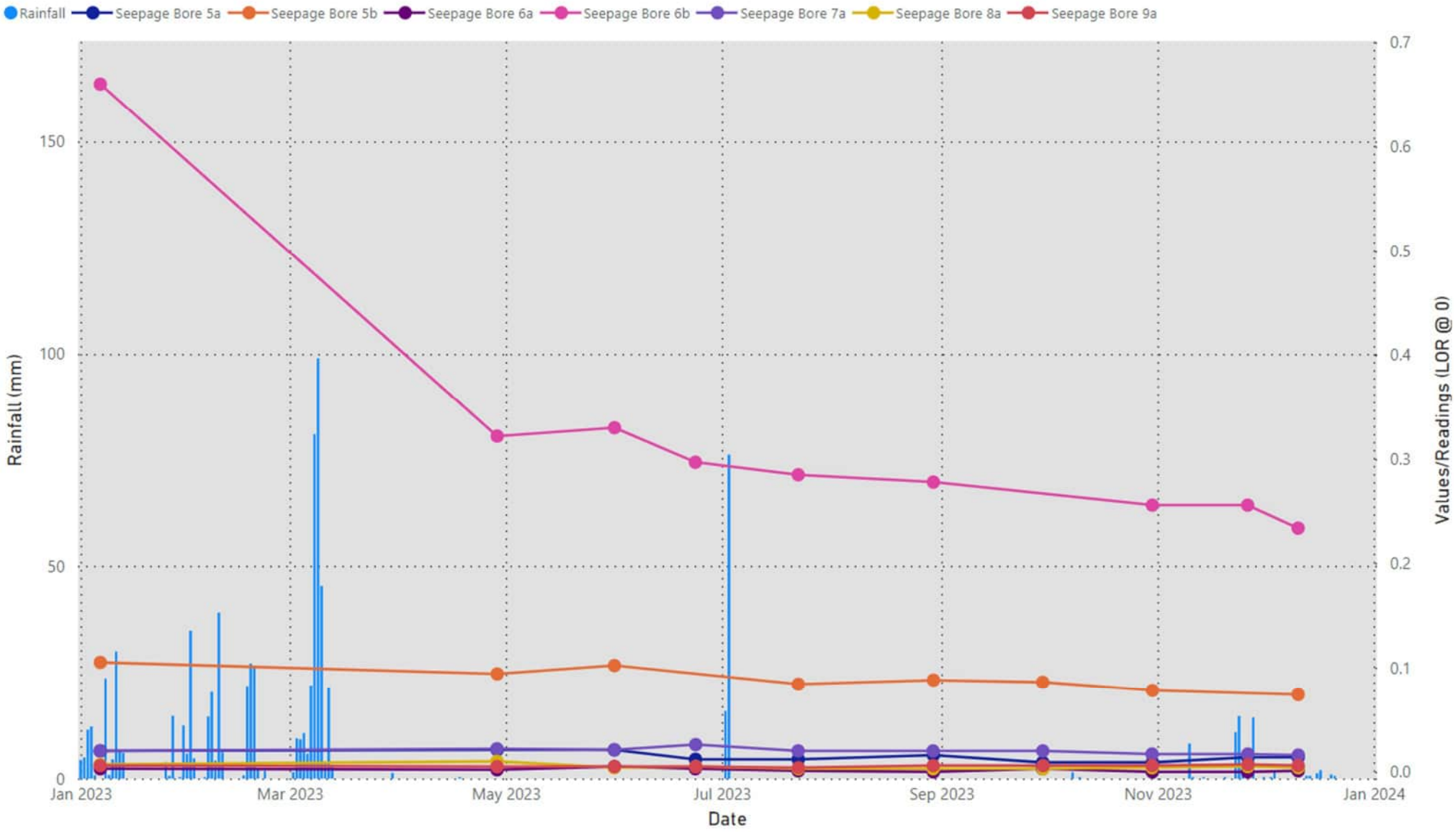
Cobalt - total (mg/L)



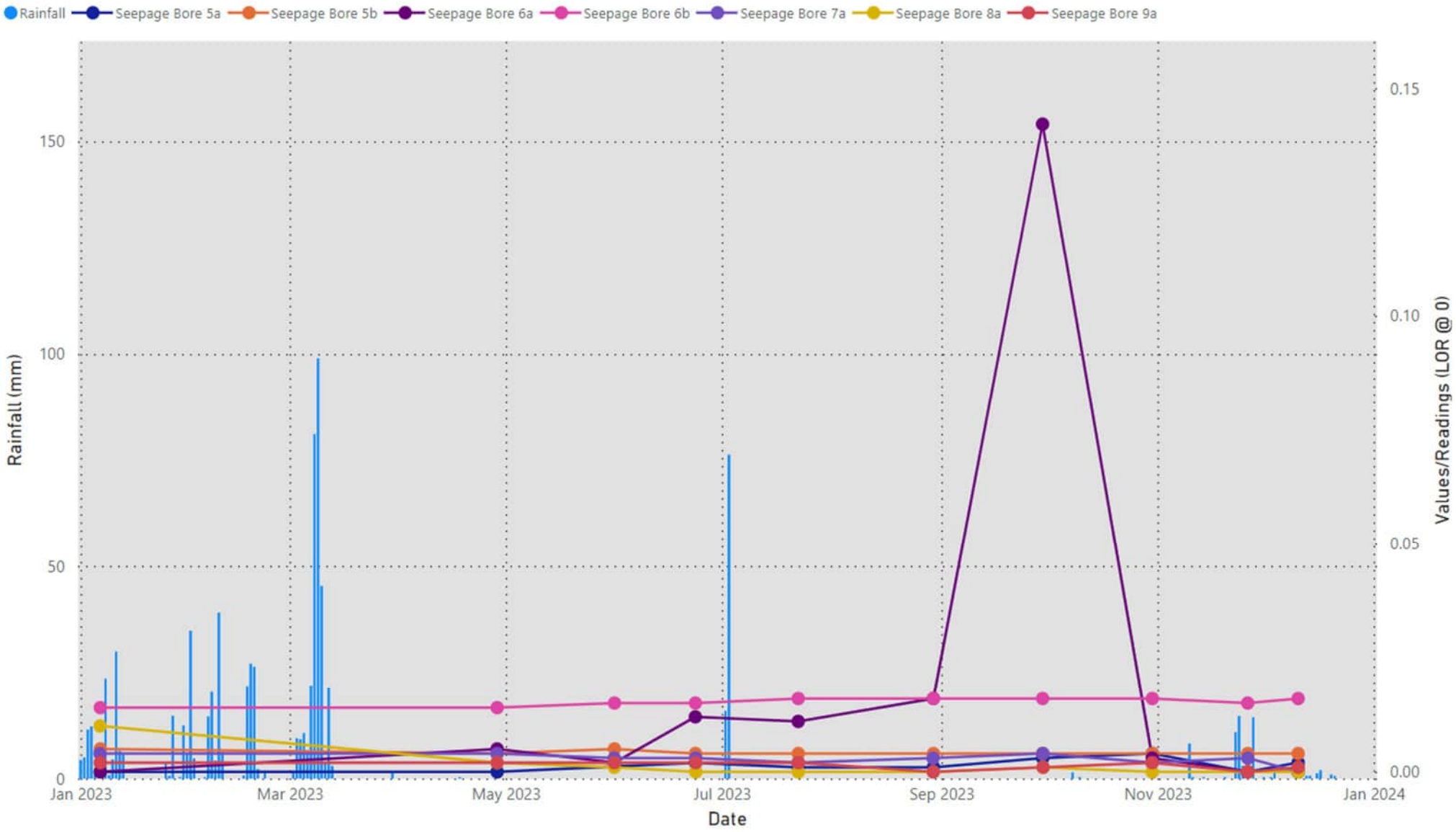
Copper - total (mg/L)



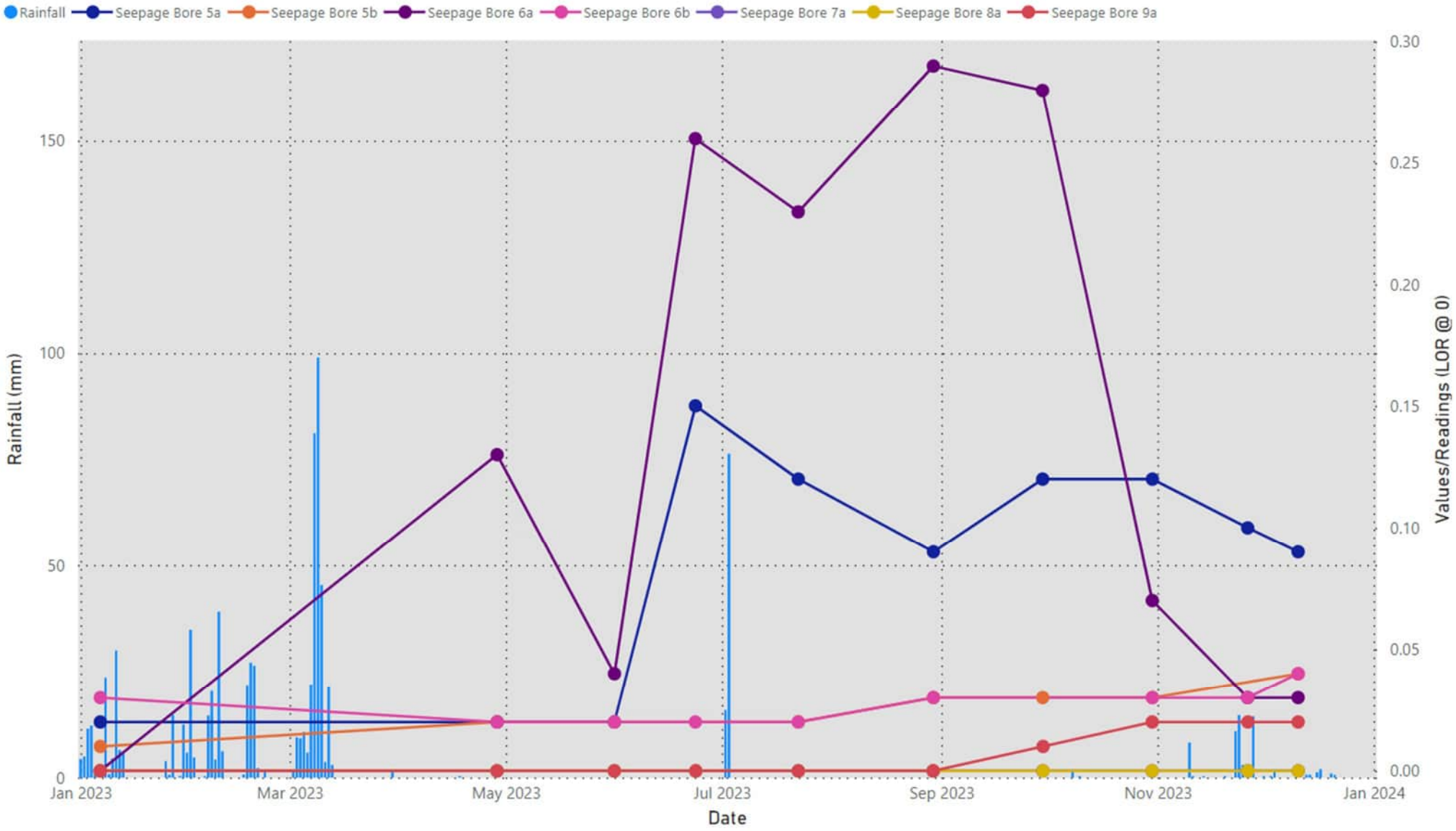
Molybdenum - total (mg/L)



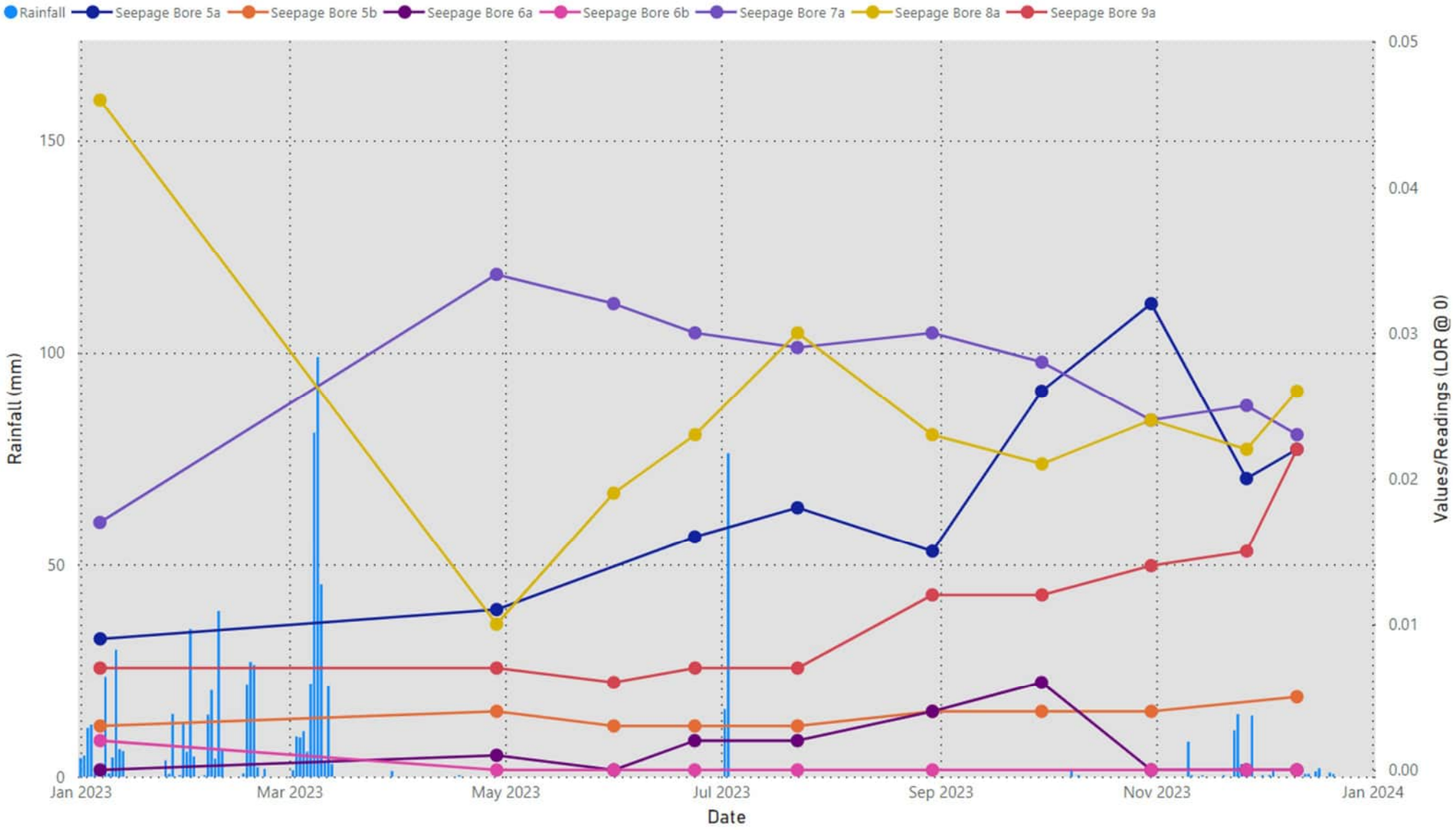
Nickel - total (mg/L)



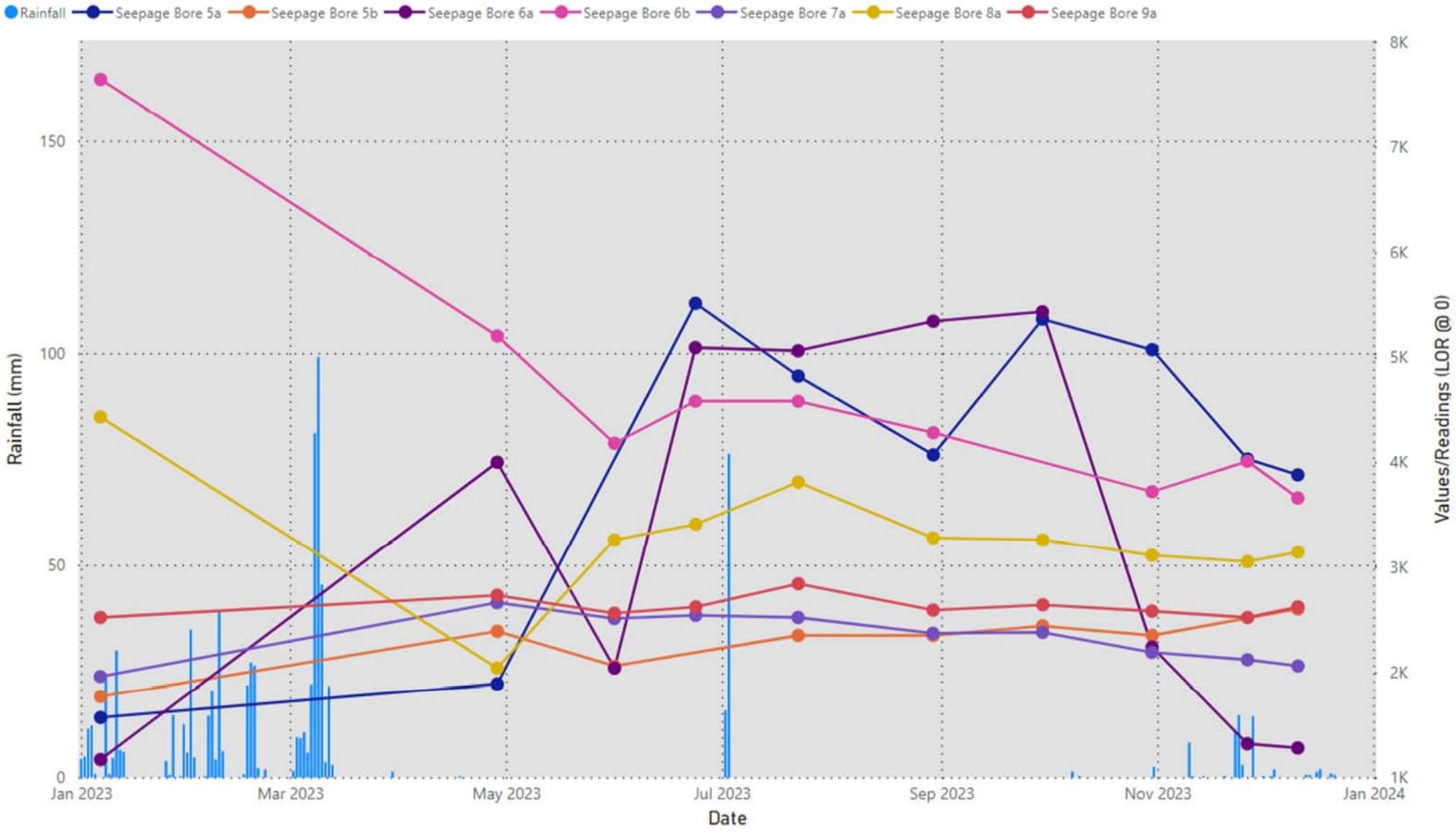
Selenium - total (mg/L)

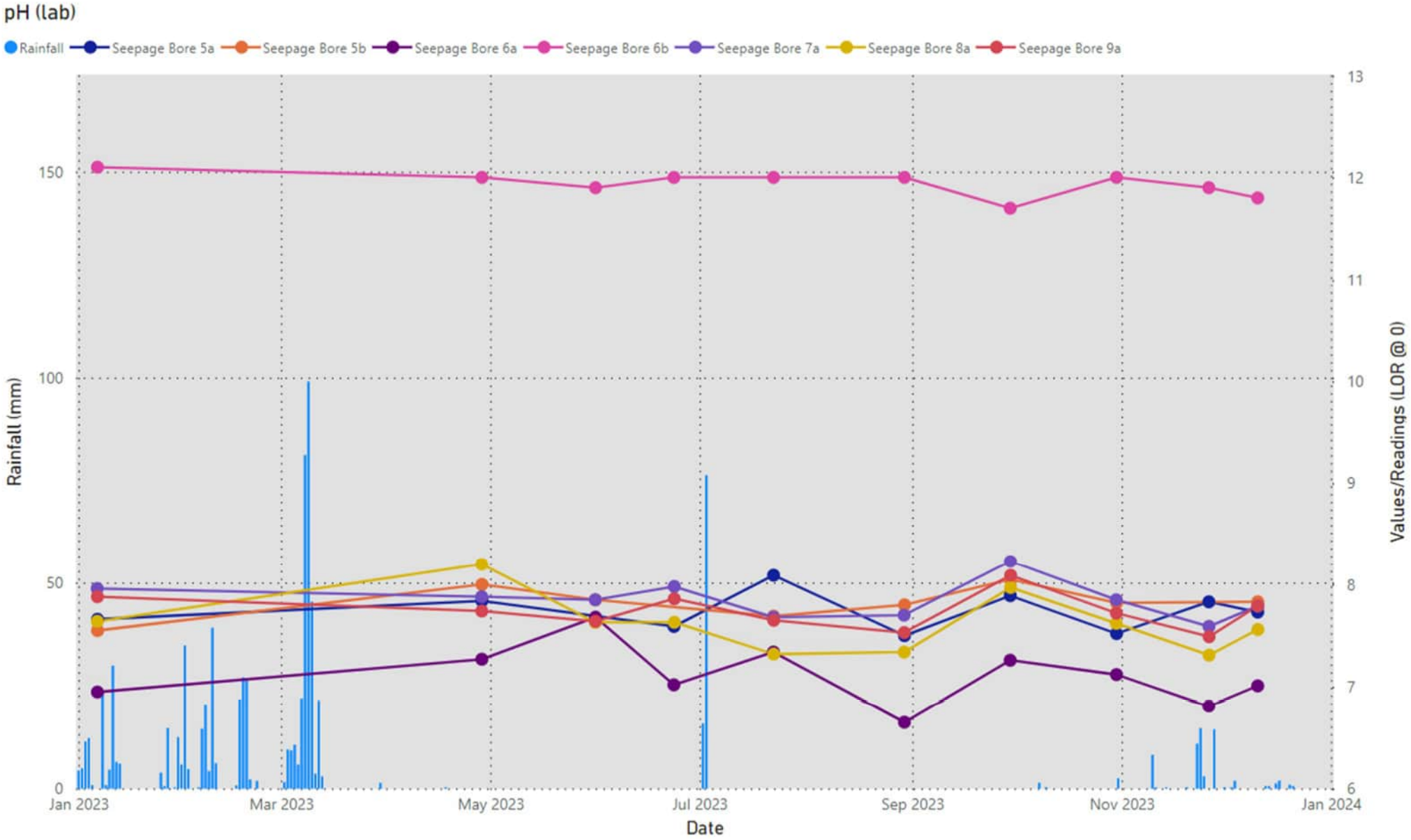


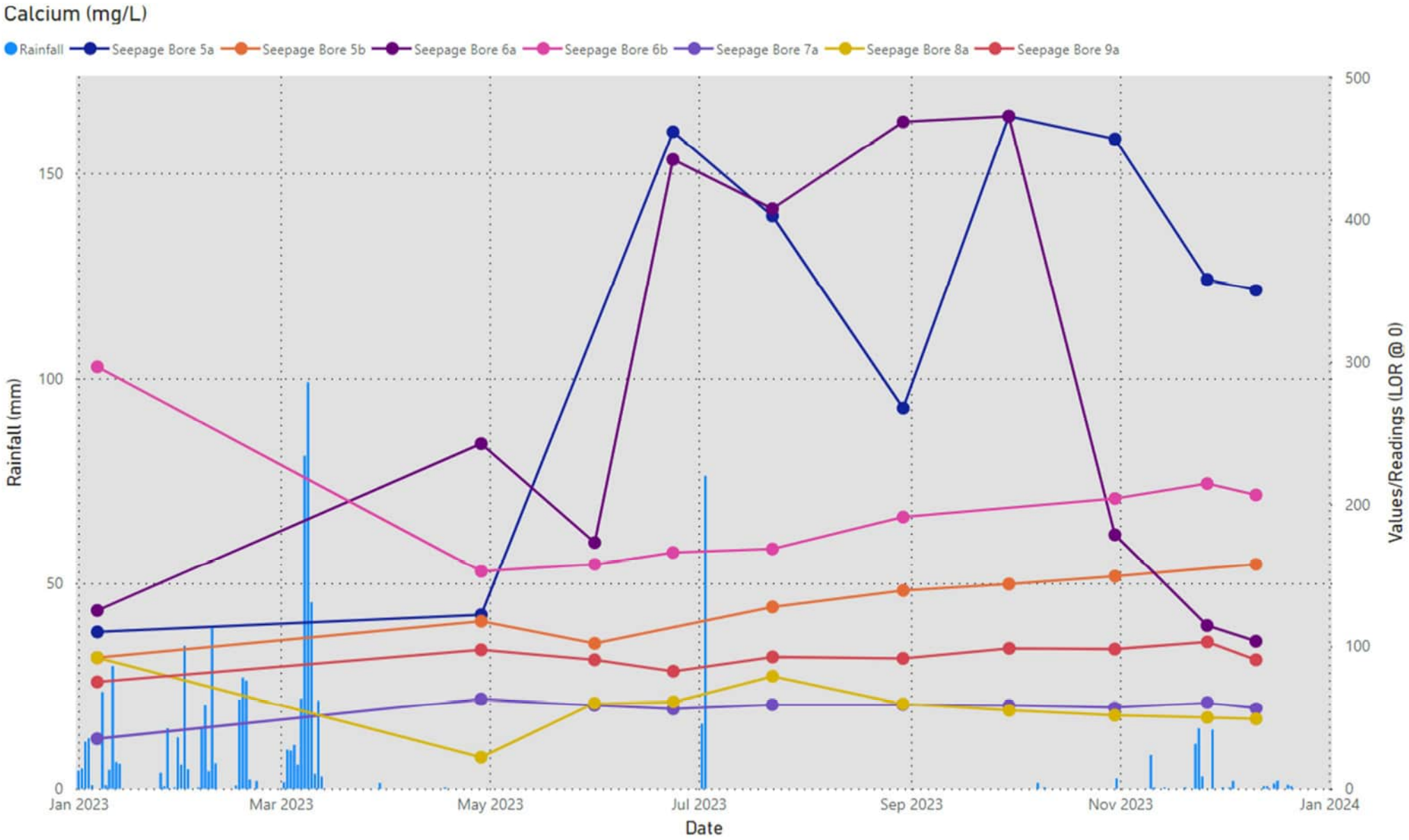
Uranium - total (mg/L)

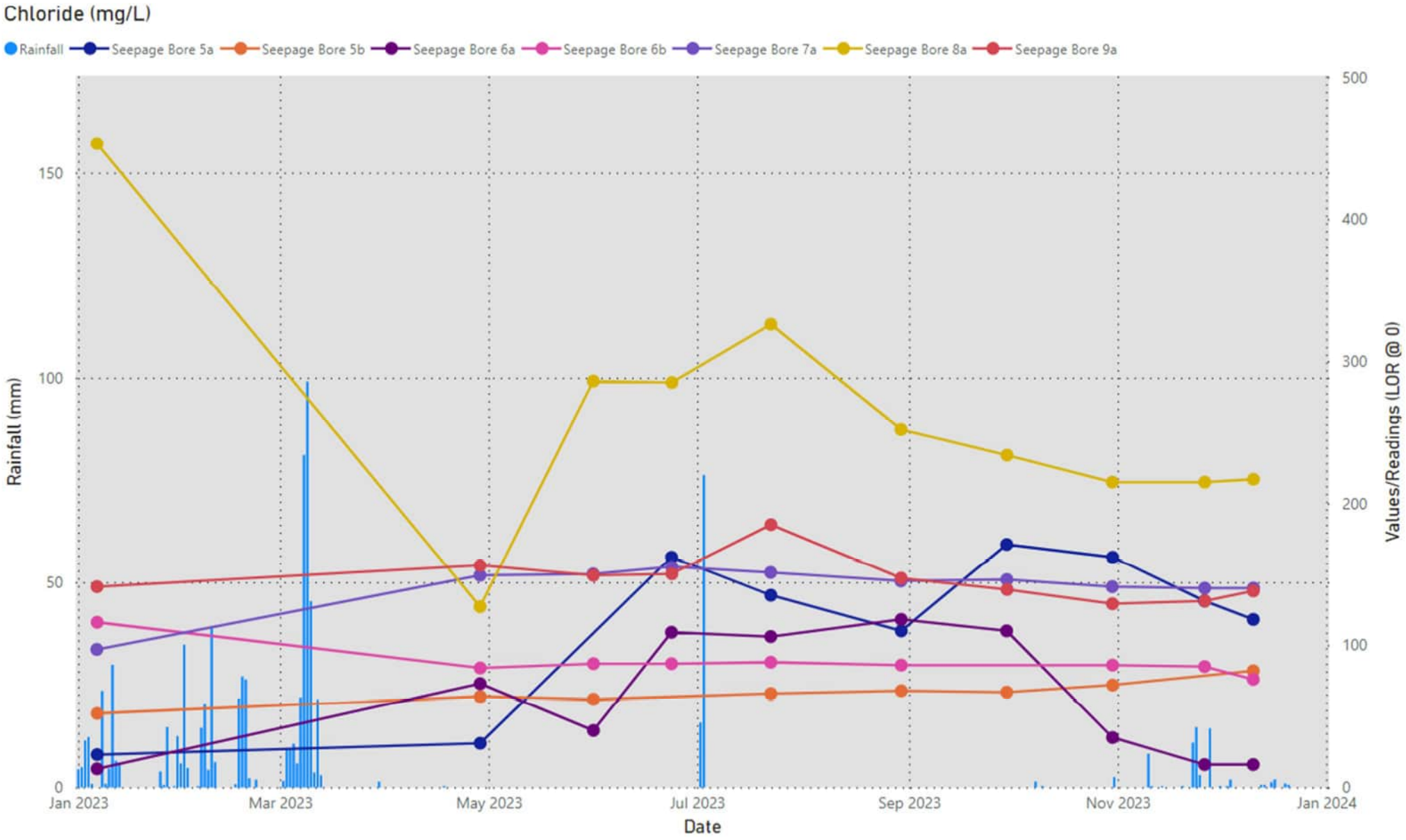


Electrical Conductivity (µS/cm)

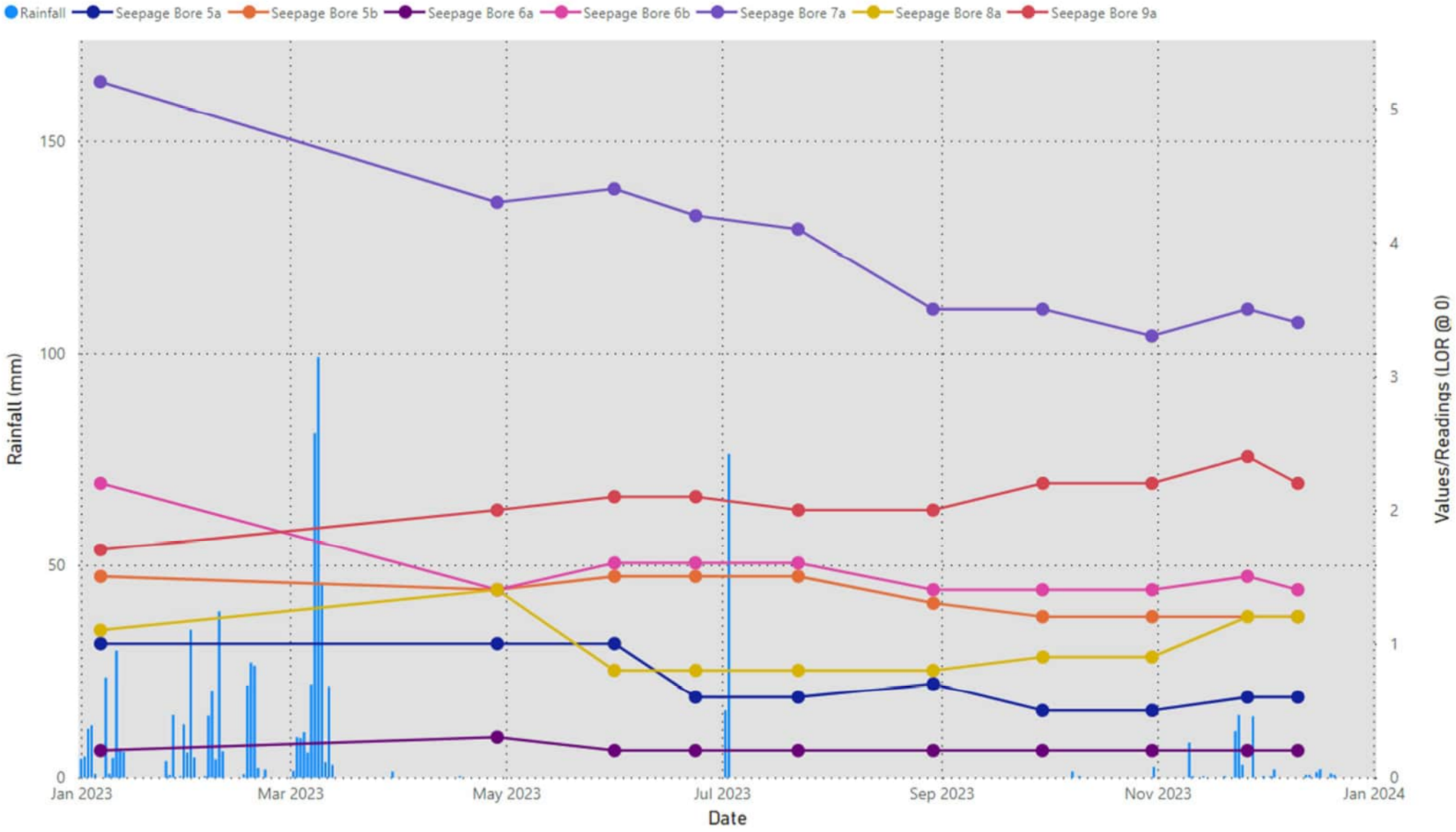



pH (lab)
Rainfall
Seepage Bore 5a
Seepage Bore 5b
Seepage Bore 6a
Seepage Bore 6b
Seepage Bore 7a
Seepage Bore 8a
Seepage Bore 9a
Rainfall (mm)
Values/Readings (LOR @ 0)
0
50
100
150
6
7
8
9
10
11
12
13
Jan 2023
Mar 2023
May 2023
Jul 2023
Sep 2023
Nov 2023
Jan 2024
Date

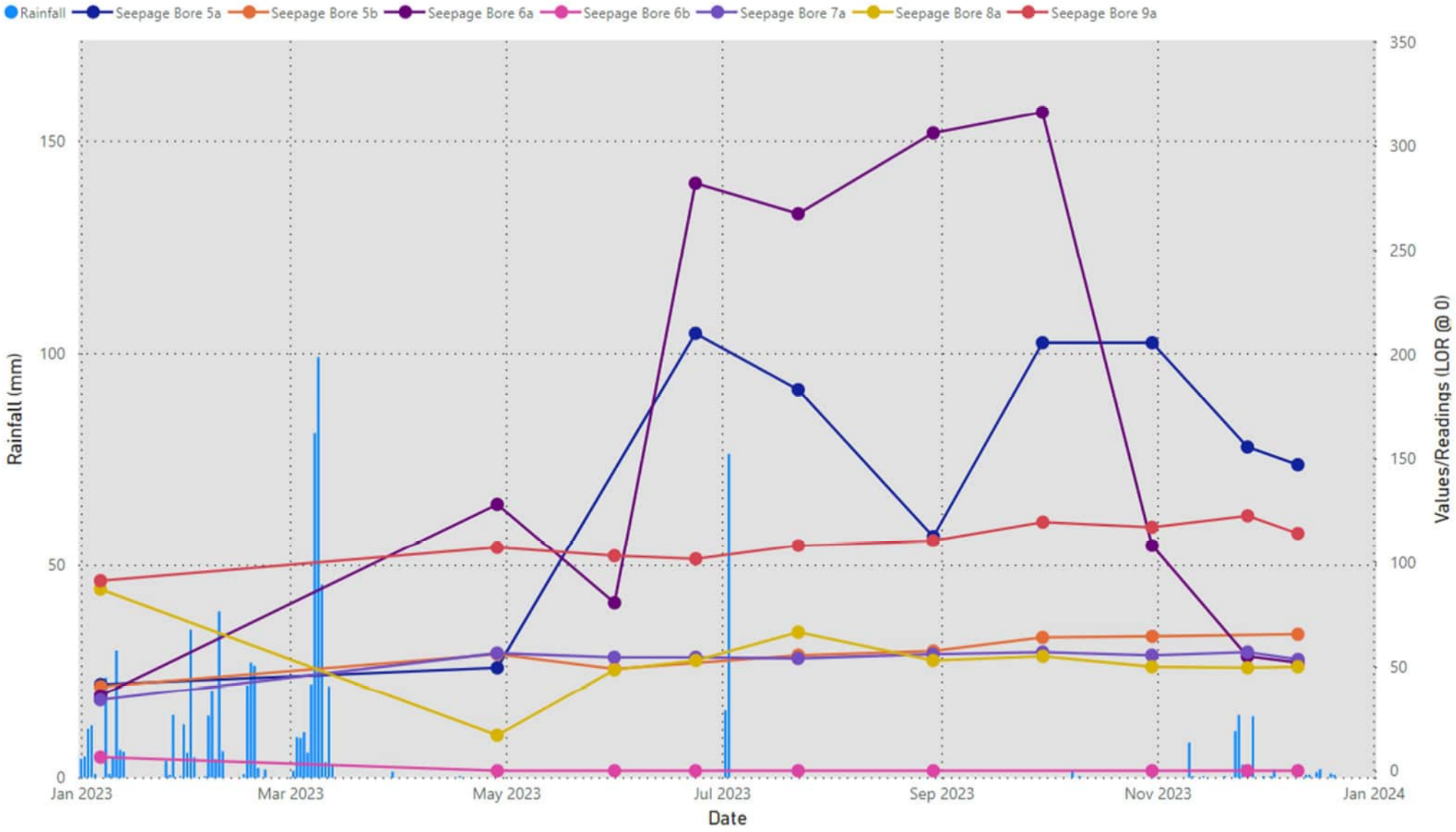

Calcium (mg/L)
Rainfall
Seepage Bore 5a
Seepage Bore 5b
Seepage Bore 6a
Seepage Bore 6b
Seepage Bore 7a
Seepage Bore 8a
Seepage Bore 9a
Rainfall (mm)
Values/Readings (LOR @ 0)
0
50
100
150
0
100
200
300
400
500
Jan 2023
Mar 2023
May 2023
Jul 2023
Sep 2023
Nov 2023
Jan 2024
Date


Chloride (mg/L)
Rainfall
Seepage Bore 5a
Seepage Bore 5b
Seepage Bore 6a
Seepage Bore 6b
Seepage Bore 7a
Seepage Bore 8a
Seepage Bore 9a
Rainfall (mm)
Values/Readings (LOR @ 0)
0
50
100
150
0
100
200
300
400
500
Jan 2023
Mar 2023
May 2023
Jul 2023
Sep 2023
Nov 2023
Jan 2024
Date

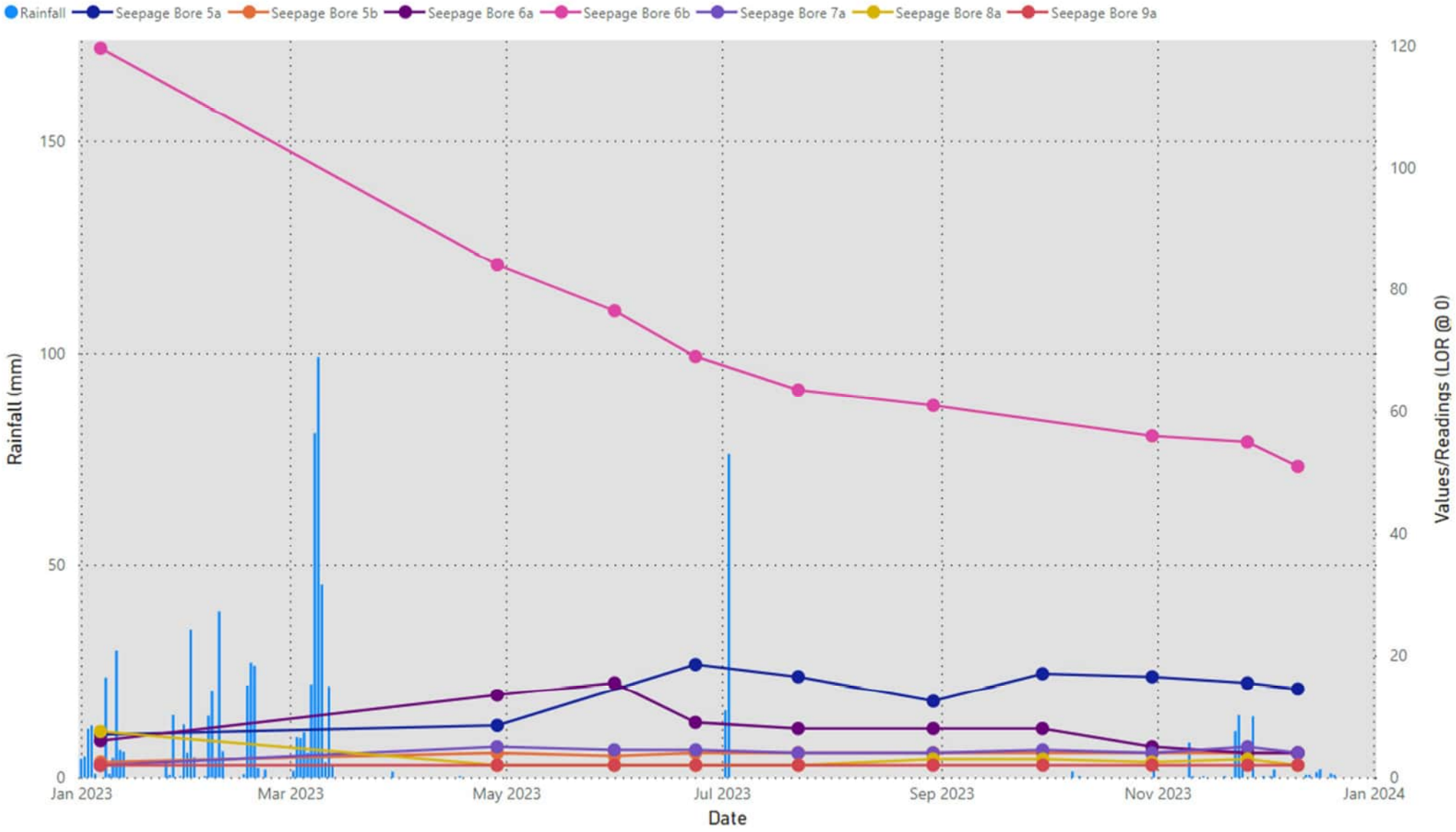
Fluoride (mg/L)



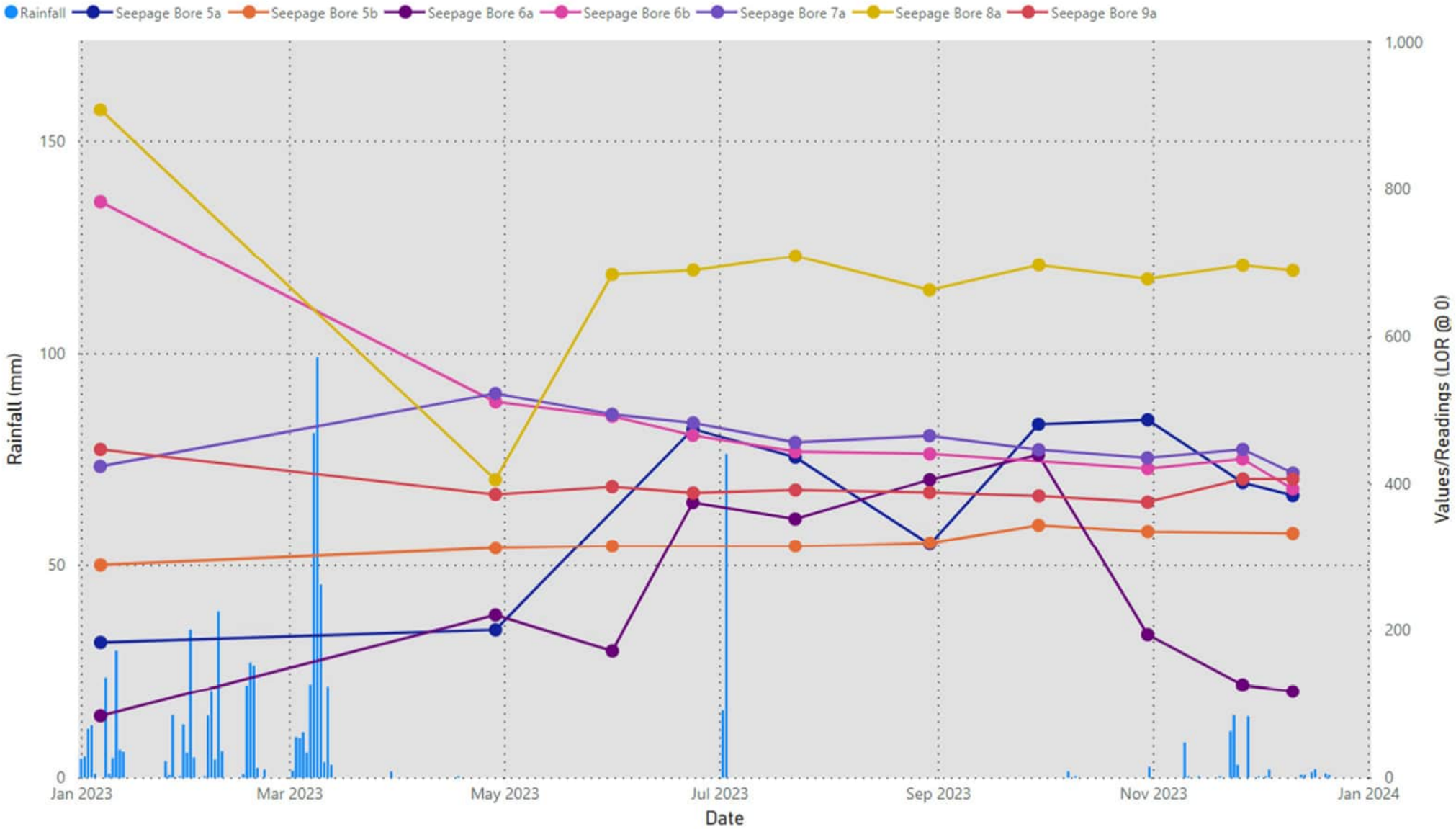
Magnesium (mg/L)



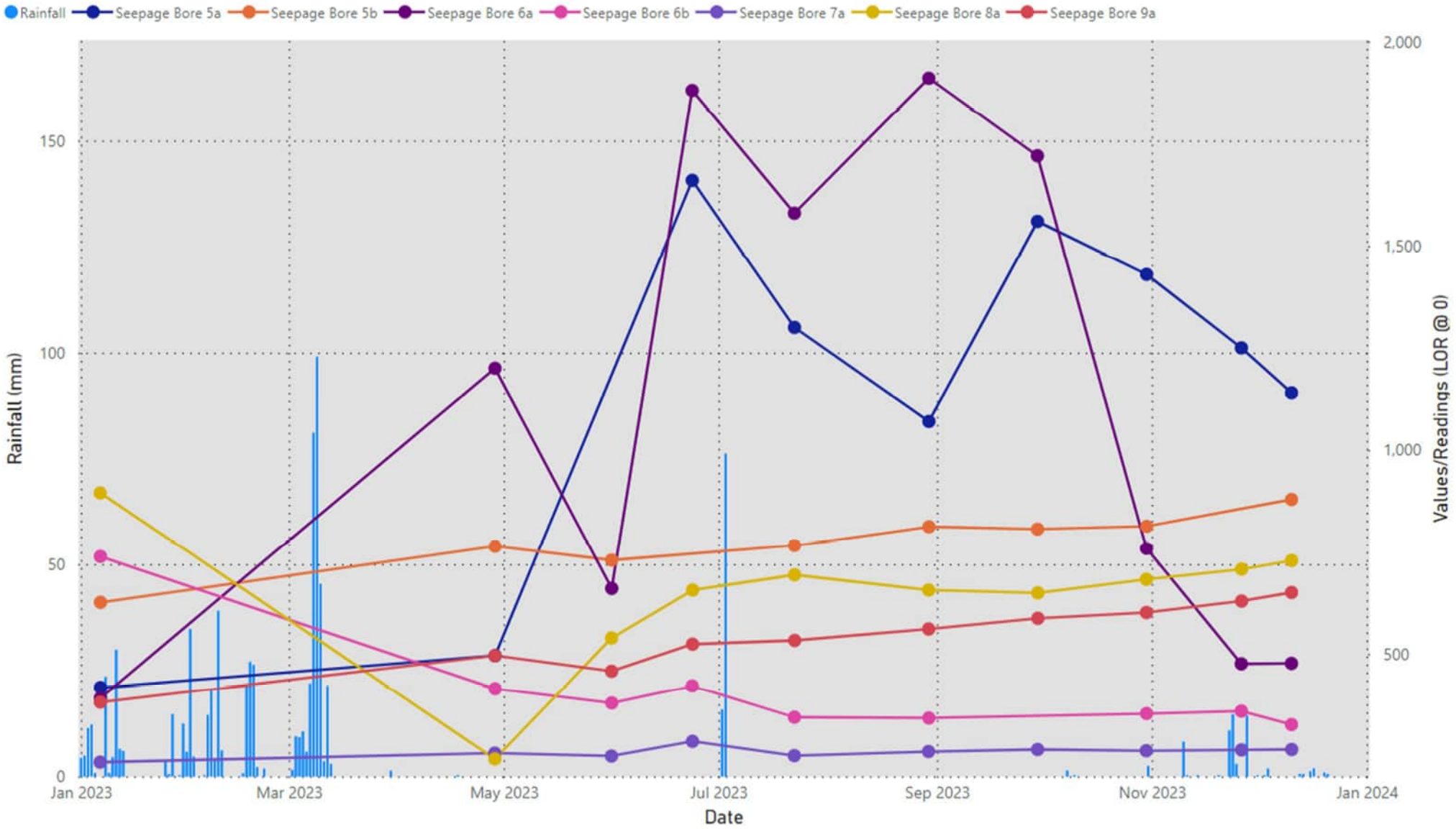
Potassium (mg/L)



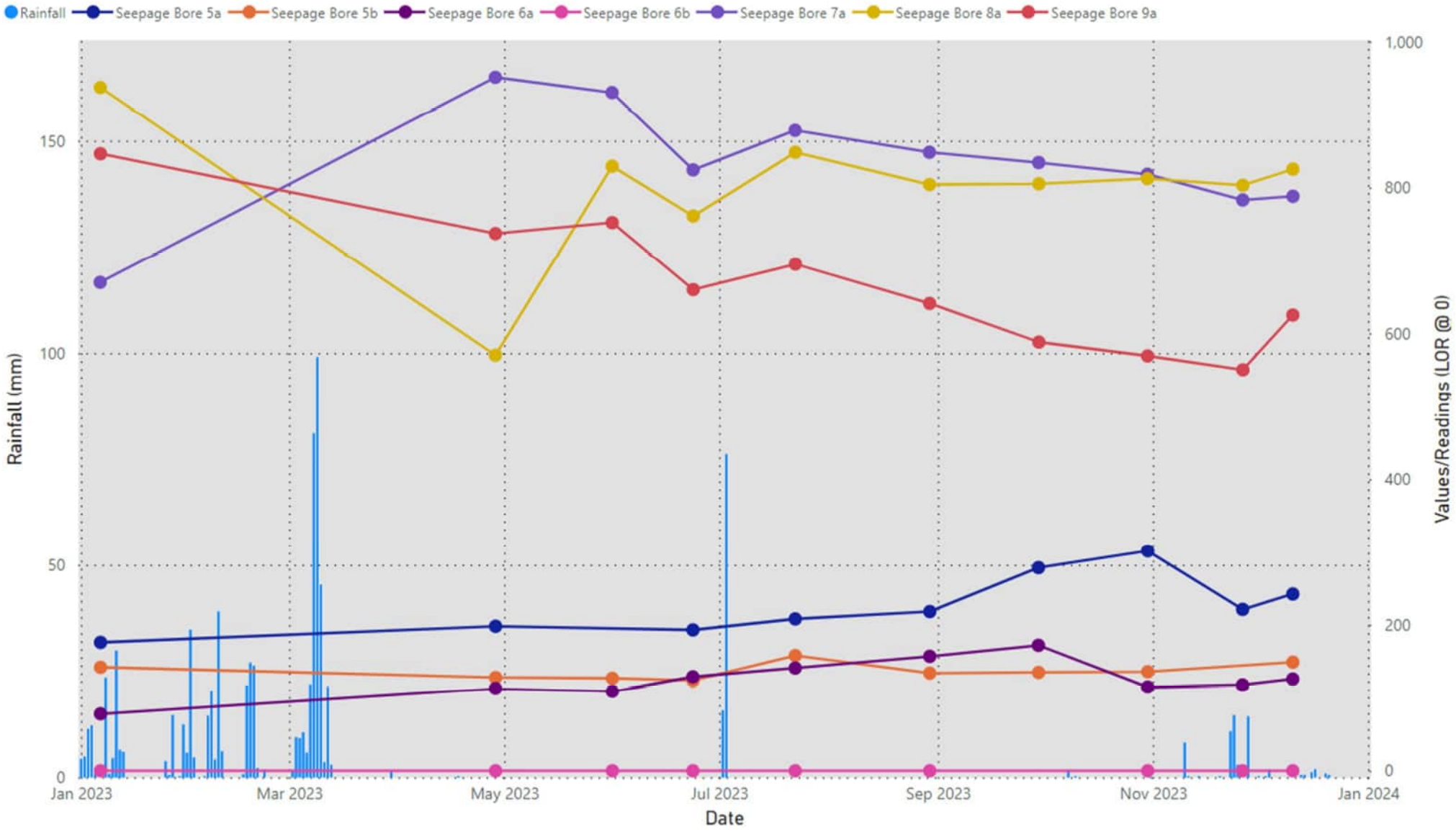
Sodium (mg/L)


Rainfall
Seepage Bore 5a
Seepage Bore 5b
Seepage Bore 6a
Seepage Bore 6b
Seepage Bore 7a
Seepage Bore 8a
Seepage Bore 9a
Rainfall (mm)
150
100
50
0
1,000
800
600
400
200
0
Values/Readings (LOR @ 0)
Jan 2023
Mar 2023
May 2023
Jul 2023
Sep 2023
Nov 2023
Jan 2024
Date

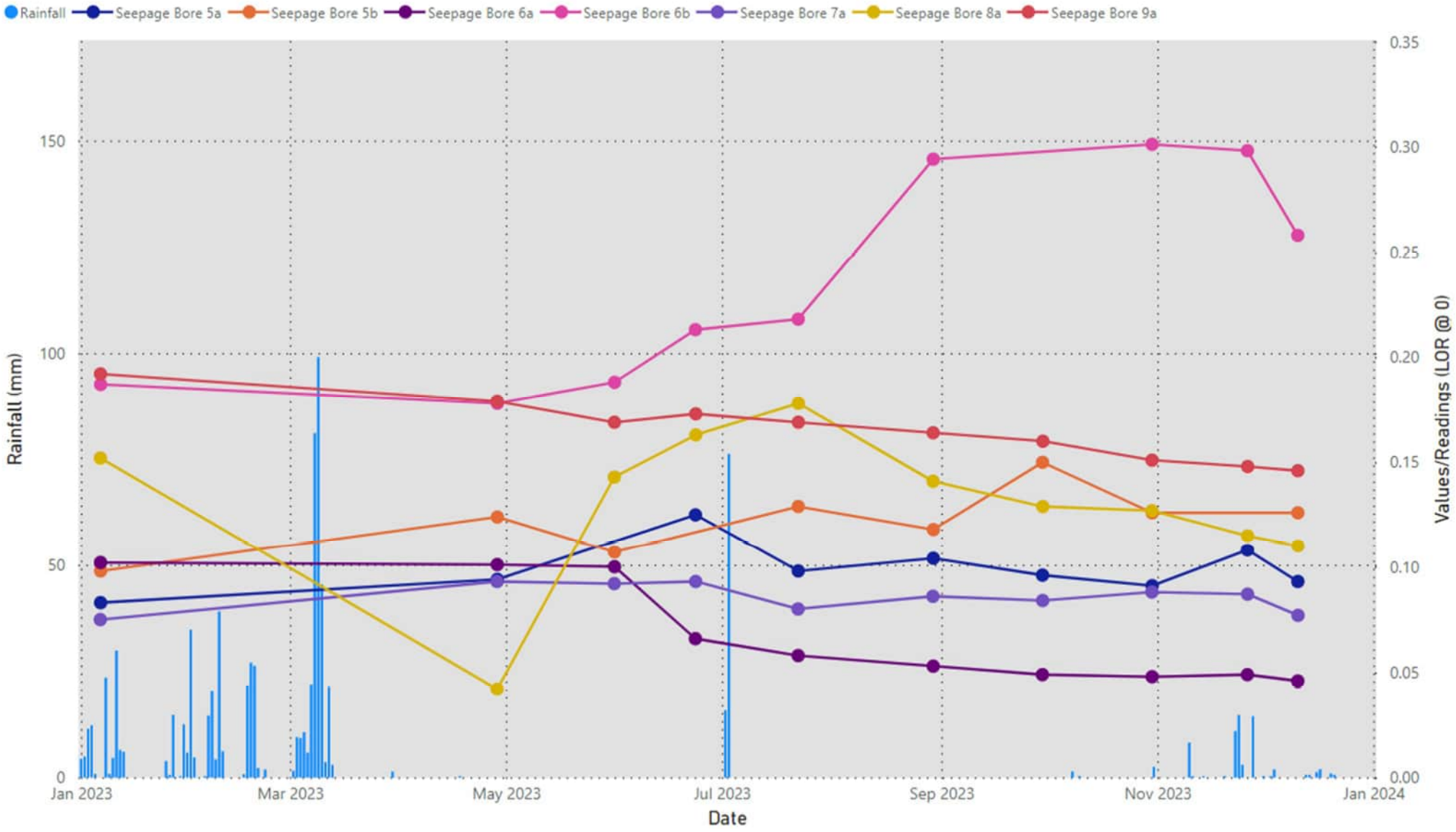
Sulfate (as SO4)



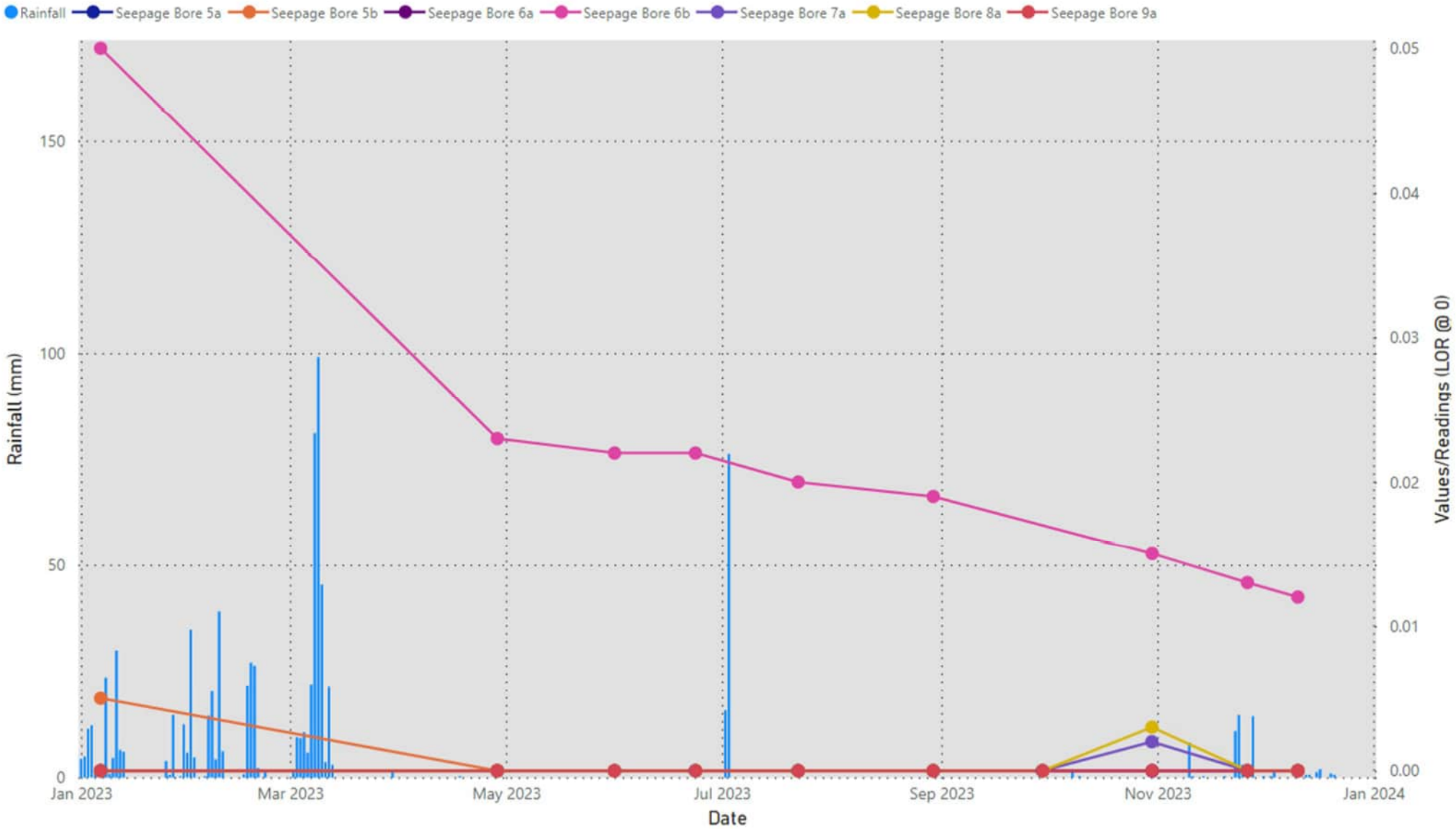
Bicarbonate Alkalinity as CaCO3 (mg/L)



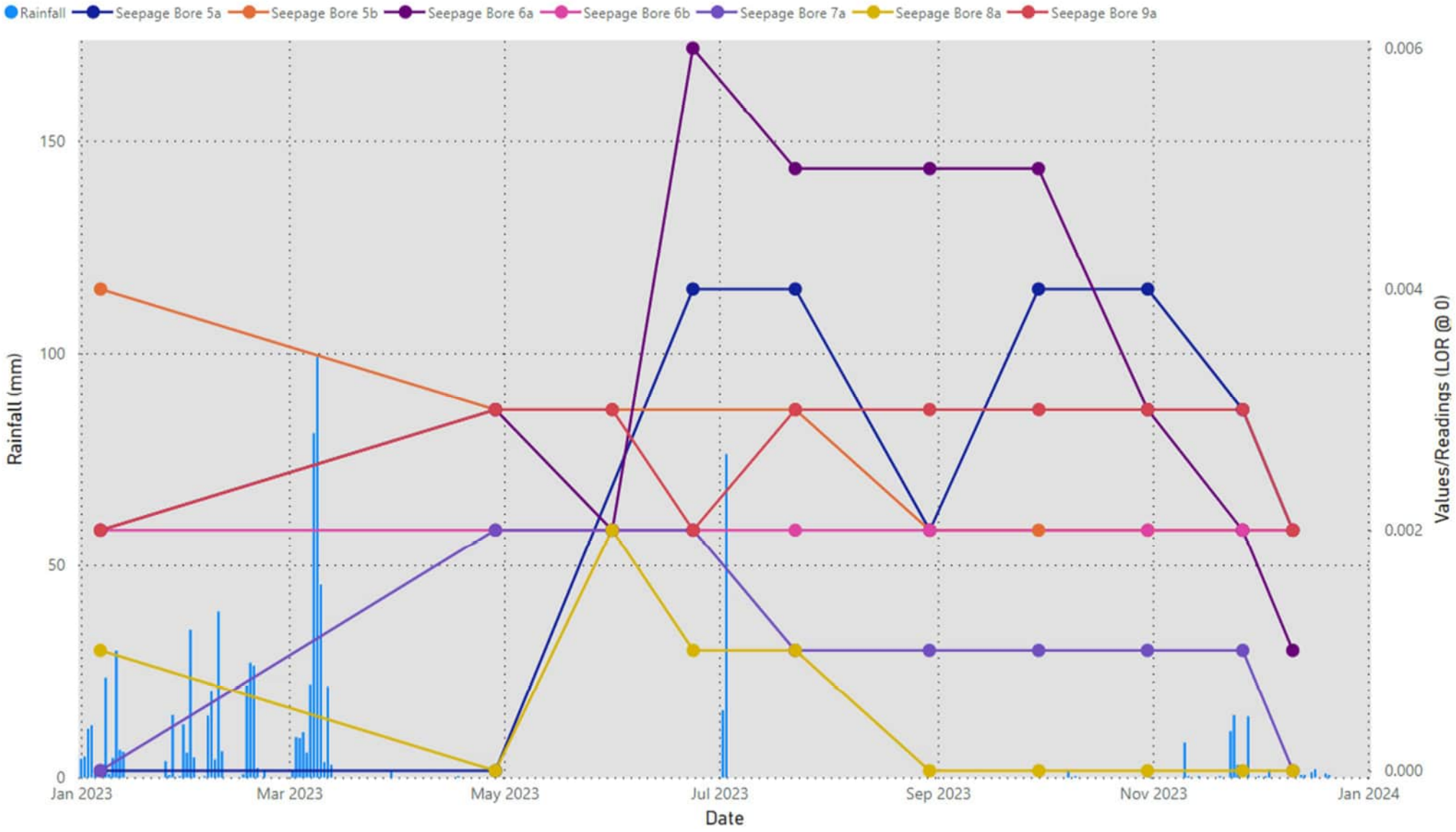
Barium - dissolved (mg/L)



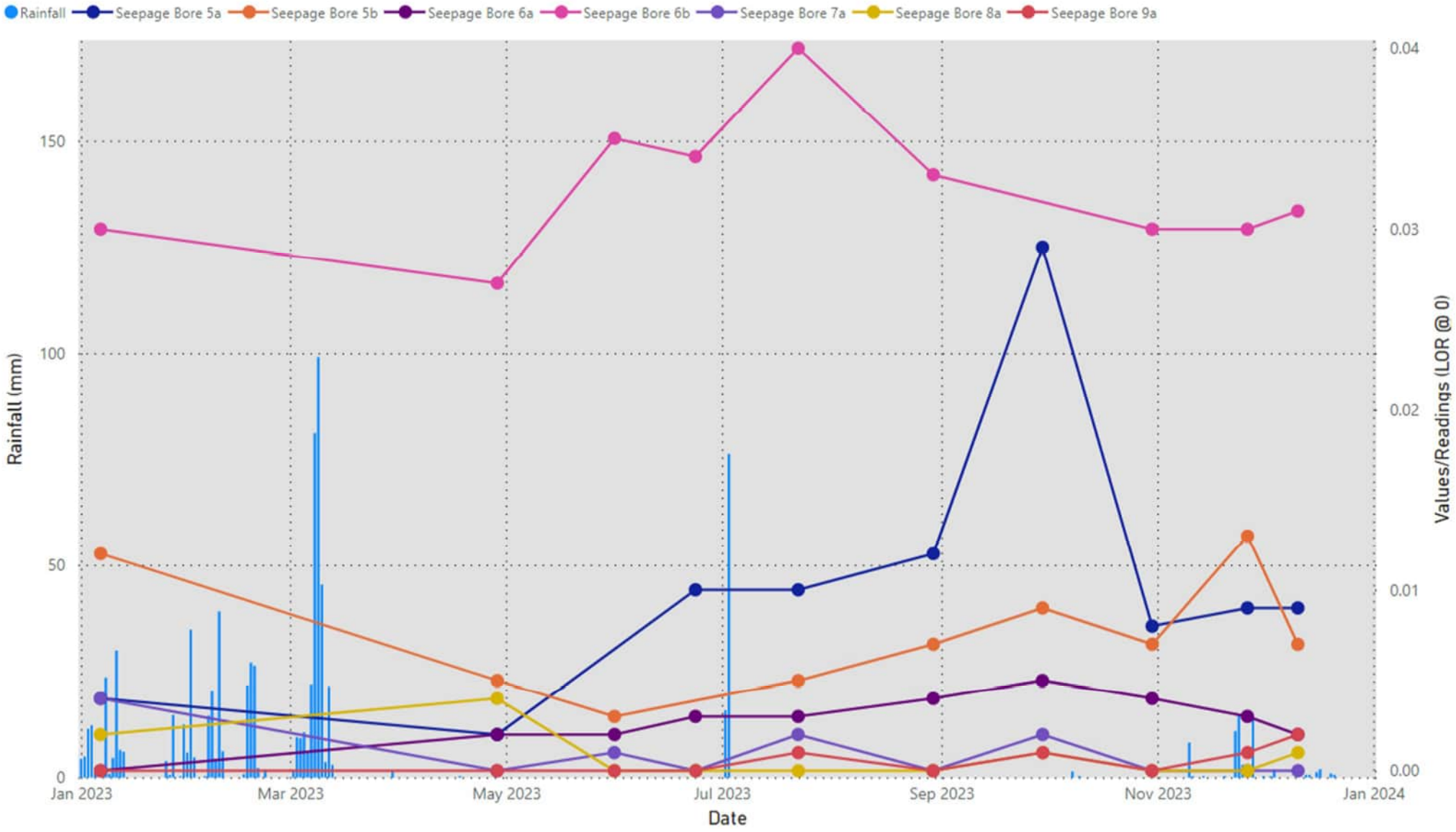
Chromium - dissolved (mg/L)



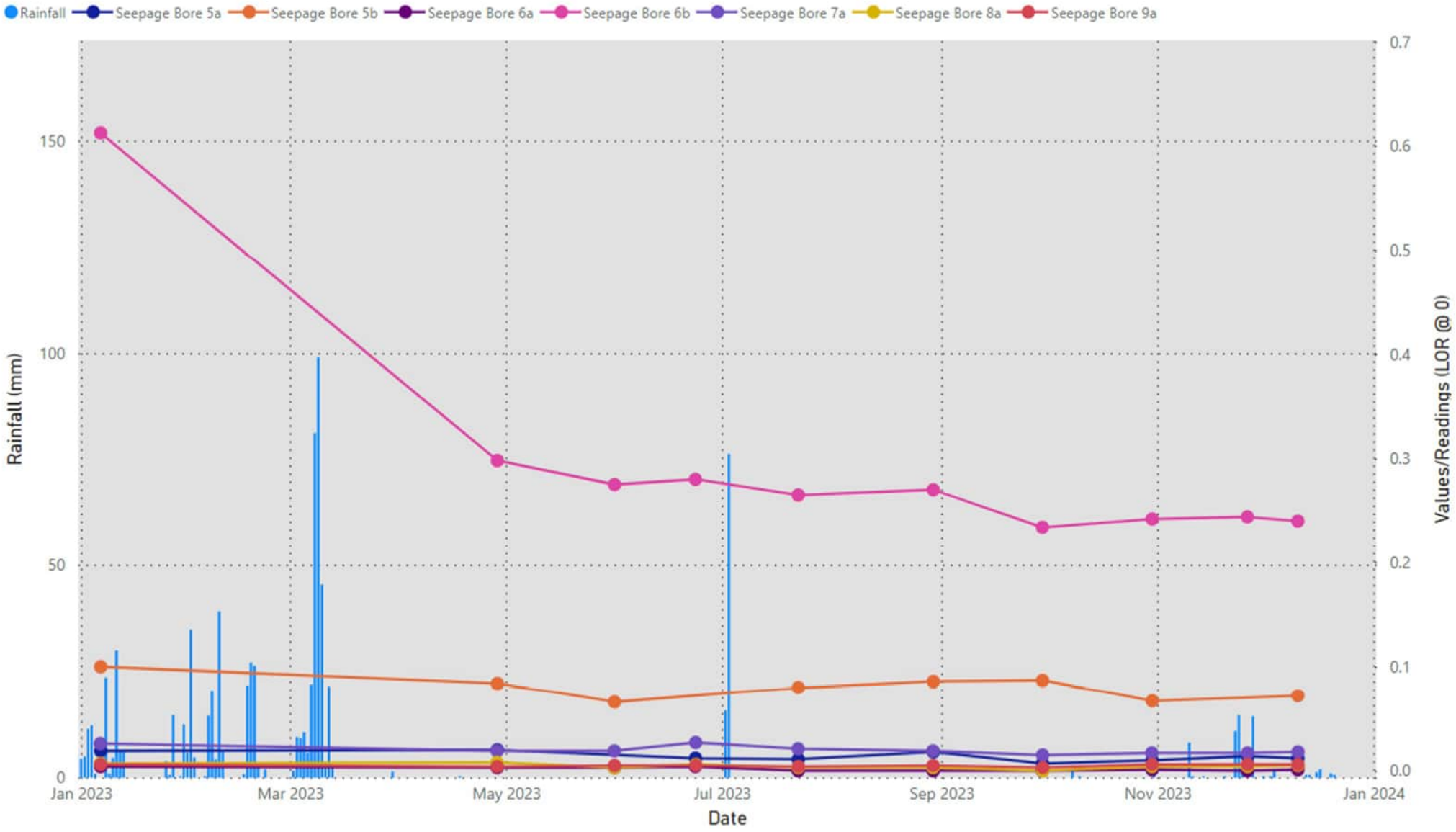
Cobalt - dissolved (mg/L)



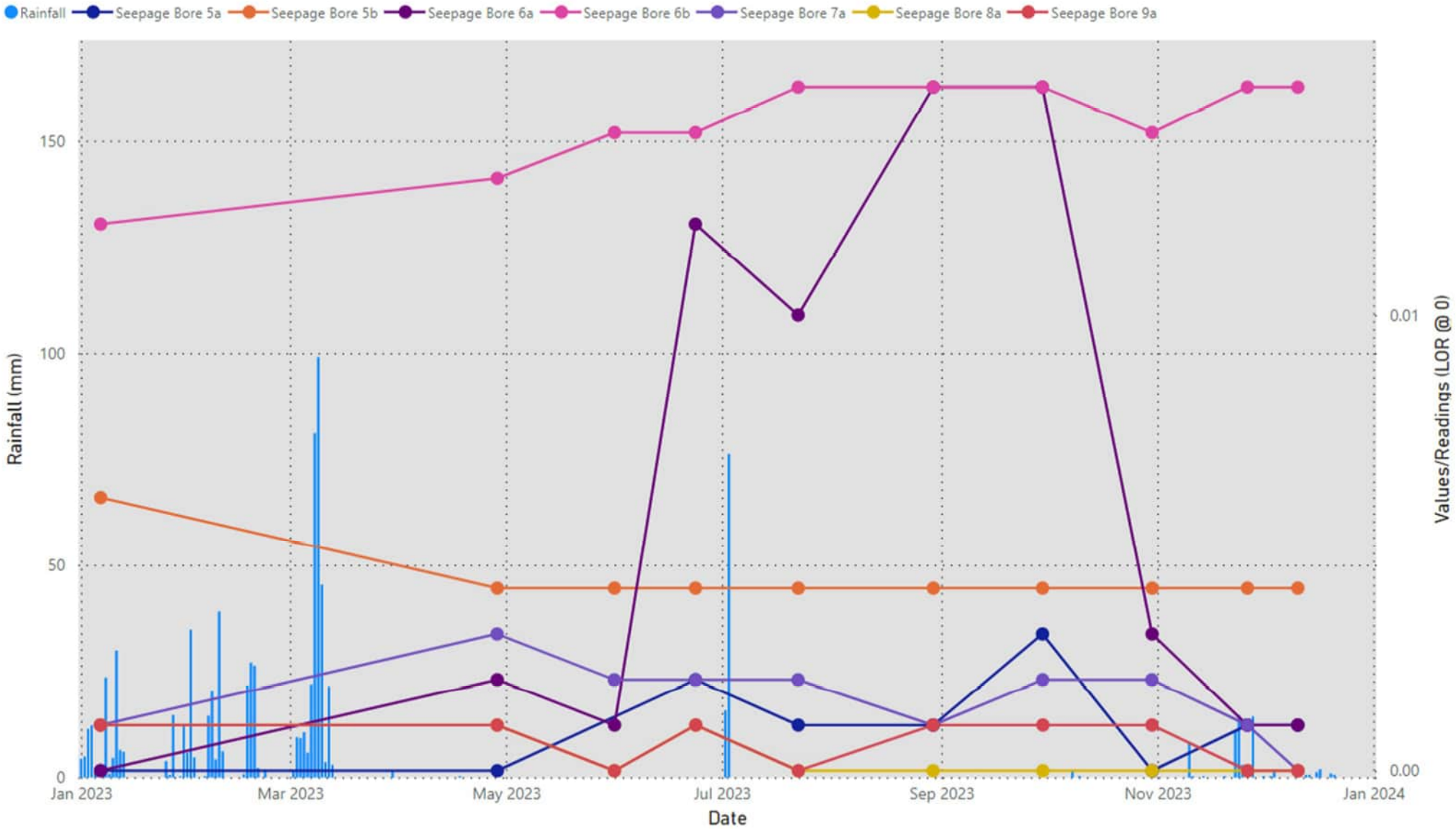
Copper - dissolved (mg/L)



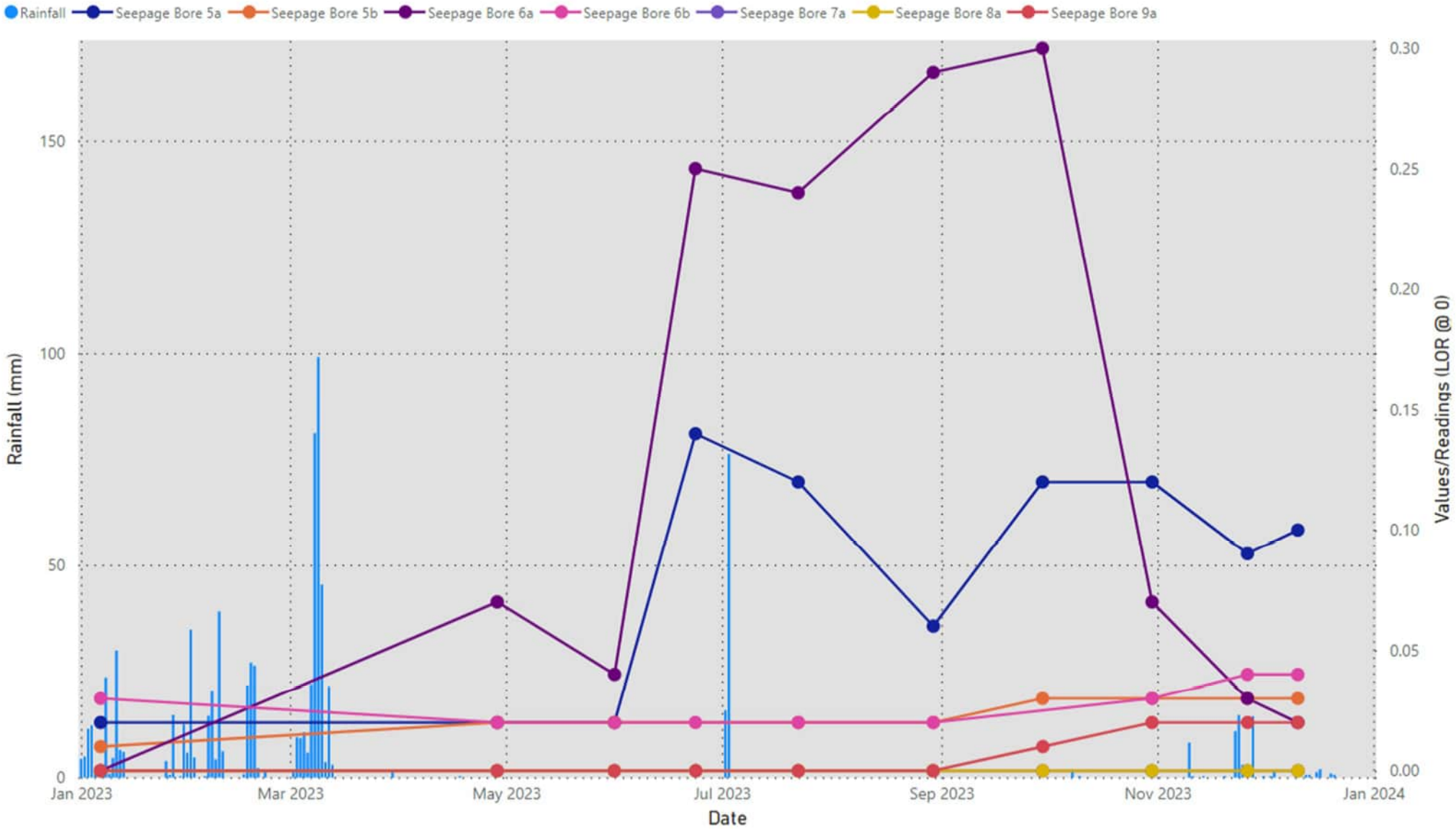
Molybdenum - dissolved (mg/L)



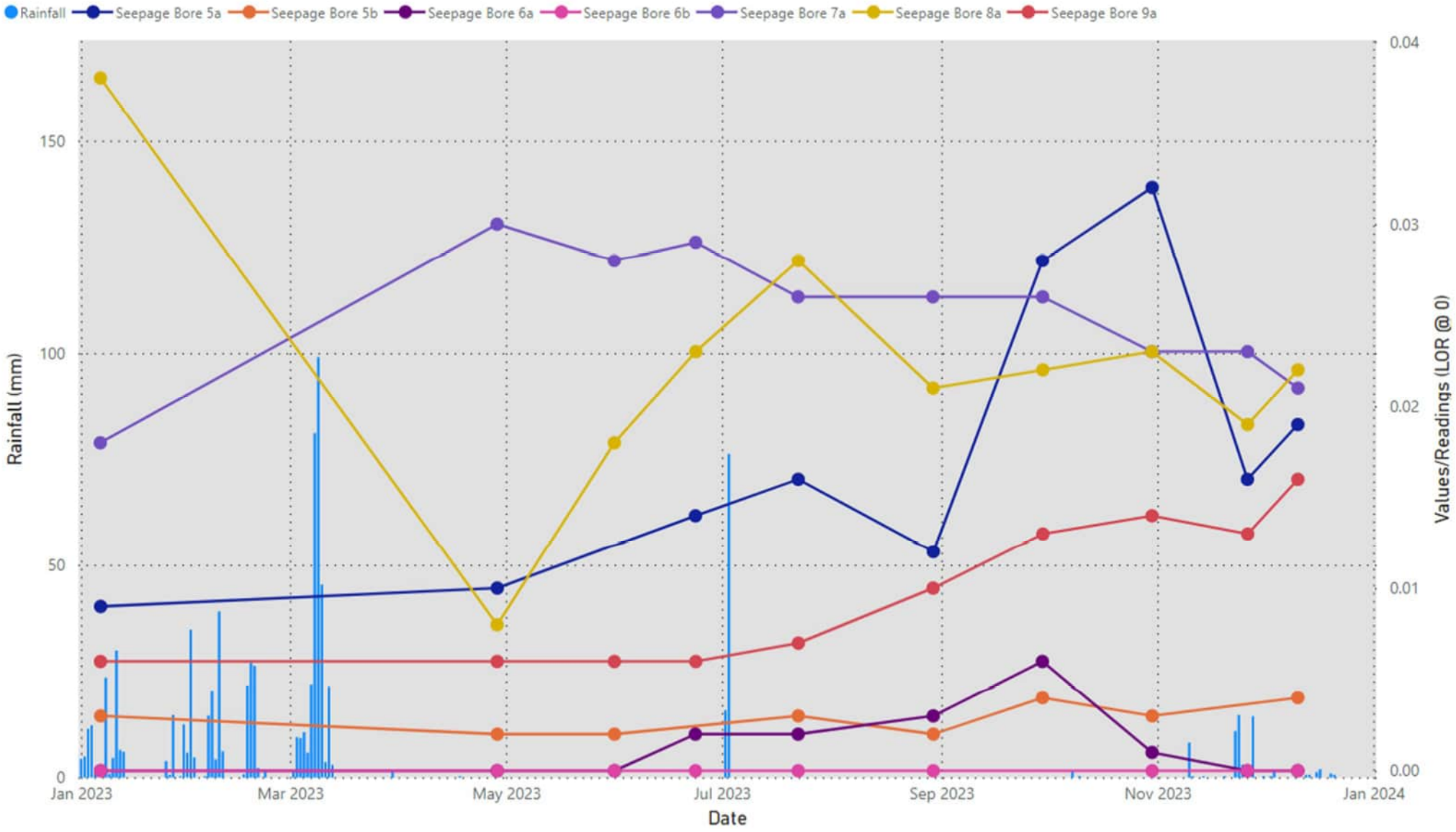
Nickel - dissolved (mg/L)



Selenium - dissolved (mg/L)

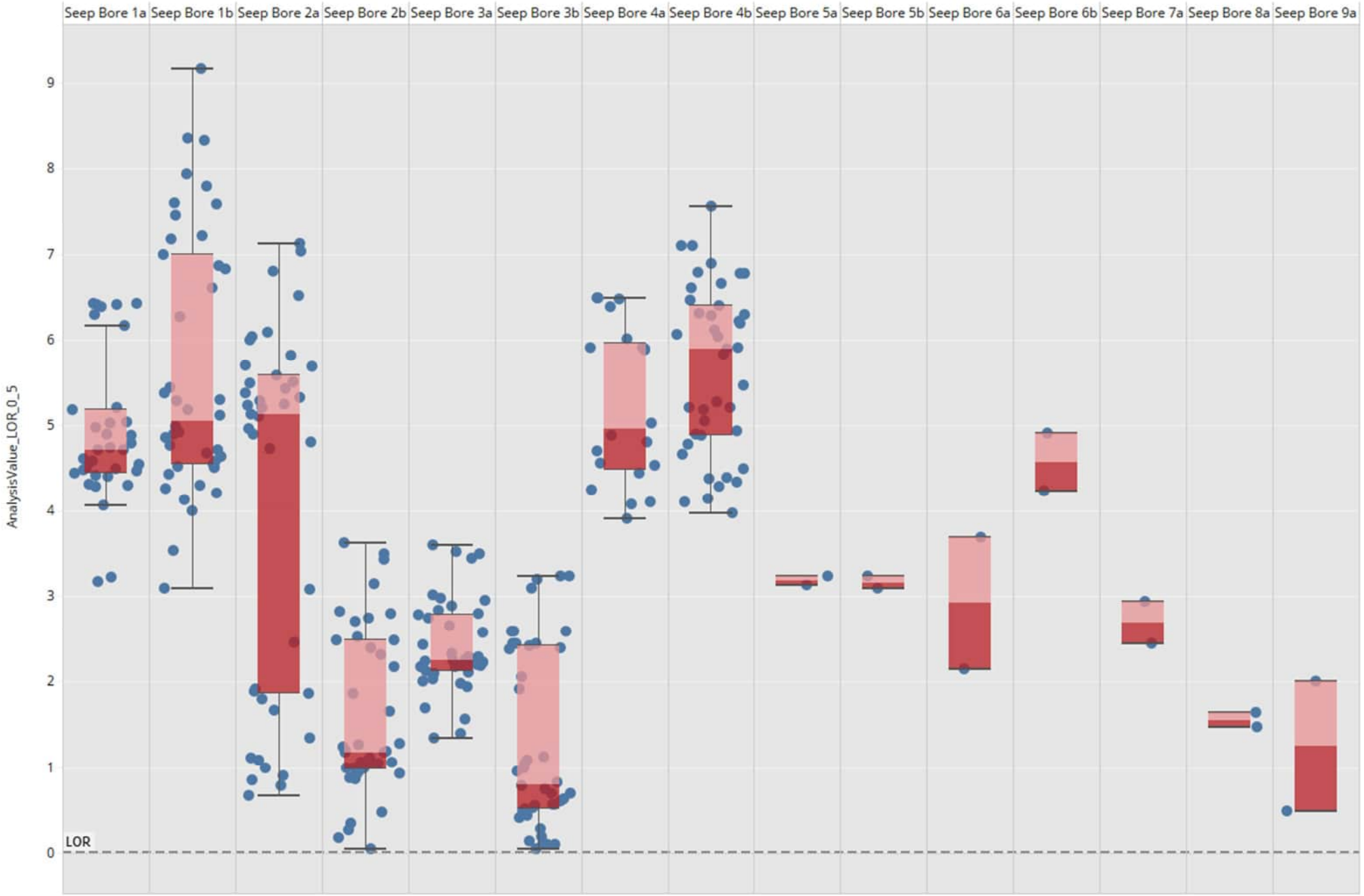


Uranium - dissolved (mg/L)

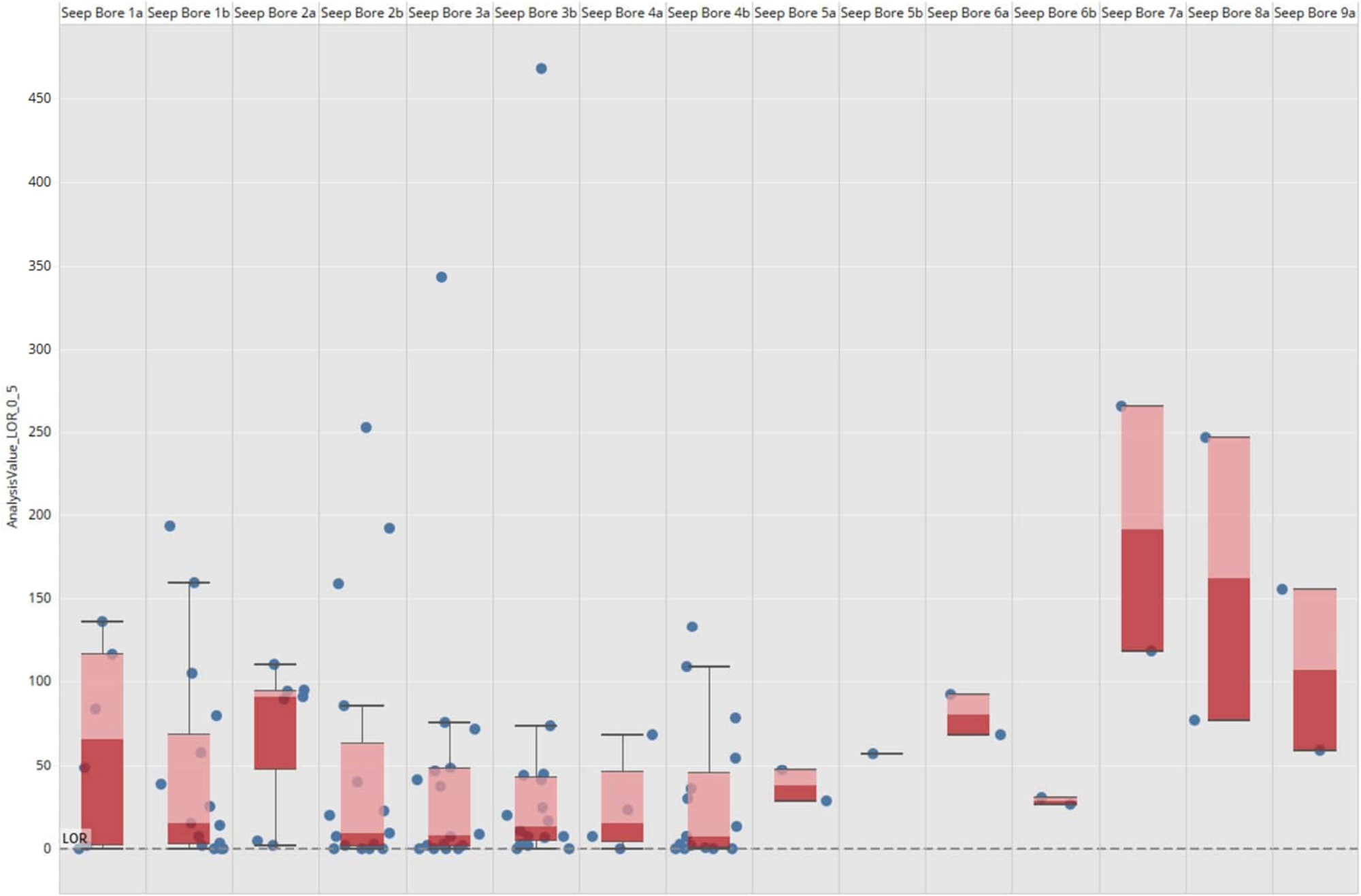


H.3 Water quality box & whisker plots

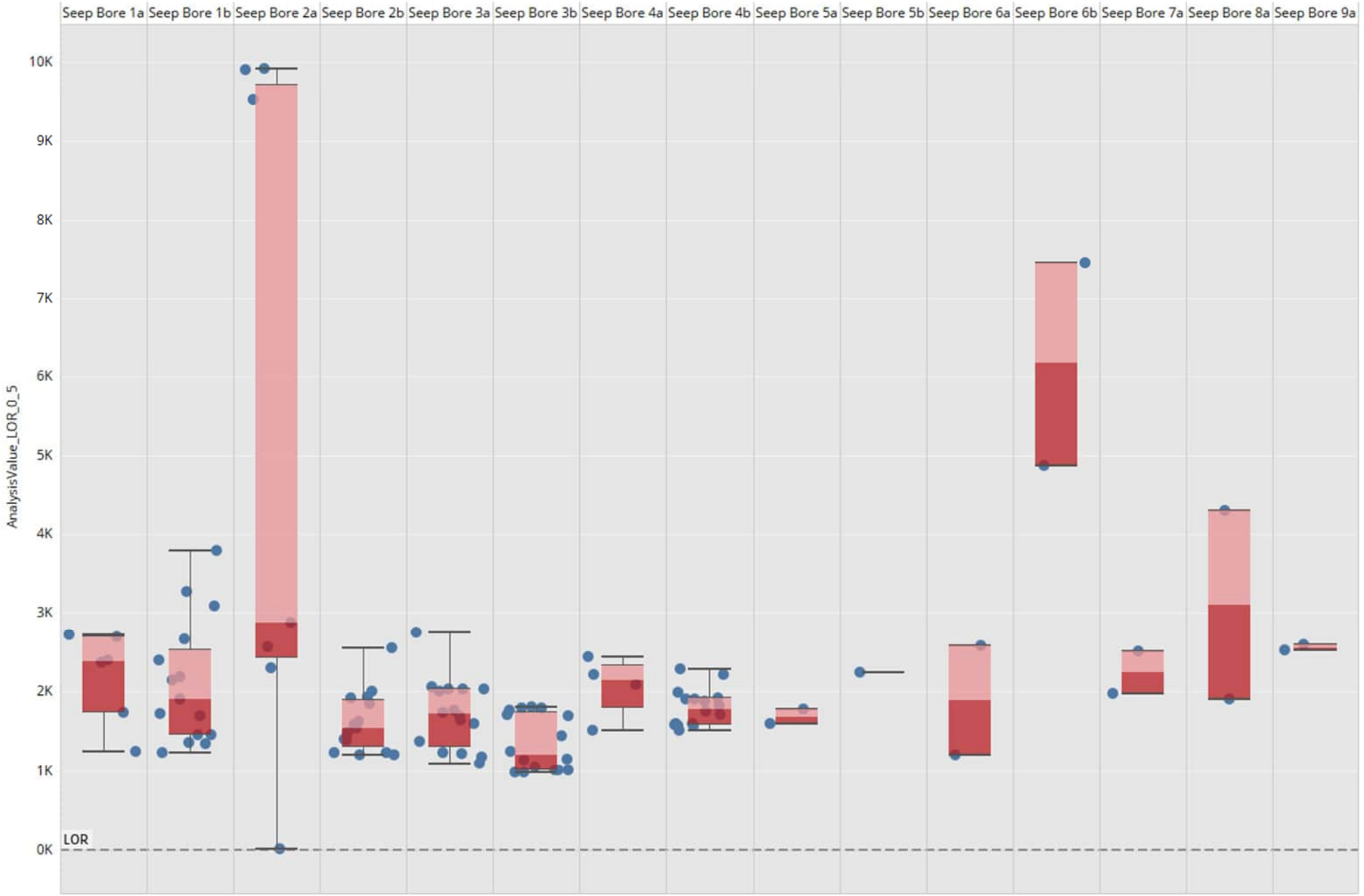
Depth to Water (mbRL)



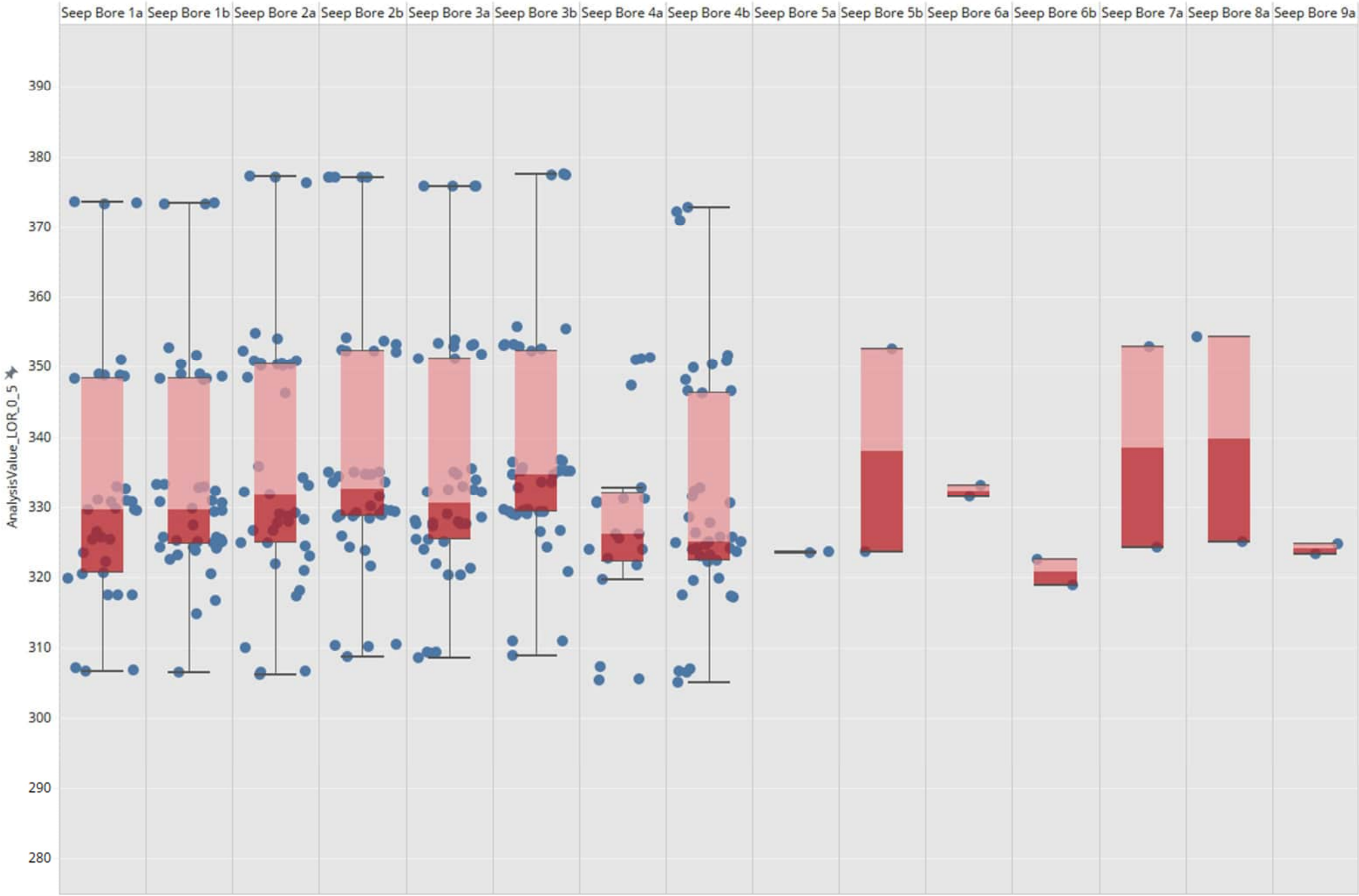
Dissolved Oxygen (field) (% sat)



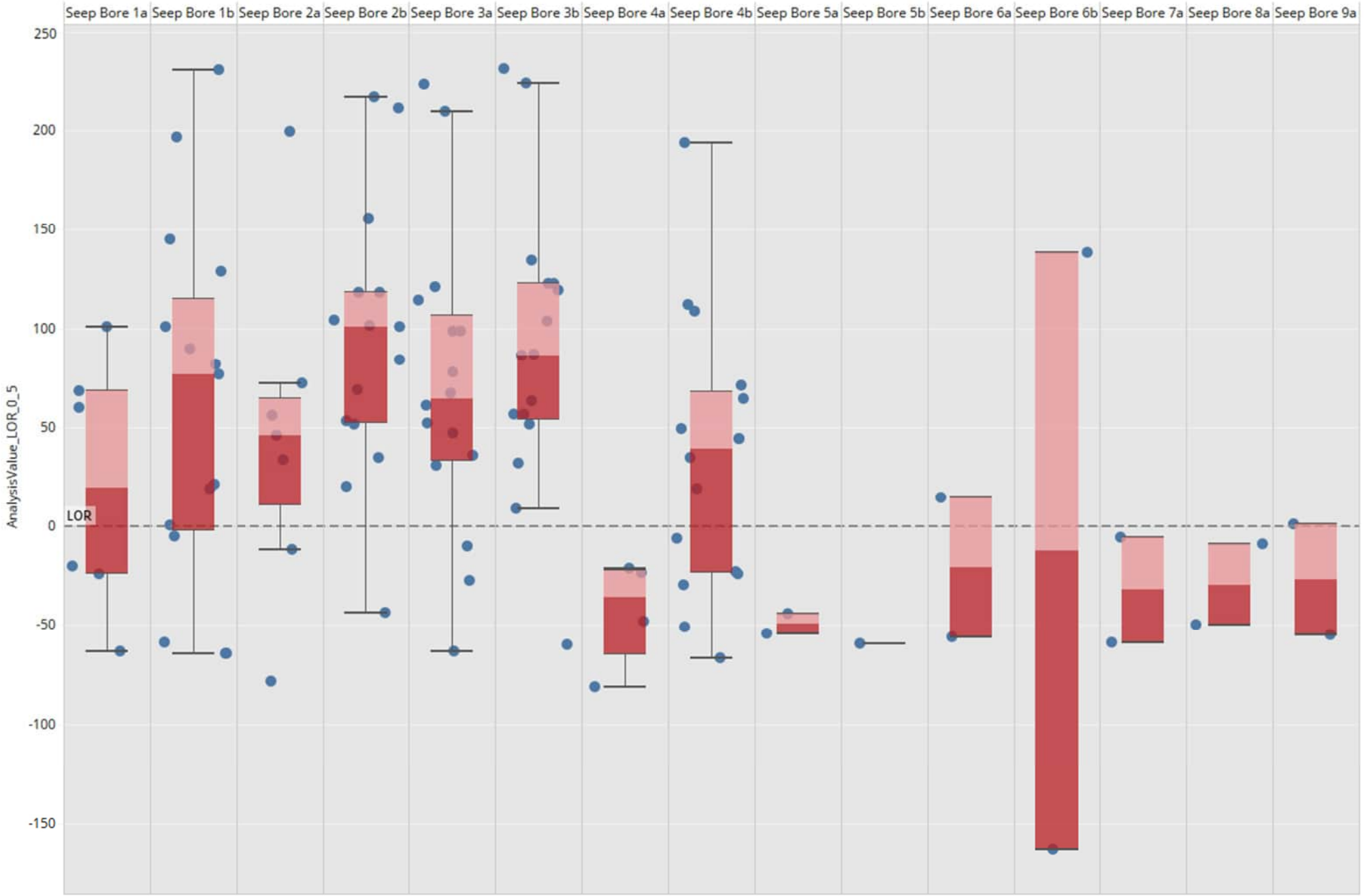
Electrical Conductivity (field) (µS/cm)



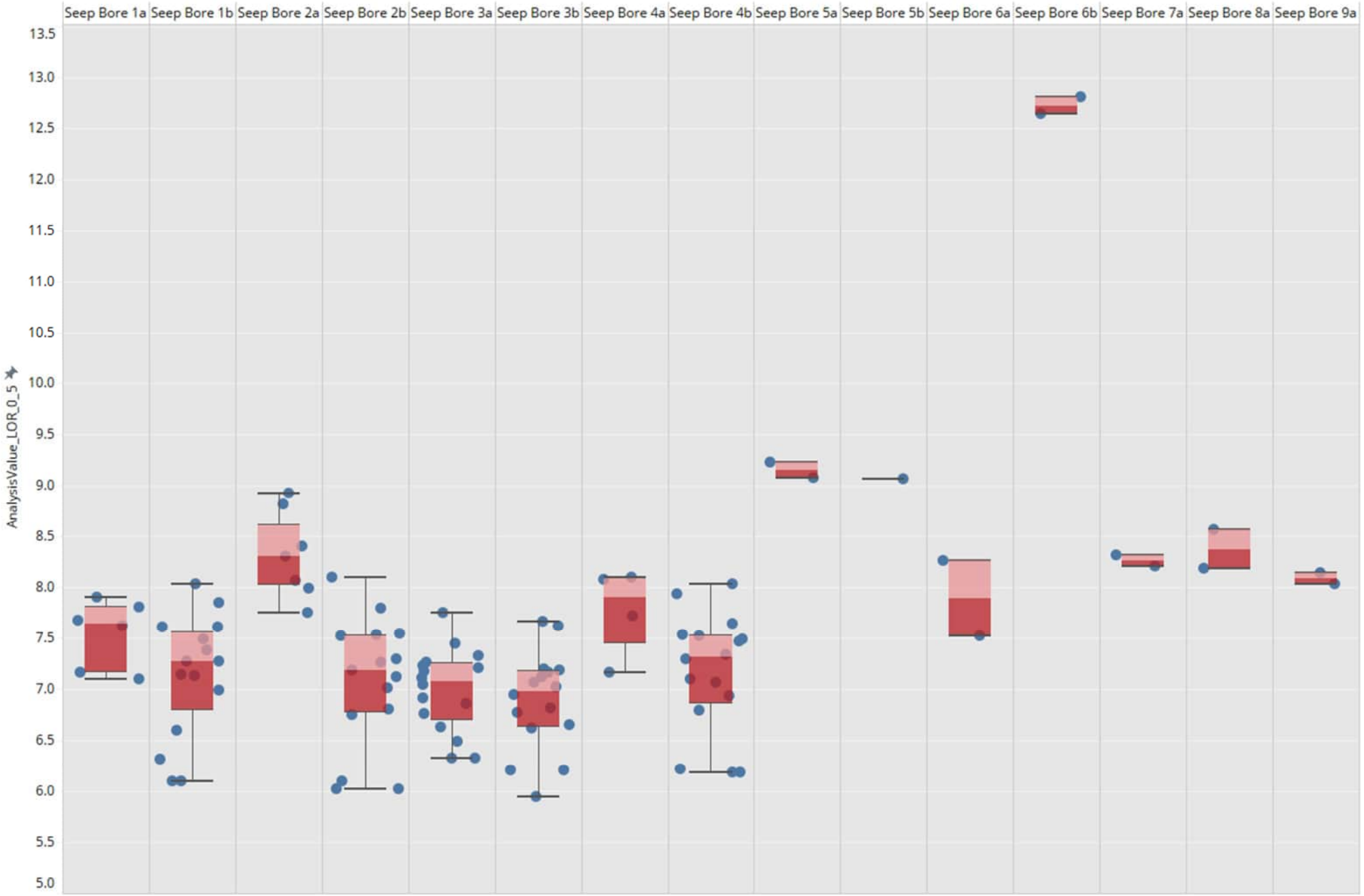
Groundwater Level (mAHD)



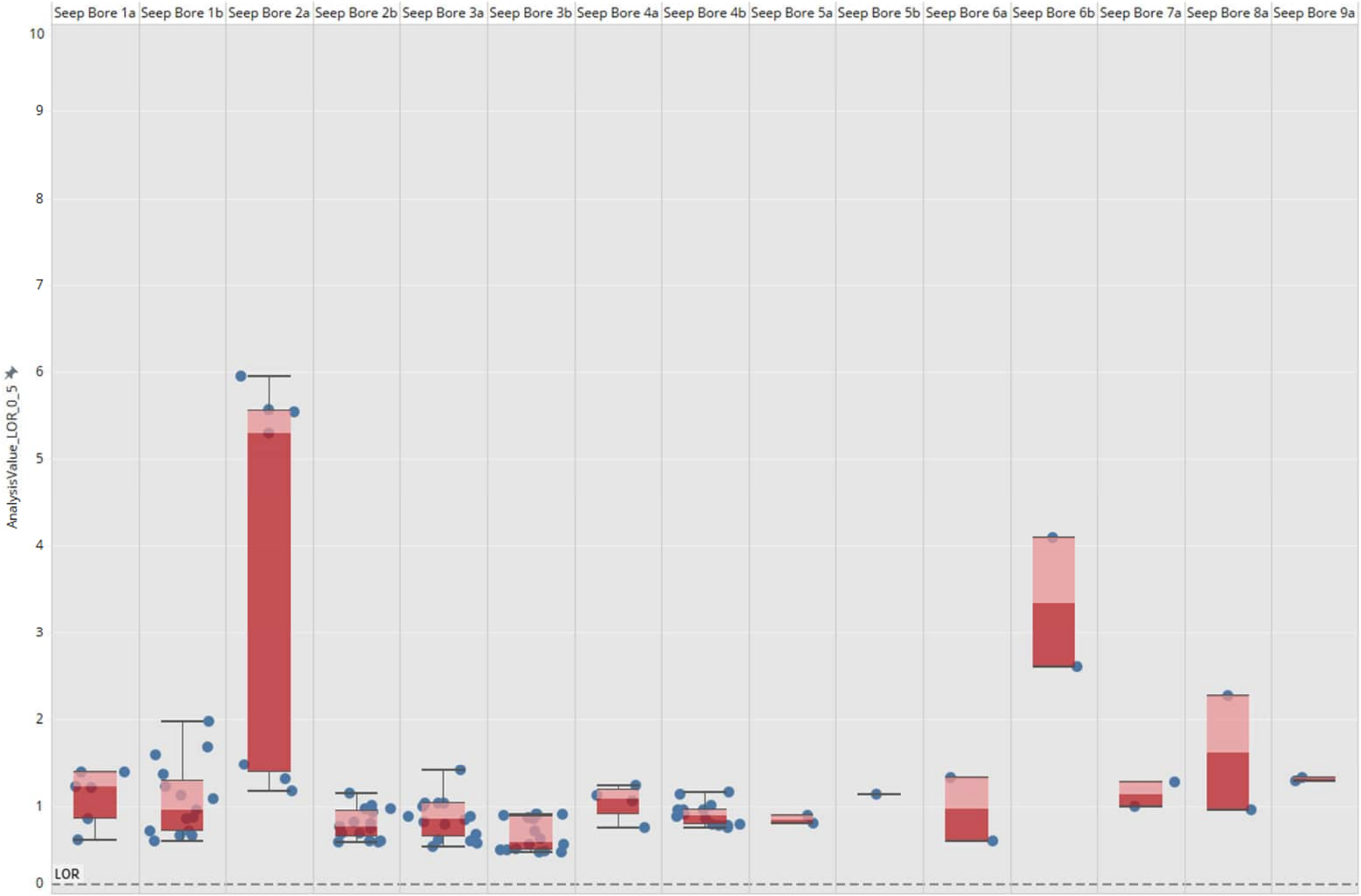
ORP (field) (mV)


Seep Bore 1a
Seep Bore 1b
Seep Bore 2a
Seep Bore 2b
Seep Bore 3a
Seep Bore 3b
Seep Bore 4a
Seep Bore 4b
Seep Bore 5a
Seep Bore 5b
Seep Bore 6a
Seep Bore 6b
Seep Bore 7a
Seep Bore 8a
Seep Bore 9a
250
200
150
100
50
0
-50
-100
-150
AnalysisValue_LOR_0_5
LOR

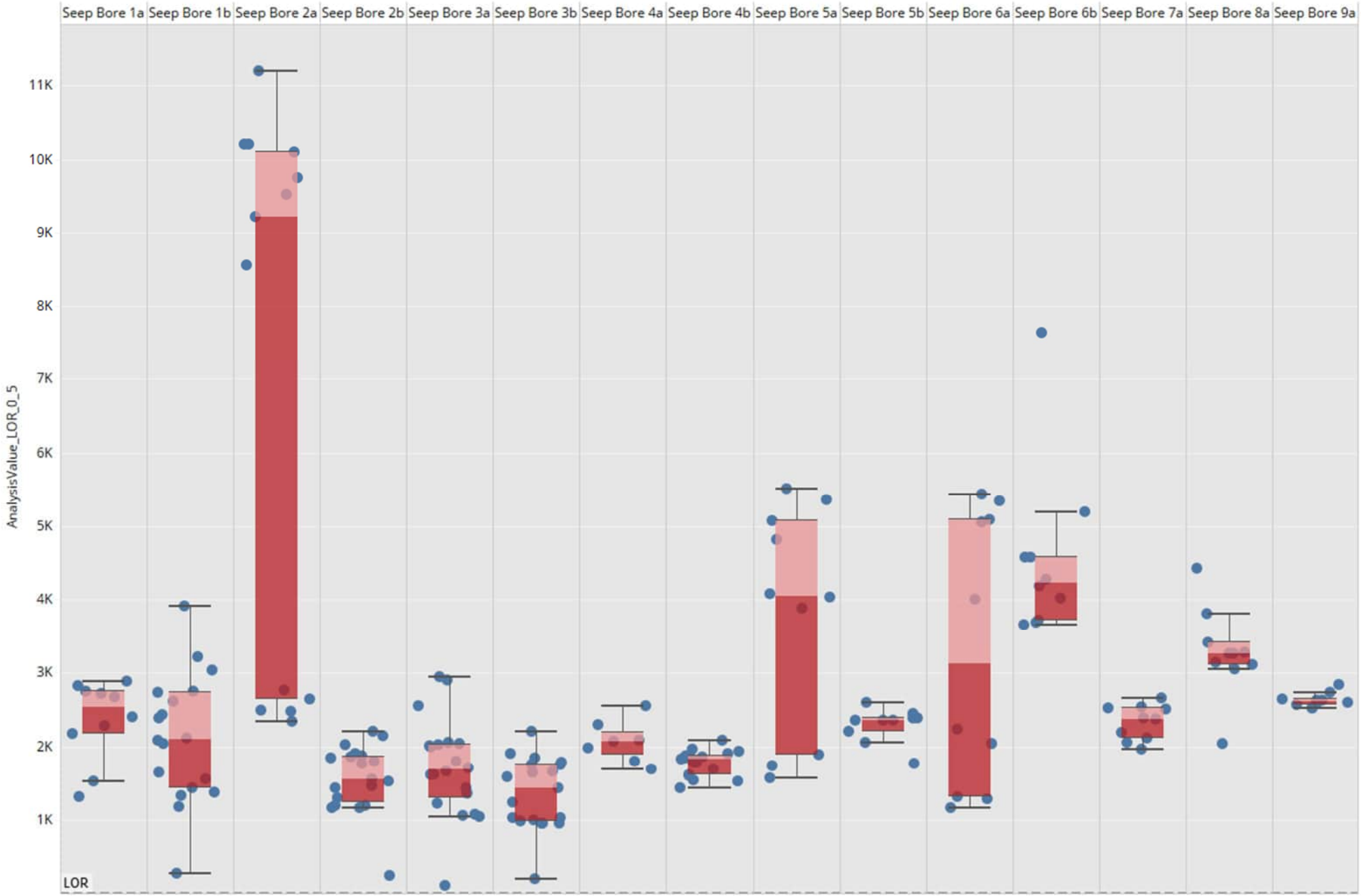
pH (field)


Seep Bore 1a
Seep Bore 1b
Seep Bore 2a
Seep Bore 2b
Seep Bore 3a
Seep Bore 3b
Seep Bore 4a
Seep Bore 4b
Seep Bore 5a
Seep Bore 5b
Seep Bore 6a
Seep Bore 6b
Seep Bore 7a
Seep Bore 8a
Seep Bore 9a
AnalysisValue_LOR_0_5
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0

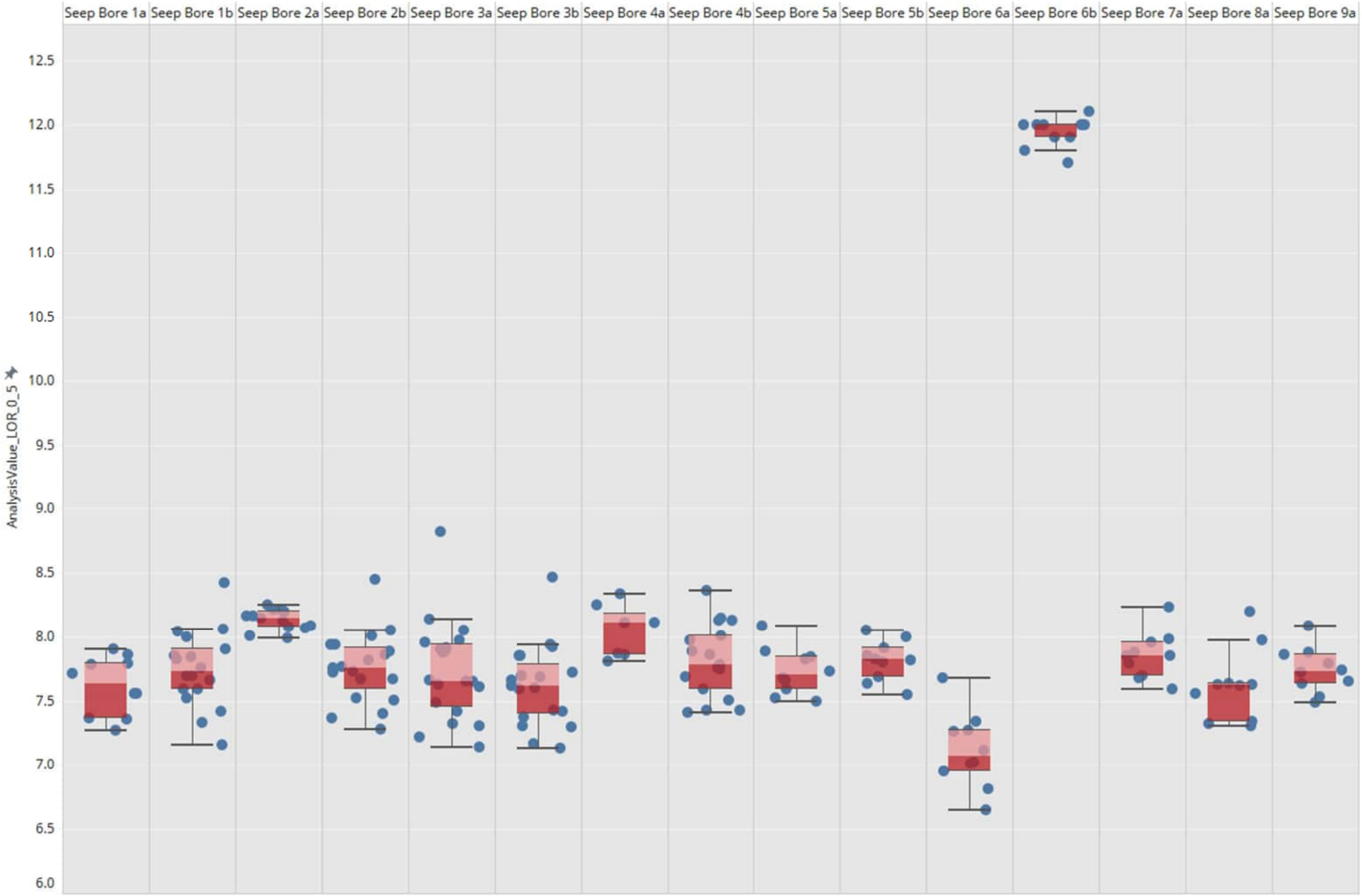
Salinity (field) (PSU)



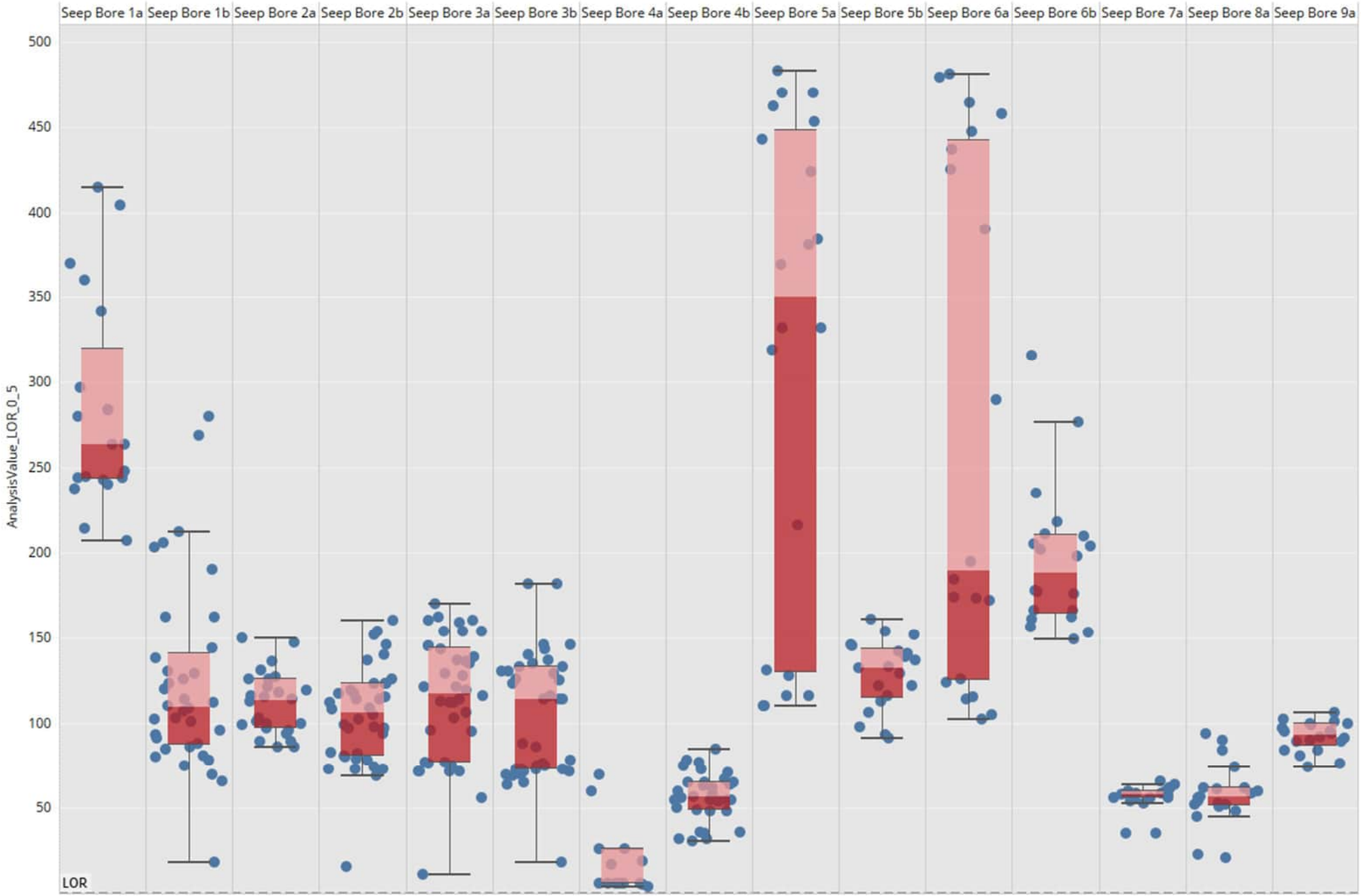
Electrical Conductivity (µS/cm)



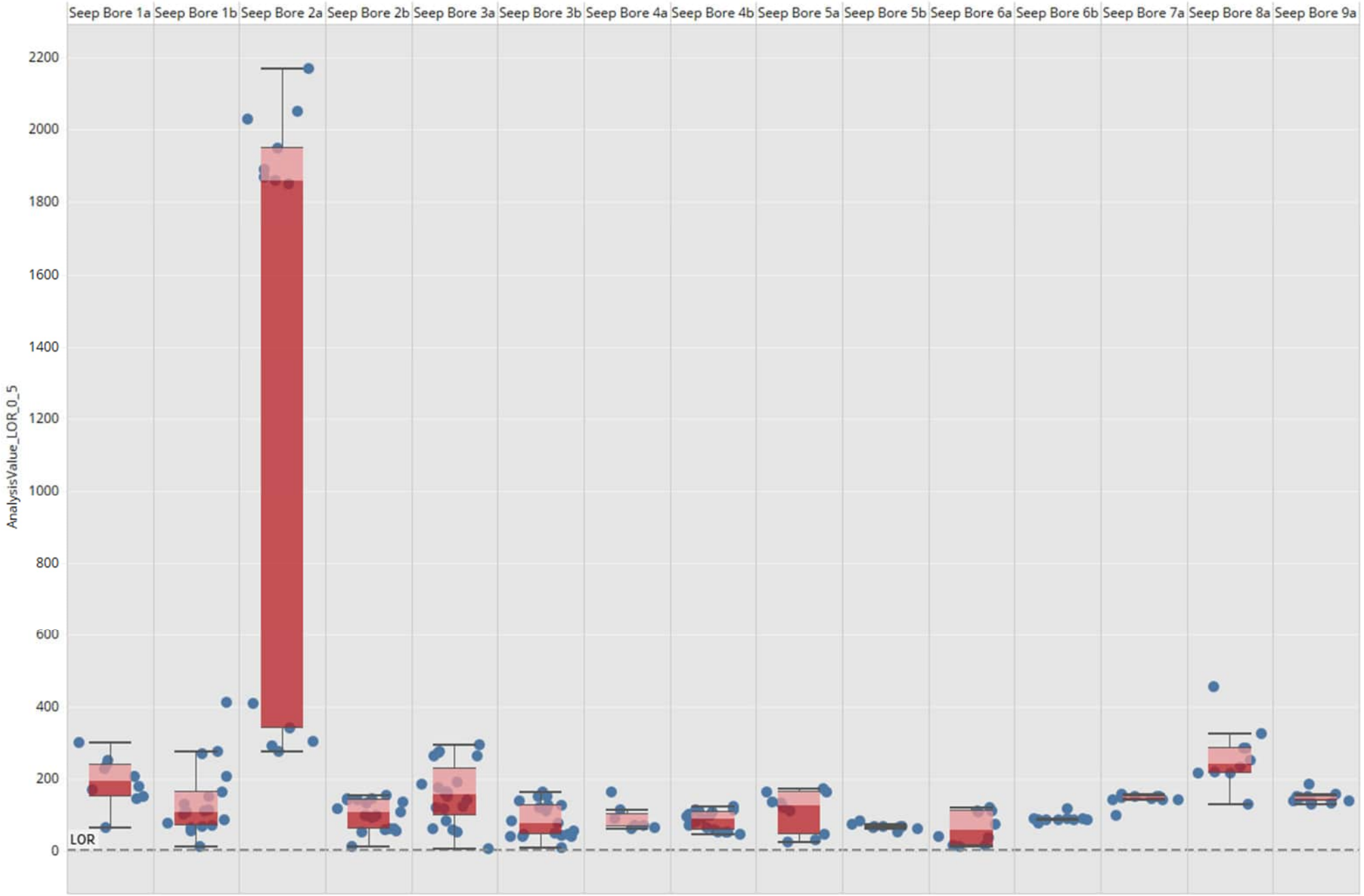
pH (lab)


Seep Bore 1a
Seep Bore 1b
Seep Bore 2a
Seep Bore 2b
Seep Bore 3a
Seep Bore 3b
Seep Bore 4a
Seep Bore 4b
Seep Bore 5a
Seep Bore 5b
Seep Bore 6a
Seep Bore 6b
Seep Bore 7a
Seep Bore 8a
Seep Bore 9a
AnalysisValue_LOR_0_5
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0

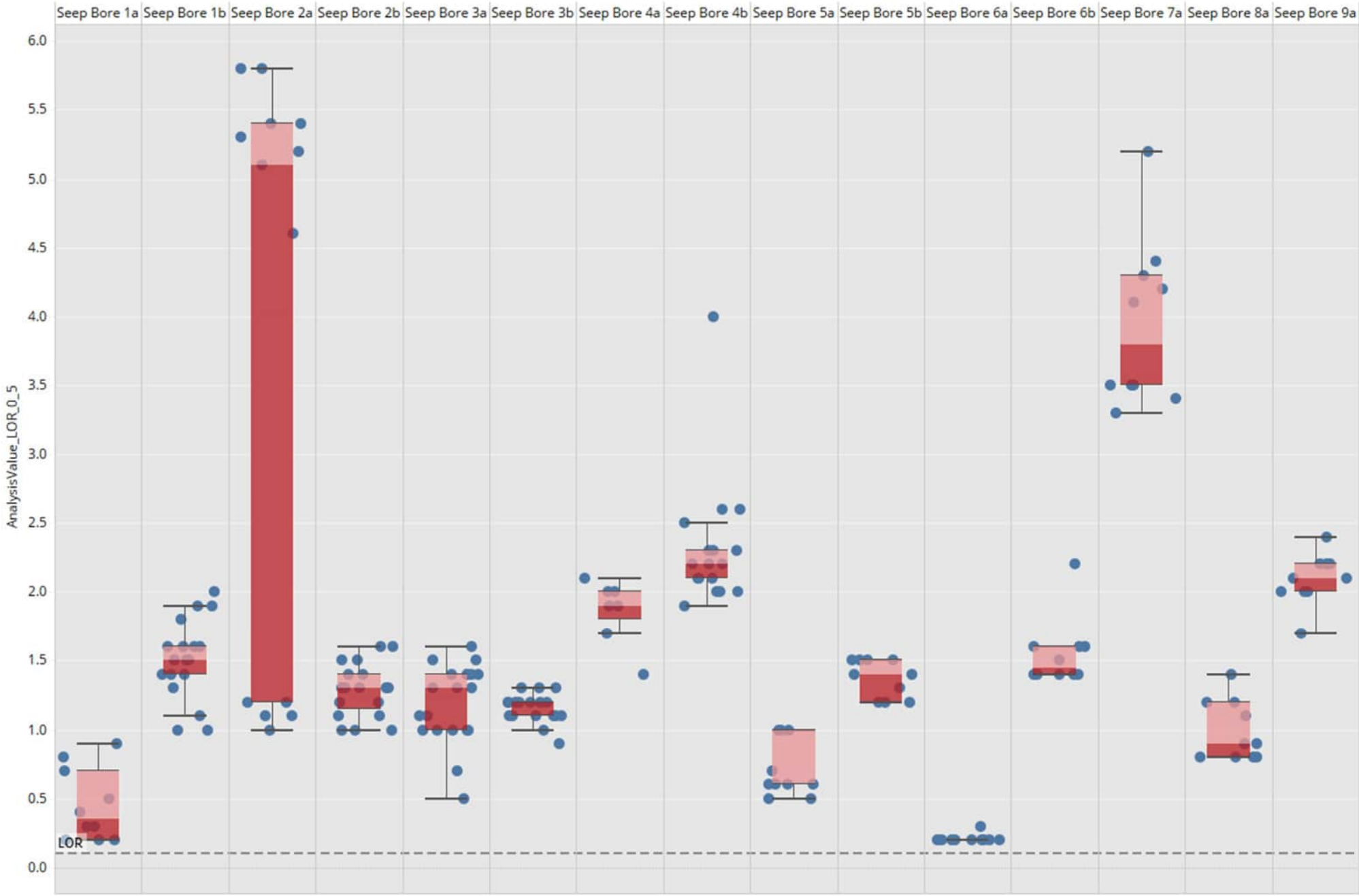
Calcium (mg/L)


Seep Bore 1a
Seep Bore 1b
Seep Bore 2a
Seep Bore 2b
Seep Bore 3a
Seep Bore 3b
Seep Bore 4a
Seep Bore 4b
Seep Bore 5a
Seep Bore 5b
Seep Bore 6a
Seep Bore 6b
Seep Bore 7a
Seep Bore 8a
Seep Bore 9a
AnalysisValue_LOR_0_5
500
450
400
350
300
250
200
150
100
50
LOR

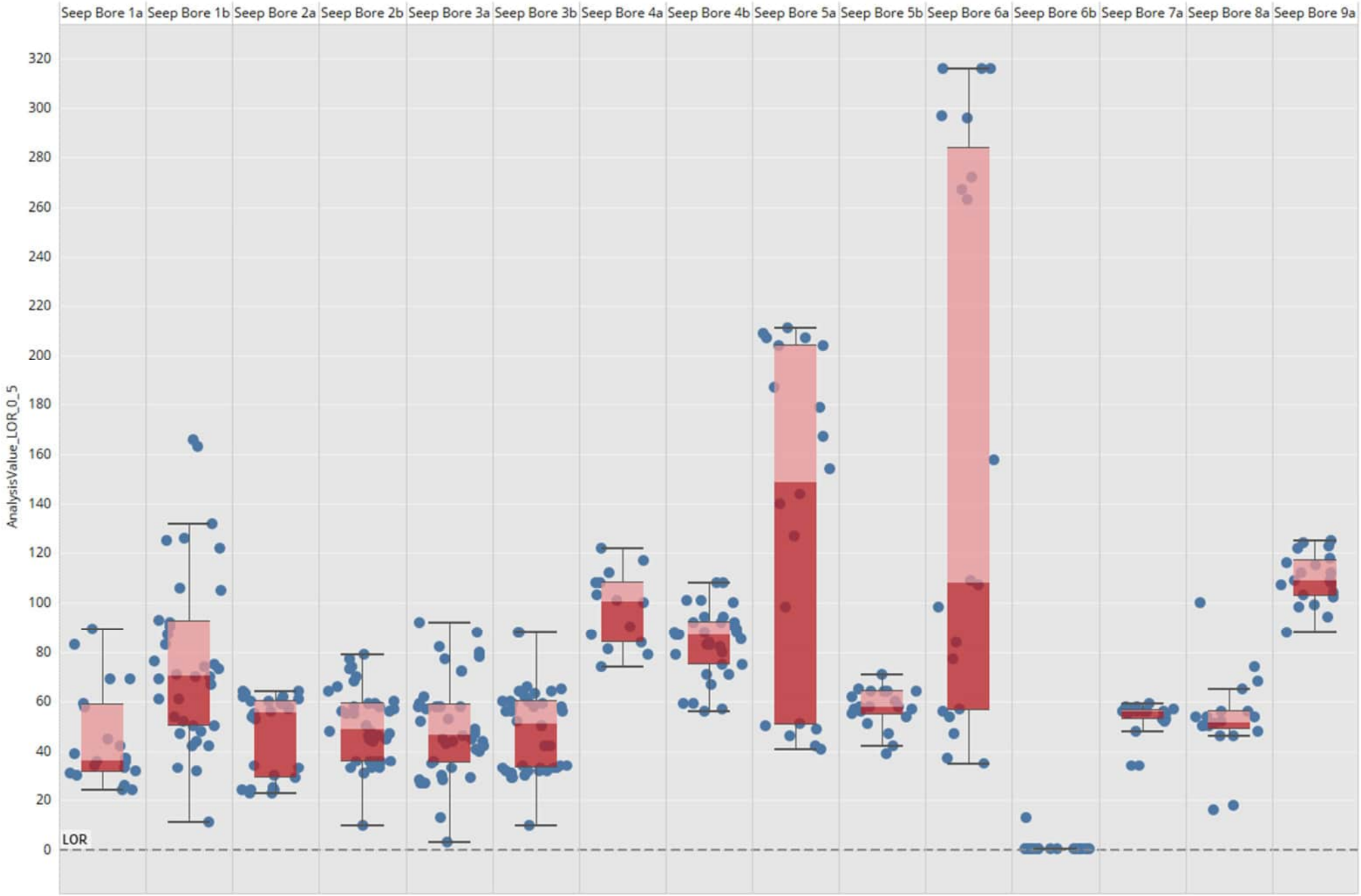
Chloride (mg/L)



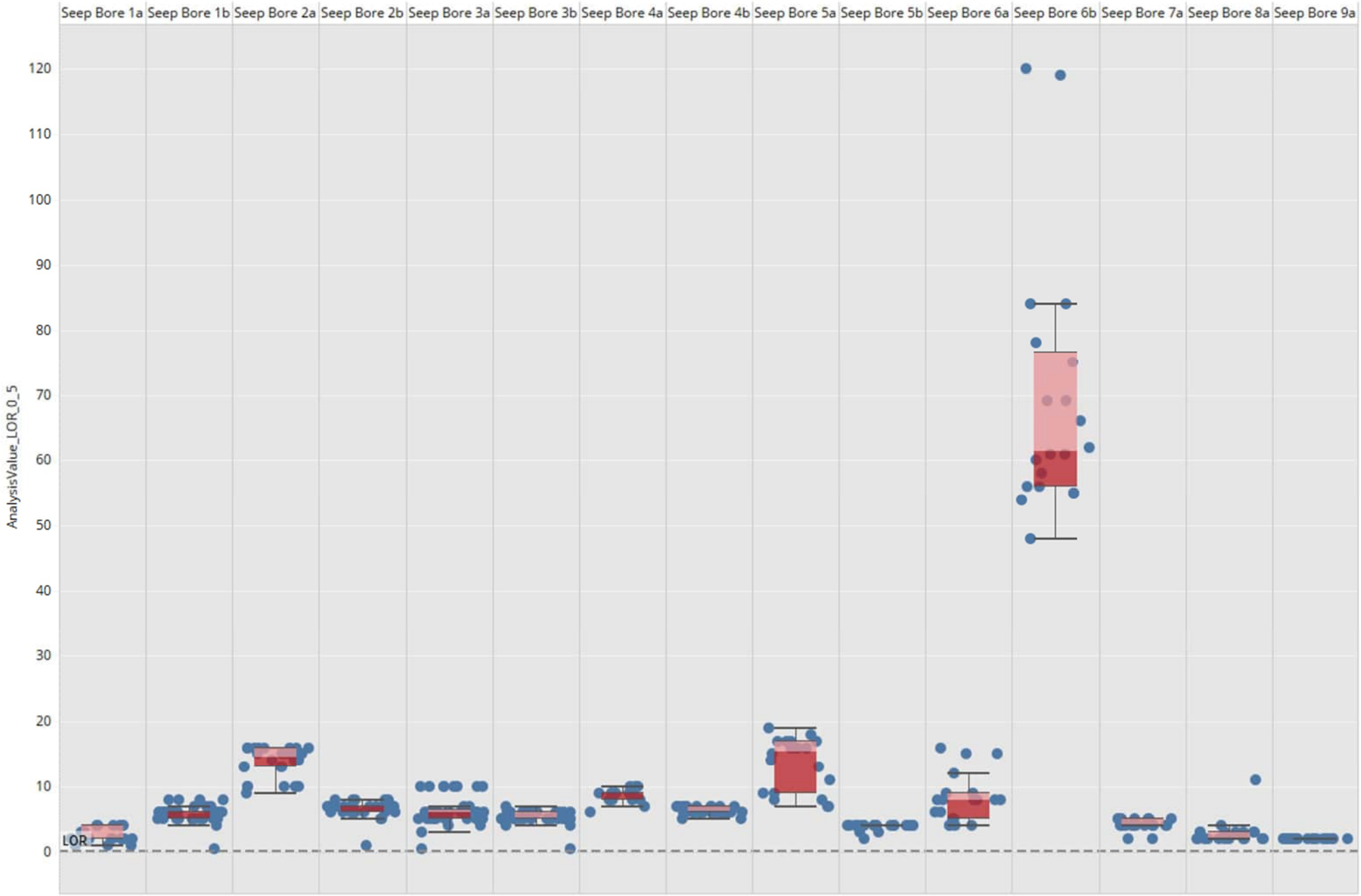
Fluoride (mg/L)



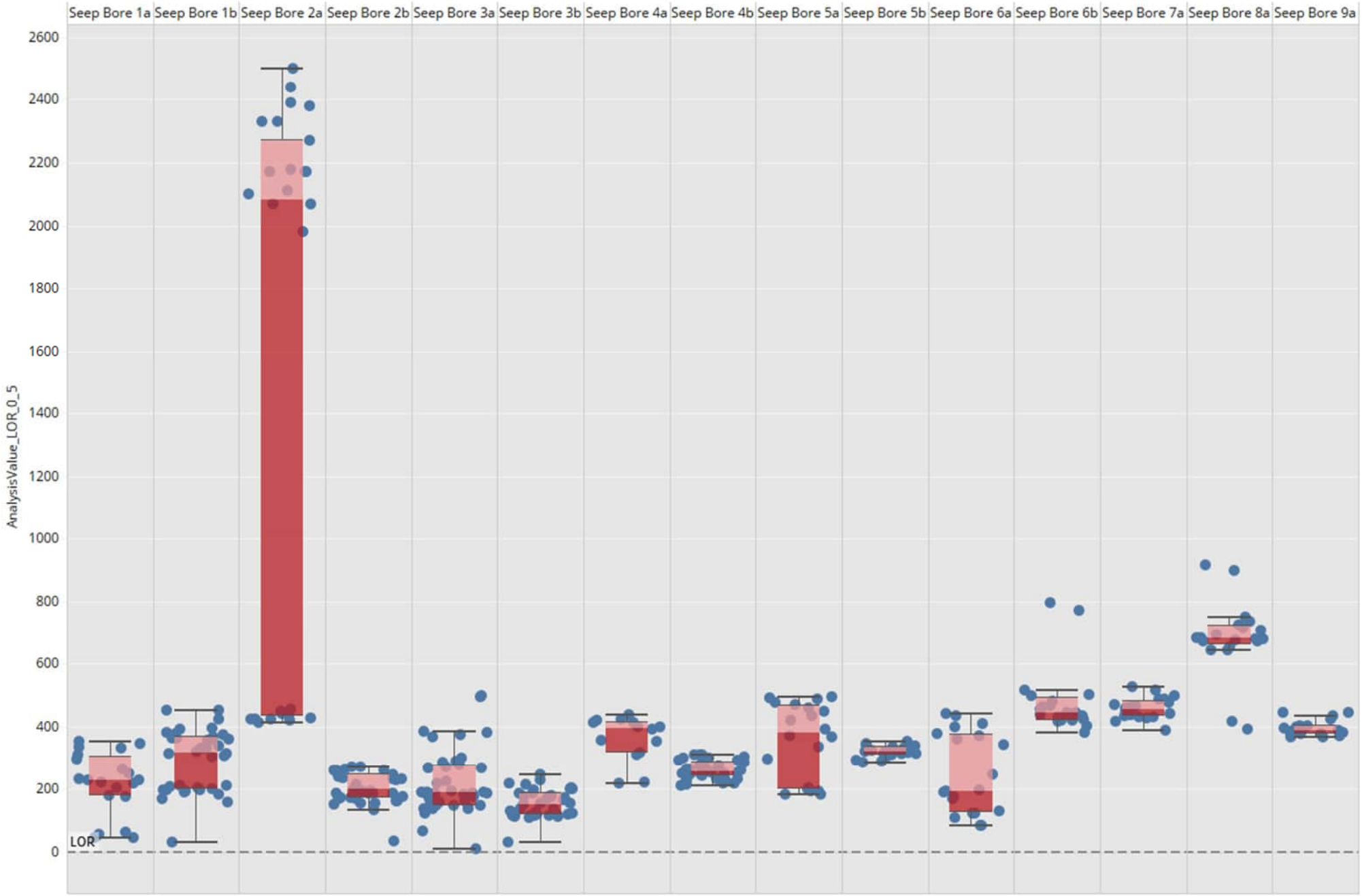
Magnesium (mg/L)



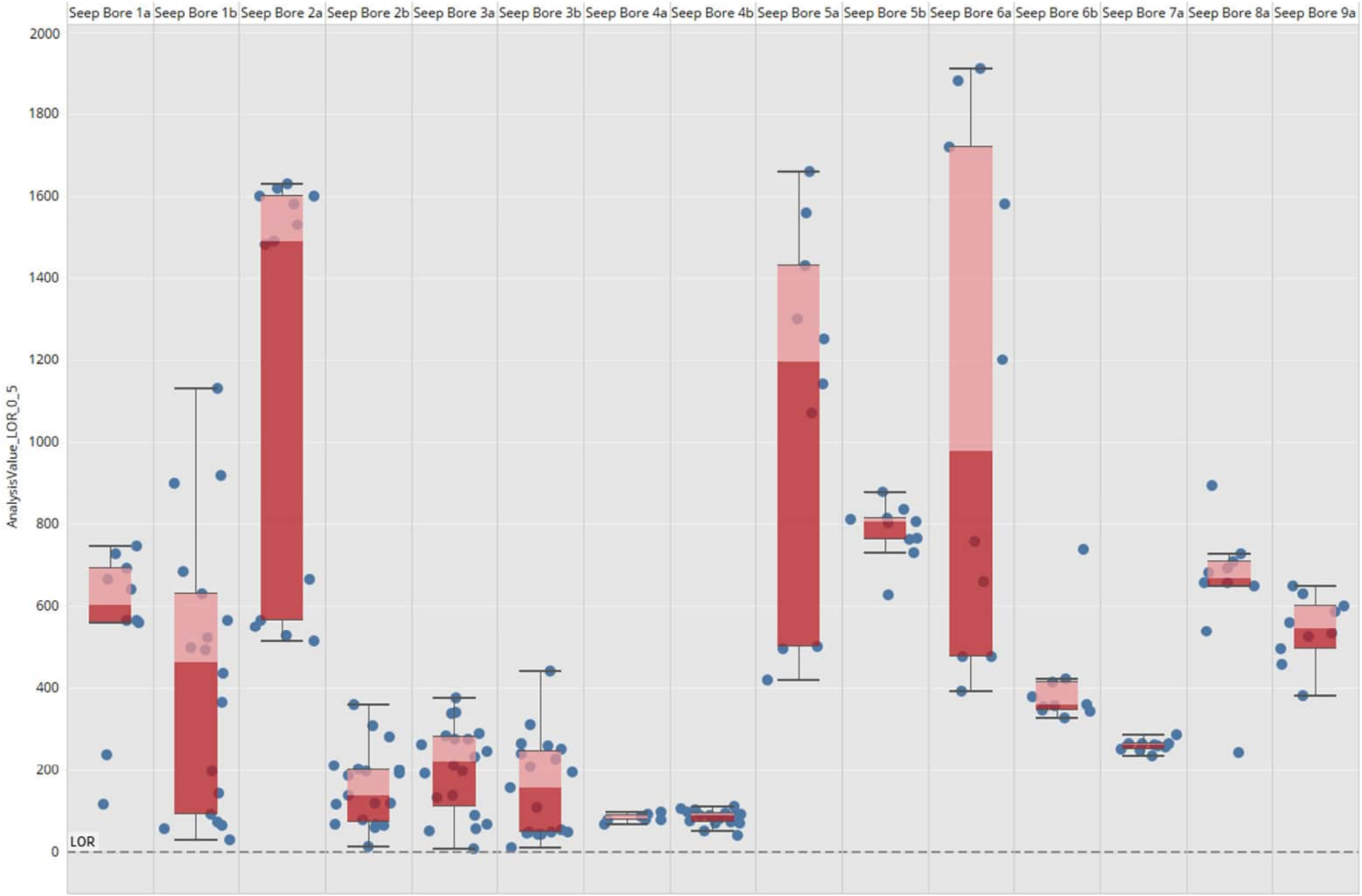
Potassium (mg/L)



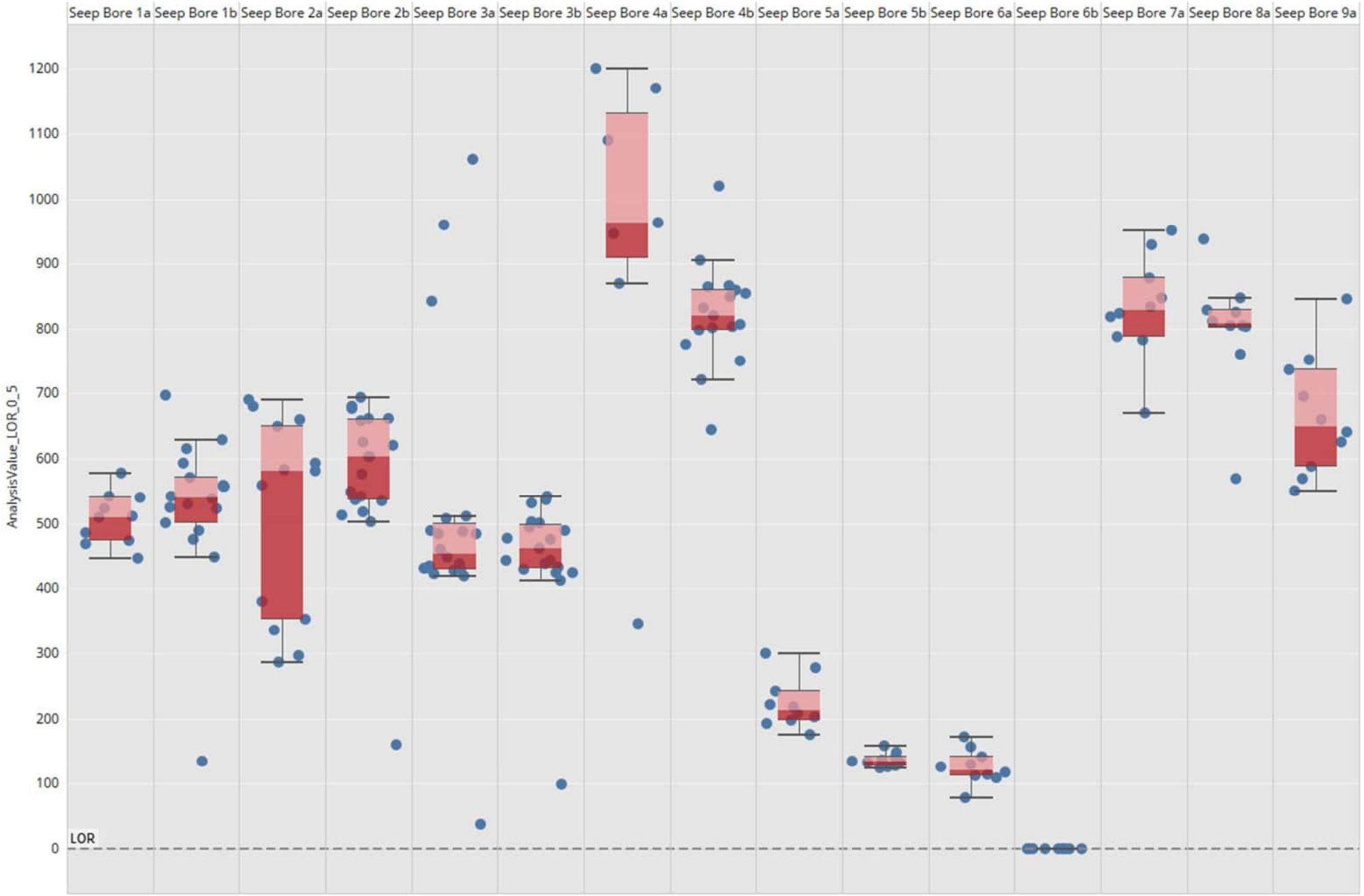
Sodium (mg/L)


Seep Bore 1a
Seep Bore 1b
Seep Bore 2a
Seep Bore 2b
Seep Bore 3a
Seep Bore 3b
Seep Bore 4a
Seep Bore 4b
Seep Bore 5a
Seep Bore 5b
Seep Bore 6a
Seep Bore 6b
Seep Bore 7a
Seep Bore 8a
Seep Bore 9a
AnalysisValue_LOR_0_5
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
LOR

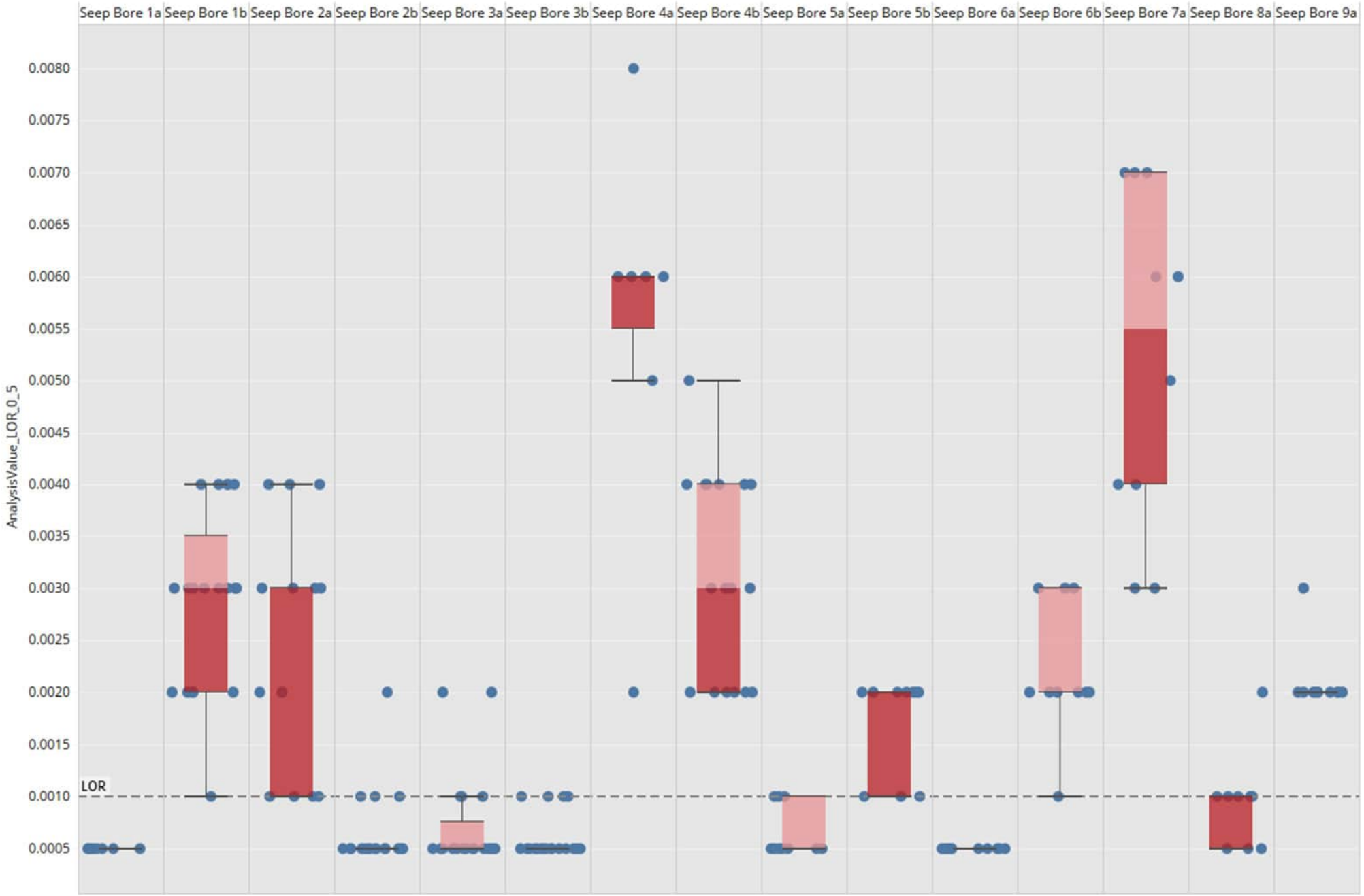
Sulfate (as SO4)



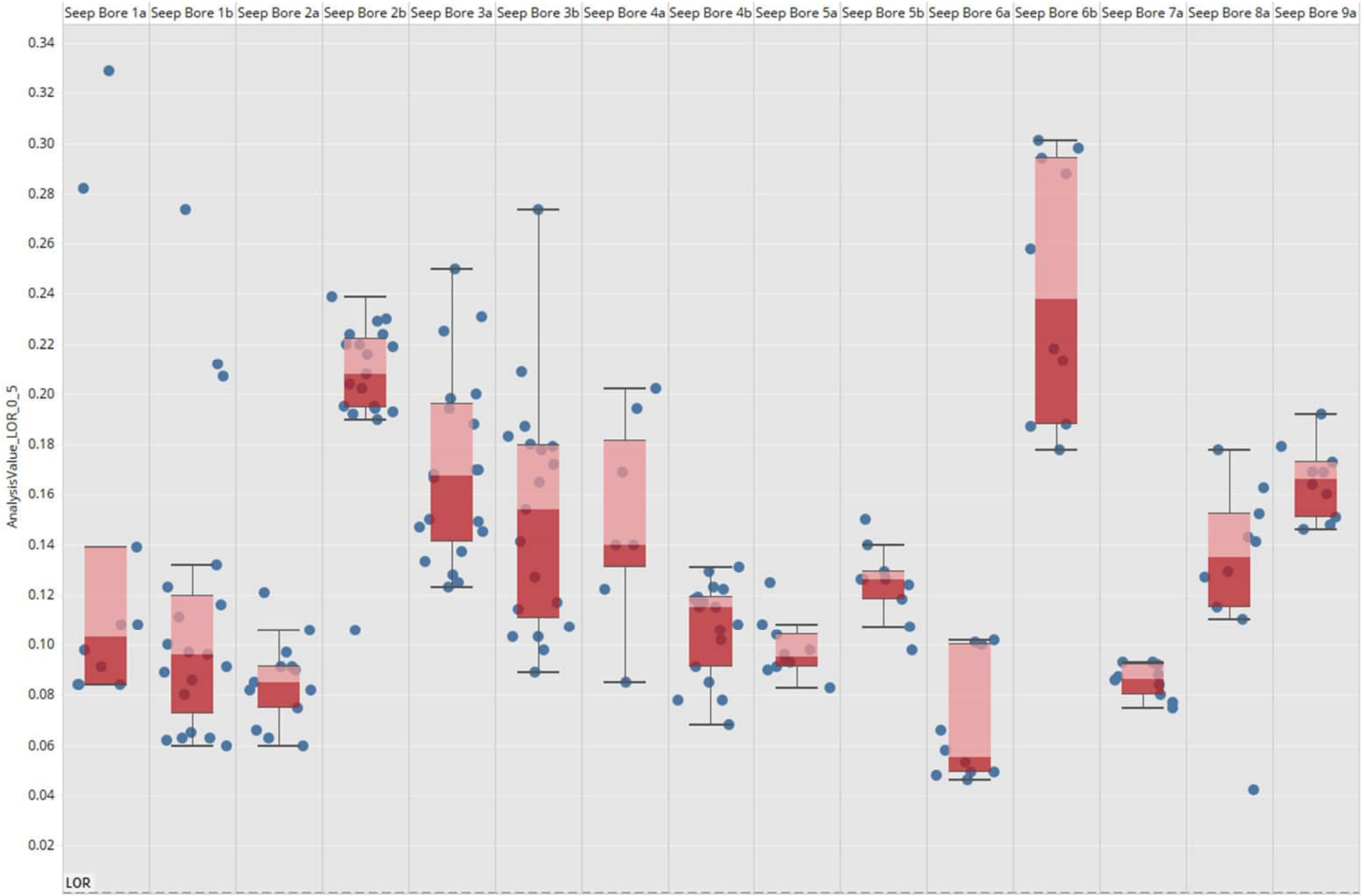
Bicarbonate Alkalinity as CaCO3 (mg/L)



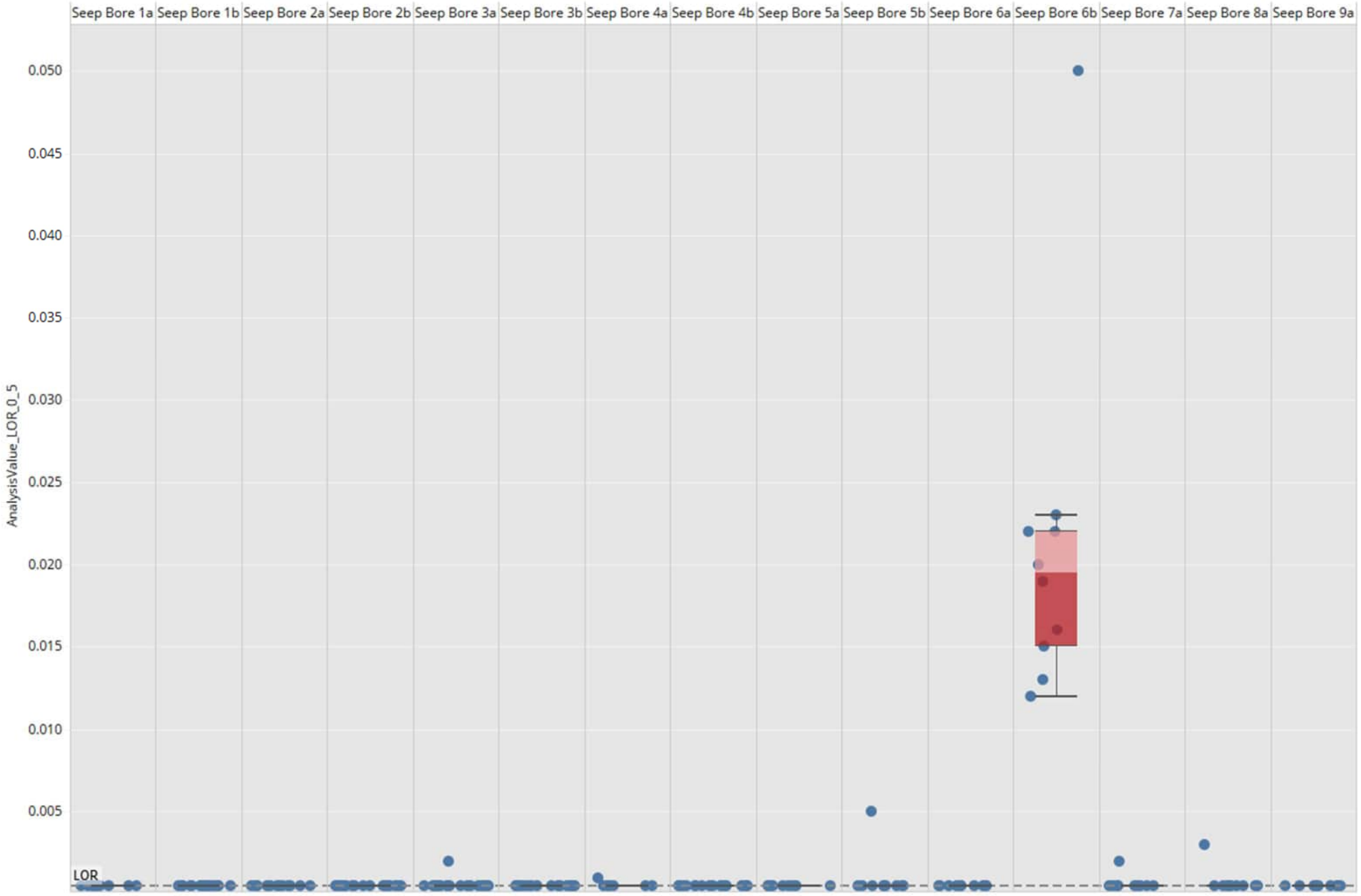
Arsenic - dissolved (mg/L)



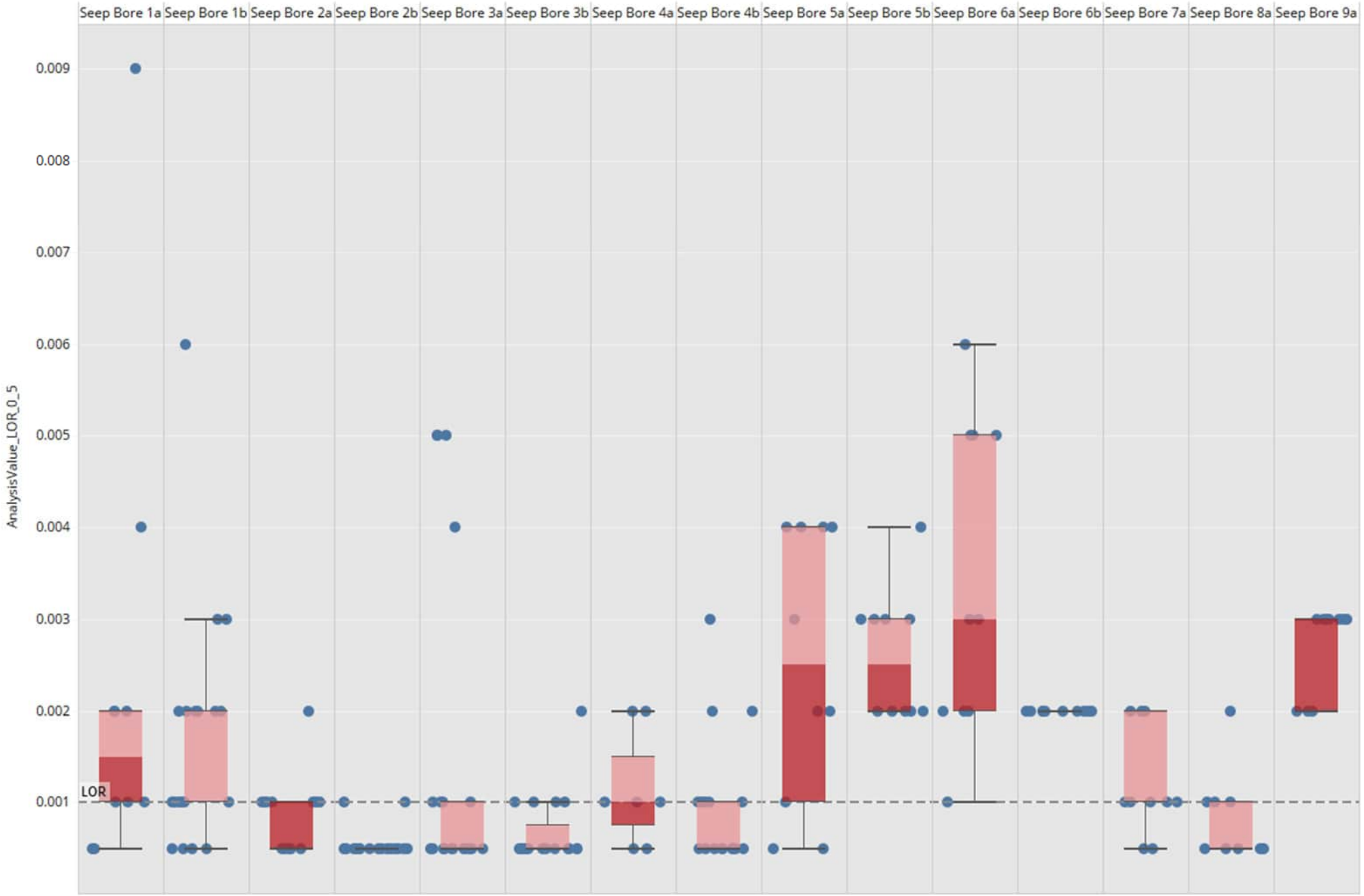
Barium - dissolved (mg/L)



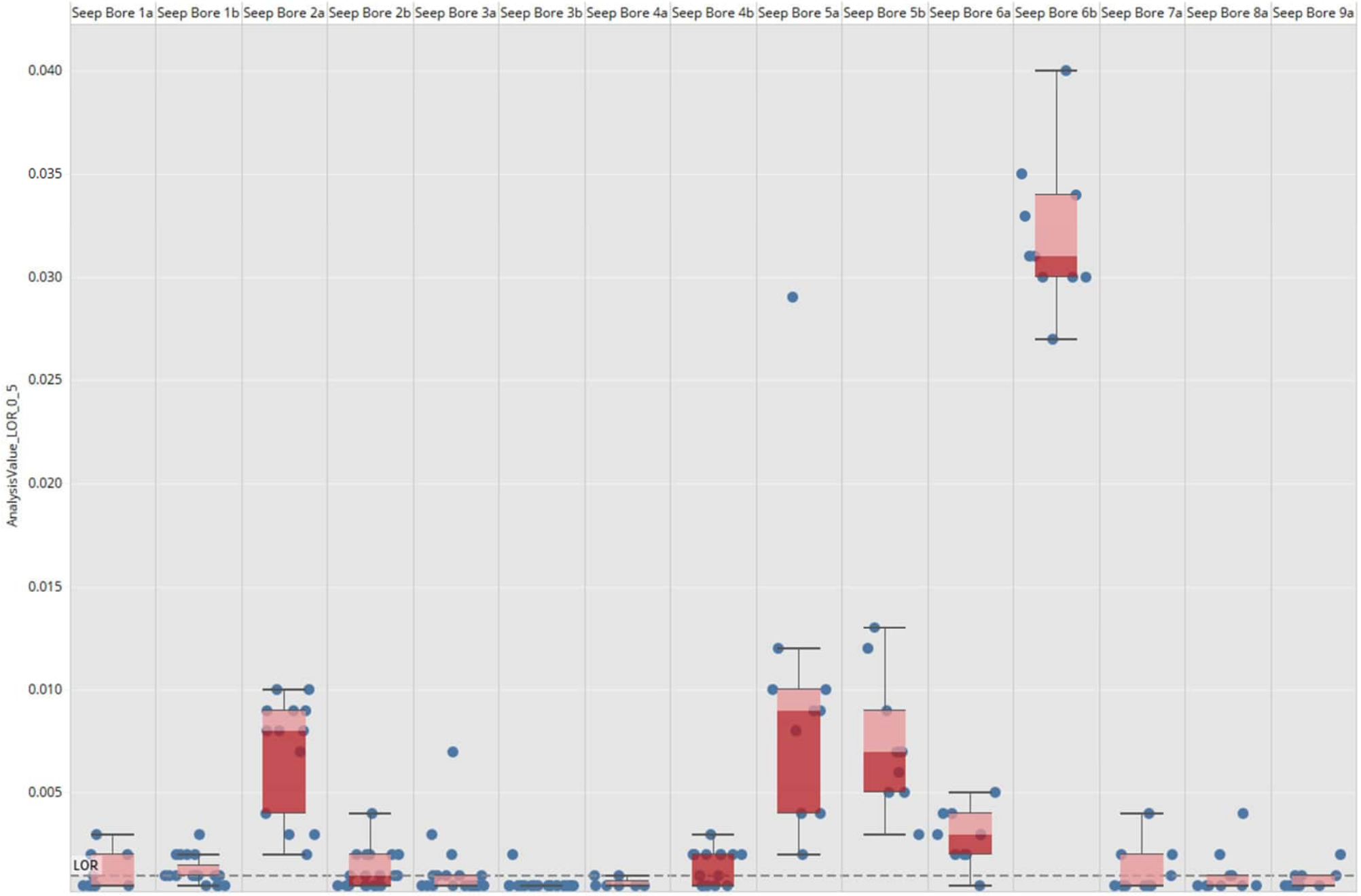
Chromium - dissolved (mg/L)



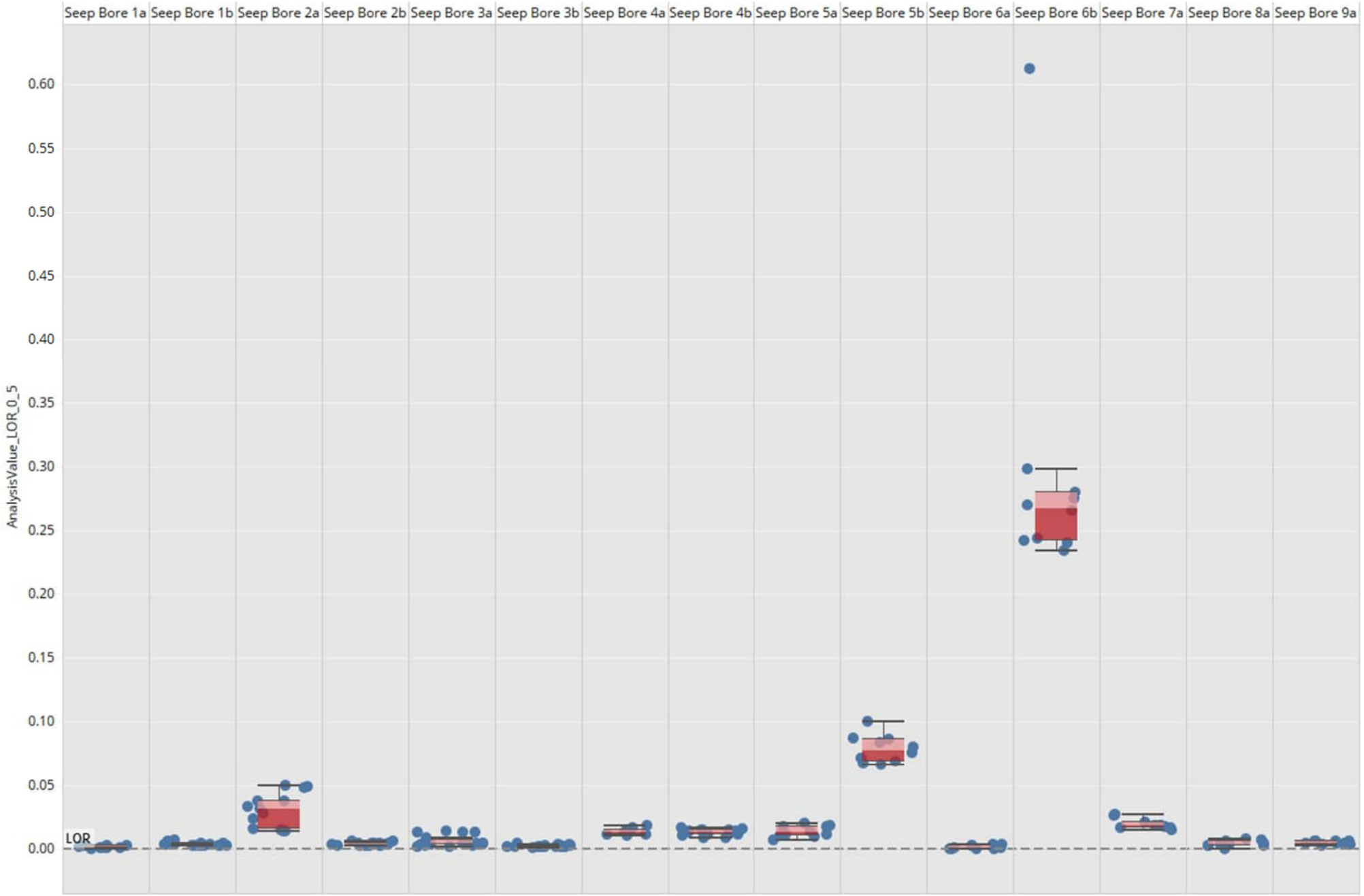
Cobalt - dissolved (mg/L)



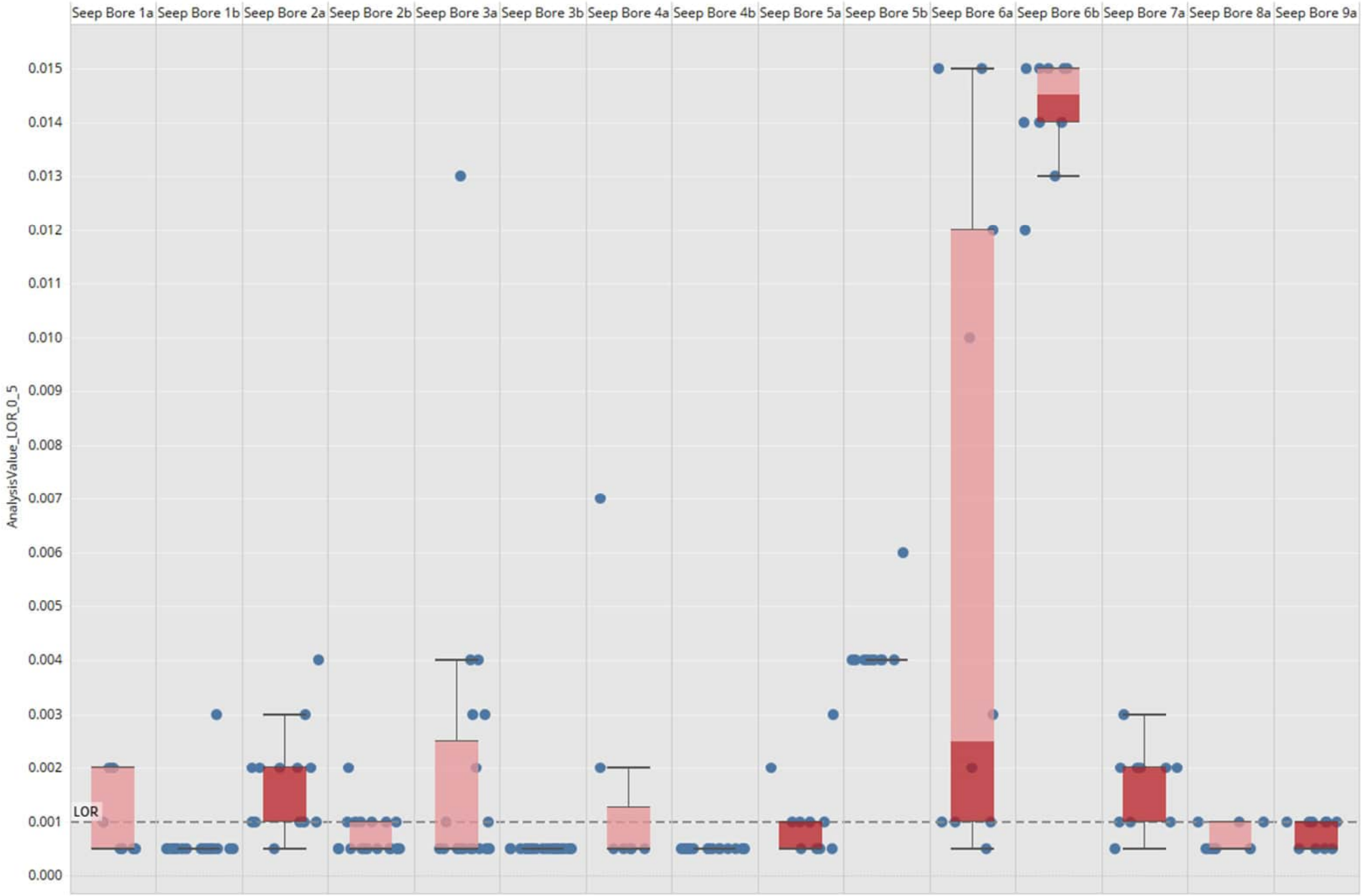
Copper - dissolved (mg/L)



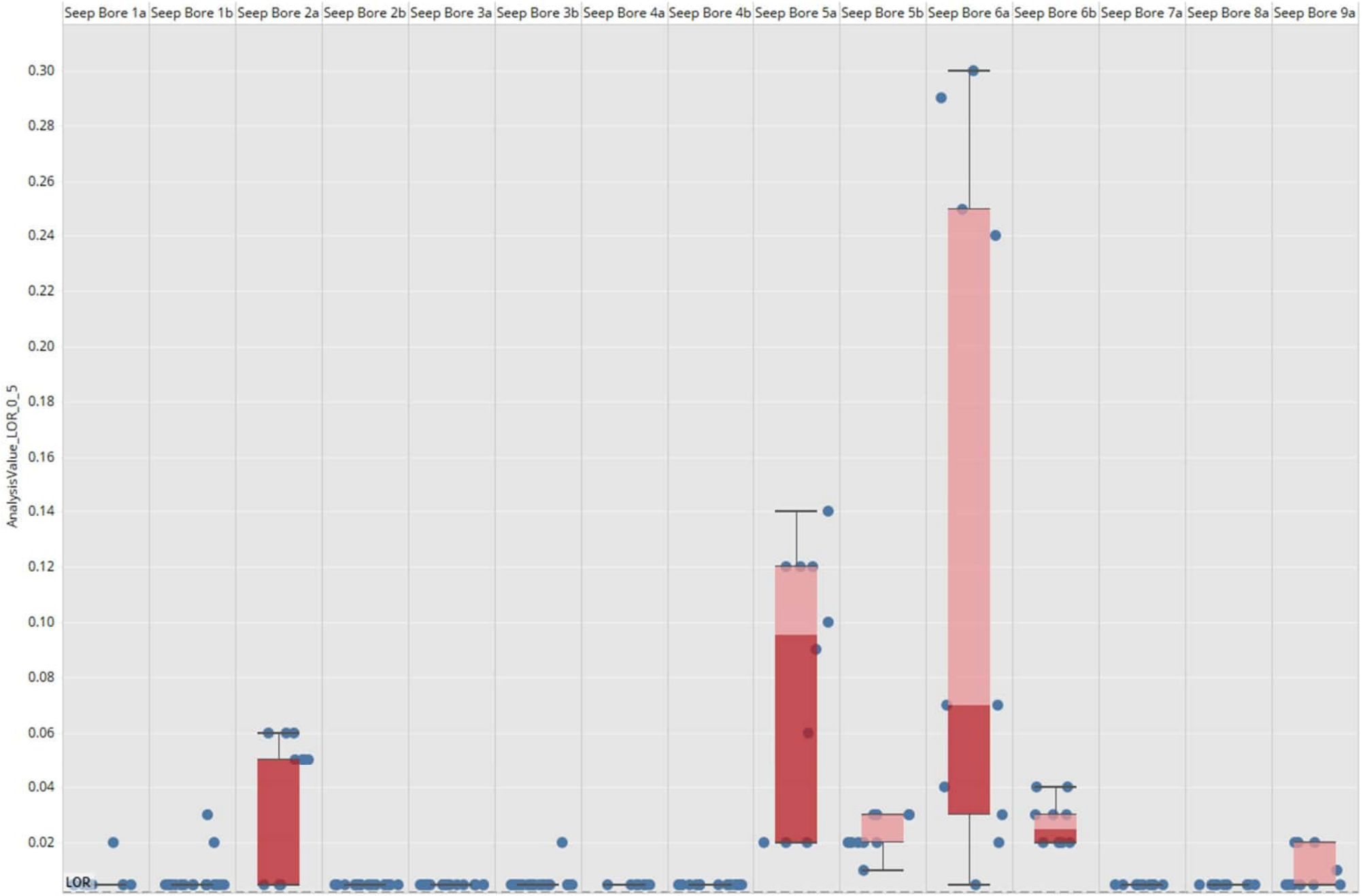
Molybdenum - dissolved (mg/L)



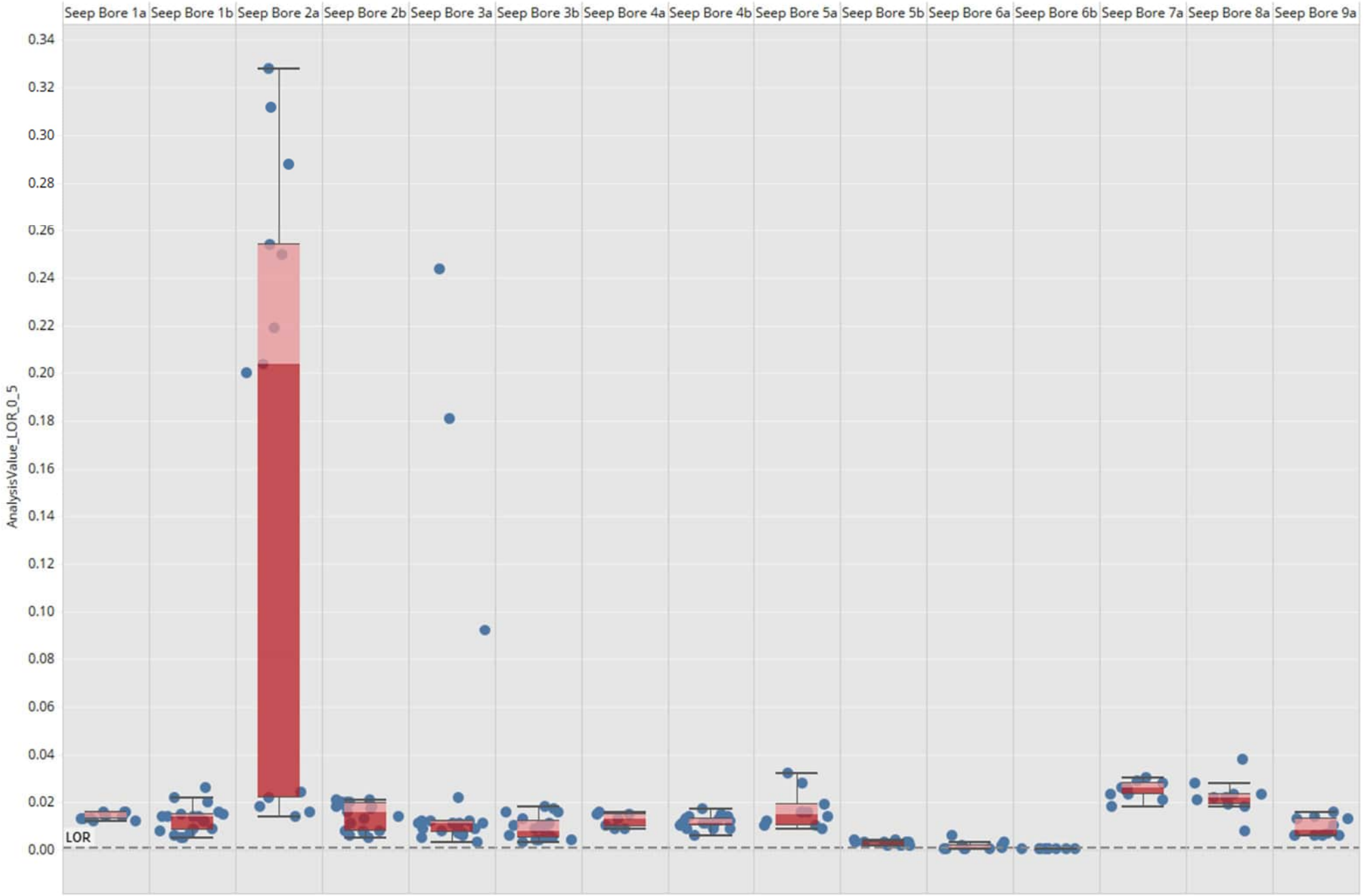
Nickel - dissolved (mg/L)



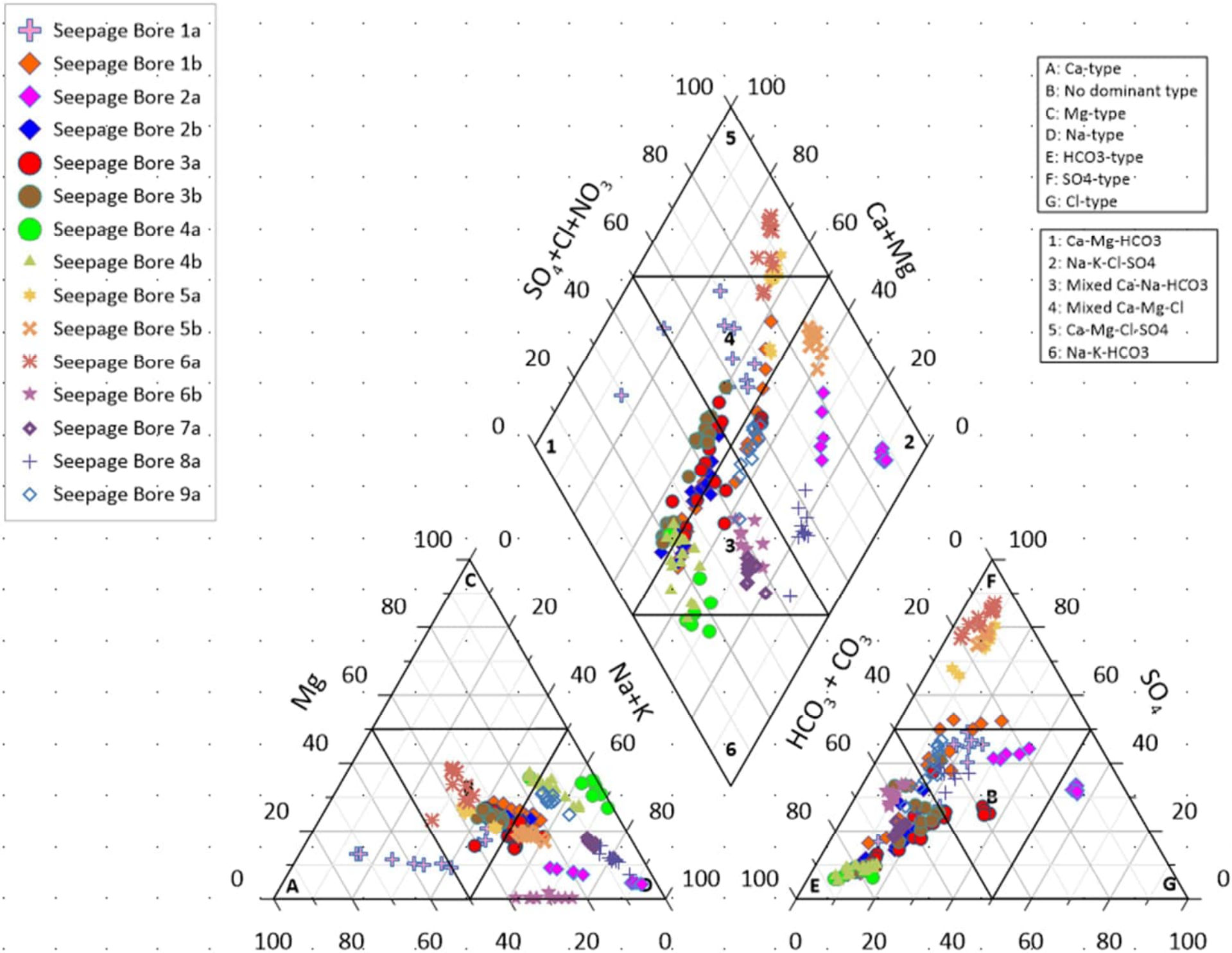
Selenium - dissolved (mg/L)

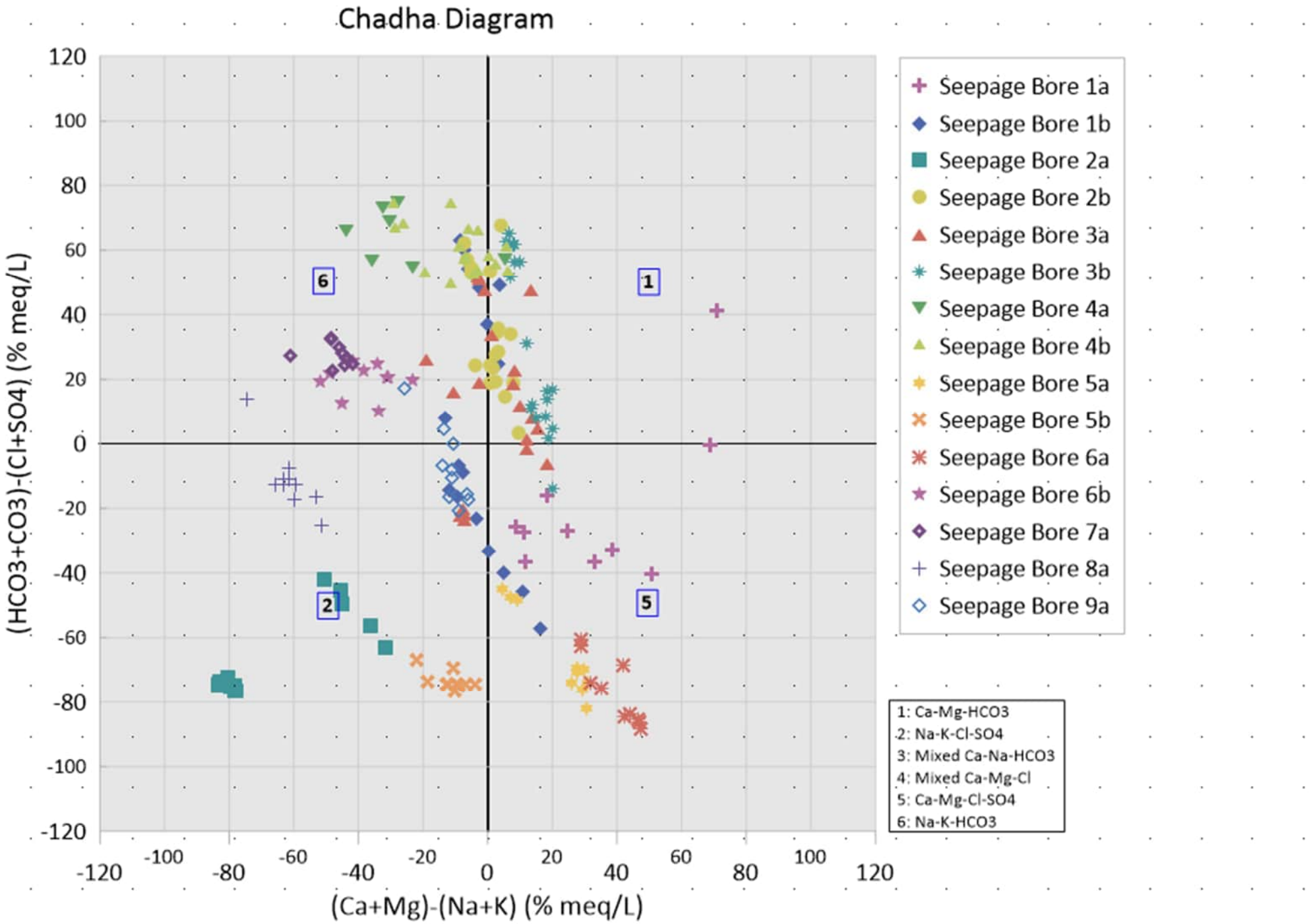


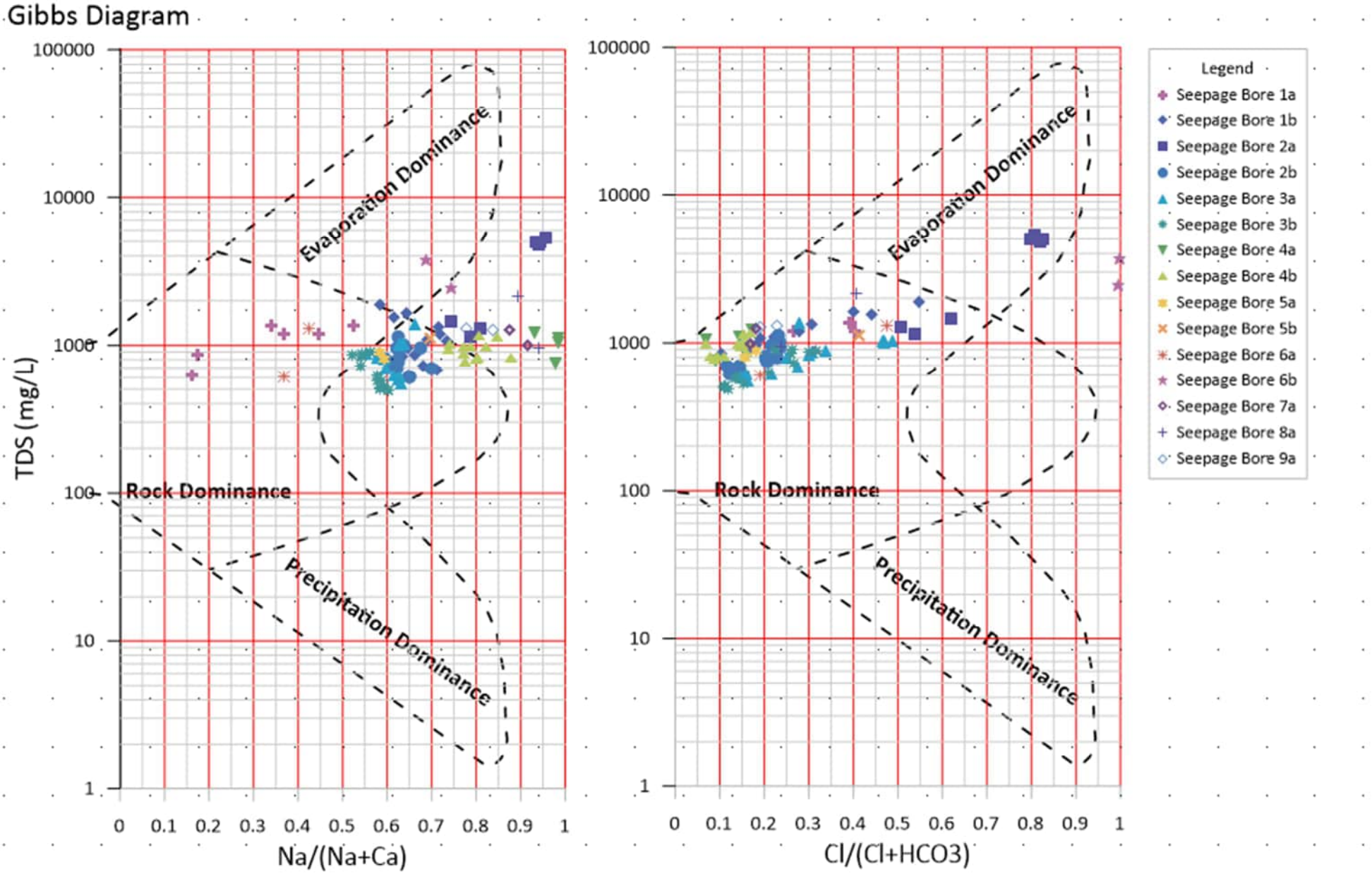
Uranium - dissolved (mg/L)

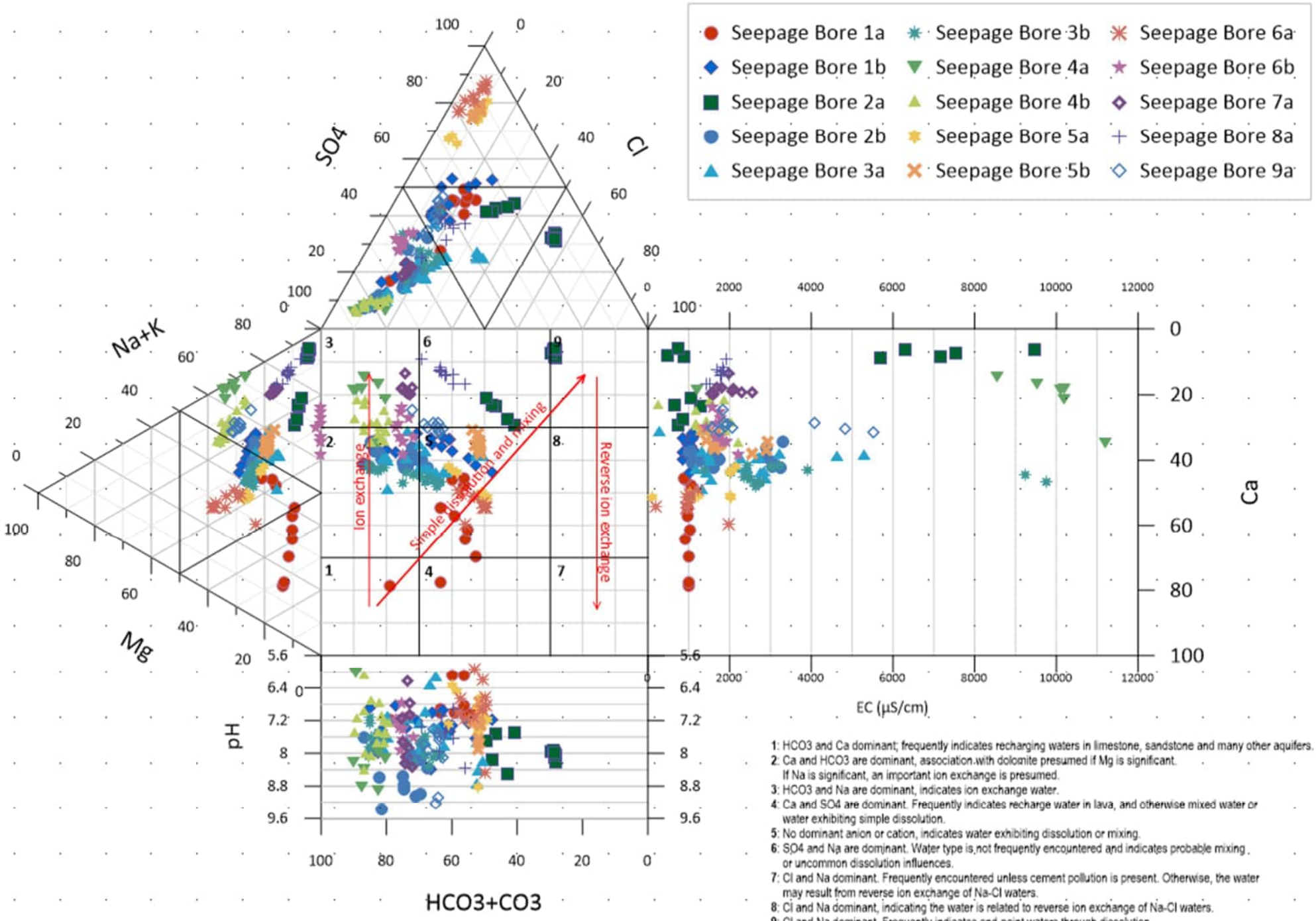


H.4 Hydrogeochemistry plots


Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Seepage Bore 5a
Seepage Bore 5b
Seepage Bore 6a
Seepage Bore 6b
Seepage Bore 7a
Seepage Bore 8a
Seepage Bore 9a
A: Ca-type
B: No dominant type
C: Mg-type
D: Na-type
E: HCO3-type
F: SO4-type
G: Cl-type
1: Ca-Mg-HCO3
2: Na-K-Cl-SO4
3: Mixed Ca-Na-HCO3
4: Mixed Ca-Mg-Cl
5: Ca-Mg-Cl-SO4
6: Na-K-HCO3
SO4+Cl+NO3
Ca+Mg
Mg
Na+K
HCO3 + CO3
SO4


Chadha Diagram
(HCO3+CO3)-(Cl+SO4) (% meq/L)
(Ca+Mg)-(Na+K) (% meq/L)
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-120
-100
-80
-60
-40
-20
0
20
40
60
80
100
120
1
2
5
6
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Seepage Bore 5a
Seepage Bore 5b
Seepage Bore 6a
Seepage Bore 6b
Seepage Bore 7a
Seepage Bore 8a
Seepage Bore 9a
1: Ca-Mg-HCO3
2: Na-K-Cl-SO4
3: Mixed Ca-Na-HCO3
4: Mixed Ca-Mg-Cl
5: Ca-Mg-Cl-SO4
6: Na-K-HCO3


Gibbs Diagram
TDS (mg/L)
100000
10000
1000
100
10
1
Evaporation Dominance
Rock Dominance
Precipitation Dominance
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Na/(Na+Ca)
Cl/(Cl+HCO3)
Legend
Seepage Bore 1a
Seepage Bore 1b
Seepage Bore 2a
Seepage Bore 2b
Seepage Bore 3a
Seepage Bore 3b
Seepage Bore 4a
Seepage Bore 4b
Seepage Bore 5a
Seepage Bore 5b
Seepage Bore 6a
Seepage Bore 6b
Seepage Bore 7a
Seepage Bore 8a
Seepage Bore 9a



1: HCO3 and Ca dominant; frequently indicates recharging waters in limestone, sandstone and many other aquifers.
2: Ca and HCO3 are dominant, association with dolomite presumed if Mg is significant. If Na is significant, an important ion exchange is presumed.
3: HCO3 and Na are dominant, indicates ion exchange water.
4: Ca and SO4 are dominant. Frequently indicates recharge water in lava, and otherwise mixed water or water exhibiting simple dissolution.
5: No dominant anion or cation, indicates water exhibiting dissolution or mixing.
6: SO4 and Na are dominant. Water type is not frequently encountered and indicates probable mixing, or uncommon dissolution influences.
7: Cl and Na dominant. Frequently encountered unless cement pollution is present. Otherwise, the water may result from reverse ion exchange of Na-Cl waters.
8: Cl and Na dominant, indicating the water is related to reverse ion exchange of Na-Cl waters.
9: Cl and Na dominant. Frequently indicates end-point waters through dissolution.

Appendix I Inflow calculations for open pits and underground works

I.1 North pit radius of influence and groundwater inflows

Plate I.1 North Pit stage-storage relationship

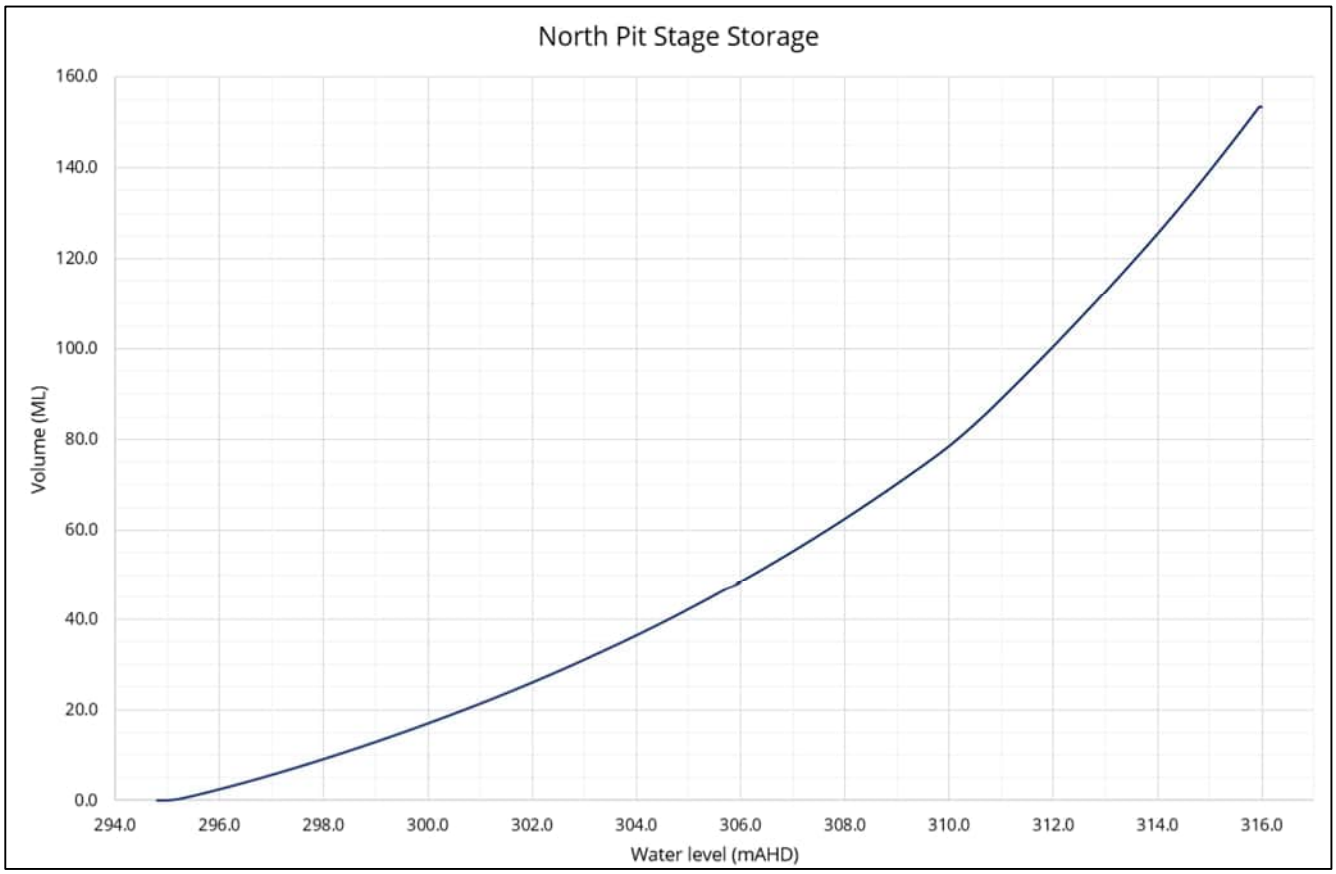


Plate I.2 North Pit groundwater inflows

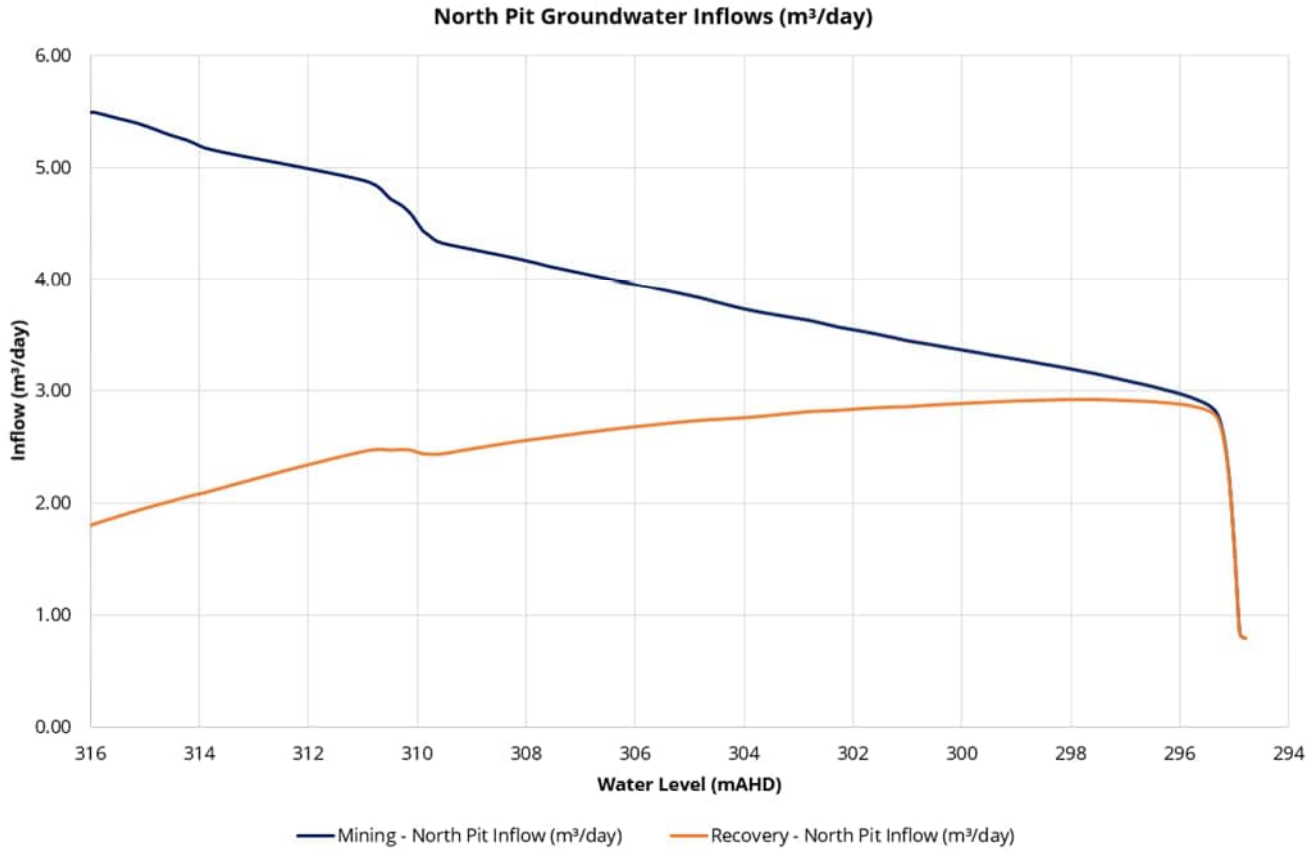
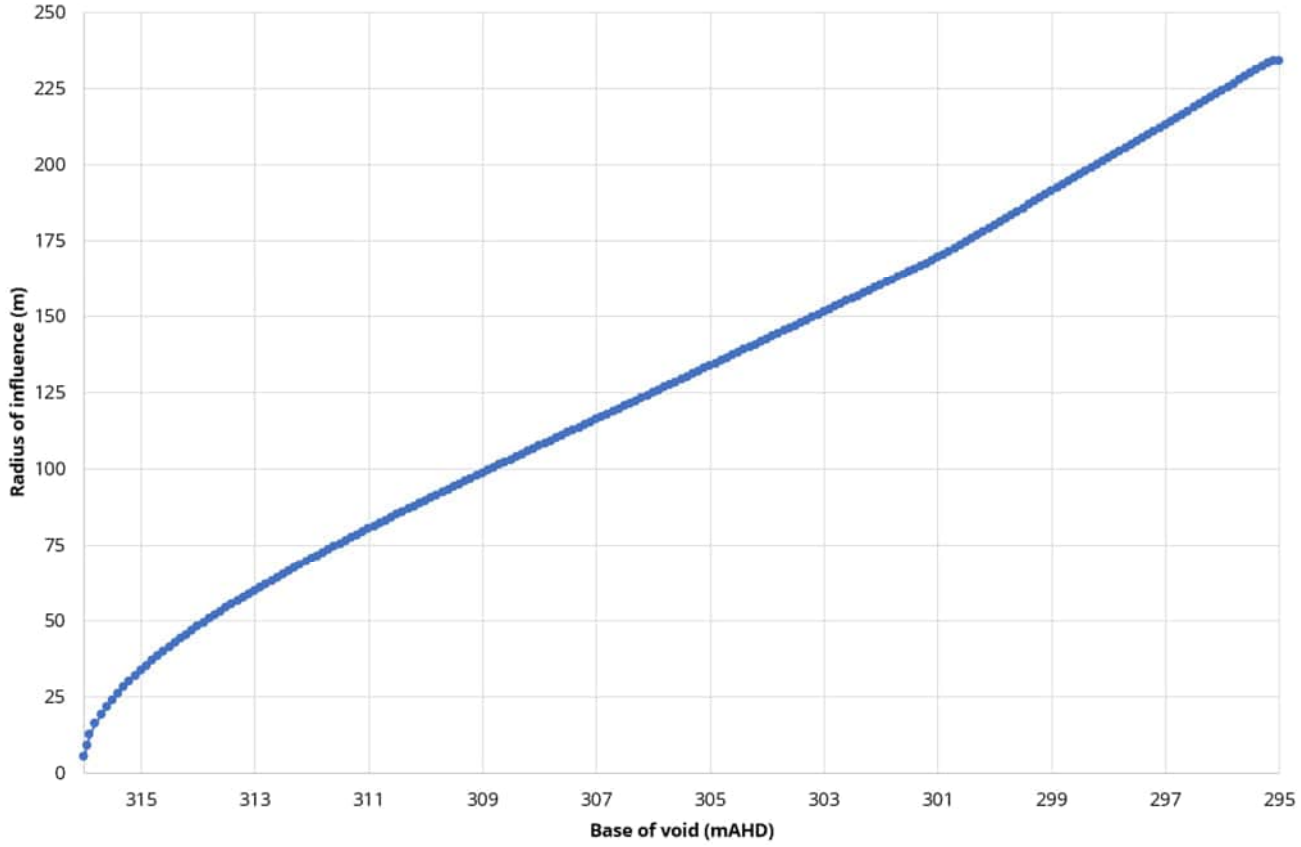


Plate I.3 North Pit radius of influence



I.2 South pit radius of influence and groundwater inflows

Plate I.4 South pit stage-storage relationship

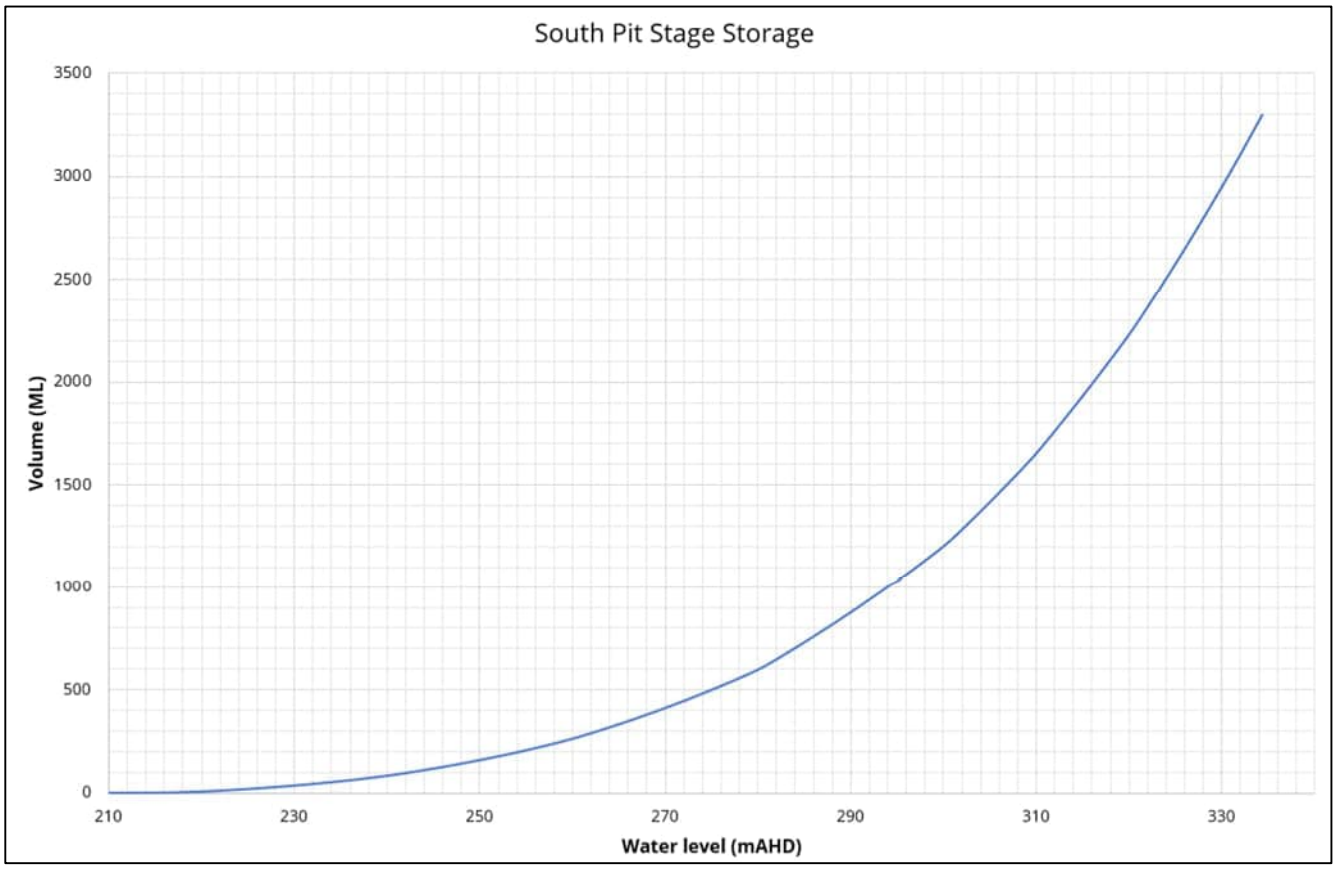


Plate I.5 South pit groundwater inflows

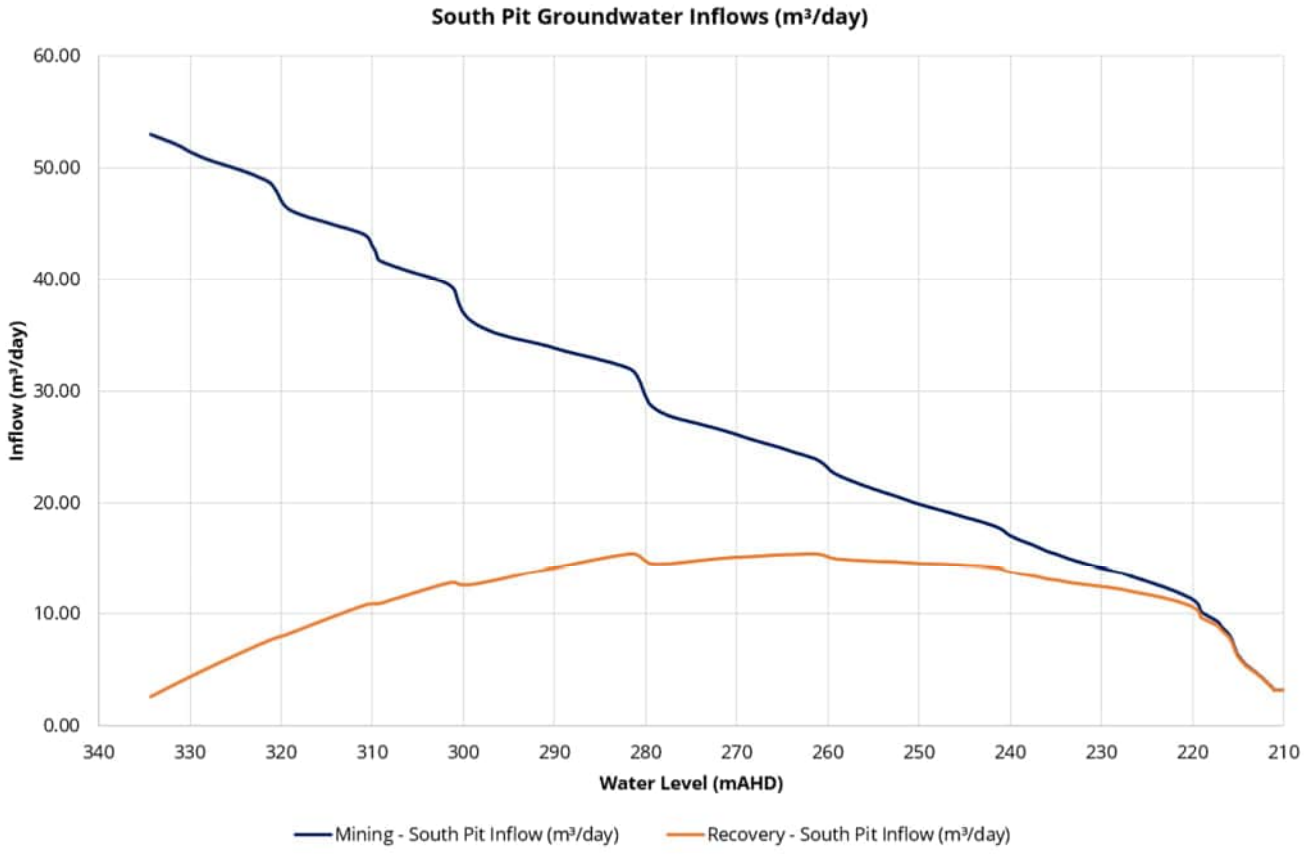
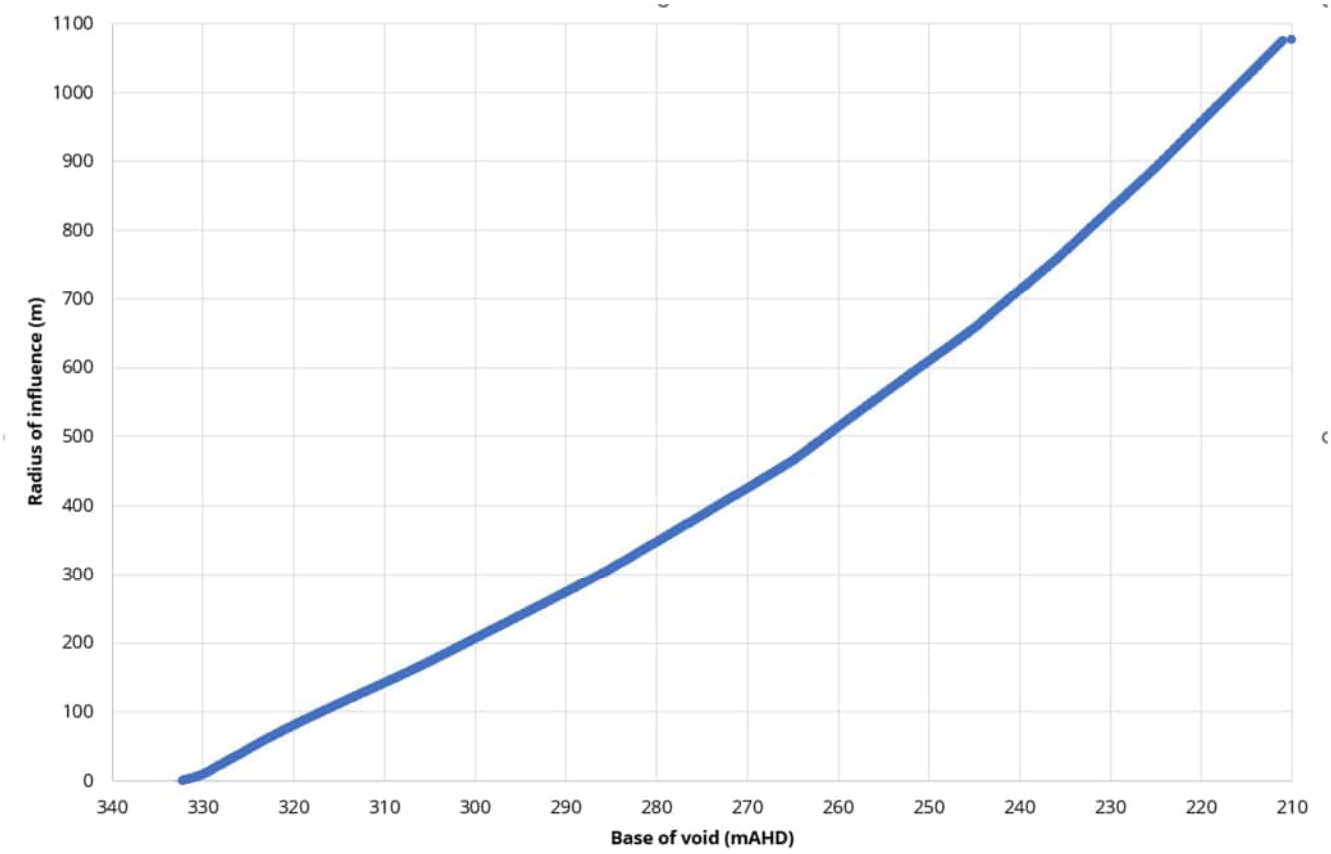


Plate I.6 South pit radius of influence



I.3 Underground workings radius of influence and groundwater inflows

Plate I.7 underground workings groundwater inflows

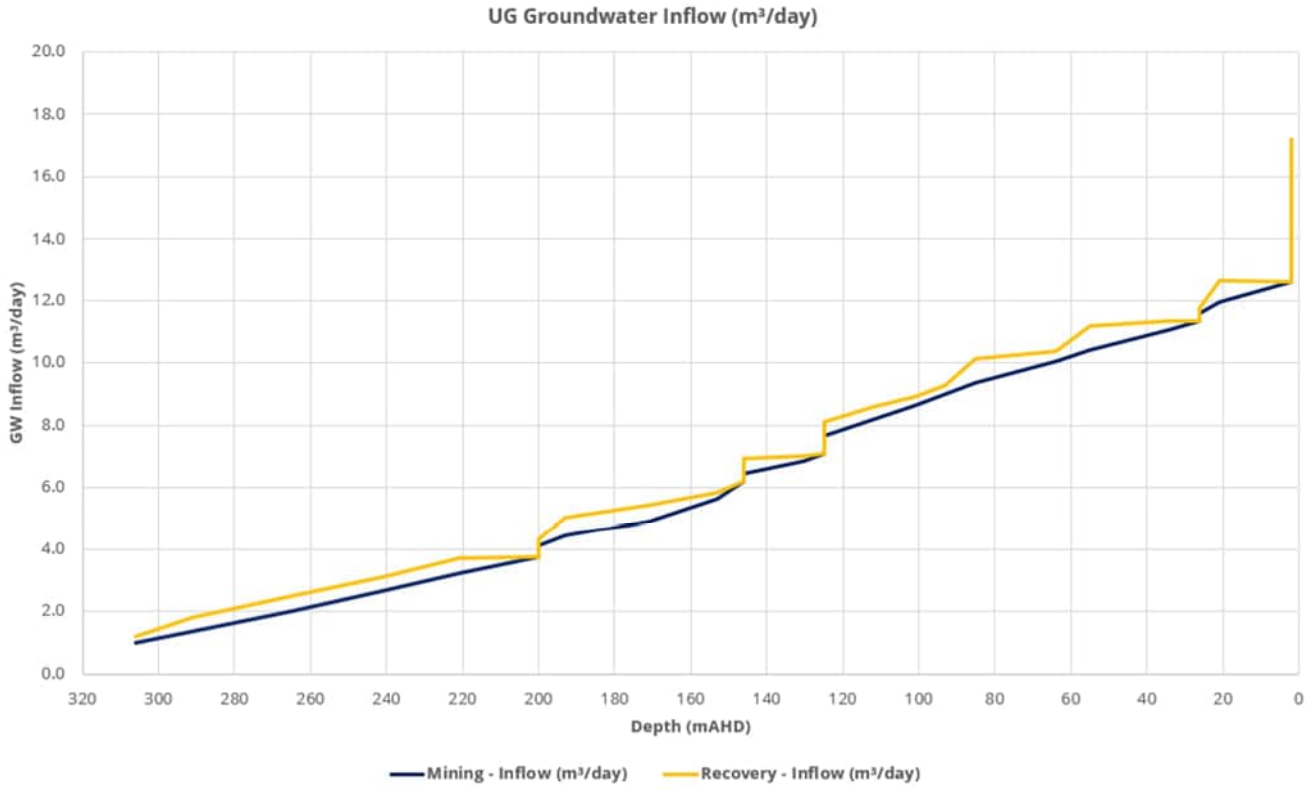
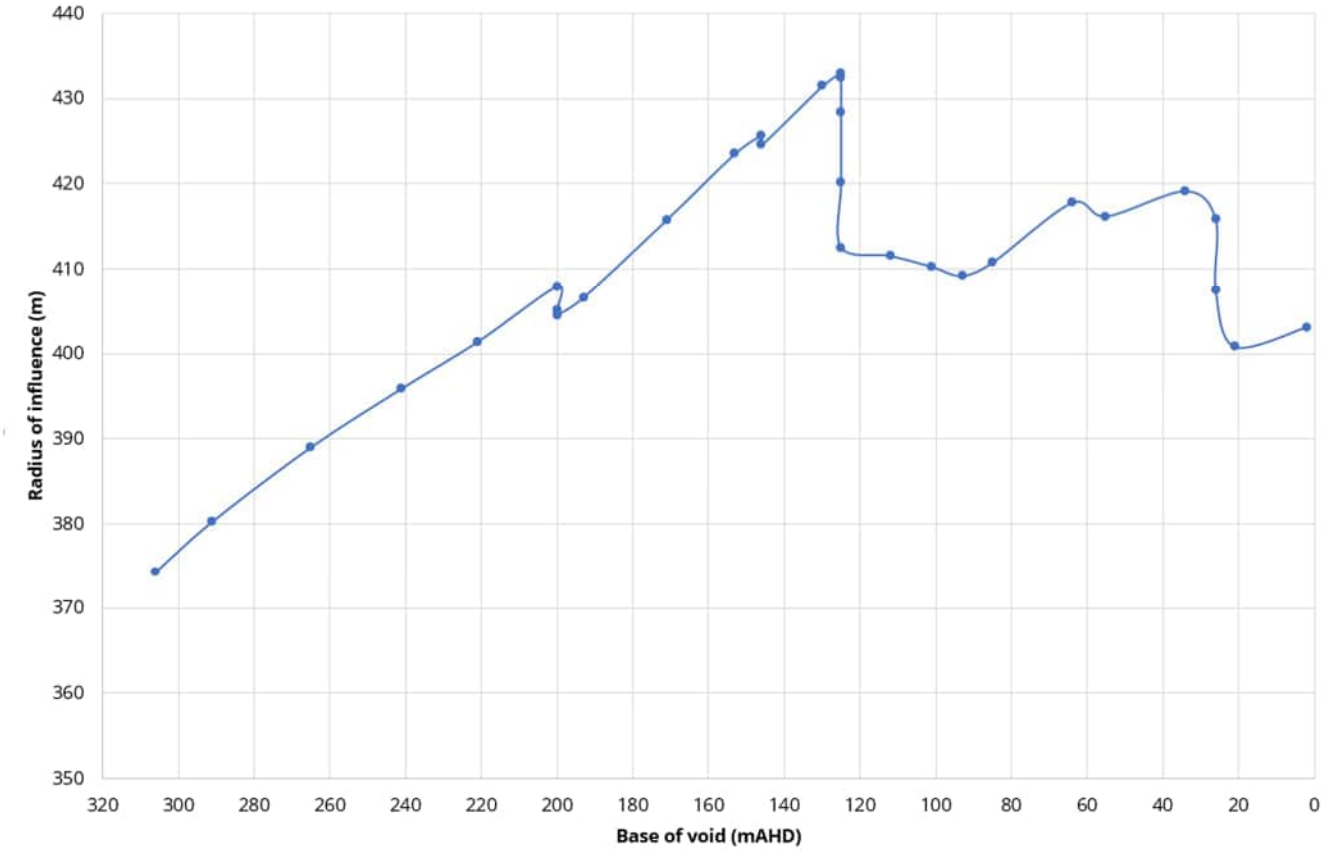


Plate I.8 underground workings radius of influence



Appendix J WQM results for open pits and WRD sediment dam

J.1 Water Quality Models

In 2023 and as part of the preparation of the PRCP for the BCP Project, ATC Williams developed water quality models (WQMs) for the North Pit, South Pit and WRD Sediment Dam by linking the output of the Goldsim WBM with a PHREEQC (USGS, ver. 3.6.2.15100) geochemical model. It is noted that these WQMs model did not include the proposed underground workings. However, the results of these WQMs are still considered relevant and representative.

PHREEQC is based on the equilibrium chemistry of aqueous solutions interacting with minerals, gases, solid solutions, exchangers, and sorption surfaces. The model is designed to perform a wide variety of aqueous geochemical calculations, including speciation, batch-reaction, one-dimensional reactive transport, and inverse geochemical calculations.

Solutes enter the open pits/sediment dam in rainfall runoff and groundwater inflow and may be removed from the voids in groundwater outflow and through geochemical reactions. The solute concentrations in the pit voids and sediment dam are defined by the fractions and solute concentrations of inflow water (from surface water runoff and groundwater inflow), the existing pit void/sediment dam water volumes and solute concentrations, evaporative processes and the occurring geochemical reactions.

Given the complexity of linking the Goldsim probabilistic output to PHREEQC, three different water balance scenarios were evaluated, corresponding with the following Goldsim™ WBM stochastical results:

- The median climatic conditions, corresponding with an occurrence probability of 50% (i.e. 50th percentile or P50).
- Interquartile climatic conditions, corresponding with 25th percentile ant 75th percentile climatic conditions.

Higher probabilities were not considered since increased rainfall, groundwater discharge into the pit void, and lower evaporation rates would result in improved water quality and represents a lower risk to the downstream environment or closure condition.

With respect to the geochemical process, two main scenarios were considered to evaluate the mixing of the different water types:

- A first scenario/model that only included the mixing of different water types (in terms of volumes and water quality) followed by evaporative processes in the voids/sediment dam. This model is denoted as the "mixing" model.
- A second scenario/model included speciation equilibrium modelling, i.e. the precipitation/dissolution of minerals from/into solution when the different water types are mixed. In the first instance, only the mineral phase considered was gypsum, whereby gypsum precipitation could occur if calcium and sulphate concentrations in the mixed water were sufficiently elevated. This model is denoted as the "equilibrium" model.

In the first instance, inflow water is mixed with existing pit voids/sediment dam water and solute concentrations are calculated though a mixing process, before evaporative losses increase the solute concentrations in the pit voids/sediment dams due to a reduction in water content. This mixed solution can be assessed without any equilibrium phases or equilibrated with gypsum. The resulting solution represents the pit void/sediment dam water quality that can outflow to either surface water or groundwater.

Assumptions made in the water quality model include the following (ATC Williams, March 2023):

- In general, surface water inflow into the pit void was equilibrated with standard atmosphere conditions (CO_2(g) -3.2, O_2(g) 0.67)) and groundwater with carbonate (CO_2(g) -1.5) to maintain the pH values of site water quality solutions used in this assessment.
- To reduce the number of parameters in the model and allows for the focus on bulk water chemistry, the models assume that no stratification occurs within the pit void.
- Concerning the equilibrium model, an equilibrium reaction with gypsum was the only parameter considered relevant for the loss of solids from solution in the pit voids and sediment dam.

J.2 Representative initial water quality conditions

Sediment Dam and final voids (North Pit and South Pit) are presented as a time series of modelled concentrations for the following parameters and compounds:

- pH
- salinity: total dissolved solids
- major ions: calcium, magnesium, sodium, potassium, sulphate, chloride and fluoride, bicarbonate alkalinity
- Metals/metalloids: arsenic, barium, chromium, copper, molybdenum, nickel, uranium and zinc

These parameters and compounds have been selected as they represent the post-closure water quality in the voids and sediment dam from a geochemical modelling perspective.

With respect to the two different geochemical processes modelled in PHREEQC:

- The mixing modelling affects levels/concentrations of all selected parameters/solutes, and corresponding time series are presented.
- The speciation equilibrium modelling only affects the results for pH, total dissolved solids, calcium and sulphate, as the precipitation or dissolution of gypsum influences the calcium and sulphate concentrations. Therefore, speciation equilibrium time series are only included for these parameters/solutes The speciation equilibrium modelling does not affect the concentrations of metals, compared to the mixing modelling.

With respect to the modelled water quality:

- Overall, the effect of gypsum precipitation on water quality in the open pits and sediment dam is evident. Concentrations of total dissolved solids, calcium and sulphate in the equilibrium model are markedly less than in the mixing model. Precipitation of gypsum in the final voids is considered likely.
- The long-term temporal changes in solute concentrations generally approximate a power or logarithmic trend, especially once concentrations have stabilised during the initial years. Power and logarithmic trends are characterised by an initial rapid change, which then trails off slowly over time.

J.3 WRD Sediment Dam water quality

Detailed time series of the modelled long-term water quality in the WRD Sediment Dam is provided at the end of this appendix. The following processes govern the long-term water quality in the WRD Sediment Dam:

- Rainfall runoff and evaporation.

- Due to the presence of the HDPE liner on the dam, there is no interaction with the groundwater (i.e. no groundwater in- or outflows).
- The water level in the WRD Sediment Dam reaches the spillway level over several periods. Post-closure, any spillover water will flow into the North Pit diversion and then into the receiving environment.
- The WRD Sediment Dam runs dry over several periods, due to the effect of evaporation exceeding the combined rainfall runoff and available water in storage.

Selected time series are presented in Plate J.1 and Plate J.2. The maximum and long-term modelled water quality in the WRD Sediment Dam is summarised in Table J.1.

Table J.1 Long-term modelled (2080) water quality in WRD Sediment Dam

Parameter/ solute	ANZECC 2000 WQG for Livestock Watering	Mixing Model						Speciation Equilibrium Model					
		P25		P50		P75		P25		P50		P75	
Physico-chemical		Max	Final	Max	Final	Max	Final	Max	Final	Max	Final	Max	Final
pH	6.5 - 8.5	8.22	7.91	8.22	7.91	8.22	7.91	8.36	8.36	8.36	8.36	8.36	8.36
TDS (mg/L)	4000	3004	2238	2918	2238	3023	2255	1397	162	1002	161	1426	189
Major Ions (mg/L)		Max	Final	Max	Final	Max	Final	Max	Final	Max	Final	Max	Final
Calcium	1000	712.6	629.3	712.6	629.3	712.6	629.2	153.9	17.8	110.3	17.7	157.1	20.7
Magnesium	-	67.7	7.8	48.6	7.8	69.2	9.1	67.8	7.8	48.6	7.8	69.2	9.1
Sodium	-	159.0	18.4	123.9	18.3	162.3	21.4	159.0	18.4	123.9	18.3	162.4	21.4
Potassium	-	45.4	5.2	32.5	5.2	46.3	6.1	45.4	5.2	32.5	5.2	46.4	6.1
Sulphate	2000	1852.4	1548.2	1754.7	1548.0	1859.6	1554.7	715.2	82.7	512.4	82.3	730.2	96.2
Chloride	-	280.8	19.5	280.8	19.4	280.8	22.6	280.8	19.5	280.8	19.4	280.8	22.7
Fluoride	2	1.7	0.2	1.3	0.2	1.8	0.2	1.7	0.2	1.3	0.2	1.8	0.2
Bicarbonate	-	184.2	9.7	184.2	9.7	184.2	11.3	184.2	10.6	184.2	10.6	184.2	12.3
Metals (mg/L)		Max	Final	Max	Final	Max	Final	Max	Final	Max	Final	Max	Final
Aluminium	5	0.0130	0.0000	0.0130	0.0000	0.0130	0.0000	0.0130	0.0000	0.0130	0.0000	0.0130	0.0000
Arsenic	0.5	0.0180	0.0006	0.0180	0.0006	0.0180	0.0008	0.0180	0.0006	0.0180	0.0006	0.0180	0.0008
Barium	-	0.0030	0.0002	0.0030	0.0002	0.0030	0.0002	0.0030	0.0002	0.0030	0.0002	0.0030	0.0002
Chromium	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Copper	0.5	0.0140	0.0016	0.0100	0.0016	0.0143	0.0019	0.0140	0.0016	0.0100	0.0016	0.0143	0.0019
Manganese	-	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Molybdenum	0.15	0.0712	0.0082	0.0510	0.0082	0.0727	0.0096	0.0713	0.0082	0.0510	0.0082	0.0727	0.0096
Nickel	1	0.0126	0.0015	0.0090	0.0014	0.0128	0.0017	0.0126	0.0015	0.0090	0.0014	0.0128	0.0017
Uranium	0.2	0.0838	0.0097	0.0601	0.0096	0.0855	0.0113	0.0838	0.0097	0.0601	0.0096	0.0856	0.0113
Zinc	20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

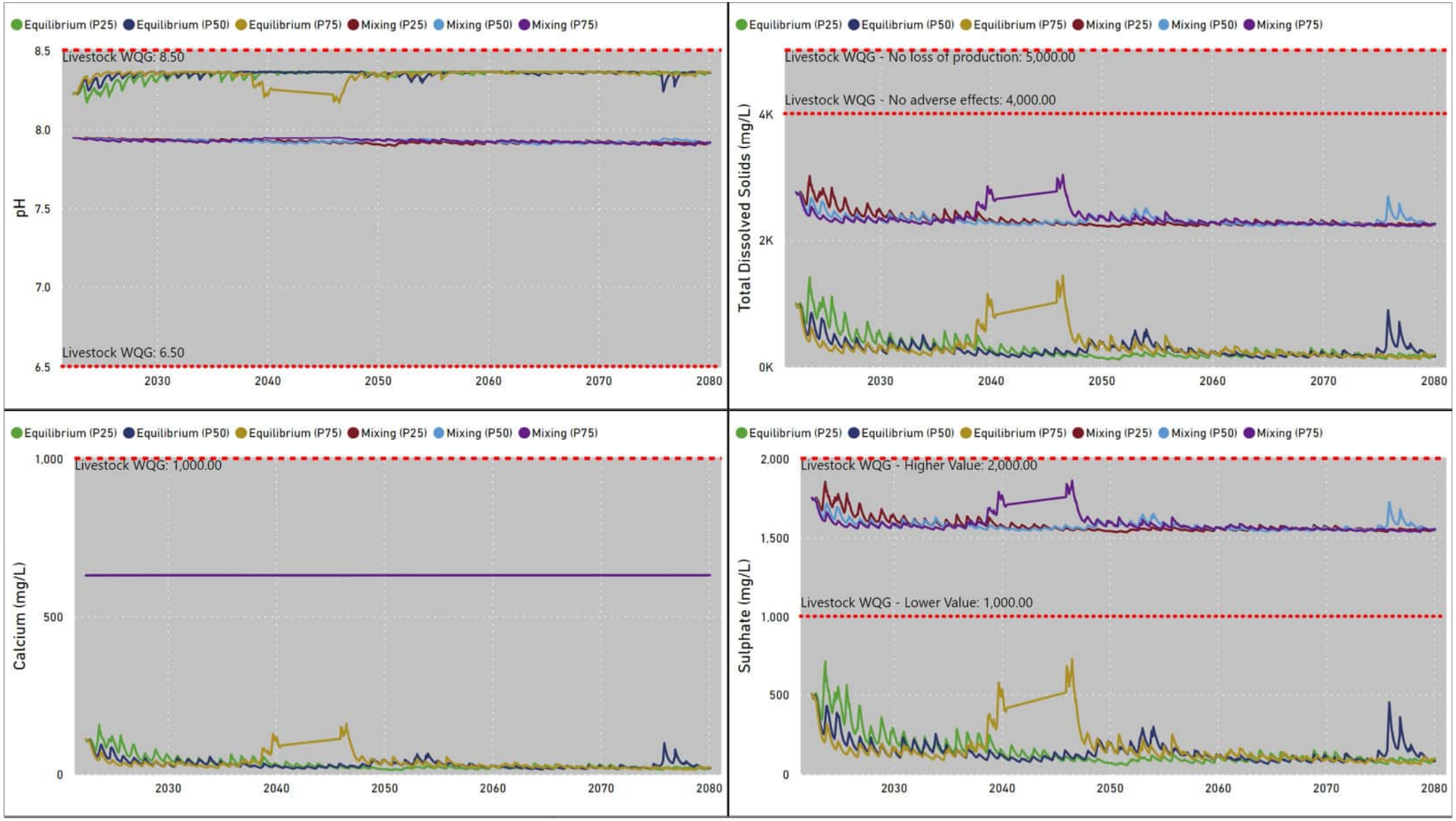


Plate J.1 WRD Sediment Dam modelled water quality – pH, TDS, calcium and sulphate

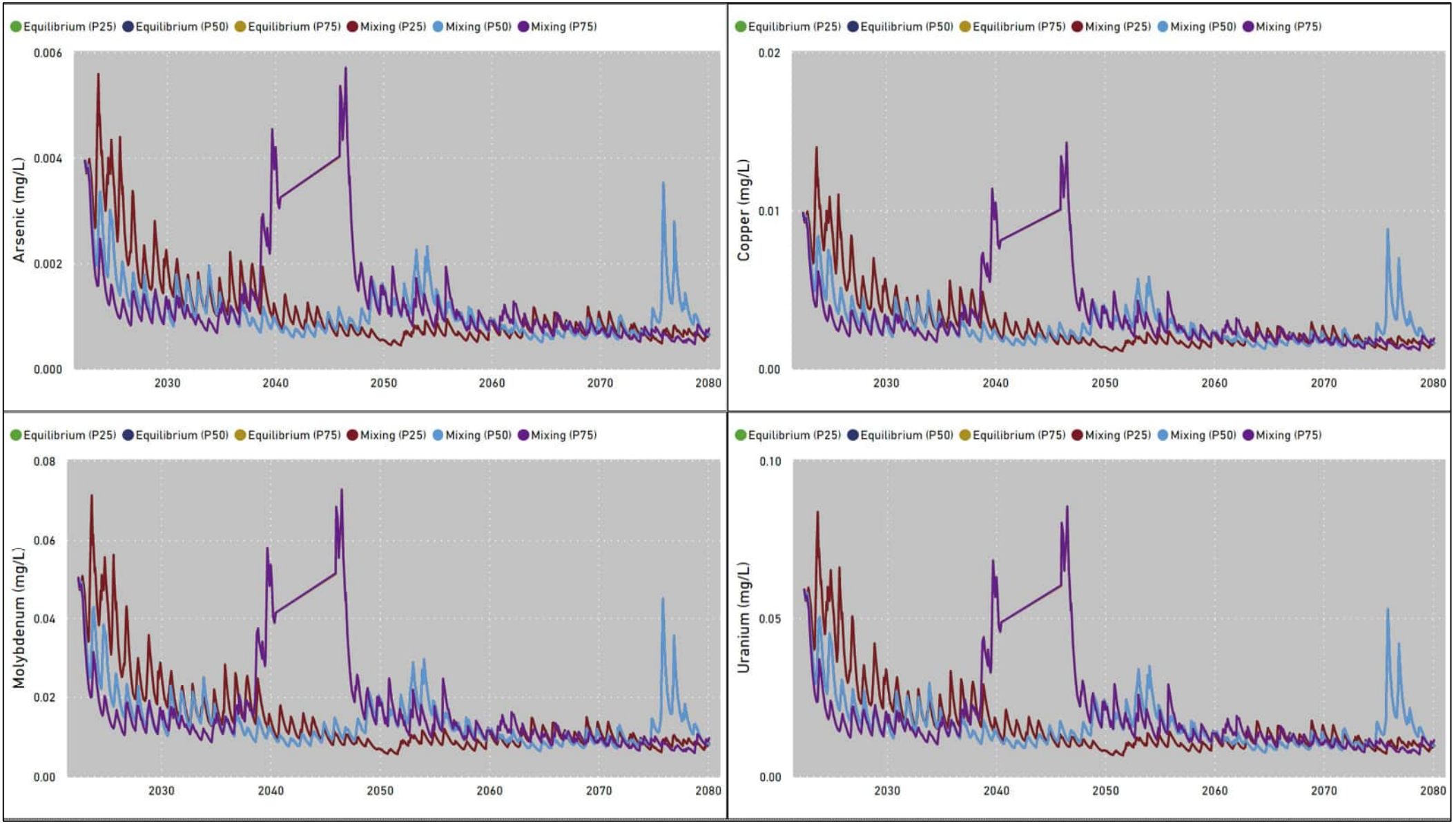


Plate J.2 WRD Sediment Dam modelled water quality – arsenic, copper, molybdenum and uranium

The modelled water quality results indicate the following:

- The solute concentrations at all times and for both models (i.e. mixing and equilibrium models) remain below the applicable ANZECC 2000 Water Quality Guideline values for livestock watering.
- The main processes that impact solute levels in the sediment dam are dilution due to rainfall runoff into the pit and concentration due to evaporation from the open pit. Due to the presence of the HDPE liner, groundwater inflow or outflow does not occur. The short-term or seasonal variations in solute concentrations can be correlated with the net balance between rainfall and evaporation.
- Under the 75th percentile climatic conditions, the WRD sediment Dam runs dry between early-2040 and end-2045. This affects the water quality in the WRD Sediment Dam.
- Physico-chemical parameters
  - pH levels: Long-term pH levels in the sediment dam stabilise relatively quickly and trend towards slightly alkaline conditions in the mixing and equilibrium models. pH levels are higher in the equilibrium model due to the geochemical gypsum equilibrium reactions and trend towards the pH of the runoff entering the sediment dam.
  - Total Dissolved Solids: Long-term TDS concentrations trend towards stable levels in both models, with short-term variations defined by seasonal climatic conditions (i.e. rainfall runoff versus evaporation).
- Major ions:
  - Calcium and sulphate: concentrations differ between the mixing and equilibrium models, with lower concentrations in the latter model due to gypsum equilibrium reactions.
  - Magnesium, sodium, potassium, chloride and fluoride: Gypsum equilibrium reactions do not affect solute concentrations. Concentrations are determined by the concentrations in the inflow water and evaporation from the open pit.
  - Long-term major ion concentrations trend towards stable levels in both models, with short-term variations defined by seasonal climatic conditions (i.e. rainfall runoff versus evaporation).
- Metals/metalloids
  - Modelled concentrations of meals/metalloids are not affected by gypsum speciation/equilibrium processes.
  - Solute concentrations in the pit are determined by the concentrations in the runoff water and evaporation from the open pit.
  - Long-term concentrations trend towards stable levels in both models, with short-term variations defined by seasonal climatic conditions (i.e. rainfall runoff versus evaporation).

J.4 North Pit water quality

The long-term water quality in the North Pit is governed by the following processes/interactions:

- Rainfall runoff from the pit catchment into the open pit.
- Direct rainfall into and evaporation from the open pit.
- Groundwater inflow into the open pit. Hydrogeological studies indicate that the North Pit will generally remain a groundwater sink.
- Groundwater seepage from the North Pit to the South Pit.
- The results of the WBM indicated that there would be no overflow from the North Pit.

Detailed time series of the modelled long-term water quality in the North Pit is provided in Appendix J. Selected time series are presented in Plate J.3 and Plate J.4.

The long-term modelled water quality in the North Pit is summarised in Table J.2.

Table J.2 Long-term modelled (Feb-2080) water quality in North Pit

Parameter/ solute	ANZECC 2000 WQG for Livestock Watering	Mixing Model						Speciation Equilibrium Model					
		P25		P50		P75		P25		P50		P75	
Physico-chemical		Max	Final	Max	Final	Max	Final	Max	Final	Max	Final	Max	Final
pH	6.5 - 8.5	8.20	7.71	8.20	7.72	8.20	7.74	8.20	7.88	8.20	7.93	8.20	7.96
TDS (mg/L)	4000	3766	3764	3320	3288	3020	3018	1772	1765	1316	1275	1014	1012
Major Ions (mg/L)		Max	Final	Max	Final	Max	Final	Max	Final	Max	Final	Max	Final
Calcium	1000	758.2	758.1	717.8	716.5	700.7	690.6	163.7	162.8	122.7	118.6	95.8	95.5
Magnesium	-	88.2	88.0	64.6	62.6	48.8	48.7	88.3	88.0	64.6	62.6	48.9	48.7
Sodium	-	243.5	242.7	179.4	173.6	135.7	135.4	243.6	242.9	179.5	173.7	135.8	135.4
Potassium	-	61.6	61.3	44.8	43.5	34.3	34.3	61.6	61.4	44.8	43.6	34.4	34.3
Sulphate	2000	1768.7	1764.3	1724.0	1708.9	1720.3	1680.3	502.6	337.6	451.6	275.9	444.0	254.1
Chloride	-	458.6	458.3	357.6	312.6	357.6	224.7	458.9	458.5	357.6	312.7	357.6	224.8
Fluoride	2	1.8	1.3	1.5	1.1	1.5	0.9	1.8	1.4	1.5	1.1	1.5	0.9
Bicarbonate	-	391.1	390.8	275.8	270.0	204.8	204.6	413.6	413.3	293.4	287.4	218.9	218.7
Metals (mg/L)		Max	Final	Max	Final	Max	Final	Max	Final	Max	Final	Max	Final
Aluminium	5	0.0601	0.0601	0.0408	0.0401	0.0286	0.0286	0.0601	0.0601	0.0409	0.0401	0.0286	0.0286
Arsenic	0.5	0.0087	0.0087	0.0062	0.0060	0.0046	0.0046	0.0087	0.0087	0.0062	0.0060	0.0046	0.0046
Barium	-	0.2476	0.2474	0.1902	0.1736	0.1902	0.1302	0.2477	0.2475	0.1902	0.1737	0.1902	0.1303
Chromium	1	0.0007	0.0003	0.0007	0.0002	0.0007	0.0001	0.0007	0.0003	0.0007	0.0002	0.0007	0.0001
Copper	0.5	0.0411	0.0399	0.0353	0.0305	0.0347	0.0263	0.0412	0.0399	0.0353	0.0305	0.0347	0.0263
Manganese	-	1.5012	0.6787	1.5012	0.4676	1.5012	0.3141	1.5012	0.6790	1.5012	0.4678	1.5012	0.3142
Molybdenum	0.15	0.0161	0.0140	0.0139	0.0109	0.0137	0.0095	0.0162	0.0140	0.0139	0.0109	0.0137	0.0095
Nickel	1	0.0108	0.0069	0.0096	0.0057	0.0094	0.0053	0.0108	0.0069	0.0096	0.0057	0.0095	0.0053
Uranium	0.2	0.0152	0.0151	0.0110	0.0107	0.0083	0.0083	0.0152	0.0151	0.0110	0.0107	0.0083	0.0083
Zinc	20	0.0140	0.0063	0.0140	0.0044	0.0140	0.0029	0.0140	0.0063	0.0140	0.0044	0.0140	0.0029

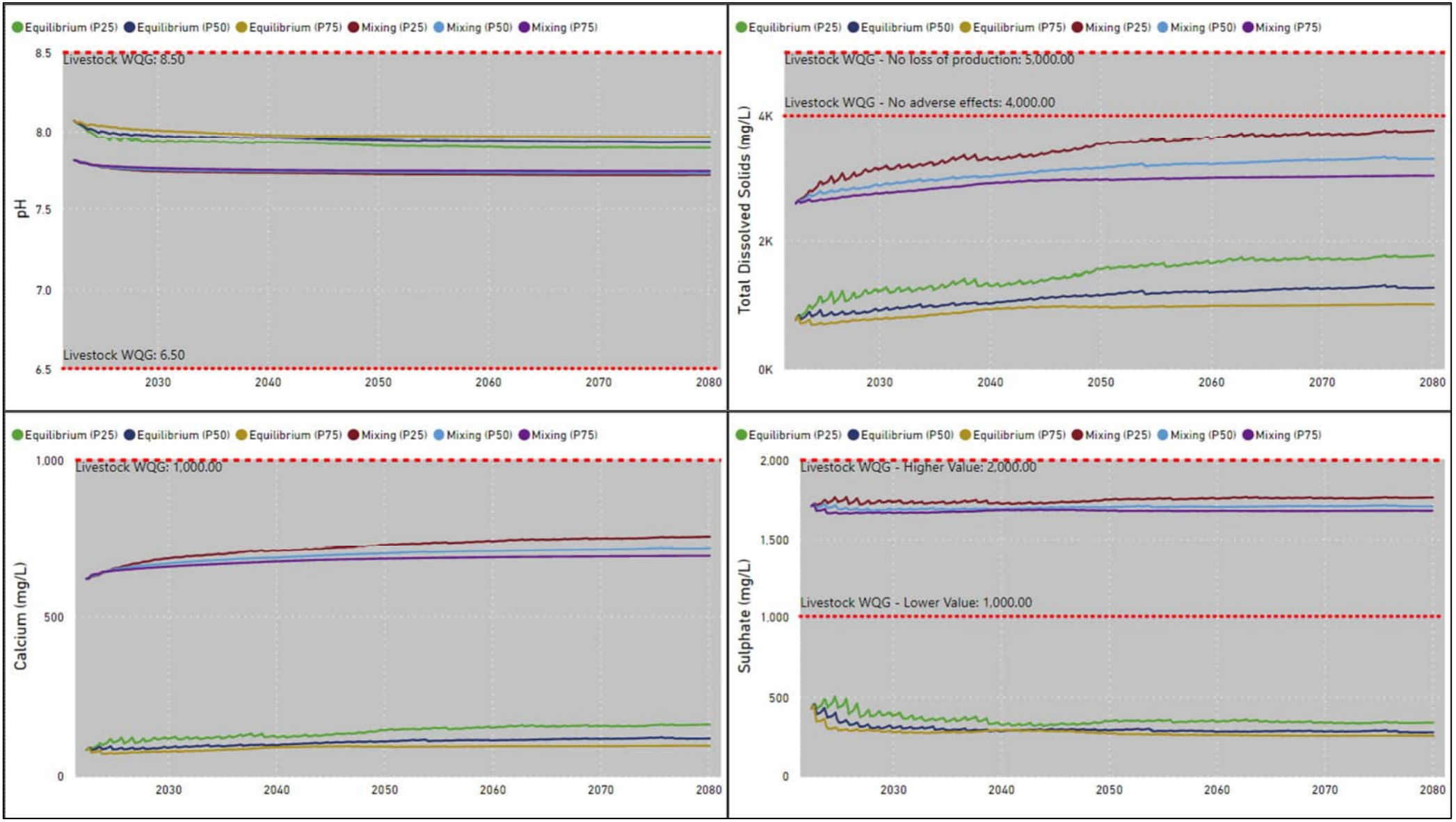


Plate J.3 North Pit modelled water quality – pH, TDS, calcium and sulphate

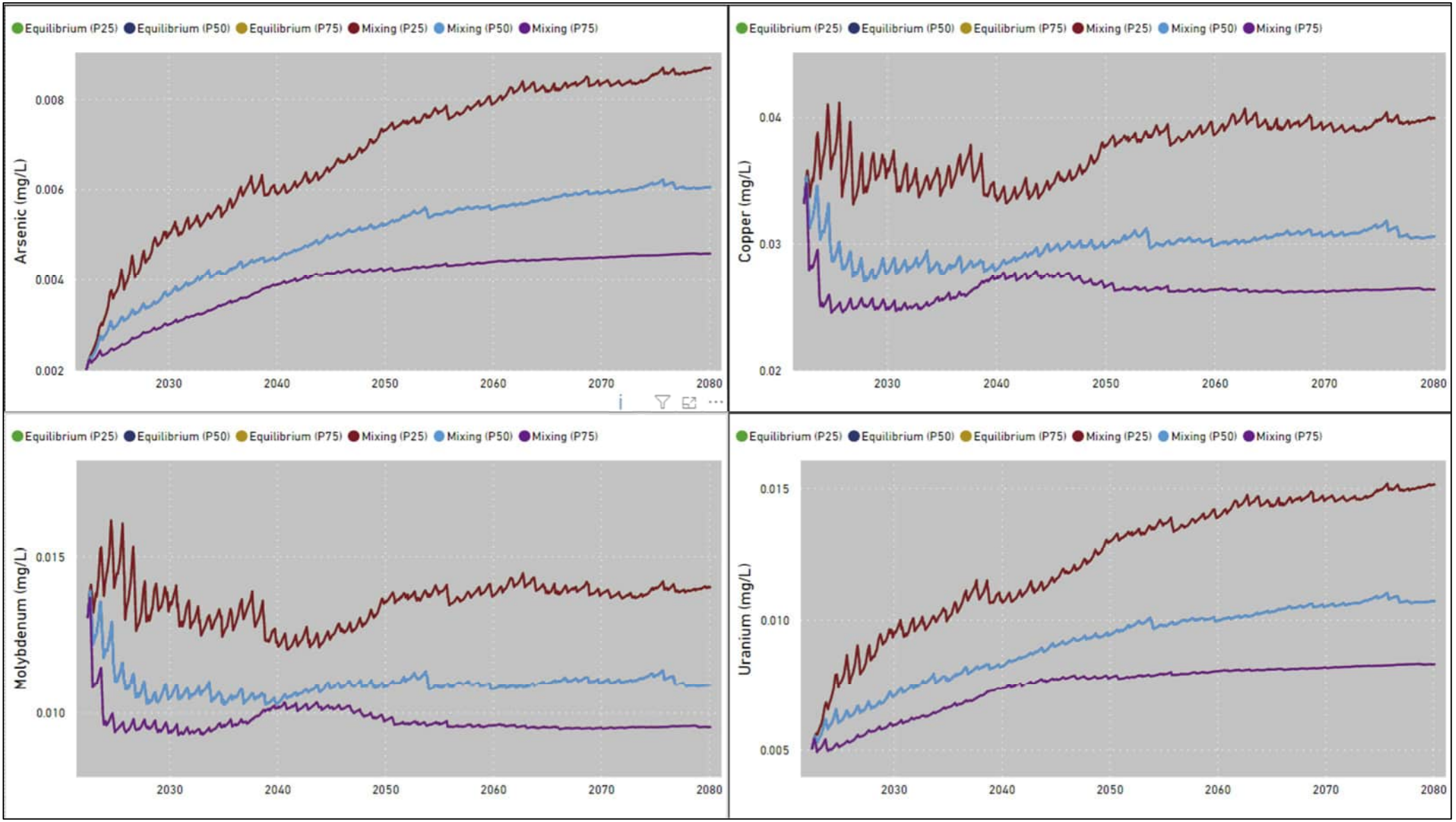


Plate J.4 North Pit modelled water quality – arsenic, copper, molybdenum and uranium

The modelled water quality results indicate the following:

- The solute concentrations at all times and for both models (i.e. mixing and equilibrium models) remain below the applicable ANZECC 2000 Water Quality Guideline values for livestock watering.
- The main physical processes that impact solute levels in the open pit are dilution due to rainfall runoff, groundwater inflow into the pit, and concentration due to evaporation from the open pit. Groundwater inflow only plays a minor role, with long-term groundwater inflows comprising only ±10% of total inflows into the open pit. Short-term variations in solute concentrations are related to the net flow balance between inflows and evaporation. Whilst groundwater inflow is only a minor component of pit inflows, it does buffer the effect of evaporation on solute concentrations.
- Physico-chemical parameters
  - pH levels: pH levels stabilise relatively quickly and trend towards near neutral/slightly alkaline conditions in the mixing and equilibrium models. pH levels are higher in the equilibrium model, due to the geochemical gypsum equilibrium reactions and trend towards the pH of the runoff entering the open pit.
  - Total Dissolved Solids: Long-term TDS concentrations trend towards stable levels in both models, with short-term variations defined by seasonal climatic conditions (i.e. rainfall runoff versus evaporation). The influence of the gypsum equilibrium is evident, with TDS concentrations lower in the equilibrium model than in the mixing model.
- Major ions:
  - Calcium and sulphate: concentrations differ between the mixing and equilibrium models, with lower concentrations in the latter model due to gypsum equilibrium reactions.
  - Magnesium, sodium, potassium, chloride and fluoride: Gypsum equilibrium reactions do not affect solute concentrations. Concentrations are determined by the concentrations in the inflow water and evaporation from the open pit.
  - Long-term major ion concentrations trend towards stable levels in both models, with short-term variations defined by seasonal climatic conditions (i.e. rainfall runoff versus evaporation) and the effect of evaporation buffered by groundwater inflow.
- Metals/metalloids
  - Modelled concentrations of meals/metalloids are not affected by gypsum speciation/equilibrium processes.
  - Solute concentrations in the pit are determined by the concentrations in the inflow water and evaporation from the open pit.
  - Long-term concentrations trend towards stable levels in both models, with short-term variations defined by seasonal climatic conditions (i.e. rainfall runoff versus evaporation) and the effect of evaporation buffered by groundwater inflow.

J.5 South Pit water quality

The long-term water quality in the South Pit is governed by the following processes/interactions:

- Rainfall runoff from the pit catchment into the open pit.
- Direct rainfall into and evaporation from the open pit.
- Groundwater inflow into the open pit. Hydrogeological studies indicate that the South Pit will generally remain a groundwater sink.
- Groundwater seepage from the North Pit to the South Pit.
- The results of the WBM indicated that there would be no overflow from the North Pit.

Detailed time series of the modelled long-term water quality in the South Pit are provided in Appendix J. Selected time series are presented in Plate J.5 to Plate J.8. The long-term modelled water quality is summarised in Table J.3 and Table J.4.

Table J.3 Long-term modelled (Feb-2080) water quality in South Pit (scenario 1)

Parameter/ solute	ANZECC 2000 WQG for Livestock Watering	Mixing Model						Speciation Equilibrium Model					
		P25		P50		P75		P25		P50		P75	
Physico-chemical		Max	Final	Max	Final	Max	Final	Max	Final	Max	Final	Max	Final
pH	6.5 - 8.5	8.20	7.79	8.20	7.79	8.20	7.79	8.20	8.04	8.20	8.04	8.20	8.05
TDS (mg/L)	4000	4154	3074	4154	2976	4154	2893	1981	1200	1981	1103	1981	1022
Major Ions (mg/L)		Max	Final	Max	Final	Max	Final	Max	Final	Max	Final	Max	Final
Calcium	1000	696.1	651.7	696.1	648.3	696.1	645.4	140.4	98.0	140.4	94.9	140.4	92.6
Magnesium	-	81.5	57.1	81.5	53.0	81.5	49.7	81.5	57.1	81.5	53.0	81.5	49.7
Sodium	-	535.4	196.9	535.4	171.4	535.4	149.6	535.4	197.0	535.4	171.4	535.4	149.7
Potassium	-	27.3	21.9	27.3	21.4	27.3	21.1	27.3	21.9	27.3	21.4	27.3	21.1
Sulphate	2000	1984.2	1800.9	1984.2	1777.7	1984.2	1758.1	705.3	473.9	702.2	451.5	699.9	433.3
Chloride	-	801.4	244.0	801.4	205.8	801.4	173.2	801.4	244.2	801.4	205.9	801.4	173.3
Fluoride	2	1.2	0.8	1.2	0.7	1.2	0.7	1.2	0.8	1.2	0.7	1.2	0.7
Bicarbonate	-	101.5	101.5	98.2	98.2	95.8	95.8	108.1	108.1	104.6	104.6	102.2	102.2
Metals (mg/L)		Max	Final	Max	Final	Max	Final	Max	Final	Max	Final	Max	Final
Aluminium	5	0.0130	0.0076	0.0130	0.0075	0.0130	0.0074	0.0130	0.0076	0.0130	0.0075	0.0130	0.0074
Arsenic	0.5	0.0060	0.0045	0.0060	0.0043	0.0060	0.0043	0.0060	0.0045	0.0060	0.0043	0.0060	0.0043
Barium	-	0.0509	0.0509	0.0482	0.0482	0.0481	0.0461	0.0509	0.0509	0.0482	0.0482	0.0481	0.0461
Chromium	1	0.0015	0.0004	0.0015	0.0003	0.0015	0.0002	0.0015	0.0004	0.0015	0.0003	0.0015	0.0002
Copper	0.5	0.0164	0.0132	0.0163	0.0126	0.0163	0.0122	0.0164	0.0132	0.0163	0.0127	0.0163	0.0122
Manganese	-	0.0070	0.0017	0.0070	0.0014	0.0070	0.0011	0.0070	0.0017	0.0070	0.0014	0.0070	0.0011
Molybdenum	0.15	0.0445	0.0253	0.0445	0.0248	0.0445	0.0245	0.0445	0.0253	0.0445	0.0248	0.0445	0.0245
Nickel	1	0.0190	0.0105	0.0190	0.0104	0.0190	0.0102	0.0190	0.0105	0.0190	0.0104	0.0190	0.0102
Uranium	0.2	0.0251	0.0118	0.0251	0.0105	0.0251	0.0095	0.0251	0.0118	0.0251	0.0106	0.0251	0.0095
Zinc	20	0.0461	0.0111	0.0461	0.0089	0.0461	0.0071	0.0461	0.0111	0.0461	0.0089	0.0461	0.0071

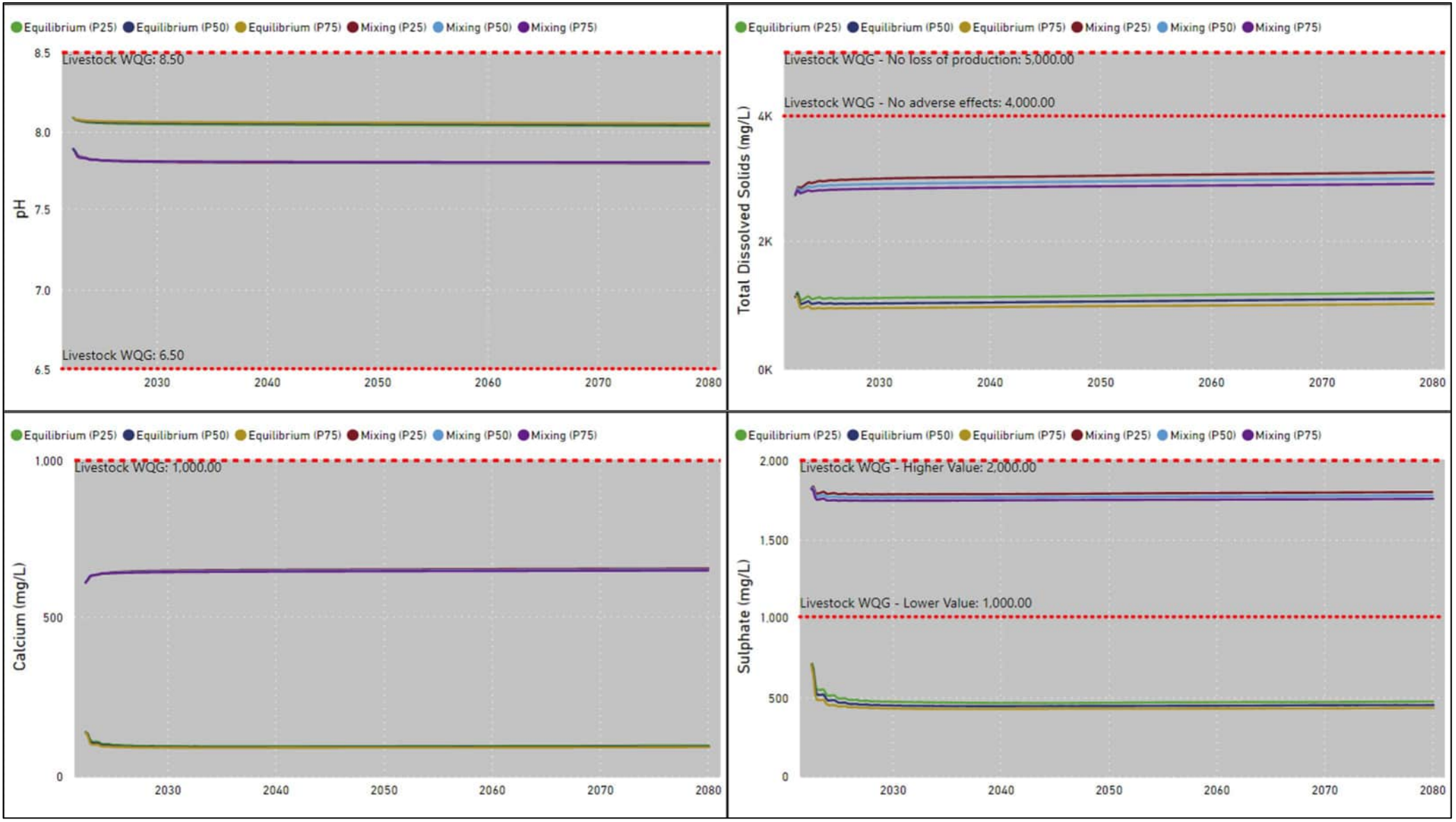


Plate J.5 South Pit (scenario 1) modelled water quality – pH, TDS, calcium and sulphate

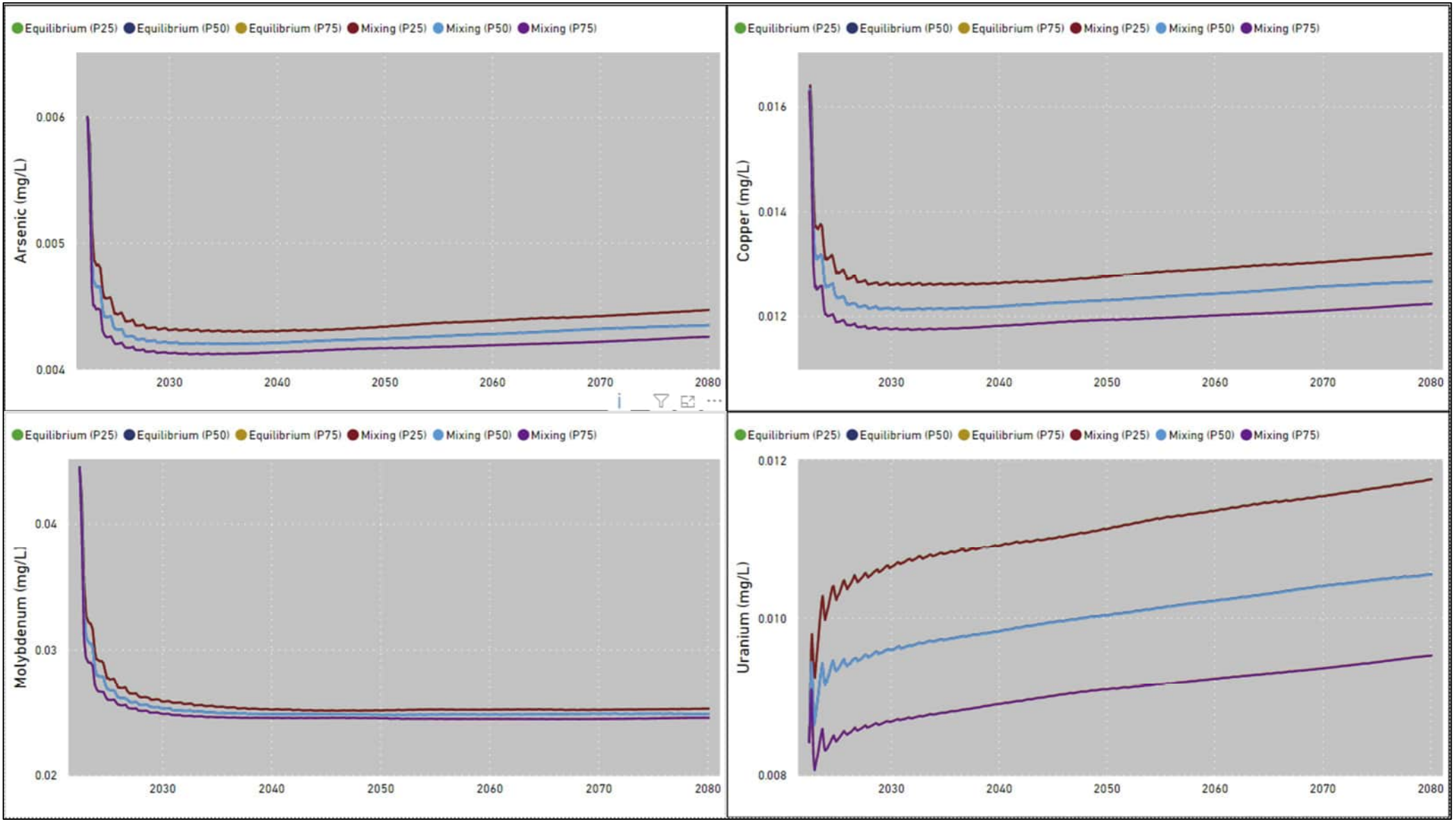


Plate J.6 South Pit (scenario 1) modelled water quality – arsenic, copper, molybdenum and uranium

Table J.4 Long-term modelled (Feb-2080) water quality in South Pit (scenario 2)

Parameter/ solute	ANZECC 2000 WQG for Livestock Watering	Mixing Model P25		Mixing Model P50		Mixing Model P75		Speciation Equilibrium Model P25		Speciation Equilibrium Model P50		Speciation Equilibrium Model P75	
Physico-chemical		Max	Final	Max	Final	Max	Final	Max	Final	Max	Final	Max	Final
pH	6.5 - 8.5	8.20	7.79	8.20	7.79	8.20	7.79	8.20	8.04	8.20	8.05	8.20	8.06
TDS (mg/L)	4000	4154	3044	4154	2943	4154	2857	1981	1169	1981	1070	1981	986
Major Ions (mg/L)		Max	Final	Max	Final	Max	Final	Max	Final	Max	Final	Max	Final
Calcium	1000	696.1	650.7	696.1	647.2	696.1	644.1	140.4	96.9	140.4	93.7	140.4	91.2
Magnesium	-	81.5	55.8	81.5	51.6	81.5	48.1	81.5	55.8	81.5	51.6	81.5	48.1
Sodium	-	535.4	189.0	535.4	163.1	535.4	140.5	535.4	189.1	535.4	163.2	535.4	140.6
Potassium	-	27.3	21.7	27.3	21.2	27.3	20.9	27.3	21.7	27.3	21.2	27.3	20.9
Sulphate	2000	1984.2	1793.6	1984.2	1769.9	1984.2	1749.4	705.3	466.4	702.2	443.5	699.9	424.3
Chloride	-	801.4	232.4	801.4	193.5	801.4	159.8	801.4	232.5	801.4	193.6	801.4	159.8
Fluoride	2	1.2	0.8	1.2	0.7	1.2	0.7	1.2	0.8	1.2	0.7	1.2	0.7
Bicarbonate	-	100.3	100.3	96.8	96.8	94.2	94.2	106.8	106.8	103.2	103.2	100.5	100.5
Metals (mg/L)		Max	Final	Max	Final	Max	Final	Max	Final	Max	Final	Max	Final
Aluminium	5	0.0130	0.0076	0.0130	0.0074	0.0130	0.0073	0.0130	0.0076	0.0130	0.0074	0.0130	0.0073
Arsenic	0.5	0.0060	0.0044	0.0060	0.0043	0.0060	0.0042	0.0060	0.0044	0.0060	0.0043	0.0060	0.0042
Barium	-	0.0500	0.0500	0.0481	0.0472	0.0481	0.0450	0.0500	0.0500	0.0481	0.0473	0.0481	0.0450
Chromium	1	0.0015	0.0003	0.0015	0.0003	0.0015	0.0002	0.0015	0.0003	0.0015	0.0003	0.0015	0.0002
Copper	0.5	0.0164	0.0130	0.0163	0.0124	0.0163	0.0120	0.0164	0.0130	0.0163	0.0125	0.0163	0.0120
Manganese	-	0.0070	0.0016	0.0070	0.0013	0.0070	0.0010	0.0070	0.0016	0.0070	0.0013	0.0070	0.0010
Molybdenum	0.15	0.0445	0.0251	0.0445	0.0246	0.0445	0.0243	0.0445	0.0251	0.0445	0.0246	0.0445	0.0243
Nickel	1	0.0190	0.0105	0.0190	0.0103	0.0190	0.0101	0.0190	0.0105	0.0190	0.0103	0.0190	0.0101
Uranium	0.2	0.0251	0.0114	0.0251	0.0101	0.0251	0.0091	0.0251	0.0114	0.0251	0.0101	0.0251	0.0091
Zinc	20	0.0461	0.0104	0.0461	0.0083	0.0461	0.0063	0.0461	0.0104	0.0461	0.0083	0.0461	0.0063

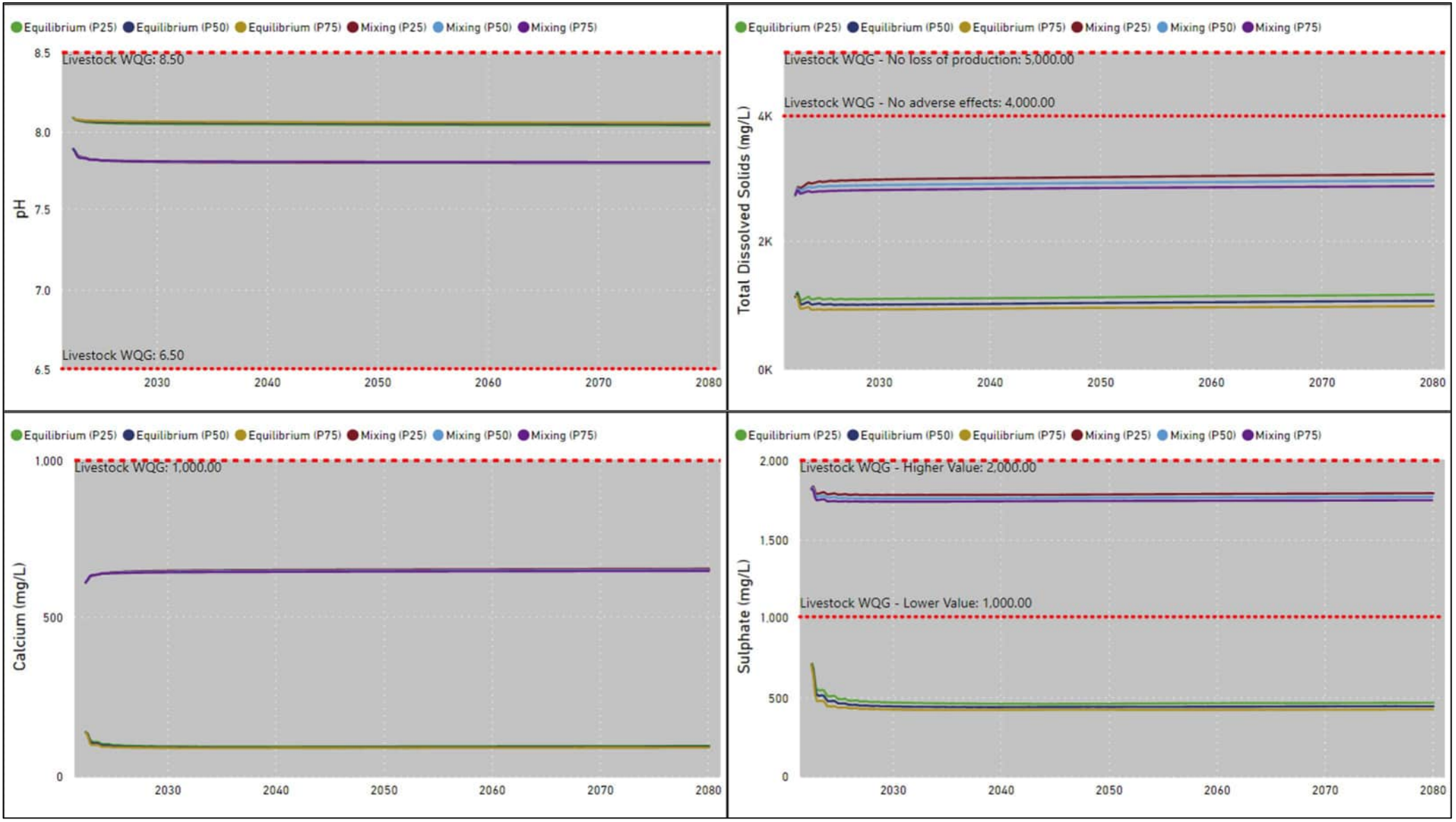


Plate J.7 South Pit (Scenario 2) modelled water quality – pH, TDS, calcium and sulphate

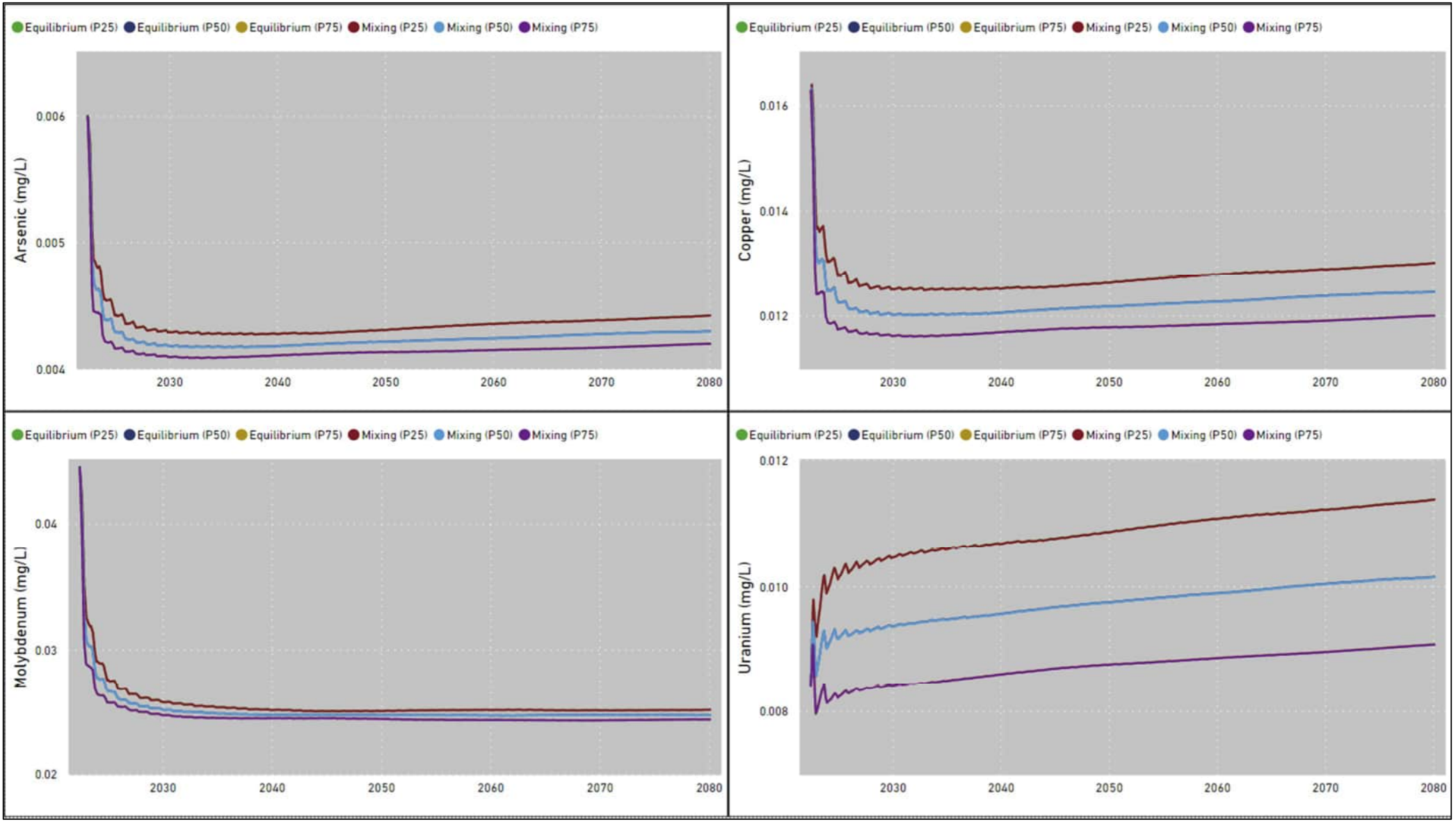


Plate J.8 South Pit (scenario 2) modelled water quality – arsenic, copper, molybdenum and uranium

The modelled water quality results indicate the following:

- There is little difference in modelled water quality between both scenarios. Water quality under scenario 2, which includes a larger amount of rainfall runoff from a large catchment area, is better than under scenario 1.
- The solute concentrations at all times and for both models (i.e. mixing and equilibrium models) and scenarios remain below the applicable ANZECC 2000 Water Quality Guideline values for livestock watering.
- The main physical processes that impact solute levels in the open pit are dilution due to rainfall runoff, groundwater inflow into the pit, and concentration due to evaporation from the open pit. Groundwater inflow plays a moderate role, with long-term groundwater inflows (combination of regional inflow and seepage from the North Pit) comprising ±20% of total inflows into the open pit. Short-term variations in solute concentrations are related to the net flow balance between inflows and evaporation. Groundwater inflow buffers the effect of evaporation on solute concentrations.
- Physico-chemical parameters
  - pH levels: pH levels in the South Pit stabilise relatively quickly and trend towards near-neutral/slightly alkaline conditions in the mixing and equilibrium models. pH levels are higher in the mixing model due to the geochemical gypsum equilibrium reactions and trend towards the pH of the runoff entering the open pit.
  - Total Dissolved Solids: Long-term TDS concentrations trend towards stable levels in both models, with short-term variations defined by seasonal climatic conditions (i.e. rainfall runoff versus evaporation). The influence of the gypsum equilibrium is evident, with TDS concentrations lower in the equilibrium model than in the mixing model.
- Major ions:
  - Calcium and sulphate: concentrations differ between the mixing and equilibrium models, with lower concentrations in the latter model due to gypsum equilibrium reactions.
  - Magnesium, sodium, potassium, chloride and fluoride: Gypsum equilibrium reactions do not affect solute concentrations. Concentrations are determined by the concentrations in the inflow water and evaporation from the open pit.
  - Long-term major ion concentrations trend towards stable levels in both models, with short-term variations defined by seasonal climatic conditions (i.e. rainfall runoff versus evaporation) and the effect of evaporation buffered by groundwater inflow.
- Metals/metalloids
  - Modelled concentrations of meals/metalloids are not affected by gypsum speciation/equilibrium processes.
  - Solute concentrations in the pit are determined by the concentrations in the inflow water and evaporation from the open pit.
  - Long-term major ion concentrations trend towards stable levels in both models, with short-term variations defined by seasonal climatic conditions (i.e. rainfall runoff versus evaporation) and the effect of evaporation buffered by groundwater inflow.

J.6 Summary

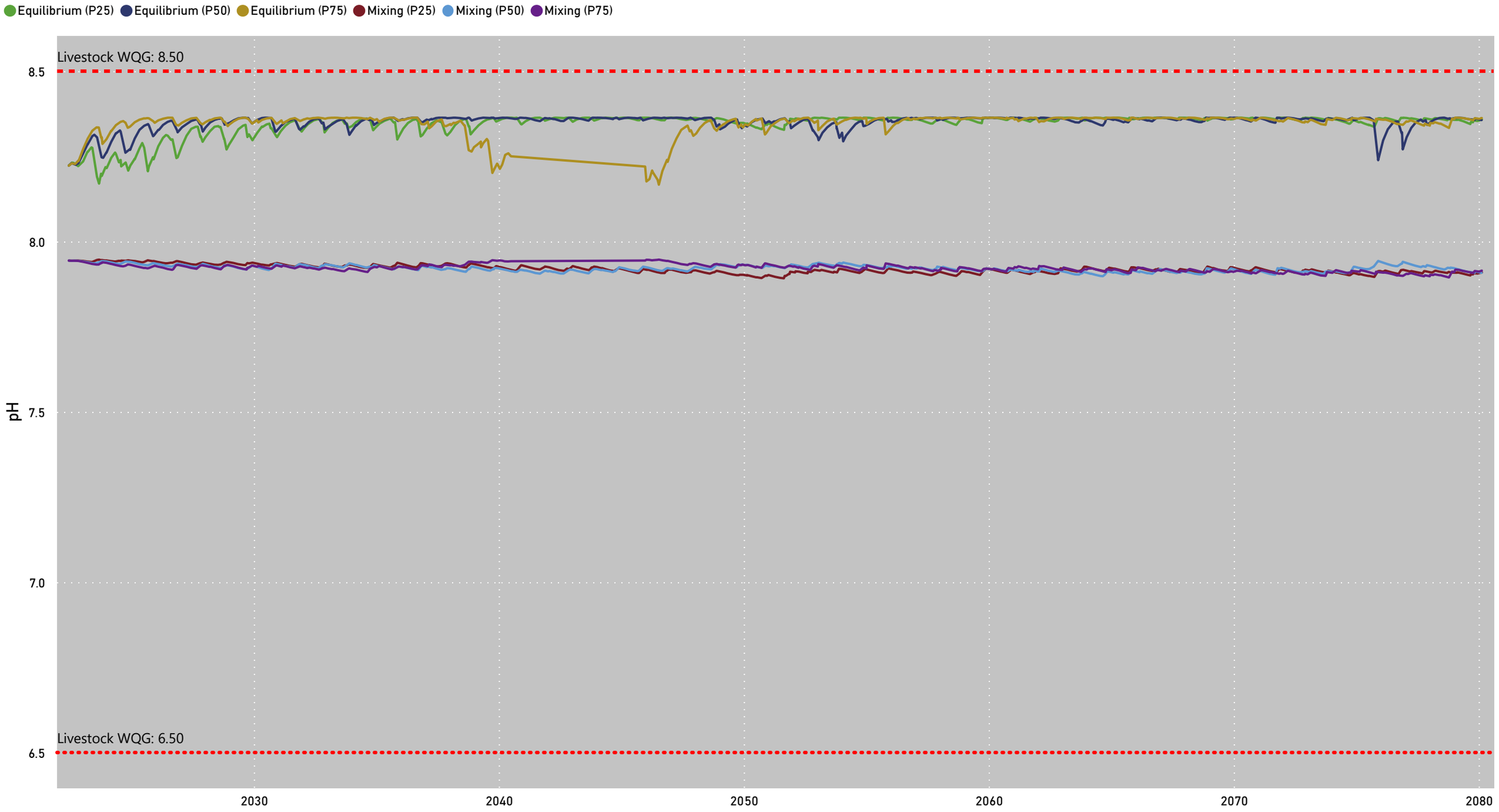
The water quality modelling indicates that the modelled solute concentrations at all times and for both models (i.e. mixing and equilibrium models) remain below the applicable ANZECC 2000 Water Quality Guideline values for livestock watering.

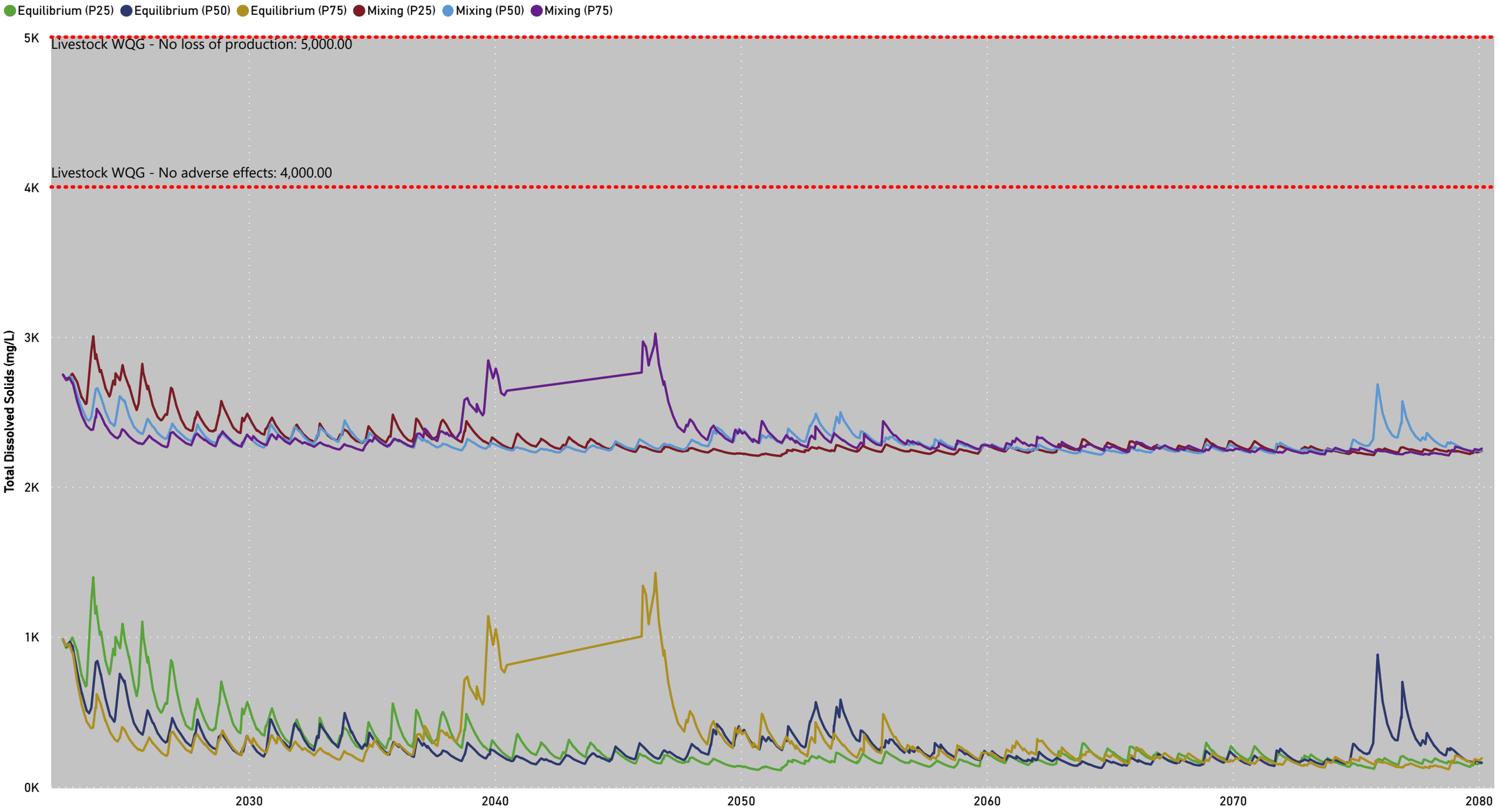
Long-term water quality in the pits and voids is determined by climatic conditions and geochemical reactions and tends to stabilise. The net flow balance between rainfall runoff plus groundwater inflow and evaporation determines short-term variations.

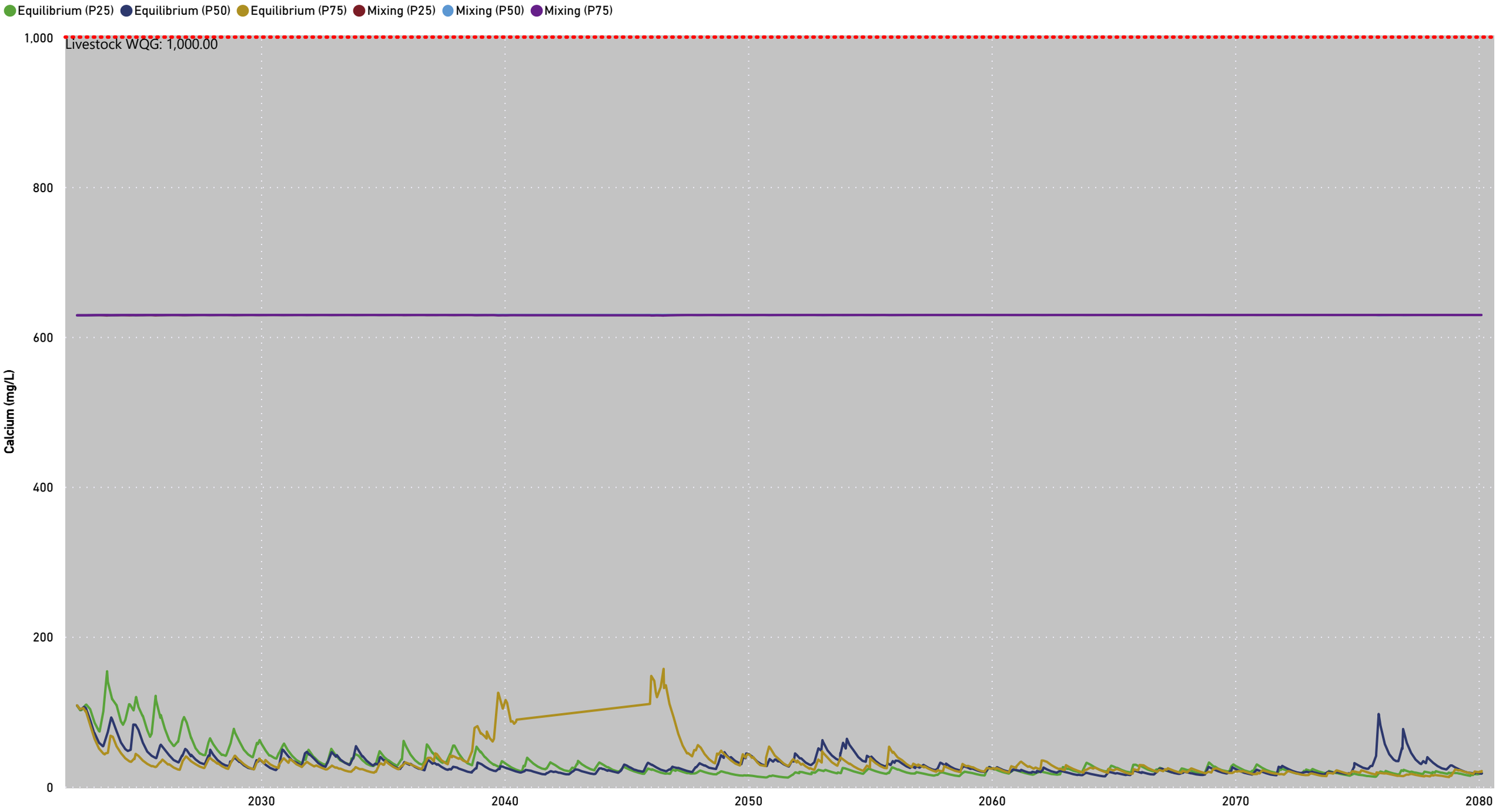
Based on the WQM results, the North Pit, South Pit and WRD Sediment Dam are considered suitable as PMLUs for livestock watering.

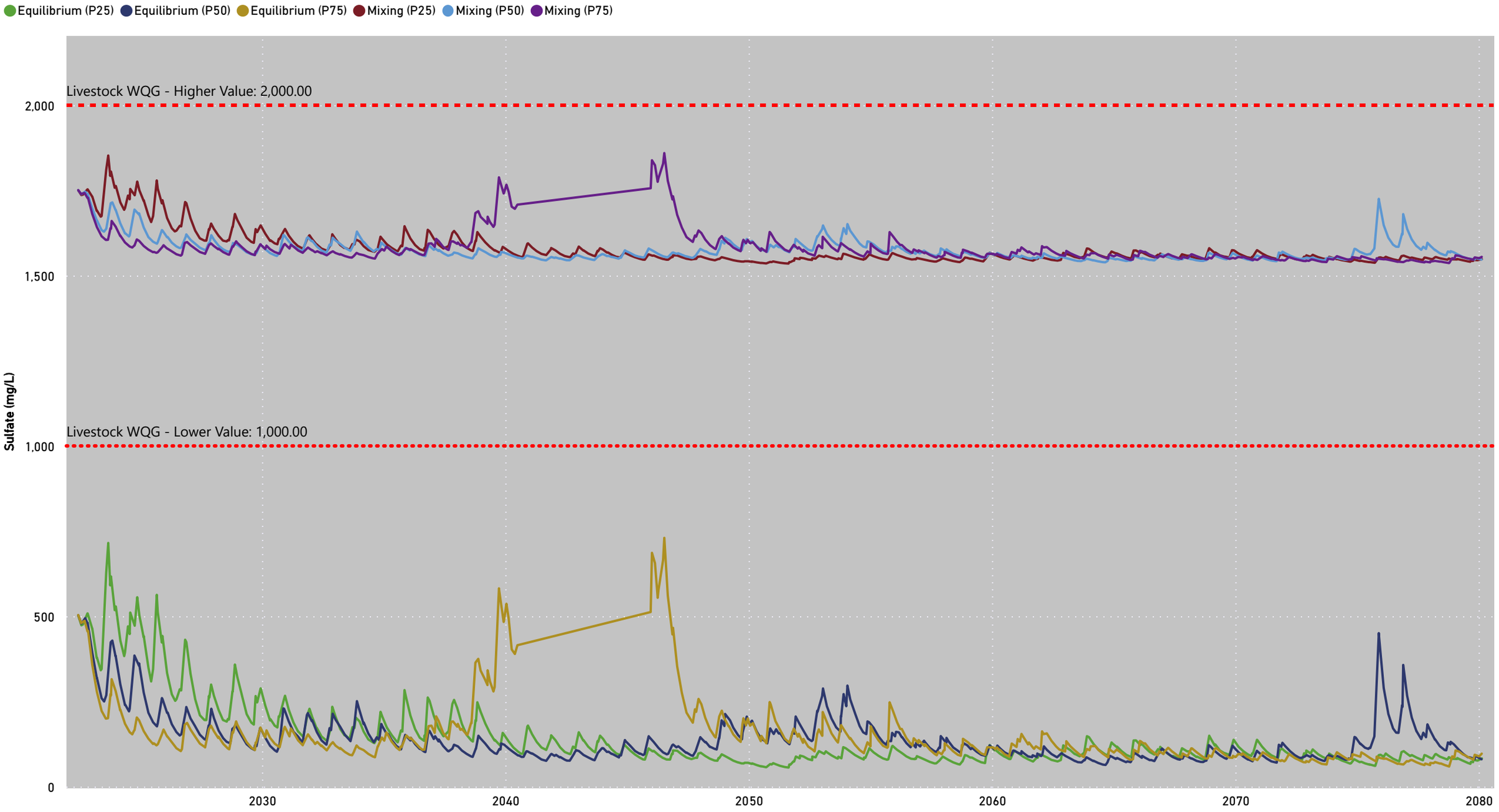
J.7 Charts and Plots

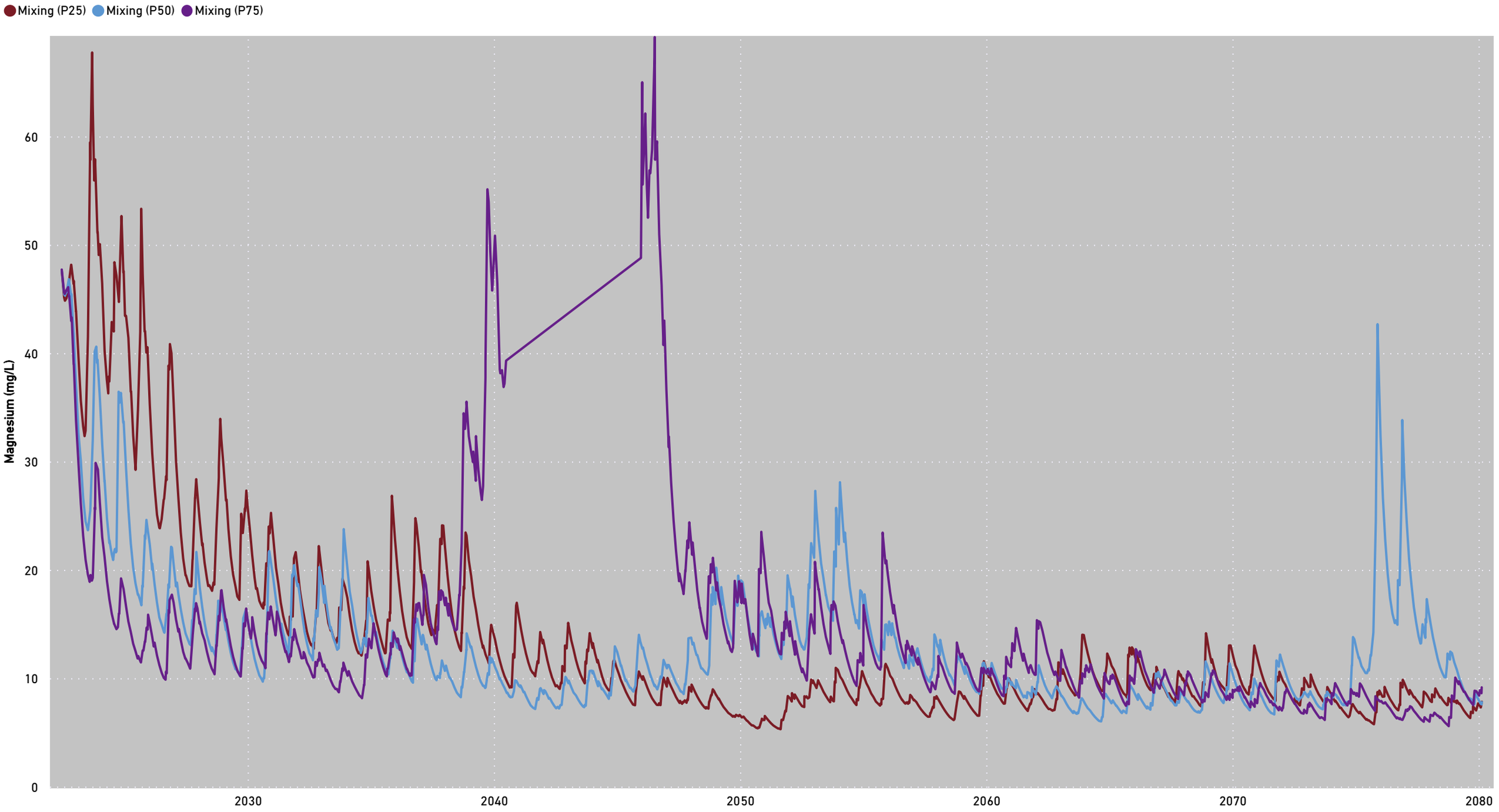
J.7.1 WRD Sediment Dam modelled long-term water quality

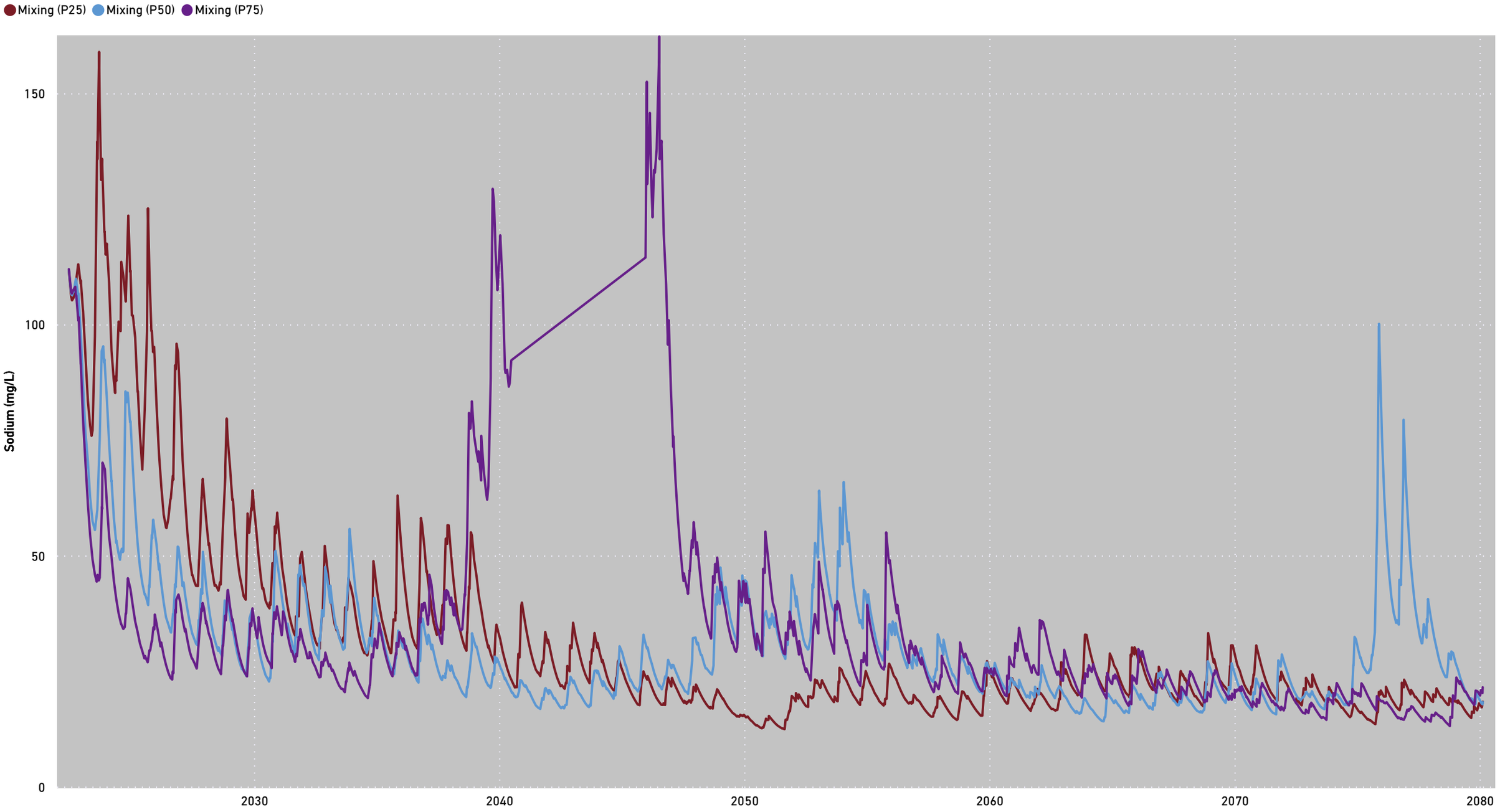

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 8.50
Livestock WQG: 6.50
pH
8.5
8.0
7.5
7.0
6.5
2030
2040
2050
2060
2070
2080

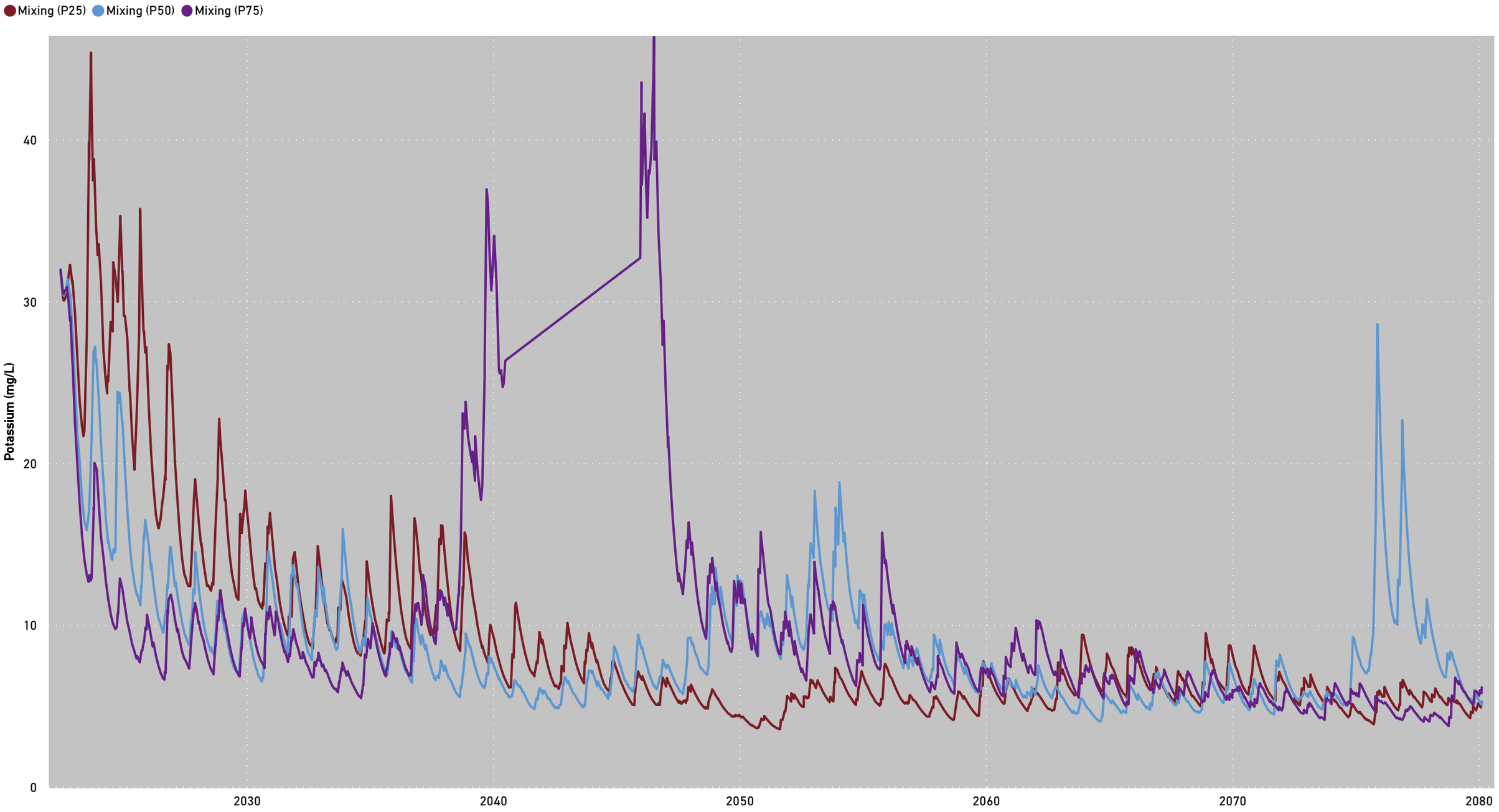

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG - No loss of production: 5,000.00
Livestock WQG - No adverse effects: 4,000.00
Total Dissolved Solids (mg/L)
5K
4K
3K
2K
1K
0K
2030
2040
2050
2060
2070
2080

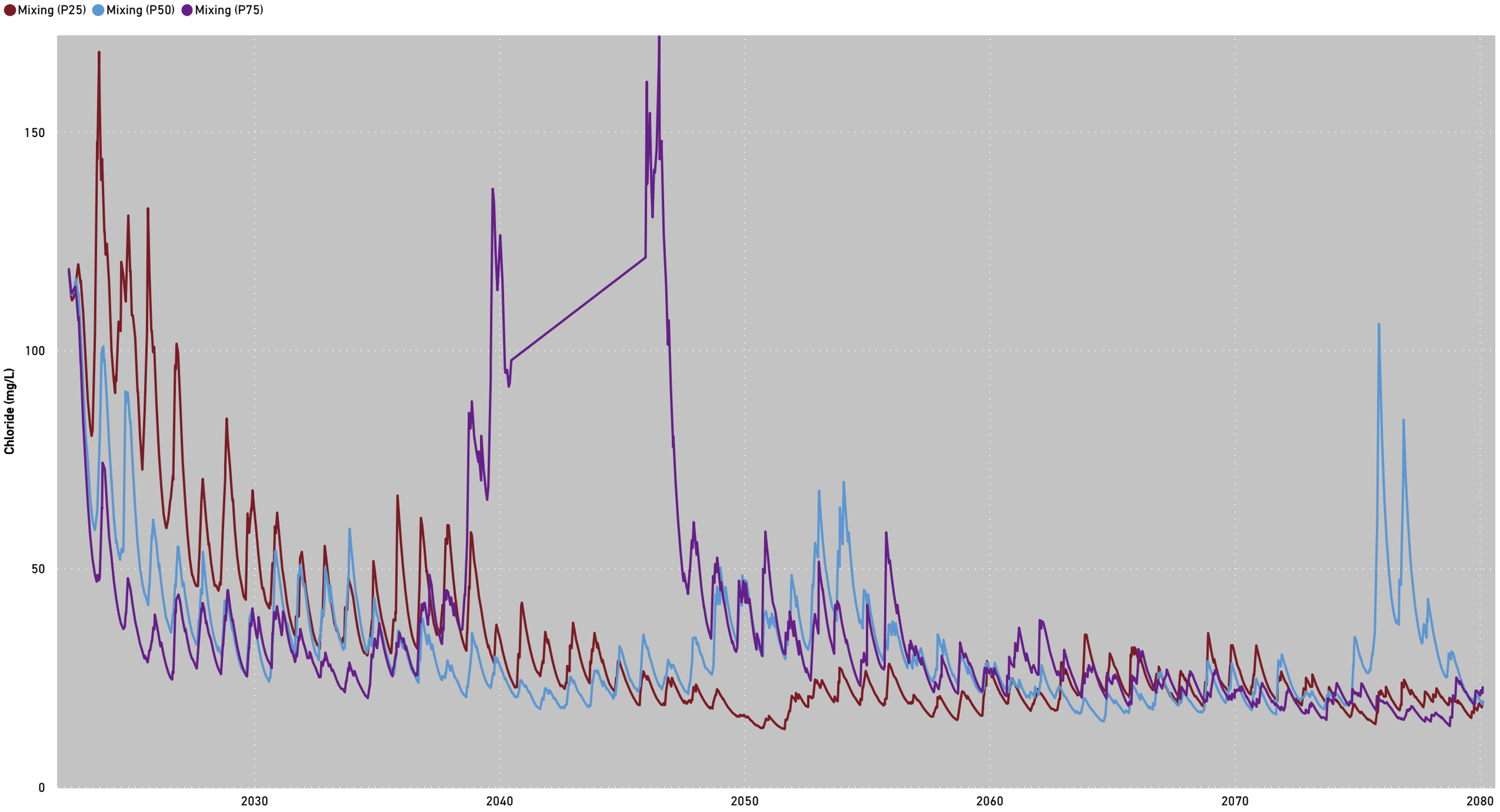

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 1,000.00
1,000
800
600
400
200
0
Calcium (mg/L)
2030
2040
2050
2060
2070
2080

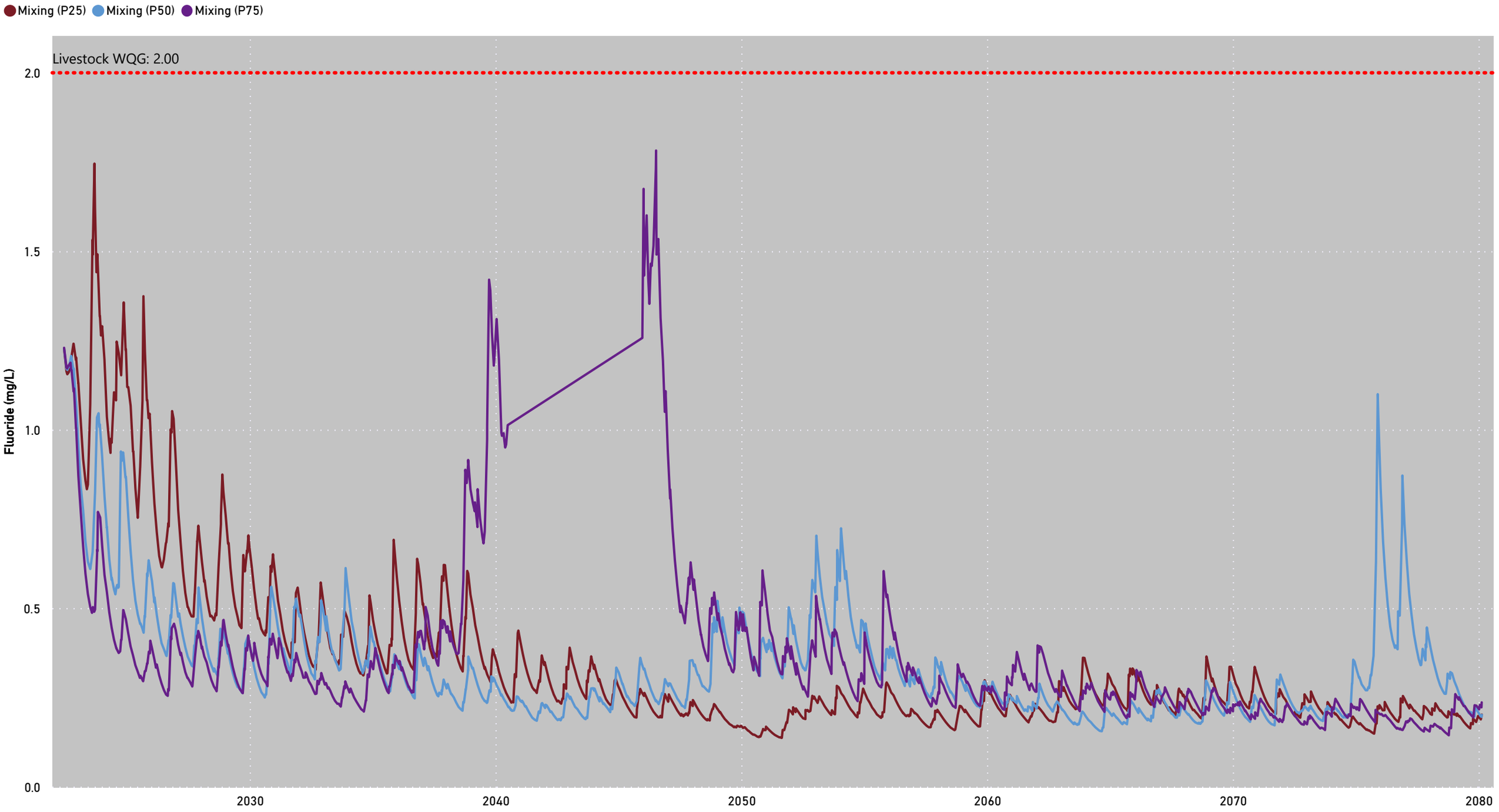

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG - Higher Value: 2,000.00
Livestock WQG - Lower Value: 1,000.00
Sulfate (mg/L)
2,000
1,500
1,000
500
0
2030
2040
2050
2060
2070
2080

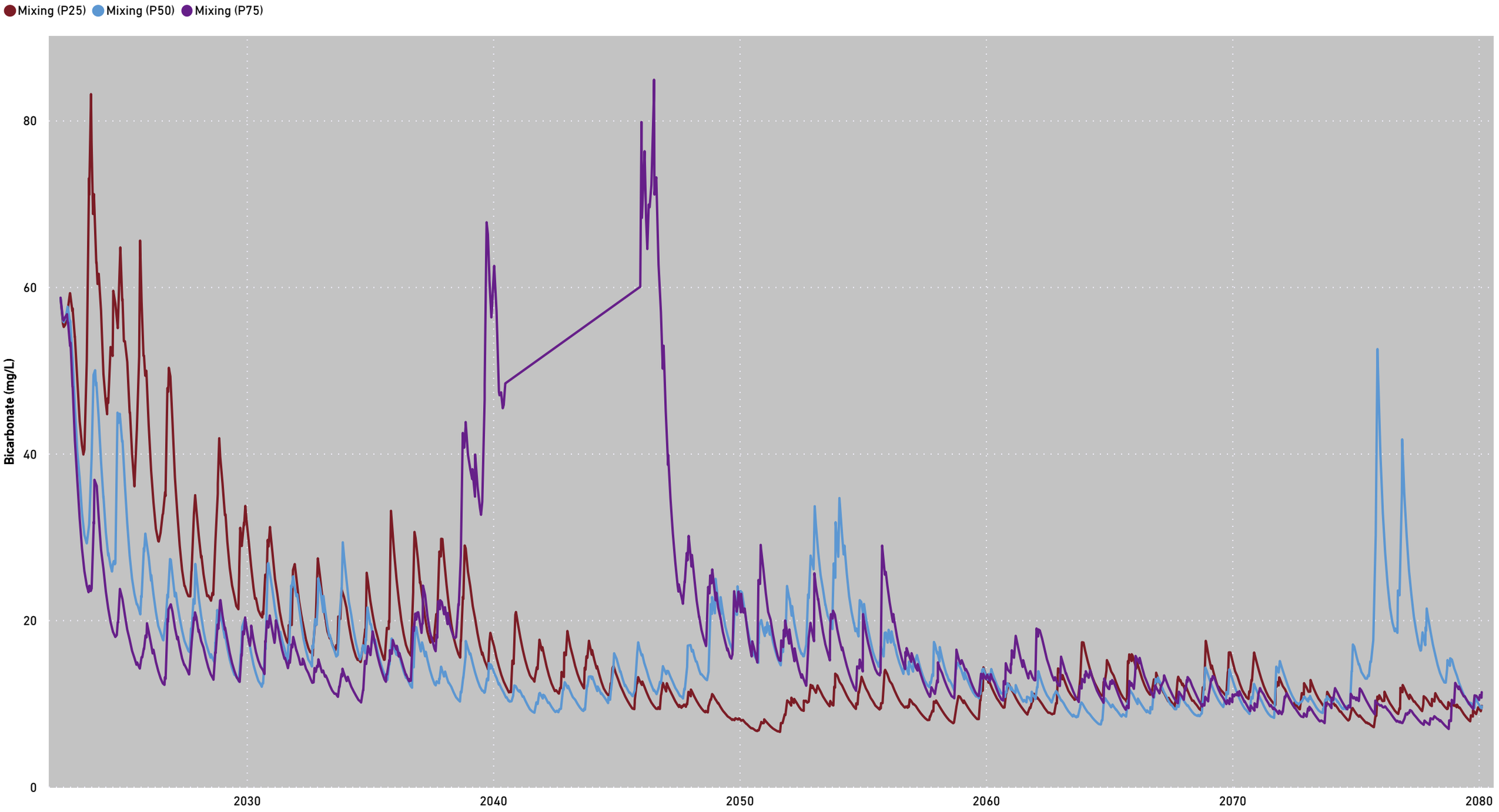

Mixing (P25)
Mixing (P50)
Mixing (P75)
Magnesium (mg/L)
0
10
20
30
40
50
60
2030
2040
2050
2060
2070
2080

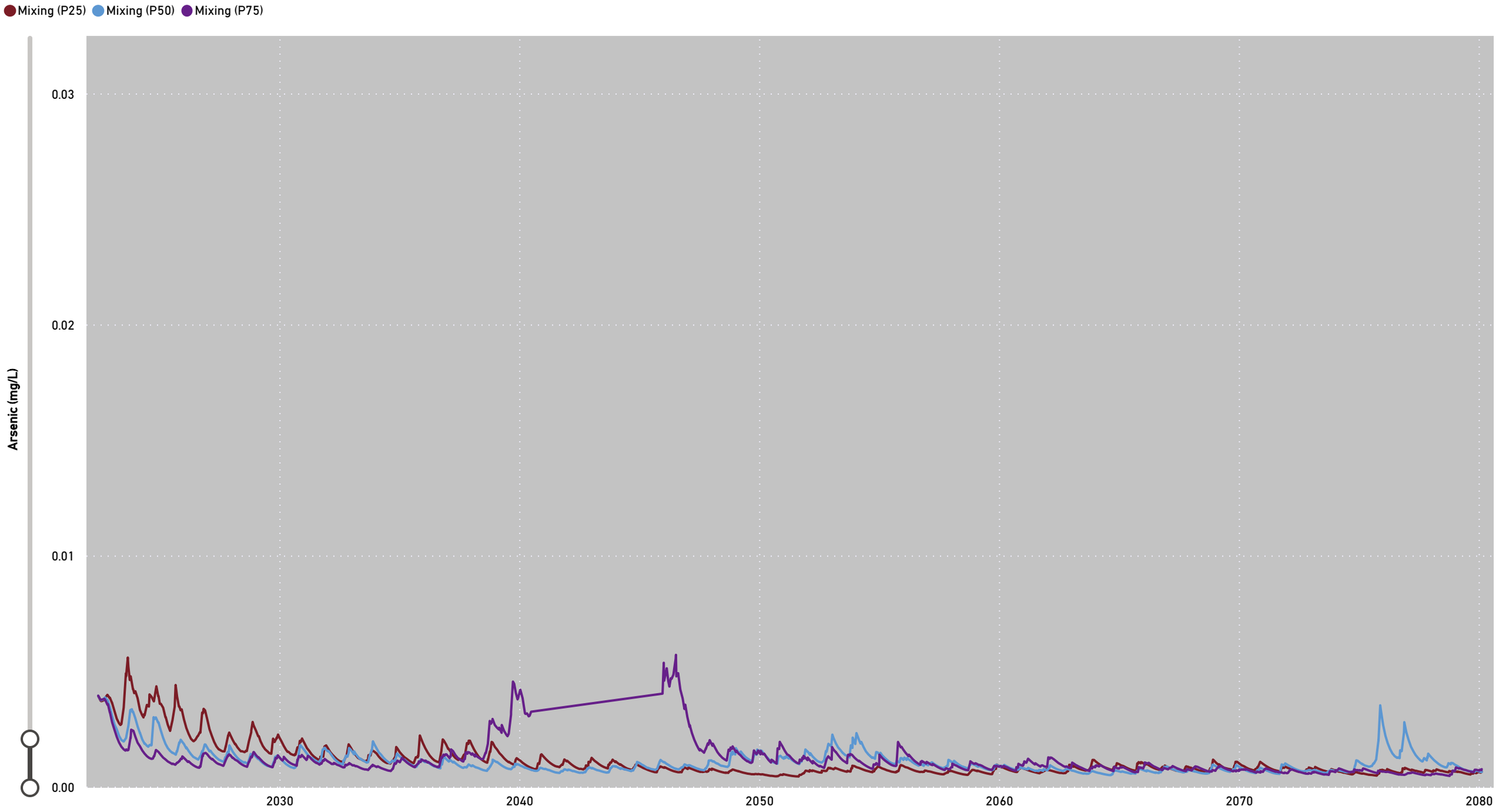

Mixing (P25)
Mixing (P50)
Mixing (P75)
Sodium (mg/L)
150
100
50
0
2030
2040
2050
2060
2070
2080

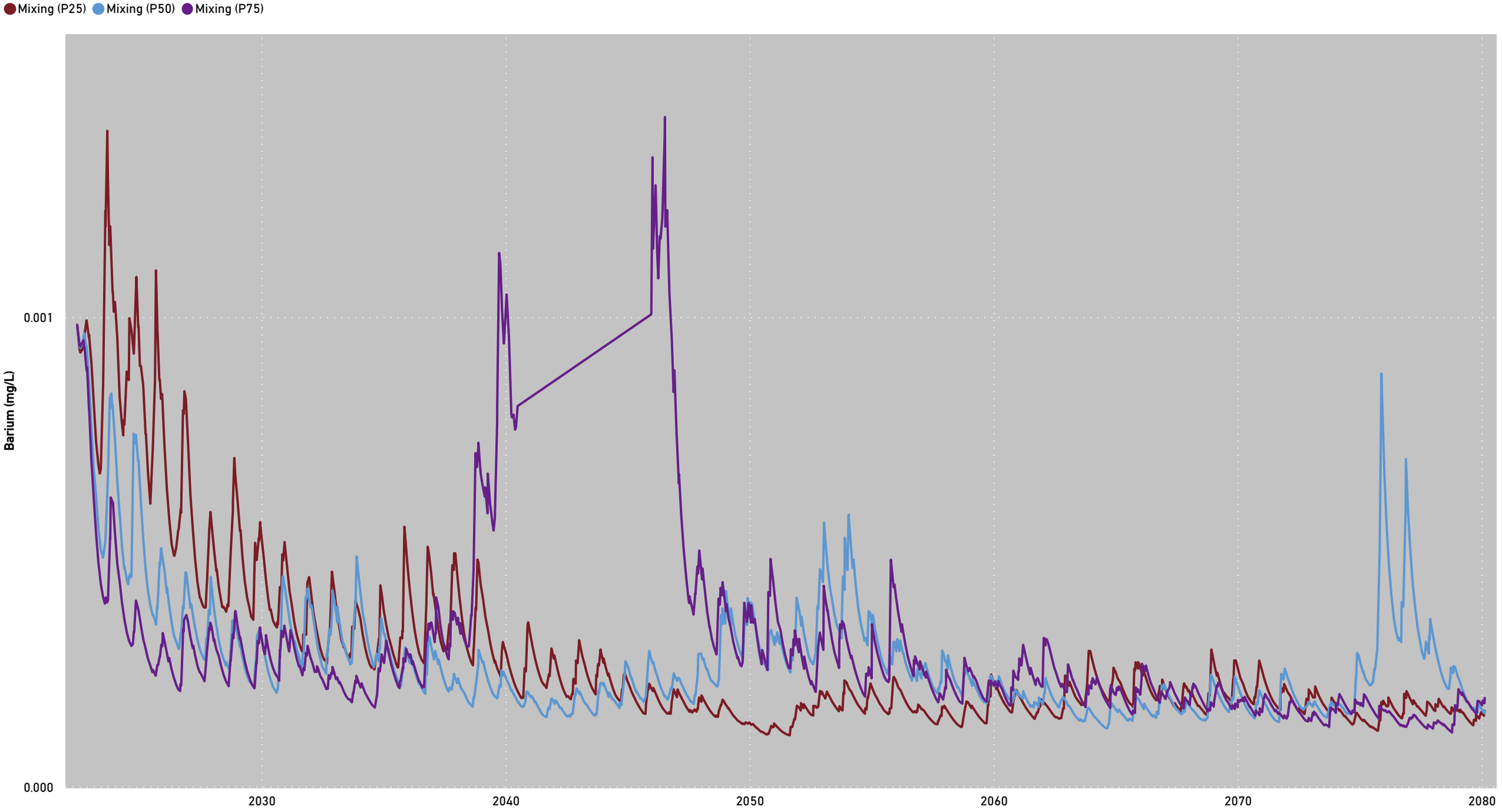

Mixing (P25)
Mixing (P50)
Mixing (P75)
Potassium (mg/L)
0
10
20
30
40
2030
2040
2050
2060
2070
2080

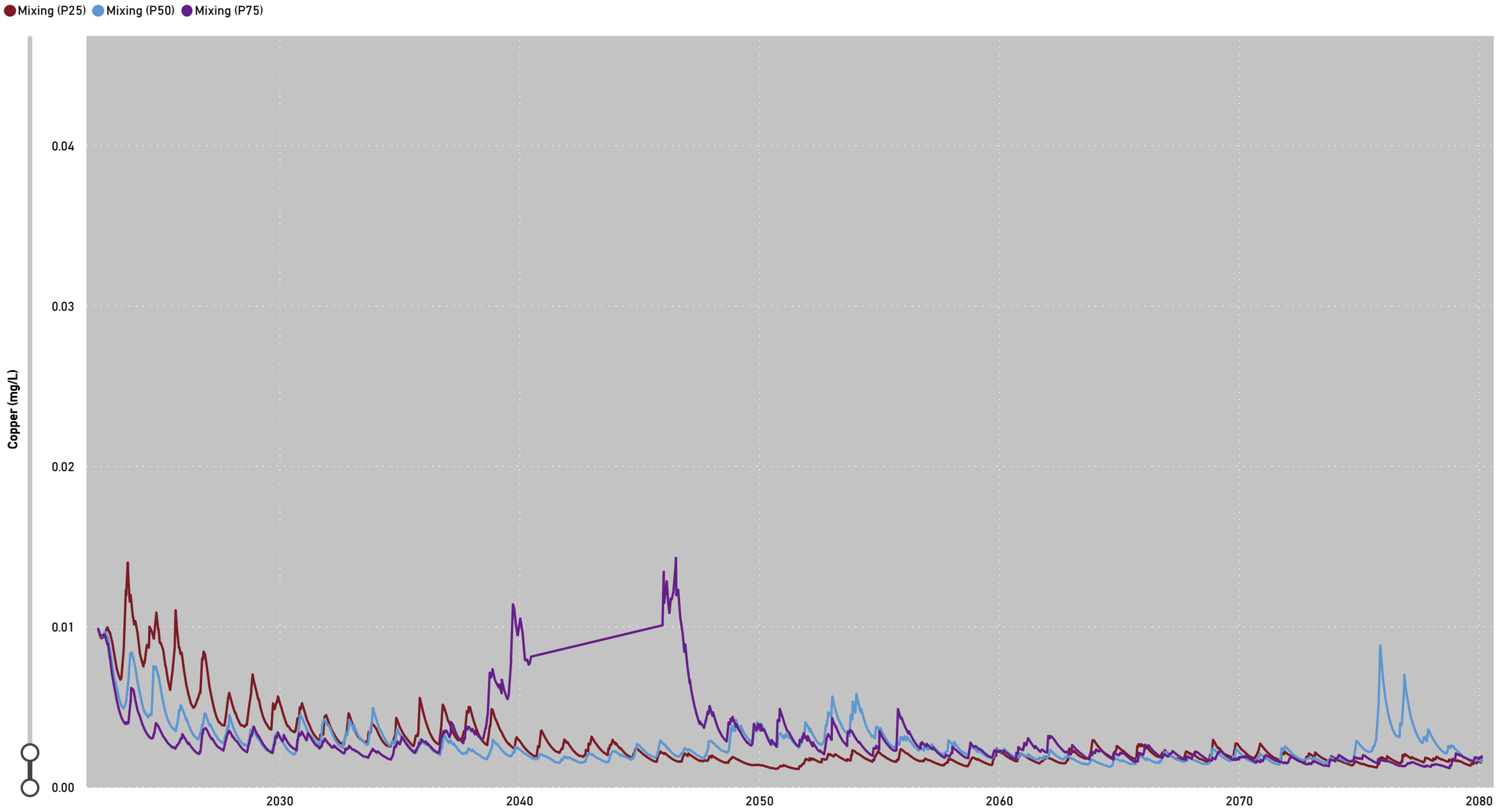

Mixing (P25)
Mixing (P50)
Mixing (P75)
Chloride (mg/L)
0
50
100
150
2030
2040
2050
2060
2070
2080

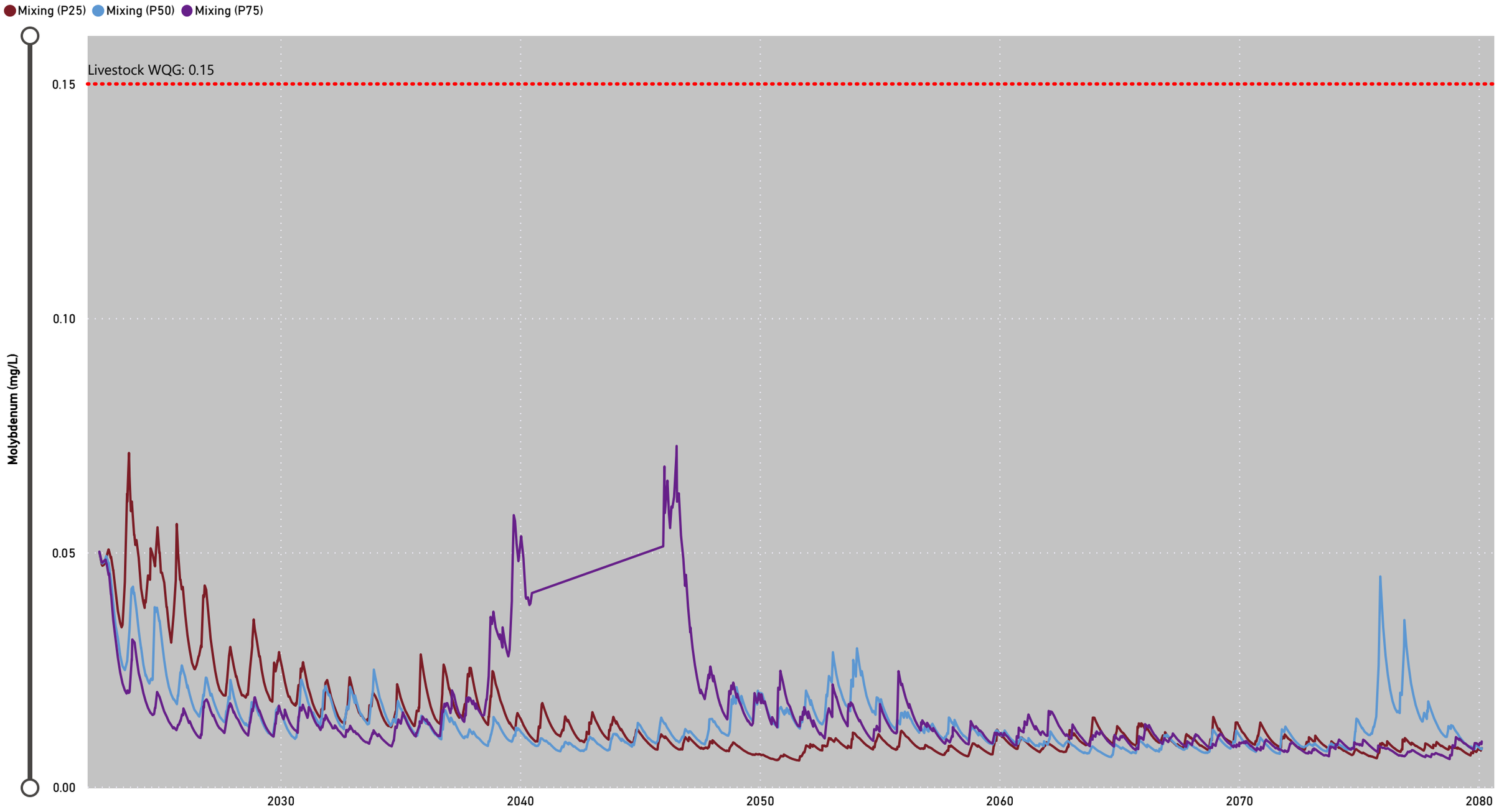

Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 2.00
Fluoride (mg/L)
2.0
1.5
1.0
0.5
0.0
2030
2040
2050
2060
2070
2080

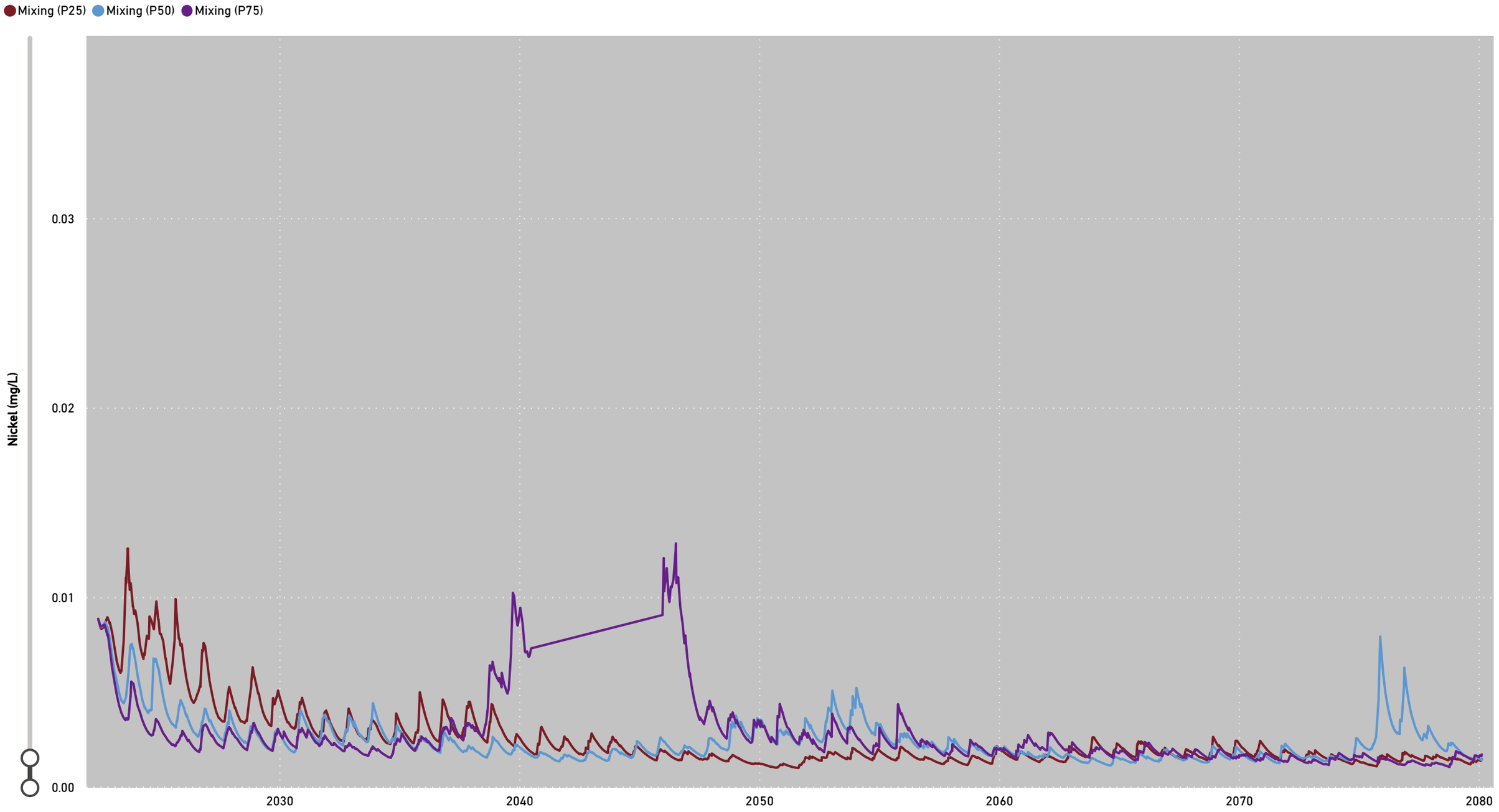

Mixing (P25)
Mixing (P50)
Mixing (P75)
Bicarbonate (mg/L)
0
20
40
60
80
2030
2040
2050
2060
2070
2080

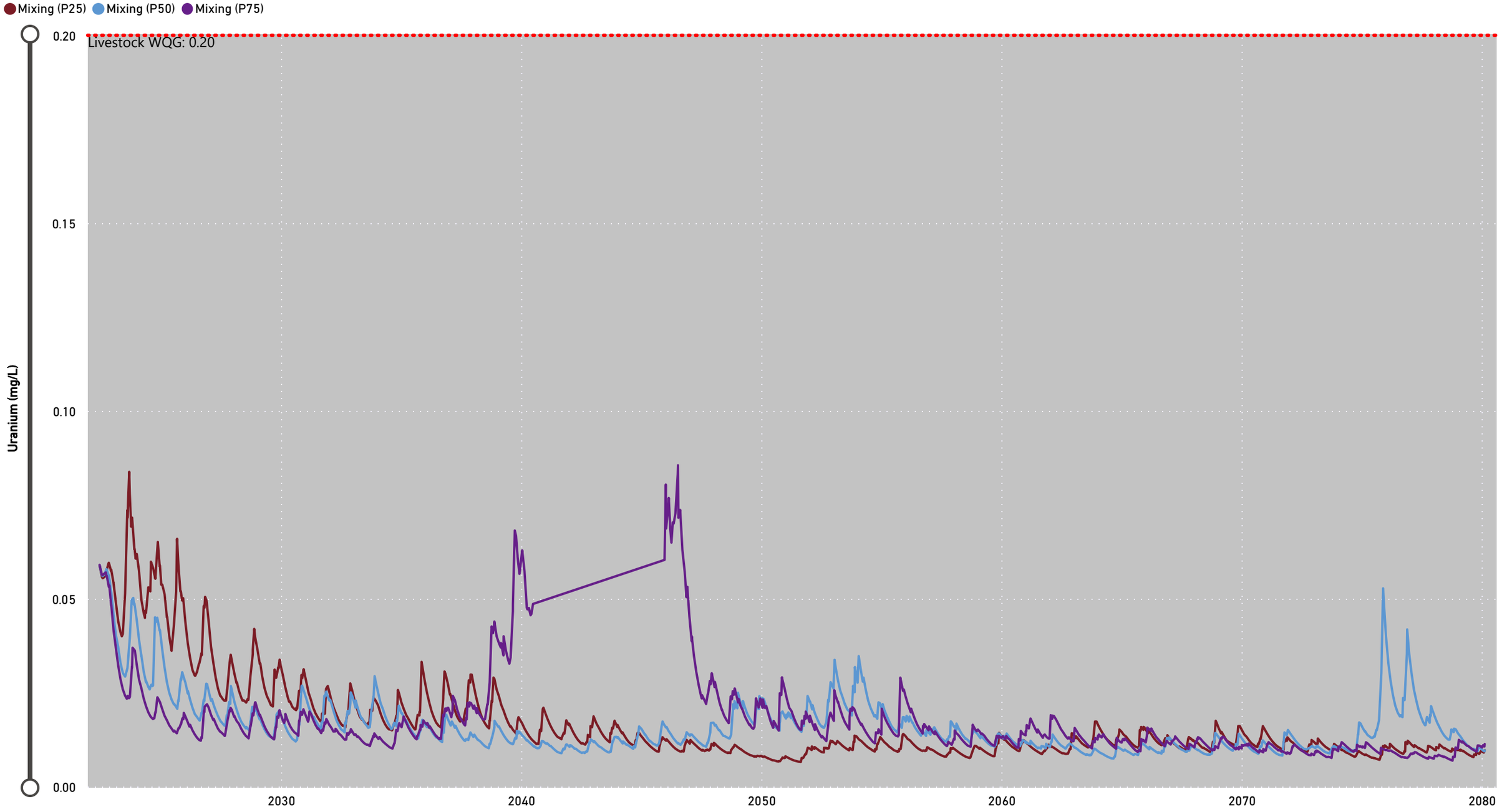

Mixing (P25)
Mixing (P50)
Mixing (P75)
Arsenic (mg/L)
0.03
0.02
0.01
0.00
2030
2040
2050
2060
2070
2080


Mixing (P25)
Mixing (P50)
Mixing (P75)
Barium (mg/L)
0.001
0.000
2030
2040
2050
2060
2070
2080

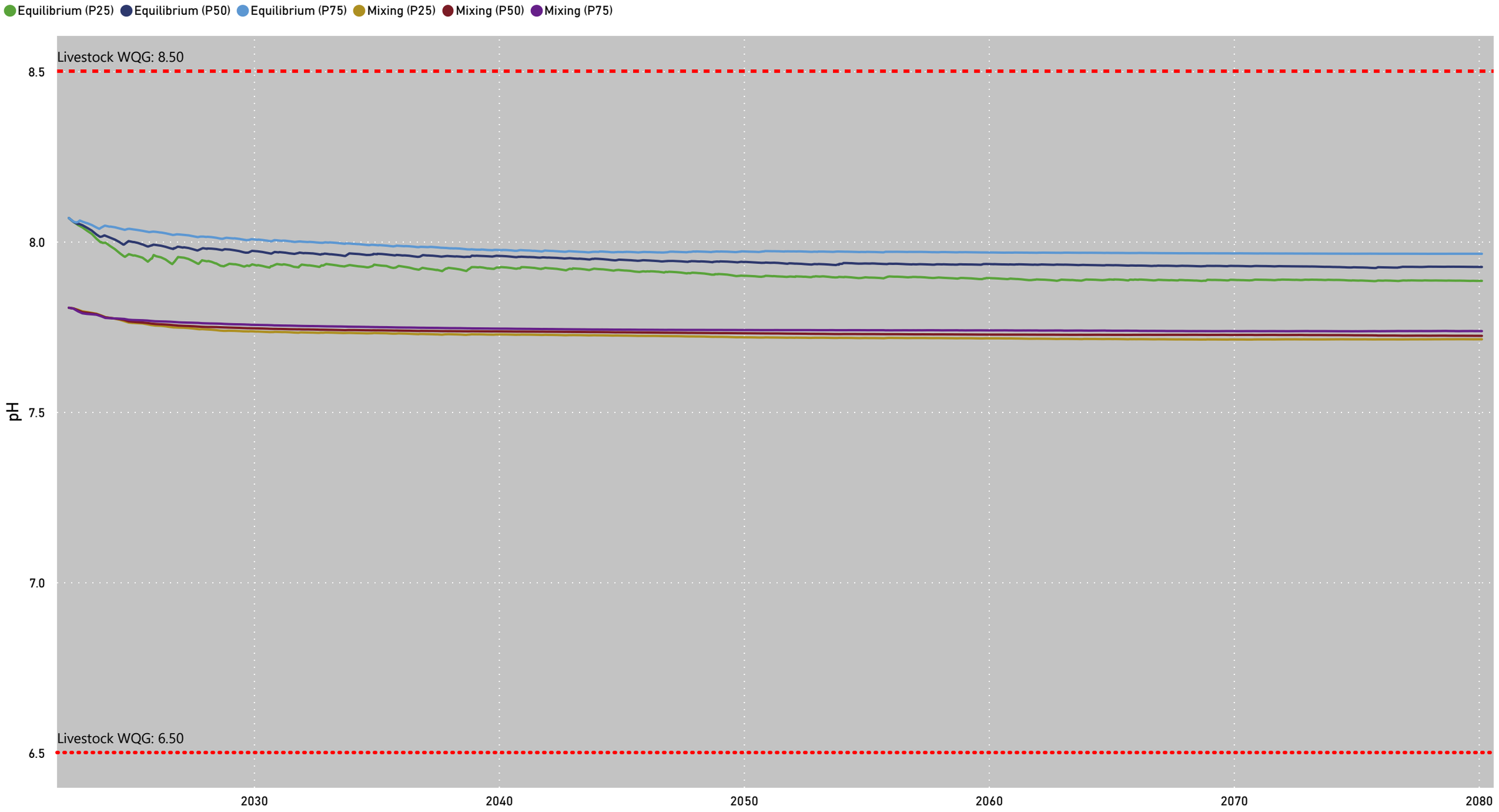

Mixing (P25)
Mixing (P50)
Mixing (P75)
Copper (mg/L)
0.04
0.03
0.02
0.01
0.00
2030
2040
2050
2060
2070
2080

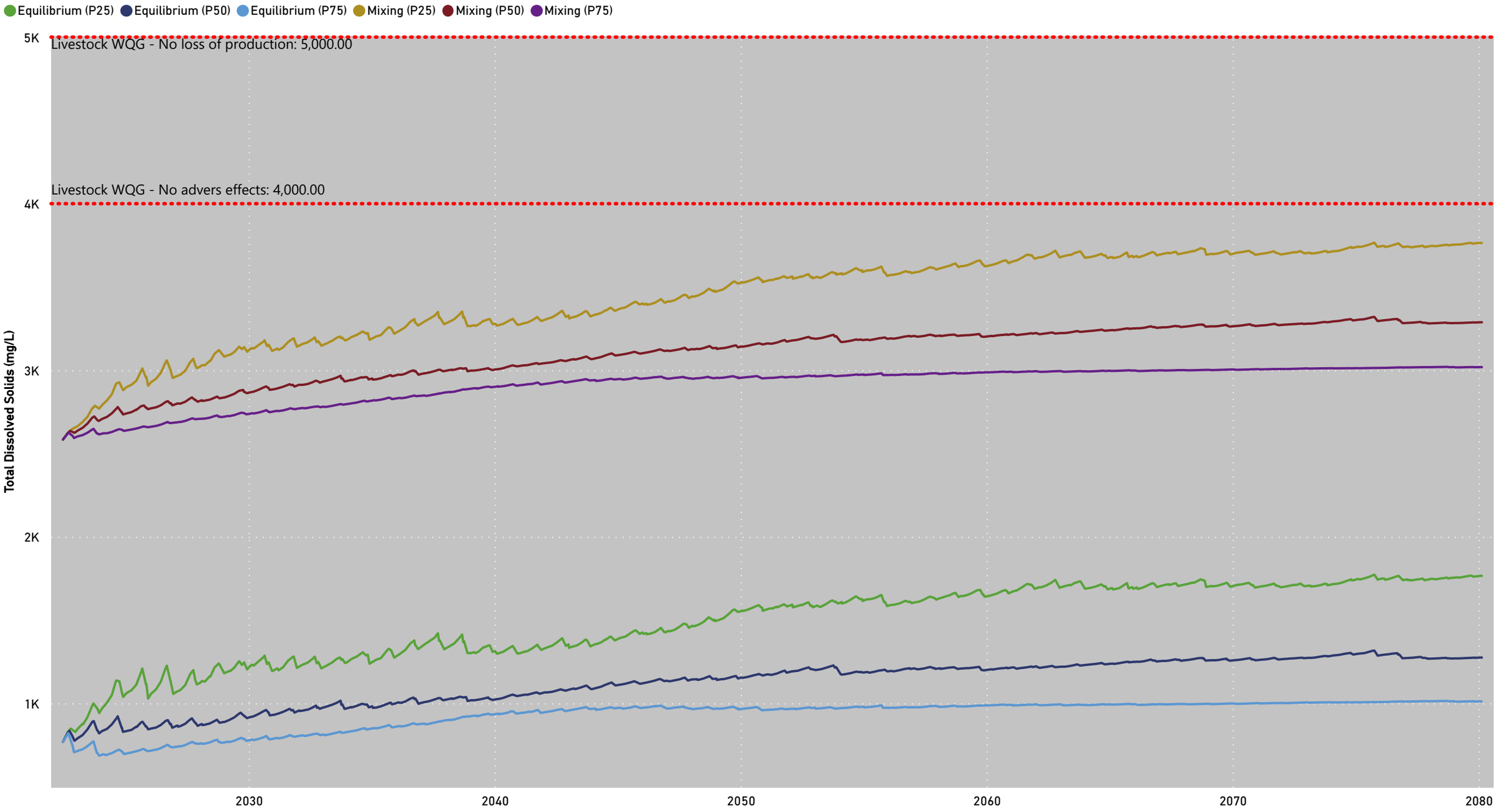

Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 0.15
0.15
0.10
0.05
0.00
Molybdenum (mg/L)
2030
2040
2050
2060
2070
2080

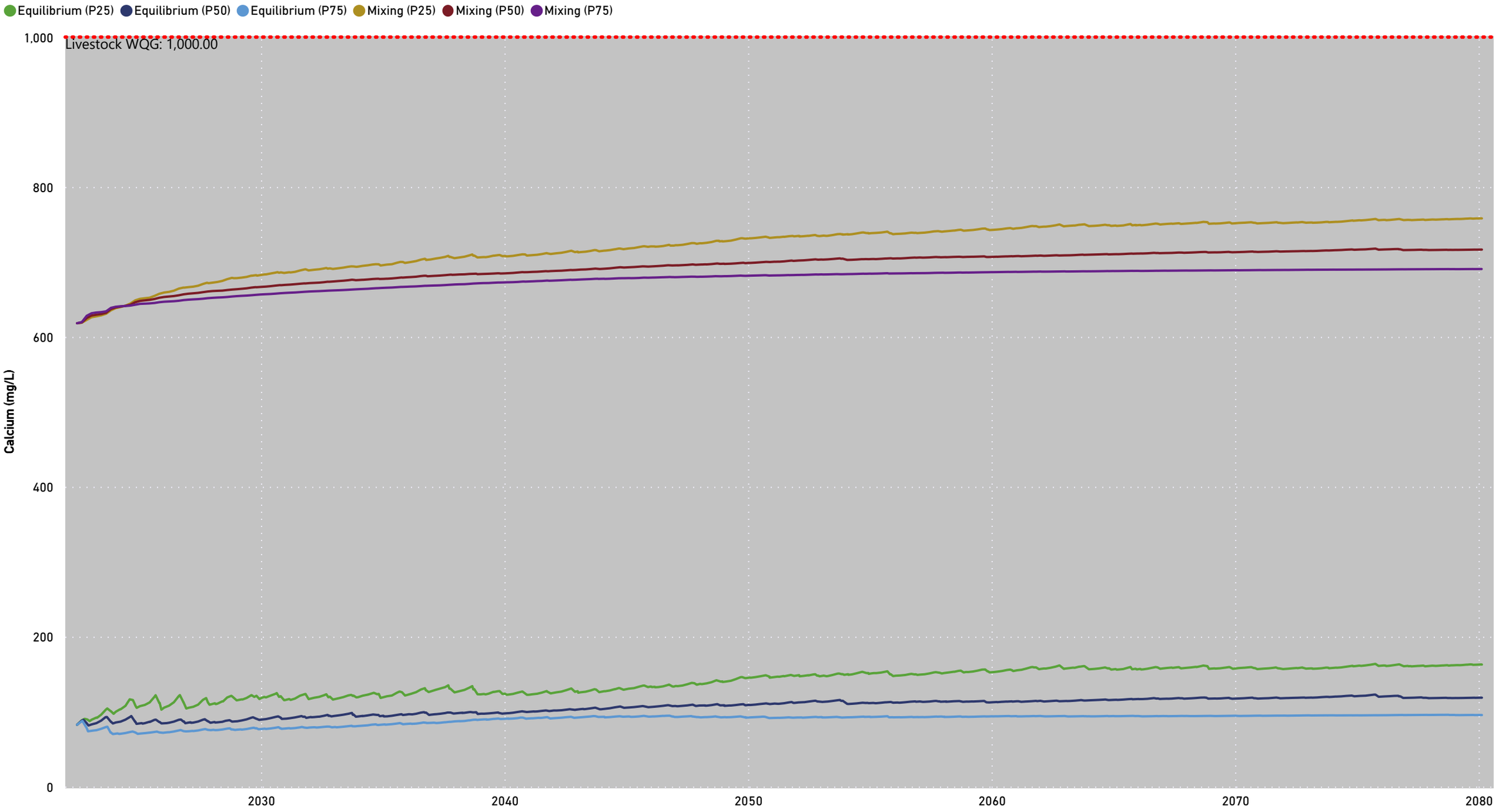

Mixing (P25)
Mixing (P50)
Mixing (P75)
Nickel (mg/L)
0.03
0.02
0.01
0.00
2030
2040
2050
2060
2070
2080

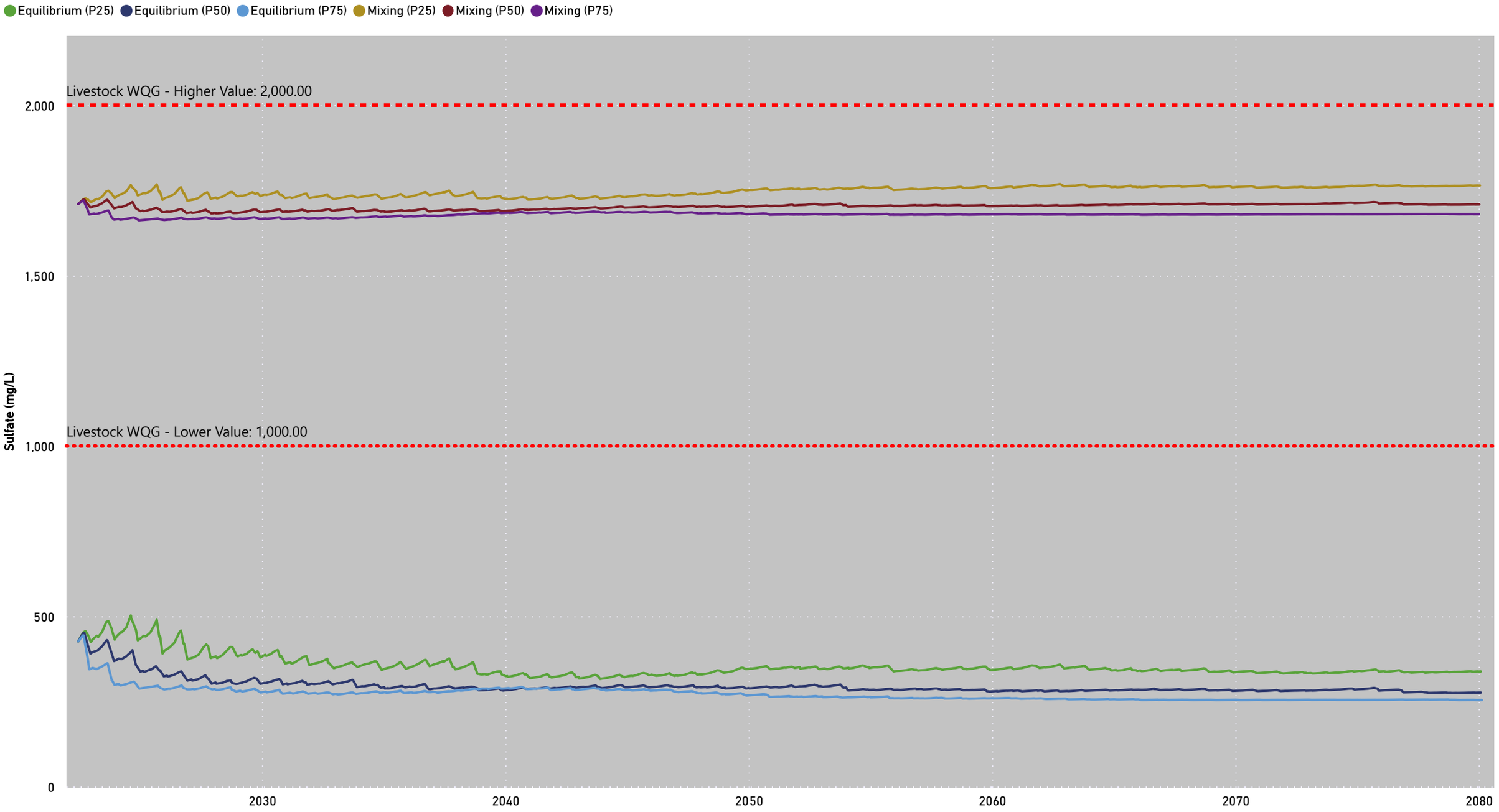

Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 0.20
Uranium (mg/L)
0.20
0.15
0.10
0.05
0.00
2030
2040
2050
2060
2070
2080

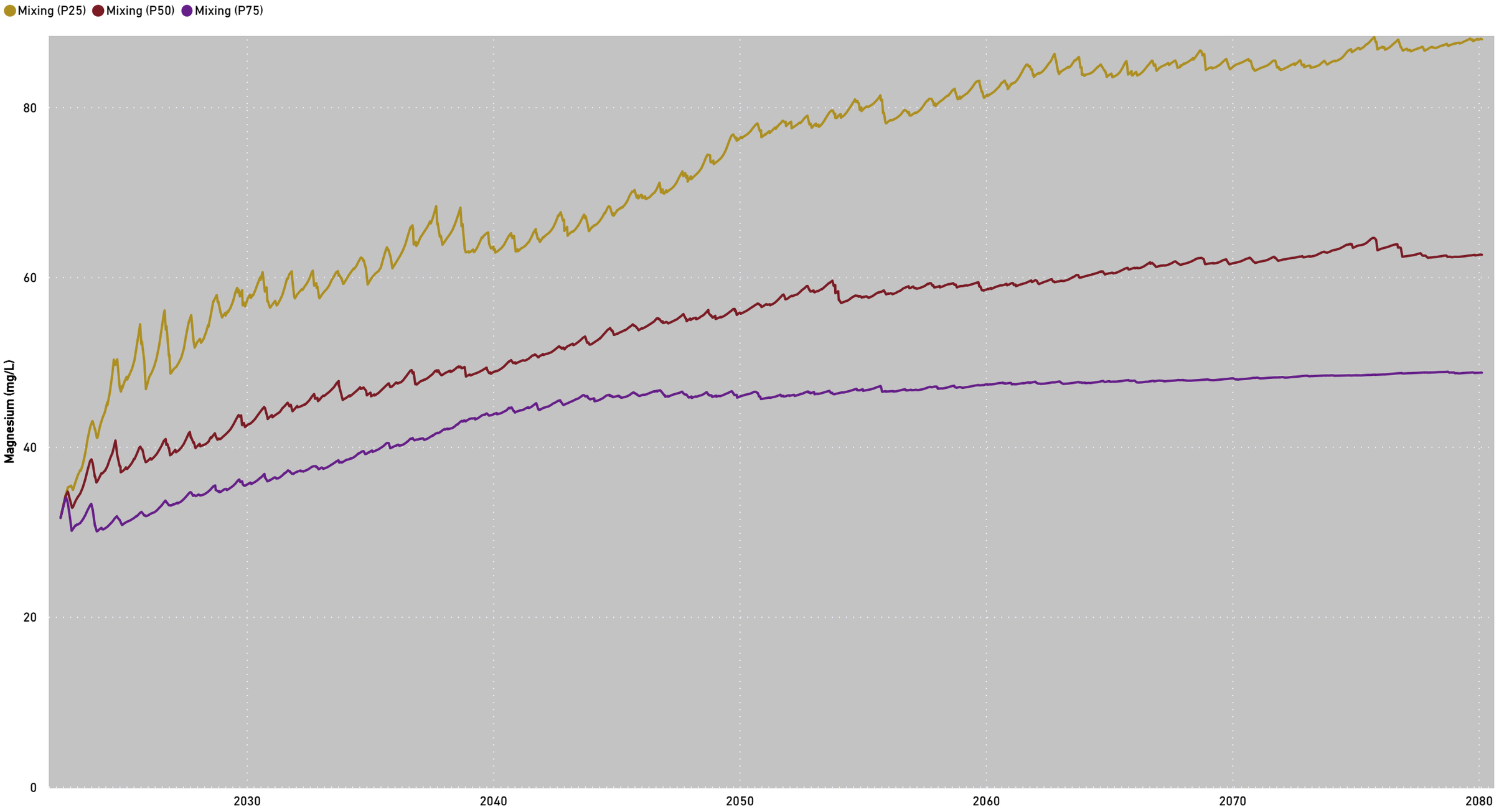
J.7.2 North Pit modelled long-term water quality

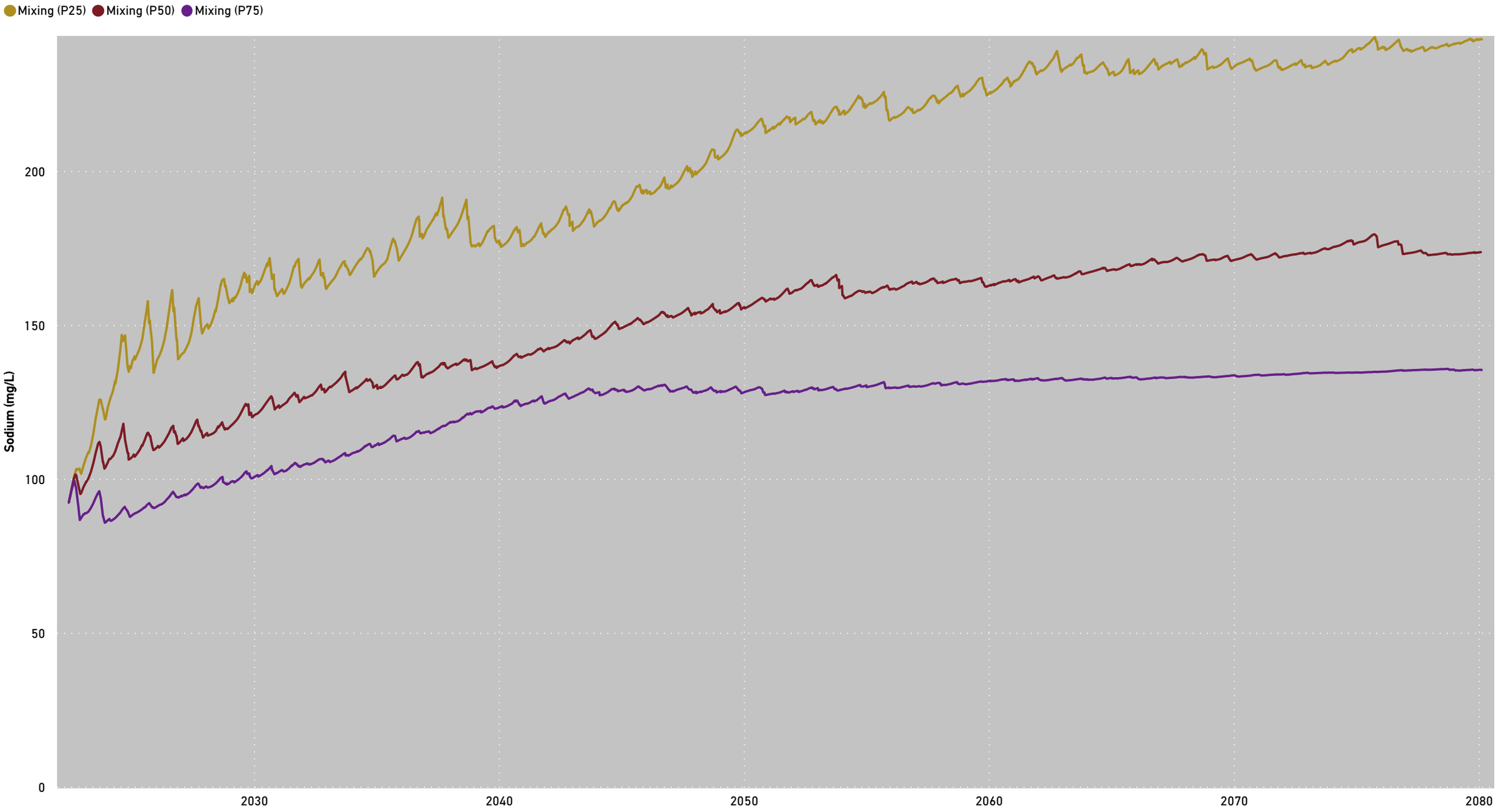

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 8.50
Livestock WQG: 6.50
pH
8.5
8.0
7.5
7.0
6.5
2030
2040
2050
2060
2070
2080

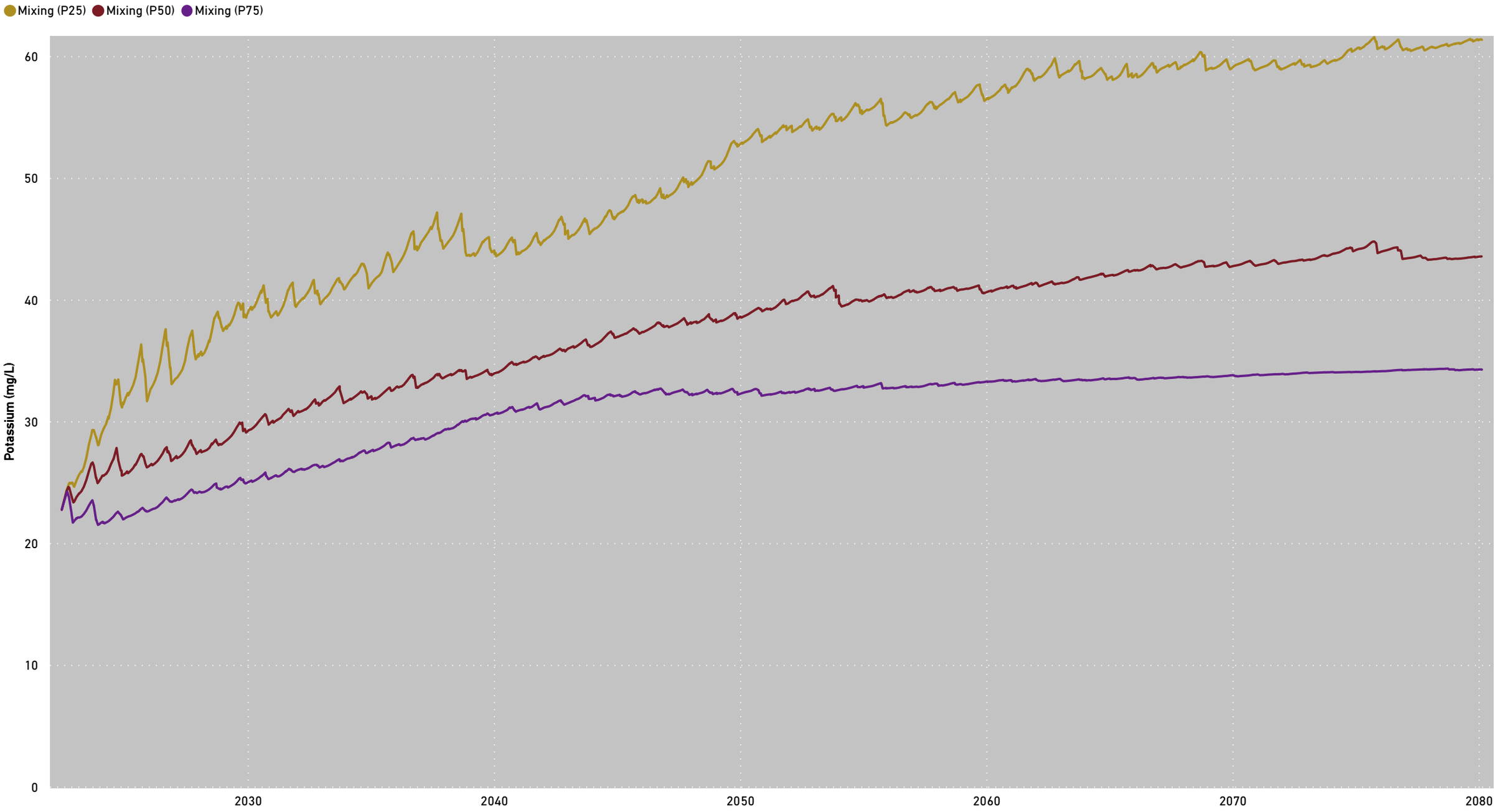

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG - No loss of production: 5,000.00
Livestock WQG - No advers effects: 4,000.00
Total Dissolved Solids (mg/L)
5K
4K
3K
2K
1K
2030
2040
2050
2060
2070
2080

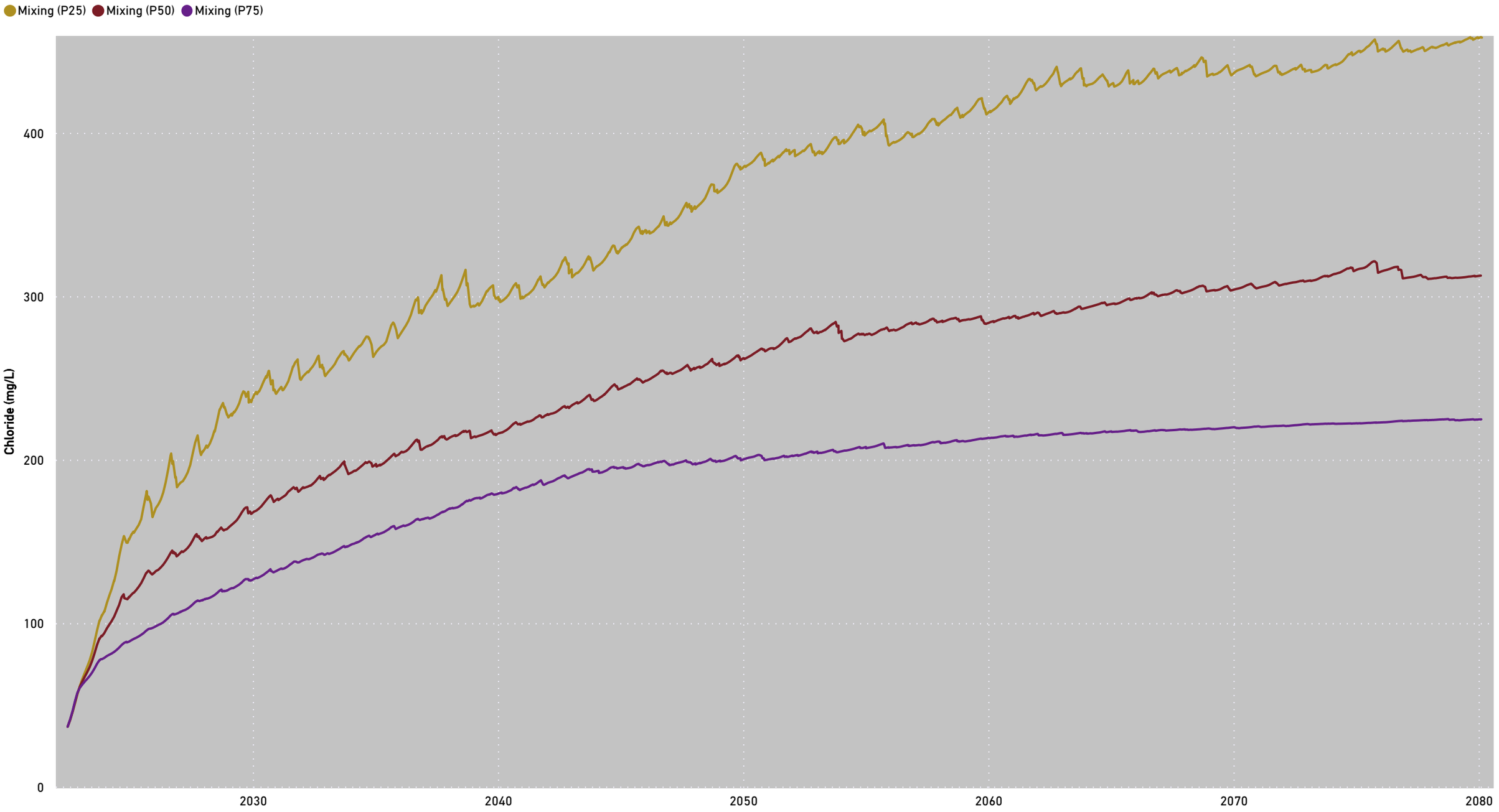

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 1,000.00
Calcium (mg/L)
1,000
800
600
400
200
0
2030
2040
2050
2060
2070
2080

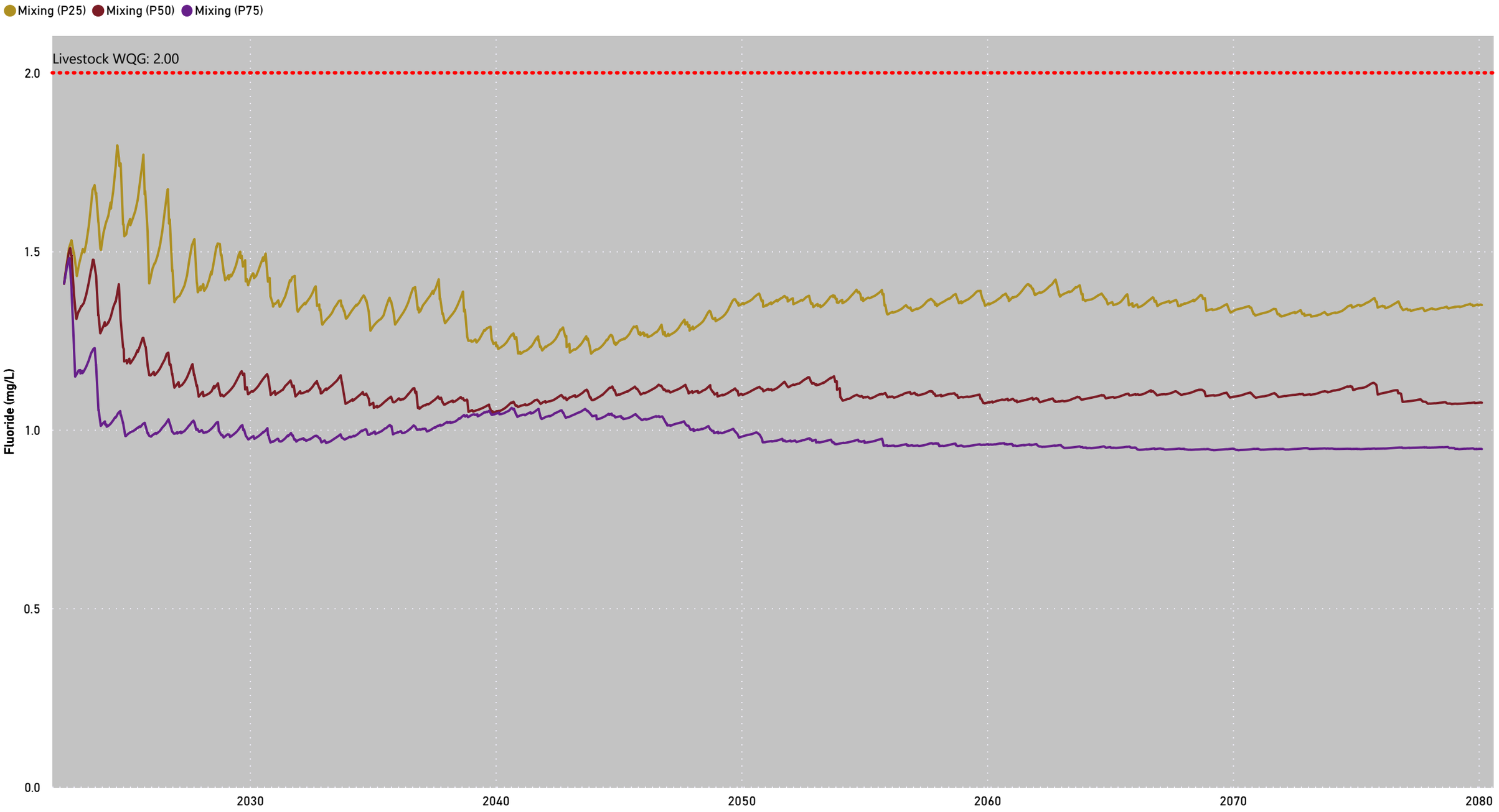

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG - Higher Value: 2,000.00
Livestock WQG - Lower Value: 1,000.00
Sulfate (mg/L)
2,000
1,500
1,000
500
0
2030
2040
2050
2060
2070
2080

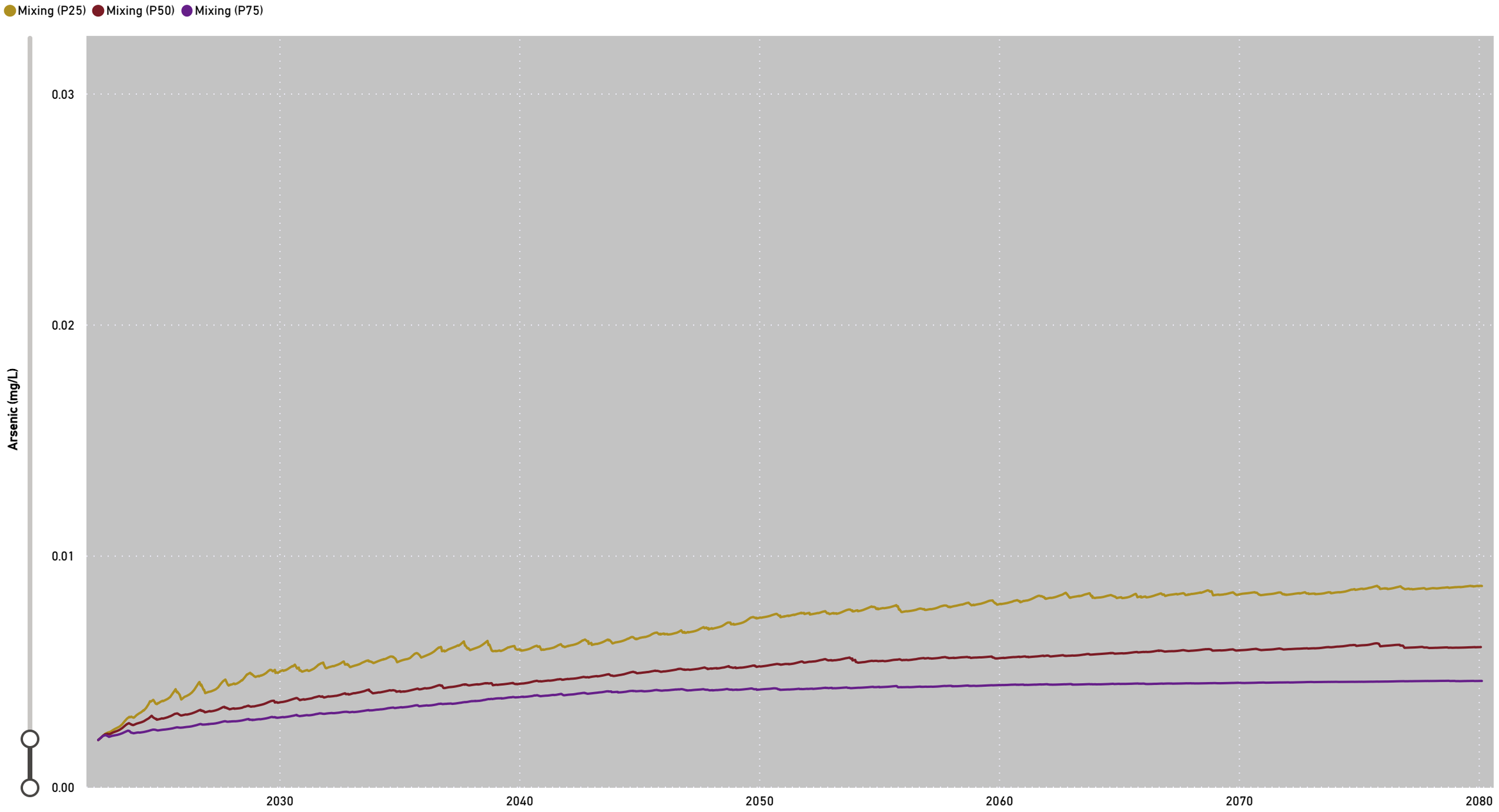

Mixing (P25)
Mixing (P50)
Mixing (P75)
Magnesium (mg/L)
0
20
40
60
80
2030
2040
2050
2060
2070
2080

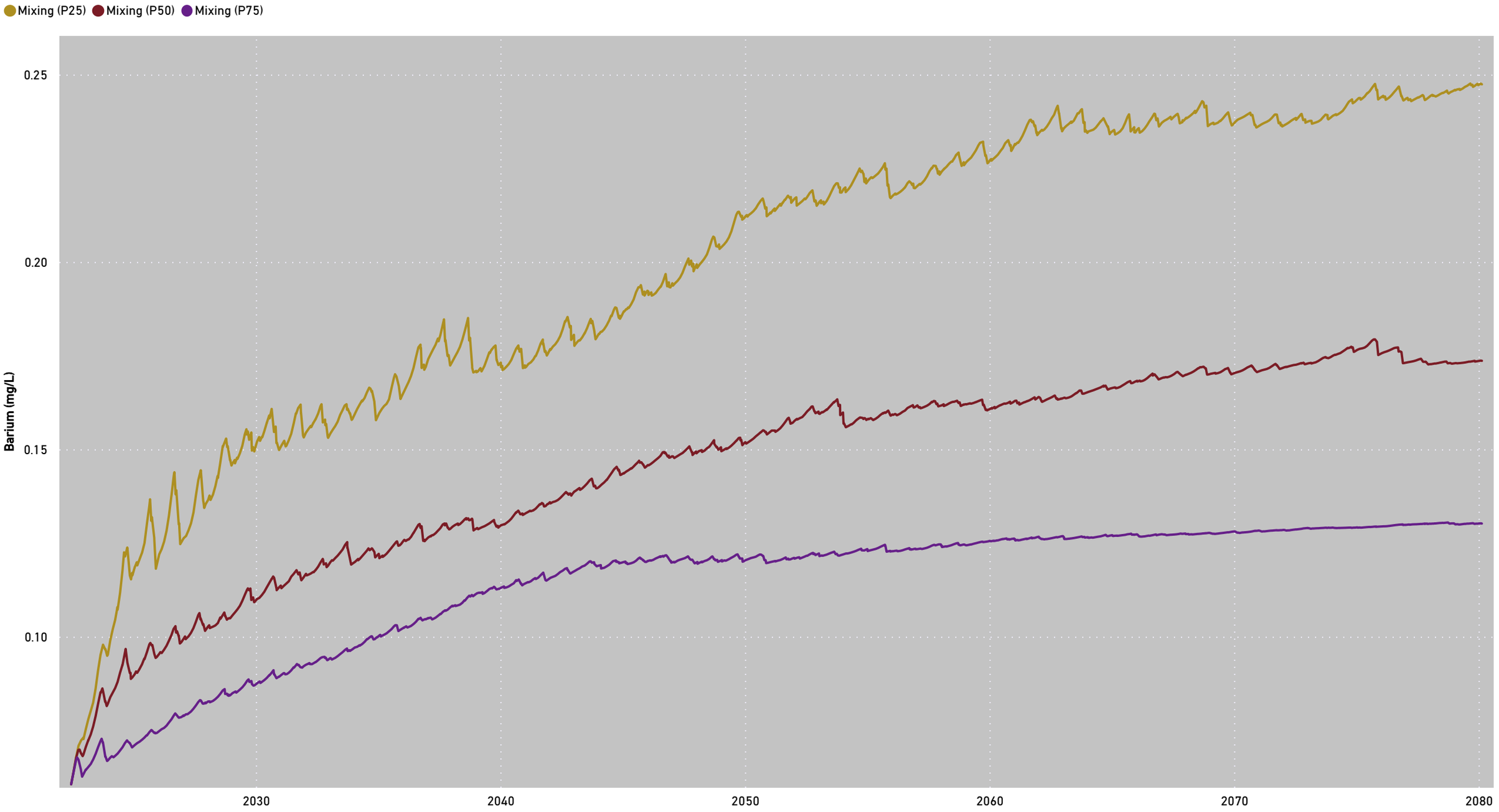

Mixing (P25)
Mixing (P50)
Mixing (P75)
Sodium (mg/L)
0
50
100
150
200
2030
2040
2050
2060
2070
2080

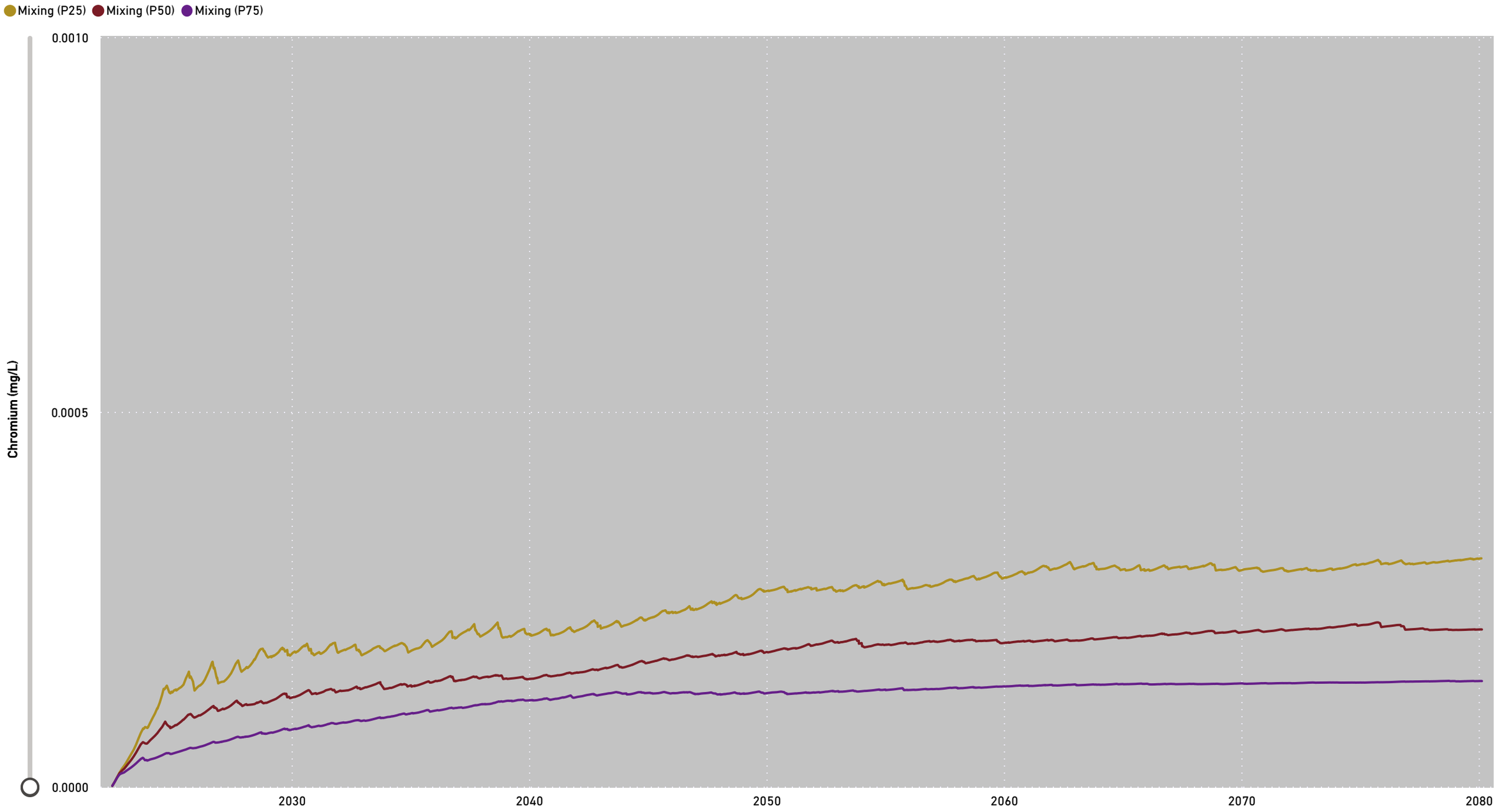

Mixing (P25)
Mixing (P50)
Mixing (P75)
Potassium (mg/L)
60
50
40
30
20
10
0
2030
2040
2050
2060
2070
2080

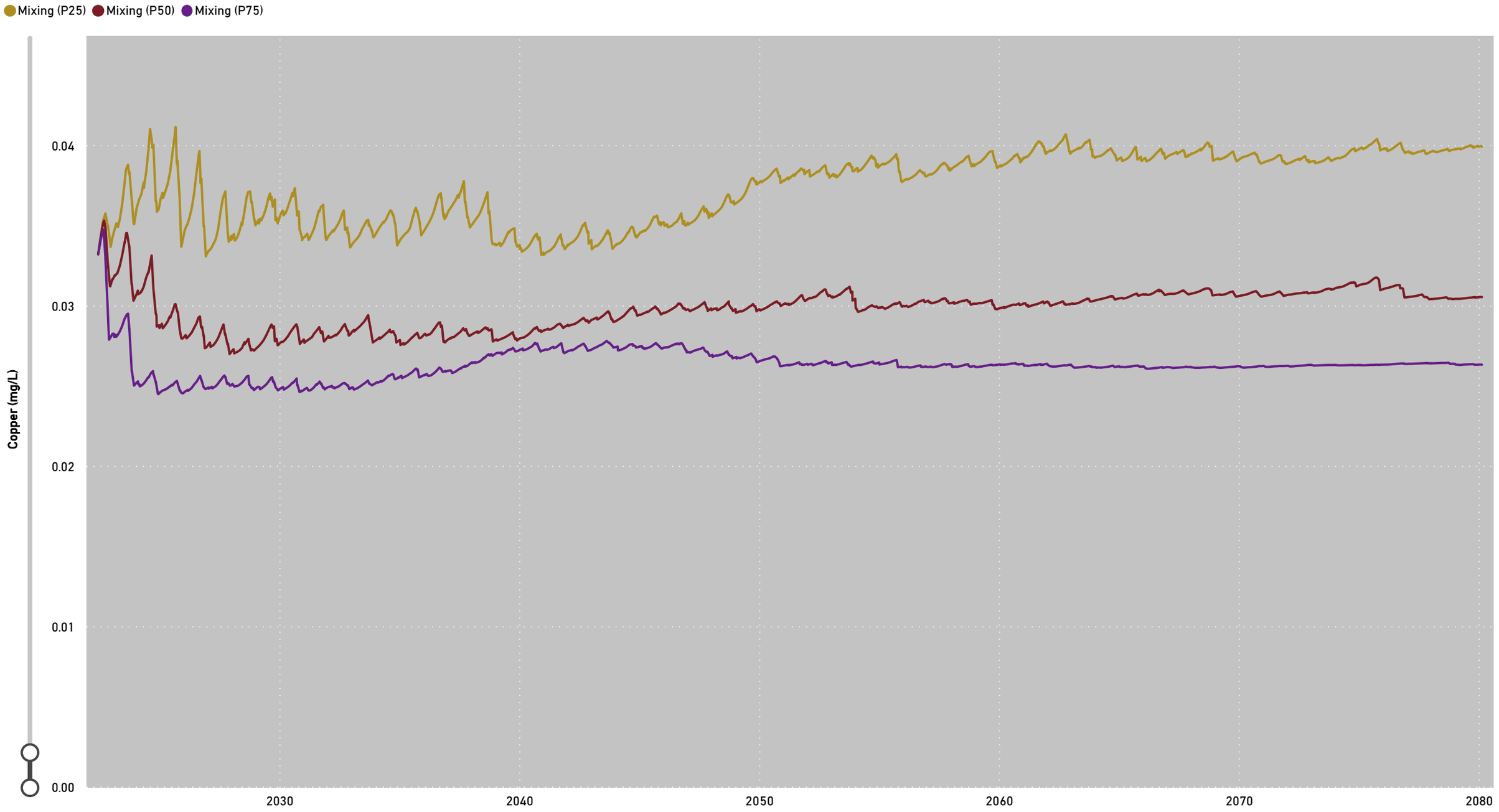

Mixing (P25)
Mixing (P50)
Mixing (P75)
Chloride (mg/L)
0
100
200
300
400
2030
2040
2050
2060
2070
2080

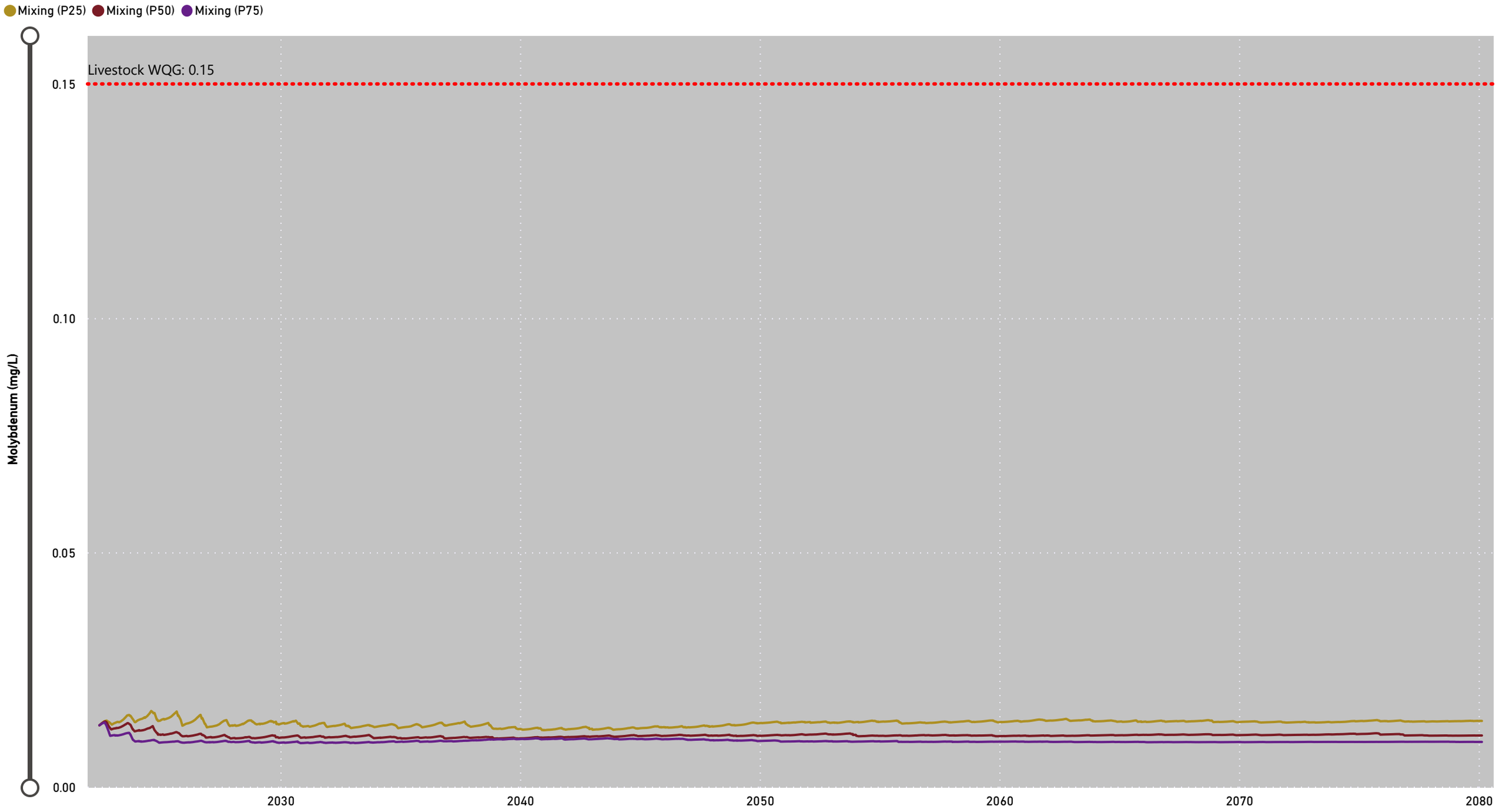

Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 2.00
2.0
1.5
1.0
0.5
0.0
Fluoride (mg/L)
2030
2040
2050
2060
2070
2080

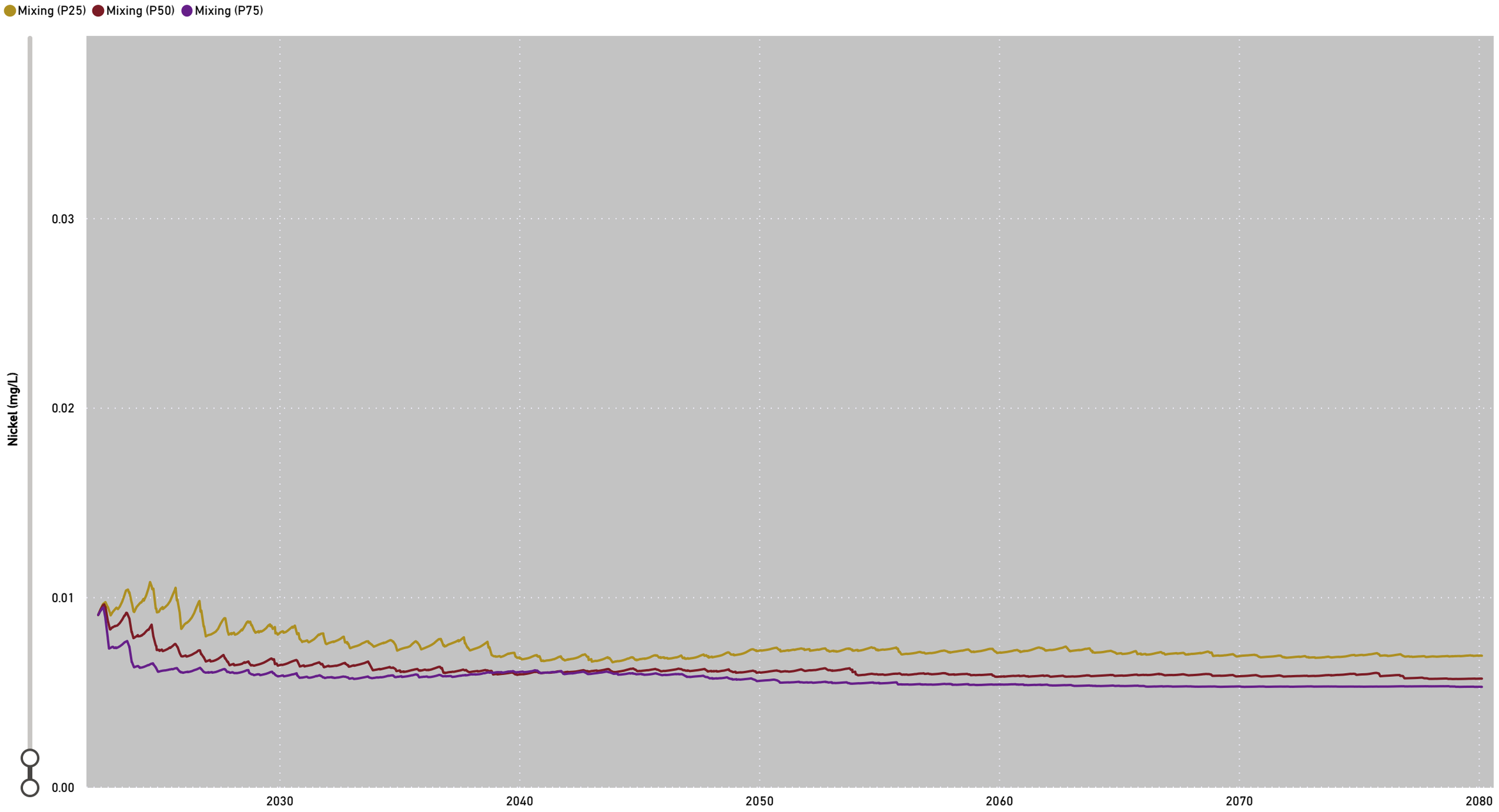

Mixing (P25)
Mixing (P50)
Mixing (P75)
Arsenic (mg/L)
0.03
0.02
0.01
0.00
2030
2040
2050
2060
2070
2080

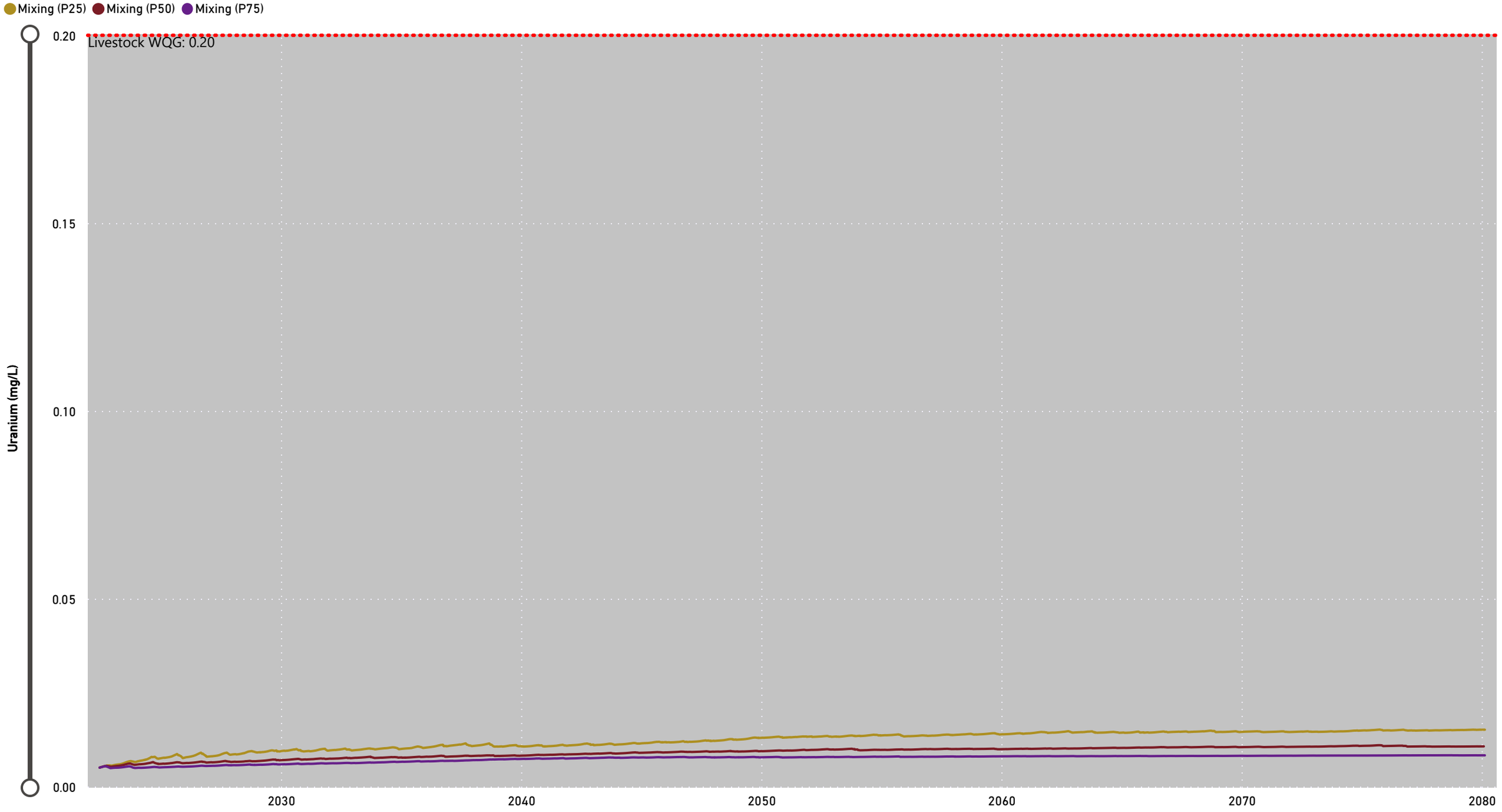

Mixing (P25)
Mixing (P50)
Mixing (P75)
Barium (mg/L)
0.25
0.20
0.15
0.10
2030
2040
2050
2060
2070
2080


Mixing (P25)
Mixing (P50)
Mixing (P75)
Chromium (mg/L)
0.0010
0.0005
0.0000
2030
2040
2050
2060
2070
2080

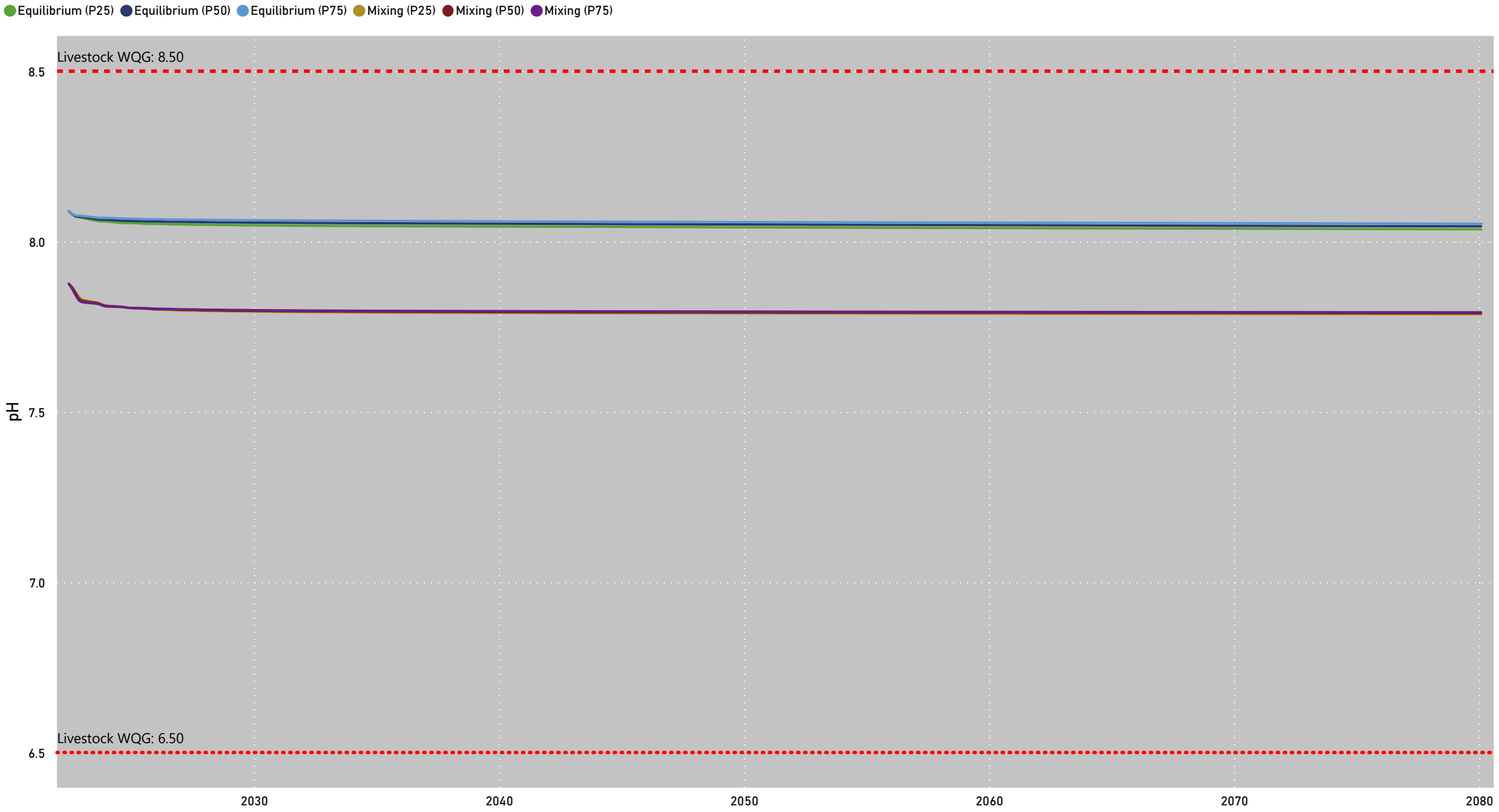

Mixing (P25)
Mixing (P50)
Mixing (P75)
Copper (mg/L)
0.04
0.03
0.02
0.01
0.00
2030
2040
2050
2060
2070
2080

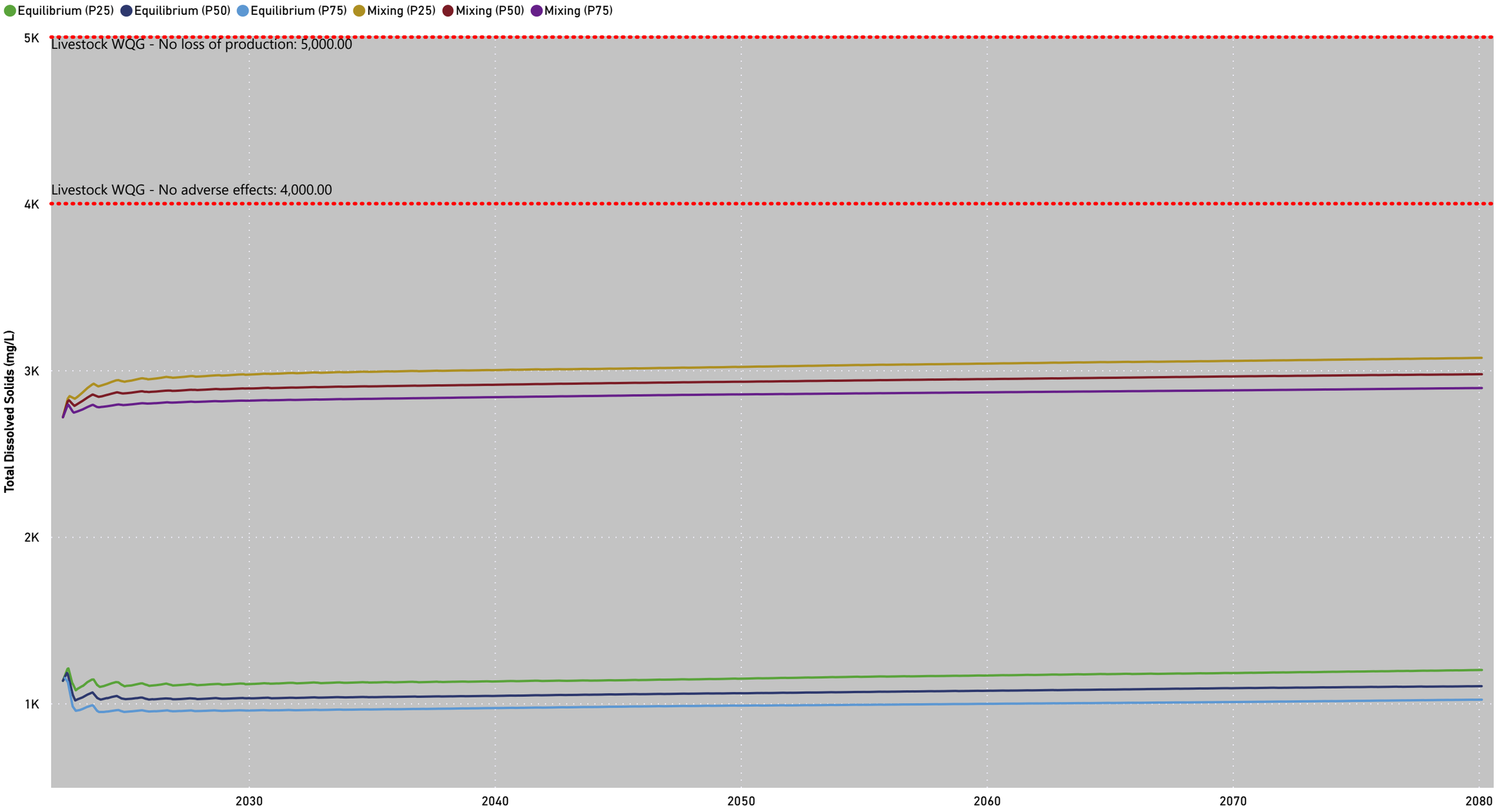

Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 0.15
Molybdenum (mg/L)
0.15
0.10
0.05
0.00
2030
2040
2050
2060
2070
2080

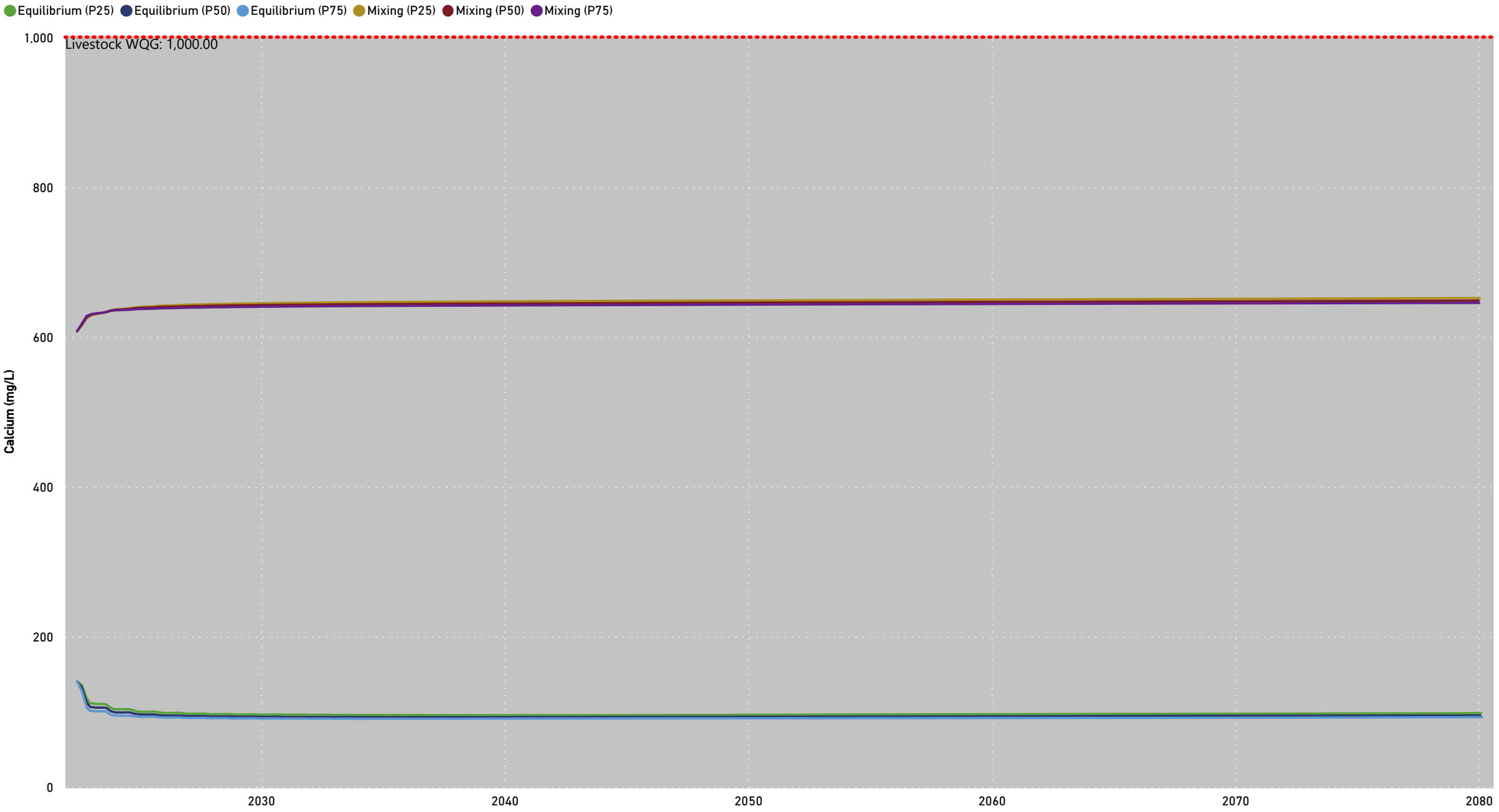

Mixing (P25)
Mixing (P50)
Mixing (P75)
Nickel (mg/L)
0.03
0.02
0.01
0.00
2030
2040
2050
2060
2070
2080

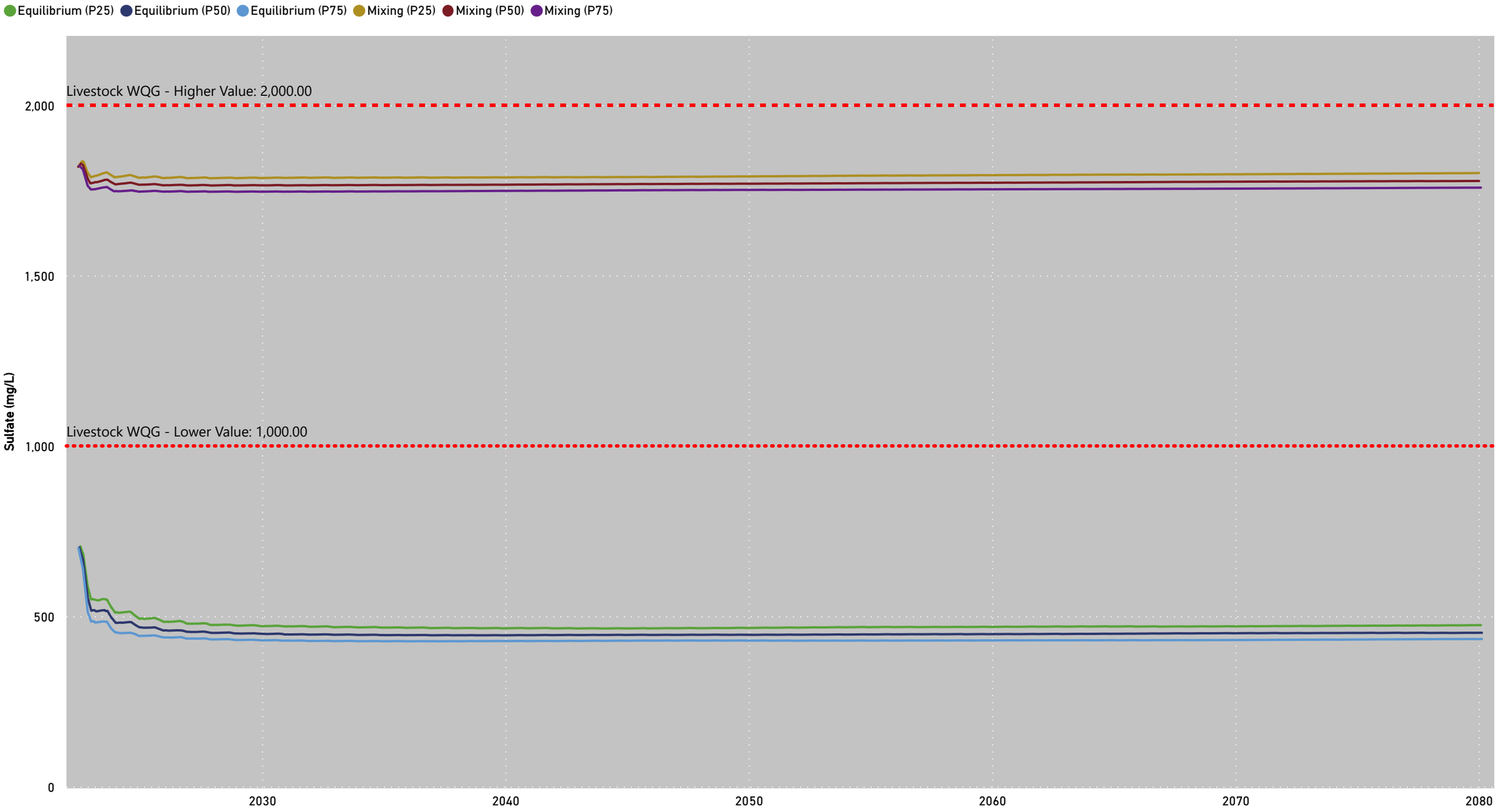

Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 0.20
Uranium (mg/L)
0.20
0.15
0.10
0.05
0.00
2030
2040
2050
2060
2070
2080

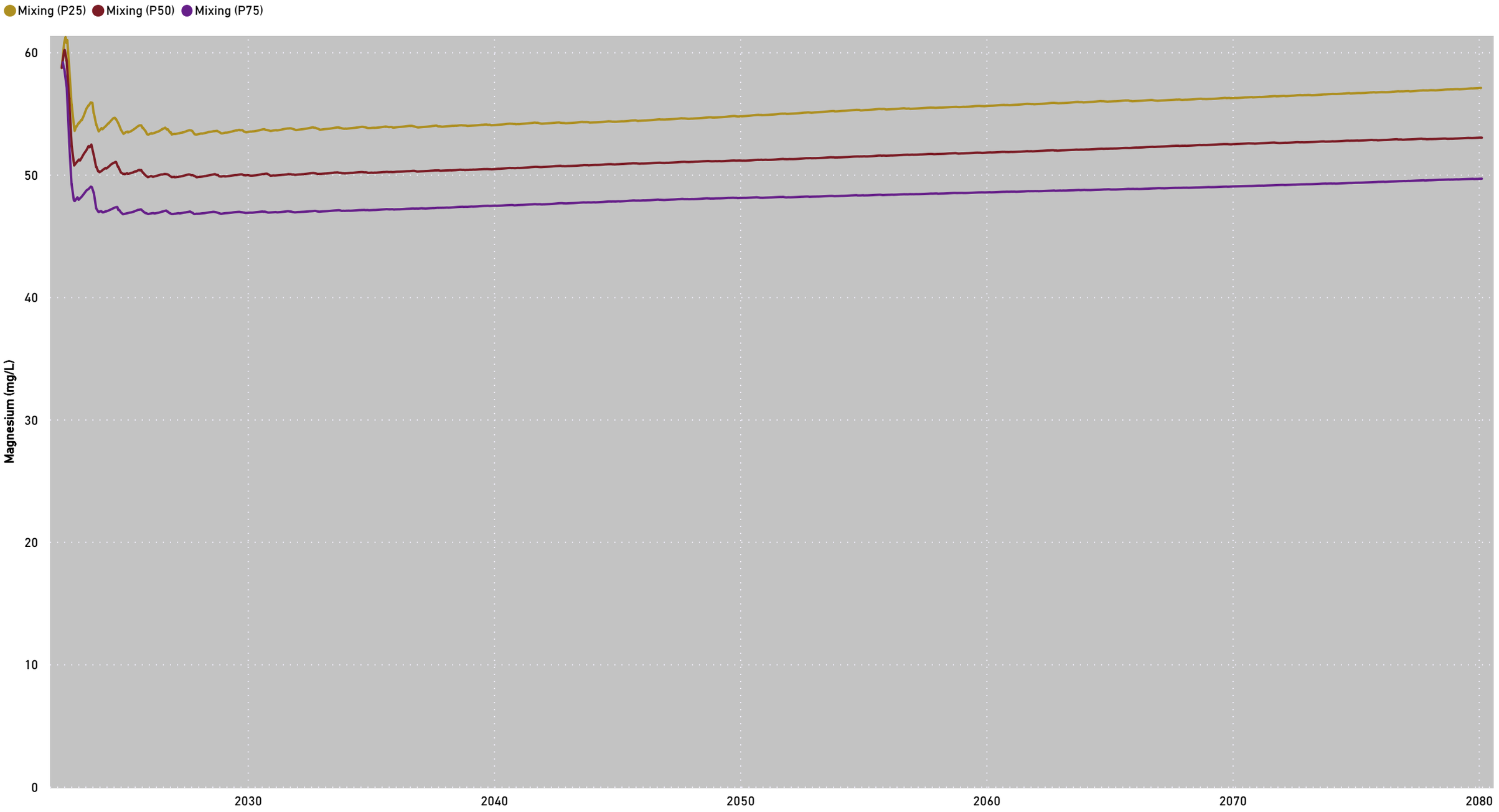
J.7.3 South Pit modelled long-term water quality (scenario 1)

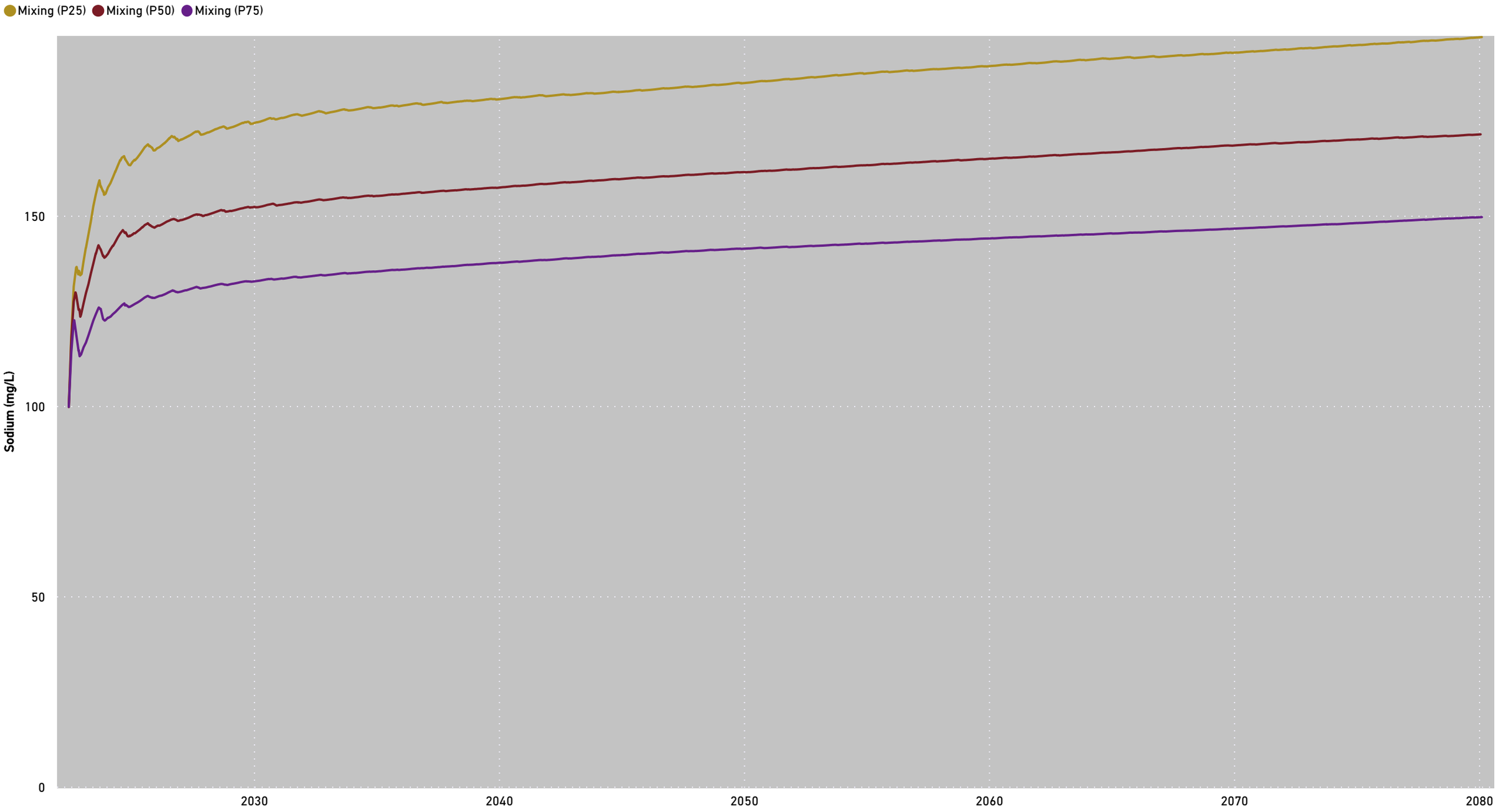

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 8.50
Livestock WQG: 6.50
pH
8.5
8.0
7.5
7.0
6.5
2030
2040
2050
2060
2070
2080

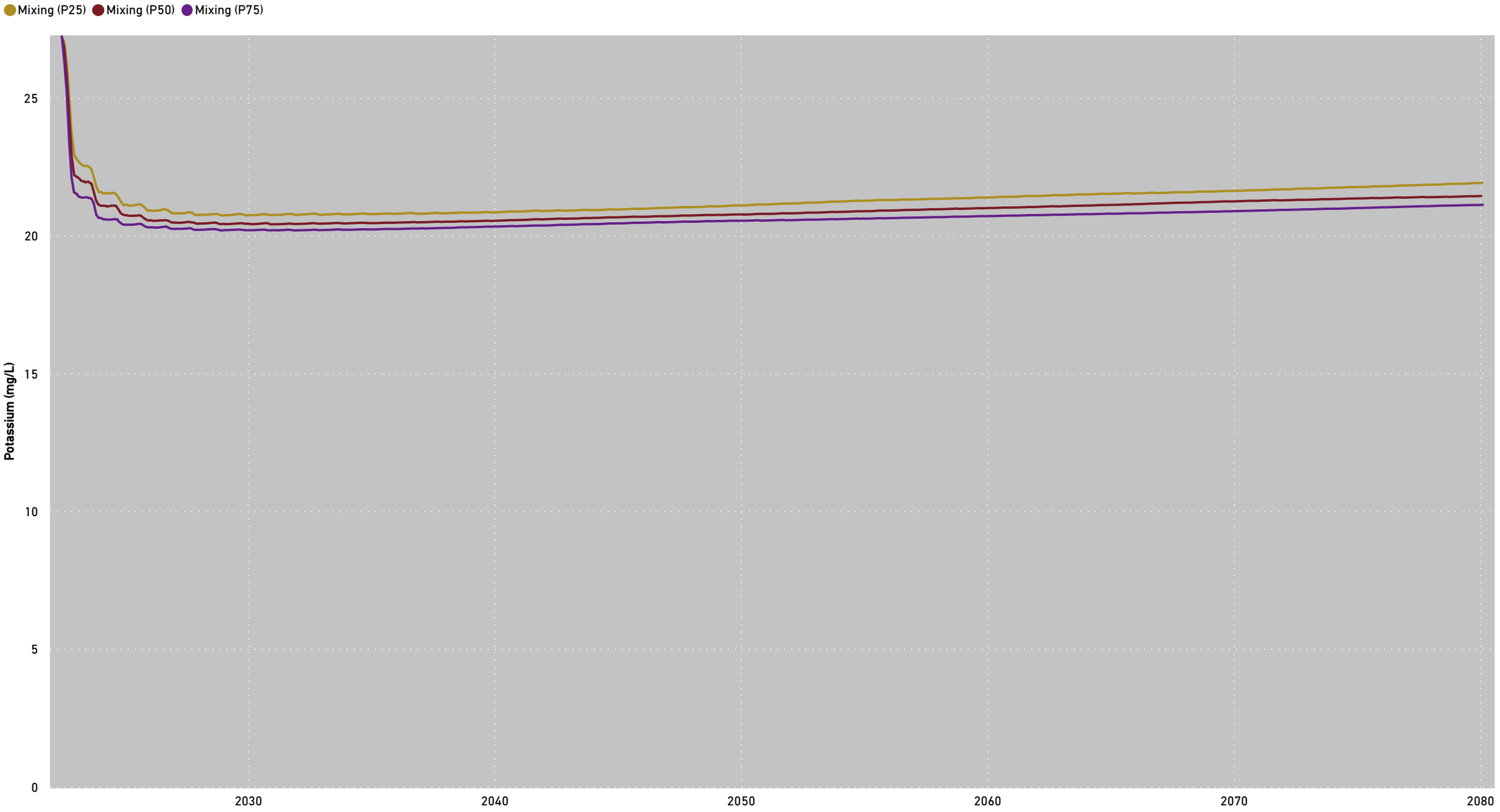

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG - No loss of production: 5,000.00
Livestock WQG - No adverse effects: 4,000.00
Total Dissolved Solids (mg/L)
5K
4K
3K
2K
1K
2030
2040
2050
2060
2070
2080

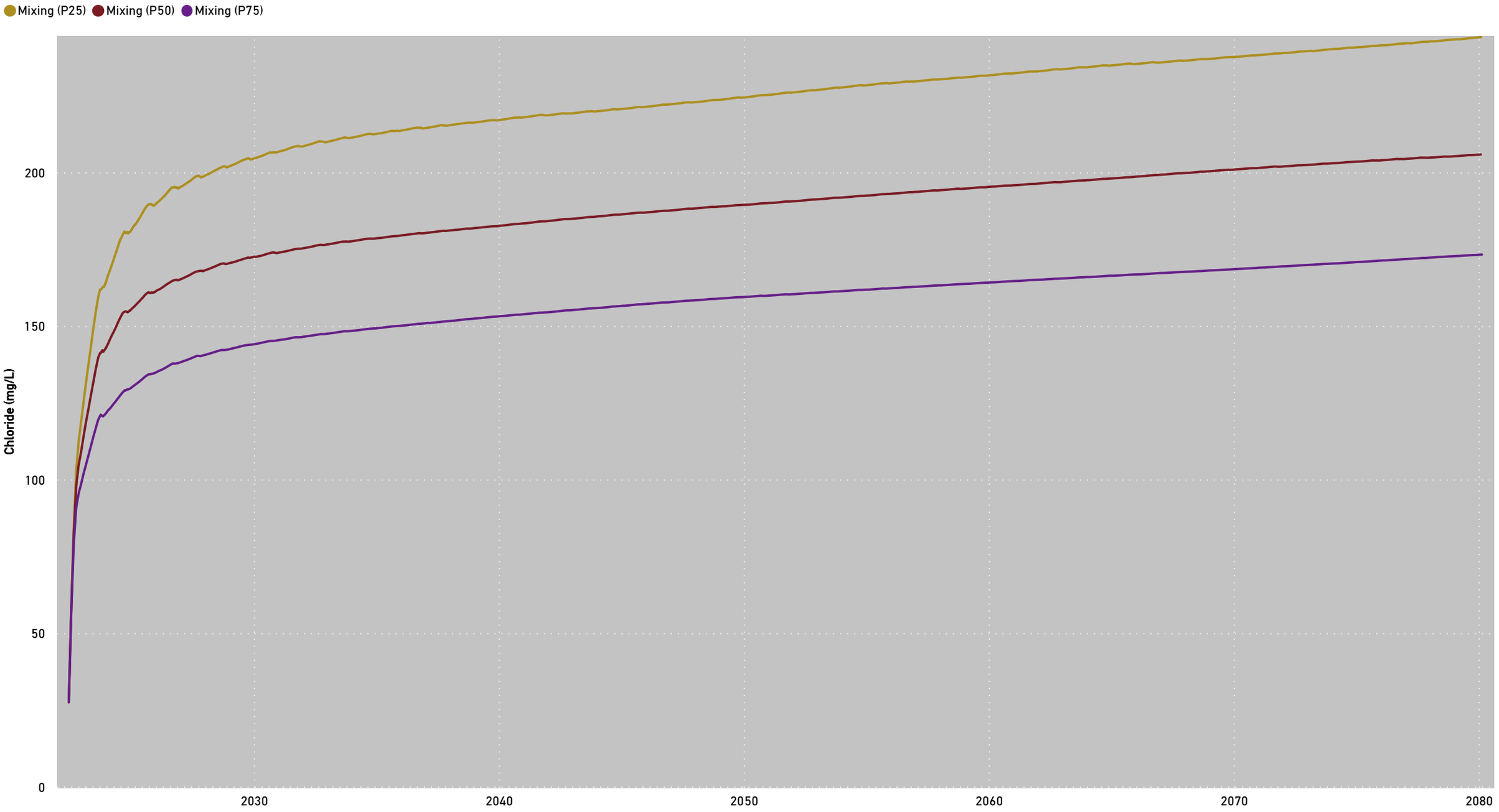

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 1,000.00
1,000
800
600
400
200
0
Calcium (mg/L)
2030
2040
2050
2060
2070
2080

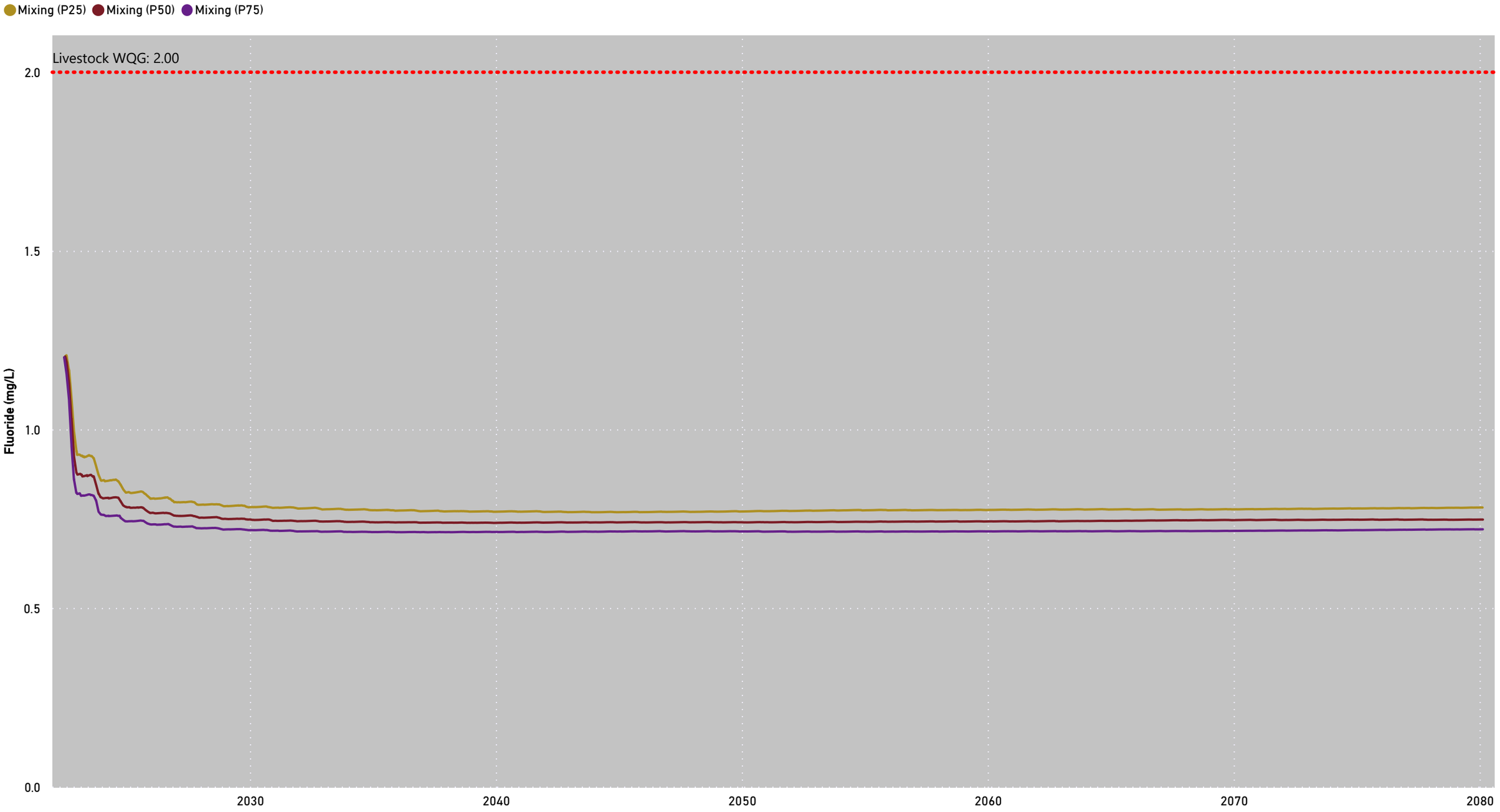

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG - Higher Value: 2,000.00
Livestock WQG - Lower Value: 1,000.00
Sulfate (mg/L)
2,000
1,500
1,000
500
0
2030
2040
2050
2060
2070
2080

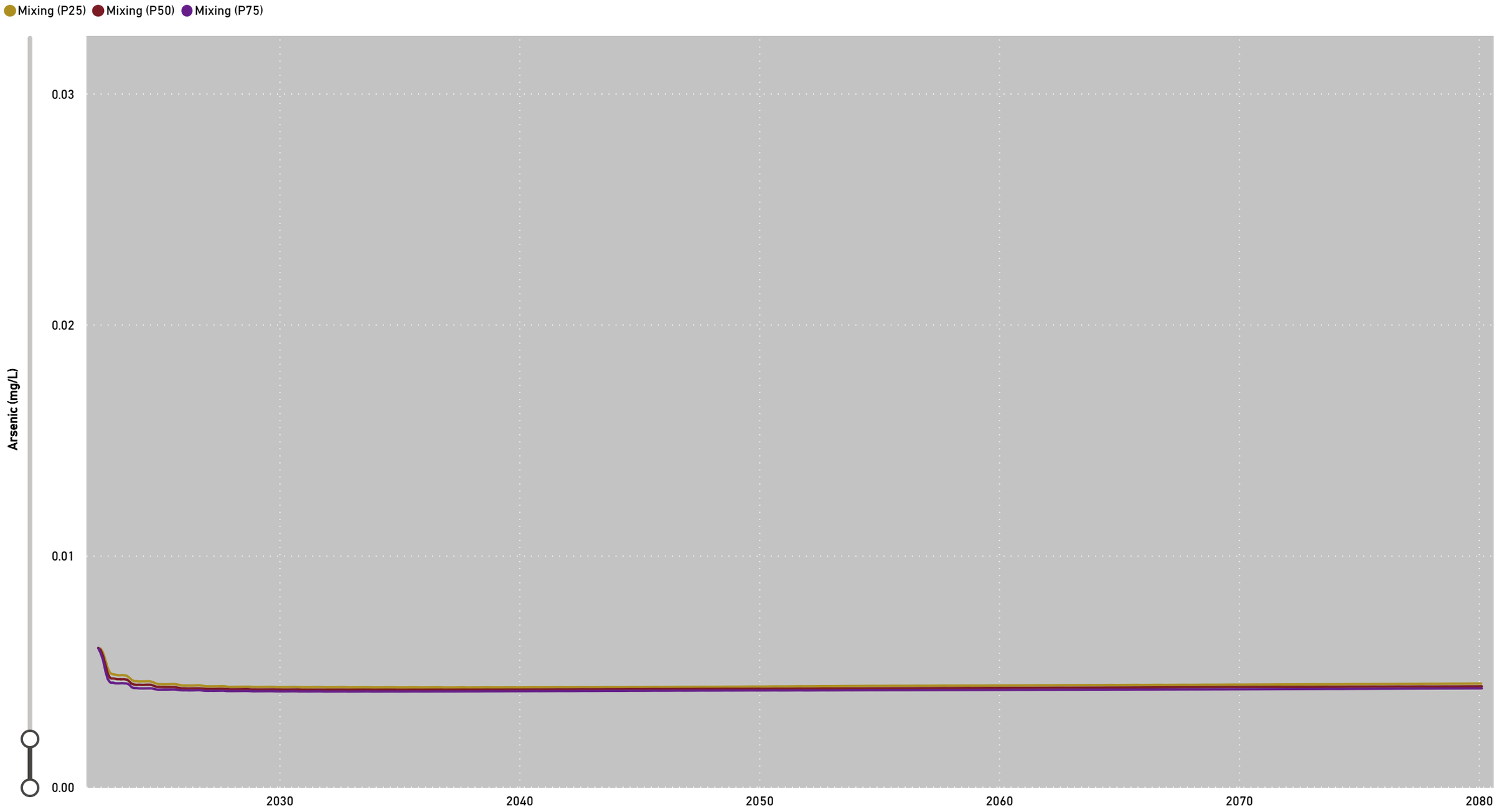

Mixing (P25)
Mixing (P50)
Mixing (P75)
Magnesium (mg/L)
60
50
40
30
20
10
0
2030
2040
2050
2060
2070
2080

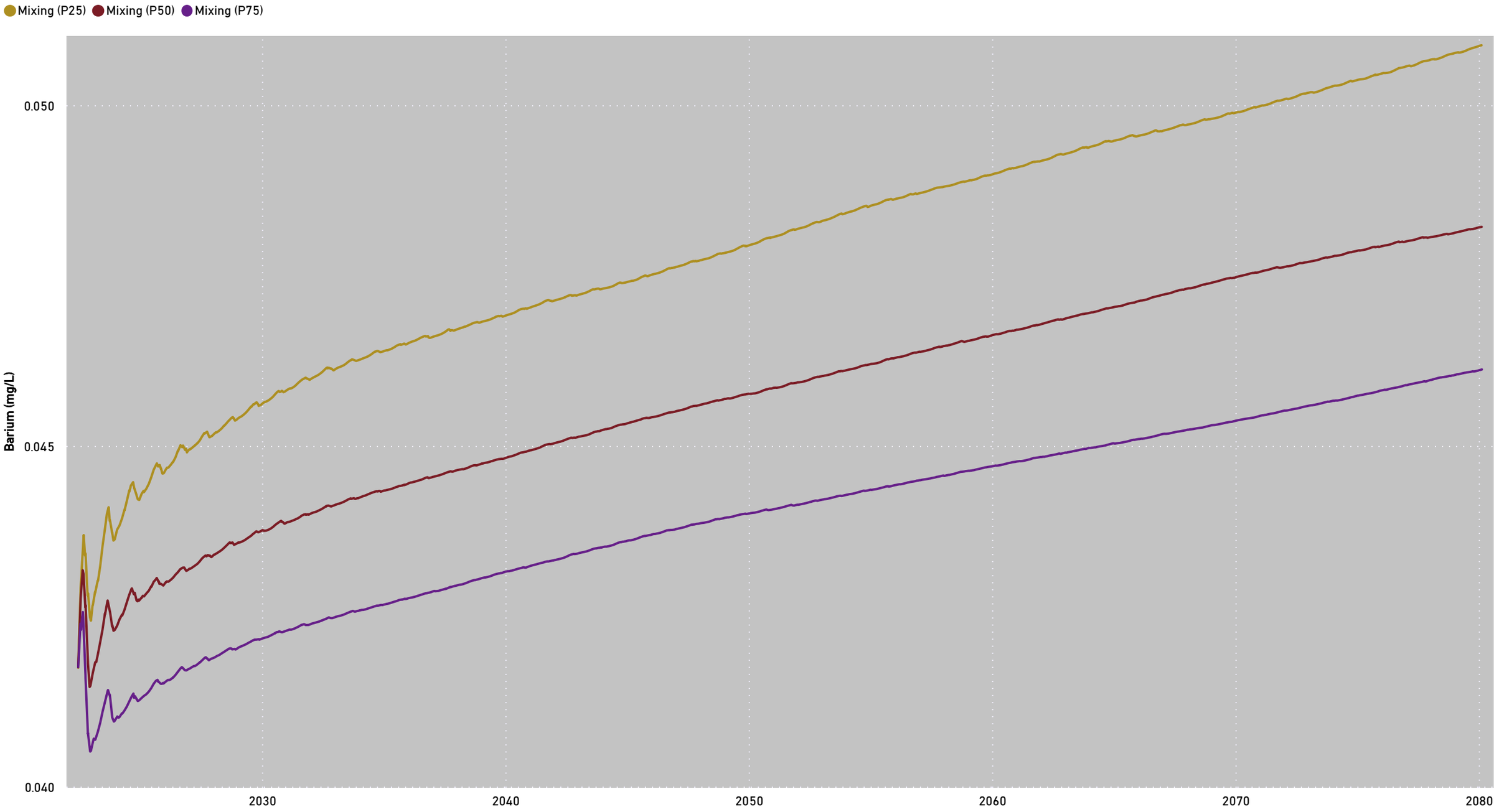

Mixing (P25)
Mixing (P50)
Mixing (P75)
Sodium (mg/L)
0
50
100
150
2030
2040
2050
2060
2070
2080

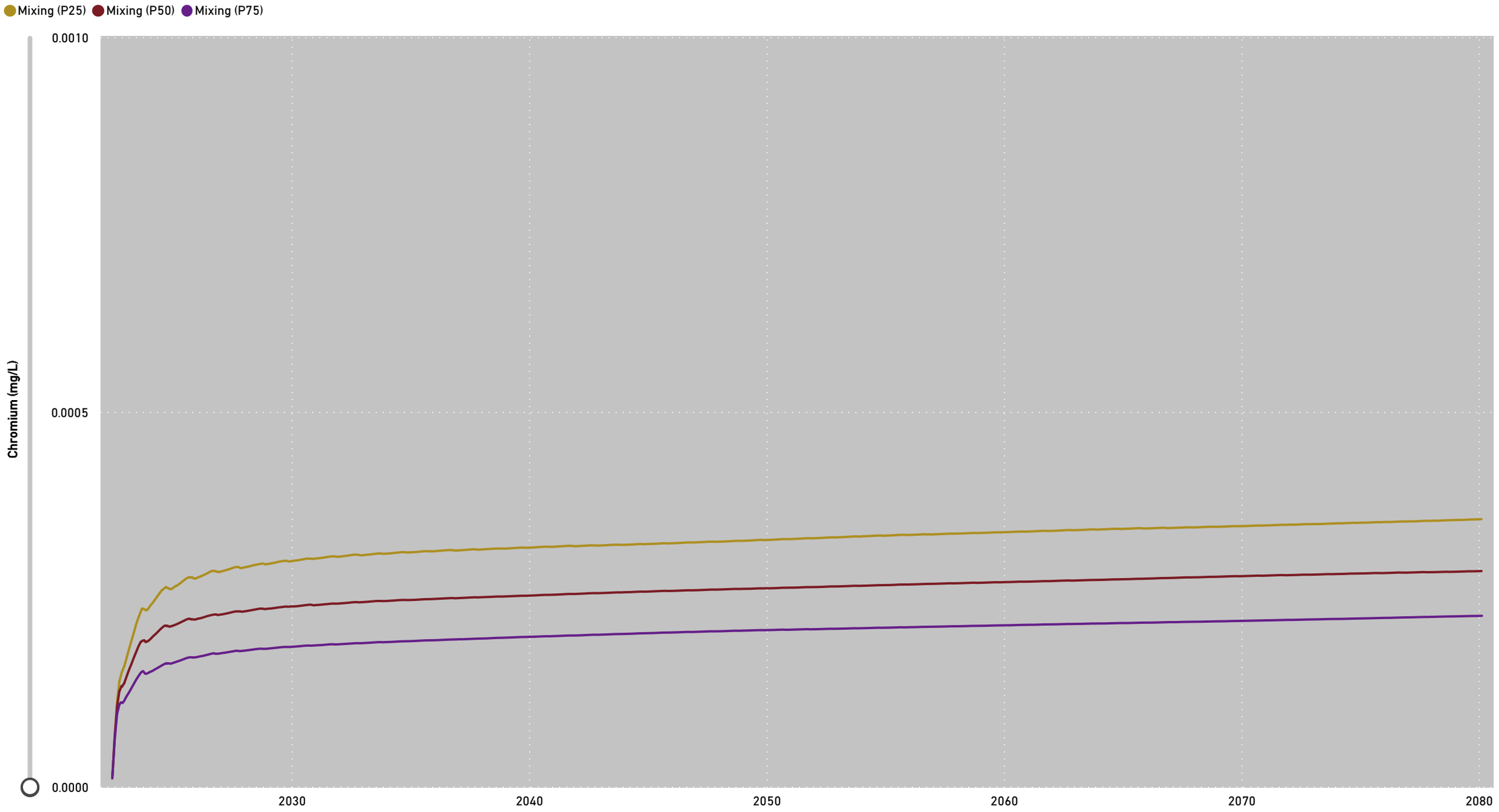

Mixing (P25)
Mixing (P50)
Mixing (P75)
Potassium (mg/L)
0
5
10
15
20
25
2030
2040
2050
2060
2070
2080

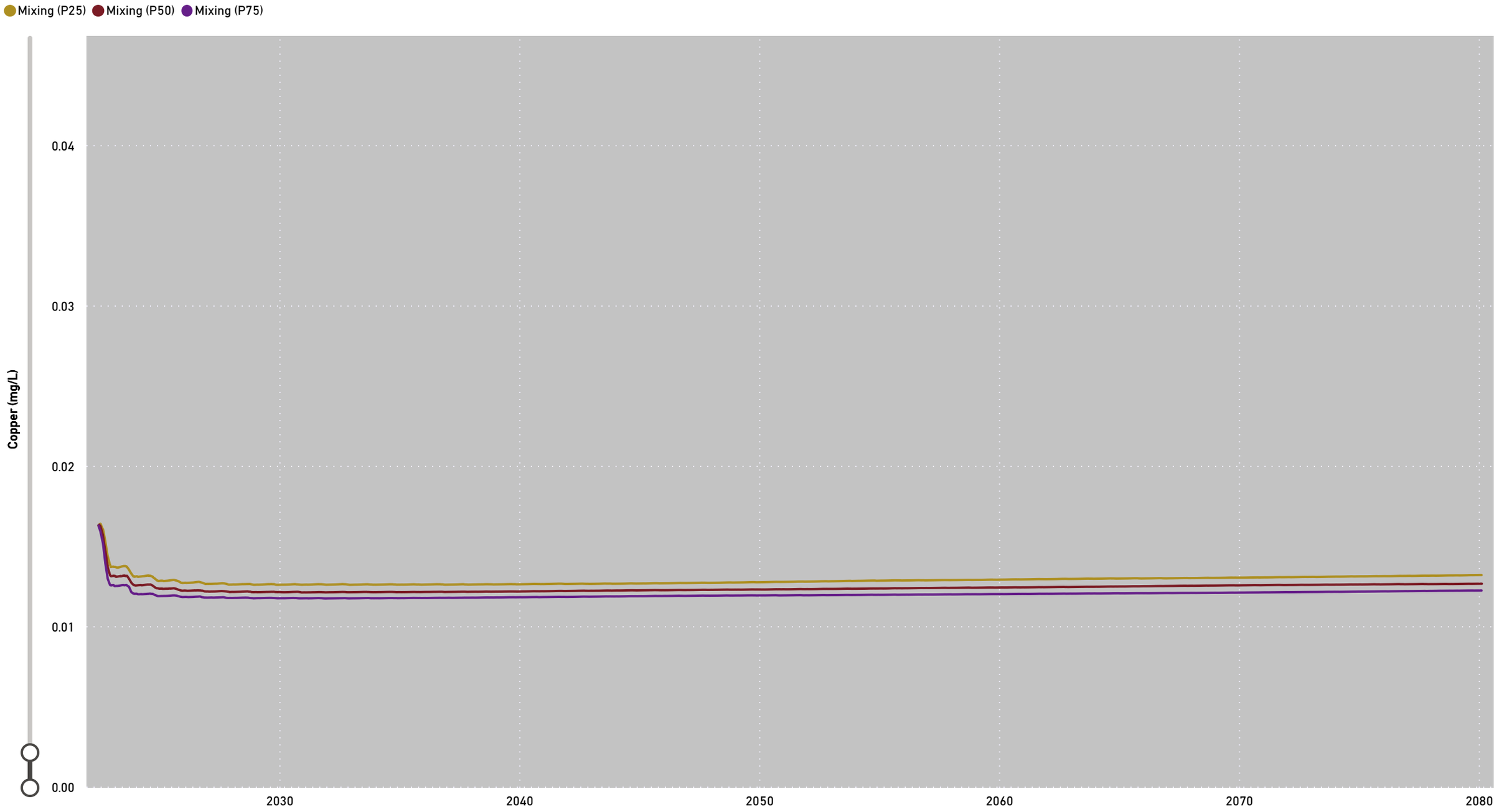

Mixing (P25)
Mixing (P50)
Mixing (P75)
Chloride (mg/L)
0
50
100
150
200
2030
2040
2050
2060
2070
2080

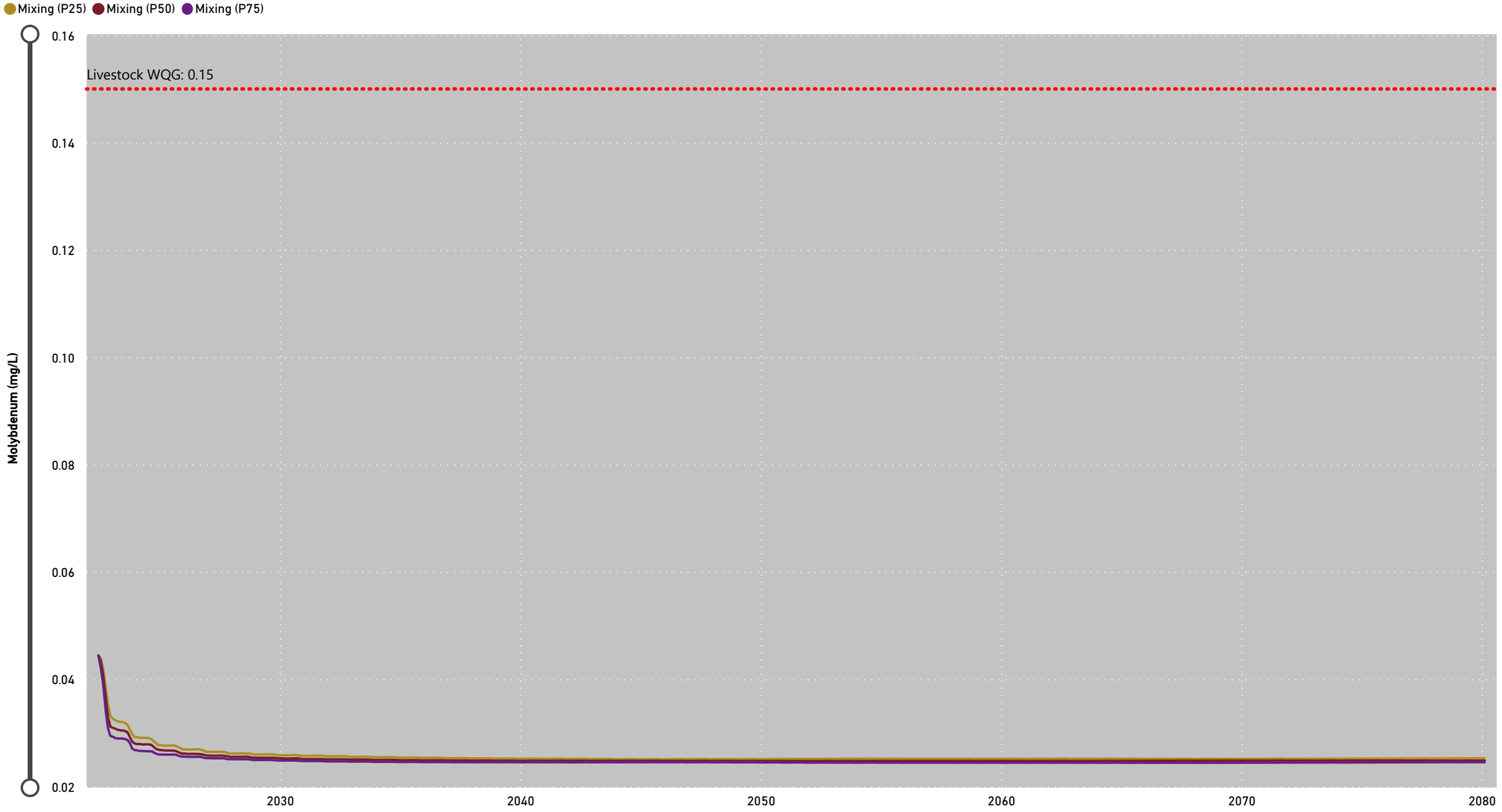

Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 2.00
2.0
1.5
1.0
0.5
0.0
Fluoride (mg/L)
2030
2040
2050
2060
2070
2080

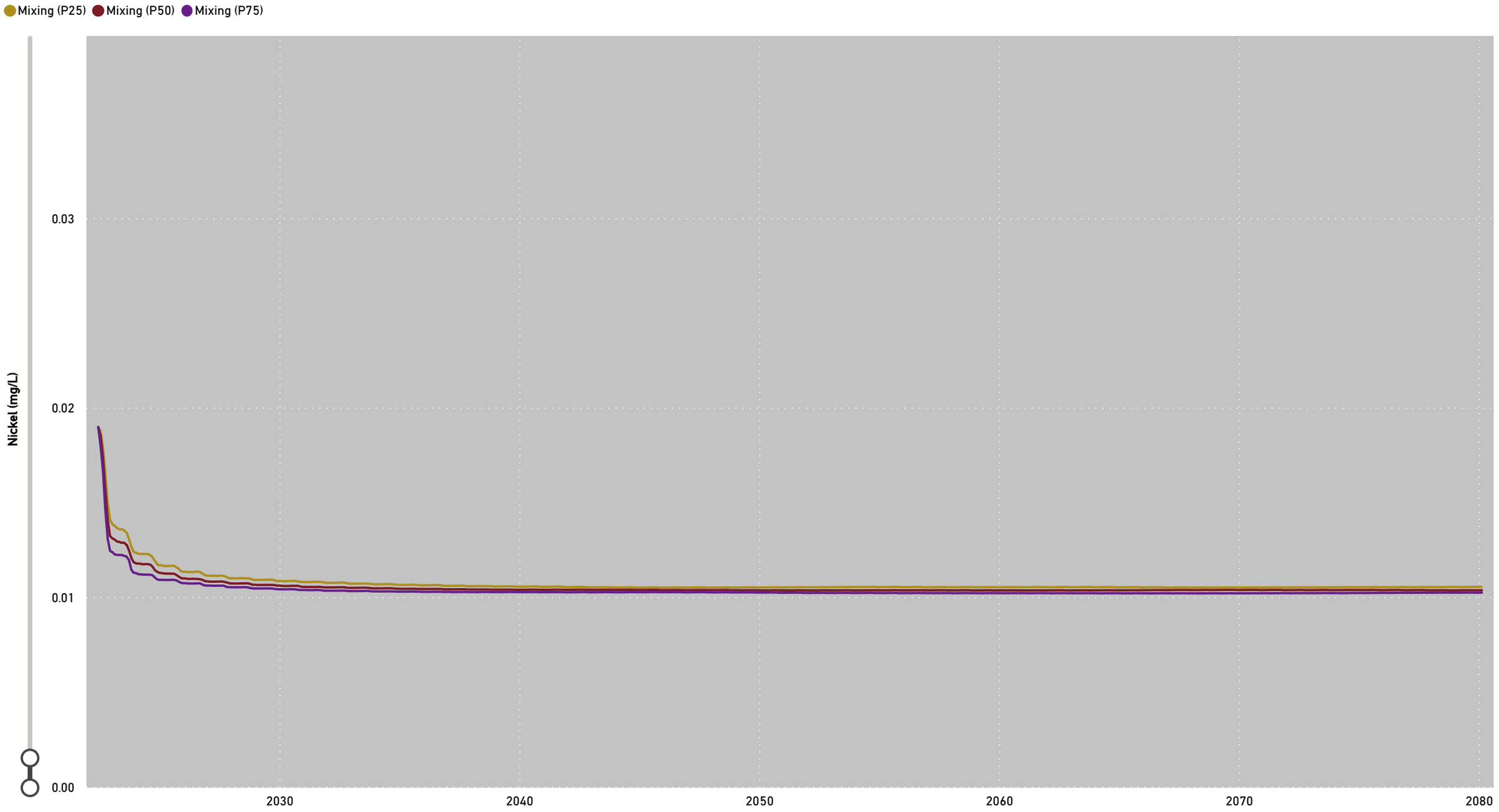

Mixing (P25)
Mixing (P50)
Mixing (P75)
Arsenic (mg/L)
0.03
0.02
0.01
0.00
2030
2040
2050
2060
2070
2080

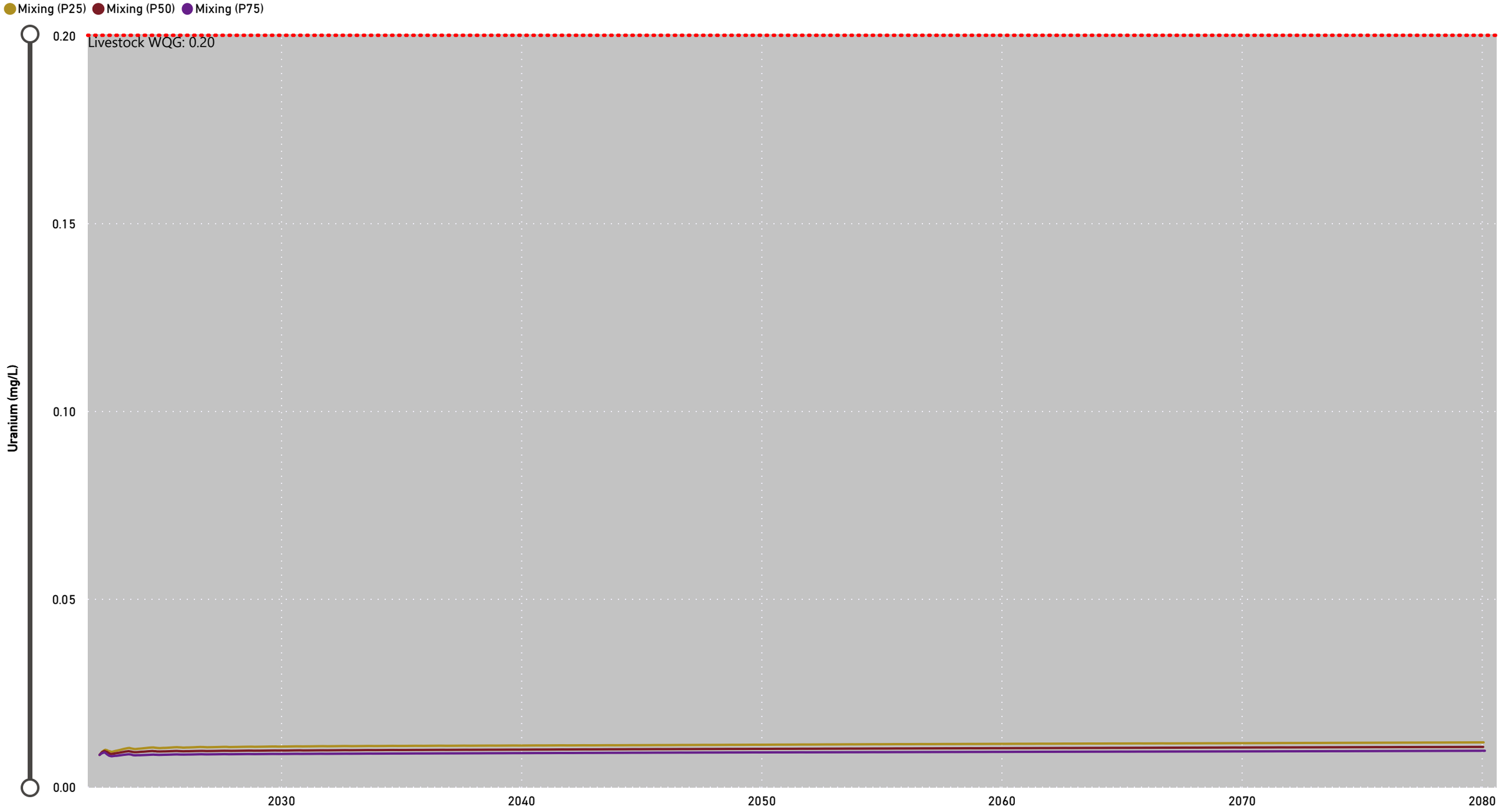

Mixing (P25)
Mixing (P50)
Mixing (P75)
Barium (mg/L)
0.050
0.045
0.040
2030
2040
2050
2060
2070
2080


Mixing (P25)
Mixing (P50)
Mixing (P75)
Chromium (mg/L)
0.0010
0.0005
0.0000
2030
2040
2050
2060
2070
2080

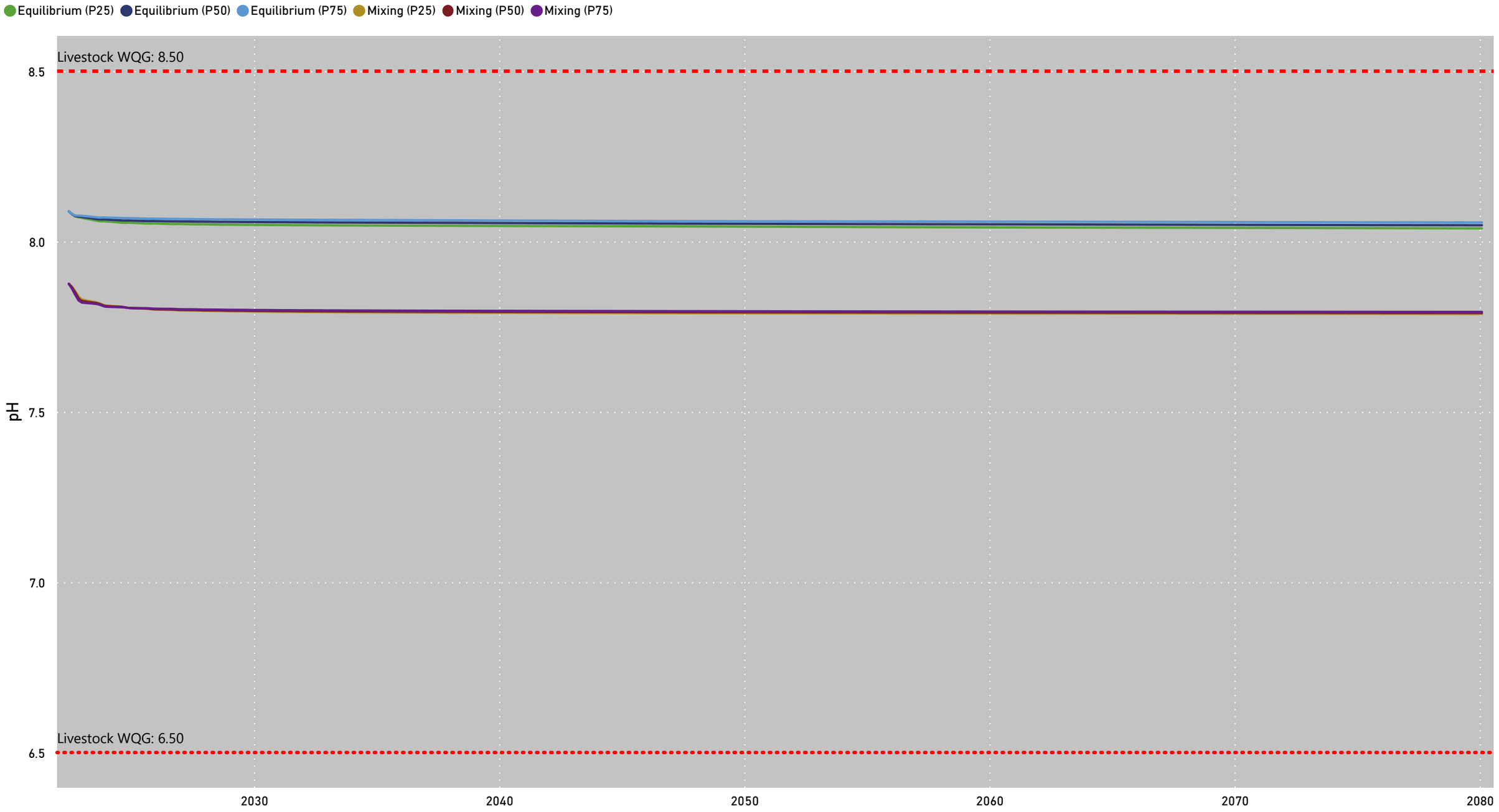

Mixing (P25)
Mixing (P50)
Mixing (P75)
Copper (mg/L)
0.04
0.03
0.02
0.01
0.00
2030
2040
2050
2060
2070
2080

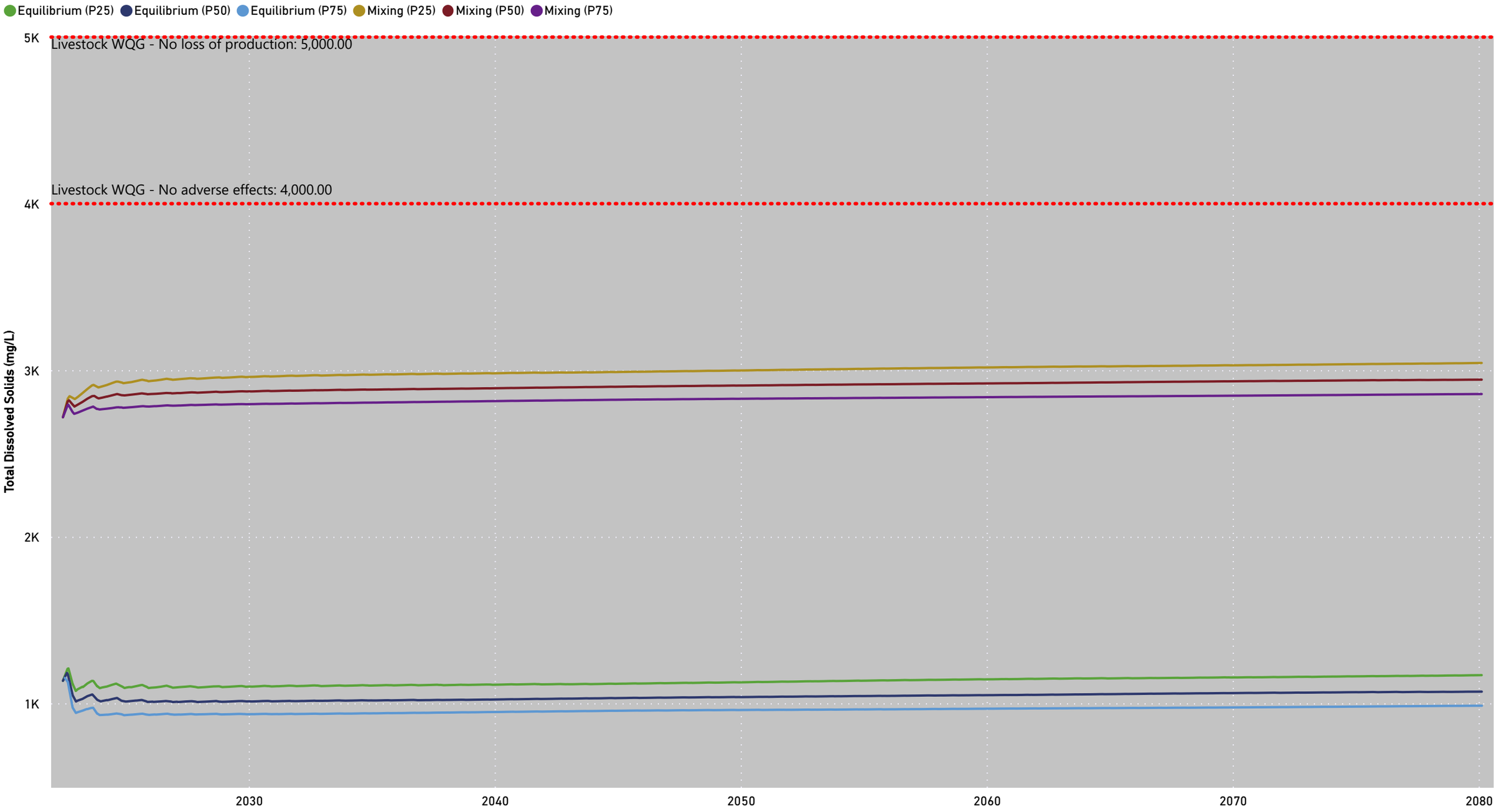

Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 0.15
Molybdenum (mg/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
2030
2040
2050
2060
2070
2080

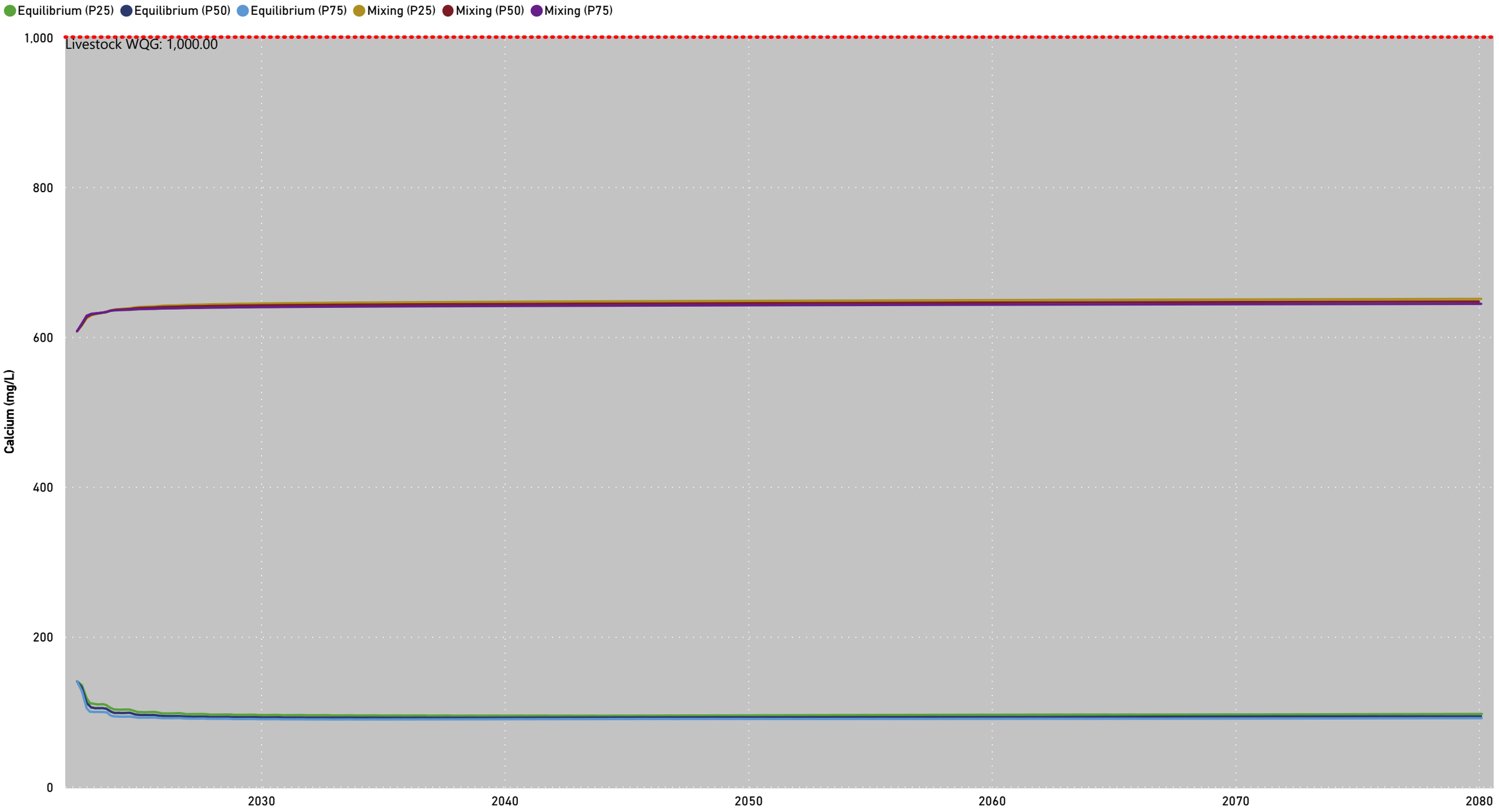

Mixing (P25)
Mixing (P50)
Mixing (P75)
Nickel (mg/L)
0.03
0.02
0.01
0.00
2030
2040
2050
2060
2070
2080

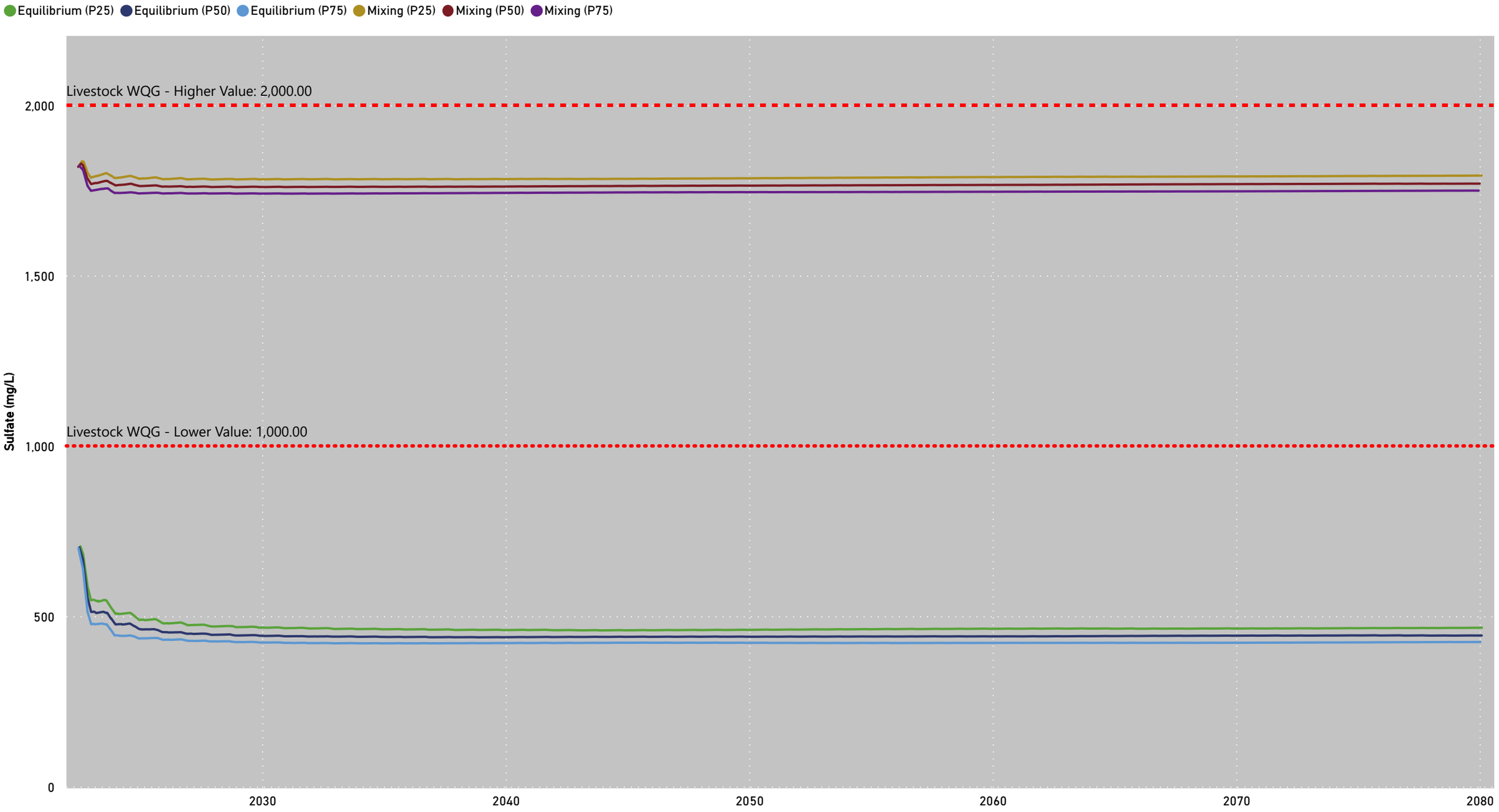

Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 0.20
Uranium (mg/L)
0.20
0.15
0.10
0.05
0.00
2030
2040
2050
2060
2070
2080

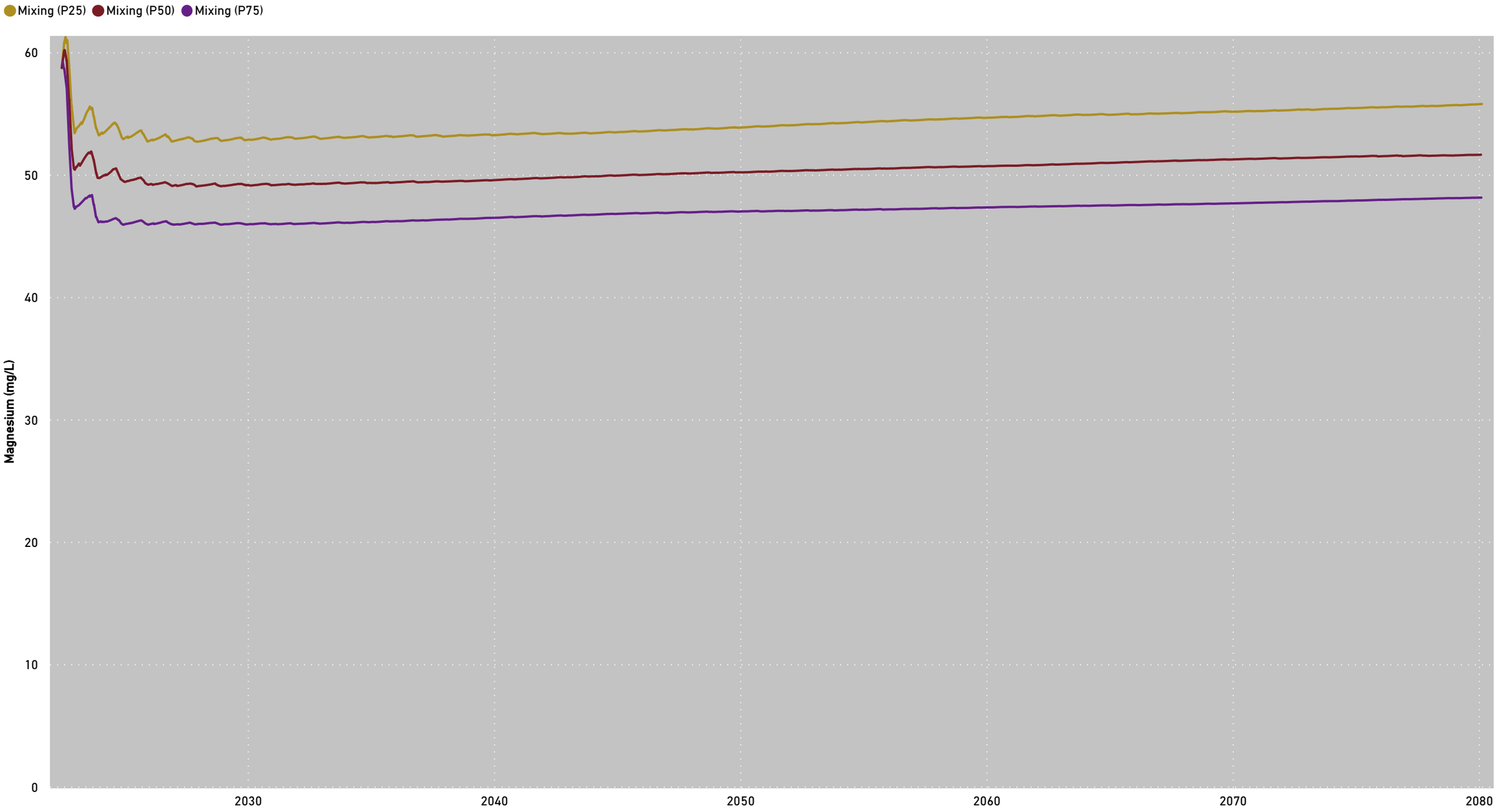
J.7.4 South Pit modelled long-term water quality (scenario 2)

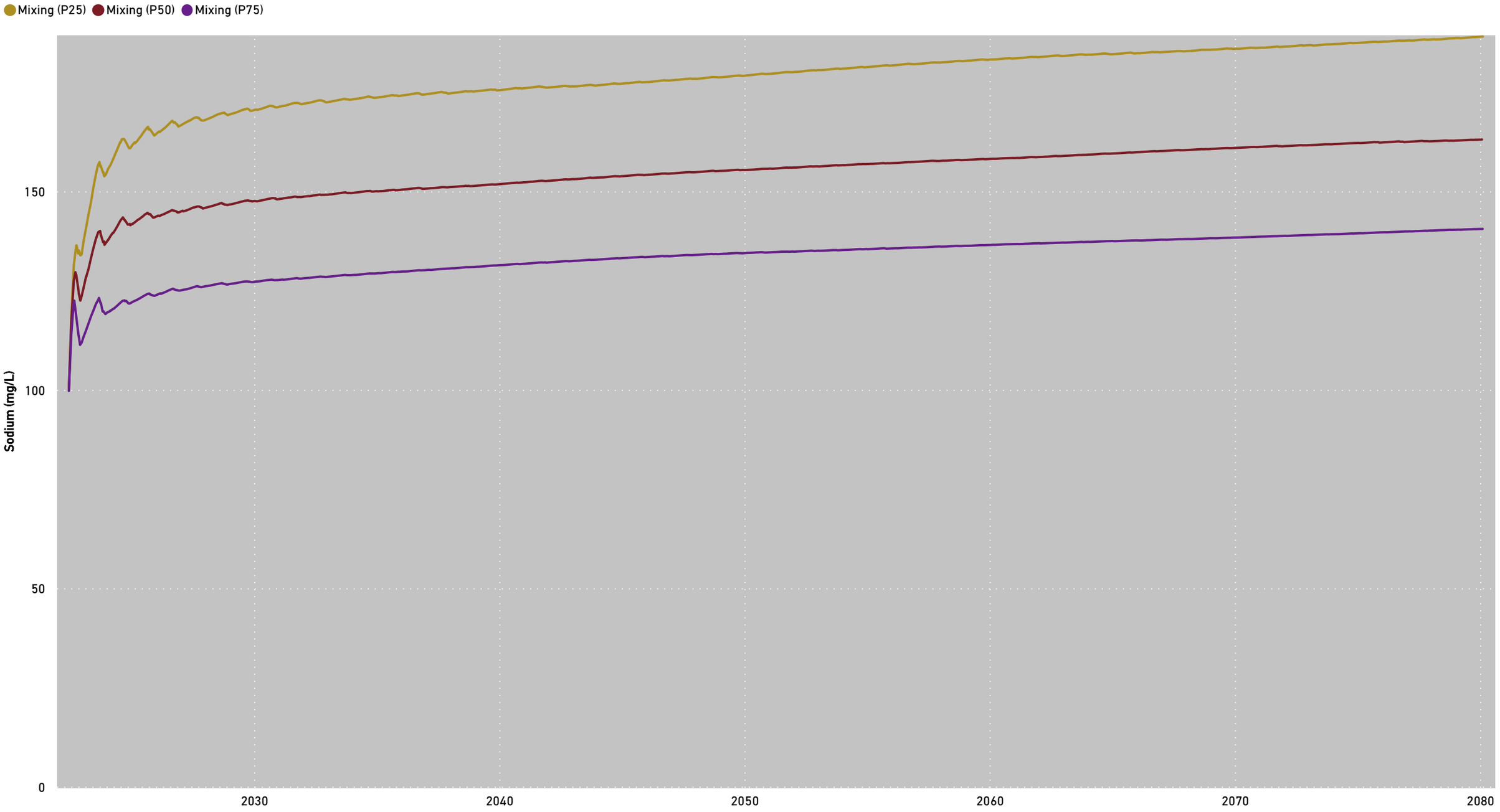

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 8.50
Livestock WQG: 6.50
pH
8.5
8.0
7.5
7.0
6.5
2030
2040
2050
2060
2070
2080

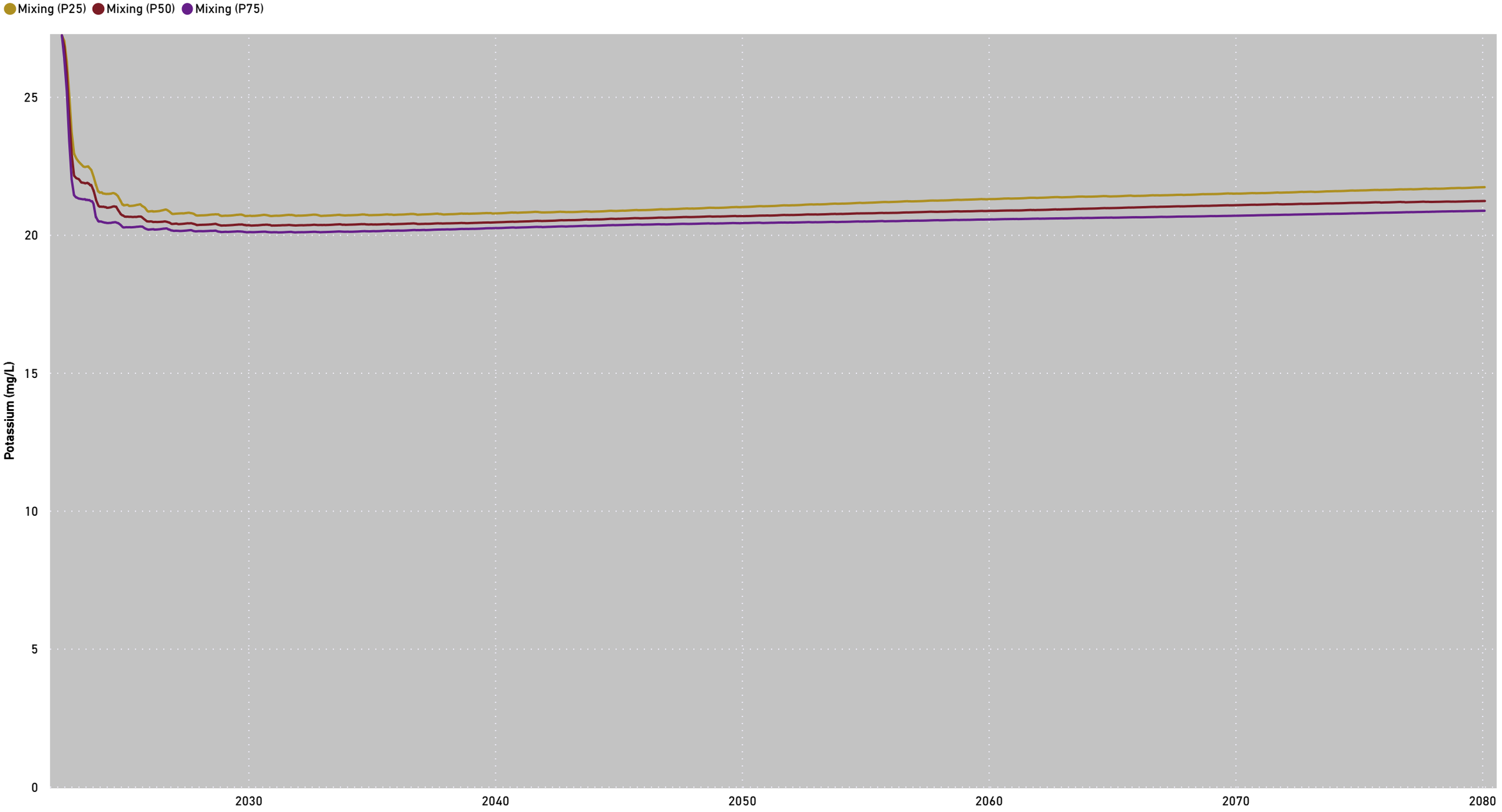

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG - No loss of production: 5,000.00
Livestock WQG - No adverse effects: 4,000.00
Total Dissolved Solids (mg/L)
5K
4K
3K
2K
1K
2030
2040
2050
2060
2070
2080

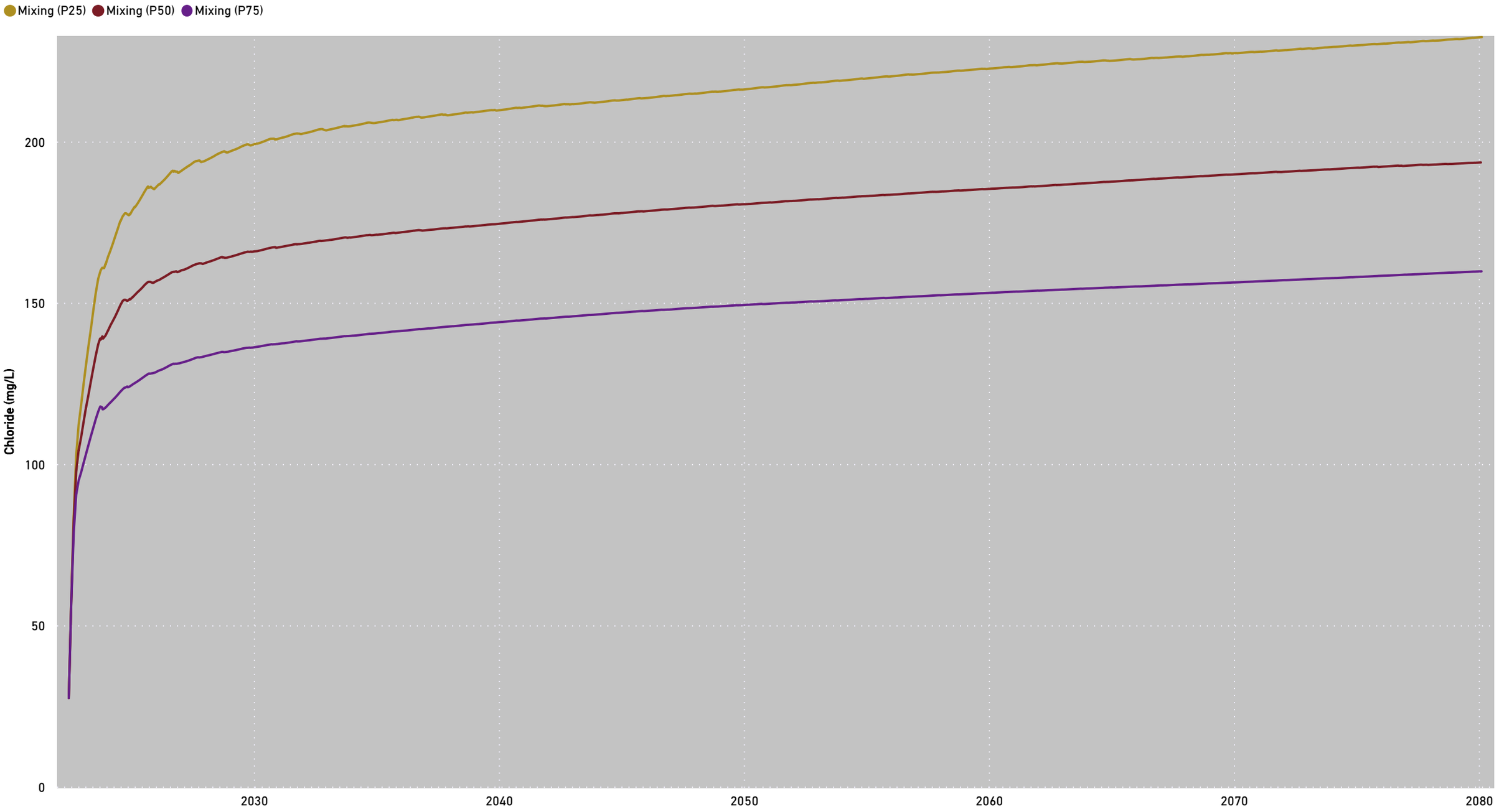

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 1,000.00
Calcium (mg/L)
1,000
800
600
400
200
0
2030
2040
2050
2060
2070
2080

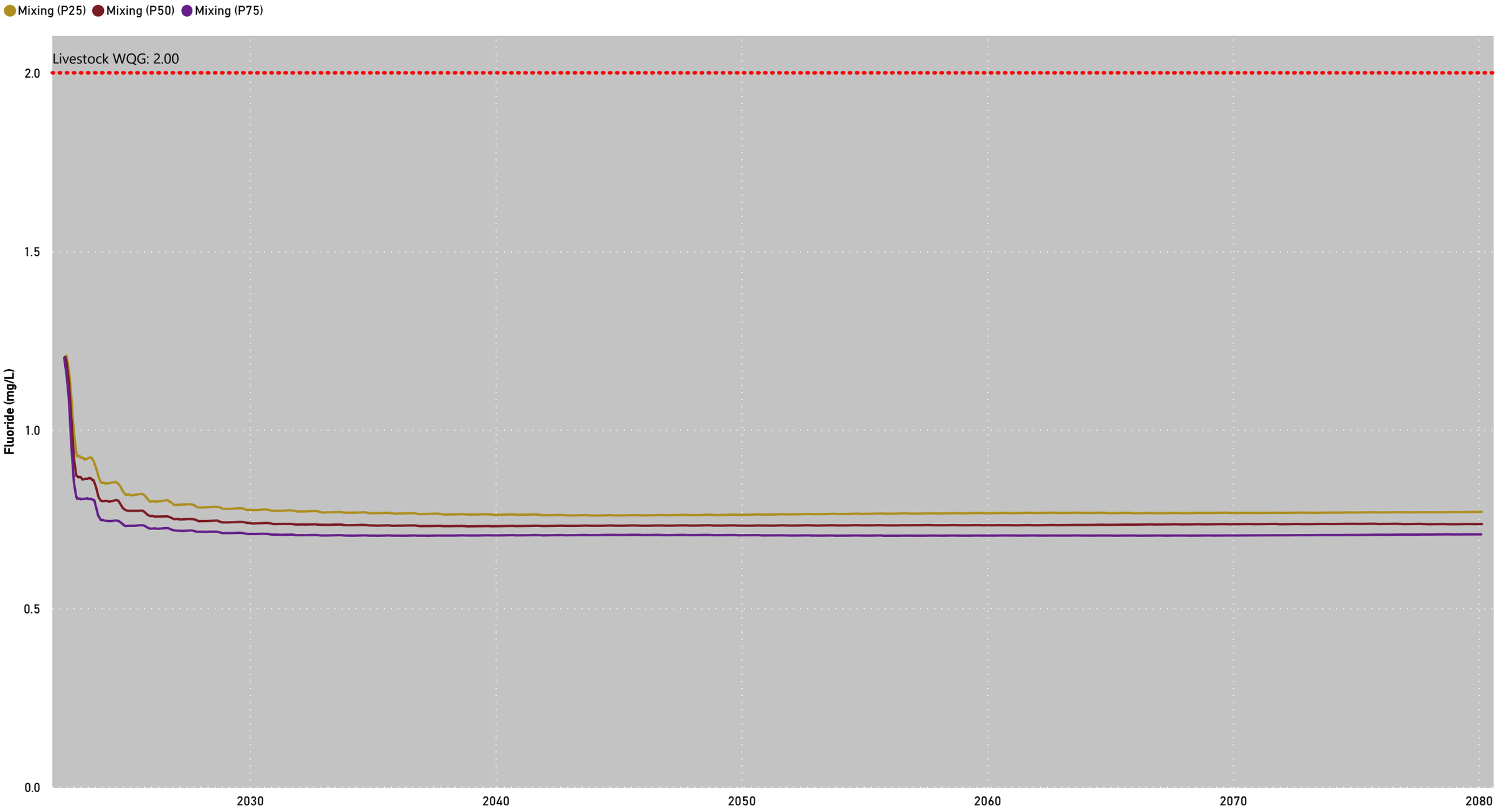

Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG - Higher Value: 2,000.00
Livestock WQG - Lower Value: 1,000.00
Sulfate (mg/L)
2,000
1,500
1,000
500
0
2030
2040
2050
2060
2070
2080

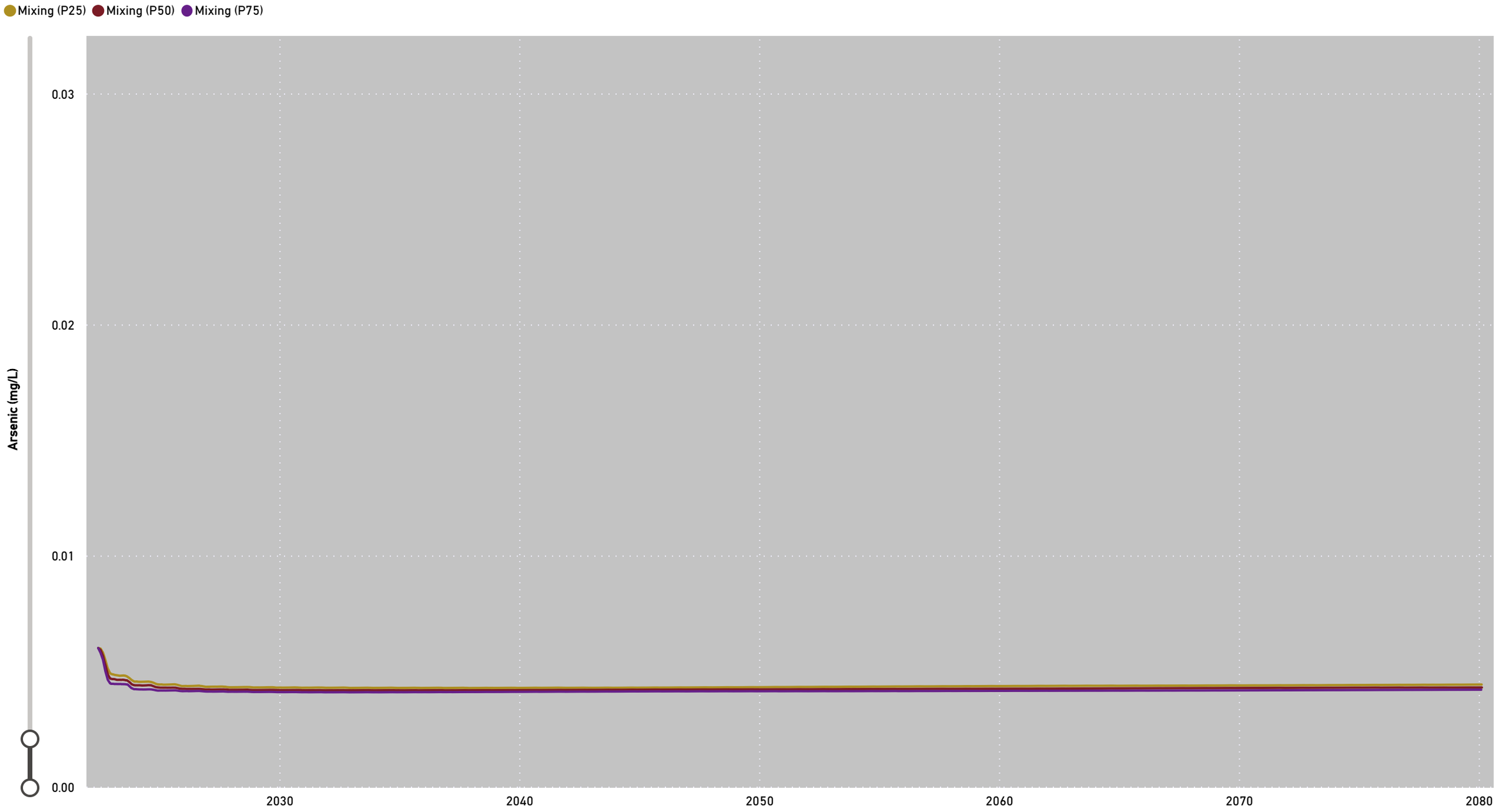

Mixing (P25)
Mixing (P50)
Mixing (P75)
Magnesium (mg/L)
60
50
40
30
20
10
0
2030
2040
2050
2060
2070
2080

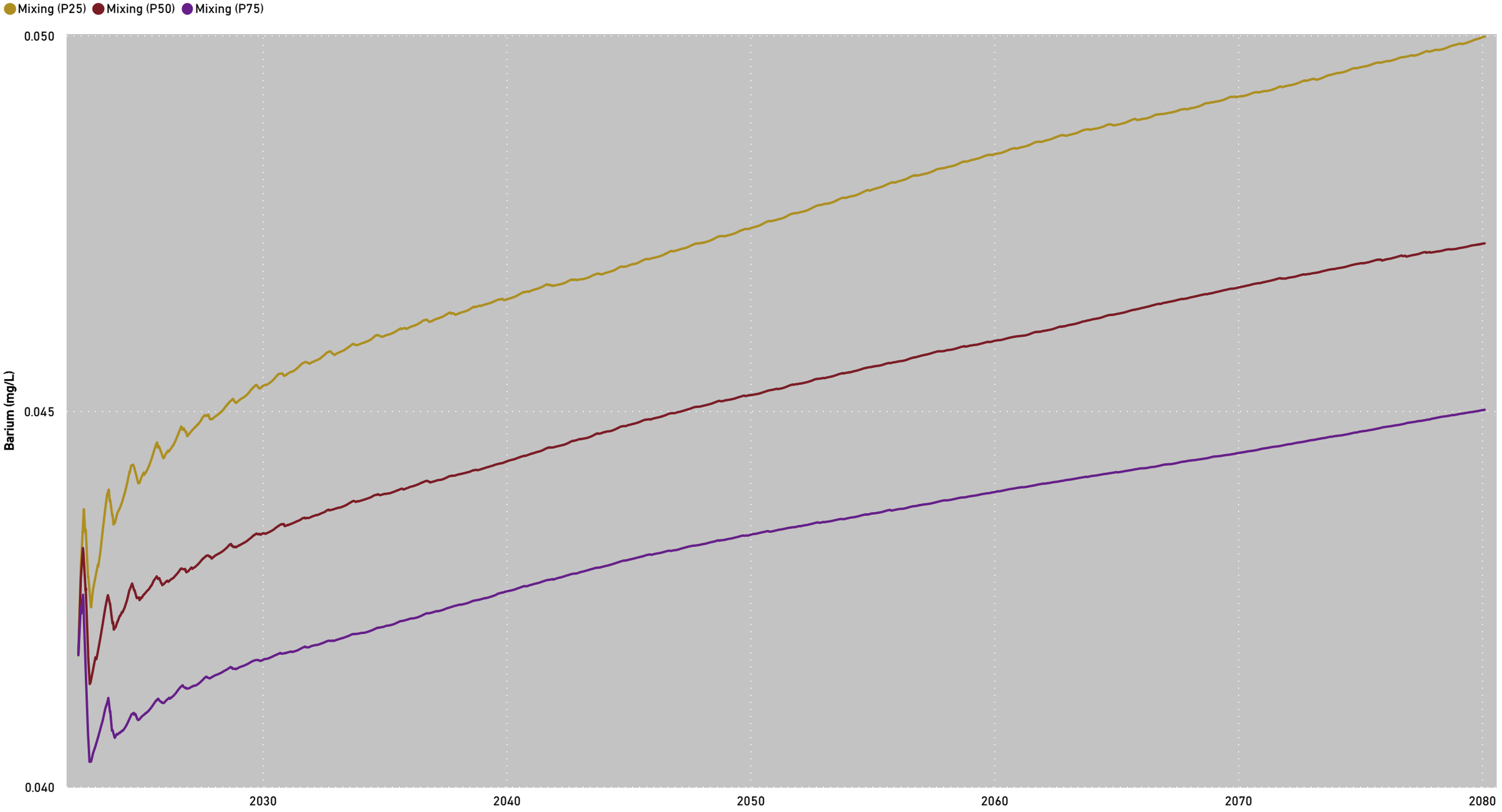

Mixing (P25)
Mixing (P50)
Mixing (P75)
Sodium (mg/L)
150
100
50
0
2030
2040
2050
2060
2070
2080

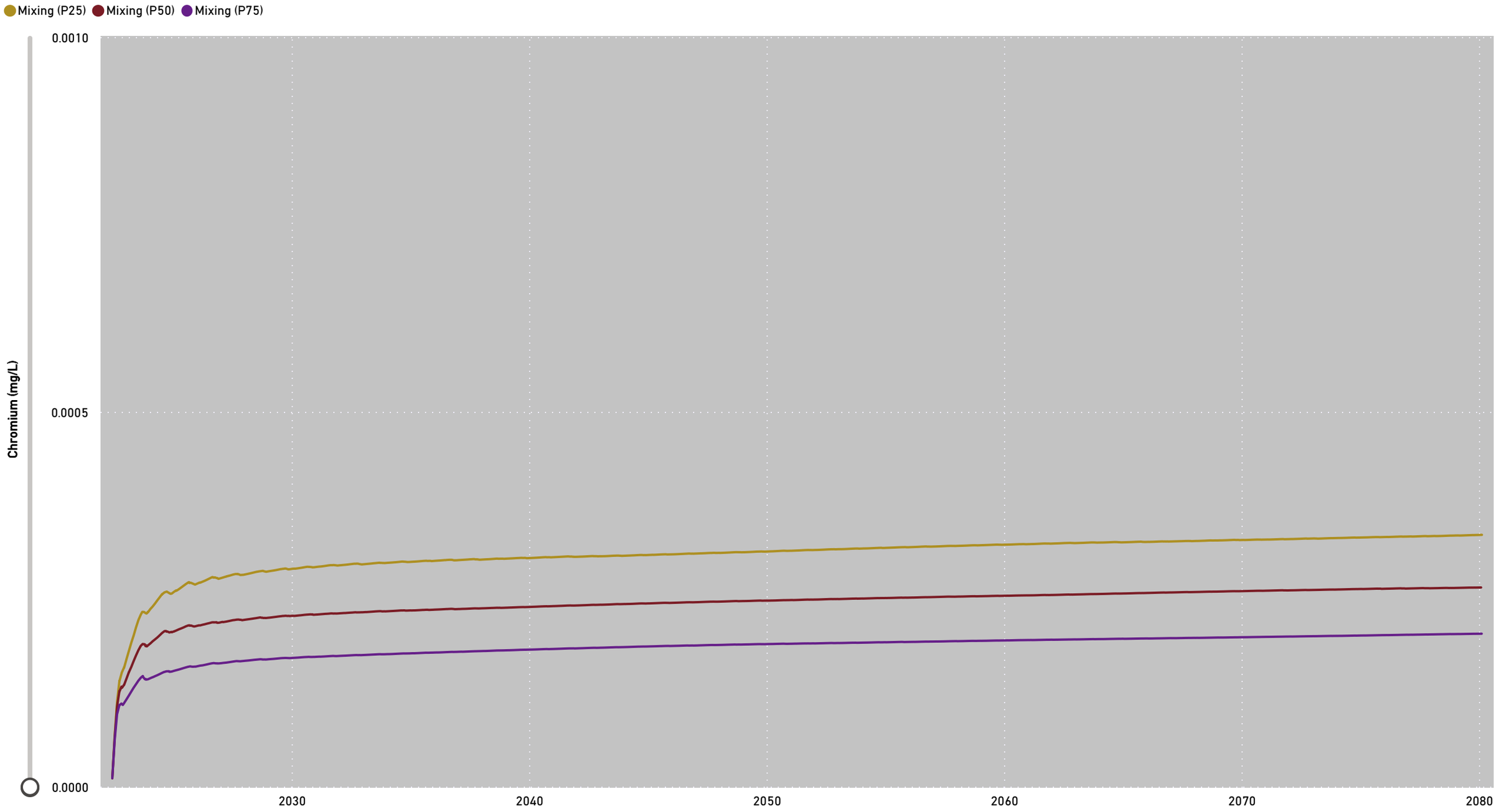

Mixing (P25)
Mixing (P50)
Mixing (P75)
Potassium (mg/L)
0
5
10
15
20
25
2030
2040
2050
2060
2070
2080

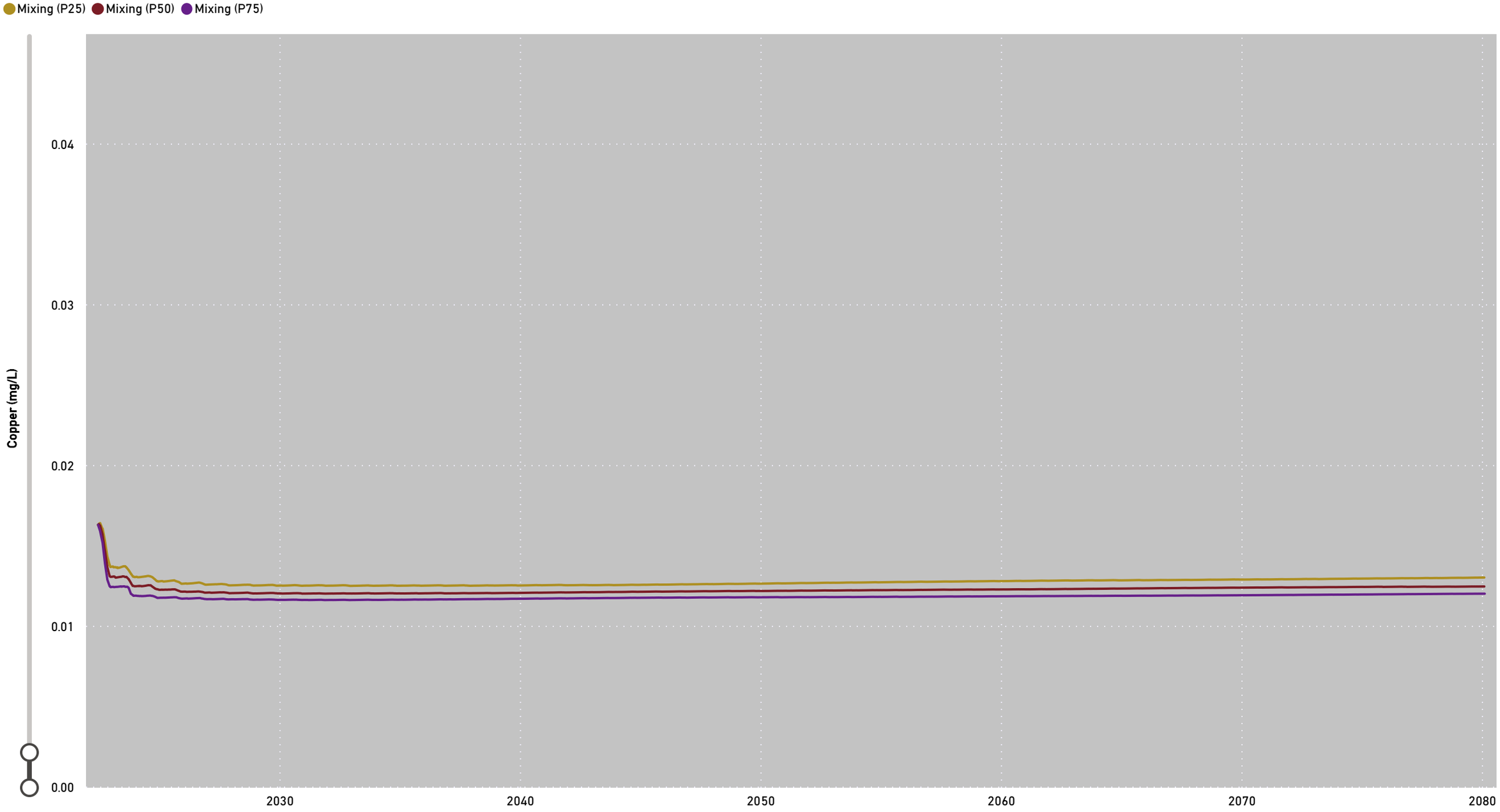

Mixing (P25)
Mixing (P50)
Mixing (P75)
Chloride (mg/L)
0
50
100
150
200
2030
2040
2050
2060
2070
2080

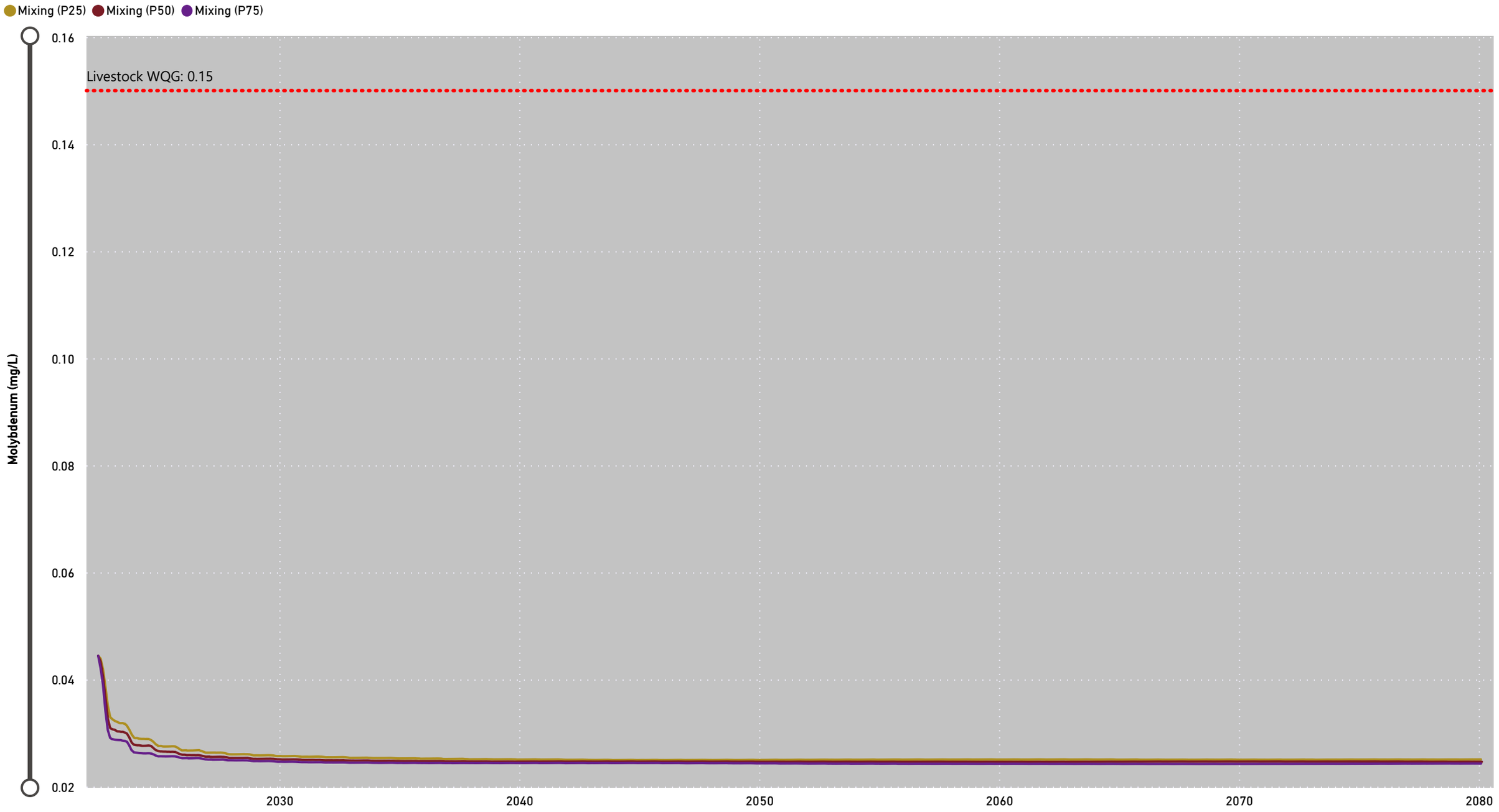

Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 2.00
2.0
1.5
1.0
0.5
0.0
Fluoride (mg/L)
2030
2040
2050
2060
2070
2080

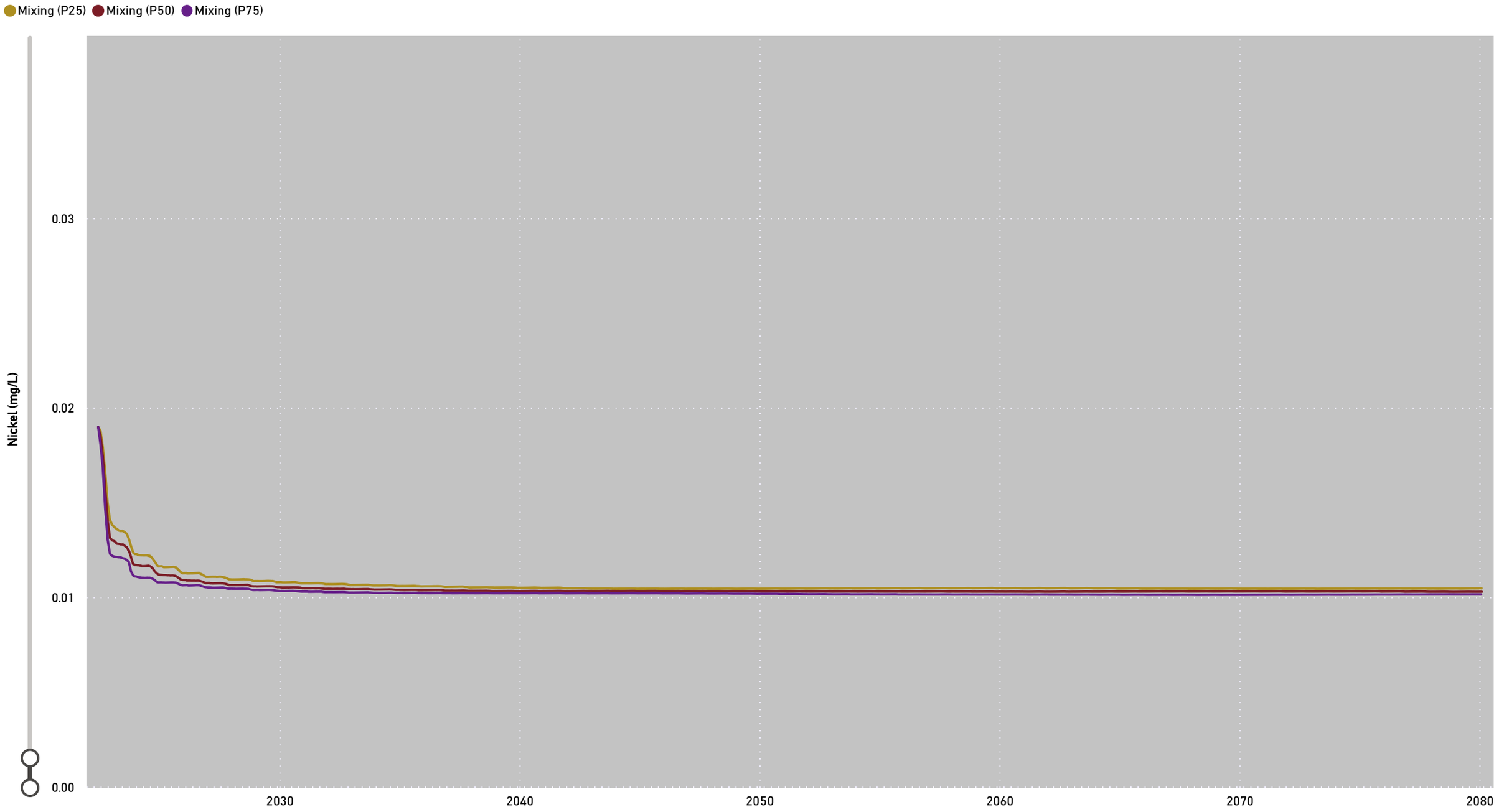

Mixing (P25)
Mixing (P50)
Mixing (P75)
Arsenic (mg/L)
0.03
0.02
0.01
0.00
2030
2040
2050
2060
2070
2080

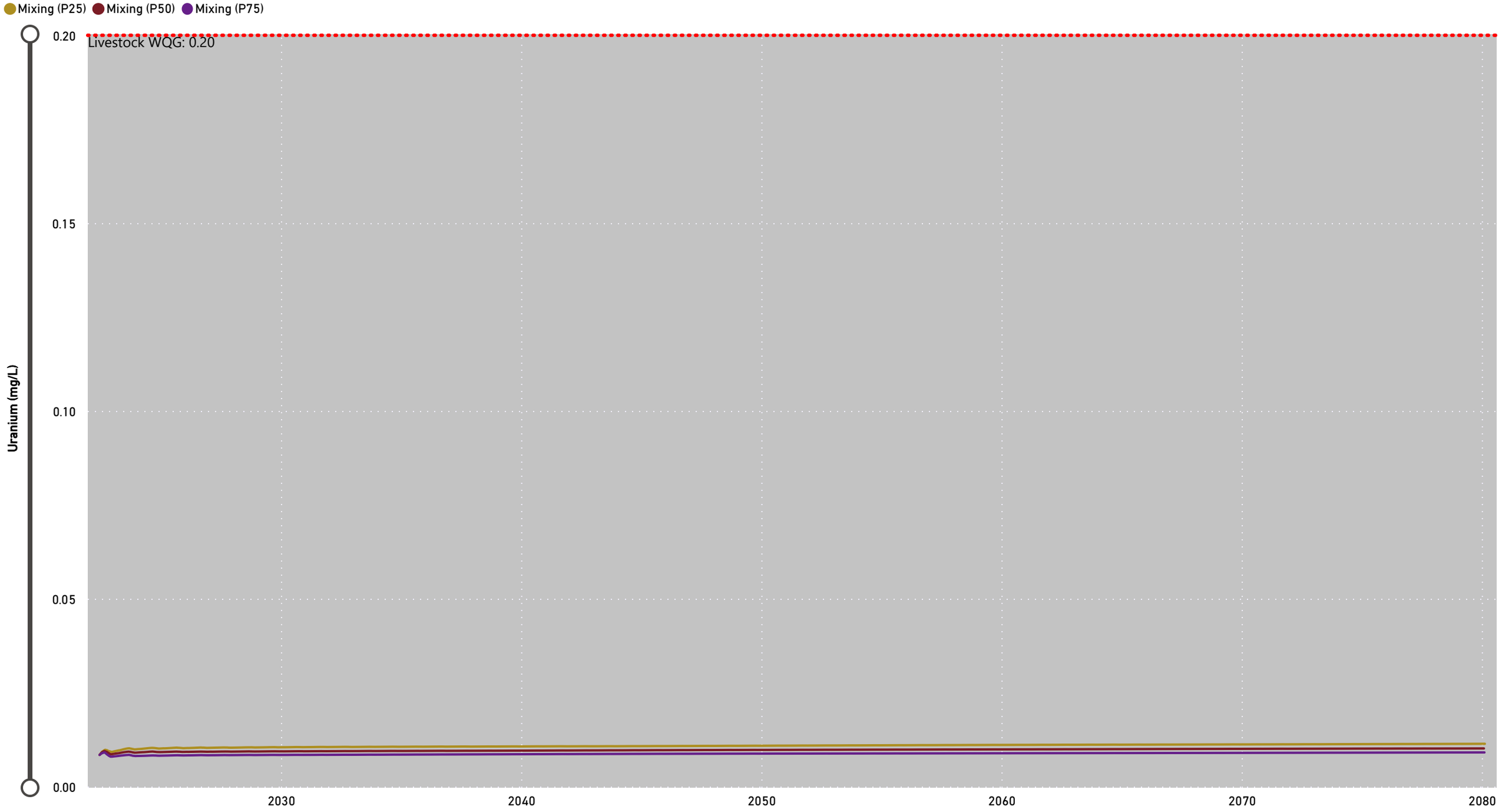

Mixing (P25)
Mixing (P50)
Mixing (P75)
0.050
0.045
0.040
Barium (mg/L)
2030
2040
2050
2060
2070
2080


Mixing (P25)
Mixing (P50)
Mixing (P75)
Chromium (mg/L)
0.0010
0.0005
0.0000
2030
2040
2050
2060
2070
2080


Mixing (P25)
Mixing (P50)
Mixing (P75)
Copper (mg/L)
0.04
0.03
0.02
0.01
0.00
2030
2040
2050
2060
2070
2080

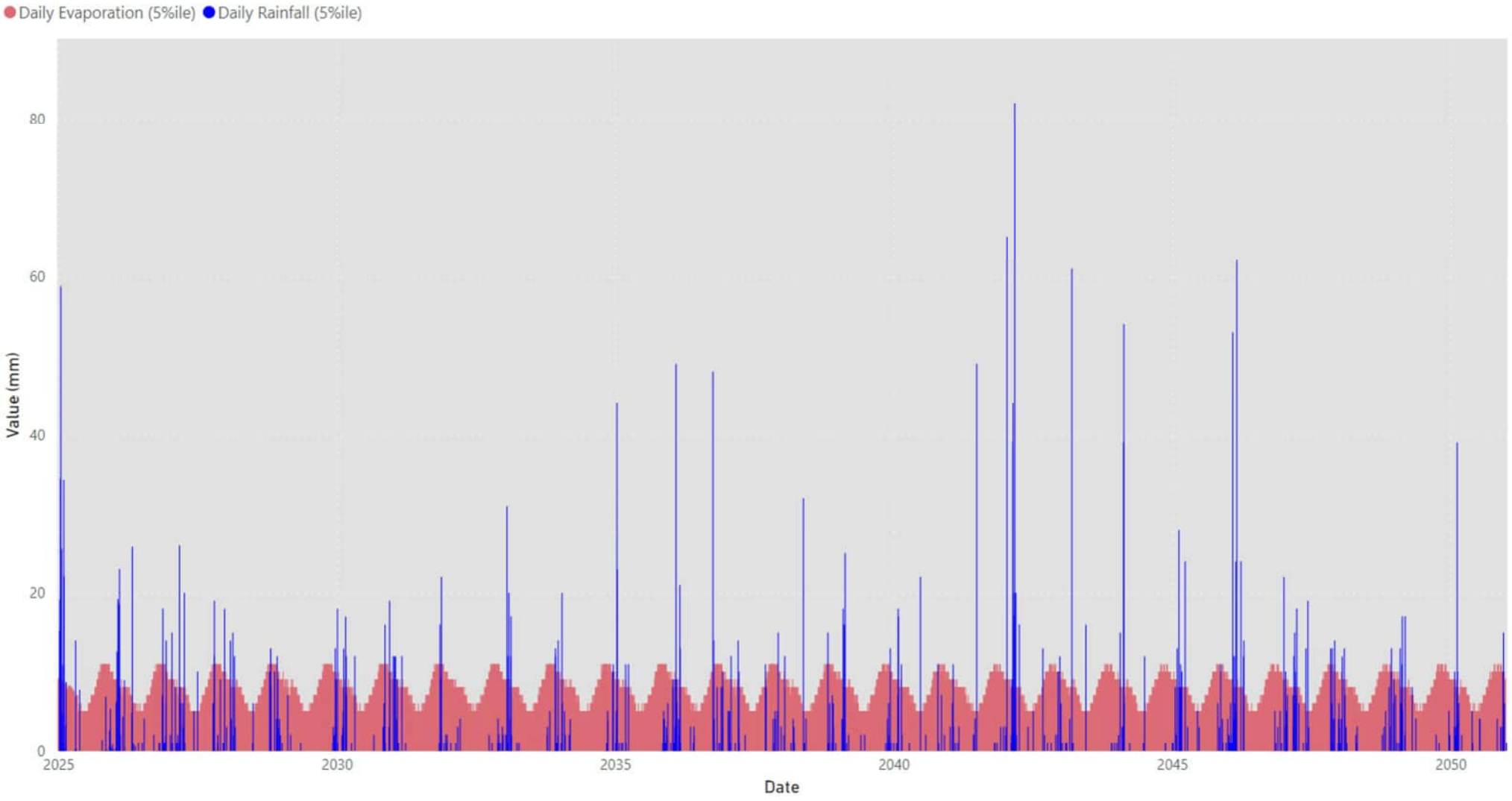

Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 0.15
Molybdenum (mg/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
2030
2040
2050
2060
2070
2080

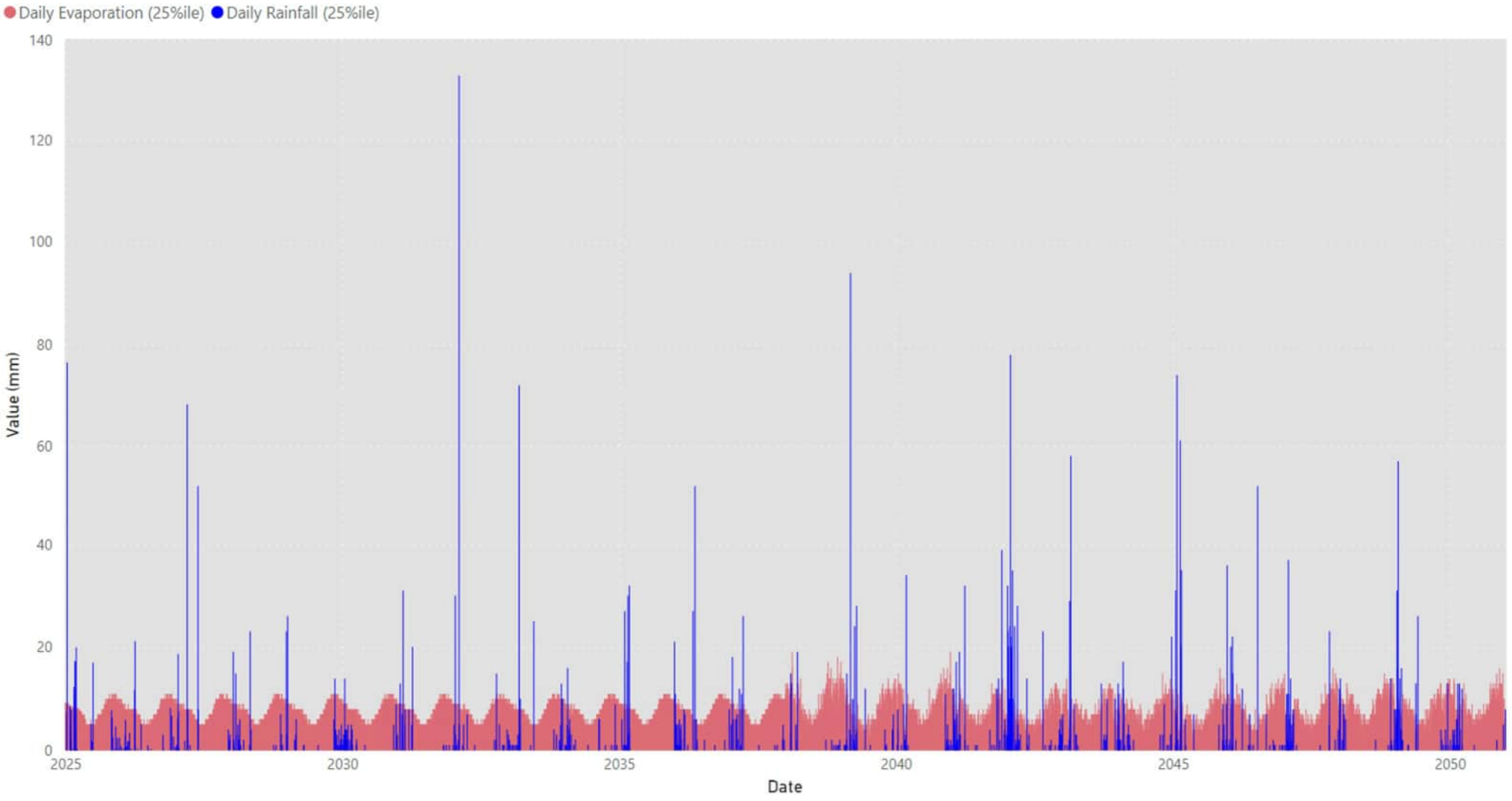

Mixing (P25)
Mixing (P50)
Mixing (P75)
Nickel (mg/L)
0.03
0.02
0.01
0.00
2030
2040
2050
2060
2070
2080

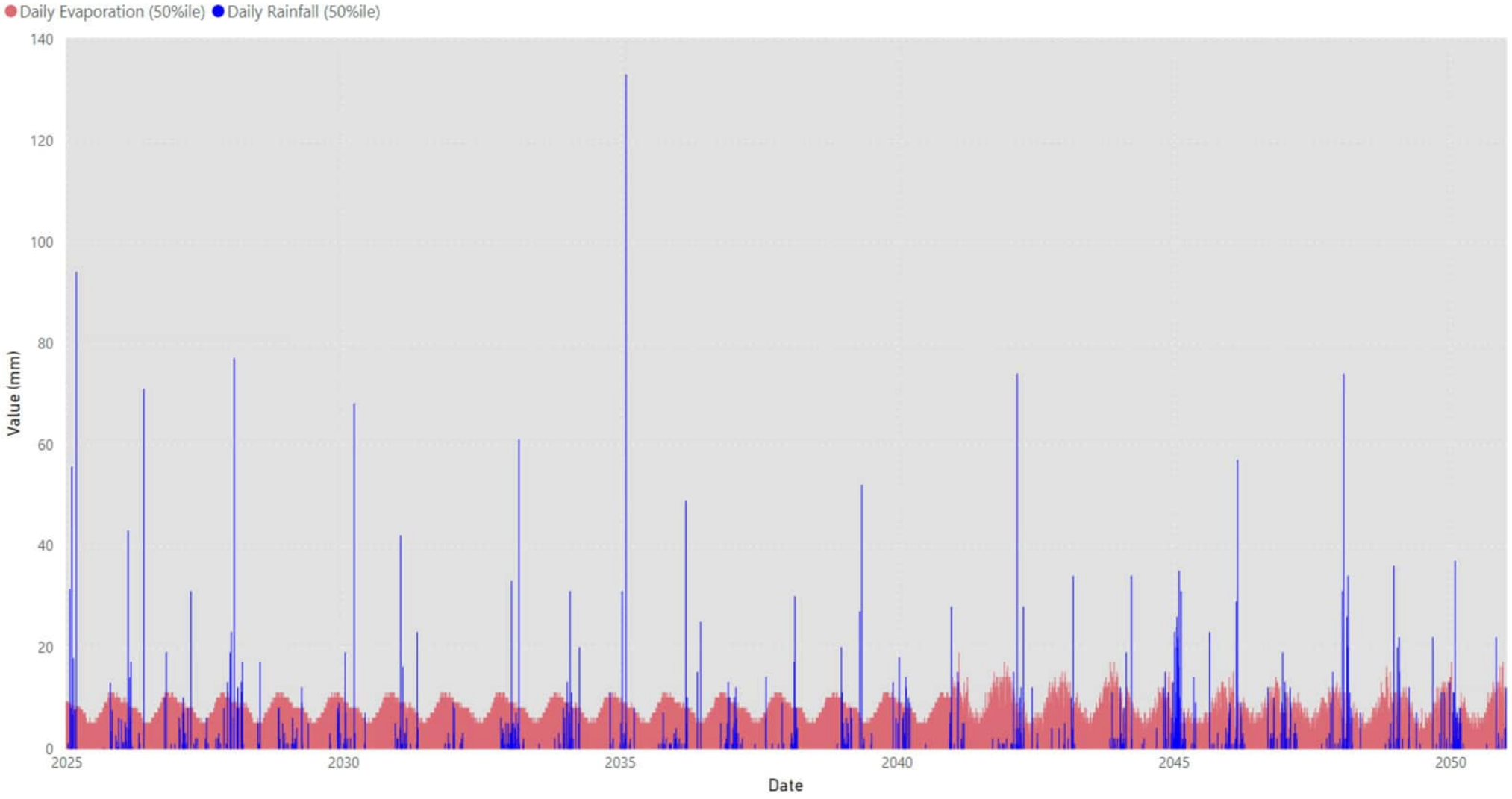

Mixing (P25)
Mixing (P50)
Mixing (P75)
Livestock WQG: 0.20
Uranium (mg/L)
0.20
0.15
0.10
0.05
0.00
2030
2040
2050
2060
2070
2080

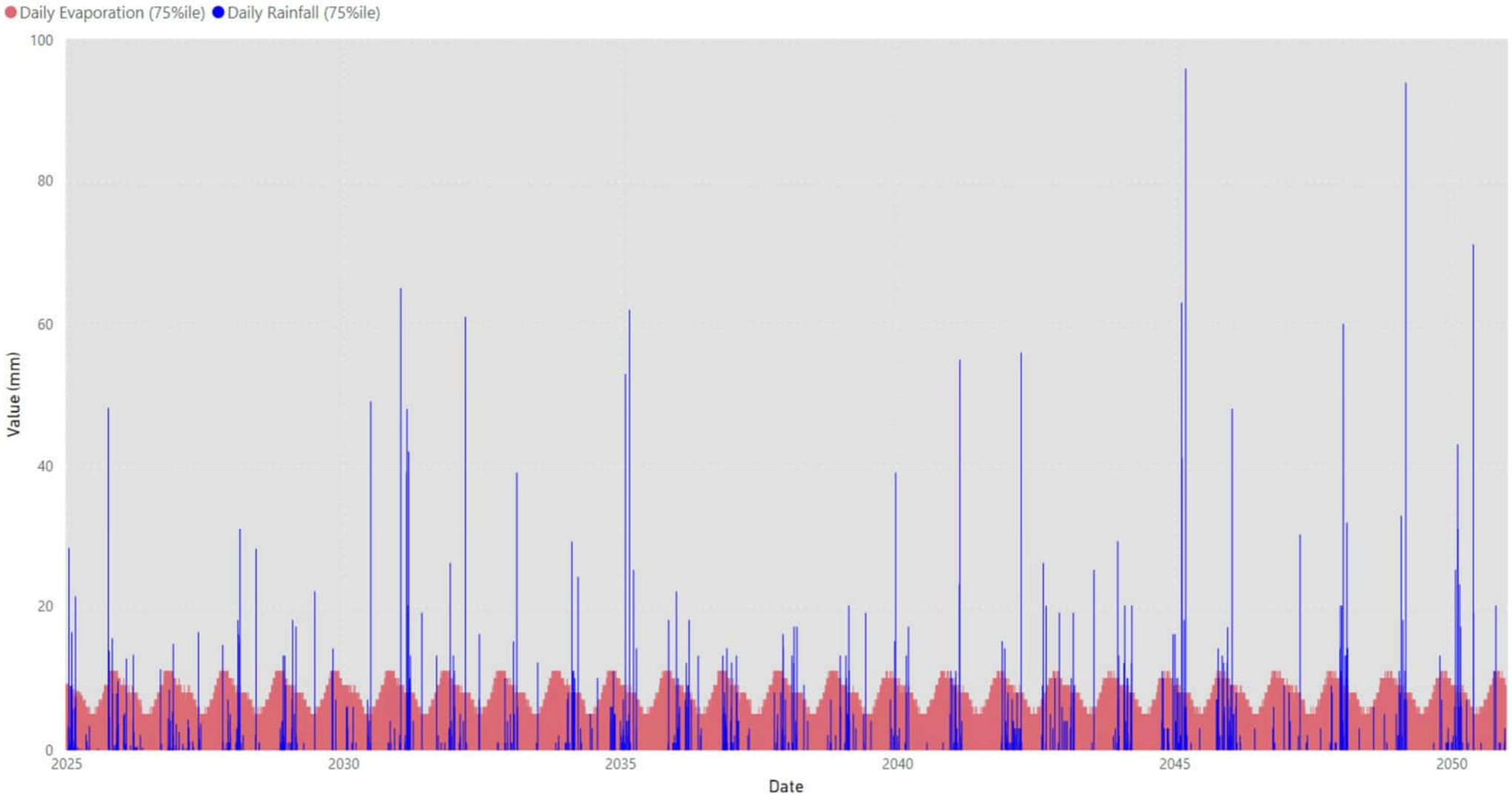
Appendix K WQM results for underground workings

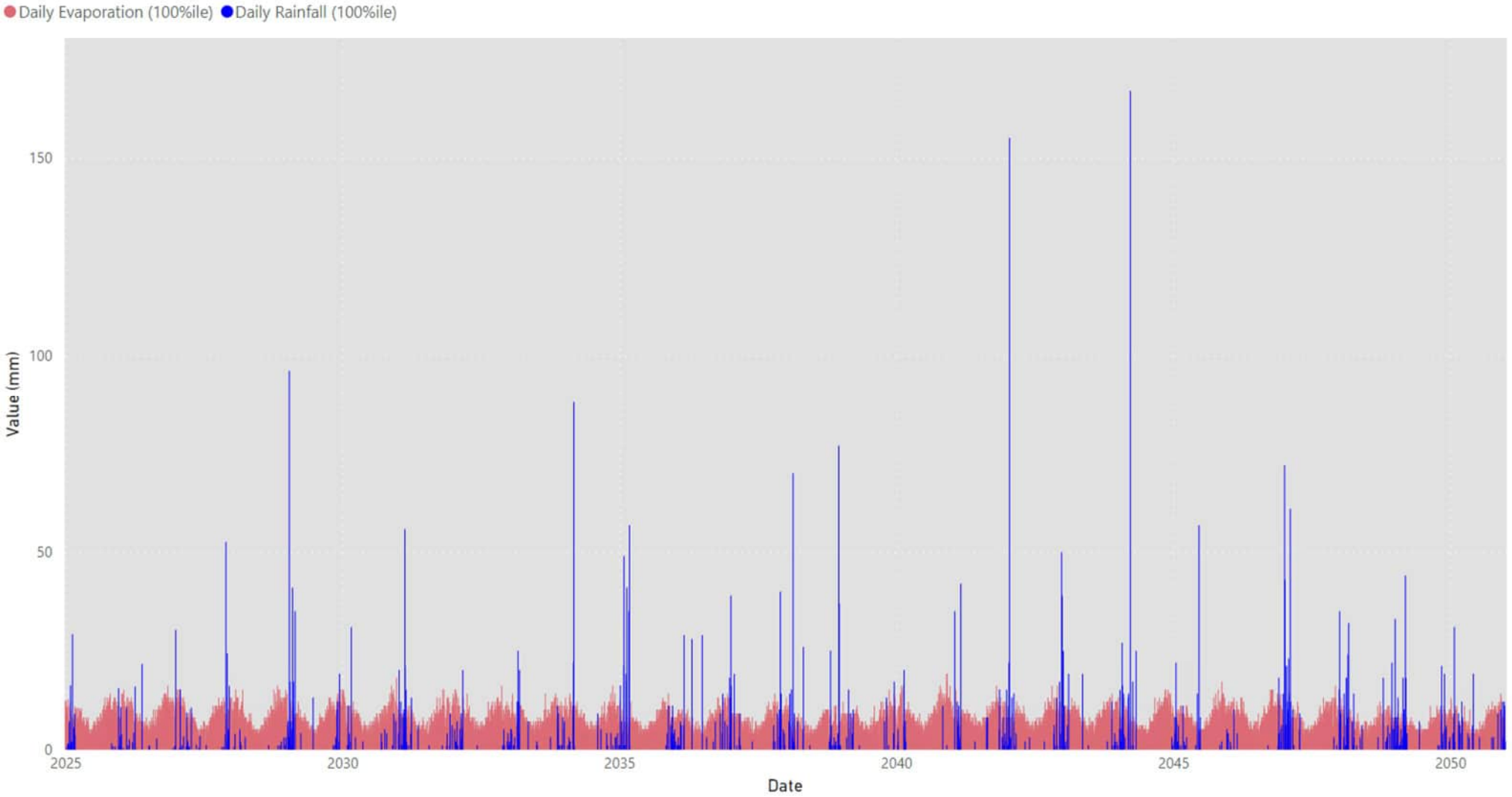
K.1 Climate data for UG water quality model


Daily Evaporation (5%ile)
Daily Rainfall (5%ile)
Value (mm)
0
20
40
60
80
2025
2030
2035
2040
2045
2050
Date


Daily Evaporation (25%ile)
Daily Rainfall (25%ile)
140
120
100
80
60
40
20
0
Value (mm)
2025
2030
2035
2040
2045
2050
Date

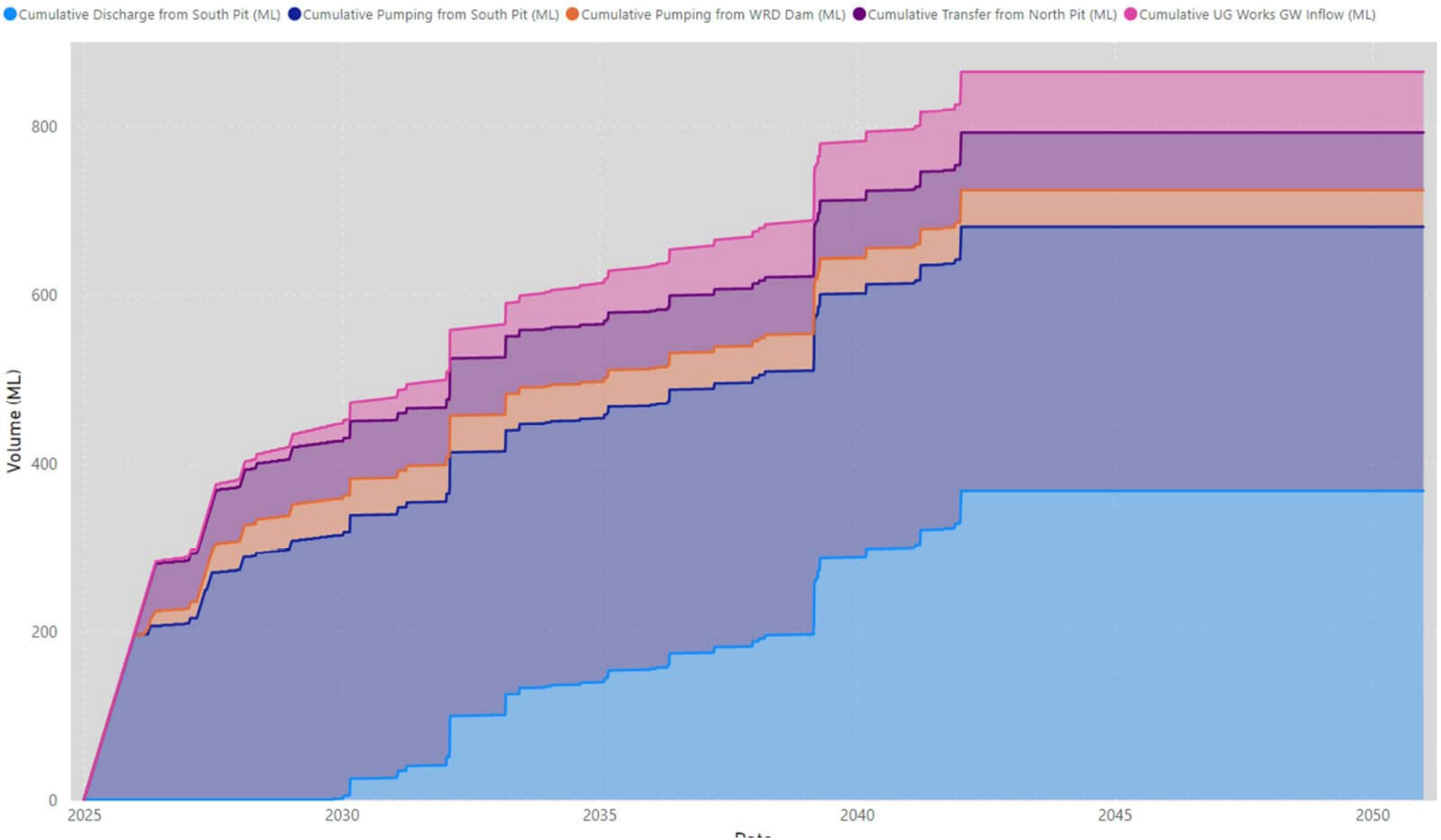

Daily Evaporation (50%ile)
Daily Rainfall (50%ile)
140
120
100
80
60
40
20
0
Value (mm)
2025
2030
2035
2040
2045
2050
Date

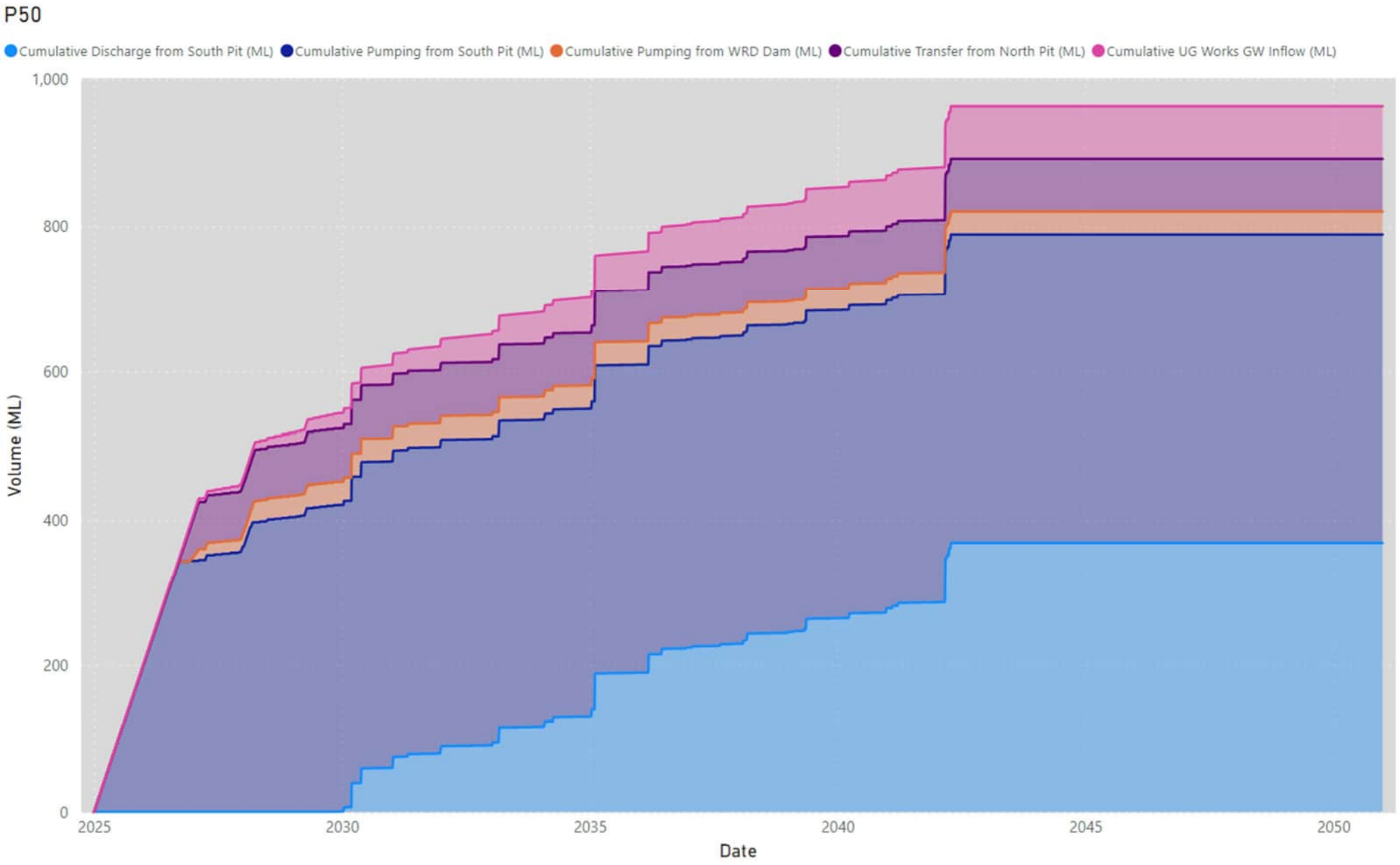

Daily Evaporation (75%ile)
Daily Rainfall (75%ile)
100
80
60
40
20
0
Value (mm)
2025
2030
2035
2040
2045
2050
Date

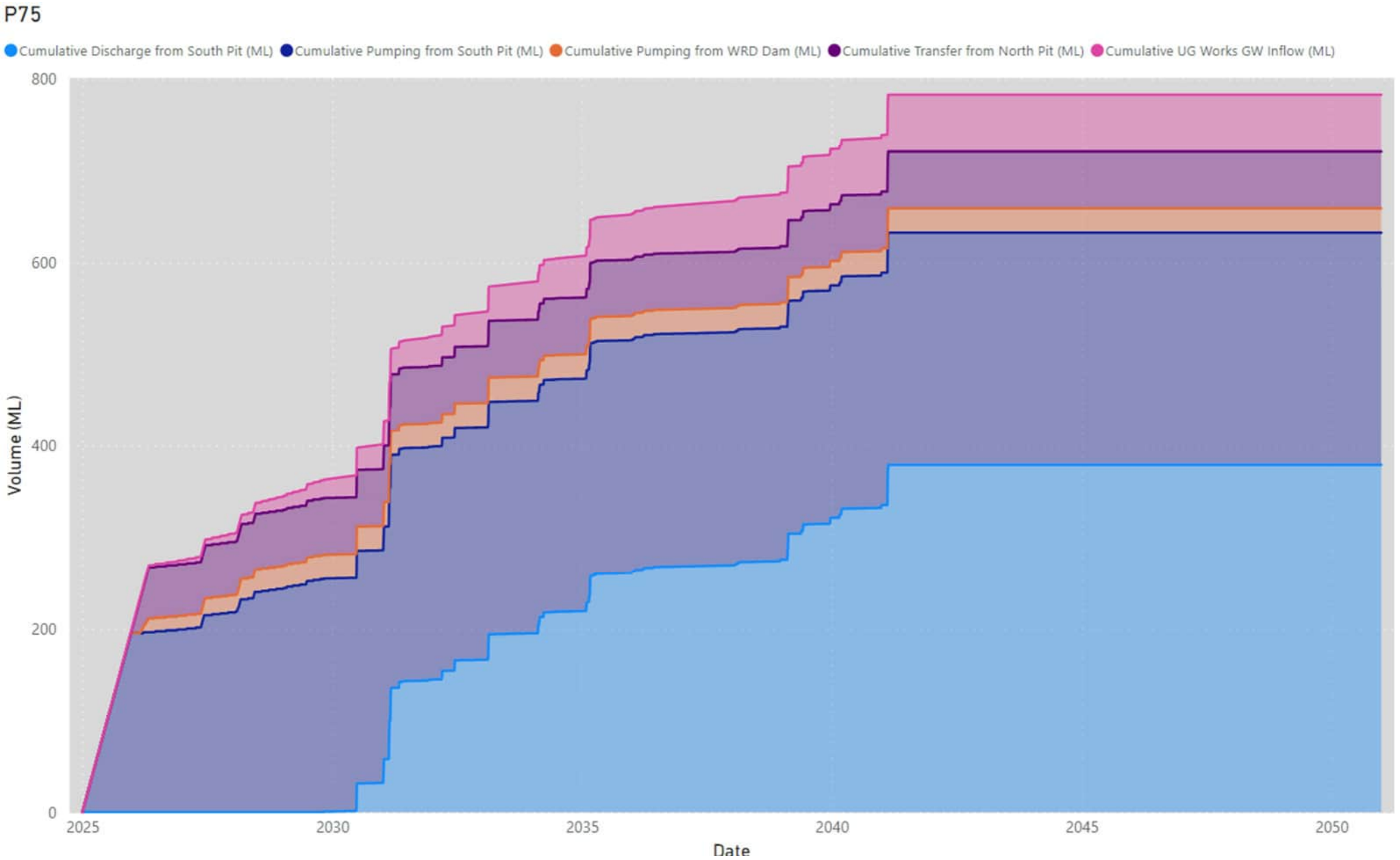

Daily Evaporation (100%ile)
Daily Rainfall (100%ile)
Value (mm)
150
100
50
0
2025
2030
2035
2040
2045
2050
Date

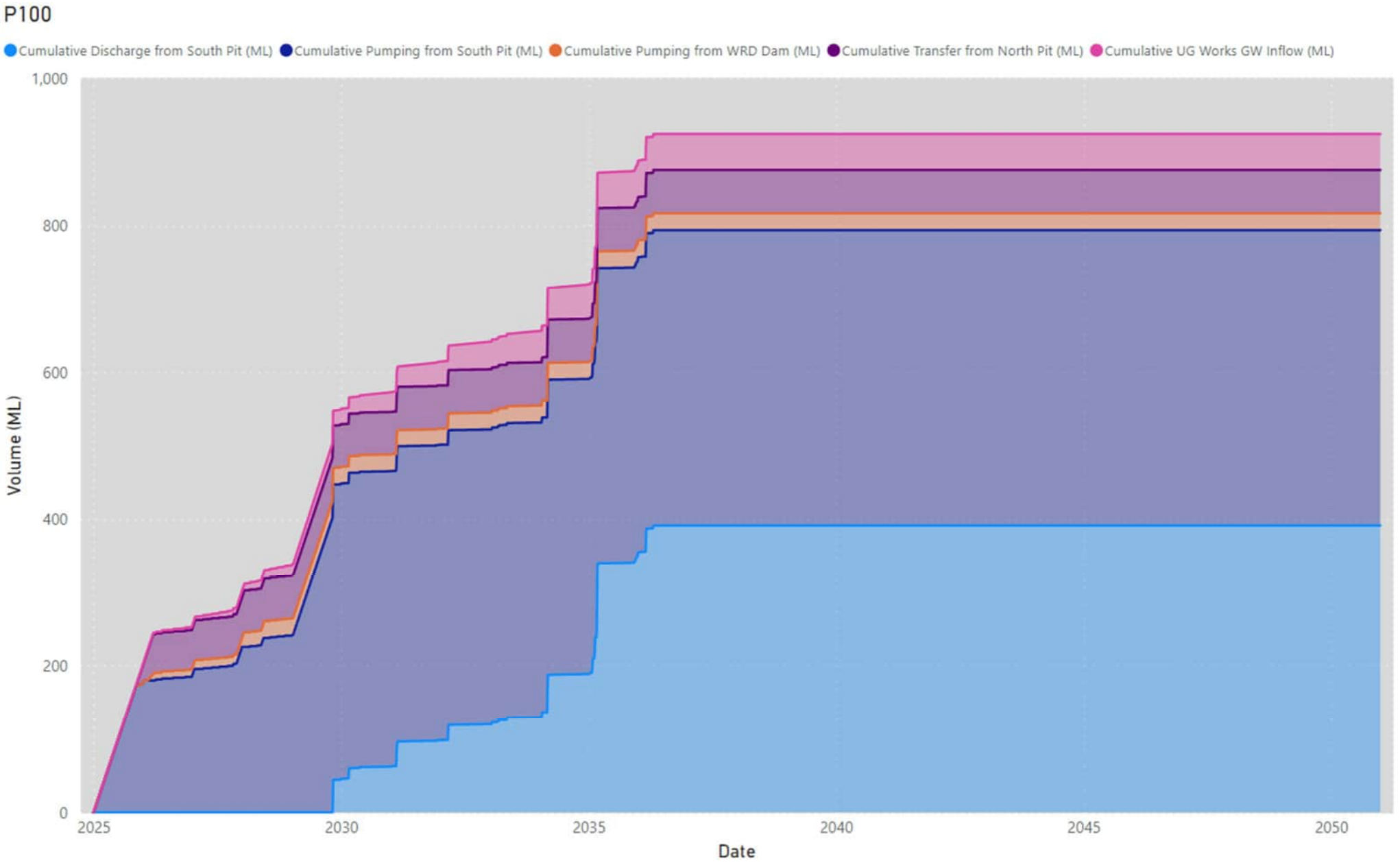
K.2 UG water quality model - volumes

P25

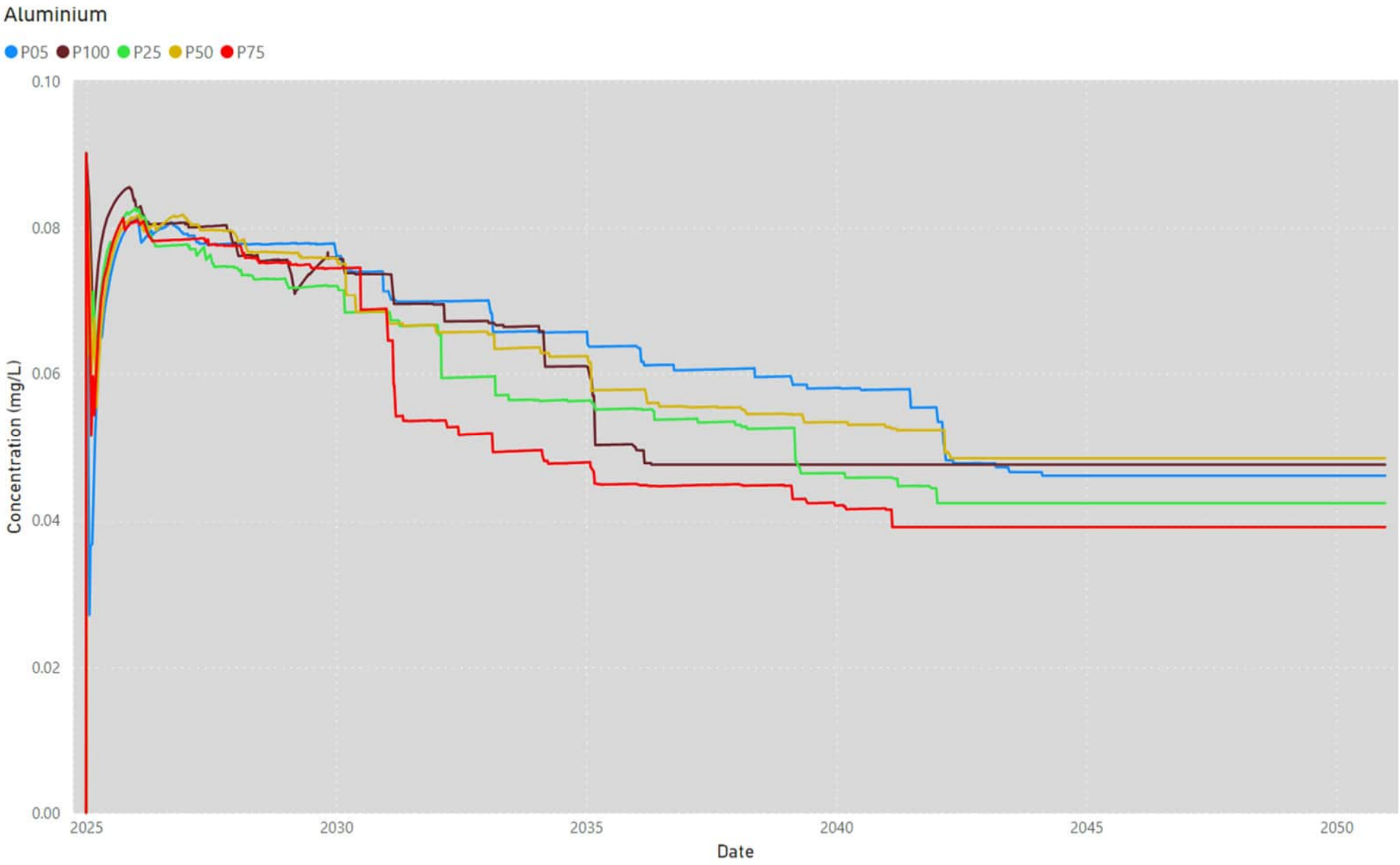

Cumulative Discharge from South Pit (ML)
Cumulative Pumping from South Pit (ML)
Cumulative Pumping from WRD Dam (ML)
Cumulative Transfer from North Pit (ML)
Cumulative UG Works GW Inflow (ML)
Volume (ML)
0
200
400
600
800
2025
2030
2035
2040
2045
2050

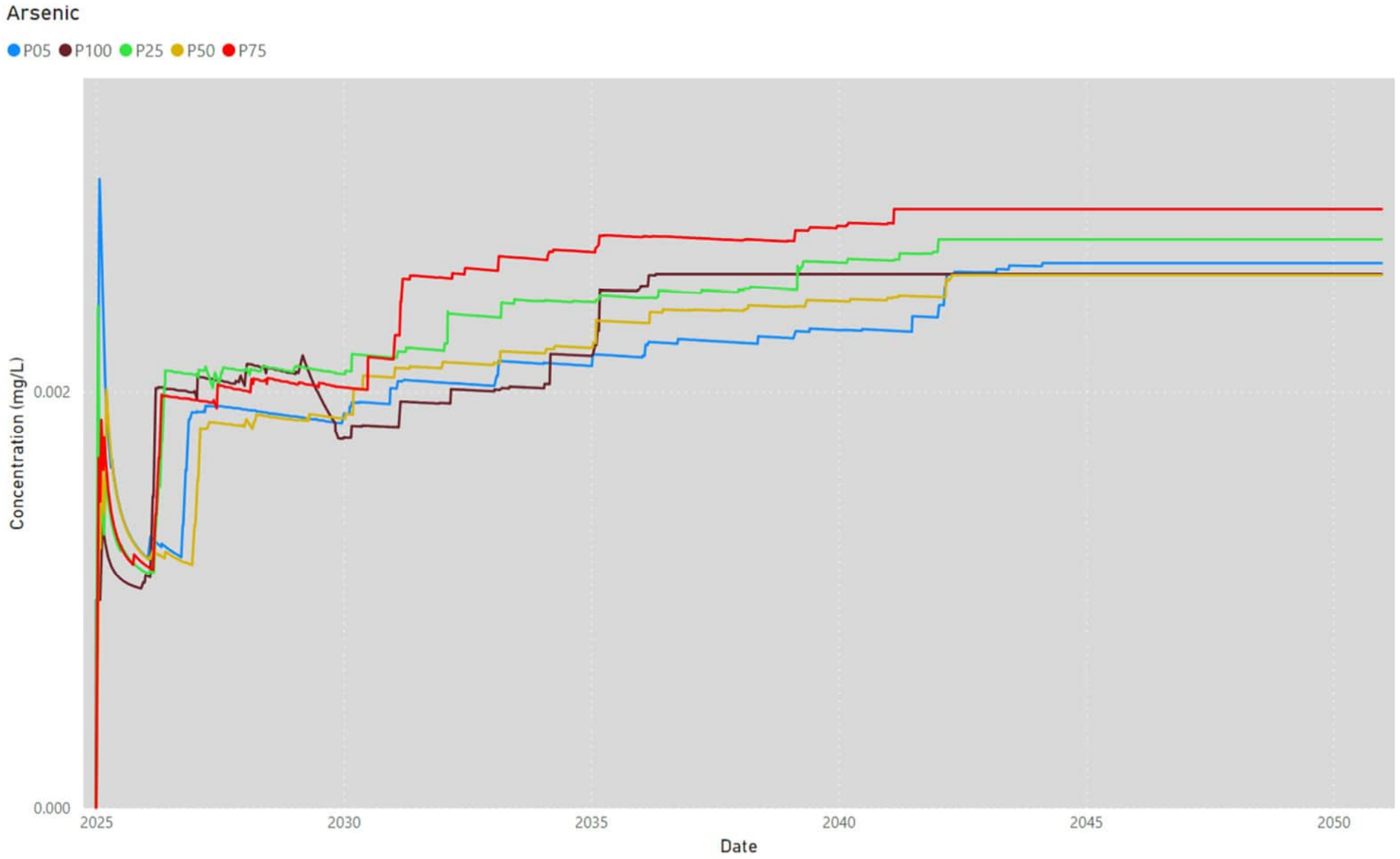

P50
Cumulative Discharge from South Pit (ML)
Cumulative Pumping from South Pit (ML)
Cumulative Pumping from WRD Dam (ML)
Cumulative Transfer from North Pit (ML)
Cumulative UG Works GW Inflow (ML)
1,000
800
600
400
200
0
Volume (ML)
2025
2030
2035
2040
2045
2050
Date

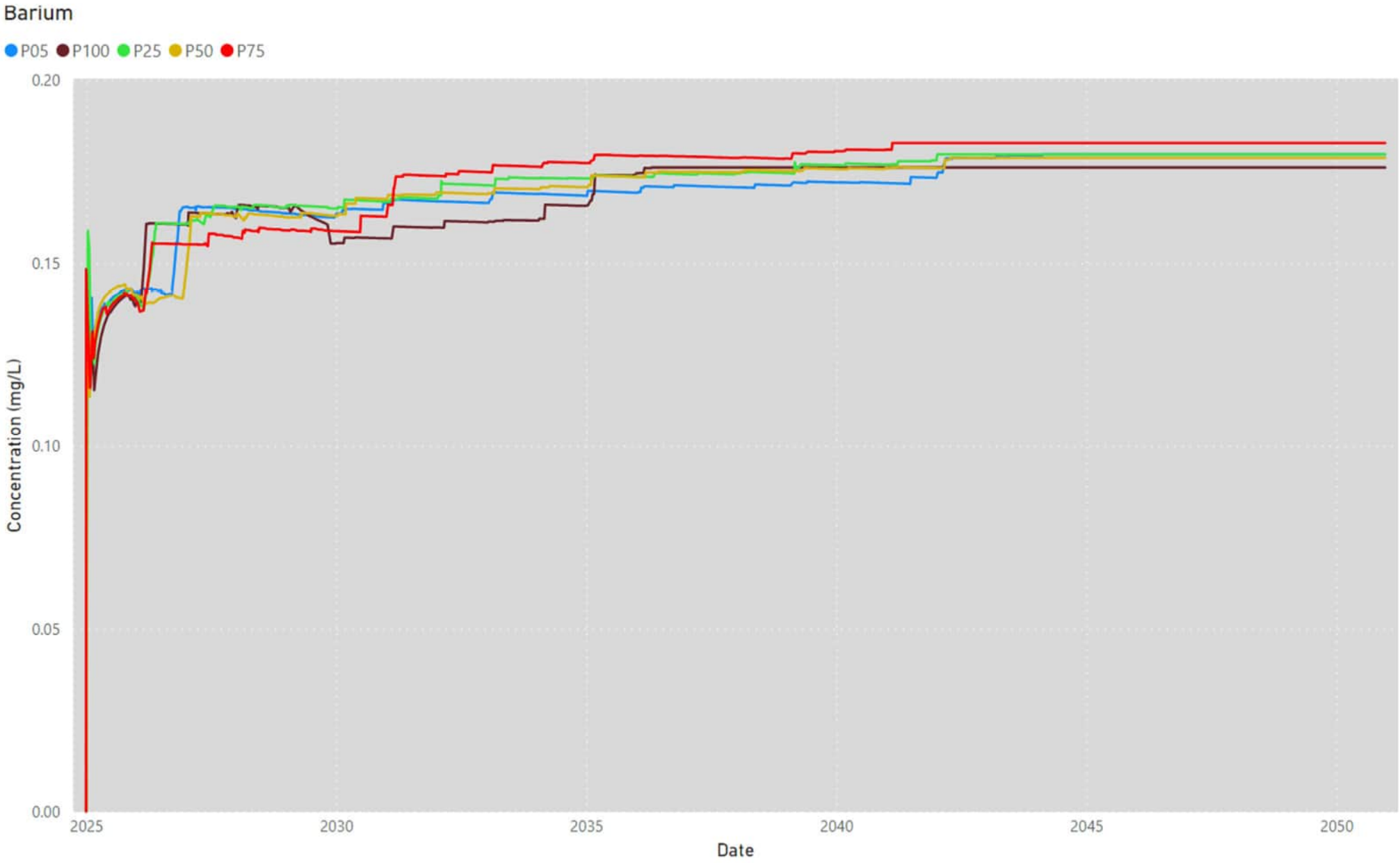

P75
Cumulative Discharge from South Pit (ML)
Cumulative Pumping from South Pit (ML)
Cumulative Pumping from WRD Dam (ML)
Cumulative Transfer from North Pit (ML)
Cumulative UG Works GW Inflow (ML)
800
600
400
200
0
Volume (ML)
2025
2030
2035
2040
2045
2050
Date

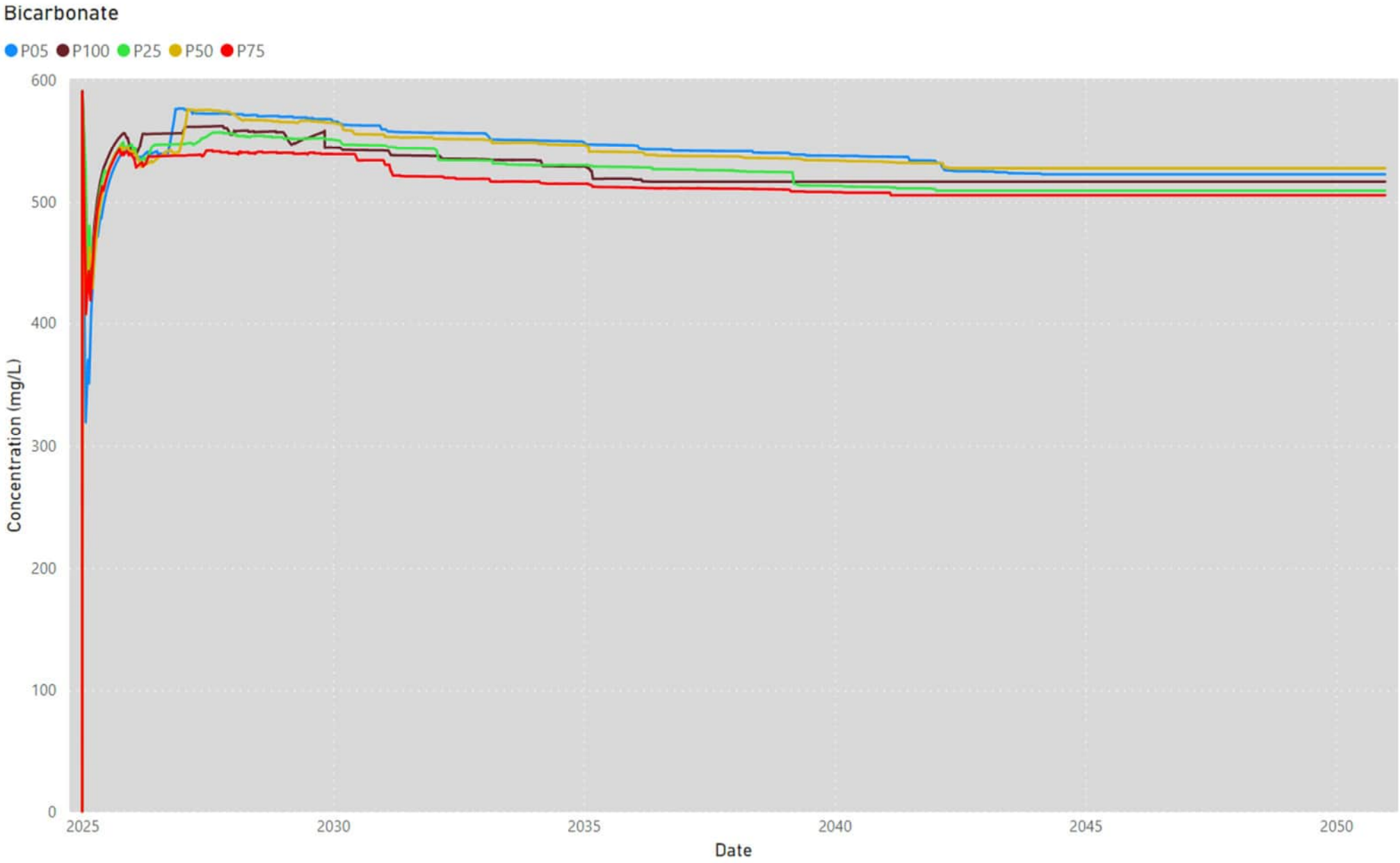

P100
Cumulative Discharge from South Pit (ML)
Cumulative Pumping from South Pit (ML)
Cumulative Pumping from WRD Dam (ML)
Cumulative Transfer from North Pit (ML)
Cumulative UG Works GW Inflow (ML)
1,000
800
600
400
200
0
Volume (ML)
2025
2030
2035
2040
2045
2050
Date

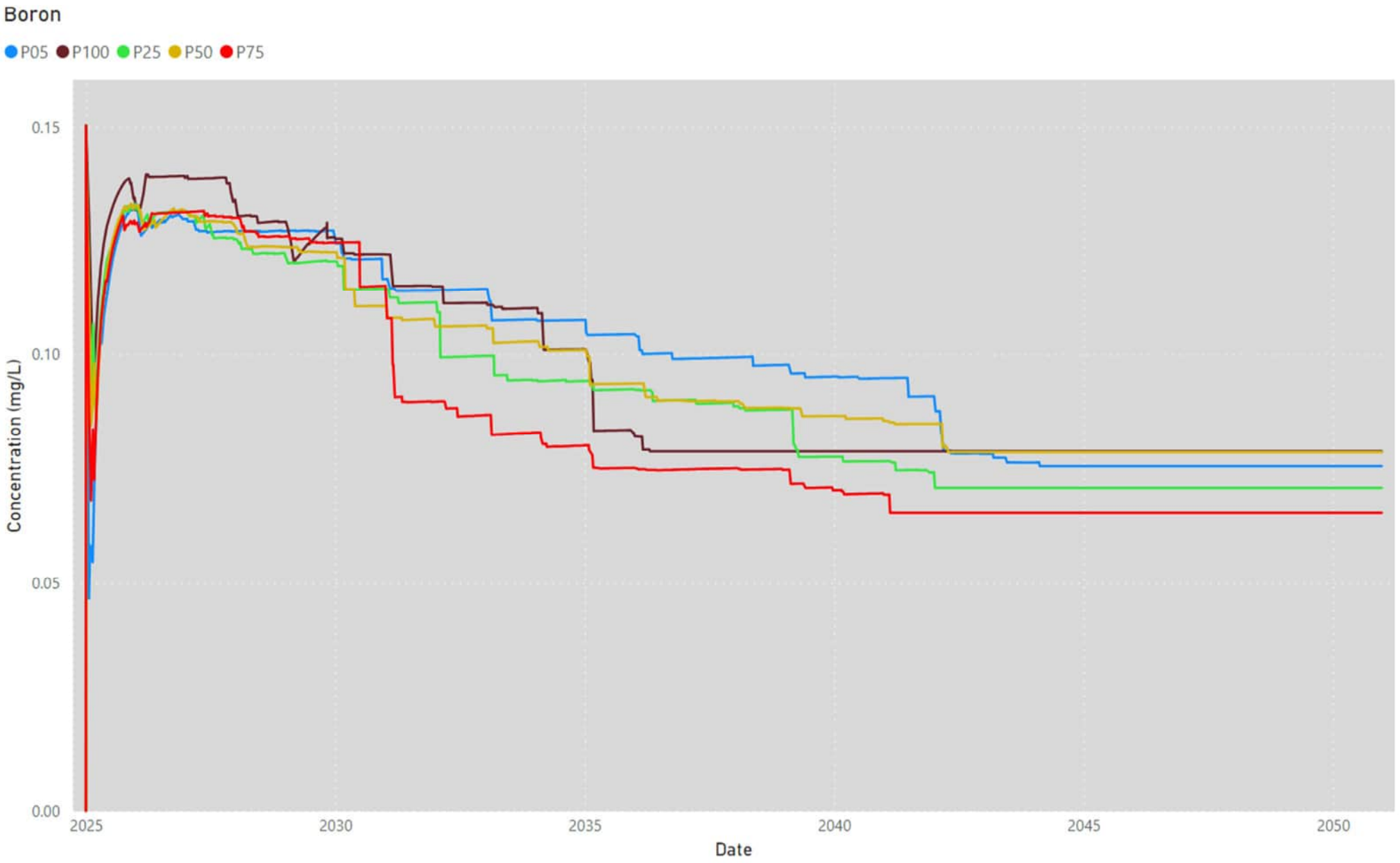
K.3 UG final void water quality charts

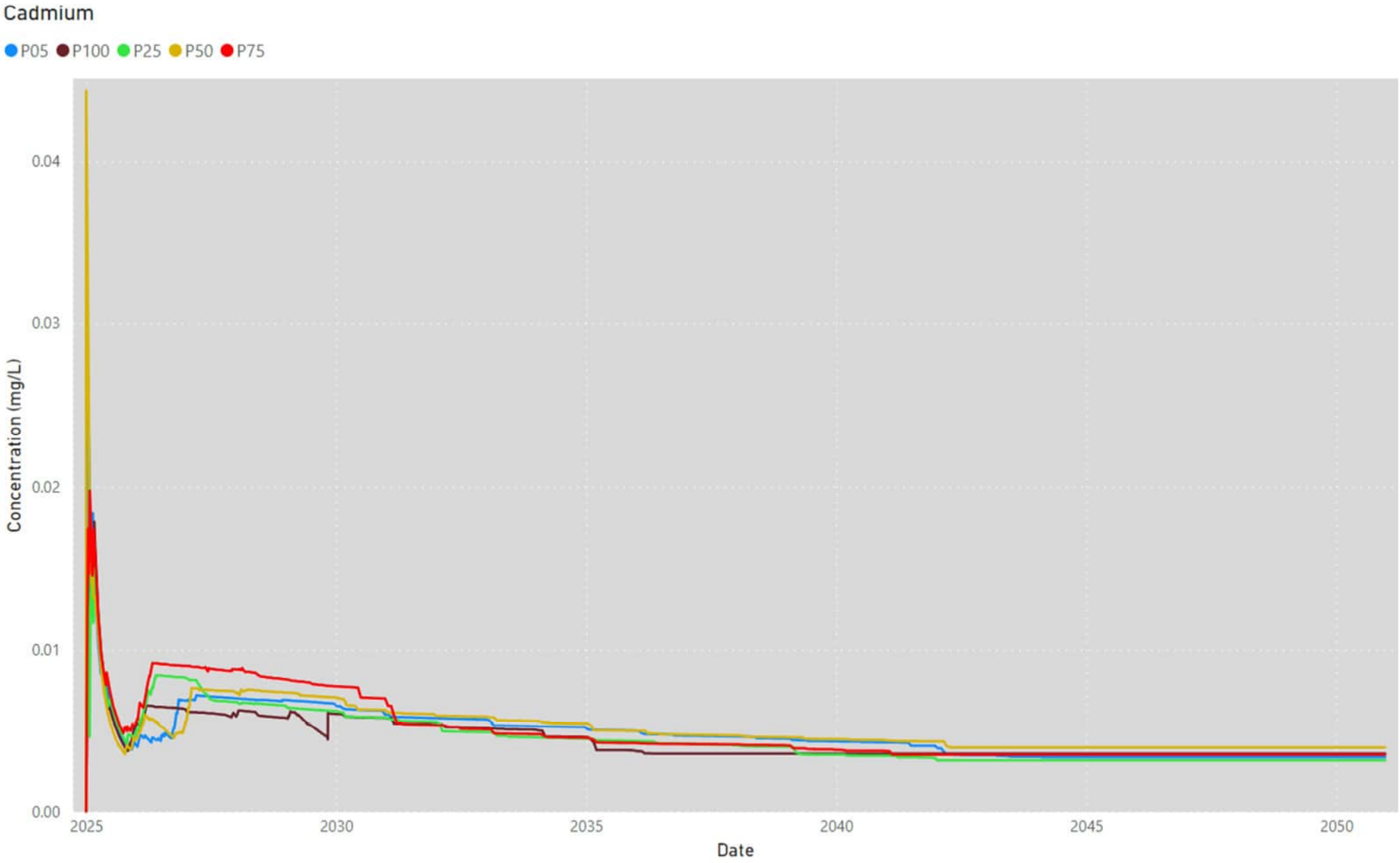

Aluminium
P05
P100
P25
P50
P75
0.10
0.08
0.06
0.04
0.02
0.00
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

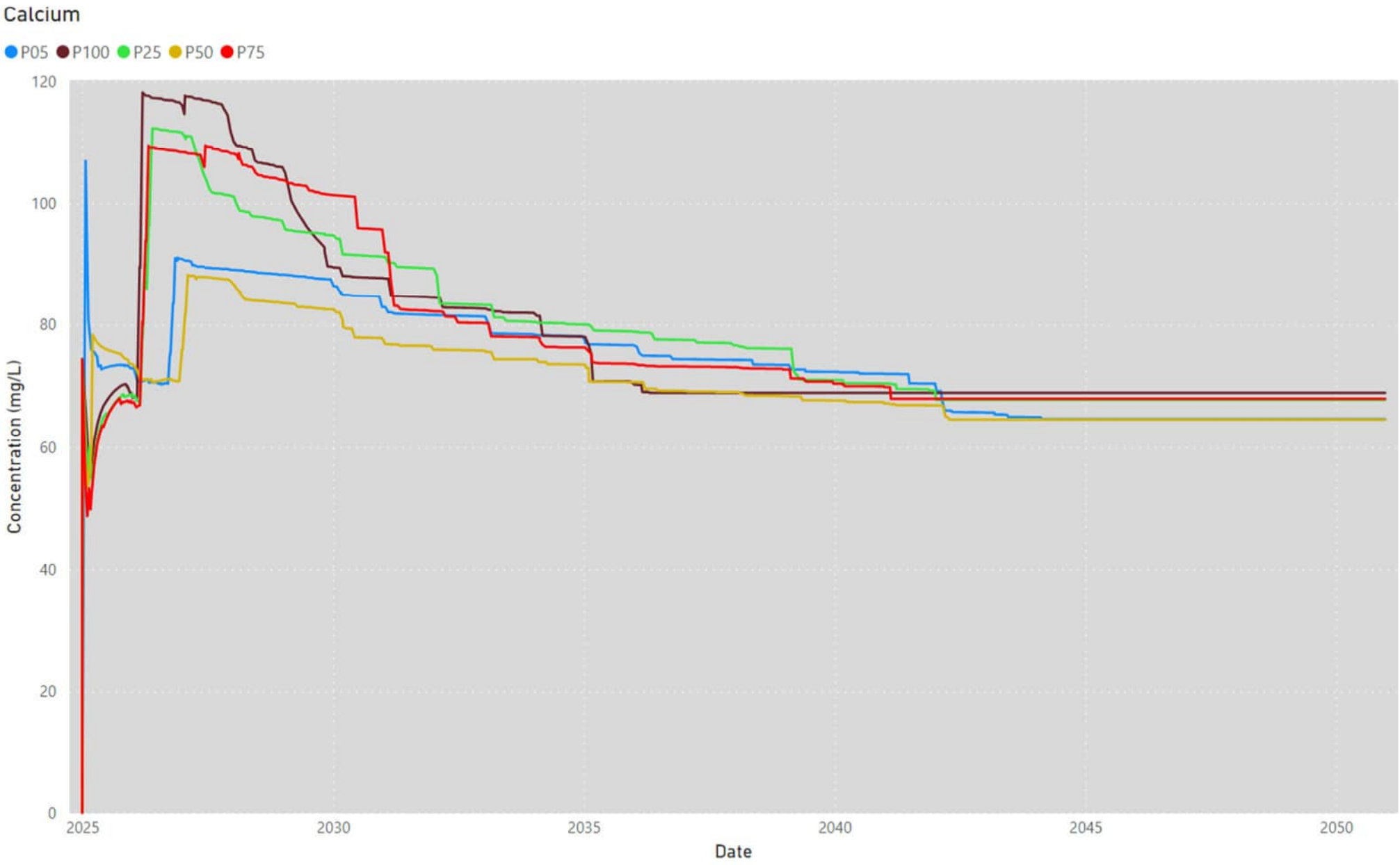

Arsenic
P05
P100
P25
P50
P75
Concentration (mg/L)
0.002
0.000
2025
2030
2035
2040
2045
2050
Date

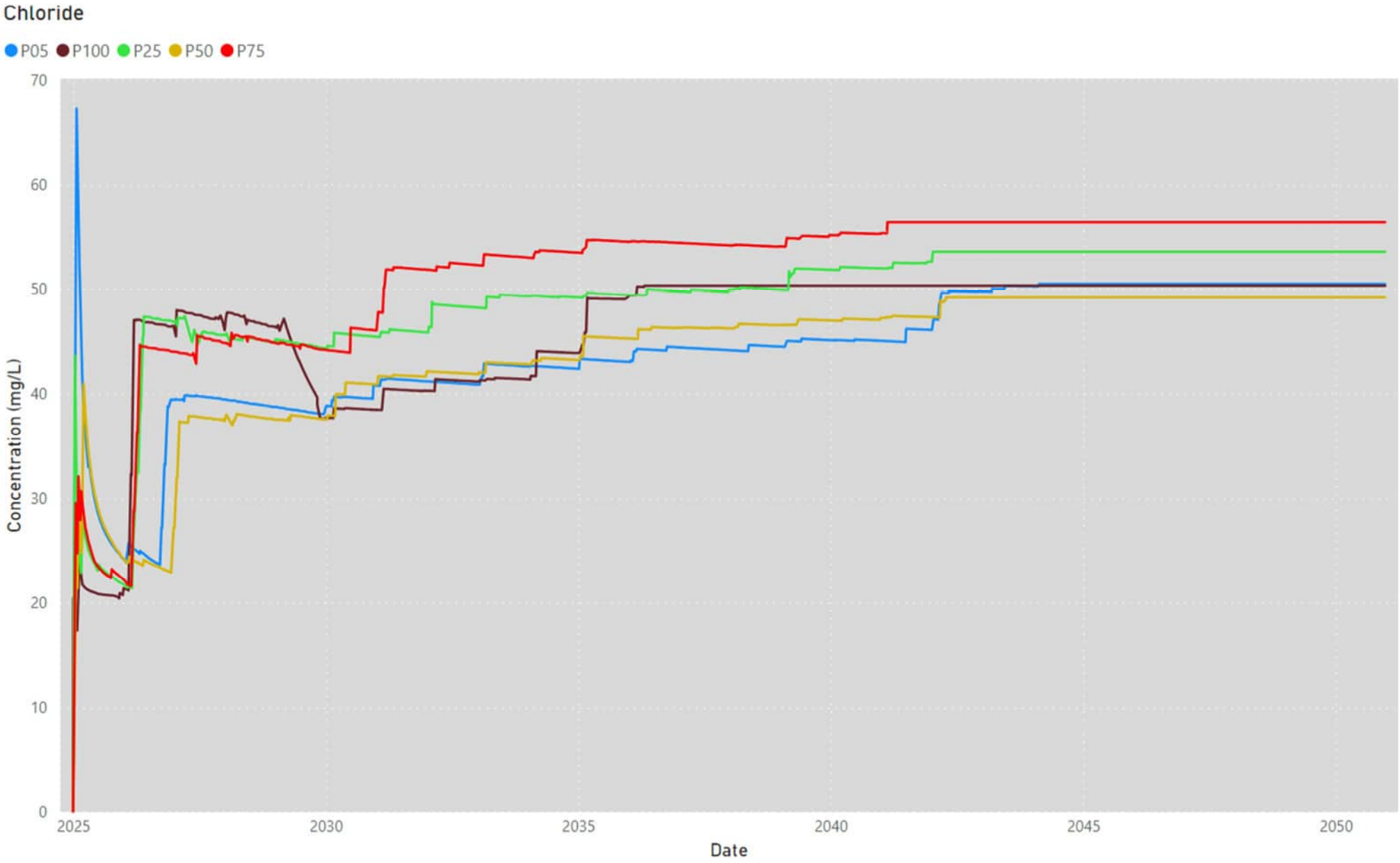

Barium
P05
P100
P25
P50
P75
0.20
0.15
0.10
0.05
0.00
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

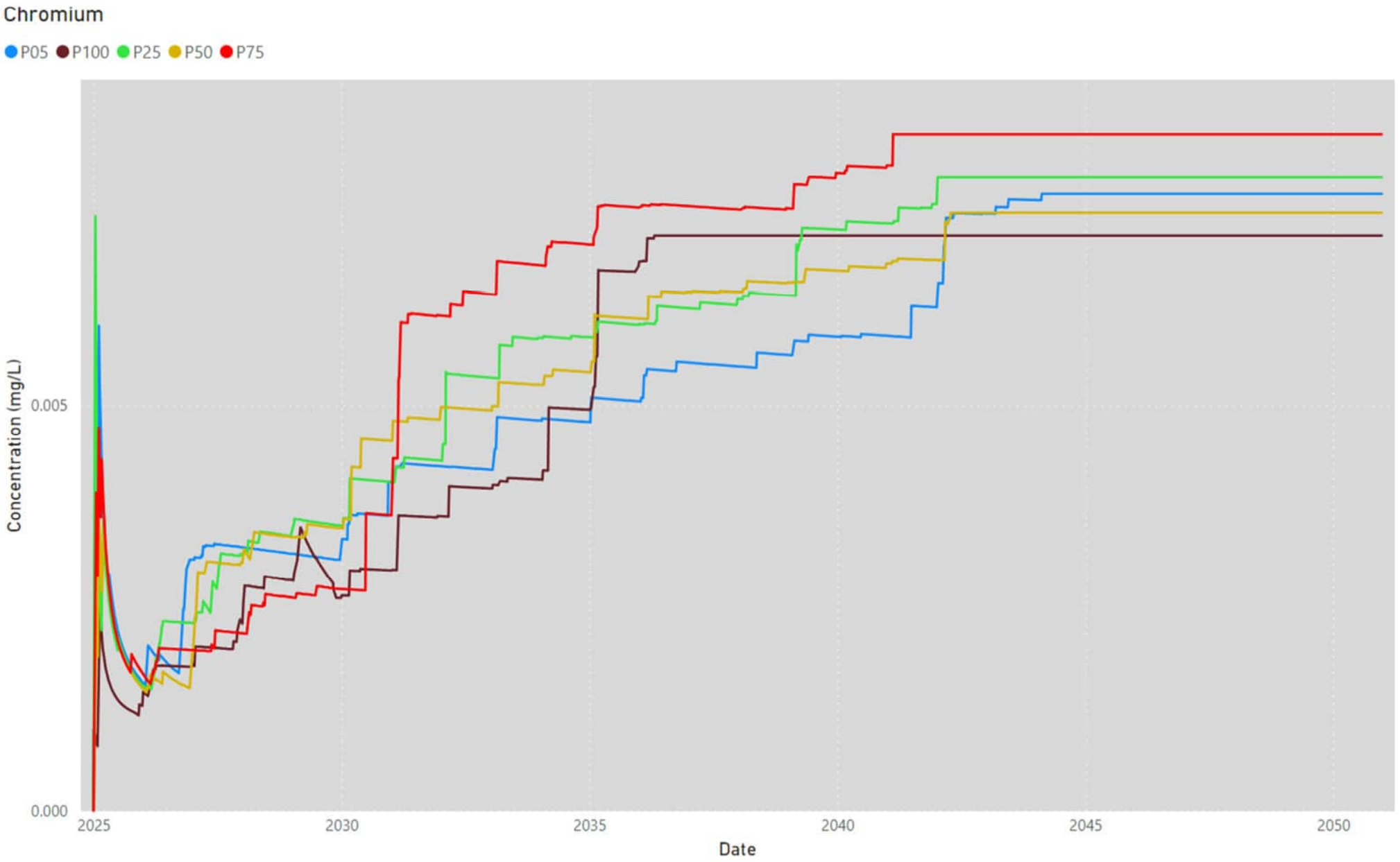

Bicarbonate
P05
P100
P25
P50
P75
600
500
400
300
200
100
0
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

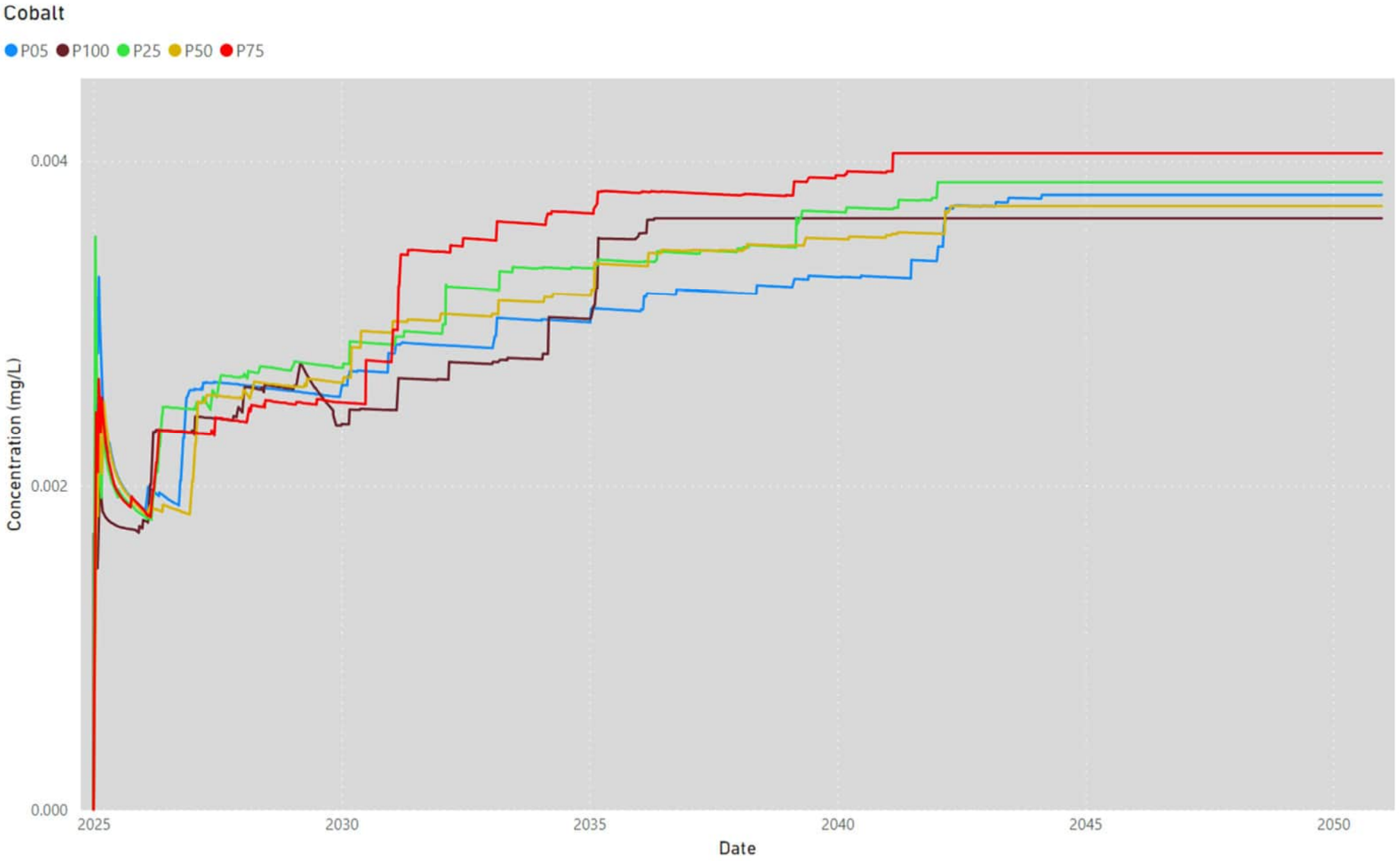

Boron
P05
P100
P25
P50
P75
0.15
0.10
0.05
0.00
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

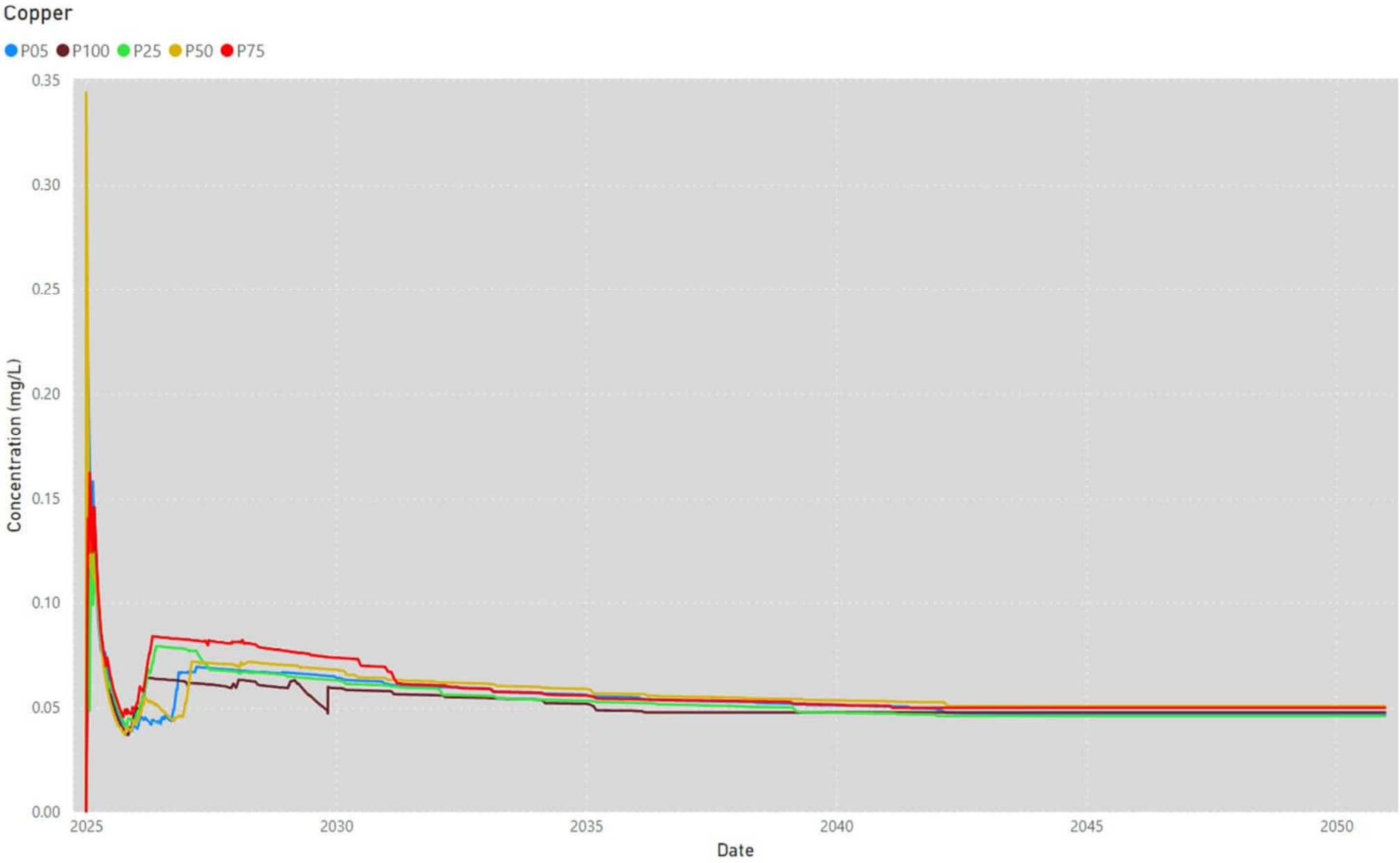

Cadmium
P05
P100
P25
P50
P75
0.04
0.03
0.02
0.01
0.00
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date


Calcium
P05
P100
P25
P50
P75
120
100
80
60
40
20
0
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

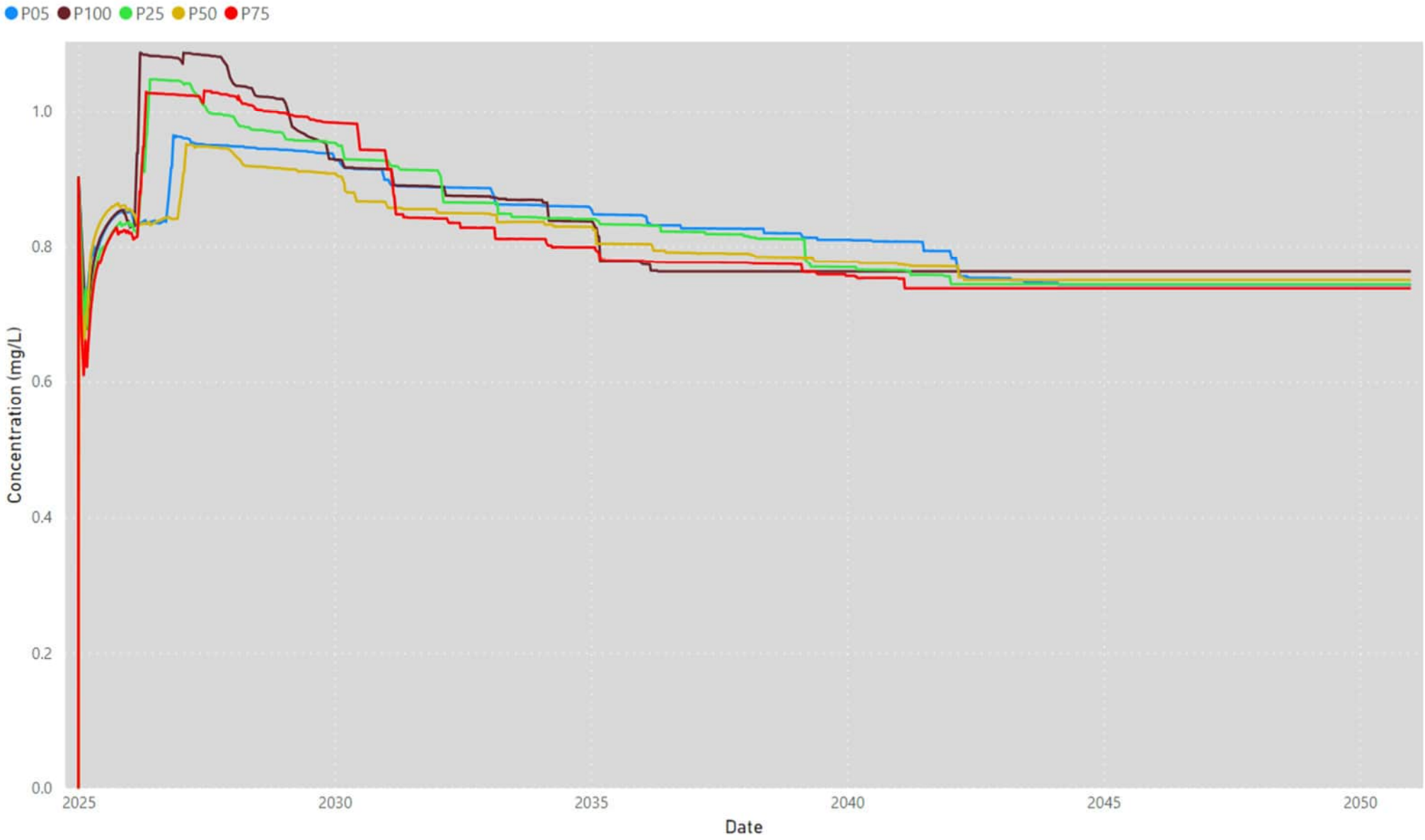

Chloride
P05
P100
P25
P50
P75
70
60
50
40
30
20
10
0
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

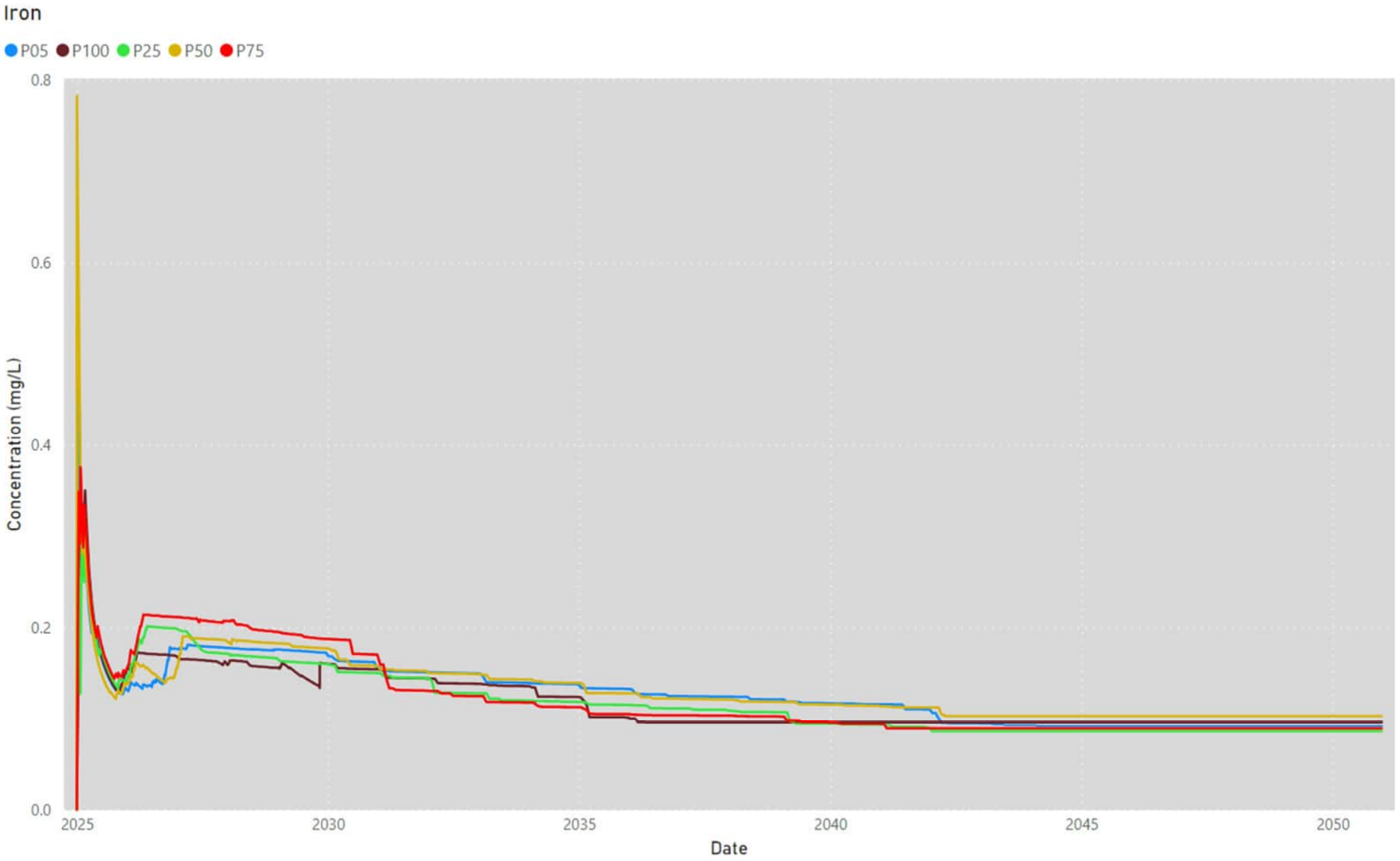

Chromium
P05
P100
P25
P50
P75
Concentration (mg/L)
0.005
0.000
2025
2030
2035
2040
2045
2050
Date

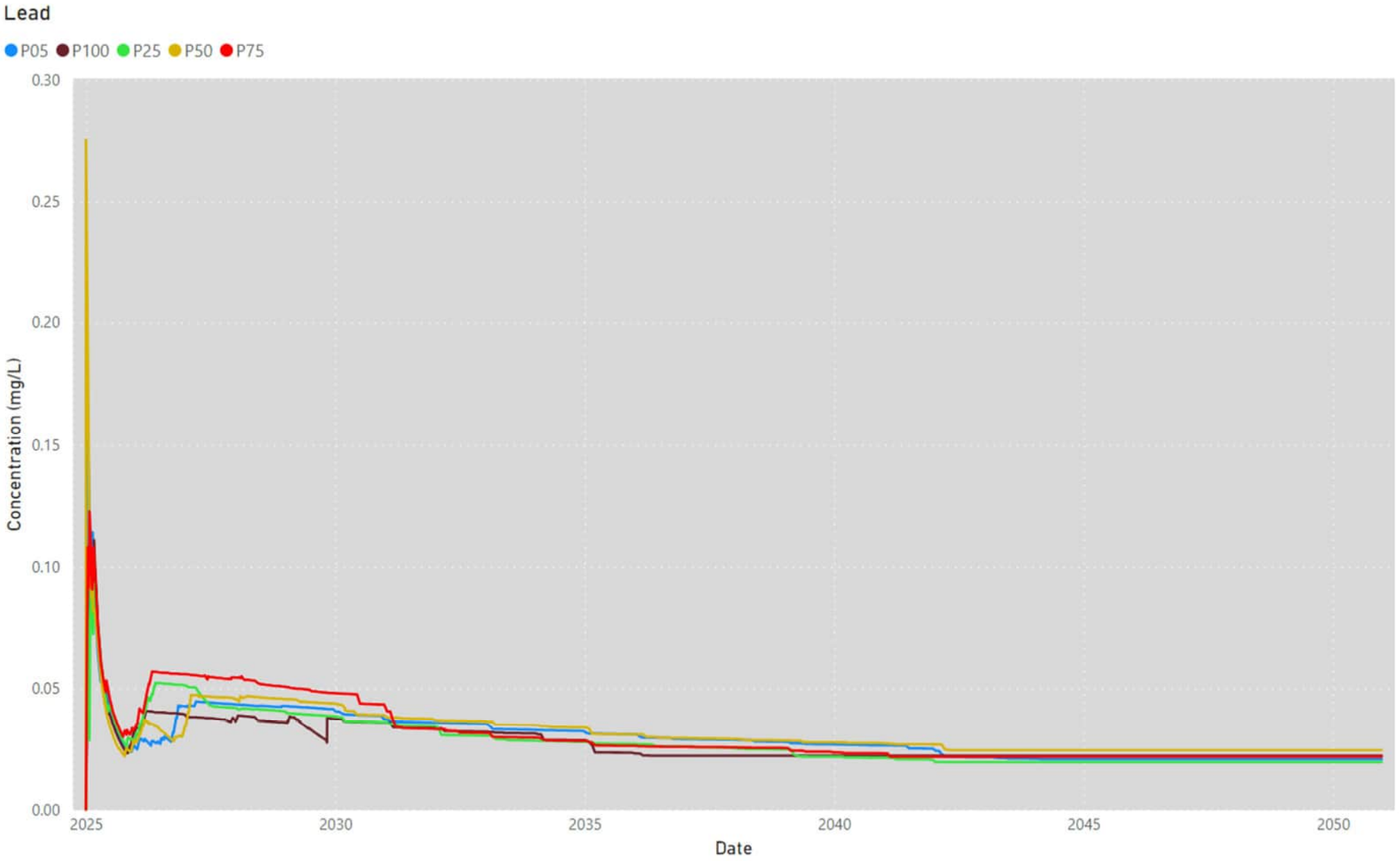

Cobalt
P05
P100
P25
P50
P75
0.004
0.002
0.000
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

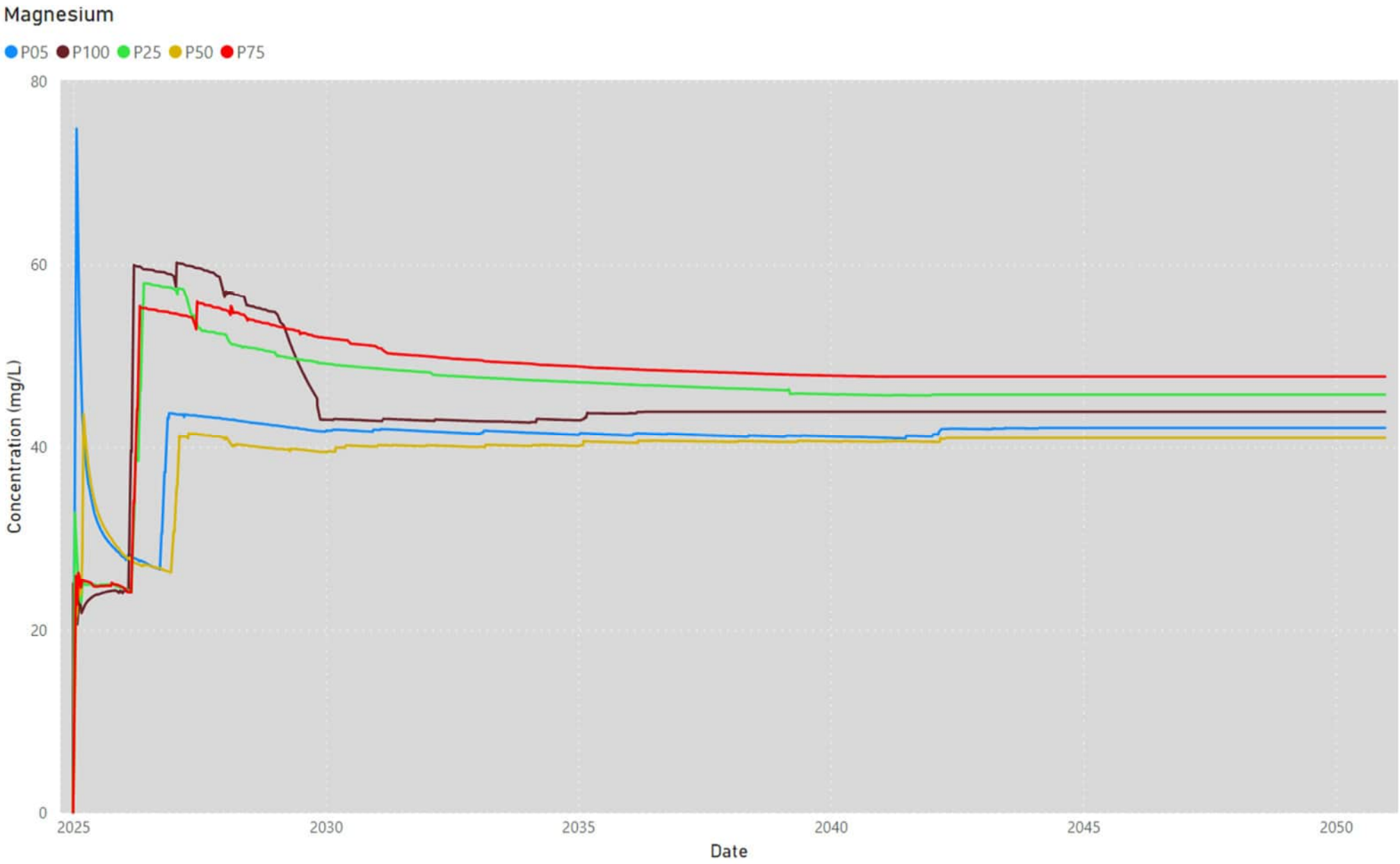

Copper
P05
P100
P25
P50
P75
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

Fluoride

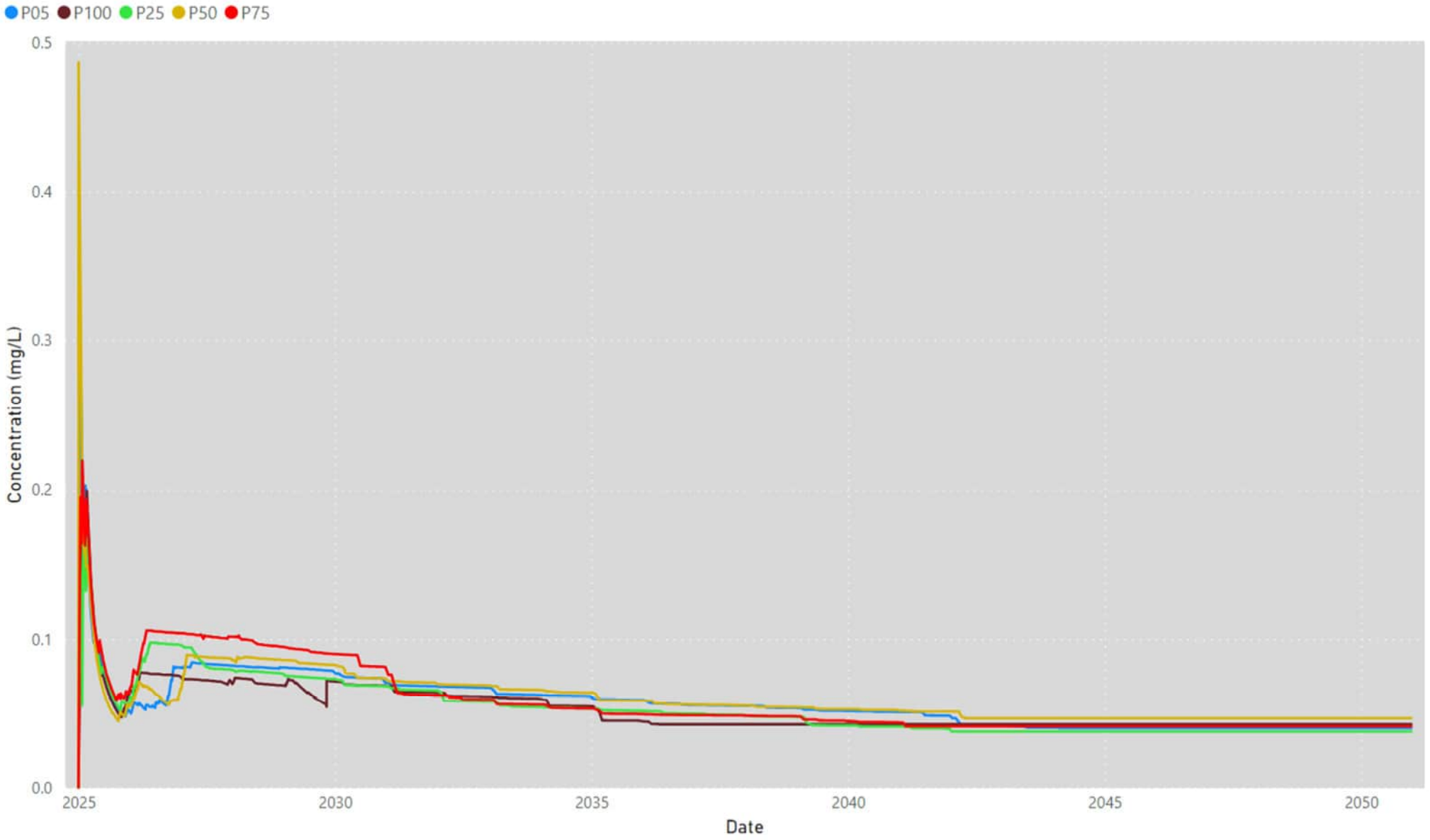

P05
P100
P25
P50
P75
1.0
0.8
0.6
0.4
0.2
0.0
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

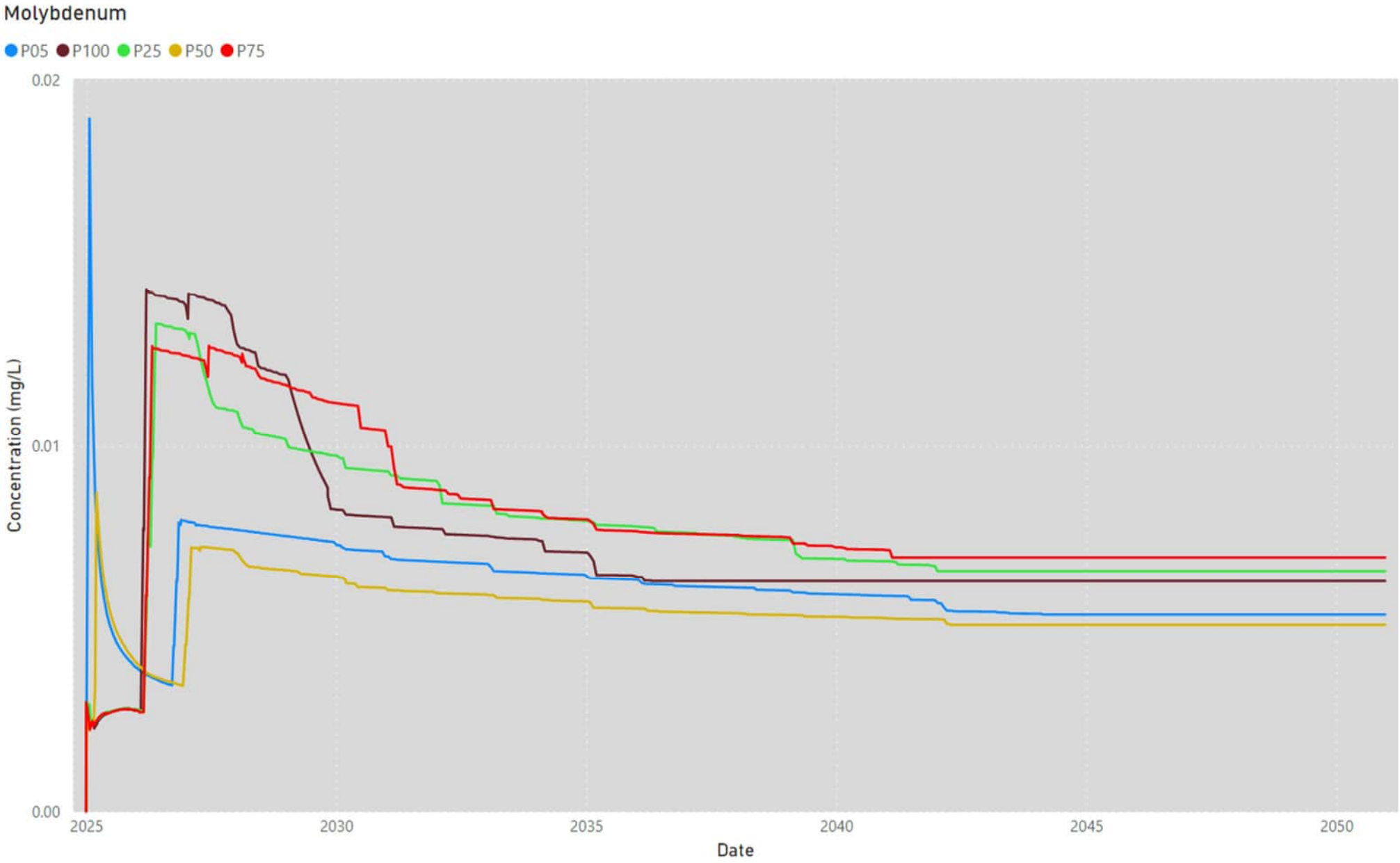

Iron
P05
P100
P25
P50
P75
0.8
0.6
0.4
0.2
0.0
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

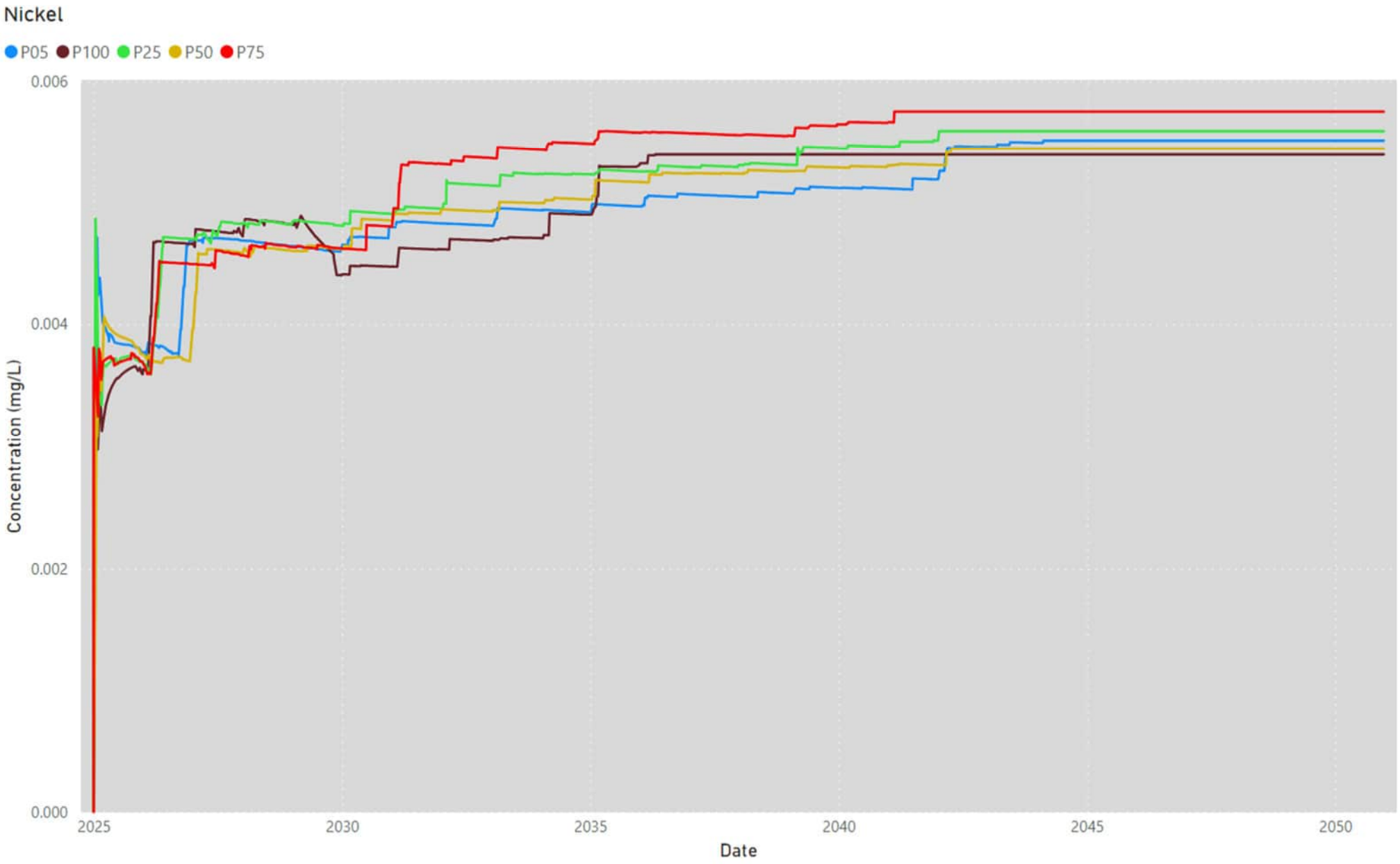

Lead
P05
P100
P25
P50
P75
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

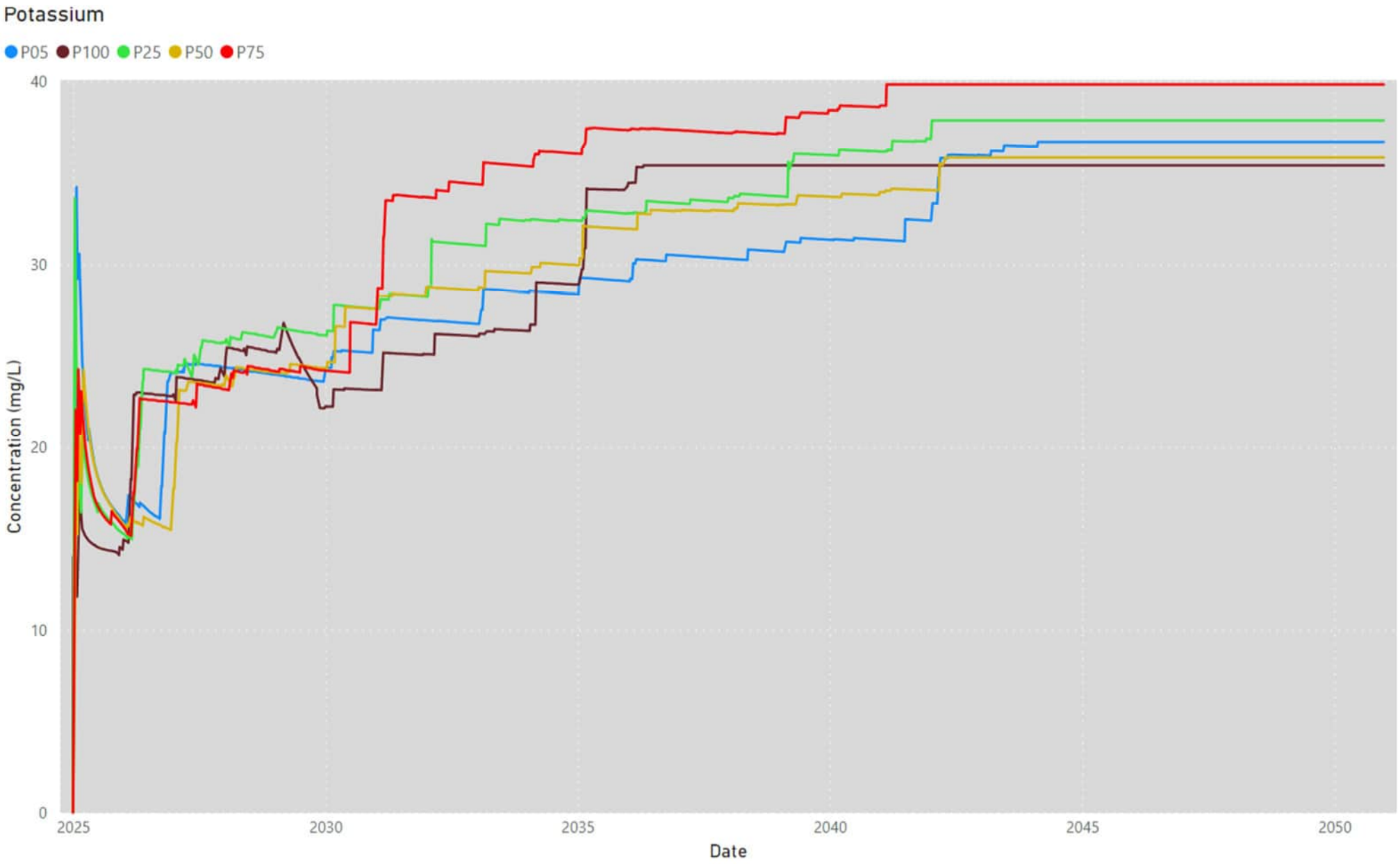

Magnesium
P05
P100
P25
P50
P75
80
60
40
20
0
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

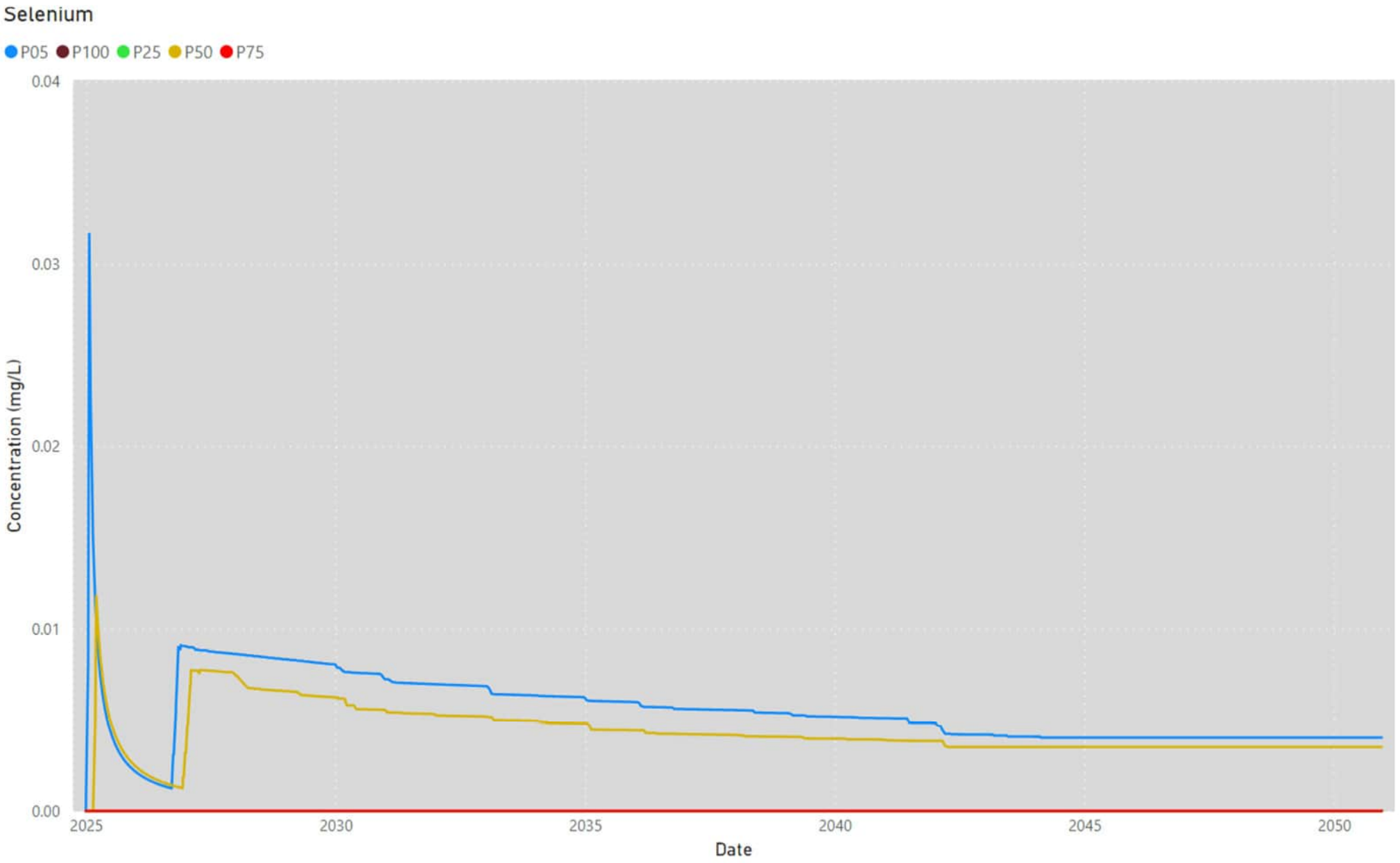
Manganese


P05
P100
P25
P50
P75
0.5
0.4
0.3
0.2
0.1
0.0
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

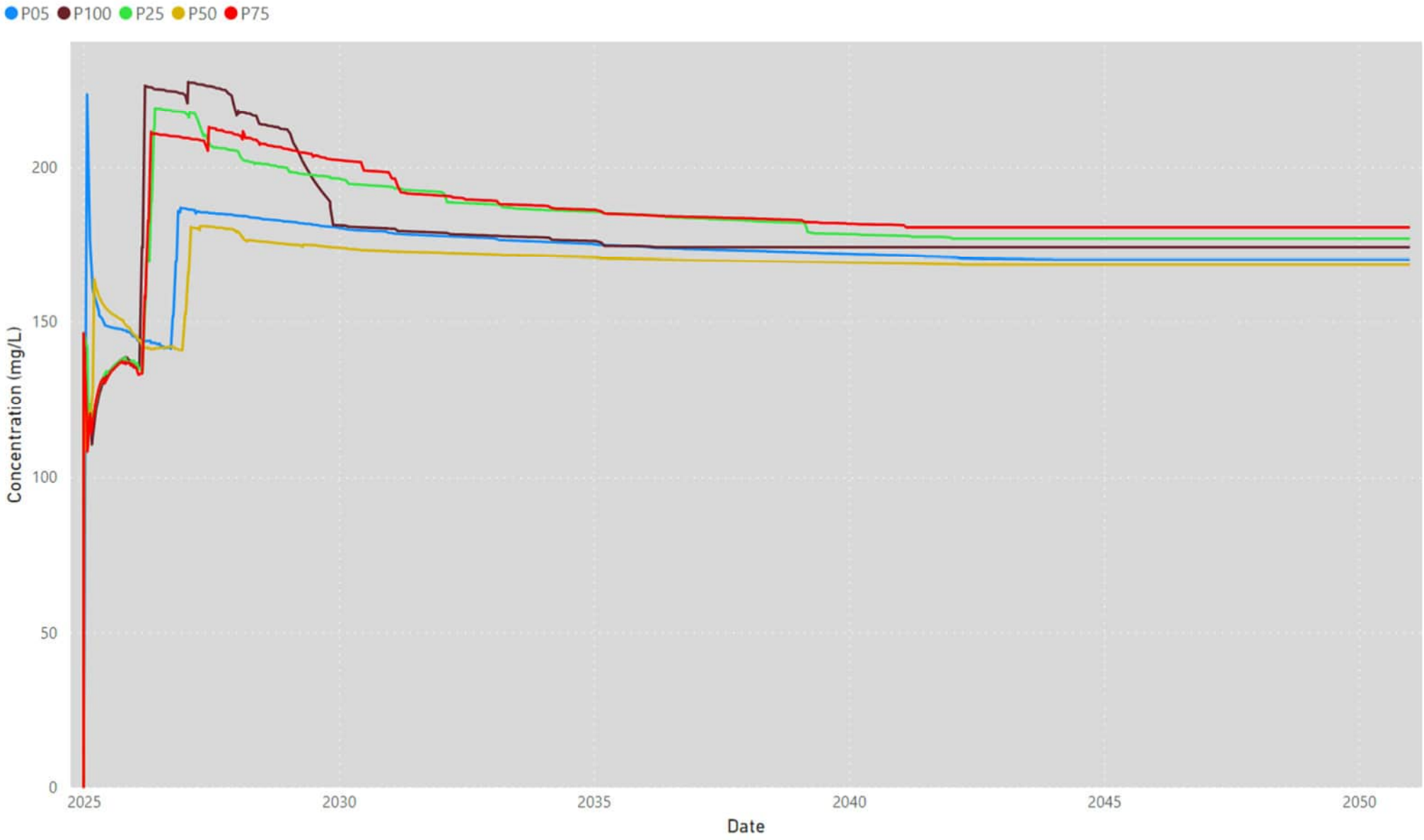

Molybdenum
P05
P100
P25
P50
P75
0.02
0.01
0.00
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

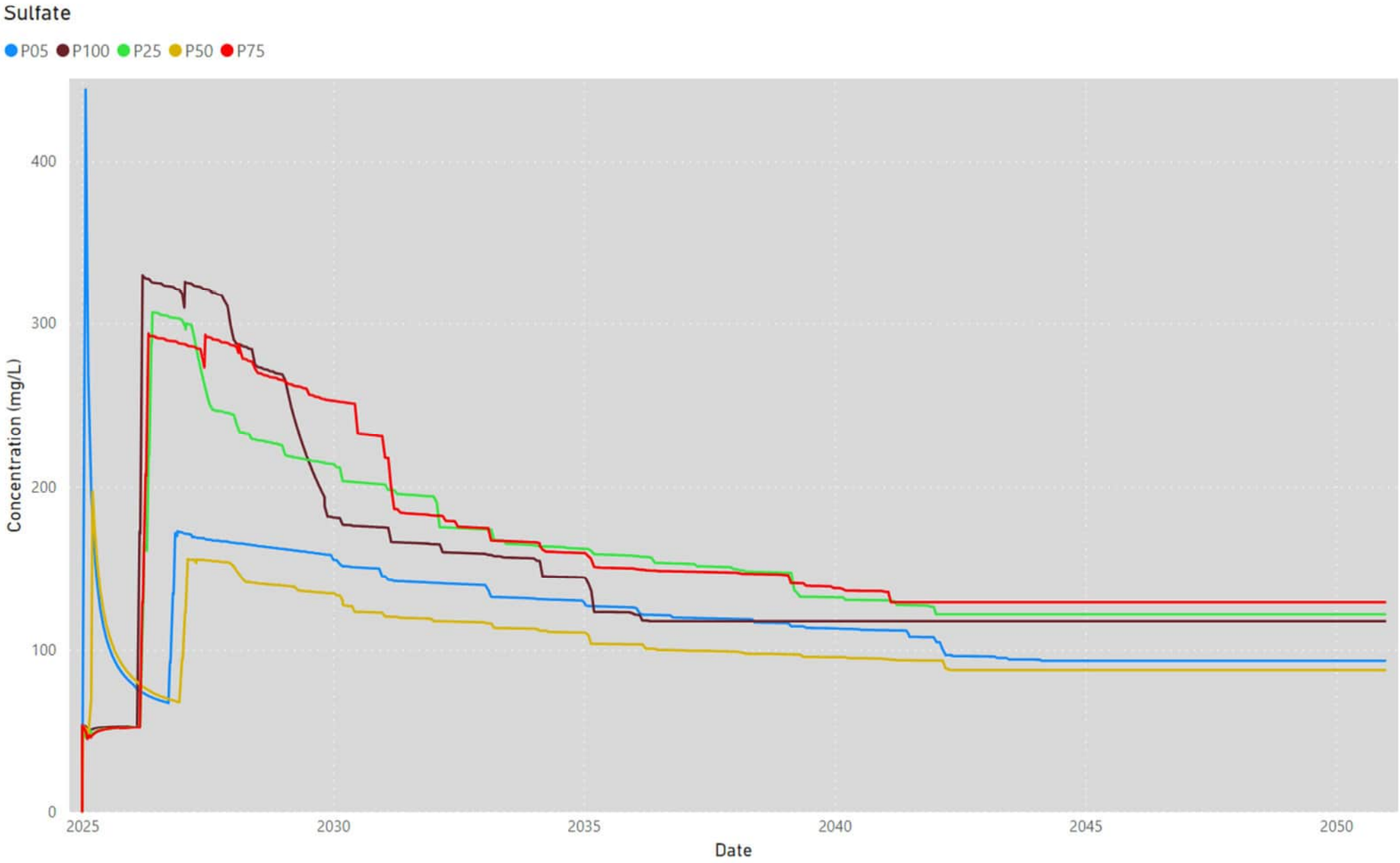

Nickel
P05
P100
P25
P50
P75
0.006
0.004
0.002
0.000
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

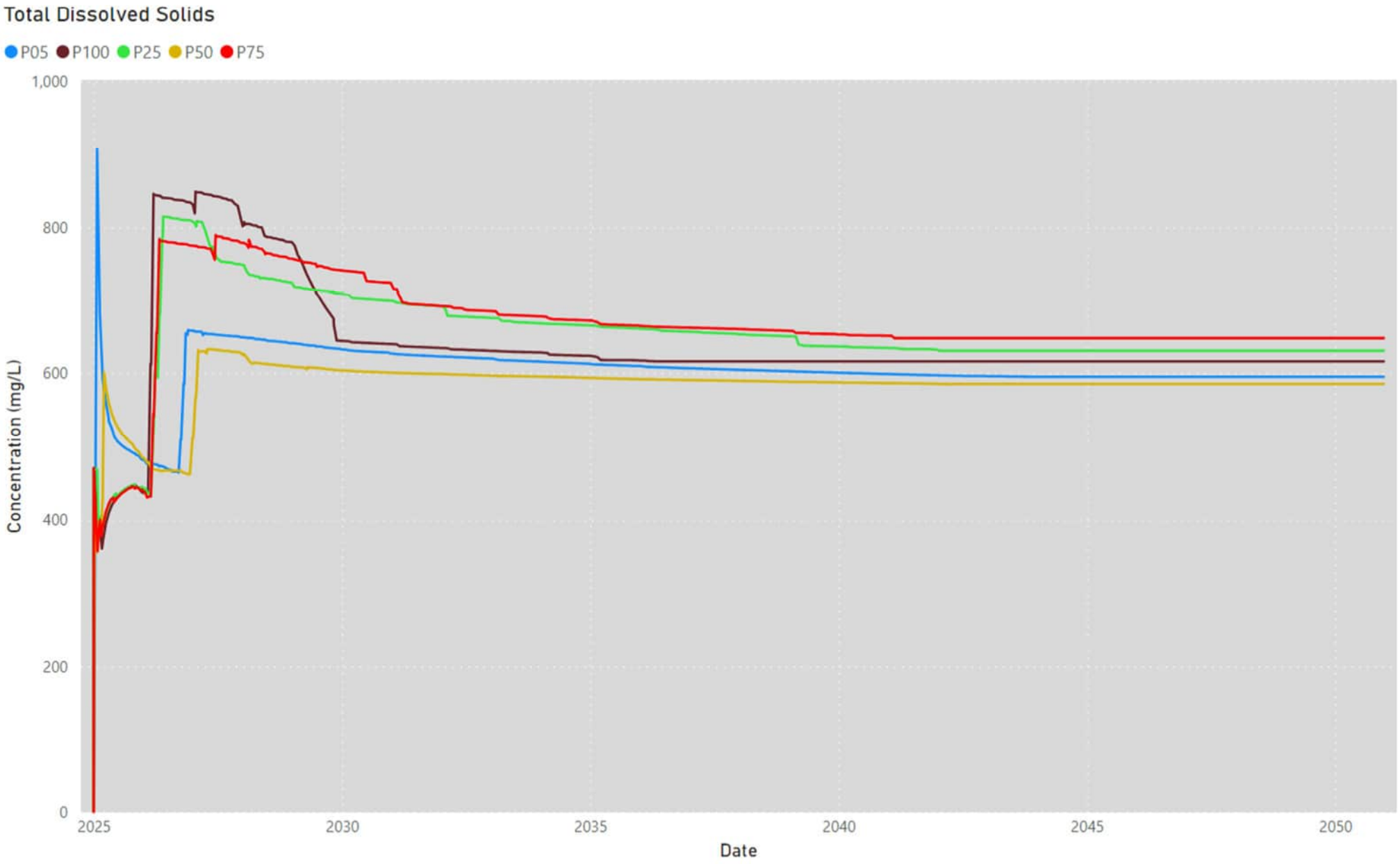

Potassium
P05
P100
P25
P50
P75
40
30
20
10
0
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

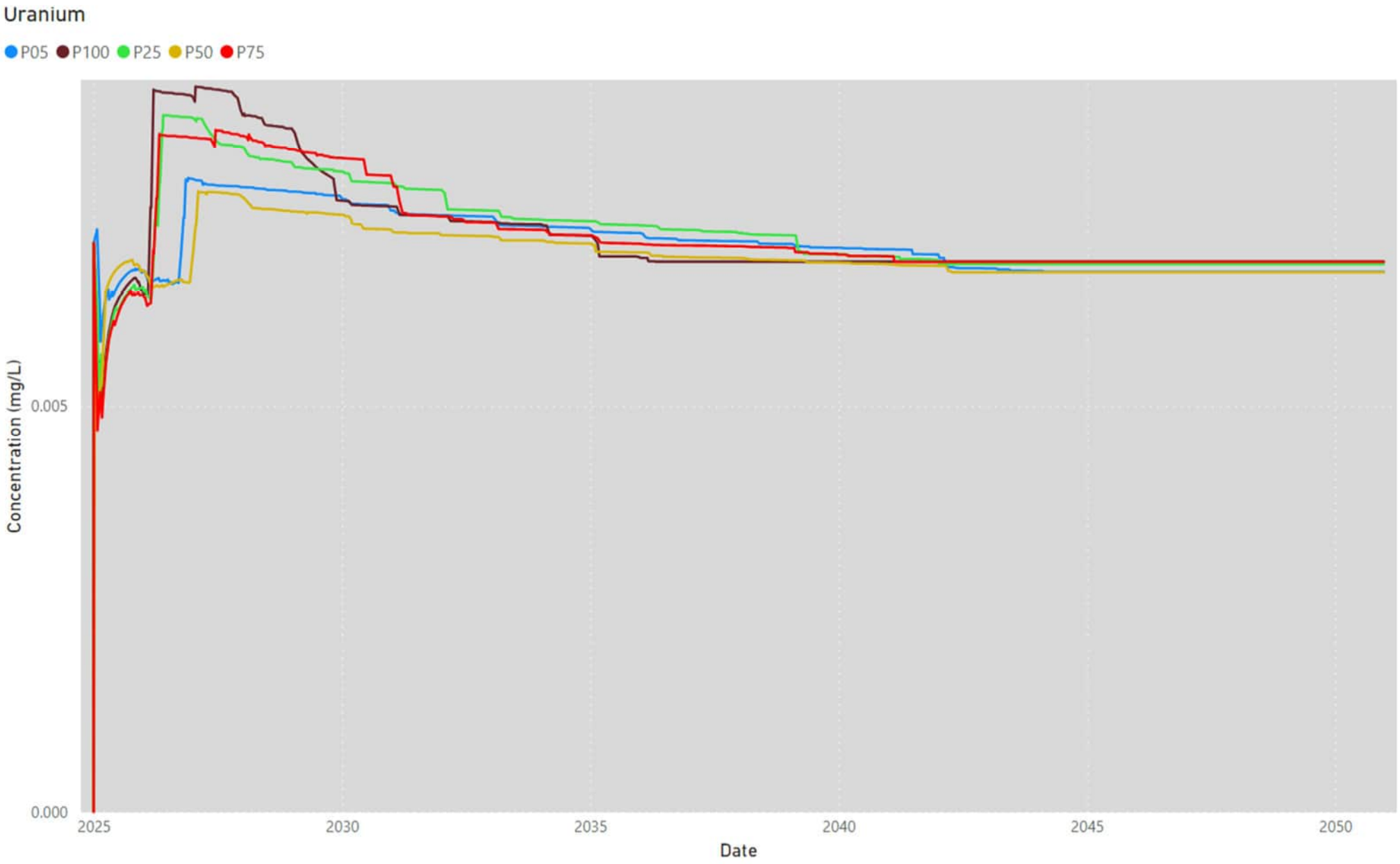

Selenium
P05
P100
P25
P50
P75
0.04
0.03
0.02
0.01
0.00
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

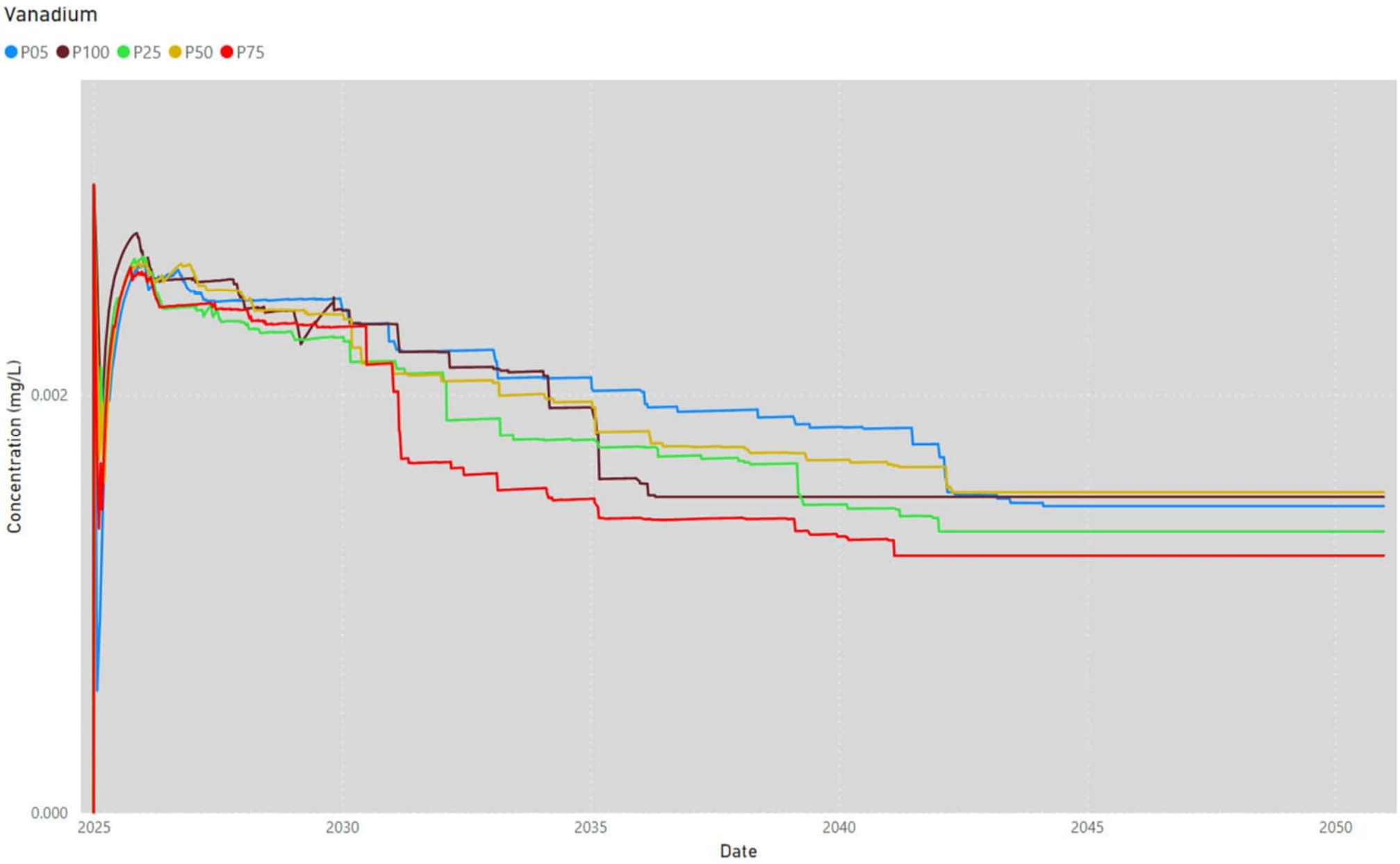
Sodium


P05
P100
P25
P50
P75
Concentration (mg/L)
0
50
100
150
200
2025
2030
2035
2040
2045
2050
Date

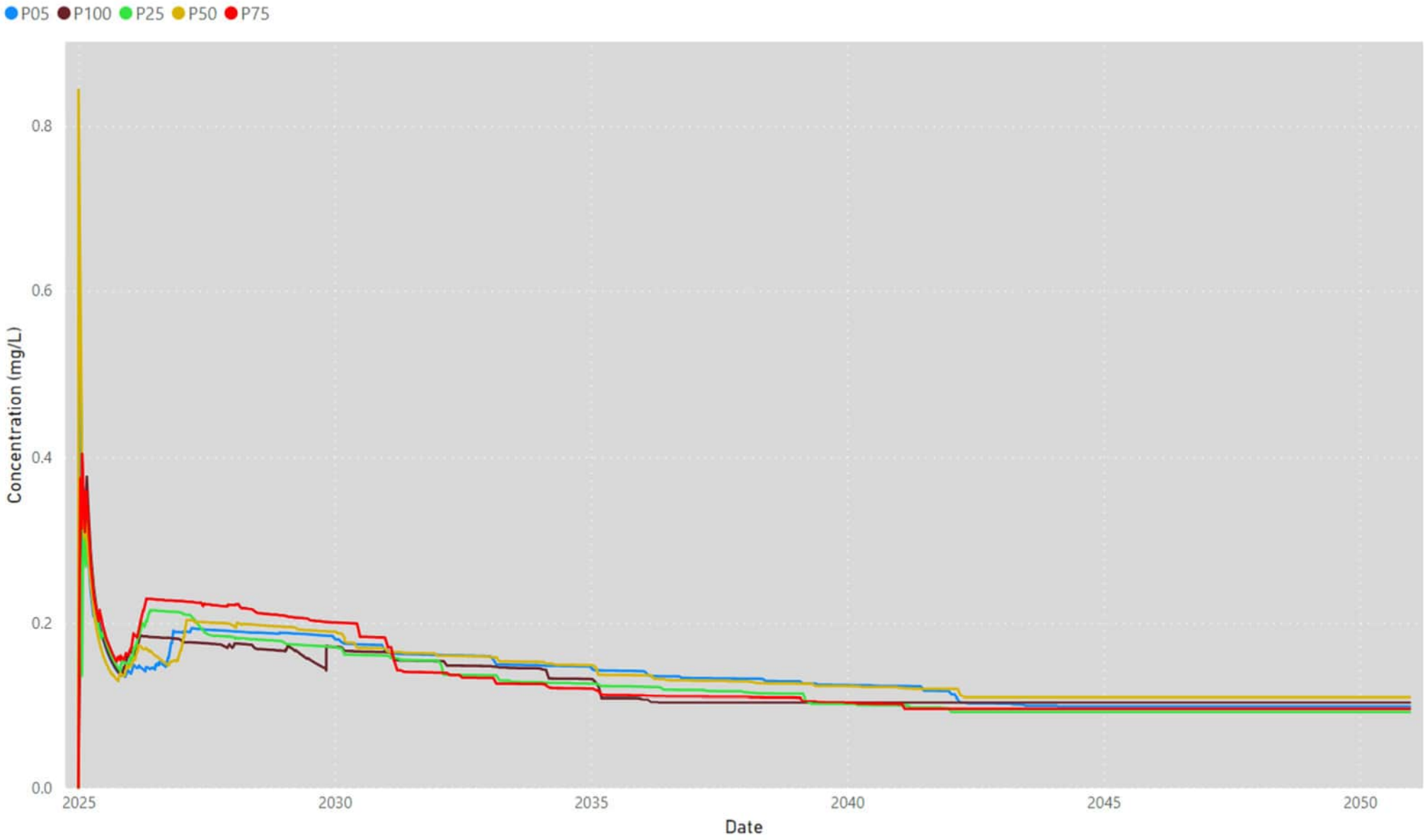

Sulfate
P05
P100
P25
P50
P75
Concentration (mg/L)
0
100
200
300
400
2025
2030
2035
2040
2045
2050
Date


Total Dissolved Solids
P05
P100
P25
P50
P75
1,000
800
600
400
200
0
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date


Uranium
P05
P100
P25
P50
P75
Concentration (mg/L)
0.005
0.000
2025
2030
2035
2040
2045
2050
Date


Vanadium
P05
P100
P25
P50
P75
Concentration (mg/L)
0.002
0.000
2025
2030
2035
2040
2045
2050
Date

Zinc


P05
P100
P25
P50
P75
0.8
0.6
0.4
0.2
0.0
Concentration (mg/L)
2025
2030
2035
2040
2045
2050
Date

K.4 PAF disposal UG water quality model – Phreeqc input and output files

```
# P05 Scenario

SOLUTION 1 UG Water P05
    temp      25
    pH        8.112
    units     mg/L
    density   1
      Al    0.0789
      As    0.0026
      Ba    0.1797
      B     0.1282
      Ca    89.0
      Cl    50.5
      Mg    43.0
      Na    184.3
      K     36.7
      F     0.9477
      S(6)  165.8
      Cd    0.0070
      Cr    0.0076
      Co    0.0038
      Cu    0.0678
      Fe    0.1777
      Pb    0.0435
      Mn    0.0822
      Mo    0.0077
      Ni    0.0055
      Se    0.0086
      U     0.0077
      V     0.0025
      Zn    0.1896
      Alkalinity 483.2 as HCO3
    -water    1 # kg

SOLUTION 2 PAF Material
    temp      25
    pH        7.5
    units     mg/L
    density   1
      Al    0.020
      As    0
      Ba    0.020
      B     0
      Ca    67.0
      Cl    0
      Mg    8.0
      Na    1.0
      K     13.0
      F     0.300
      S(6)  197.0
      Cd    0.000
      Cr    0
      Co    0.007
      Cu    0.028
      Fe    0
      Pb    0
      Mn    0.040
      Mo    0.003
      Ni    0.004
      Se    0
      U     0
      V     0
      Zn    0
      Alkalinity 22 as HCO3
    -water    1 # kg
```

```
SOLUTION 3 NAF Material
    temp      25
    pH        7.6
    units     mg/L
    density   1
      Al    0.140
      As    0.029
      Ba    0.020
      B     0
      Ca    122.0
      Cl    0
      Mg    18.0
      Na    1.0
      K     16.0
      F     0.300
      S(6)  331.0
      Cd    0.000
      Cr    0
      Co    0.002
      Cu    0.019
      Fe    0.070
      Pb    0
      Mn    0.130
      Mo    0.005
      Ni    0.001
      Se    0
      U     0.001
      V     0
      Zn    0
      Alkalinity 28 as HCO3
    -water    1 # kg


SOLUTION 4 Make-up Material
    temp      25
    pH        7.7
    units     mg/L
    density   1
      Al    0.020
      As    0
      Ba    0.020
      B     0
      Ca    67.0
      Cl    0
      Mg    8.0
      Na    1.0
      K     13.0
      F     0.300
      S(6)  197.0
      Cd    0.000
      Cr    0
      Co    0.007
      Cu    0.028
      Fe    0
      Pb    0
      Mn    0.040
      Mo    0.003
      Ni    0.004
      Se    0
      U     0
      V     0
      Zn    0
      Alkalinity 22 as HCO3
    -water    1 # kg

# Mix the three solutions together
```

```
MIX 1 Mix within UG Works
    1    0.342
    2    0.105
    3    0.380
    4    0.173

SAVE Solution 5

SELECTED_OUTPUT 2
    -file                D:\selected_output_3.txt
    -high_precision      true
    -reset               true
    -distance            false
    -time                false
    -temperature         false
    -ionic_strength      false
    -water               false
    -totals              pH Al As Ba B Ca Cl Mg
                         Na K  F  S(6) Cd Cr Co
                         Cu Fe Pb Mn Mo  Ni Se
                         U V Zn Alkalinity
END
```

```
   Input file: P:\J23011 - BCP Underground EA (Aeris)\2. Tech Work Area\2.08 Water Quality
Model\2.08.02 PAF Assessment\BPC_UG_PAF_Disposal_P05.pqi
  Output file: P:\J23011 - BCP Underground EA (Aeris)\2. Tech Work Area\2.08 Water Quality
Model\2.08.02 PAF Assessment\BPC_UG_PAF_Disposal_P05.pqo
Database file: c:\phreeqc\database\minteq.v4.dat

------------------
Reading data base.
------------------

      SOLUTION_MASTER_SPECIES
      SOLUTION_SPECIES
      SOLUTION_SPECIES
      PHASES
      PHASES
      SURFACE_MASTER_SPECIES
      SURFACE_SPECIES
      END
------------------------------------
Reading input data for simulation 1.
------------------------------------

      DATABASE c:\phreeqc\database\minteq.v4.dat
      SOLUTION 1 UG Water P05
          temp      25
          pH        8.112
          units     mg/L
          density   1
            Al    0.0789
            As    0.0026
            Ba    0.1797
            B     0.1282
            Ca    89.0
            Cl    50.5
            Mg    43.0
            Na    184.3
            K     36.7
            F     0.9477
            S(6)  165.8
            Cd    0.0070
            Cr    0.0076
            Co    0.0038
            Cu    0.0678
            Fe    0.1777
            Pb    0.0435
            Mn    0.0822
            Mo    0.0077
            Ni    0.0055
            Se    0.0086
            U     0.0077
            V     0.0025
            Zn    0.1896
            Alkalinity 483.2 as HCO3
          water    1 # kg
      SOLUTION 2 PAF Material
          temp      25
          pH        7.5
          units     mg/L
          density   1
            Al    0.020
            As    0
            Ba    0.020
            B     0
            Ca    67.0
            Cl    0
            Mg    8.0
```

```
            Na    1.0
            K     13.0
            F     0.300
            S(6)  197.0
            Cd    0.000
            Cr    0
            Co    0.007
            Cu    0.028
            Fe    0
            Pb    0
            Mn    0.040
            Mo    0.003
            Ni    0.004
            Se    0
            U     0
            V     0
            Zn    0
            Alkalinity 22 as HCO3
        water    1 # kg
    SOLUTION 3 NAF Material
        temp      25
        pH        7.6
        units     mg/L
        density   1
            Al    0.140
            As    0.029
            Ba    0.020
            B     0
            Ca    122.0
            Cl    0
            Mg    18.0
            Na    1.0
            K     16.0
            F     0.300
            S(6)  331.0
            Cd    0.000
            Cr    0
            Co    0.002
            Cu    0.019
            Fe    0.070
            Pb    0
            Mn    0.130
            Mo    0.005
            Ni    0.001
            Se    0
            U     0.001
            V     0
            Zn    0
            Alkalinity 28 as HCO3
        water    1 # kg
    SOLUTION 4 Make-up Material
        temp      25
        pH        7.7
        units     mg/L
        density   1
            Al    0.020
            As    0
            Ba    0.020
            B     0
            Ca    67.0
            Cl    0
            Mg    8.0
            Na    1.0
            K     13.0
            F     0.300
            S(6)  197.0
            Cd    0.000
            Cr    0
            Co    0.007
            Cu    0.028
            Fe    0
            Pb    0
            Mn    0.040
            Mo    0.003
            Ni    0.004
            Se    0
            U     0
            V     0
            Zn    0
            Alkalinity 22 as HCO3
        water    1 # kg
    MIX 1 Mix within UG Works
        1    0.342
        2    0.105
        3    0.380
        4    0.173
    SAVE Solution 5
    SELECTED_OUTPUT 2
        file                 D:\selected_output_3.txt
        high_precision       true
        reset                true
        distance             false
        time                 false
        temperature          false
        ionic_strength       false
        water                false
        totals               pH Al As Ba B Ca Cl Mg
WARNING: Expected element name to begin with upper case letter.
                              Na K  F  S(6) Cd Cr Co
                              Cu Fe Pb Mn Mo  Ni Se
                              U V Zn Alkalinity
    END
-------------------------------------------
Beginning of initial solution calculations.
-------------------------------------------

Initial solution 1.     UG Water P05

------------------------------Solution composition------------------------------

      Elements           Molality       Moles

      Al                 2.927e-06   2.927e-06
      Alkalinity         7.927e-03   7.927e-03
      As                 3.474e-08   3.474e-08
      B                  1.187e-05   1.187e-05
      Ba                 1.310e-06   1.310e-06
      Ca                 2.223e-03   2.223e-03
      Cd                 6.234e-08   6.234e-08
      Cl                 1.426e-03   1.426e-03
      Co                 6.455e-08   6.455e-08
      Cr                 1.463e-07   1.463e-07
      Cu                 1.068e-06   1.068e-06
      F                  4.994e-05   4.994e-05
      Fe                 3.185e-06   3.185e-06
      K                  9.397e-04   9.397e-04
      Mg                 1.771e-03   1.771e-03
      Mn                 1.498e-06   1.498e-06
      Mo                 8.034e-08   8.034e-08
      Na                 8.025e-03   8.025e-03
      Ni                 9.381e-08   9.381e-08
      Pb                 2.102e-07   2.102e-07
      S(6)               1.728e-03   1.728e-03
      Se                 1.090e-07   1.090e-07
      U                  3.238e-08   3.238e-08
      V                  4.913e-08   4.913e-08
      Zn                 2.903e-06   2.903e-06

----------------------------Description of solution----------------------------

                                    pH  =   8.112
                                    pe  =   4.000
                          Activity of water  =   1.000
                 Ionic strength (mol/kgw)  =   1.857e-02
                      Mass of water (kg)  =   1.000e+00
                 Total carbon (mol/kg)  =   7.851e-03
                    Total CO2 (mol/kg)  =   7.851e-03
                       Temperature (°C)  =  25.00
                 Electrical balance (eq)  =   4.121e-03
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  14.96
                              Iterations  =  10
                                 Total H  = 1.110215e+02
                                 Total O  = 5.553736e+01

----------------------------Distribution of species----------------------------

                                          Log       Log       Log    mole V
   Species          Molality    Activity  Molality  Activity     Gamma    cm³/mol

   OH-            1.496e-06   1.303e-06    -5.825    -5.885    -0.060     (0)
   H+             8.837e-09   7.727e-09    -8.054    -8.112    -0.058     0.00
   H2O            5.551e+01   9.996e-01     1.744    -0.000     0.000    18.07
Al             2.927e-06
   Al(OH)4-       2.911e-06   2.548e-06    -5.536    -5.594    -0.058     (0)
   Al(OH)3        1.554e-08   1.554e-08    -7.809    -7.809     0.000     (0)
   Al(OH)2+       6.800e-10   5.978e-10    -9.167    -9.223    -0.056     (0)
   AlF2+          3.073e-12   2.701e-12   -11.512   -11.568    -0.056     (0)
   AlF3           1.330e-12   1.330e-12   -11.876   -11.876     0.000     (0)
   AlOH+2         9.674e-13   5.777e-13   -12.014   -12.238    -0.224     (0)
   AlF+2          2.905e-13   1.735e-13   -12.537   -12.761    -0.224     (0)
   AlF4-          2.979e-14   2.608e-14   -13.526   -13.584    -0.058     (0)
   AlSO4+         3.135e-15   2.744e-15   -14.504   -14.562    -0.058     (0)
   Al+3           1.485e-15   4.435e-16   -14.828   -15.353    -0.525     (0)
   Al(SO4)2-      2.678e-17   2.344e-17   -16.572   -16.630    -0.058     (0)
   AlMo6O21-3     0.000e+00   0.000e+00   -52.377   -53.002    -0.625     (0)
As(3)          8.447e-21
   H3AsO3         7.836e-21   7.836e-21   -20.106   -20.106     0.000     (0)
   H2AsO3-        6.104e-22   5.201e-22   -21.214   -21.284    -0.069     (0)
   HAsO3-2        1.164e-25   6.139e-26   -24.934   -25.212    -0.278     (0)
   H4AsO3+        3.520e-29   3.000e-29   -28.453   -28.523    -0.069     (0)
   AsO3-3         1.293e-30   3.063e-31   -29.888   -30.514    -0.625     (0)
As(5)          3.474e-08
   HAsO4-2        3.326e-08   1.754e-08    -7.478    -7.756    -0.278     (0)
   H2AsO4-        1.450e-09   1.236e-09    -8.839    -8.908    -0.069     (0)
   AsO4-3         3.030e-11   7.177e-12   -10.519   -11.144    -0.625     (0)
   H3AsO4         1.652e-15   1.659e-15   -14.782   -14.780     0.002     (0)
B              1.187e-05
   H3BO3          1.083e-05   1.088e-05    -4.965    -4.963     0.002     (0)
   H2BO3-         9.441e-07   8.176e-07    -6.025    -6.087    -0.063     (0)
   CaH2BO3+       5.772e-08   4.998e-08    -7.239    -7.301    -0.063     (0)
   MgH2BO3+       2.943e-08   2.549e-08    -7.531    -7.594    -0.063     (0)
   NaH2BO3        9.018e-09   9.018e-09    -8.045    -8.045     0.000     (0)
   BF(OH)3-       1.961e-10   1.698e-10    -9.708    -9.770    -0.063     (0)
   BaH2BO3+       2.122e-11   1.838e-11   -10.673   -10.736    -0.063     (0)
   H5(BO3)2-      8.741e-12   7.570e-12   -11.058   -11.121    -0.063     (0)
   H8(BO3)3-      9.509e-15   8.234e-15   -14.022   -14.084    -0.063     (0)
   BF2(OH)2-      6.337e-15   5.488e-15   -14.198   -14.261    -0.063     (0)
   BF3OH-         7.454e-22   6.455e-22   -21.128   -21.190    -0.063     (0)
   BF4-           1.109e-27   9.603e-28   -26.955   -27.018    -0.063     (0)
Ba             1.310e-06
   Ba+2           1.245e-06   7.273e-07    -5.905    -6.138    -0.233     (0)
   BaHCO3+        5.078e-08   4.476e-08    -7.294    -7.349    -0.055     (0)
   BaCO3          1.458e-08   1.458e-08    -7.836    -7.836     0.000     (0)
   BaH2BO3+       2.122e-11   1.838e-11   -10.673   -10.736    -0.063     (0)
   BaOH+          4.713e-12   4.136e-12   -11.327   -11.383    -0.057     (0)
C(4)           7.851e-03
   HCO3-          7.330e-03   6.444e-03    -2.135    -2.191    -0.056     (0)
   CaHCO3+        1.446e-04   1.275e-04    -3.840    -3.895    -0.055     (0)
   H2CO3          1.120e-04   1.120e-04    -3.951    -3.951     0.000     (0)
   MgHCO3+        6.790e-05   5.929e-05    -4.168    -4.227    -0.059     (0)
   CO3-2          6.690e-05   3.910e-05    -4.175    -4.408    -0.233     (0)
   CaCO3          6.584e-05   6.584e-05    -4.182    -4.182     0.000     (0)
   MgCO3          2.924e-05   2.924e-05    -4.534    -4.534     0.000     (0)
   NaHCO3         2.522e-05   2.522e-05    -4.598    -4.598     0.000     (0)
   NaCO3-         5.764e-06   5.067e-06    -5.239    -5.295    -0.056     (0)
   ZnCO3          1.430e-06   1.430e-06    -5.845    -5.845     0.000     (0)
   CuCO3          8.643e-07   8.643e-07    -6.063    -6.063     0.000     (0)
   Cu(CO3)2-2     1.725e-07   9.095e-08    -6.763    -7.041    -0.278     (0)
   PbCO3          1.600e-07   1.600e-07    -6.796    -6.796     0.000     (0)
   ZnHCO3+        1.520e-07   1.295e-07    -6.818    -6.888    -0.069     (0)
   MnHCO3+        1.001e-07   8.785e-08    -6.999    -7.056    -0.057     (0)
   BaHCO3+        5.078e-08   4.476e-08    -7.294    -7.349    -0.055     (0)
   Pb(CO3)2-2     3.421e-08   1.804e-08    -7.466    -7.744    -0.278     (0)
   NiCO3          3.192e-08   3.192e-08    -7.496    -7.496     0.000     (0)
   UO2(CO3)3-4    3.013e-08   2.328e-09    -7.521    -8.633    -1.112     (0)
   NiHCO3+        2.040e-08   1.738e-08    -7.690    -7.760    -0.069     (0)
   CdCO3          1.840e-08   1.840e-08    -7.735    -7.735     0.000     (0)
   BaCO3          1.458e-08   1.458e-08    -7.836    -7.836     0.000     (0)
   CoCO3          1.276e-08   1.276e-08    -7.894    -7.894     0.000     (0)
   CoHCO3+        1.135e-08   9.674e-09    -7.945    -8.014    -0.069     (0)
   PbHCO3+        7.647e-09   6.516e-09    -8.117    -8.186    -0.069     (0)
   UO2(CO3)2-2    2.254e-09   1.188e-09    -8.647    -8.925    -0.278     (0)
   CuHCO3+        1.791e-09   1.526e-09    -8.747    -8.816    -0.069     (0)
   Cd(CO3)2-2     1.012e-09   5.334e-10    -8.995    -9.273    -0.278     (0)
   CdHCO3+        3.555e-10   3.030e-10    -9.449    -9.519    -0.069     (0)
   FeHCO3+        2.707e-10   2.386e-10    -9.568    -9.622    -0.055     (0)
   UO2CO3         1.523e-12   1.523e-12   -11.817   -11.817     0.000     (0)
Ca             2.223e-03
   Ca+2           1.818e-03   1.062e-03    -2.740    -2.974    -0.233     (0)
   CaSO4          1.940e-04   1.940e-04    -3.712    -3.712     0.000     (0)
   CaHCO3+        1.446e-04   1.275e-04    -3.840    -3.895    -0.055     (0)
   CaCO3          6.584e-05   6.584e-05    -4.182    -4.182     0.000     (0)
   CaF+           5.169e-07   4.536e-07    -6.287    -6.343    -0.057     (0)
   CaH2BO3+       5.772e-08   4.998e-08    -7.239    -7.301    -0.063     (0)
   CaOH+          3.133e-08   2.761e-08    -7.504    -7.559    -0.055     (0)
Cd             6.234e-08
   Cd+2           3.533e-08   2.065e-08    -7.452    -7.685    -0.233     (0)
   CdCO3          1.840e-08   1.840e-08    -7.735    -7.735     0.000     (0)
   CdSO4          3.859e-09   3.859e-09    -8.414    -8.414     0.000     (0)
   CdCl+          2.885e-09   2.459e-09    -8.540    -8.609    -0.069     (0)
   Cd(CO3)2-2     1.012e-09   5.334e-10    -8.995    -9.273    -0.278     (0)
   CdHCO3+        3.555e-10   3.030e-10    -9.449    -9.519    -0.069     (0)
   CdOH+          2.507e-10   2.137e-10    -9.601    -9.670    -0.069     (0)
   CdOHCl         1.314e-10   1.314e-10    -9.881    -9.881     0.000     (0)
   Cd(SO4)2-2     7.869e-11   4.149e-11   -10.104   -10.382    -0.278     (0)
   CdF+           1.502e-11   1.280e-11   -10.823   -10.893    -0.069     (0)
   CdCl2          1.278e-11   1.278e-11   -10.894   -10.894     0.000     (0)
   Cd(OH)2        1.756e-12   1.756e-12   -11.755   -11.755     0.000     (0)
   CdCl3-         1.180e-14   1.005e-14   -13.928   -13.998    -0.069     (0)
   CdF2           9.991e-16   9.991e-16   -15.000   -15.000     0.000     (0)
   Cd(OH)3-       1.640e-16   1.398e-16   -15.785   -15.855    -0.069     (0)
   Cd2OH+3        9.335e-17   2.211e-17   -16.030   -16.655    -0.625     (0)
   Cd(SeO3)2-2    2.202e-17   1.161e-17   -16.657   -16.935    -0.278     (0)
   CdSeO4         2.078e-17   2.078e-17   -16.682   -16.682     0.000     (0)
```

Cd(OH)4-2	5.652e-23	2.980e-23	-22.248	-22.526	-0.278	(0)
Cl	1.426e-03					
Cl-	1.426e-03	1.247e-03	-2.846	-2.904	-0.058	(0)
ZnOHCl	3.395e-09	3.395e-09	-8.469	-8.469	0.000	(0)
CdCl+	2.885e-09	2.459e-09	-8.540	-8.609	-0.069	(0)
ZnCl+	2.280e-09	1.990e-09	-8.642	-8.701	-0.059	(0)
MnCl+	1.222e-09	1.072e-09	-8.913	-8.970	-0.057	(0)
CuCl	2.886e-10	2.886e-10	-9.540	-9.540	0.000	(0)
CdOHCl	1.314e-10	1.314e-10	-9.881	-9.881	0.000	(0)
CoCl+	9.768e-11	8.324e-11	-10.010	-10.080	-0.069	(0)
CuCl2-	8.610e-11	7.517e-11	-10.065	-10.124	-0.059	(0)
NiCl+	8.192e-11	6.980e-11	-10.087	-10.156	-0.069	(0)
PbCl+	7.065e-11	6.020e-11	-10.151	-10.220	-0.069	(0)
CdCl2	1.278e-11	1.278e-11	-10.894	-10.894	0.000	(0)
CuCl+	8.496e-12	7.418e-12	-11.071	-11.130	-0.059	(0)
ZnCl2	3.933e-12	3.933e-12	-11.405	-11.405	0.000	(0)
MnCl2	1.889e-12	1.889e-12	-11.724	-11.724	0.000	(0)
PbCl2	3.353e-13	3.353e-13	-12.475	-12.475	0.000	(0)
CuCl3-2	3.380e-14	2.004e-14	-13.471	-13.698	-0.227	(0)
CdCl3-	1.180e-14	1.005e-14	-13.928	-13.998	-0.069	(0)
ZnCl3-	4.461e-15	3.895e-15	-14.351	-14.409	-0.059	(0)
CuCl2	3.207e-15	3.207e-15	-14.494	-14.494	0.000	(0)
MnCl3-	7.391e-16	6.485e-16	-15.131	-15.188	-0.057	(0)
NiCl2	4.382e-16	4.382e-16	-15.358	-15.358	0.000	(0)
PbCl3-	1.953e-16	1.664e-16	-15.709	-15.779	-0.069	(0)
CrCl+2	5.693e-17	3.002e-17	-16.245	-16.523	-0.278	(0)
ZnCl4-2	4.097e-18	2.428e-18	-17.388	-17.615	-0.227	(0)
CrOHCl2	9.266e-19	9.266e-19	-18.033	-18.033	0.000	(0)
PbCl4-2	1.799e-19	9.483e-20	-18.745	-19.023	-0.278	(0)
FeCl+2	1.735e-19	1.029e-19	-18.761	-18.988	-0.227	(0)
CuCl3-	4.273e-20	3.731e-20	-19.369	-19.428	-0.059	(0)
UO2Cl+	2.322e-20	1.979e-20	-19.634	-19.704	-0.069	(0)
CrCl2+	4.167e-21	3.551e-21	-20.380	-20.450	-0.069	(0)
FeCl2+	6.529e-22	5.728e-22	-21.185	-21.242	-0.057	(0)
VOCl+	6.415e-23	5.467e-23	-22.193	-22.262	-0.069	(0)
CuCl4-2	3.933e-25	2.331e-25	-24.405	-24.632	-0.227	(0)
FeCl3	7.142e-26	7.142e-26	-25.146	-25.146	0.000	(0)
CrO3Cl-	2.952e-26	2.516e-26	-25.530	-25.599	-0.069	(0)
CoCl+2	3.697e-37	1.949e-37	-36.432	-36.710	-0.278	(0)
UCl+3	0.000e+00	0.000e+00	-48.820	-49.445	-0.625	(0)
Co(2)	6.455e-08					
Co+2	3.660e-08	1.930e-08	-7.436	-7.714	-0.278	(0)
CoCO3	1.276e-08	1.276e-08	-7.894	-7.894	0.000	(0)
CoHCO3+	1.135e-08	9.674e-09	-7.945	-8.014	-0.069	(0)
CoSO4	3.069e-09	3.069e-09	-8.513	-8.513	0.000	(0)
CoOH+	5.887e-10	5.016e-10	-9.230	-9.300	-0.069	(0)
CoCl+	9.768e-11	8.324e-11	-10.010	-10.080	-0.069	(0)
Co(OH)2	5.190e-11	5.190e-11	-10.285	-10.285	0.000	(0)
CoF+	2.801e-11	2.387e-11	-10.553	-10.622	-0.069	(0)
Co(OH)3-	1.583e-15	1.349e-15	-14.800	-14.870	-0.069	(0)
CoOOH-	3.974e-16	3.386e-16	-15.401	-15.470	-0.069	(0)
CoSeO4	5.228e-17	5.228e-17	-16.282	-16.282	0.000	(0)
Co2OH+3	2.048e-18	4.852e-19	-17.689	-18.314	-0.625	(0)
Co(OH)4-2	5.282e-22	2.785e-22	-21.277	-21.555	-0.278	(0)
Co4(OH)4+4	1.635e-28	1.263e-29	-27.787	-28.899	-1.112	(0)
Co(3)	9.646e-30					
CoOH+2	9.646e-30	5.086e-30	-29.016	-29.294	-0.278	(0)
Co+3	2.573e-36	7.683e-37	-35.590	-36.114	-0.525	(0)
CoCl+2	3.697e-37	1.949e-37	-36.432	-36.710	-0.278	(0)
Cr(2)	8.429e-25					
Cr+2	8.429e-25	4.444e-25	-24.074	-24.352	-0.278	(0)
Cr(3)	1.463e-07					
Cr(OH)2+	9.862e-08	8.404e-08	-7.006	-7.076	-0.069	(0)
Cr(OH)3	4.112e-08	4.112e-08	-7.386	-7.386	0.000	(0)
CrO2-	2.967e-09	2.529e-09	-8.528	-8.597	-0.069	(0)
Cr(OH)4-	2.503e-09	2.133e-09	-8.602	-8.671	-0.069	(0)
Cr(OH)+2	1.006e-09	5.302e-10	-8.998	-9.276	-0.278	(0)
CrOHSO4	1.003e-10	1.003e-10	-9.999	-9.999	0.000	(0)
CrF+2	2.187e-13	1.153e-13	-12.660	-12.938	-0.278	(0)
Cr+3	7.853e-14	1.860e-14	-13.105	-13.730	-0.625	(0)
CrSO4+	4.064e-14	3.463e-14	-13.391	-13.461	-0.069	(0)
CrCl+2	5.693e-17	3.002e-17	-16.245	-16.523	-0.278	(0)
Cr2(OH)2SO4+2	9.115e-18	4.806e-18	-17.040	-17.318	-0.278	(0)
CrOHCl2	9.266e-19	9.266e-19	-18.033	-18.033	0.000	(0)
Cr2(OH)2(SO4)2	2.276e-19	2.276e-19	-18.643	-18.643	0.000	(0)
CrCl2+	4.167e-21	3.551e-21	-20.380	-20.450	-0.069	(0)
Cr(6)	2.963e-14					
CrO4-2	2.841e-14	1.660e-14	-13.547	-13.780	-0.233	(0)
NaCrO4-	6.738e-16	5.741e-16	-15.171	-15.241	-0.069	(0)
HCrO4-	4.871e-16	4.151e-16	-15.312	-15.382	-0.069	(0)
KCrO4-	5.913e-17	5.039e-17	-16.228	-16.298	-0.069	(0)
H2CrO4	2.600e-24	2.600e-24	-23.585	-23.585	0.000	(0)
CrO3SO4-2	1.477e-24	7.790e-25	-23.831	-24.108	-0.278	(0)
CrO3Cl-	2.952e-26	2.516e-26	-25.530	-25.599	-0.069	(0)
Cr2O7-2	1.133e-29	5.976e-30	-28.946	-29.224	-0.278	(0)
Cu(1)	5.905e-10					
CuCl	2.886e-10	2.886e-10	-9.540	-9.540	0.000	(0)
Cu+	2.158e-10	1.839e-10	-9.666	-9.735	-0.069	(0)
CuCl2-	8.610e-11	7.517e-11	-10.065	-10.124	-0.059	(0)
CuCl3-2	3.380e-14	2.004e-14	-13.471	-13.698	-0.227	(0)
Cu(2)	1.067e-06					
CuCO3	8.643e-07	8.643e-07	-6.063	-6.063	0.000	(0)
Cu(CO3)2-2	1.725e-07	9.095e-08	-6.763	-7.041	-0.278	(0)
CuOH+	1.771e-08	1.546e-08	-7.752	-7.811	-0.059	(0)
Cu+2	6.424e-09	3.754e-09	-8.192	-8.425	-0.233	(0)
Cu(OH)2	4.019e-09	4.019e-09	-8.396	-8.396	0.000	(0)
CuHCO3+	1.791e-09	1.526e-09	-8.747	-8.816	-0.069	(0)
CuSO4	6.855e-10	6.855e-10	-9.164	-9.164	0.000	(0)
Cu(OH)3-	1.260e-11	1.074e-11	-10.900	-10.969	-0.069	(0)
Cu2(OH)2+2	1.139e-11	6.007e-12	-10.943	-11.221	-0.278	(0)
CuF+	1.087e-11	9.265e-12	-10.964	-11.033	-0.069	(0)
CuCl+	8.496e-12	7.418e-12	-11.071	-11.130	-0.059	(0)
CuCl2	3.207e-15	3.207e-15	-14.494	-14.494	0.000	(0)
Cu(OH)4-2	2.088e-16	1.101e-16	-15.680	-15.958	-0.278	(0)
CuCl3-	4.273e-20	3.731e-20	-19.369	-19.428	-0.059	(0)
CuCl4-2	3.933e-25	2.331e-25	-24.405	-24.632	-0.227	(0)
F	4.994e-05					
F-	4.474e-05	3.911e-05	-4.349	-4.408	-0.058	(0)
MgF+	4.508e-06	3.946e-06	-5.346	-5.404	-0.058	(0)
CaF+	5.169e-07	4.536e-07	-6.287	-6.343	-0.057	(0)
NaF	1.718e-07	1.718e-07	-6.765	-6.765	0.000	(0)
MnF+	1.213e-09	1.064e-09	-8.916	-8.973	-0.057	(0)
ZnF+	5.821e-10	4.961e-10	-9.235	-9.304	-0.069	(0)
HF	4.470e-10	4.470e-10	-9.350	-9.350	0.000	(0)
BF(OH)3-	1.961e-10	1.698e-10	-9.708	-9.770	-0.063	(0)
CoF+	2.801e-11	2.387e-11	-10.553	-10.622	-0.069	(0)
NiF+	2.523e-11	2.150e-11	-10.598	-10.668	-0.069	(0)
CdF+	1.502e-11	1.280e-11	-10.823	-10.893	-0.069	(0)
CuF+	1.087e-11	9.265e-12	-10.964	-11.033	-0.069	(0)
PbF+	4.402e-12	3.751e-12	-11.356	-11.426	-0.069	(0)
AlF2+	3.073e-12	2.701e-12	-11.512	-11.568	-0.056	(0)
AlF3	1.330e-12	1.330e-12	-11.876	-11.876	0.000	(0)
AlF+2	2.905e-13	1.735e-13	-12.537	-12.761	-0.224	(0)
CrF+2	2.187e-13	1.153e-13	-12.660	-12.938	-0.278	(0)
HF2-	7.634e-14	6.648e-14	-13.117	-13.177	-0.060	(0)
AlF4-	2.979e-14	2.608e-14	-13.526	-13.584	-0.058	(0)
BF2(OH)2-	6.337e-15	5.488e-15	-14.198	-14.261	-0.063	(0)
PbF2	2.888e-15	2.888e-15	-14.539	-14.539	0.000	(0)
CdF2	9.991e-16	9.991e-16	-15.000	-15.000	0.000	(0)
FeF+2	1.977e-16	1.172e-16	-15.704	-15.931	-0.227	(0)
FeF2+	1.398e-16	1.227e-16	-15.855	-15.911	-0.057	(0)
UO2F+	6.200e-17	5.284e-17	-16.208	-16.277	-0.069	(0)
FeF3	6.769e-18	6.769e-18	-17.169	-17.169	0.000	(0)
UO2F2	5.960e-18	5.960e-18	-17.225	-17.225	0.000	(0)
VO2F	2.244e-18	2.244e-18	-17.649	-17.649	0.000	(0)
H2F2	5.354e-19	5.354e-19	-18.271	-18.271	0.000	(0)
PbF3-	2.514e-19	2.142e-19	-18.600	-18.669	-0.069	(0)
UO2F3-	6.872e-20	5.856e-20	-19.163	-19.232	-0.069	(0)
VO2F2-	3.741e-20	3.188e-20	-19.427	-19.497	-0.069	(0)
VOF+	4.303e-21	3.667e-21	-20.366	-20.436	-0.069	(0)
BF3OH-	7.454e-22	6.455e-22	-21.128	-21.190	-0.063	(0)
VOF2	5.378e-23	5.378e-23	-22.269	-22.269	0.000	(0)
UO2F4-2	3.451e-23	1.820e-23	-22.462	-22.740	-0.278	(0)
VO2F3-2	2.950e-23	1.555e-23	-22.530	-22.808	-0.278	(0)
PbF4-2	7.607e-24	4.011e-24	-23.119	-23.397	-0.278	(0)
VOF3-	8.759e-26	7.464e-26	-25.058	-25.127	-0.069	(0)
VO2F4-3	1.264e-27	2.993e-28	-26.898	-27.524	-0.625	(0)
BF4-	1.109e-27	9.603e-28	-26.955	-27.018	-0.063	(0)
VOF4-2	2.235e-29	1.178e-29	-28.651	-28.929	-0.278	(0)
UF3+	1.605e-40	1.368e-40	-39.795	-39.864	-0.069	(0)
UF2+2	0.000e+00	0.000e+00	-40.378	-40.656	-0.278	(0)
UF4	0.000e+00	0.000e+00	-42.232	-42.232	0.000	(0)
UF+3	0.000e+00	0.000e+00	-42.723	-43.349	-0.625	(0)
UF5-	0.000e+00	0.000e+00	-44.972	-45.041	-0.069	(0)
UF6-2	0.000e+00	0.000e+00	-46.691	-46.969	-0.278	(0)
Fe(2)	6.598e-09					
Fe+2	5.578e-09	2.941e-09	-8.254	-8.532	-0.278	(0)
FeSO4	5.754e-10	5.754e-10	-9.240	-9.240	0.000	(0)
FeHCO3+	2.707e-10	2.386e-10	-9.568	-9.622	-0.055	(0)
FeOH+	1.738e-10	1.525e-10	-9.760	-9.817	-0.057	(0)
Fe(OH)2	1.578e-13	1.578e-13	-12.802	-12.802	0.000	(0)
Fe(OH)3-	7.409e-14	6.501e-14	-13.130	-13.187	-0.057	(0)
Fe(3)	3.179e-06					
Fe(OH)3	1.629e-06	1.629e-06	-5.788	-5.788	0.000	(0)
Fe(OH)2+	1.325e-06	1.165e-06	-5.878	-5.934	-0.056	(0)
Fe(OH)4-	2.248e-07	1.976e-07	-6.648	-6.704	-0.056	(0)
FeOH+2	3.877e-12	2.298e-12	-11.412	-11.639	-0.227	(0)
FeF+2	1.977e-16	1.172e-16	-15.704	-15.931	-0.227	(0)
FeF2+	1.398e-16	1.227e-16	-15.855	-15.911	-0.057	(0)
FeSO4+	2.785e-17	2.443e-17	-16.555	-16.612	-0.057	(0)
Fe+3	9.149e-18	2.732e-18	-17.039	-17.564	-0.525	(0)
FeF3	6.769e-18	6.769e-18	-17.169	-17.169	0.000	(0)
Fe(SO4)2-	4.887e-19	4.164e-19	-18.311	-18.380	-0.069	(0)
FeCl+2	1.735e-19	1.029e-19	-18.761	-18.988	-0.227	(0)
Fe2(OH)2+4	2.262e-21	1.748e-22	-20.645	-21.757	-1.112	(0)
FeHSeO3+2	6.941e-22	3.659e-22	-21.159	-21.437	-0.278	(0)
FeCl2+	6.529e-22	5.728e-22	-21.185	-21.242	-0.057	(0)
Fe3(OH)4+5	1.607e-25	2.943e-27	-24.794	-26.531	-1.737	(0)
FeCl3	7.142e-26	7.142e-26	-25.146	-25.146	0.000	(0)
H(0)	8.417e-28					
H2	4.209e-28	4.227e-28	-27.376	-27.374	0.002	(0)
K	9.397e-04					
K+	9.344e-04	8.170e-04	-3.029	-3.088	-0.058	(0)
KSO4-	5.244e-06	4.610e-06	-5.280	-5.336	-0.056	(0)
KCrO4-	5.913e-17	5.039e-17	-16.228	-16.298	-0.069	(0)
Mg	1.771e-03					
Mg+2	1.538e-03	8.991e-04	-2.813	-3.046	-0.233	(0)
MgSO4	1.304e-04	1.304e-04	-3.885	-3.885	0.000	(0)
MgHCO3+	6.790e-05	5.929e-05	-4.168	-4.227	-0.059	(0)
MgCO3	2.924e-05	2.924e-05	-4.534	-4.534	0.000	(0)
MgF+	4.508e-06	3.946e-06	-5.346	-5.404	-0.058	(0)
MgOH+	5.278e-07	4.663e-07	-6.278	-6.331	-0.054	(0)
MgH2BO3+	2.943e-08	2.549e-08	-7.531	-7.594	-0.063	(0)
Mn(2)	1.498e-06					
Mn+2	1.296e-06	6.832e-07	-5.887	-6.165	-0.278	(0)
MnHCO3+	1.001e-07	8.785e-08	-6.999	-7.056	-0.057	(0)
MnSO4	9.685e-08	9.685e-08	-7.014	-7.014	0.000	(0)
MnOH+	2.548e-09	2.236e-09	-8.594	-8.651	-0.057	(0)
MnCl+	1.222e-09	1.072e-09	-8.913	-8.970	-0.057	(0)
MnF+	1.213e-09	1.064e-09	-8.916	-8.973	-0.057	(0)
MnCl2	1.889e-12	1.889e-12	-11.724	-11.724	0.000	(0)
MnSeO4	9.939e-16	9.939e-16	-15.003	-15.003	0.000	(0)
MnCl3-	7.391e-16	6.485e-16	-15.131	-15.188	-0.057	(0)
Mn(OH)3-	2.672e-17	2.345e-17	-16.573	-16.630	-0.057	(0)
Mn(OH)4-2	1.664e-22	9.860e-23	-21.779	-22.006	-0.227	(0)
MnSe	2.851e-39	2.851e-39	-38.545	-38.545	0.000	(0)
Mn(3)	1.022e-27					
Mn+3	1.022e-27	3.052e-28	-26.991	-27.515	-0.525	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-43.465	-43.692	-0.227	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-49.003	-49.064	-0.061	(0)
Mo	8.034e-08					
MoO4-2	8.033e-08	4.695e-08	-7.095	-7.328	-0.233	(0)
HMoO4-	8.471e-12	7.218e-12	-11.072	-11.142	-0.069	(0)
H2MoO4	4.085e-16	4.085e-16	-15.389	-15.389	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-52.377	-53.002	-0.625	(0)
Mo7O24-6	0.000e+00	0.000e+00	-60.702	-63.204	-2.502	(0)
HMo7O24-5	0.000e+00	0.000e+00	-63.192	-64.929	-1.737	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-67.147	-68.259	-1.112	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-72.500	-73.125	-0.625	(0)
Na	8.025e-03					
Na+	7.960e-03	6.960e-03	-2.099	-2.157	-0.058	(0)
NaSO4-	3.389e-05	2.979e-05	-4.470	-4.526	-0.056	(0)
NaHCO3	2.522e-05	2.522e-05	-4.598	-4.598	0.000	(0)
NaCO3-	5.764e-06	5.067e-06	-5.239	-5.295	-0.056	(0)
NaF	1.718e-07	1.718e-07	-6.765	-6.765	0.000	(0)
NaH2BO3	9.018e-09	9.018e-09	-8.045	-8.045	0.000	(0)
NaCrO4-	6.738e-16	5.741e-16	-15.171	-15.241	-0.069	(0)
Ni	9.381e-08					
Ni+2	3.744e-08	2.188e-08	-7.427	-7.660	-0.233	(0)
NiCO3	3.192e-08	3.192e-08	-7.496	-7.496	0.000	(0)
NiHCO3+	2.040e-08	1.738e-08	-7.690	-7.760	-0.069	(0)
NiSO4	3.480e-09	3.480e-09	-8.458	-8.458	0.000	(0)
NiOH+	4.211e-10	3.589e-10	-9.376	-9.445	-0.069	(0)
NiCl+	8.192e-11	6.980e-11	-10.087	-10.156	-0.069	(0)
Ni(OH)2	3.713e-11	3.713e-11	-10.430	-10.430	0.000	(0)
NiF+	2.523e-11	2.150e-11	-10.598	-10.668	-0.069	(0)
Ni(SO4)2-2	1.742e-13	9.186e-14	-12.759	-13.037	-0.278	(0)
Ni(OH)3-	5.677e-14	4.837e-14	-13.246	-13.315	-0.069	(0)
NiCl2	4.382e-16	4.382e-16	-15.358	-15.358	0.000	(0)
NiSeO4	5.532e-17	5.532e-17	-16.257	-16.257	0.000	(0)
O(0)	5.646e-38					
O2	2.823e-38	2.835e-38	-37.549	-37.547	0.002	(0)
Pb	2.102e-07					
PbCO3	1.600e-07	1.600e-07	-6.796	-6.796	0.000	(0)
Pb(CO3)2-2	3.421e-08	1.804e-08	-7.466	-7.744	-0.278	(0)
PbHCO3+	7.647e-09	6.516e-09	-8.117	-8.186	-0.069	(0)
PbOH+	5.226e-09	4.453e-09	-8.282	-8.351	-0.069	(0)
Pb+2	2.329e-09	1.361e-09	-8.633	-8.866	-0.233	(0)
PbSO4	5.313e-10	5.313e-10	-9.275	-9.275	0.000	(0)
Pb(OH)2	1.834e-10	1.834e-10	-9.736	-9.736	0.000	(0)
PbCl+	7.065e-11	6.020e-11	-10.151	-10.220	-0.069	(0)
Pb(SO4)2-2	4.840e-12	2.552e-12	-11.315	-11.593	-0.278	(0)
PbF+	4.402e-12	3.751e-12	-11.356	-11.426	-0.069	(0)
PbCl2	3.353e-13	3.353e-13	-12.475	-12.475	0.000	(0)
Pb(OH)3-	2.804e-13	2.390e-13	-12.552	-12.622	-0.069	(0)
PbF2	2.888e-15	2.888e-15	-14.539	-14.539	0.000	(0)
Pb2OH+3	4.055e-16	9.605e-17	-15.392	-16.017	-0.625	(0)
PbCl3-	1.953e-16	1.664e-16	-15.709	-15.779	-0.069	(0)
Pb(OH)4-2	1.446e-16	7.624e-17	-15.840	-16.118	-0.278	(0)
Pb3(OH)4+2	1.733e-18	9.138e-19	-17.761	-18.039	-0.278	(0)
PbF3-	2.514e-19	2.142e-19	-18.600	-18.669	-0.069	(0)
PbCl4-2	1.799e-19	9.483e-20	-18.745	-19.023	-0.278	(0)

Pb4(OH)4+4	1.278e-22	9.879e-24	-21.893	-23.005	-1.112	(0)
PbF4-2	7.607e-24	4.011e-24	-23.119	-23.397	-0.278	(0)
S(6)	1.728e-03					
SO4-2	1.364e-03	7.971e-04	-2.865	-3.098	-0.233	(0)
CaSO4	1.940e-04	1.940e-04	-3.712	-3.712	0.000	(0)
MgSO4	1.304e-04	1.304e-04	-3.885	-3.885	0.000	(0)
NaSO4-	3.389e-05	2.979e-05	-4.470	-4.526	-0.056	(0)
KSO4-	5.244e-06	4.610e-06	-5.280	-5.336	-0.056	(0)
ZnSO4	1.108e-07	1.108e-07	-6.955	-6.955	0.000	(0)
MnSO4	9.685e-08	9.685e-08	-7.014	-7.014	0.000	(0)
CdSO4	3.859e-09	3.859e-09	-8.414	-8.414	0.000	(0)
NiSO4	3.480e-09	3.480e-09	-8.458	-8.458	0.000	(0)
CoSO4	3.069e-09	3.069e-09	-8.513	-8.513	0.000	(0)
Zn(SO4)2-2	1.459e-09	7.695e-10	-8.836	-9.114	-0.278	(0)
HSO4-	6.876e-10	6.019e-10	-9.163	-9.220	-0.058	(0)
CuSO4	6.855e-10	6.855e-10	-9.164	-9.164	0.000	(0)
FeSO4	5.754e-10	5.754e-10	-9.240	-9.240	0.000	(0)
PbSO4	5.313e-10	5.313e-10	-9.275	-9.275	0.000	(0)
CrOHSO4	1.003e-10	1.003e-10	-9.999	-9.999	0.000	(0)
Cd(SO4)2-2	7.869e-11	4.149e-11	-10.104	-10.382	-0.278	(0)
Pb(SO4)2-2	4.840e-12	2.552e-12	-11.315	-11.593	-0.278	(0)
Ni(SO4)2-2	1.742e-13	9.186e-14	-12.759	-13.037	-0.278	(0)
CrSO4+	4.064e-14	3.463e-14	-13.391	-13.461	-0.069	(0)
AlSO4+	3.135e-15	2.744e-15	-14.504	-14.562	-0.058	(0)
FeSO4+	2.785e-17	2.443e-17	-16.555	-16.612	-0.057	(0)
Al(SO4)2-	2.678e-17	2.344e-17	-16.572	-16.630	-0.058	(0)
UO2SO4	1.181e-17	1.181e-17	-16.928	-16.928	0.000	(0)
Cr2(OH)2SO4+2	9.115e-18	4.806e-18	-17.040	-17.318	-0.278	(0)
VO2SO4-	7.308e-19	6.227e-19	-18.136	-18.206	-0.069	(0)
Fe(SO4)2-	4.887e-19	4.164e-19	-18.311	-18.380	-0.069	(0)
UO2(SO4)2-2	2.353e-19	1.241e-19	-18.628	-18.906	-0.278	(0)
Cr2(OH)2(SO4)2	2.276e-19	2.276e-19	-18.643	-18.643	0.000	(0)
VOSO4	3.431e-21	3.431e-21	-20.465	-20.465	0.000	(0)
CrO3SO4-2	1.477e-24	7.790e-25	-23.831	-24.108	-0.278	(0)
VSO4+	2.047e-35	1.744e-35	-34.689	-34.758	-0.069	(0)
U(SO4)2	0.000e+00	0.000e+00	-43.938	-43.938	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-44.462	-44.740	-0.278	(0)
Se(-2)	9.185e-36					
HSe-	9.182e-36	7.824e-36	-35.037	-35.107	-0.069	(0)
MnSe	2.851e-39	2.851e-39	-38.545	-38.545	0.000	(0)
H2Se	4.693e-40	4.693e-40	-39.329	-39.329	0.000	(0)
Se-2	0.000e+00	0.000e+00	-41.717	-41.995	-0.278	(0)
Se(4)	1.090e-07					
HSeO3-	5.949e-08	5.069e-08	-7.226	-7.295	-0.069	(0)
SeO3-2	4.953e-08	2.612e-08	-7.305	-7.583	-0.278	(0)
H2SeO3	1.671e-13	1.671e-13	-12.777	-12.777	0.000	(0)
Cd(SeO3)2-2	2.202e-17	1.161e-17	-16.657	-16.935	-0.278	(0)
FeHSeO3+2	6.941e-22	3.659e-22	-21.159	-21.437	-0.278	(0)
Se(6)	9.249e-12					
SeO4-2	9.248e-12	5.405e-12	-11.034	-11.267	-0.233	(0)
MnSeO4	9.939e-16	9.939e-16	-15.003	-15.003	0.000	(0)
ZnSeO4	5.320e-16	5.320e-16	-15.274	-15.274	0.000	(0)
NiSeO4	5.532e-17	5.532e-17	-16.257	-16.257	0.000	(0)
CoSeO4	5.228e-17	5.228e-17	-16.282	-16.282	0.000	(0)
CdSeO4	2.078e-17	2.078e-17	-16.682	-16.682	0.000	(0)
HSeO4-	2.456e-18	2.093e-18	-17.610	-17.679	-0.069	(0)
Zn(SeO4)2-2	5.529e-27	2.915e-27	-26.257	-26.535	-0.278	(0)
U(3)	0.000e+00					
U+3	0.000e+00	0.000e+00	-60.412	-61.037	-0.625	(0)
U(4)	1.852e-21					
U(OH)5-	1.852e-21	1.578e-21	-20.732	-20.802	-0.069	(0)
U(OH)4	5.108e-25	5.108e-25	-24.292	-24.292	0.000	(0)
U(OH)3+	1.694e-29	1.443e-29	-28.771	-28.841	-0.069	(0)
U(OH)2+2	9.785e-35	5.159e-35	-34.009	-34.287	-0.278	(0)
UF3+	1.605e-40	1.368e-40	-39.795	-39.864	-0.069	(0)
UOH+3	0.000e+00	0.000e+00	-40.101	-40.726	-0.625	(0)
UF2+2	0.000e+00	0.000e+00	-40.378	-40.656	-0.278	(0)
UF4	0.000e+00	0.000e+00	-42.232	-42.232	0.000	(0)
UF+3	0.000e+00	0.000e+00	-42.723	-43.349	-0.625	(0)
U(SO4)2	0.000e+00	0.000e+00	-43.938	-43.938	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-44.462	-44.740	-0.278	(0)
UF5-	0.000e+00	0.000e+00	-44.972	-45.041	-0.069	(0)
UF6-2	0.000e+00	0.000e+00	-46.691	-46.969	-0.278	(0)
U+4	0.000e+00	0.000e+00	-47.129	-48.241	-1.112	(0)
UCl+3	0.000e+00	0.000e+00	-48.820	-49.445	-0.625	(0)
U6(OH)15+9	0.000e+00	0.000e+00	-179.295	-184.924	-5.629	(0)
U(5)	7.000e-19					
UO2+	7.000e-19	5.965e-19	-18.155	-18.224	-0.069	(0)
U(6)	3.238e-08					
UO2(CO3)3-4	3.013e-08	2.328e-09	-7.521	-8.633	-1.112	(0)
UO2(CO3)2-2	2.254e-09	1.188e-09	-8.647	-8.925	-0.278	(0)
UO2CO3	1.523e-12	1.523e-12	-11.817	-11.817	0.000	(0)
UO2OH+	1.883e-15	1.605e-15	-14.725	-14.795	-0.069	(0)
UO2F+	6.200e-17	5.284e-17	-16.208	-16.277	-0.069	(0)
UO2+2	1.674e-17	9.785e-18	-16.776	-17.009	-0.233	(0)
UO2SO4	1.181e-17	1.181e-17	-16.928	-16.928	0.000	(0)
UO2F2	5.960e-18	5.960e-18	-17.225	-17.225	0.000	(0)
UO2(SO4)2-2	2.353e-19	1.241e-19	-18.628	-18.906	-0.278	(0)
UO2F3-	6.872e-20	5.856e-20	-19.163	-19.232	-0.069	(0)
UO2Cl+	2.322e-20	1.979e-20	-19.634	-19.704	-0.069	(0)
UO2F4-2	3.451e-23	1.820e-23	-22.462	-22.740	-0.278	(0)
(UO2)2(OH)2+2	8.106e-24	4.274e-24	-23.091	-23.369	-0.278	(0)
(UO2)3(OH)5+	1.036e-26	8.828e-27	-25.985	-26.054	-0.069	(0)
V(2)	0.000e+00					
VOH+	0.000e+00	0.000e+00	-40.950	-41.019	-0.069	(0)
V+2	0.000e+00	0.000e+00	-42.366	-42.644	-0.278	(0)
V(3)	8.266e-14					
V(OH)3	8.266e-14	8.266e-14	-13.083	-13.083	0.000	(0)
V(OH)2+	4.845e-25	4.128e-25	-24.315	-24.384	-0.069	(0)
VOH+2	5.740e-29	3.027e-29	-28.241	-28.519	-0.278	(0)
V+3	1.957e-34	4.636e-35	-33.708	-34.334	-0.625	(0)
VSO4+	2.047e-35	1.744e-35	-34.689	-34.758	-0.069	(0)
V2(OH)3+3	0.000e+00	0.000e+00	-53.826	-54.451	-0.625	(0)
V2(OH)2+4	0.000e+00	0.000e+00	-55.126	-56.238	-1.112	(0)
V(4)	4.803e-18					
V(OH)3+	4.765e-18	4.061e-18	-17.322	-17.391	-0.069	(0)
VO+2	2.964e-20	1.563e-20	-19.528	-19.806	-0.278	(0)
VOF+	4.303e-21	3.667e-21	-20.366	-20.436	-0.069	(0)
VOSO4	3.431e-21	3.431e-21	-20.465	-20.465	0.000	(0)
VOCl+	6.415e-23	5.467e-23	-22.193	-22.262	-0.069	(0)
VOF2	5.378e-23	5.378e-23	-22.269	-22.269	0.000	(0)
VOF3-	8.759e-26	7.464e-26	-25.058	-25.127	-0.069	(0)
VOF4-2	2.235e-29	1.178e-29	-28.651	-28.929	-0.278	(0)
H2V2O4+2	1.569e-30	8.271e-31	-29.804	-30.082	-0.278	(0)
V(5)	4.913e-08					
H2VO4-	3.221e-08	2.744e-08	-7.492	-7.562	-0.069	(0)
HVO4-2	1.692e-08	8.921e-09	-7.772	-8.050	-0.278	(0)
H3VO4	2.120e-12	2.120e-12	-11.674	-11.674	0.000	(0)
H3V2O7-	4.411e-13	3.759e-13	-12.355	-12.425	-0.069	(0)
HV2O7-3	3.503e-13	8.299e-14	-12.456	-13.081	-0.625	(0)
VO4-3	2.443e-14	5.787e-15	-13.612	-14.238	-0.625	(0)
V2O7-4	3.741e-15	2.891e-16	-14.427	-15.539	-1.112	(0)
V3O9-3	9.147e-17	2.167e-17	-16.039	-16.664	-0.625	(0)
VO2+	3.742e-17	3.272e-17	-16.427	-16.485	-0.058	(0)
VO2F	2.244e-18	2.244e-18	-17.649	-17.649	0.000	(0)
VO2SO4-	7.308e-19	6.227e-19	-18.136	-18.206	-0.069	(0)
VO2F2-	3.741e-20	3.188e-20	-19.427	-19.497	-0.069	(0)
V4O12-4	3.209e-21	2.480e-22	-20.494	-21.606	-1.112	(0)
VO2F3-2	2.950e-23	1.555e-23	-22.530	-22.808	-0.278	(0)
VO2F4-3	1.264e-27	2.993e-28	-26.898	-27.524	-0.625	(0)
V10O28-6	0.000e+00	0.000e+00	-56.654	-59.156	-2.502	(0)
HV10O28-5	0.000e+00	0.000e+00	-57.344	-59.081	-1.737	(0)
H2V10O28-4	0.000e+00	0.000e+00	-60.874	-61.986	-1.112	(0)
Zn	2.903e-06					
ZnCO3	1.430e-06	1.430e-06	-5.845	-5.845	0.000	(0)
Zn+2	1.088e-06	6.356e-07	-5.964	-6.197	-0.233	(0)
ZnHCO3+	1.520e-07	1.295e-07	-6.818	-6.888	-0.069	(0)
ZnSO4	1.108e-07	1.108e-07	-6.955	-6.955	0.000	(0)
ZnOH+	9.717e-08	8.280e-08	-7.012	-7.082	-0.069	(0)
Zn(OH)2	1.709e-08	1.709e-08	-7.767	-7.767	0.000	(0)
ZnOHCl	3.395e-09	3.395e-09	-8.469	-8.469	0.000	(0)
ZnCl+	2.280e-09	1.990e-09	-8.642	-8.701	-0.059	(0)
Zn(SO4)2-2	1.459e-09	7.695e-10	-8.836	-9.114	-0.278	(0)
ZnF+	5.821e-10	4.961e-10	-9.235	-9.304	-0.069	(0)
Zn(OH)3-	1.310e-10	1.116e-10	-9.883	-9.952	-0.069	(0)
ZnCl2	3.933e-12	3.933e-12	-11.405	-11.405	0.000	(0)
Zn(OH)4-2	1.098e-14	5.788e-15	-13.960	-14.238	-0.278	(0)
ZnCl3-	4.461e-15	3.895e-15	-14.351	-14.409	-0.059	(0)
ZnSeO4	5.320e-16	5.320e-16	-15.274	-15.274	0.000	(0)
ZnCl4-2	4.097e-18	2.428e-18	-17.388	-17.615	-0.227	(0)
Zn(SeO4)2-2	5.529e-27	2.915e-27	-26.257	-26.535	-0.278	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.82	8.98	10.80	Al(OH)3
Al2(MoO4)3	-55.06	-52.69	2.37	Al2(MoO4)3
Al2O3	-1.69	17.97	19.65	Al2O3
Al4(OH)10SO4	-6.09	16.61	22.70	Al4(OH)10SO4
AlAsO4:2H2O	-10.60	-5.80	4.80	AlAsO4:2H2O
AlOHSO4	-7.11	-10.34	-3.23	AlOHSO4
Alunite	-5.27	-6.67	-1.40	KAl3(SO4)2(OH)6
Anglesite	-4.17	-11.96	-7.79	PbSO4
Anhydrite	-1.71	-6.07	-4.36	CaSO4
Antlerite	-4.72	4.07	8.79	Cu3(OH)4SO4
Aragonite	0.92	-7.38	-8.30	CaCO3
Arsenolite	-77.66	-80.42	-2.76	As4O6
Artinite	-3.88	5.72	9.60	MgCO3:Mg(OH)2:3H2O
As2O5	-36.27	-29.56	6.71	As2O5
Atacamite	-2.81	4.58	7.39	Cu2(OH)3Cl
Azurite	-0.96	-17.87	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-14.31	10.08	24.39	Ba(OH)2:8H2O
Ba2V2O7:2H2O	-12.45	3.42	15.87	Ba2V2O7:2H2O
Ba3(AsO4)2	9.61	0.70	-8.91	Ba3(AsO4)2
Ba3(VO4)2:4H2O	-19.43	13.51	32.94	Ba3(VO4)2:4H2O
BaCrO4	-10.25	-19.92	-9.67	BaCrO4
BaF2	-9.13	-14.95	-5.82	BaF2
BaMoO4	-6.51	-13.47	-6.96	BaMoO4
Barite	0.74	-9.24	-9.98	BaSO4
BaSeO3	-7.15	-5.32	1.83	BaSeO3
BaSeO4	-9.95	-17.41	-7.46	BaSeO4
Bianchite	-7.53	-9.30	-1.76	ZnSO4:6H2O
Birnessite	-9.16	8.93	18.09	MnO2
Bixbyite	-5.71	-6.36	-0.64	Mn2O3
Boehmite	0.40	8.98	8.58	AlOOH
Brochantite	-3.35	11.87	15.22	Cu4(OH)6SO4
Brucite	-3.67	13.18	16.84	Mg(OH)2
Bunsenite	-3.88	8.56	12.45	NiO
Ca(VO3)2	-9.16	-3.50	5.66	Ca(VO3)2
Ca2V2O7	-7.75	9.75	17.50	Ca2V2O7
Ca2V2O7:2H2O	-11.80	9.75	21.55	Ca2V2O7:2H2O
Ca3(AsO4)2:4H2O	-12.11	10.19	22.30	Ca3(AsO4)2:4H2O
Ca3(VO4)2	-15.96	23.00	38.96	Ca3(VO4)2
Ca3(VO4)2:4H2O	-16.86	23.00	39.86	Ca3(VO4)2:4H2O
CaCrO4	-14.49	-16.75	-2.27	CaCrO4
Calcite	1.10	-7.38	-8.48	CaCO3
CaMoO4	-2.35	-10.30	-7.95	CaMoO4
Carnotite	-4.36	-4.13	0.23	KUO2VO4
CaSeO3:2H2O	-4.97	-2.16	2.81	CaSeO3:2H2O
CaSeO4:2H2O	-11.22	-14.24	-3.02	CaSeO4:2H2O
Cd(BO2)2	-11.23	-1.39	9.84	Cd(BO2)2
Cd(OH)2	-5.11	8.54	13.64	Cd(OH)2
Cd(OH)2(am)	-5.19	8.54	13.73	Cd(OH)2
Cd3(OH)2(SO4)2	-19.74	-13.03	6.71	Cd3(OH)2(SO4)2
Cd3(OH)4SO4	-16.27	6.29	22.56	Cd3(OH)4SO4
Cd4(OH)6SO4	-13.57	14.83	28.40	Cd4(OH)6SO4
CdCl2	-12.83	-13.49	-0.66	CdCl2
CdCl2:1H2O	-11.80	-13.49	-1.69	CdCl2:1H2O
CdCl2:2.5H2O	-11.58	-13.49	-1.91	CdCl2:2.5H2O
CdF2	-15.29	-16.50	-1.21	CdF2
Cdmetal(alpha)	-29.20	-15.69	13.51	Cd
Cdmetal(gamma)	-29.30	-15.69	13.62	Cd
CdMoO4	-0.86	-15.01	-14.15	CdMoO4
CdOHCl	-6.01	-2.48	3.54	CdOHCl
CdSe	-14.48	-34.68	-20.20	CdSe
CdSeO4:2H2O	-17.10	-18.95	-1.85	CdSeO4:2H2O
CdSO4	-10.61	-10.78	-0.17	CdSO4
CdSO4:1H2O	-9.06	-10.78	-1.73	CdSO4:1H2O
CdSO4:2.67H2O	-8.91	-10.78	-1.87	CdSO4:2.67H2O
Cerussite	-0.14	-13.27	-13.13	PbCO3
CH4(g)	-76.48	-117.53	-41.05	CH4
Chalcanthite	-8.88	-11.52	-2.64	CuSO4:5H2O
Claudetite	-77.36	-80.42	-3.06	As4O6
Clausthalite	-8.76	-35.86	-27.10	PbSe
Co(BO2)2	-28.49	-1.42	27.07	Co(BO2)2
Co(OH)2	-4.58	8.51	13.09	Co(OH)2
Co(OH)3	-9.47	-11.78	-2.31	Co(OH)3
CO2(g)	-2.48	-20.63	-18.15	CO2
Co3(AsO4)2	-17.07	-4.03	13.03	Co3(AsO4)2
Co3O4	-4.55	-15.05	-10.50	Co3O4
CoCl2	-21.79	-13.52	8.27	CoCl2
CoCl2:6H2O	-16.06	-13.52	2.54	CoCl2:6H2O
CoCO3	-2.14	-12.12	-9.98	CoCO3
CoF2	-14.93	-16.53	-1.60	CoF2
CoF3	-47.88	-49.34	-1.46	CoF3
CoFe2O4	25.58	22.05	-3.53	CoFe2O4
CoMoO4	-7.28	-15.04	-7.76	CoMoO4
CoO	-5.08	8.51	13.59	CoO
CoSe	-18.51	-34.71	-16.20	CoSe
CoSeO3	-8.22	-6.90	1.32	CoSeO3
CoSeO4:6H2O	-17.45	-18.98	-1.53	CoSeO4:6H2O
CoSO4	-13.62	-10.81	2.80	CoSO4
CoSO4:6H2O	-8.34	-10.81	-2.47	CoSO4:6H2O
Cotunnite	-9.89	-14.67	-4.78	PbCl2
Cr(OH)2	-18.95	-8.13	10.82	Cr(OH)2
Cr(OH)3	-0.30	1.04	1.34	Cr(OH)3
Cr(OH)3(am)	1.79	1.04	-0.75	Cr(OH)3
Cr2O3	4.43	2.07	-2.36	Cr2O3
CrCl2	-44.25	-30.16	14.09	CrCl2
CrCl3	-47.13	-32.01	15.11	CrCl3
CrF3	-25.19	-36.52	-11.34	CrF3
Crmetal	-62.84	-32.35	30.48	Cr
CrO3	-26.79	-30.00	-3.21	CrO3
Cryolite	-14.43	-48.27	-33.84	Na3AlF6
Cu(OH)2	-0.88	7.80	8.67	Cu(OH)2
Cu2Se(alpha)	-0.67	-46.47	-45.80	Cu2Se
Cu2SO4	-20.62	-22.57	-1.95	Cu2SO4
Cu3(AsO4)2:2H2O	-12.26	-6.16	6.10	Cu3(AsO4)2:2H2O
Cu3Se2	-18.39	-81.89	-63.49	Cu3Se2
CuCO3	-1.33	-12.83	-11.50	CuCO3
CuCrO4	-16.77	-22.21	-5.44	CuCrO4
CuF	-9.24	-14.14	-4.91	CuF
CuF2	-18.36	-17.24	1.12	CuF2

CuF2:2H2O	-12.69	-17.24	-4.55	CuF2:2H2O
Cumetal	-4.98	-13.74	-8.76	Cu
CuMoO4	-2.68	-15.75	-13.08	CuMoO4
CuOCuSO4	-14.03	-3.73	10.30	CuOCuSO4
Cupricferrite	15.35	21.34	5.99	CuFe2O4
Cuprite	-1.84	-3.25	-1.41	Cu2O
Cuprousferrite	14.07	5.15	-8.92	CuFeO2
CuSe	-2.32	-35.42	-33.10	CuSe
CuSe2	-21.05	-54.41	-33.37	CuSe2
CuSeO3:2H2O	-8.12	-7.61	0.51	CuSeO3:2H2O
CuSeO4:5H2O	-17.25	-19.69	-2.44	CuSeO4:5H2O
CuSO4	-14.46	-11.52	2.94	CuSO4
Diaspore	2.11	8.98	6.87	AlOOH
Dolomite(disordered)	1.70	-14.84	-16.54	CaMg(CO3)2
Dolomite(ordered)	2.25	-14.84	-17.09	CaMg(CO3)2
Epsomite	-4.02	-6.15	-2.13	MgSO4:7H2O
Fe(OH)2	-5.87	7.69	13.56	Fe(OH)2
Fe(OH)2.7Cl.3	6.51	3.47	-3.04	Fe(OH)2.7Cl.3
Fe(VO3)2	-5.33	-9.05	-3.72	Fe(VO3)2
Fe2(OH)4SeO3	-3.42	-1.86	1.55	Fe2(OH)4SeO3
Fe2(SeO3)3:2H2O	-12.05	-32.68	-20.63	Fe2(SeO3)3:2H2O
Fe2(SO4)3	-40.69	-44.42	-3.73	Fe2(SO4)3
Fe3(OH)8	1.01	21.24	20.22	Fe3(OH)8
FeAsO4:2H2O	-8.41	-8.01	0.40	FeAsO4:2H2O
FeCr2O4	2.57	9.77	7.20	FeCr2O4
FeMoO4	-5.77	-15.86	-10.09	FeMoO4
Ferrihydrite	3.58	6.77	3.19	Fe(OH)3
Ferroselite	-35.92	-54.52	-18.60	FeSe2
FeSe	-24.53	-35.53	-11.00	FeSe
Fluorite	-1.29	-11.79	-10.50	CaF2
Gibbsite	0.69	8.98	8.29	Al(OH)3
Goethite	6.28	6.77	0.49	FeOOH
Goslarite	-7.29	-9.30	-2.01	ZnSO4:7H2O
Gummite	-8.46	-0.79	7.67	UO3
Gypsum	-1.46	-6.07	-4.61	CaSO4:2H2O
H-Jarosite	-6.23	-18.33	-12.10	(H3O)Fe3(SO4)2(OH)6
H2MoO4	-10.68	-23.55	-12.88	H2MoO4
H2Se(g)	-38.26	-43.22	-4.96	H2Se
Halite	-6.66	-5.06	1.60	NaCl
Hausmannite	-6.63	54.40	61.03	Mn3O4
Hematite	14.96	13.54	-1.42	Fe2O3
Hercynite	2.76	25.66	22.89	FeAl2O4
Huntite	0.22	-29.74	-29.97	CaMg3(CO3)4
Hydrocerussite	-0.42	-19.19	-18.77	Pb3(OH)2(CO3)2
Hydromagnesite	-7.87	-16.64	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-19.47	-24.64	-5.17	KAl(SO4)2:12H2O
K-Jarosite	1.50	-13.30	-14.80	KFe3(SO4)2(OH)6
K2Cr2O7	-32.72	-49.96	-17.24	K2Cr2O7
K2CrO4	-19.44	-19.96	-0.51	K2CrO4
K2MoO4	-16.77	-13.50	3.26	K2MoO4
K2SeO4	-16.71	-17.44	-0.73	K2SeO4
Langite	-5.62	11.87	17.49	Cu4(OH)6SO4:H2O
Larnakite	-4.17	-4.61	-0.43	PbO:PbSO4
Laurionite	-4.28	-3.66	0.62	PbOHCl
Lepidocrocite	5.40	6.77	1.37	FeOOH
Lime	-19.45	13.25	32.70	CaO
Litharge	-5.34	7.36	12.69	PbO
Maghemite	7.16	13.54	6.39	Fe2O3
Magnesioferrite	9.86	26.72	16.86	Fe2MgO4
Magnesite	0.01	-7.45	-7.46	MgCO3
Magnetite	17.83	21.24	3.40	Fe3O4
Malachite	0.27	-5.04	-5.31	Cu2(OH)2CO3
Manganite	-3.17	22.17	25.34	MnOOH
Massicot	-5.54	7.36	12.89	PbO
Matlockite	-7.20	-16.18	-8.97	PbClF
Melanothallite	-20.49	-14.23	6.26	CuCl2
Melanterite	-9.42	-11.63	-2.21	FeSO4:7H2O
Mg(OH)2(active)	-5.62	13.18	18.79	Mg(OH)2
Mg(VO3)2	-14.85	-3.57	11.28	Mg(VO3)2
Mg2V2O7	-16.75	9.61	26.36	Mg2V2O7
MgCr2O4	-0.95	15.25	16.20	MgCr2O4
MgCrO4	-22.21	-16.83	5.38	MgCrO4
MgF2	-3.73	-11.86	-8.13	MgF2
MgMoO4	-8.52	-10.37	-1.85	MgMoO4
MgSeO3:6H2O	-5.29	-2.23	3.06	MgSeO3:6H2O
MgSeO4:6H2O	-13.11	-14.31	-1.20	MgSeO4:6H2O
Minium	-27.23	46.30	73.52	Pb3O4
Mirabilite	-6.30	-7.42	-1.11	Na2SO4:10H2O
Mn(VO3)2	-11.59	-6.69	4.90	Mn(VO3)2
Mn2(SO4)3	-58.62	-64.33	-5.71	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-11.89	0.61	12.50	Mn3(AsO4)2:8H2O
MnCl2:4H2O	-14.69	-11.97	2.72	MnCl2:4H2O
MnSe	-36.66	-33.16	3.50	MnSe
MnSeO3	-6.48	-5.35	1.13	MnSeO3
MnSeO3:2H2O	-6.33	-5.35	0.98	MnSeO3:2H2O
MnSeO4:5H2O	-15.38	-17.43	-2.05	MnSeO4:5H2O
MnSO4	-11.85	-9.26	2.58	MnSO4
Monteponite	-6.56	8.54	15.10	CdO
MoO3	-15.55	-23.55	-8.00	MoO3
Morenosite	-8.61	-10.76	-2.14	NiSO4:7H2O
Na-Jarosite	-1.17	-12.37	-11.20	NaFe3(SO4)2(OH)6
Na2Cr2O7	-38.20	-48.10	-9.90	Na2Cr2O7
Na2CrO4	-21.02	-18.09	2.93	Na2CrO4
Na2Mo2O7	-18.60	-35.20	-16.60	Na2Mo2O7
Na2MoO4	-13.13	-11.64	1.49	Na2MoO4
Na2MoO4:2H2O	-12.87	-11.64	1.22	Na2MoO4:2H2O
Na2SeO3:5H2O	-13.80	-3.50	10.30	Na2SeO3:5H2O
Na2SeO4	-16.86	-15.58	1.28	Na2SeO4
Na3VO4	-27.19	9.49	36.68	Na3VO4
Na4V2O7	-30.33	7.07	37.40	Na4V2O7
Nantokite	-5.91	-12.64	-6.73	CuCl
Natron	-7.41	-8.72	-1.31	Na2CO3:10H2O
NaVO3	-6.28	-2.42	3.86	NaVO3
Nesquehonite	-2.78	-7.45	-4.67	MgCO3:3H2O
Ni(OH)2	-4.23	8.56	12.79	Ni(OH)2
Ni3(AsO4)2:8H2O	-19.57	-3.87	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-17.07	14.93	32.00	Ni4(OH)6SO4
NiCO3	-5.20	-12.07	-6.87	NiCO3
NiMoO4	-3.85	-14.99	-11.14	NiMoO4
NiSe	-16.95	-34.65	-17.70	NiSe
NiSeO3:2H2O	-9.66	-6.84	2.81	NiSeO3:2H2O
NiSeO4:6H2O	-17.41	-18.93	-1.52	NiSeO4:6H2O
Nsutite	-8.57	8.93	17.50	MnO2
O2(g)	-34.64	48.45	83.09	O2
Otavite	-0.09	-12.09	-12.00	CdCO3
Pb(BO2)2	-9.09	-2.57	6.52	Pb(BO2)2
Pb(OH)2	-0.79	7.36	8.15	Pb(OH)2
Pb10(OH)6O(CO3)6	-41.45	-50.21	-8.76	Pb10(OH)6O(CO3)6
Pb2(OH)3Cl	-5.09	3.70	8.79	Pb2(OH)3Cl
Pb2O(OH)2	-11.47	14.72	26.19	Pb2O(OH)2
Pb2O3	-22.10	38.94	61.04	Pb2O3
Pb2OCO3	-5.36	-5.92	-0.56	Pb2OCO3
Pb2V2O7	-0.13	-2.03	-1.90	Pb2V2O7
Pb3(AsO4)2	-13.29	-7.49	5.80	Pb3(AsO4)2
Pb3(VO4)2	-0.81	5.33	6.14	Pb3(VO4)2
Pb3O2CO3	-9.58	1.44	11.02	Pb3O2CO3
Pb3O2SO4	-7.94	2.75	10.69	Pb3O2SO4
Pb4(OH)6SO4	-10.99	10.11	21.10	Pb4(OH)6SO4
Pb4O3SO4	-11.77	10.11	21.88	Pb4O3SO4
PbCrO4	-10.05	-22.65	-12.60	PbCrO4
PbF2	-10.24	-17.68	-7.44	PbF2
Pbmetal	-21.11	-16.87	4.25	Pb
PbMoO4	-0.57	-16.19	-15.62	PbMoO4
PbO:0.3H2O	-5.62	7.36	12.98	PbO:0.33H2O
PbSeO4	-13.29	-20.13	-6.84	PbSeO4
Periclase	-8.41	13.18	21.58	MgO
Phosgenite	-8.14	-27.95	-19.81	PbCl2:PbCO3
Plattnerite	-18.02	31.58	49.60	PbO2
Portlandite	-9.55	13.25	22.80	Ca(OH)2
Pyrochroite	-5.14	10.06	15.19	Mn(OH)2
Pyrolusite	-7.10	34.28	41.38	MnO2
Retgersite	-8.72	-10.76	-2.04	NiSO4:6H2O
Rhodochrosite	0.01	-10.57	-10.58	MnCO3
Rutherfordine	-6.92	-21.42	-14.50	UO2CO3
Schoepite	-6.78	-0.79	5.99	UO2(OH)2:H2O
Semetal(am)	-11.88	-18.99	-7.11	Se
Semetal(hex)	-11.29	-18.99	-7.71	Se
SeO2	-15.53	-15.41	0.12	SeO2
SeO3	-48.54	-27.49	21.04	SeO3
Siderite	-2.70	-12.94	-10.24	FeCO3
Smithsonite	-0.60	-10.60	-10.00	ZnCO3
Spinel	-5.70	31.14	36.85	MgAl2O4
Tenorite	0.15	7.80	7.64	CuO
Thenardite	-7.73	-7.41	0.32	Na2SO4
Thermonatrite	-9.36	-8.72	0.64	Na2CO3:H2O
Tyuyamunite	-9.15	-5.07	4.08	Ca(UO2)2(VO4)2
U3O8	-20.02	1.07	21.08	U3O8
U4O9	-35.93	-38.95	-3.02	U4O9
UF4	-36.33	-65.87	-29.54	UF4
UF4:2.5H2O	-33.15	-65.87	-32.72	UF4:2.5H2O
UO2(am)	-16.73	-15.79	0.93	UO2
UO2(OH)2(beta)	-6.40	-0.79	5.61	UO2(OH)2
UO2SeO4:4H2O	-26.03	-28.28	-2.25	UO2SeO4:4H2O
UO3	-8.49	-0.79	7.70	UO3
Uraninite	-11.12	-15.79	-4.67	UO2
V(OH)3	-17.59	-10.00	7.59	V(OH)3
V2O5	-15.39	-16.75	-1.36	V2O5
V3O5	-36.81	-34.97	1.84	V3O5
V4O7	-45.74	-38.55	7.19	V4O7
V6O13	-37.83	-98.69	-60.86	V6O13
VCl2	-63.02	-44.14	18.87	VCl2
VCl3	-66.48	-43.05	23.43	VCl3
VF4	-68.59	-53.66	14.93	VF4
Vmetal	-90.36	-46.33	44.03	V
VO	-36.87	-22.11	14.76	VO
VO(OH)2	-8.73	-3.58	5.15	VO(OH)2
VO2Cl	-22.23	-19.39	2.84	VO2Cl
VOCl	-32.17	-21.01	11.15	VOCl
VOCl2	-38.37	-25.61	12.76	VOCl2
VOSO4	-26.51	-22.90	3.61	VOSO4
Witherite	-1.98	-10.55	-8.57	BaCO3
Zincite	-1.31	10.03	11.33	ZnO
Zincosite	-13.22	-9.30	3.93	ZnSO4
Zn(BO2)2	-8.19	0.10	8.29	Zn(BO2)2
Zn(OH)2	-2.17	10.03	12.20	Zn(OH)2
Zn(OH)2(am)	-2.45	10.03	12.47	Zn(OH)2
Zn(OH)2(beta)	-1.73	10.03	11.75	Zn(OH)2
Zn(OH)2(epsilon)	-1.51	10.03	11.53	Zn(OH)2
Zn(OH)2(gamma)	-1.71	10.03	11.73	Zn(OH)2
Zn2(OH)2SO4	-6.77	0.73	7.50	Zn2(OH)2SO4
Zn2(OH)3Cl	-6.15	9.04	15.19	Zn2(OH)3Cl
Zn3(AsO4)2:2.5H2O	-13.13	0.52	13.65	Zn3(AsO4)2:2.5H2O
Zn3O(SO4)2	-27.48	-8.56	18.91	Zn3O(SO4)2
Zn4(OH)6SO4	-7.61	20.79	28.40	Zn4(OH)6SO4
Zn5(OH)8Cl2	-10.40	28.10	38.50	Zn5(OH)8Cl2
ZnCl2	-19.06	-12.01	7.05	ZnCl2
ZnCO3:1H2O	-0.34	-10.60	-10.26	ZnCO3:1H2O
ZnF2	-14.48	-15.01	-0.53	ZnF2
Znmetal	-39.99	-14.20	25.79	Zn
ZnMoO4	-3.40	-13.53	-10.13	ZnMoO4
ZnO(active)	-1.16	10.03	11.19	ZnO
ZnSe	-18.79	-33.19	-14.40	ZnSe
ZnSeO4:6H2O	-15.95	-17.47	-1.52	ZnSeO4:6H2O
ZnSO4:1H2O	-8.66	-9.30	-0.64	ZnSO4:1H2O

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Initial solution 2. PAF Material

----------Solution composition----------

Elements	Molality	Moles
Al	7.415e-07	7.415e-07
Alkalinity	3.607e-04	3.607e-04
Ba	1.457e-07	1.457e-07
Ca	1.672e-03	1.672e-03
Co	1.188e-07	1.188e-07
Cu	4.408e-07	4.408e-07
F	1.580e-05	1.580e-05
K	3.326e-04	3.326e-04
Mg	3.293e-04	3.293e-04
Mn	7.283e-07	7.283e-07
Mo	3.128e-08	3.128e-08
Na	4.351e-05	4.351e-05
Ni	6.818e-08	6.818e-08
S(6)	2.051e-03	2.051e-03

----------Description of solution----------

pH	=	7.500
pe	=	4.000
Activity of water	=	1.000
Ionic strength (mol/kgw)	=	7.200e-03
Mass of water (kg)	=	1.000e+00
Total carbon (mol/kg)	=	3.782e-04
Total CO2 (mol/kg)	=	3.782e-04
Temperature (°C)	=	25.00
Electrical balance (eq)	=	-9.478e-05
Percent error, 100*(Cat-|An|)/(Cat+|An|)	=	-1.25
Iterations	=	13 (23 overall)
Total H	=	1.110141e+02
Total O	=	5.551618e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
OH-	3.487e-07	3.184e-07	-6.458	-6.497	-0.039	(0)
H+	3.458e-08	3.162e-08	-7.461	-7.500	-0.039	0.00
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000	18.07
Al	7.415e-07					
Al(OH)4-	7.221e-07	6.609e-07	-6.141	-6.180	-0.038	(0)
Al(OH)3	1.649e-08	1.649e-08	-7.783	-7.783	0.000	(0)
Al(OH)2+	2.830e-09	2.595e-09	-8.548	-8.586	-0.038	(0)
AlF2+	2.736e-11	2.509e-11	-10.563	-10.600	-0.038	(0)
AlOH+2	1.451e-11	1.026e-11	-10.838	-10.989	-0.150	(0)
AlF+2	6.374e-12	4.507e-12	-11.196	-11.346	-0.150	(0)
AlF3	4.418e-12	4.418e-12	-11.355	-11.355	0.000	(0)
AlSO4+	3.315e-13	3.034e-13	-12.480	-12.518	-0.038	(0)
Al+3	7.201e-14	3.223e-14	-13.143	-13.492	-0.349	(0)
AlF4-	3.383e-14	3.096e-14	-13.471	-13.509	-0.038	(0)

Al(SO4)2-	4.307e-15	3.942e-15	-14.366	-14.404	-0.038	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-49.070	-49.460	-0.390	(0)
Ba	1.457e-07					
Ba+2	1.453e-07	1.017e-07	-6.838	-6.993	-0.155	(0)
BaHCO3+	3.363e-10	3.088e-10	-9.473	-9.510	-0.037	(0)
BaCO3	2.459e-11	2.459e-11	-10.609	-10.609	0.000	(0)
BaOH+	1.542e-13	1.413e-13	-12.812	-12.850	-0.038	(0)
C(4)	3.782e-04					
HCO3-	3.469e-04	3.181e-04	-3.460	-3.497	-0.038	(0)
H2CO3	2.262e-05	2.262e-05	-4.645	-4.645	0.000	(0)
CaHCO3+	6.292e-06	5.777e-06	-5.201	-5.238	-0.037	(0)
CaCO3	7.289e-07	7.289e-07	-6.137	-6.137	0.000	(0)
MgHCO3+	7.079e-07	6.472e-07	-6.150	-6.189	-0.039	(0)
CO3-2	6.741e-07	4.716e-07	-6.171	-6.326	-0.155	(0)
CuCO3	2.133e-07	2.133e-07	-6.671	-6.671	0.000	(0)
MgCO3	7.799e-08	7.799e-08	-7.108	-7.108	0.000	(0)
NaHCO3	7.071e-09	7.071e-09	-8.151	-8.151	0.000	(0)
MnHCO3+	2.944e-09	2.697e-09	-8.531	-8.569	-0.038	(0)
CoHCO3+	1.830e-09	1.657e-09	-8.738	-8.781	-0.043	(0)
CuHCO3+	1.703e-09	1.542e-09	-8.769	-8.812	-0.043	(0)
NiHCO3+	1.700e-09	1.539e-09	-8.770	-8.813	-0.043	(0)
NiCO3	6.904e-10	6.904e-10	-9.161	-9.161	0.000	(0)
CoCO3	5.337e-10	5.337e-10	-9.273	-9.273	0.000	(0)
Cu(CO3)2-2	4.033e-10	2.707e-10	-9.394	-9.567	-0.173	(0)
NaCO3-	3.785e-10	3.471e-10	-9.422	-9.460	-0.038	(0)
BaHCO3+	3.363e-10	3.088e-10	-9.473	-9.510	-0.037	(0)
BaCO3	2.459e-11	2.459e-11	-10.609	-10.609	0.000	(0)
Ca	1.672e-03					
Ca+2	1.394e-03	9.753e-04	-2.856	-3.011	-0.155	(0)
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)
CaHCO3+	6.292e-06	5.777e-06	-5.201	-5.238	-0.037	(0)
CaCO3	7.289e-07	7.289e-07	-6.137	-6.137	0.000	(0)
CaF+	1.625e-07	1.489e-07	-6.789	-6.827	-0.038	(0)
CaOH+	6.748e-09	6.196e-09	-8.171	-8.208	-0.037	(0)
Co(2)	1.188e-07					
Co+2	9.974e-08	6.695e-08	-7.001	-7.174	-0.173	(0)
CoSO4	1.620e-08	1.620e-08	-7.791	-7.791	0.000	(0)
CoHCO3+	1.830e-09	1.657e-09	-8.738	-8.781	-0.043	(0)
CoCO3	5.337e-10	5.337e-10	-9.273	-9.273	0.000	(0)
CoOH+	4.699e-10	4.253e-10	-9.328	-9.371	-0.043	(0)
CoF+	3.271e-11	2.961e-11	-10.485	-10.529	-0.043	(0)
Co(OH)2	1.076e-11	1.076e-11	-10.968	-10.968	0.000	(0)
Co(OH)3-	7.550e-17	6.834e-17	-16.122	-16.165	-0.043	(0)
CoOOH-	1.894e-17	1.715e-17	-16.723	-16.766	-0.043	(0)
Co2OH+3	3.499e-18	1.427e-18	-17.456	-17.846	-0.390	(0)
Co(OH)4-2	5.137e-24	3.448e-24	-23.289	-23.462	-0.173	(0)
Co4(OH)4+4	3.216e-29	6.530e-30	-28.493	-29.185	-0.692	(0)
Co(3)	6.424e-30					
CoOH+2	6.424e-30	4.312e-30	-29.192	-29.365	-0.173	(0)
Co+3	5.955e-36	2.665e-36	-35.225	-35.574	-0.349	(0)
Cu(1)	4.157e-09					
Cu+	4.157e-09	3.762e-09	-8.381	-8.425	-0.043	(0)
Cu(2)	4.366e-07					
CuCO3	2.133e-07	2.133e-07	-6.671	-6.671	0.000	(0)
Cu+2	1.098e-07	7.682e-08	-6.959	-7.115	-0.155	(0)
CuOH+	8.460e-08	7.735e-08	-7.073	-7.112	-0.039	(0)
CuSO4	2.134e-08	2.134e-08	-7.671	-7.671	0.000	(0)
Cu(OH)2	4.914e-09	4.914e-09	-8.309	-8.309	0.000	(0)
CuHCO3+	1.703e-09	1.542e-09	-8.769	-8.812	-0.043	(0)
Cu(CO3)2-2	4.033e-10	2.707e-10	-9.394	-9.567	-0.173	(0)
Cu2(OH)2+2	2.239e-10	1.503e-10	-9.650	-9.823	-0.173	(0)
CuF+	7.488e-11	6.778e-11	-10.126	-10.169	-0.043	(0)
Cu(OH)3-	3.545e-12	3.209e-12	-11.450	-11.494	-0.043	(0)
Cu(OH)4-2	1.198e-17	8.042e-18	-16.922	-17.095	-0.173	(0)
F	1.580e-05					
F-	1.529e-05	1.398e-05	-4.816	-4.854	-0.039	(0)

MgF+	3.409e-07	3.120e-07	-6.467	-6.506	-0.038	(0)
CaF+	1.625e-07	1.489e-07	-6.789	-6.827	-0.038	(0)
HF	6.541e-10	6.541e-10	-9.184	-9.184	0.000	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
MnF+	2.582e-10	2.366e-10	-9.588	-9.626	-0.038	(0)
CuF+	7.488e-11	6.778e-11	-10.126	-10.169	-0.043	(0)
CoF+	3.271e-11	2.961e-11	-10.485	-10.529	-0.043	(0)
AlF2+	2.736e-11	2.509e-11	-10.563	-10.600	-0.038	(0)
NiF+	1.523e-11	1.379e-11	-10.817	-10.861	-0.043	(0)
AlF+2	6.374e-12	4.507e-12	-11.196	-11.346	-0.150	(0)
AlF3	4.418e-12	4.418e-12	-11.355	-11.355	0.000	(0)
HF2-	3.808e-14	3.478e-14	-13.419	-13.459	-0.039	(0)
AlF4-	3.383e-14	3.096e-14	-13.471	-13.509	-0.038	(0)
H2F2	1.146e-18	1.146e-18	-17.941	-17.941	0.000	(0)
H(0)	1.414e-26					
H2	7.068e-27	7.079e-27	-26.151	-26.150	0.001	(0)
K	3.326e-04					
K+	3.298e-04	3.016e-04	-3.482	-3.521	-0.039	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
Mg	3.293e-04					
Mg+2	2.842e-04	1.988e-04	-3.546	-3.702	-0.155	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
MgHCO3+	7.079e-07	6.472e-07	-6.150	-6.189	-0.039	(0)
MgF+	3.409e-07	3.120e-07	-6.467	-6.506	-0.038	(0)
MgCO3	7.799e-08	7.799e-08	-7.108	-7.108	0.000	(0)
MgOH+	2.742e-08	2.520e-08	-7.562	-7.599	-0.037	(0)
Mn(2)	7.283e-07					
Mn+2	6.331e-07	4.250e-07	-6.199	-6.372	-0.173	(0)
MnSO4	9.164e-08	9.164e-08	-7.038	-7.038	0.000	(0)
MnHCO3+	2.944e-09	2.697e-09	-8.531	-8.569	-0.038	(0)
MnOH+	3.710e-10	3.399e-10	-9.431	-9.469	-0.038	(0)
MnF+	2.582e-10	2.366e-10	-9.588	-9.626	-0.038	(0)
Mn(OH)3-	2.324e-19	2.129e-19	-18.634	-18.672	-0.038	(0)
Mn(OH)4-2	3.106e-25	2.189e-25	-24.508	-24.660	-0.152	(0)
Mn(3)	4.241e-28					
Mn+3	4.241e-28	1.898e-28	-27.373	-27.722	-0.349	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-48.642	-48.794	-0.152	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-54.126	-54.166	-0.040	(0)
Mo	3.128e-08					
MoO4-2	3.126e-08	2.187e-08	-7.505	-7.660	-0.155	(0)
HMoO4-	1.520e-11	1.376e-11	-10.818	-10.861	-0.043	(0)
H2MoO4	3.188e-15	3.188e-15	-14.497	-14.497	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-49.070	-49.460	-0.390	(0)
Mo7O24-6	0.000e+00	0.000e+00	-59.073	-60.631	-1.558	(0)
HMo7O24-5	0.000e+00	0.000e+00	-60.662	-61.744	-1.082	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-63.769	-64.462	-0.692	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-68.326	-68.716	-0.390	(0)
Na	4.351e-05					
Na+	4.322e-05	3.953e-05	-4.364	-4.403	-0.039	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
NaHCO3	7.071e-09	7.071e-09	-8.151	-8.151	0.000	(0)
NaCO3-	3.785e-10	3.471e-10	-9.422	-9.460	-0.038	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
Ni	6.818e-08					
Ni+2	5.610e-08	3.924e-08	-7.251	-7.406	-0.155	(0)
NiSO4	9.495e-09	9.495e-09	-8.023	-8.023	0.000	(0)
NiHCO3+	1.700e-09	1.539e-09	-8.770	-8.813	-0.043	(0)
NiCO3	6.904e-10	6.904e-10	-9.161	-9.161	0.000	(0)
NiOH+	1.738e-10	1.573e-10	-9.760	-9.803	-0.043	(0)
NiF+	1.523e-11	1.379e-11	-10.817	-10.861	-0.043	(0)
Ni(OH)2	3.978e-12	3.978e-12	-11.400	-11.400	0.000	(0)
Ni(SO4)2-2	5.679e-13	3.812e-13	-12.246	-12.419	-0.173	(0)
Ni(OH)3-	1.399e-15	1.267e-15	-14.854	-14.897	-0.043	(0)
O(0)	2.019e-40					

O2	1.010e-40	1.011e-40	-39.996	-39.995	0.001	(0)
S(6)	2.051e-03					
SO4-2	1.733e-03	1.213e-03	-2.761	-2.916	-0.155	(0)
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
MnSO4	9.164e-08	9.164e-08	-7.038	-7.038	0.000	(0)
CuSO4	2.134e-08	2.134e-08	-7.671	-7.671	0.000	(0)
CoSO4	1.620e-08	1.620e-08	-7.791	-7.791	0.000	(0)
NiSO4	9.495e-09	9.495e-09	-8.023	-8.023	0.000	(0)
HSO4-	4.094e-09	3.747e-09	-8.388	-8.426	-0.038	(0)
Ni(SO4)2-2	5.679e-13	3.812e-13	-12.246	-12.419	-0.173	(0)
AlSO4+	3.315e-13	3.034e-13	-12.480	-12.518	-0.038	(0)
Al(SO4)2-	4.307e-15	3.942e-15	-14.366	-14.404	-0.038	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.79	9.01	10.80	Al(OH)3
Al2(MoO4)3	-52.33	-49.96	2.37	Al2(MoO4)3
Al2O3	-1.64	18.02	19.65	Al2O3
Al4(OH)10SO4	-4.58	18.12	22.70	Al4(OH)10SO4
AlOHSO4	-5.68	-8.91	-3.23	AlOHSO4
Alunite	-3.43	-4.83	-1.40	KAl3(SO4)2(OH)6
Anhydrite	-1.57	-5.93	-4.36	CaSO4
Antlerite	-3.05	5.74	8.79	Cu3(OH)4SO4
Aragonite	-1.04	-9.34	-8.30	CaCO3
Artinite	-8.33	1.27	9.60	MgCO3:Mg(OH)2:3H2O
Azurite	-2.09	-19.00	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-16.39	8.01	24.39	Ba(OH)2:8H2O
BaF2	-10.88	-16.70	-5.82	BaF2
BaMoO4	-7.69	-14.65	-6.96	BaMoO4
Barite	0.07	-9.91	-9.98	BaSO4
Birnessite	-11.81	6.28	18.09	MnO2
Bixbyite	-9.80	-10.44	-0.64	Mn2O3
Boehmite	0.43	9.01	8.58	AlOOH
Brochantite	-1.60	13.63	15.22	Cu4(OH)6SO4
Brucite	-5.55	11.30	16.84	Mg(OH)2
Bunsenite	-4.85	7.59	12.45	NiO
Calcite	-0.86	-9.34	-8.48	CaCO3
CaMoO4	-2.72	-10.67	-7.95	CaMoO4
CH4(g)	-72.28	-113.33	-41.05	CH4
Chalcanthite	-7.39	-10.03	-2.64	CuSO4:5H2O
Co(OH)2	-5.27	7.83	13.09	Co(OH)2
Co(OH)3	-10.77	-13.07	-2.31	Co(OH)3
CO2(g)	-3.18	-21.33	-18.15	CO2
Co3O4	-7.83	-18.32	-10.50	Co3O4
CoCO3	-3.52	-13.50	-9.98	CoCO3
CoF2	-15.29	-16.88	-1.60	CoF2
CoF3	-48.68	-50.14	-1.46	CoF3
CoMoO4	-7.07	-14.83	-7.76	CoMoO4
CoO	-5.76	7.83	13.59	CoO
CoSO4	-12.89	-10.09	2.80	CoSO4
CoSO4:6H2O	-7.62	-10.09	-2.47	CoSO4:6H2O
Cryolite	-21.99	-55.83	-33.84	Na3AlF6
Cu(OH)2	-0.79	7.89	8.67	Cu(OH)2
Cu2SO4	-17.82	-19.77	-1.95	Cu2SO4
CuCO3	-1.94	-13.44	-11.50	CuCO3
CuF	-8.37	-13.28	-4.91	CuF
CuF2	-17.94	-16.82	1.12	CuF2
CuF2:2H2O	-12.27	-16.82	-4.55	CuF2:2H2O
Cumetal	-3.67	-12.42	-8.76	Cu
CuMoO4	-1.70	-14.77	-13.08	CuMoO4
CuOCuSO4	-12.45	-2.15	10.30	CuOCuSO4
Cuprite	-0.44	-1.85	-1.41	Cu2O
CuSO4	-12.97	-10.03	2.94	CuSO4
Diaspore	2.14	9.01	6.87	AlOOH
Dolomite(disordered)	-2.83	-19.37	-16.54	CaMg(CO3)2
Dolomite(ordered)	-2.28	-19.37	-17.09	CaMg(CO3)2
Epsomite	-4.49	-6.62	-2.13	MgSO4:7H2O
Fluorite	-2.22	-12.72	-10.50	CaF2
Gibbsite	0.72	9.01	8.29	Al(OH)3
Gypsum	-1.32	-5.93	-4.61	CaSO4:2H2O
H2MoO4	-9.78	-22.66	-12.88	H2MoO4
Hausmannite	-12.15	48.88	61.03	Mn3O4
Huntite	-9.45	-39.42	-29.97	CaMg3(CO3)4
Hydromagnesite	-20.05	-28.81	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-17.68	-22.85	-5.17	KAl(SO4)2:12H2O
K2MoO4	-17.96	-14.70	3.26	K2MoO4
Langite	-3.86	13.63	17.49	Cu4(OH)6SO4:H2O
Lime	-20.71	11.99	32.70	CaO
Magnesite	-2.57	-10.03	-7.46	MgCO3
Malachite	-0.25	-5.56	-5.31	Cu2(OH)2CO3
Manganite	-5.21	20.13	25.34	MnOOH
Mg(OH)2(active)	-7.50	11.30	18.79	Mg(OH)2
MgF2	-5.28	-13.41	-8.13	MgF2
MgMoO4	-9.51	-11.36	-1.85	MgMoO4
Mirabilite	-10.61	-11.72	-1.11	Na2SO4:10H2O
Mn2(SO4)3	-58.48	-64.19	-5.71	Mn2(SO4)3
MnSO4	-11.87	-9.29	2.58	MnSO4
MoO3	-14.66	-22.66	-8.00	MoO3
Morenosite	-8.18	-10.32	-2.14	NiSO4:7H2O
Na2Mo2O7	-22.53	-39.13	-16.60	Na2Mo2O7
Na2MoO4	-17.96	-16.47	1.49	Na2MoO4
Na2MoO4:2H2O	-17.69	-16.47	1.22	Na2MoO4:2H2O
Natron	-13.82	-15.13	-1.31	Na2CO3:10H2O
Nesquehonite	-5.36	-10.03	-4.67	MgCO3:3H2O
Ni(OH)2	-5.20	7.59	12.79	Ni(OH)2
Ni4(OH)6SO4	-19.54	12.46	32.00	Ni4(OH)6SO4
NiCO3	-6.86	-13.73	-6.87	NiCO3
NiMoO4	-3.92	-15.07	-11.14	NiMoO4
Nsutite	-11.23	6.28	17.50	MnO2
O2(g)	-37.09	46.00	83.09	O2
Periclase	-10.29	11.30	21.58	MgO
Portlandite	-10.81	11.99	22.80	Ca(OH)2
Pyrochroite	-6.57	8.63	15.19	Mn(OH)2
Pyrolusite	-9.75	31.63	41.38	MnO2
Retgersite	-8.28	-10.32	-2.04	NiSO4:6H2O
Rhodochrosite	-2.12	-12.70	-10.58	MnCO3
Spinel	-7.53	29.31	36.85	MgAl2O4
Tenorite	0.24	7.89	7.64	CuO
Thenardite	-12.04	-11.72	0.32	Na2SO4
Thermonatrite	-15.77	-15.13	0.64	Na2CO3:H2O
Witherite	-4.75	-13.32	-8.57	BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Initial solution 3. NAF Material

----------Solution composition----------

Elements	Molality	Moles
Al	5.191e-06	5.191e-06
Alkalinity	4.591e-04	4.591e-04
As	3.873e-07	3.873e-07
Ba	1.457e-07	1.457e-07
Ca	3.046e-03	3.046e-03
Co	3.395e-08	3.395e-08

Cu	2.992e-07	2.992e-07
F	1.580e-05	1.580e-05
Fe	1.254e-06	1.254e-06
K	4.094e-04	4.094e-04
Mg	7.410e-04	7.410e-04
Mn	2.368e-06	2.368e-06
Mo	5.214e-08	5.214e-08
Na	4.352e-05	4.352e-05
Ni	1.705e-08	1.705e-08
S(6)	3.447e-03	3.447e-03
U	4.203e-09	4.203e-09

----------Description of solution----------

pH	=	7.600
pe	=	4.000
Activity of water	=	1.000
Ionic strength (mol/kgw)	=	1.193e-02
Mass of water (kg)	=	1.000e+00
Total carbon (mol/kg)	=	4.552e-04
Total CO2 (mol/kg)	=	4.552e-04
Temperature (°C)	=	25.00
Electrical balance (eq)	=	6.787e-04
Percent error, 100*(Cat-|An|)/(Cat+|An|)	=	5.48
Iterations	=	11 (34 overall)
Total H	=	1.110142e+02
Total O	=	5.552201e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol	
OH-	4.492e-07	4.008e-07	-6.348	-6.397	-0.049	(0)	
H+	2.808e-08	2.512e-08	-7.552	-7.600	-0.048	0.00	
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000	18.07	
Al	5.191e-06						
Al(OH)4-	5.088e-06	4.556e-06	-5.293	-5.341	-0.048	(0)	
Al(OH)3	9.030e-08	9.030e-08	-7.044	-7.044	0.000	(0)	
Al(OH)2+	1.257e-08	1.129e-08	-7.901	-7.947	-0.047	(0)	
AlF2+	6.958e-11	6.249e-11	-10.158	-10.204	-0.047	(0)	
AlOH+2	5.451e-11	3.546e-11	-10.264	-10.450	-0.187	(0)	
AlF+2	1.811e-11	1.178e-11	-10.742	-10.929	-0.187	(0)	
AlF3	1.048e-11	1.048e-11	-10.980	-10.980	0.000	(0)	
AlSO4+	1.328e-12	1.189e-12	-11.877	-11.925	-0.048	(0)	
Al+3	2.412e-13	8.848e-14	-12.618	-13.053	-0.436	(0)	
AlF4-	7.812e-14	6.995e-14	-13.107	-13.155	-0.048	(0)	
Al(SO4)2-	2.463e-14	2.206e-14	-13.608	-13.656	-0.048	(0)	
AlMo6O21-3	0.000e+00	0.000e+00	-48.018	-48.520	-0.501	(0)	
As(3)	1.024e-17						
H3AsO3	1.000e-17	1.000e-17	-17.000	-17.000	0.000	(0)	
H2AsO3-	2.322e-19	2.043e-19	-18.634	-18.690	-0.056	(0)	
HAsO3-2	1.239e-23	7.417e-24	-22.907	-23.130	-0.223	(0)	
H4AsO3+	1.416e-25	1.245e-25	-24.849	-24.905	-0.056	(0)	
AsO3-3	3.611e-29	1.138e-29	-28.442	-28.944	-0.501	(0)	
As(5)	3.873e-07						
HAsO4-2	3.350e-07	2.005e-07	-6.475	-6.698	-0.223	(0)	
H2AsO4-	5.222e-08	4.594e-08	-7.282	-7.338	-0.056	(0)	
AsO4-3	8.009e-11	2.524e-11	-10.096	-10.598	-0.501	(0)	
H3AsO4	2.000e-13	2.005e-13	-12.699	-12.698	0.001	(0)	
Ba	1.457e-07						
Ba+2	1.453e-07	9.304e-08	-6.838	-7.031	-0.194	(0)	
BaHCO3+	3.699e-10	3.328e-10	-9.432	-9.478	-0.046	(0)	
BaCO3	3.336e-11	3.336e-11	-10.477	-10.477	0.000	(0)	
BaOH+	1.815e-13	1.628e-13	-12.741	-12.788	-0.047	(0)	
C(4)	4.552e-04						
HCO3-	4.171e-04	3.746e-04	-3.380	-3.426	-0.047	(0)	
H2CO3	2.116e-05	2.116e-05	-4.674	-4.674	0.000	(0)	
CaHCO3+	1.200e-05	1.080e-05	-4.921	-4.967	-0.046	(0)	
CaCO3	1.715e-06	1.715e-06	-5.766	-5.766	0.000	(0)	
MgHCO3+	1.687e-06	1.508e-06	-5.773	-5.822	-0.049	(0)	
CO3-2	1.092e-06	6.991e-07	-5.962	-6.155	-0.194	(0)	
MgCO3	2.288e-07	2.288e-07	-6.641	-6.641	0.000	(0)	
CuCO3	1.600e-07	1.600e-07	-6.796	-6.796	0.000	(0)	
MnHCO3+	9.921e-09	8.899e-09	-8.003	-8.051	-0.047	(0)	
NaHCO3	8.124e-09	8.124e-09	-8.090	-8.090	0.000	(0)	
UO2(CO3)2-2	3.482e-09	2.084e-09	-8.458	-8.681	-0.223	(0)	
CuHCO3+	1.044e-09	9.187e-10	-8.981	-9.037	-0.056	(0)	
UO2(CO3)3-4	5.687e-10	7.303e-11	-9.245	-10.136	-0.891	(0)	
NaCO3-	5.590e-10	5.020e-10	-9.253	-9.299	-0.047	(0)	
CoHCO3+	5.432e-10	4.778e-10	-9.265	-9.321	-0.056	(0)	
Cu(CO3)2-2	5.030e-10	3.011e-10	-9.298	-9.521	-0.223	(0)	
NiHCO3+	4.493e-10	3.952e-10	-9.347	-9.403	-0.056	(0)	
BaHCO3+	3.699e-10	3.328e-10	-9.432	-9.478	-0.046	(0)	
NiCO3	2.232e-10	2.232e-10	-9.651	-9.651	0.000	(0)	
CoCO3	1.938e-10	1.938e-10	-9.713	-9.713	0.000	(0)	
UO2CO3	1.494e-10	1.494e-10	-9.826	-9.826	0.000	(0)	
FeHCO3+	1.083e-10	9.748e-11	-9.965	-10.011	-0.046	(0)	
BaCO3	3.336e-11	3.336e-11	-10.477	-10.477	0.000	(0)	
Ca	3.046e-03						
Ca+2	2.418e-03	1.548e-03	-2.617	-2.810	-0.194	(0)	
CaSO4	6.140e-04	6.140e-04	-3.212	-3.212	0.000	(0)	
CaHCO3+	1.200e-05	1.080e-05	-4.921	-4.967	-0.046	(0)	
CaCO3	1.715e-06	1.715e-06	-5.766	-5.766	0.000	(0)	
CaF+	2.509e-07	2.251e-07	-6.600	-6.648	-0.047	(0)	
CaOH+	1.376e-08	1.238e-08	-7.861	-7.907	-0.046	(0)	
Co(2)	3.395e-08						
Co+2	2.739e-08	1.640e-08	-7.562	-7.785	-0.223	(0)	
CoSO4	5.664e-09	5.664e-09	-8.247	-8.247	0.000	(0)	
CoHCO3+	5.432e-10	4.778e-10	-9.265	-9.321	-0.056	(0)	
CoCO3	1.938e-10	1.938e-10	-9.713	-9.713	0.000	(0)	
CoOH+	1.491e-10	1.311e-10	-9.827	-9.882	-0.056	(0)	
CoF+	7.852e-12	6.907e-12	-11.105	-11.161	-0.056	(0)	
Co(OH)2	4.175e-12	4.175e-12	-11.379	-11.379	0.000	(0)	
Co(OH)3-	3.796e-17	3.339e-17	-16.421	-16.476	-0.056	(0)	
CoOOH-	9.525e-18	8.379e-18	-17.021	-17.077	-0.056	(0)	
Co2OH+3	3.419e-19	1.078e-19	-18.466	-18.968	-0.501	(0)	
Co(OH)4-2	3.543e-24	2.121e-24	-23.451	-23.673	-0.223	(0)	
Co4(OH)4+4	4.595e-31	5.900e-32	-30.338	-31.229	-0.891	(0)	
Co(3)	2.221e-30						
CoOH+2	2.221e-30	1.330e-30	-29.653	-29.876	-0.223	(0)	
Co+3	1.780e-36	6.528e-37	-35.750	-36.185	-0.436	(0)	
Cu(1)	2.164e-09						
Cu+	2.164e-09	1.904e-09	-8.665	-8.720	-0.056	(0)	
Cu(2)	2.970e-07						
CuCO3	1.600e-07	1.600e-07	-6.796	-6.796	0.000	(0)	
Cu+2	6.070e-08	3.887e-08	-7.217	-7.410	-0.194	(0)	
CuOH+	5.512e-08	4.927e-08	-7.259	-7.307	-0.049	(0)	
CuSO4	1.542e-08	1.542e-08	-7.812	-7.812	0.000	(0)	
Cu(OH)2	3.940e-09	3.940e-09	-8.404	-8.404	0.000	(0)	
CuHCO3+	1.044e-09	9.187e-10	-8.981	-9.037	-0.056	(0)	
Cu(CO3)2-2	5.030e-10	3.011e-10	-9.298	-9.521	-0.223	(0)	
Cu2(OH)2+2	1.019e-10	6.097e-11	-9.992	-10.215	-0.223	(0)	
CuF+	3.714e-11	3.267e-11	-10.430	-10.486	-0.056	(0)	
Cu(OH)3-	3.683e-12	3.239e-12	-11.434	-11.490	-0.056	(0)	
Cu(OH)4-2	1.707e-17	1.022e-17	-16.768	-16.991	-0.223	(0)	
F	1.580e-05						
F-	1.489e-05	1.332e-05	-4.827	-4.876	-0.048	(0)	
MgF+	6.566e-07	5.879e-07	-6.183	-6.231	-0.048	(0)	
CaF+	2.509e-07	2.251e-07	-6.600	-6.648	-0.047	(0)	
MnF+	7.039e-10	6.314e-10	-9.152	-9.200	-0.047	(0)	
HF	4.949e-10	4.949e-10	-9.306	-9.306	0.000	(0)	
NaF	3.241e-10	3.241e-10	-9.489	-9.489	0.000	(0)	
AlF2+	6.958e-11	6.249e-11	-10.158	-10.204	-0.047	(0)	
CuF+	3.714e-11	3.267e-11	-10.430	-10.486	-0.056	(0)	
AlF+2	1.811e-11	1.178e-11	-10.742	-10.929	-0.187	(0)	
AlF3	1.048e-11	1.048e-11	-10.980	-10.980	0.000	(0)	
CoF+	7.852e-12	6.907e-12	-11.105	-11.161	-0.056	(0)	
NiF+	3.255e-12	2.863e-12	-11.487	-11.543	-0.056	(0)	
UO2F+	1.122e-13	9.871e-14	-12.950	-13.006	-0.056	(0)	
AlF4-	7.812e-14	6.995e-14	-13.107	-13.155	-0.048	(0)	
HF2-	2.808e-14	2.506e-14	-13.552	-13.601	-0.049	(0)	
UO2F2	3.792e-15	3.792e-15	-14.421	-14.421	0.000	(0)	
FeF+2	4.333e-16	2.804e-16	-15.363	-15.552	-0.189	(0)	
FeF2+	1.114e-16	9.996e-17	-15.953	-16.000	-0.047	(0)	
UO2F3-	1.442e-17	1.269e-17	-16.841	-16.897	-0.056	(0)	
FeF3	1.879e-18	1.879e-18	-17.726	-17.726	0.000	(0)	
H2F2	6.561e-19	6.561e-19	-18.183	-18.183	0.000	(0)	
UO2F4-2	2.242e-21	1.342e-21	-20.649	-20.872	-0.223	(0)	
UF3+	3.760e-36	3.307e-36	-35.425	-35.481	-0.056	(0)	
UF2+2	2.617e-36	1.567e-36	-35.582	-35.805	-0.223	(0)	
UF+3	2.964e-38	9.342e-39	-37.528	-38.030	-0.501	(0)	
UF4	4.830e-39	4.830e-39	-38.316	-38.316	0.000	(0)	
UF5-	0.000e+00	0.000e+00	-41.538	-41.594	-0.056	(0)	
UF6-2	0.000e+00	0.000e+00	-43.766	-43.989	-0.223	(0)	
Fe(2)	4.379e-08						
Fe+2	3.453e-08	2.067e-08	-7.462	-7.685	-0.223	(0)	
FeSO4	8.785e-09	8.785e-09	-8.056	-8.056	0.000	(0)	
FeOH+	3.677e-10	3.298e-10	-9.434	-9.482	-0.047	(0)	
FeHCO3+	1.083e-10	9.748e-11	-9.965	-10.011	-0.046	(0)	
Fe(OH)2	1.050e-13	1.050e-13	-12.979	-12.979	0.000	(0)	
Fe(OH)3-	1.484e-14	1.331e-14	-13.829	-13.876	-0.047	(0)	
Fe(3)	1.210e-06						
Fe(OH)2+	8.628e-07	7.749e-07	-6.064	-6.111	-0.047	(0)	
Fe(OH)3	3.336e-07	3.336e-07	-6.477	-6.477	0.000	(0)	
Fe(OH)4-	1.386e-08	1.245e-08	-7.858	-7.905	-0.047	(0)	
FeOH+2	7.678e-12	4.969e-12	-11.115	-11.304	-0.189	(0)	
FeF+2	4.333e-16	2.804e-16	-15.363	-15.552	-0.189	(0)	
FeSO4+	4.159e-16	3.730e-16	-15.381	-15.428	-0.047	(0)	
FeF2+	1.114e-16	9.996e-17	-15.953	-16.000	-0.047	(0)	
Fe+3	5.236e-17	1.920e-17	-16.281	-16.717	-0.436	(0)	
Fe(SO4)2-	1.570e-17	1.381e-17	-16.804	-16.860	-0.056	(0)	
FeF3	1.879e-18	1.879e-18	-17.726	-17.726	0.000	(0)	
Fe2(OH)2+4	6.368e-21	8.178e-22	-20.196	-21.087	-0.891	(0)	
Fe3(OH)4+5	2.263e-25	9.160e-27	-24.645	-26.038	-1.393	(0)	
H(0)	8.909e-27						
H2	4.455e-27	4.467e-27	-26.351	-26.350	0.001	(0)	
K	4.094e-04						
K+	4.045e-04	3.618e-04	-3.393	-3.441	-0.048	(0)	
KSO4-	4.938e-06	4.435e-06	-5.306	-5.353	-0.047	(0)	
Mg	7.410e-04						
Mg+2	6.144e-04	3.934e-04	-3.212	-3.405	-0.194	(0)	
MgSO4	1.239e-04	1.239e-04	-3.907	-3.907	0.000	(0)	
MgHCO3+	1.687e-06	1.508e-06	-5.773	-5.822	-0.049	(0)	
MgF+	6.566e-07	5.879e-07	-6.183	-6.231	-0.048	(0)	
MgCO3	2.288e-07	2.288e-07	-6.641	-6.641	0.000	(0)	
MgOH+	6.966e-08	6.278e-08	-7.157	-7.202	-0.045	(0)	
Mn(2)	2.368e-06						
Mn+2	1.989e-06	1.191e-06	-5.701	-5.924	-0.223	(0)	
MnSO4	3.666e-07	3.666e-07	-6.436	-6.436	0.000	(0)	
MnHCO3+	9.921e-09	8.899e-09	-8.003	-8.051	-0.047	(0)	
MnOH+	1.337e-09	1.199e-09	-8.874	-8.921	-0.047	(0)	
MnF+	7.039e-10	6.314e-10	-9.152	-9.200	-0.047	(0)	
Mn(OH)3-	1.327e-18	1.190e-18	-17.877	-17.924	-0.047	(0)	
Mn(OH)4-2	2.380e-24	1.540e-24	-23.623	-23.812	-0.189	(0)	
Mn(3)	1.450e-27						
Mn+3	1.450e-27	5.318e-28	-26.839	-27.274	-0.436	(0)	
Mn(6)	0.000e+00						
MnO4-2	0.000e+00	0.000e+00	-47.357	-47.546	-0.189	(0)	
Mn(7)	0.000e+00						
MnO4-	0.000e+00	0.000e+00	-52.868	-52.918	-0.050	(0)	
Mo	5.214e-08						
MoO4-2	5.212e-08	3.338e-08	-7.283	-7.477	-0.194	(0)	
HMoO4-	1.896e-11	1.668e-11	-10.722	-10.778	-0.056	(0)	
H2MoO4	3.069e-15	3.069e-15	-14.513	-14.513	0.000	(0)	
AlMo6O21-3	0.000e+00	0.000e+00	-48.018	-48.520	-0.501	(0)	
Mo7O24-6	0.000e+00	0.000e+00	-58.140	-60.146	-2.006	(0)	
HMo7O24-5	0.000e+00	0.000e+00	-59.966	-61.359	-1.393	(0)	
H2Mo7O24-4	0.000e+00	0.000e+00	-63.285	-64.177	-0.891	(0)	
H3Mo7O24-3	0.000e+00	0.000e+00	-68.029	-68.531	-0.501	(0)	
Na	4.352e-05						
Na+	4.311e-05	3.857e-05	-4.365	-4.414	-0.048	(0)	
NaSO4-	3.992e-07	3.586e-07	-6.399	-6.445	-0.047	(0)	
NaHCO3	8.124e-09	8.124e-09	-8.090	-8.090	0.000	(0)	
NaCO3-	5.590e-10	5.020e-10	-9.253	-9.299	-0.047	(0)	
NaF	3.241e-10	3.241e-10	-9.489	-9.489	0.000	(0)	
Ni	1.705e-08						
Ni+2	1.336e-08	8.558e-09	-7.874	-8.068	-0.194	(0)	
NiSO4	2.956e-09	2.956e-09	-8.529	-8.529	0.000	(0)	
NiHCO3+	4.493e-10	3.952e-10	-9.347	-9.403	-0.056	(0)	
NiCO3	2.232e-10	2.232e-10	-9.651	-9.651	0.000	(0)	
NiOH+	4.909e-11	4.318e-11	-10.309	-10.365	-0.056	(0)	
NiF+	3.255e-12	2.863e-12	-11.487	-11.543	-0.056	(0)	
Ni(OH)2	1.375e-12	1.375e-12	-11.862	-11.862	0.000	(0)	
Ni(SO4)2-2	2.831e-13	1.695e-13	-12.548	-12.771	-0.223	(0)	
Ni(OH)3-	6.265e-16	5.511e-16	-15.203	-15.259	-0.056	(0)	
O(0)	5.066e-40						
O2	2.533e-40	2.540e-40	-39.596	-39.595	0.001	(0)	
S(6)	3.447e-03						
SO4-2	2.704e-03	1.731e-03	-2.568	-2.762	-0.194	(0)	
CaSO4	6.140e-04	6.140e-04	-3.212	-3.212	0.000	(0)	
MgSO4	1.239e-04	1.239e-04	-3.907	-3.907	0.000	(0)	
KSO4-	4.938e-06	4.435e-06	-5.306	-5.353	-0.047	(0)	
NaSO4-	3.992e-07	3.586e-07	-6.399	-6.445	-0.047	(0)	
MnSO4	3.666e-07	3.666e-07	-6.436	-6.436	0.000	(0)	
CuSO4	1.542e-08	1.542e-08	-7.812	-7.812	0.000	(0)	
FeSO4	8.785e-09	8.785e-09	-8.056	-8.056	0.000	(0)	
CoSO4	5.664e-09	5.664e-09	-8.247	-8.247	0.000	(0)	
HSO4-	4.746e-09	4.250e-09	-8.324	-8.372	-0.048	(0)	
NiSO4	2.956e-09	2.956e-09	-8.529	-8.529	0.000	(0)	
AlSO4+	1.328e-12	1.189e-12	-11.877	-11.925	-0.048	(0)	
Ni(SO4)2-2	2.831e-13	1.695e-13	-12.548	-12.771	-0.223	(0)	
UO2SO4	1.407e-13	1.407e-13	-12.852	-12.852	0.000	(0)	
Al(SO4)2-	2.463e-14	2.206e-14	-13.608	-13.656	-0.048	(0)	
UO2(SO4)2-2	5.363e-15	3.210e-15	-14.271	-14.493	-0.223	(0)	
FeSO4+	4.159e-16	3.730e-16	-15.381	-15.428	-0.047	(0)	
Fe(SO4)2-	1.570e-17	1.381e-17	-16.804	-16.860	-0.056	(0)	
U(SO4)2	3.332e-38	3.332e-38	-37.477	-37.477	0.000	(0)	
USO4+2	4.047e-39	2.423e-39	-38.393	-38.616	-0.223	(0)	
U(3)	0.000e+00						
U+3	0.000e+00	0.000e+00	-54.749	-55.250	-0.501	(0)	
U(4)	3.033e-18						
U(OH)5-	3.030e-18	2.665e-18	-17.519	-17.574	-0.056	(0)	
U(OH)4	2.804e-21	2.804e-21	-20.552	-20.552	0.000	(0)	
U(OH)3+	2.928e-25	2.575e-25	-24.533	-24.589	-0.056	(0)	
U(OH)2+2	4.997e-30	2.991e-30	-29.301	-29.524	-0.223	(0)	
UOH+3	1.123e-35	3.539e-36	-34.950	-35.451	-0.501	(0)	
UF3+	3.760e-36	3.307e-36	-35.425	-35.481	-0.056	(0)	
UF2+2	2.617e-36	1.567e-36	-35.582	-35.805	-0.223	(0)	
U(SO4)2	3.332e-38	3.332e-38	-37.477	-37.477	0.000	(0)	
UF+3	2.964e-38	9.342e-39	-37.528	-38.030	-0.501	(0)	
UF4	4.830e-39	4.830e-39	-38.316	-38.316	0.000	(0)	
USO4+2	4.047e-39	2.423e-39	-38.393	-38.616	-0.223	(0)	
UF5-	0.000e+00	0.000e+00	-41.538	-41.594	-0.056	(0)	

```
   U+4             0.000e+00   0.000e+00   -41.563   -42.454    -0.891     (0)
   UF6-2           0.000e+00   0.000e+00   -43.766   -43.989    -0.223     (0)
   U6(OH)15+9      0.000e+00   0.000e+00  -153.367  -157.880    -4.513     (0)
U(5)          3.720e-15
   UO2+            3.720e-15   3.272e-15   -14.429   -14.485    -0.056     (0)
U(6)          4.203e-09
   UO2(CO3)2-2     3.482e-09   2.084e-09    -8.458    -8.681    -0.223     (0)
   UO2(CO3)3-4     5.687e-10   7.303e-11    -9.245   -10.136    -0.891     (0)
   UO2CO3          1.494e-10   1.494e-10    -9.826    -9.826     0.000     (0)
   UO2OH+          3.080e-12   2.709e-12   -11.511   -11.567    -0.056     (0)
   UO2SO4          1.407e-13   1.407e-13   -12.852   -12.852     0.000     (0)
   UO2F+           1.122e-13   9.871e-14   -12.950   -13.006    -0.056     (0)
   UO2+2           8.384e-14   5.369e-14   -13.077   -13.270    -0.194     (0)
   UO2(SO4)2-2     5.363e-15   3.210e-15   -14.271   -14.493    -0.223     (0)
   UO2F2           3.792e-15   3.792e-15   -14.421   -14.421     0.000     (0)
   (UO2)2(OH)2+2   2.034e-17   1.218e-17   -16.692   -16.914    -0.223     (0)
   UO2F3-          1.442e-17   1.269e-17   -16.841   -16.897    -0.056     (0)
   (UO2)3(OH)5+    4.571e-18   4.021e-18   -17.340   -17.396    -0.056     (0)
   UO2F4-2         2.242e-21   1.342e-21   -20.649   -20.872    -0.223     (0)

-----------------------------Saturation indices-------------------------------

  Phase               SI** log IAP   log K(298 K,   1 atm)

  Al(OH)3(am)      -1.05      9.75   10.80  Al(OH)3
  Al2(MoO4)3      -50.90    -48.54    2.37  Al2(MoO4)3
  Al2O3            -0.16     19.49   19.65  Al2O3
  Al4(OH)10SO4     -1.67     21.03   22.70  Al4(OH)10SO4
  AlAsO4:2H2O      -7.75     -2.95    4.80  AlAsO4:2H2O
  AlOHSO4          -4.98     -8.21   -3.23  AlOHSO4
  Alunite          -1.12     -2.52   -1.40  KAl3(SO4)2(OH)6
  Anhydrite        -1.21     -5.57   -4.36  CaSO4
  Antlerite        -3.38      5.41    8.79  Cu3(OH)4SO4
  Aragonite        -0.67     -8.97   -8.30  CaCO3
  Arsenolite      -65.24    -68.00   -2.76  As4O6
  Artinite         -7.37      2.23    9.60  MgCO3:Mg(OH)2:3H2O
  As2O5           -32.10    -25.40    6.71  As2O5
  Azurite          -2.44    -19.34  -16.91  Cu3(OH)2(CO3)2
  Ba(OH)2:8H2O    -16.23      8.17   24.39  Ba(OH)2:8H2O
  Ba3(AsO4)2        8.02     -0.89   -8.91  Ba3(AsO4)2
  BaF2            -10.96    -16.78   -5.82  BaF2
  BaMoO4           -7.55    -14.51   -6.96  BaMoO4
  Barite            0.19     -9.79   -9.98  BaSO4
  Birnessite      -10.97      7.13   18.09  MnO2
  Bixbyite         -8.30     -8.95   -0.64  Mn2O3
  Boehmite          1.17      9.75    8.58  AlOOH
  Brochantite      -2.03     13.20   15.22  Cu4(OH)6SO4
  Brucite          -5.05     11.79   16.84  Mg(OH)2
  Bunsenite        -5.31      7.13   12.45  NiO
  Ca3(AsO4)2:4H2O -10.53     11.77   22.30  Ca3(AsO4)2:4H2O
  Calcite          -0.49     -8.97   -8.48  CaCO3
  CaMoO4           -2.34    -10.29   -7.95  CaMoO4
  CH4(g)           -73.11   -114.16  -41.05  CH4
  Chalcanthite     -7.53     -10.17   -2.64  CuSO4:5H2O
  Claudetite       -64.93    -68.00   -3.06  As4O6
  Co(OH)2          -5.68      7.41    13.09  Co(OH)2
  Co(OH)3          -11.08    -13.39   -2.31  Co(OH)3
  CO2(g)           -3.21     -21.36  -18.15  CO2
  Co3(AsO4)2       -16.19     -3.15    13.03  Co3(AsO4)2
  Co3O4            -8.86     -19.36  -10.50  Co3O4
  CoCO3            -3.96     -13.94   -9.98  CoCO3
  CoF2             -15.94    -17.54   -1.60  CoF2
  CoF3             -49.35    -50.81   -1.46  CoF3
  CoFe2O4           23.11     19.58   -3.53  CoFe2O4
  CoMoO4           -7.50     -15.26   -7.76  CoMoO4
  CoO              -6.17       7.41   13.59  CoO
  CoSO4           -13.35     -10.55    2.80  CoSO4
  CoSO4:6H2O       -8.07     -10.55   -2.47  CoSO4:6H2O
  Cryolite        -21.71     -55.55  -33.84  Na3AlF6
  Cu(OH)2          -0.88       7.79    8.67  Cu(OH)2
  Cu2SO4          -18.25     -20.20   -1.95  Cu2SO4
  Cu3(AsO4)2:2H2O  -8.13      -2.03    6.10  Cu3(AsO4)2:2H2O
  CuCO3            -2.07     -13.57  -11.50  CuCO3
  CuF              -8.69     -13.60   -4.91  CuF
  CuF2            -18.28     -17.16    1.12  CuF2
  CuF2:2H2O       -12.61     -17.16   -4.55  CuF2:2H2O
  Cumetal          -3.96     -12.72   -8.76  Cu
  CuMoO4           -1.81     -14.89  -13.08  CuMoO4
  CuOCuSO4        -12.69      -2.38   10.30  CuOCuSO4
  Cupricferrite    13.97      19.96    5.99  CuFe2O4
  Cuprite          -0.83      -2.24   -1.41  Cu2O
  Cuprousferrite   13.88       4.96   -8.92  CuFeO2
  CuSO4           -13.11     -10.17    2.94  CuSO4
  Diaspore          2.87       9.75    6.87  AlOOH
  Dolomite(disordered)  -1.99    -18.53  -16.54  CaMg(CO3)2
  Dolomite(ordered)  -1.44    -18.53  -17.09  CaMg(CO3)2
  Epsomite         -4.04      -6.17   -2.13  MgSO4:7H2O
  Fe(OH)2          -6.05       7.52   13.56  Fe(OH)2
  Fe2(SO4)3       -37.98     -41.72   -3.73  Fe2(SO4)3
  Fe3(OH)8         -0.54      19.68   20.22  Fe3(OH)8
  FeAsO4:2H2O      -7.01      -6.61    0.40  FeAsO4:2H2O
  FeMoO4           -5.07     -15.16  -10.09  FeMoO4
  Ferrihydrite      2.89       6.08    3.19  Fe(OH)3
  Fluorite         -2.06     -12.56  -10.50  CaF2
  Gibbsite          1.46       9.75    8.29  Al(OH)3
  Goethite          5.59       6.08    0.49  FeOOH
  Gummite          -5.74       1.93    7.67  UO3
  Gypsum           -0.96      -5.57   -4.61  CaSO4:2H2O
  H-Jarosite       -5.57     -17.67  -12.10  (H3O)Fe3(SO4)2(OH)6
  H2MoO4           -9.80     -22.68  -12.88  H2MoO4
  Hausmannite     -10.00      51.03   61.03  Mn3O4
  Hematite         13.58      12.17   -1.42  Fe2O3
  Hercynite         4.12      27.01   22.89  FeAl2O4
  Huntite          -7.68     -37.65  -29.97  CaMg3(CO3)4
  Hydromagnesite  -17.68     -26.45   -8.77  Mg5(CO3)4(OH)2:4H2O
  K-Alum          -16.85     -22.02   -5.17  KAl(SO4)2:12H2O
  K-Jarosite        1.28     -13.52  -14.80  KFe3(SO4)2(OH)6
  K2MoO4          -17.62     -14.36    3.26  K2MoO4
  Langite          -4.29      13.20   17.49  Cu4(OH)6SO4:H2O
  Lepidocrocite     4.71       6.08    1.37  FeOOH
  Lime            -20.31      12.39   32.70  CaO
  Maghemite         5.78      12.17    6.39  Fe2O3
  Magnesioferrite   7.10      23.96   16.86  Fe2MgO4
  Magnesite        -2.10      -9.56   -7.46  MgCO3
  Magnetite        16.28      19.68    3.40  Fe3O4
  Malachite        -0.47      -5.78   -5.31  Cu2(OH)2CO3
  Manganite        -4.46      20.88   25.34  MnOOH
  Melanterite      -8.24     -10.45   -2.21  FeSO4:7H2O
  Mg(OH)2(active)  -7.00      11.79   18.79  Mg(OH)2
  MgF2             -5.03     -13.16   -8.13  MgF2
  MgMoO4           -9.03     -10.88   -1.85  MgMoO4
  Mirabilite      -10.48     -11.59   -1.11  Na2SO4:10H2O
  Mn2(SO4)3       -57.12     -62.83   -5.71  Mn2(SO4)3
  Mn3(AsO4)2:8H2O -10.07       2.43   12.50  Mn3(AsO4)2:8H2O
  MnSO4           -11.27      -8.69    2.58  MnSO4
  MoO3            -14.68     -22.68   -8.00  MoO3
  Morenosite       -8.68     -10.83   -2.14  NiSO4:7H2O
  Na-Jarosite      -3.29     -14.49  -11.20  NaFe3(SO4)2(OH)6
  Na2Mo2O7        -22.38     -38.98  -16.60  Na2Mo2O7
  Na2MoO4         -17.79     -16.30    1.49  Na2MoO4
  Na2MoO4:2H2O    -17.53     -16.30    1.22  Na2MoO4:2H2O
  Natron          -13.67     -14.98   -1.31  Na2CO3:10H2O
  Nesquehonite     -4.89      -9.56   -4.67  MgCO3:3H2O
  Ni(OH)2          -5.66       7.13   12.79  Ni(OH)2
  Ni3(AsO4)2:8H2O -19.70      -4.00   15.70  Ni3(AsO4)2:8H2O
  Ni4(OH)6SO4     -21.43      10.57   32.00  Ni4(OH)6SO4
  NiCO3            -7.35     -14.22   -6.87  NiCO3
  NiMoO4           -4.40     -15.54  -11.14  NiMoO4
  Nsutite         -10.38       7.13   17.50  MnO2
  O2(g)           -36.69      46.40   83.09  O2
  Periclase        -9.79      11.79   21.58  MgO
  Portlandite     -10.41      12.39   22.80  Ca(OH)2
  Pyrochroite      -5.92       9.28   15.19  Mn(OH)2
  Pyrolusite       -8.90      32.48   41.38  MnO2
  Retgersite       -8.79     -10.83   -2.04  NiSO4:6H2O
  Rhodochrosite    -1.50     -12.08  -10.58  MnCO3
  Rutherfordine    -4.93     -19.43  -14.50  UO2CO3
  Schoepite        -4.06       1.93    5.99  UO2(OH)2:H2O
  Siderite         -3.60     -13.84  -10.24  FeCO3
  Spinel           -5.56      31.29   36.85  MgAl2O4
  Tenorite          0.15       7.79    7.64  CuO
  Thenardite      -11.91     -11.59    0.32  Na2SO4
  Thermonatrite   -15.62     -14.98    0.64  Na2CO3:H2O
  U3O8            -10.85      10.24   21.08  U3O8
  U4O9            -22.00     -25.02   -3.02  U4O9
  UF4             -32.42     -61.96  -29.54  UF4
  UF4:2.5H2O      -29.24     -61.96  -32.72  UF4:2.5H2O
  UO2(am)         -12.99     -12.05    0.93  UO2
  UO2(OH)2(beta)   -3.68       1.93    5.61  UO2(OH)2
  UO3              -5.77       1.93    7.70  UO3
  Uraninite        -7.38     -12.05   -4.67  UO2
  Witherite        -4.62     -13.19   -8.57  BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
  For ideal gases, phi = 1.

Initial solution 4.     Make-up Material

-----------------------------Solution composition-----------------------------

      Elements           Molality       Moles

      Al                 7.415e-07   7.415e-07
      Alkalinity         3.607e-04   3.607e-04
      Ba                 1.457e-07   1.457e-07
      Ca                 1.672e-03   1.672e-03
      Co                 1.188e-07   1.188e-07
      Cu                 4.408e-07   4.408e-07
      F                  1.580e-05   1.580e-05
      K                  3.326e-04   3.326e-04
      Mg                 3.293e-04   3.293e-04
      Mn                 7.283e-07   7.283e-07
      Mo                 3.128e-08   3.128e-08
      Na                 4.351e-05   4.351e-05
      Ni                 6.818e-08   6.818e-08
      S(6)               2.051e-03   2.051e-03

----------------------------Description of solution----------------------------

                                    pH  =   7.700
                                    pe  =   4.000
                           Activity of water  =   1.000
                  Ionic strength (mol/kgw)  =   7.199e-03
                       Mass of water (kg)  =   1.000e+00
                   Total carbon (mol/kg)  =   3.686e-04
                      Total CO2 (mol/kg)  =   3.686e-04
                         Temperature (°C)  =  25.00
                 Electrical balance (eq)  =  -9.478e-05

 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -1.25
                                 Iterations  =  12 (46 overall)
                                    Total H  = 1.110140e+02
                                    Total O  = 5.551615e+01

----------------------------Distribution of species----------------------------

                                                  Log       Log       Log    mole V
   Species          Molality    Activity  Molality  Activity     Gamma    cm³/mol

   OH-             5.526e-07   5.046e-07    -6.258    -6.297    -0.039     (0)
   H+              2.182e-08   1.995e-08    -7.661    -7.700    -0.039      0.00
   H2O             5.551e+01   9.999e-01     1.744    -0.000     0.000     18.07
Al            7.415e-07
   Al(OH)4-        7.298e-07   6.680e-07    -6.137    -6.175    -0.038     (0)
   Al(OH)3         1.051e-08   1.051e-08    -7.978    -7.978     0.000     (0)
   Al(OH)2+        1.139e-09   1.044e-09    -8.944    -8.981    -0.038     (0)
   AlF2+           4.383e-12   4.020e-12   -11.358   -11.396    -0.038     (0)
   AlOH+2          3.684e-12   2.605e-12   -11.434   -11.584    -0.150     (0)
   AlF+2           1.021e-12   7.220e-13   -11.991   -12.141    -0.150     (0)
   AlF3            7.077e-13   7.077e-13   -12.150   -12.150     0.000     (0)
   AlSO4+          5.310e-14   4.860e-14   -13.275   -13.313    -0.038     (0)
   Al+3            1.153e-14   5.163e-15   -13.938   -14.287    -0.349     (0)
   AlF4-           5.420e-15   4.960e-15   -14.266   -14.304    -0.038     (0)
   Al(SO4)2-       6.899e-16   6.315e-16   -15.161   -15.200    -0.038     (0)
   AlMo6O21-3      0.000e+00   0.000e+00   -51.065   -51.455    -0.389     (0)
Ba            1.457e-07
   Ba+2            1.453e-07   1.017e-07    -6.838    -6.993    -0.155     (0)
   BaHCO3+         3.344e-10   3.070e-10    -9.476    -9.513    -0.037     (0)
   BaCO3           3.874e-11   3.874e-11   -10.412   -10.412     0.000     (0)
   BaOH+           2.444e-13   2.239e-13   -12.612   -12.650    -0.038     (0)
C(4)          3.686e-04
   HCO3-           3.449e-04   3.163e-04    -3.462    -3.500    -0.038     (0)
   H2CO3           1.419e-05   1.419e-05    -4.848    -4.848     0.000     (0)
   CaHCO3+         6.254e-06   5.742e-06    -5.204    -5.241    -0.037     (0)
   CaCO3           1.148e-06   1.148e-06    -5.940    -5.940     0.000     (0)
   CO3-2           1.062e-06   7.431e-07    -5.974    -6.129    -0.155     (0)
   MgHCO3+         7.037e-07   6.434e-07    -6.153    -6.192    -0.039     (0)
   CuCO3           2.384e-07   2.384e-07    -6.623    -6.623     0.000     (0)
   MgCO3           1.229e-07   1.229e-07    -6.911    -6.911     0.000     (0)
   NaHCO3          7.030e-09   7.030e-09    -8.153    -8.153     0.000     (0)
   MnHCO3+         2.926e-09   2.681e-09    -8.534    -8.572    -0.038     (0)
   CoHCO3+         1.811e-09   1.639e-09    -8.742    -8.785    -0.043     (0)
   NiHCO3+         1.678e-09   1.519e-09    -8.775    -8.818    -0.043     (0)
   CuHCO3+         1.201e-09   1.087e-09    -8.920    -8.964    -0.043     (0)
   NiCO3           1.080e-09   1.080e-09    -8.967    -8.967     0.000     (0)
   CoCO3           8.369e-10   8.369e-10    -9.077    -9.077     0.000     (0)
   Cu(CO3)2-2      7.104e-10   4.768e-10    -9.149    -9.322    -0.173     (0)
   NaCO3-          5.965e-10   5.470e-10    -9.224    -9.262    -0.038     (0)
   BaHCO3+         3.344e-10   3.070e-10    -9.476    -9.513    -0.037     (0)
   BaCO3           3.874e-11   3.874e-11   -10.412   -10.412     0.000     (0)
Ca            1.672e-03
   Ca+2            1.394e-03   9.751e-04    -2.856    -3.011    -0.155     (0)
   CaSO4           2.709e-04   2.709e-04    -3.567    -3.567     0.000     (0)
   CaHCO3+         6.254e-06   5.742e-06    -5.204    -5.241    -0.037     (0)
   CaCO3           1.148e-06   1.148e-06    -5.940    -5.940     0.000     (0)
   CaF+            1.624e-07   1.488e-07    -6.789    -6.827    -0.038     (0)
   CaOH+           1.069e-08   9.818e-09    -7.971    -8.008    -0.037     (0)
Co(2)         1.188e-07
   Co+2            9.925e-08   6.662e-08    -7.003    -7.176    -0.173     (0)
   CoSO4           1.612e-08   1.612e-08    -7.793    -7.793     0.000     (0)
   CoHCO3+         1.811e-09   1.639e-09    -8.742    -8.785    -0.043     (0)
   CoCO3           8.369e-10   8.369e-10    -9.077    -9.077     0.000     (0)
   CoOH+           7.411e-10   6.708e-10    -9.130    -9.173    -0.043     (0)
   CoF+            3.255e-11   2.946e-11   -10.487   -10.531    -0.043     (0)
   Co(OH)2         2.689e-11   2.689e-11   -10.570   -10.570     0.000     (0)
```

Co(OH)3-	2.991e-16	2.707e-16	-15.524	-15.567	-0.043	(0)
CoOOH-	7.505e-17	6.793e-17	-16.125	-16.168	-0.043	(0)
Co2OH+3	5.491e-18	2.240e-18	-17.260	-17.650	-0.389	(0)
Co(OH)4-2	3.225e-23	2.165e-23	-22.491	-22.665	-0.173	(0)
Co4(OH)4+4	1.990e-28	4.040e-29	-27.701	-28.394	-0.692	(0)
Co(3)	1.013e-29					
CoOH+2	1.013e-29	6.801e-30	-28.994	-29.167	-0.173	(0)
Co+3	5.925e-36	2.652e-36	-35.227	-35.576	-0.349	(0)
Cu(1)	2.948e-09					
Cu+	2.948e-09	2.668e-09	-8.530	-8.574	-0.043	(0)
Cu(2)	4.378e-07					
CuCO3	2.384e-07	2.384e-07	-6.623	-6.623	0.000	(0)
CuOH+	9.510e-08	8.694e-08	-7.022	-7.061	-0.039	(0)
Cu+2	7.788e-08	5.448e-08	-7.109	-7.264	-0.155	(0)
CuSO4	1.514e-08	1.514e-08	-7.820	-7.820	0.000	(0)
Cu(OH)2	8.754e-09	8.754e-09	-8.058	-8.058	0.000	(0)
CuHCO3+	1.201e-09	1.087e-09	-8.920	-8.964	-0.043	(0)
Cu(CO3)2-2	7.104e-10	4.768e-10	-9.149	-9.322	-0.173	(0)
Cu2(OH)2+2	2.829e-10	1.899e-10	-9.548	-9.722	-0.173	(0)
CuF+	5.311e-11	4.808e-11	-10.275	-10.318	-0.043	(0)
Cu(OH)3-	1.001e-11	9.061e-12	-11.000	-11.043	-0.043	(0)
Cu(OH)4-2	5.361e-17	3.599e-17	-16.271	-16.444	-0.173	(0)
F	1.580e-05					
F-	1.529e-05	1.398e-05	-4.816	-4.854	-0.039	(0)
MgF+	3.408e-07	3.119e-07	-6.467	-6.506	-0.038	(0)
CaF+	1.624e-07	1.488e-07	-6.789	-6.827	-0.038	(0)
HF	4.127e-10	4.127e-10	-9.384	-9.384	0.000	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
MnF+	2.582e-10	2.365e-10	-9.588	-9.626	-0.038	(0)
CuF+	5.311e-11	4.808e-11	-10.275	-10.318	-0.043	(0)
CoF+	3.255e-11	2.946e-11	-10.487	-10.531	-0.043	(0)
NiF+	1.512e-11	1.369e-11	-10.820	-10.864	-0.043	(0)
AlF2+	4.383e-12	4.020e-12	-11.358	-11.396	-0.038	(0)
AlF+2	1.021e-12	7.220e-13	-11.991	-12.141	-0.150	(0)
AlF3	7.077e-13	7.077e-13	-12.150	-12.150	0.000	(0)
HF2-	2.403e-14	2.194e-14	-13.619	-13.659	-0.039	(0)
AlF4-	5.420e-15	4.960e-15	-14.266	-14.304	-0.038	(0)
H2F2	4.564e-19	4.564e-19	-18.341	-18.341	0.000	(0)
H(0)	5.627e-27					
H2	2.814e-27	2.818e-27	-26.551	-26.550	0.001	(0)
K	3.326e-04					
K+	3.298e-04	3.016e-04	-3.482	-3.521	-0.039	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
Mg	3.293e-04					
Mg+2	2.842e-04	1.988e-04	-3.546	-3.702	-0.155	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
MgHCO3+	7.037e-07	6.434e-07	-6.153	-6.192	-0.039	(0)
MgF+	3.408e-07	3.119e-07	-6.467	-6.506	-0.038	(0)
MgCO3	1.229e-07	1.229e-07	-6.911	-6.911	0.000	(0)
MgOH+	4.345e-08	3.994e-08	-7.362	-7.399	-0.037	(0)
Mn(2)	7.283e-07					
Mn+2	6.329e-07	4.249e-07	-6.199	-6.372	-0.173	(0)
MnSO4	9.162e-08	9.162e-08	-7.038	-7.038	0.000	(0)
MnHCO3+	2.926e-09	2.681e-09	-8.534	-8.572	-0.038	(0)
MnOH+	5.878e-10	5.385e-10	-9.231	-9.269	-0.038	(0)
MnF+	2.582e-10	2.365e-10	-9.588	-9.626	-0.038	(0)
Mn(OH)3-	9.250e-19	8.475e-19	-18.034	-18.072	-0.038	(0)
Mn(OH)4-2	1.959e-24	1.381e-24	-23.708	-23.860	-0.152	(0)
Mn(3)	4.240e-28					
Mn+3	4.240e-28	1.898e-28	-27.373	-27.722	-0.349	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-47.042	-47.194	-0.152	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-52.526	-52.566	-0.040	(0)
Mo	3.128e-08					
MoO4-2	3.127e-08	2.188e-08	-7.505	-7.660	-0.155	(0)
HMoO4-	9.595e-12	8.685e-12	-11.018	-11.061	-0.043	(0)
H2MoO4	1.269e-15	1.269e-15	-14.896	-14.896	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-51.065	-51.455	-0.389	(0)
Mo7O24-6	0.000e+00	0.000e+00	-60.672	-62.230	-1.558	(0)
HMo7O24-5	0.000e+00	0.000e+00	-62.461	-63.543	-1.082	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-65.769	-66.461	-0.692	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-70.526	-70.915	-0.389	(0)
Na	4.351e-05					
Na+	4.322e-05	3.953e-05	-4.364	-4.403	-0.039	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
NaHCO3	7.030e-09	7.030e-09	-8.153	-8.153	0.000	(0)
NaCO3-	5.965e-10	5.470e-10	-9.224	-9.262	-0.038	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
Ni	6.818e-08					
Ni+2	5.569e-08	3.896e-08	-7.254	-7.409	-0.155	(0)
NiSO4	9.427e-09	9.427e-09	-8.026	-8.026	0.000	(0)
NiHCO3+	1.678e-09	1.519e-09	-8.775	-8.818	-0.043	(0)
NiCO3	1.080e-09	1.080e-09	-8.967	-8.967	0.000	(0)
NiOH+	2.734e-10	2.475e-10	-9.563	-9.606	-0.043	(0)
NiF+	1.512e-11	1.369e-11	-10.820	-10.864	-0.043	(0)
Ni(OH)2	9.921e-12	9.921e-12	-11.003	-11.003	0.000	(0)
Ni(SO4)2-2	5.639e-13	3.785e-13	-12.249	-12.422	-0.173	(0)
Ni(OH)3-	5.531e-15	5.006e-15	-14.257	-14.300	-0.043	(0)
O(0)	1.274e-39					
O2	6.370e-40	6.381e-40	-39.196	-39.195	0.001	(0)
S(6)	2.051e-03					
SO4-2	1.733e-03	1.213e-03	-2.761	-2.916	-0.155	(0)
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
MnSO4	9.162e-08	9.162e-08	-7.038	-7.038	0.000	(0)
CoSO4	1.612e-08	1.612e-08	-7.793	-7.793	0.000	(0)
CuSO4	1.514e-08	1.514e-08	-7.820	-7.820	0.000	(0)
NiSO4	9.427e-09	9.427e-09	-8.026	-8.026	0.000	(0)
HSO4-	2.583e-09	2.364e-09	-8.588	-8.626	-0.038	(0)
Ni(SO4)2-2	5.639e-13	3.785e-13	-12.249	-12.422	-0.173	(0)
AlSO4+	5.310e-14	4.860e-14	-13.275	-13.313	-0.038	(0)
Al(SO4)2-	6.899e-16	6.315e-16	-15.161	-15.200	-0.038	(0)

-------------------------------Saturation indices--------------------------------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.99	8.81	10.80	Al(OH)3
Al2(MoO4)3	-53.92	-51.55	2.37	Al2(MoO4)3
Al2O3	-2.03	17.63	19.65	Al2O3
Al4(OH)10SO4	-5.77	16.93	22.70	Al4(OH)10SO4
AlOHSO4	-6.27	-9.50	-3.23	AlOHSO4
Alunite	-4.61	-6.01	-1.40	KAl3(SO4)2(OH)6
Anhydrite	-1.57	-5.93	-4.36	CaSO4
Antlerite	-2.70	6.09	8.79	Cu3(OH)4SO4
Aragonite	-0.84	-9.14	-8.30	CaCO3
Artinite	-7.73	1.87	9.60	MgCO3:Mg(OH)2:3H2O
Azurite	-1.74	-18.65	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-15.99	8.41	24.39	Ba(OH)2:8H2O
BaF2	-10.88	-16.70	-5.82	BaF2
BaMoO4	-7.69	-14.65	-6.96	BaMoO4
Barite	0.07	-9.91	-9.98	BaSO4
Birnessite	-11.01	7.08	18.09	MnO2
Bixbyite	-8.60	-9.24	-0.64	Mn2O3
Boehmite	0.23	8.81	8.58	AlOOH
Brochantite	-0.99	14.23	15.22	Cu4(OH)6SO4
Brucite	-5.15	11.70	16.84	Mg(OH)2
Bunsenite	-4.45	7.99	12.45	NiO
Calcite	-0.66	-9.14	-8.48	CaCO3
CaMoO4	-2.72	-10.67	-7.95	CaMoO4
CH4(g)	-74.08	-115.13	-41.05	CH4
Chalcanthite	-7.54	-10.18	-2.64	CuSO4:5H2O
Co(OH)2	-4.87	8.22	13.09	Co(OH)2
Co(OH)3	-10.17	-12.48	-2.31	Co(OH)3
CO2(g)	-3.38	-21.53	-18.15	CO2
Co3O4	-6.23	-16.73	-10.50	Co3O4
CoCO3	-3.33	-13.31	-9.98	CoCO3
CoF2	-15.29	-16.89	-1.60	CoF2
CoF3	-48.68	-50.14	-1.46	CoF3
CoMoO4	-7.08	-14.84	-7.76	CoMoO4
CoO	-5.36	8.22	13.59	CoO
CoSO4	-12.90	-10.09	2.80	CoSO4
CoSO4:6H2O	-7.62	-10.09	-2.47	CoSO4:6H2O
Cryolite	-22.78	-56.62	-33.84	Na3AlF6
Cu(OH)2	-0.54	8.14	8.67	Cu(OH)2
Cu2SO4	-18.11	-20.06	-1.95	Cu2SO4
CuCO3	-1.89	-13.39	-11.50	CuCO3
CuF	-8.52	-13.43	-4.91	CuF
CuF2	-18.09	-16.97	1.12	CuF2
CuF2:2H2O	-12.42	-16.97	-4.55	CuF2:2H2O
Cumetal	-3.82	-12.57	-8.76	Cu
CuMoO4	-1.85	-14.92	-13.08	CuMoO4
CuOCuSO4	-12.35	-2.04	10.30	CuOCuSO4
Cuprite	-0.34	-1.75	-1.41	Cu2O
CuSO4	-13.12	-10.18	2.94	CuSO4
Diaspore	1.94	8.81	6.87	AlOOH
Dolomite(disordered)	-2.43	-18.97	-16.54	CaMg(CO3)2
Dolomite(ordered)	-1.88	-18.97	-17.09	CaMg(CO3)2
Epsomite	-4.49	-6.62	-2.13	MgSO4:7H2O
Fluorite	-2.22	-12.72	-10.50	CaF2
Gibbsite	0.52	8.81	8.29	Al(OH)3
Gypsum	-1.32	-5.93	-4.61	CaSO4:2H2O
H2MoO4	-10.18	-23.06	-12.88	H2MoO4
Hausmannite	-10.55	50.48	61.03	Mn3O4
Huntite	-8.66	-38.63	-29.97	CaMg3(CO3)4
Hydromagnesite	-18.86	-27.62	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-18.47	-23.64	-5.17	KAl(SO4)2:12H2O
K2MoO4	-17.96	-14.70	3.26	K2MoO4
Langite	-3.26	14.23	17.49	Cu4(OH)6SO4:H2O
Lime	-20.31	12.39	32.70	CaO
Magnesite	-2.37	-9.83	-7.46	MgCO3
Malachite	0.05	-5.26	-5.31	Cu2(OH)2CO3
Manganite	-4.61	20.73	25.34	MnOOH
Mg(OH)2(active)	-7.10	11.70	18.79	Mg(OH)2
MgF2	-5.28	-13.41	-8.13	MgF2
MgMoO4	-9.51	-11.36	-1.85	MgMoO4
Mirabilite	-10.61	-11.72	-1.11	Na2SO4:10H2O
Mn2(SO4)3	-58.48	-64.19	-5.71	Mn2(SO4)3
MnSO4	-11.87	-9.29	2.58	MnSO4
MoO3	-15.06	-23.06	-8.00	MoO3
Morenosite	-8.18	-10.33	-2.14	NiSO4:7H2O
Na2Mo2O7	-22.93	-39.53	-16.60	Na2Mo2O7
Na2MoO4	-17.96	-16.47	1.49	Na2MoO4
Na2MoO4:2H2O	-17.69	-16.47	1.22	Na2MoO4:2H2O
Natron	-13.62	-14.94	-1.31	Na2CO3:10H2O
Nesquehonite	-5.16	-9.83	-4.67	MgCO3:3H2O
Ni(OH)2	-4.80	7.99	12.79	Ni(OH)2
Ni4(OH)6SO4	-18.35	13.65	32.00	Ni4(OH)6SO4
NiCO3	-6.67	-13.54	-6.87	NiCO3
NiMoO4	-3.93	-15.07	-11.14	NiMoO4
Nsutite	-10.43	7.08	17.50	MnO2
O2(g)	-36.29	46.80	83.09	O2
Periclase	-9.89	11.70	21.58	MgO
Portlandite	-10.42	12.39	22.80	Ca(OH)2
Pyrochroite	-6.17	9.03	15.19	Mn(OH)2
Pyrolusite	-8.95	32.43	41.38	MnO2
Retgersite	-8.29	-10.33	-2.04	NiSO4:6H2O
Rhodochrosite	-1.92	-12.50	-10.58	MnCO3
Spinel	-7.52	29.32	36.85	MgAl2O4
Tenorite	0.49	8.14	7.64	CuO
Thenardite	-12.04	-11.72	0.32	Na2SO4
Thermonatrite	-15.57	-14.94	0.64	Na2CO3:H2O
Witherite	-4.55	-13.12	-8.57	BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Beginning of batch-reaction calculations.

Reaction step 1.

Using mix 1. Mix within UG Works

Mixture 1. Mix within UG Works

3.420e-01	Solution 1 UG Water P05
1.050e-01	Solution 2 PAF Material
3.800e-01	Solution 3 NAF Material
1.730e-01	Solution 4 Make-up Material

-----------------------------Solution composition-------------------------------

Elements	Molality	Moles
Al	3.180e-06	3.180e-06
As	1.590e-07	1.590e-07
B	4.060e-06	4.060e-06
Ba	5.439e-07	5.439e-07
C	2.962e-03	2.962e-03
Ca	2.383e-03	2.383e-03
Cd	2.132e-08	2.132e-08
Cl	4.877e-04	4.877e-04
Co	6.801e-08	6.801e-08
Cr	5.004e-08	5.004e-08
Cu	6.015e-07	6.015e-07
F	2.747e-05	2.747e-05
Fe	1.566e-06	1.566e-06
K	5.694e-04	5.694e-04
Mg	9.788e-04	9.788e-04
Mn	1.614e-06	1.614e-06
Mo	5.599e-08	5.599e-08
Na	2.773e-03	2.773e-03
Ni	5.751e-08	5.751e-08
Pb	7.188e-08	7.188e-08
S	2.471e-03	2.471e-03
Se	3.729e-08	3.729e-08
U	1.267e-08	1.267e-08
V	1.680e-08	1.680e-08
Zn	9.927e-07	9.927e-07

----------------------------Description of solution-----------------------------

pH	=	8.070	Charge balance
pe	=	3.331	Adjusted to redox equilibrium
Activity of water	=	1.000	
Ionic strength (mol/kgw)	=	1.292e-02	
Mass of water (kg)	=	1.000e+00	
Total alkalinity (eq/kg)	=	2.986e-03	
Total CO2 (mol/kg)	=	2.962e-03	

Temperature (°C) = 25.00
Electrical balance (eq) = 1.641e-03
Percent error, 100*(Cat-|An|)/(Cat+|An|) = 10.08
Iterations = 12
Total H = 1.110166e+02
Total O = 5.552563e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
OH-	1.331e-06	1.183e-06	-5.876	-5.927	-0.051	(0)
H+	9.554e-09	8.513e-09	-8.020	-8.070	-0.050	0.00
H2O	5.551e+01	9.998e-01	1.744	-0.000	0.000	18.07
Al	**3.180e-06**					
Al(OH)4-	3.160e-06	2.819e-06	-5.500	-5.550	-0.050	(0)
Al(OH)3	1.894e-08	1.894e-08	-7.723	-7.723	0.000	(0)
Al(OH)2+	8.968e-10	8.025e-10	-9.047	-9.096	-0.048	(0)
AlF2+	1.670e-12	1.495e-12	-11.777	-11.825	-0.048	(0)
AlOH+2	1.332e-12	8.544e-13	-11.875	-12.068	-0.193	(0)
AlF3	4.290e-13	4.290e-13	-12.368	-12.368	0.000	(0)
AlF+2	2.569e-13	1.647e-13	-12.590	-12.783	-0.193	(0)
AlSO4+	7.841e-15	6.994e-15	-14.106	-14.155	-0.050	(0)
AlF4-	5.495e-15	4.902e-15	-14.260	-14.310	-0.050	(0)
Al+3	2.040e-15	7.225e-16	-14.690	-15.141	-0.451	(0)
Al(SO4)2-	1.048e-16	9.347e-17	-15.980	-16.029	-0.050	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-52.760	-53.281	-0.522	(0)
As(3)	**1.360e-18**					
H3AsO3	1.272e-18	1.272e-18	-17.895	-17.895	0.000	(0)
H2AsO3-	8.758e-20	7.664e-20	-19.058	-19.116	-0.058	(0)
HAsO3-2	1.400e-23	8.210e-24	-22.854	-23.086	-0.232	(0)
H4AsO3+	6.132e-27	5.366e-27	-26.212	-26.270	-0.058	(0)
AsO3-3	1.236e-28	3.717e-29	-27.908	-28.430	-0.522	(0)
As(5)	**1.590e-07**					
HAsO4-2	1.511e-07	8.857e-08	-6.821	-7.053	-0.232	(0)
H2AsO4-	7.859e-09	6.877e-09	-8.105	-8.163	-0.058	(0)
AsO4-3	1.094e-10	3.290e-11	-9.961	-10.483	-0.522	(0)
H3AsO4	1.014e-14	1.017e-14	-13.994	-13.992	0.001	(0)
B	**4.060e-06**					
H3BO3	3.744e-06	3.755e-06	-5.427	-5.425	0.001	(0)
H2BO3-	2.894e-07	2.562e-07	-6.538	-6.591	-0.053	(0)
CaH2BO3+	2.040e-08	1.805e-08	-7.690	-7.743	-0.053	(0)
MgH2BO3+	5.292e-09	4.683e-09	-8.276	-8.329	-0.053	(0)
NaH2BO3	9.952e-10	9.952e-10	-9.002	-9.002	0.000	(0)
BF(OH)3-	3.859e-11	3.416e-11	-10.413	-10.466	-0.053	(0)
BaH2BO3+	3.004e-12	2.658e-12	-11.522	-11.575	-0.053	(0)
H5(BO3)2-	9.251e-13	8.188e-13	-12.034	-12.087	-0.053	(0)
BF2(OH)2-	8.009e-16	7.089e-16	-15.096	-15.149	-0.053	(0)
H8(BO3)3-	3.474e-16	3.075e-16	-15.459	-15.512	-0.053	(0)
BF3OH-	6.049e-23	5.354e-23	-22.218	-22.271	-0.053	(0)
BF4-	5.777e-29	5.113e-29	-28.238	-28.291	-0.053	(0)
Ba	**5.439e-07**					
Ba+2	5.326e-07	3.358e-07	-6.274	-6.474	-0.200	(0)
BaHCO3+	8.885e-09	7.967e-09	-8.051	-8.099	-0.047	(0)
BaCO3	2.356e-09	2.356e-09	-8.628	-8.628	0.000	(0)
BaH2BO3+	3.004e-12	2.658e-12	-11.522	-11.575	-0.053	(0)
BaOH+	1.940e-12	1.733e-12	-11.712	-11.761	-0.049	(0)
C(4)	**2.962e-03**					
HCO3-	2.776e-03	2.484e-03	-2.557	-2.605	-0.048	(0)
CaHCO3+	6.319e-05	5.666e-05	-4.199	-4.247	-0.047	(0)
H2CO3	4.757e-05	4.757e-05	-4.323	-4.323	0.000	(0)
CaCO3	2.656e-05	2.656e-05	-4.576	-4.576	0.000	(0)
CO3-2	2.170e-05	1.368e-05	-4.664	-4.864	-0.200	(0)
MgHCO3+	1.506e-05	1.340e-05	-4.822	-4.873	-0.050	(0)
MgCO3	6.000e-06	6.000e-06	-5.222	-5.222	0.000	(0)
NaHCO3	3.424e-06	3.424e-06	-5.465	-5.465	0.000	(0)
NaCO3-	6.978e-07	6.244e-07	-6.156	-6.205	-0.048	(0)
CuCO3	5.201e-07	5.201e-07	-6.284	-6.284	0.000	(0)
ZnCO3	2.693e-07	2.693e-07	-6.570	-6.570	0.000	(0)
PbCO3	5.714e-08	5.714e-08	-7.243	-7.243	0.000	(0)
MnHCO3+	4.505e-08	4.026e-08	-7.346	-7.395	-0.049	(0)
Cu(CO3)2-2	3.267e-08	1.915e-08	-7.486	-7.718	-0.232	(0)
ZnHCO3+	3.071e-08	2.688e-08	-7.513	-7.571	-0.058	(0)
NiCO3	1.081e-08	1.081e-08	-7.966	-7.966	0.000	(0)
UO2(CO3)3-4	9.789e-09	1.157e-09	-8.009	-8.937	-0.928	(0)
BaHCO3+	8.885e-09	7.967e-09	-8.051	-8.099	-0.047	(0)
NiHCO3+	7.413e-09	6.487e-09	-8.130	-8.188	-0.058	(0)
CoCO3	6.450e-09	6.450e-09	-8.190	-8.190	0.000	(0)
CoHCO3+	6.160e-09	5.390e-09	-8.210	-8.268	-0.058	(0)
Pb(CO3)2-2	3.845e-09	2.254e-09	-8.415	-8.647	-0.232	(0)
PbHCO3+	2.931e-09	2.565e-09	-8.533	-8.591	-0.058	(0)
CdCO3	2.927e-09	2.927e-09	-8.534	-8.534	0.000	(0)
UO2(CO3)2-2	2.877e-09	1.687e-09	-8.541	-8.773	-0.232	(0)
BaCO3	2.356e-09	2.356e-09	-8.628	-8.628	0.000	(0)
CuHCO3+	1.157e-09	1.012e-09	-8.937	-8.995	-0.058	(0)
FeHCO3+	3.038e-10	2.724e-10	-9.517	-9.565	-0.047	(0)
CdHCO3+	6.068e-11	5.309e-11	-10.217	-10.275	-0.058	(0)
Cd(CO3)2-2	5.063e-11	2.969e-11	-10.296	-10.527	-0.232	(0)
UO2CO3	6.179e-12	6.179e-12	-11.209	-11.209	0.000	(0)
Ca	**2.383e-03**					
Ca+2	1.942e-03	1.225e-03	-2.712	-2.912	-0.200	(0)
CaSO4	3.499e-04	3.499e-04	-3.456	-3.456	0.000	(0)
CaHCO3+	6.319e-05	5.666e-05	-4.199	-4.247	-0.047	(0)
CaCO3	2.656e-05	2.656e-05	-4.576	-4.576	0.000	(0)
CaF+	3.410e-07	3.047e-07	-6.467	-6.516	-0.049	(0)
CaOH+	3.223e-08	2.890e-08	-7.492	-7.539	-0.047	(0)
CaH2BO3+	2.040e-08	1.805e-08	-7.690	-7.743	-0.053	(0)
Cd	**2.132e-08**					
Cd+2	1.489e-08	9.387e-09	-7.827	-8.027	-0.200	(0)
CdCO3	2.927e-09	2.927e-09	-8.534	-8.534	0.000	(0)
CdSO4	2.744e-09	2.744e-09	-8.562	-8.562	0.000	(0)
CdCl+	4.452e-10	3.895e-10	-9.351	-9.409	-0.058	(0)
CdOH+	1.008e-10	8.817e-11	-9.997	-10.055	-0.058	(0)
Cd(SO4)2-2	7.874e-11	4.617e-11	-10.104	-10.336	-0.232	(0)
CdHCO3+	6.068e-11	5.309e-11	-10.217	-10.275	-0.058	(0)
Cd(CO3)2-2	5.063e-11	2.969e-11	-10.296	-10.527	-0.232	(0)
CdOHCl	1.890e-11	1.890e-11	-10.724	-10.724	0.000	(0)
CdF+	3.876e-12	3.392e-12	-11.412	-11.470	-0.058	(0)
CdCl2	7.057e-13	7.057e-13	-12.151	-12.151	0.000	(0)
Cd(OH)2	6.579e-13	6.579e-13	-12.182	-12.182	0.000	(0)
CdCl3-	2.211e-16	1.935e-16	-15.655	-15.713	-0.058	(0)
CdF2	1.543e-16	1.543e-16	-15.812	-15.812	0.000	(0)
Cd(OH)3-	5.431e-17	4.753e-17	-16.265	-16.323	-0.058	(0)
Cd2OH+3	1.379e-17	4.148e-18	-16.860	-17.382	-0.522	(0)
Cd(SeO3)2-2	1.066e-18	6.247e-19	-17.972	-18.204	-0.232	(0)
CdSeO4	1.228e-19	1.228e-19	-18.911	-18.911	0.000	(0)
Cd(OH)4-2	1.569e-23	9.199e-24	-22.804	-23.036	-0.232	(0)
CdHS+	0.000e+00	0.000e+00	-68.479	-68.537	-0.058	(0)
Cd(HS)2	0.000e+00	0.000e+00	-129.851	-129.851	0.000	(0)
Cd(HS)3-	0.000e+00	0.000e+00	-196.411	-196.469	-0.058	(0)
Cd(HS)4-2	0.000e+00	0.000e+00	-262.559	-262.791	-0.232	(0)
Cl	**4.877e-04**					
Cl-	4.877e-04	4.346e-04	-3.312	-3.362	-0.050	(0)
CuCl	8.079e-10	8.079e-10	-9.093	-9.093	0.000	(0)
ZnOHCl	5.781e-10	5.781e-10	-9.238	-9.238	0.000	(0)
MnCl+	4.972e-10	4.443e-10	-9.303	-9.352	-0.049	(0)
CdCl+	4.452e-10	3.895e-10	-9.351	-9.409	-0.058	(0)
ZnCl+	4.194e-10	3.734e-10	-9.377	-9.428	-0.050	(0)
CuCl2-	8.239e-11	7.335e-11	-10.084	-10.135	-0.050	(0)
CoCl+	4.792e-11	4.193e-11	-10.320	-10.377	-0.058	(0)
NiCl+	2.691e-11	2.355e-11	-10.570	-10.628	-0.058	(0)
PbCl+	2.448e-11	2.142e-11	-10.611	-10.669	-0.058	(0)
CdOHCl	1.890e-11	1.890e-11	-10.724	-10.724	0.000	(0)
CuCl+	4.994e-12	4.447e-12	-11.302	-11.352	-0.050	(0)
CdCl2	7.057e-13	7.057e-13	-12.151	-12.151	0.000	(0)
MnCl2	2.727e-13	2.727e-13	-12.564	-12.564	0.000	(0)
ZnCl2	2.572e-13	2.572e-13	-12.590	-12.590	0.000	(0)
PbCl2	4.158e-14	4.158e-14	-13.381	-13.381	0.000	(0)
CuCl3-2	1.069e-14	6.815e-15	-13.971	-14.167	-0.195	(0)
CuCl2	6.700e-16	6.700e-16	-15.174	-15.174	0.000	(0)
CdCl3-	2.211e-16	1.935e-16	-15.655	-15.713	-0.058	(0)
ZnCl3-	9.970e-17	8.877e-17	-16.001	-16.052	-0.050	(0)
NiCl2	5.152e-17	5.152e-17	-16.288	-16.288	0.000	(0)
MnCl3-	3.653e-17	3.264e-17	-16.437	-16.486	-0.049	(0)
PbCl3-	8.221e-18	7.193e-18	-17.085	-17.143	-0.058	(0)
CrCl+2	7.801e-18	4.573e-18	-17.108	-17.340	-0.232	(0)
UO2Cl+	9.138e-20	7.996e-20	-19.039	-19.097	-0.058	(0)
CrOHCl2	4.467e-20	4.467e-20	-19.350	-19.350	0.000	(0)
FeCl+2	3.565e-20	2.273e-20	-19.448	-19.643	-0.195	(0)
ZnCl4-2	3.025e-20	1.929e-20	-19.519	-19.715	-0.195	(0)
CuCl3-	3.052e-21	2.717e-21	-20.515	-20.566	-0.050	(0)
PbCl4-2	2.437e-21	1.429e-21	-20.613	-20.845	-0.232	(0)
CrCl2+	2.155e-22	1.886e-22	-21.667	-21.725	-0.058	(0)
VOCl+	5.571e-23	4.875e-23	-22.254	-22.312	-0.058	(0)
FeCl2+	4.937e-23	4.412e-23	-22.306	-22.355	-0.049	(0)
CuCl4-2	9.280e-27	5.918e-27	-26.032	-26.228	-0.195	(0)
FeCl3	1.917e-27	1.917e-27	-26.717	-26.717	0.000	(0)
CrO3Cl-	2.405e-29	2.104e-29	-28.619	-28.677	-0.058	(0)
CoCl+2	3.585e-38	2.102e-38	-37.445	-37.677	-0.232	(0)
UCl+3	0.000e+00	0.000e+00	-46.810	-47.332	-0.522	(0)
Co(2)	**6.801e-08**					
Co+2	4.757e-08	2.789e-08	-7.323	-7.555	-0.232	(0)
CoSO4	6.940e-09	6.940e-09	-8.159	-8.159	0.000	(0)
CoCO3	6.450e-09	6.450e-09	-8.190	-8.190	0.000	(0)
CoHCO3+	6.160e-09	5.390e-09	-8.210	-8.268	-0.058	(0)
CoOH+	7.521e-10	6.581e-10	-9.124	-9.182	-0.058	(0)
Co(OH)2	6.181e-11	6.181e-11	-10.209	-10.209	0.000	(0)
CoCl+	4.792e-11	4.193e-11	-10.320	-10.377	-0.058	(0)
CoF+	2.298e-11	2.011e-11	-10.639	-10.697	-0.058	(0)
Co(OH)3-	1.667e-15	1.458e-15	-14.778	-14.836	-0.058	(0)
CoOOH-	4.183e-16	3.660e-16	-15.379	-15.437	-0.058	(0)
Co2OH+3	3.058e-18	9.199e-19	-17.514	-18.036	-0.522	(0)
CoSeO4	9.818e-19	9.818e-19	-18.008	-18.008	0.000	(0)
Co(OH)4-2	4.662e-22	2.733e-22	-21.331	-21.563	-0.232	(0)
Co4(OH)4+4	3.167e-28	3.742e-29	-27.499	-28.427	-0.928	(0)
Co(3)	**2.437e-30**					
CoOH+2	2.437e-30	1.429e-30	-29.613	-29.845	-0.232	(0)
Co+3	6.711e-37	2.377e-37	-36.173	-36.624	-0.451	(0)
CoCl+2	3.585e-38	2.102e-38	-37.445	-37.677	-0.232	(0)
Cr(2)	**1.548e-24**					
Cr+2	1.548e-24	9.073e-25	-23.810	-24.042	-0.232	(0)
Cr(3)	**5.004e-08**					
Cr(OH)2+	3.459e-08	3.027e-08	-7.461	-7.519	-0.058	(0)
Cr(OH)3	1.345e-08	1.345e-08	-7.871	-7.871	0.000	(0)
CrO2-	8.574e-10	7.502e-10	-9.067	-9.125	-0.058	(0)
Cr(OH)4-	7.234e-10	6.330e-10	-9.141	-9.199	-0.058	(0)
Cr(OH)+2	3.588e-10	2.104e-10	-9.445	-9.677	-0.232	(0)
CrOHSO4	6.226e-11	6.226e-11	-10.206	-10.206	0.000	(0)
CrF+2	5.011e-14	2.938e-14	-13.300	-13.532	-0.232	(0)
CrSO4+	2.706e-14	2.368e-14	-13.568	-13.626	-0.058	(0)
Cr+3	2.704e-14	8.132e-15	-13.568	-14.090	-0.522	(0)
CrCl+2	7.801e-18	4.573e-18	-17.108	-17.340	-0.232	(0)
Cr2(OH)2SO4+2	2.019e-18	1.184e-18	-17.695	-17.927	-0.232	(0)
Cr2(OH)2(SO4)2	8.770e-20	8.770e-20	-19.057	-19.057	0.000	(0)
CrOHCl2	4.467e-20	4.467e-20	-19.350	-19.350	0.000	(0)
CrCl2+	2.155e-22	1.886e-22	-21.667	-21.725	-0.058	(0)
Cr(6)	**5.361e-17**					
CrO4-2	5.205e-17	3.282e-17	-16.284	-16.484	-0.200	(0)
HCrO4-	1.033e-18	9.041e-19	-17.986	-18.044	-0.058	(0)
NaCrO4-	4.568e-19	3.997e-19	-18.340	-18.398	-0.058	(0)
KCrO4-	7.009e-20	6.133e-20	-19.154	-19.212	-0.058	(0)
H2CrO4	6.239e-27	6.239e-27	-26.205	-26.205	0.000	(0)
CrO3SO4-2	4.988e-27	2.924e-27	-26.302	-26.534	-0.232	(0)
CrO3Cl-	2.405e-29	2.104e-29	-28.619	-28.677	-0.058	(0)
Cr2O7-2	4.835e-35	2.835e-35	-34.316	-34.547	-0.232	(0)
Cu(1)	**2.578e-09**					
Cu+	1.688e-09	1.477e-09	-8.773	-8.831	-0.058	(0)
CuCl	8.079e-10	8.079e-10	-9.093	-9.093	0.000	(0)
CuCl2-	8.239e-11	7.335e-11	-10.084	-10.135	-0.050	(0)
CuCl3-2	1.069e-14	6.815e-15	-13.971	-14.167	-0.195	(0)
Cu(S4)2-3	0.000e+00	0.000e+00	-126.056	-126.337	-0.281	(0)
CuS4S5-3	0.000e+00	0.000e+00	-126.797	-127.067	-0.270	(0)
Cu(2)	**5.989e-07**					
CuCO3	5.201e-07	5.201e-07	-6.284	-6.284	0.000	(0)
Cu(CO3)2-2	3.267e-08	1.915e-08	-7.486	-7.718	-0.232	(0)
CuOH+	2.712e-08	2.414e-08	-7.567	-7.617	-0.050	(0)
Cu+2	1.024e-08	6.456e-09	-7.990	-8.190	-0.200	(0)
Cu(OH)2	5.696e-09	5.696e-09	-8.244	-8.244	0.000	(0)
CuSO4	1.845e-09	1.845e-09	-8.734	-8.734	0.000	(0)
CuHCO3+	1.157e-09	1.012e-09	-8.937	-8.995	-0.058	(0)
Cu2(OH)2+2	2.497e-11	1.464e-11	-10.603	-10.834	-0.232	(0)
Cu(OH)3-	1.579e-11	1.382e-11	-10.802	-10.860	-0.058	(0)
CuF+	1.061e-11	9.287e-12	-10.974	-11.032	-0.058	(0)
CuCl+	4.994e-12	4.447e-12	-11.302	-11.352	-0.050	(0)
CuCl2	6.700e-16	6.700e-16	-15.174	-15.174	0.000	(0)
Cu(OH)4-2	2.193e-16	1.286e-16	-15.659	-15.891	-0.232	(0)
CuCl3-	3.052e-21	2.717e-21	-20.515	-20.566	-0.050	(0)
CuCl4-2	9.280e-27	5.918e-27	-26.032	-26.228	-0.195	(0)
Cu(HS)3-	0.000e+00	0.000e+00	-187.787	-187.845	-0.058	(0)
F	**2.747e-05**					
F-	2.558e-05	2.280e-05	-4.592	-4.642	-0.050	(0)
MgF+	1.512e-06	1.349e-06	-5.820	-5.870	-0.050	(0)
CaF+	3.410e-07	3.047e-07	-6.467	-6.516	-0.049	(0)
NaF	3.526e-08	3.526e-08	-7.453	-7.453	0.000	(0)
MnF+	8.248e-10	7.371e-10	-9.084	-9.133	-0.049	(0)
HF	2.871e-10	2.871e-10	-9.542	-9.542	0.000	(0)
ZnF+	1.778e-10	1.556e-10	-9.750	-9.808	-0.058	(0)
BF(OH)3-	3.859e-11	3.416e-11	-10.413	-10.466	-0.053	(0)
CoF+	2.298e-11	2.011e-11	-10.639	-10.697	-0.058	(0)
NiF+	1.386e-11	1.213e-11	-10.858	-10.916	-0.058	(0)
CuF+	1.061e-11	9.287e-12	-10.974	-11.032	-0.058	(0)
CdF+	3.876e-12	3.392e-12	-11.412	-11.470	-0.058	(0)
PbF+	2.551e-12	2.232e-12	-11.593	-11.651	-0.058	(0)
AlF2+	1.670e-12	1.495e-12	-11.777	-11.825	-0.048	(0)
AlF3	4.290e-13	4.290e-13	-12.368	-12.368	0.000	(0)
AlF+2	2.569e-13	1.647e-13	-12.590	-12.783	-0.193	(0)
CrF+2	5.011e-14	2.938e-14	-13.300	-13.532	-0.232	(0)
HF2-	2.800e-14	2.488e-14	-13.553	-13.604	-0.051	(0)
AlF4-	5.495e-15	4.902e-15	-14.260	-14.310	-0.050	(0)
PbF2	1.001e-15	1.001e-15	-14.999	-14.999	0.000	(0)
BF2(OH)2-	8.009e-16	7.089e-16	-15.096	-15.149	-0.053	(0)
UO2F+	4.080e-16	3.570e-16	-15.389	-15.447	-0.058	(0)
CdF2	1.543e-16	1.543e-16	-15.812	-15.812	0.000	(0)
FeF+2	6.790e-17	4.330e-17	-16.168	-16.364	-0.195	(0)
FeF2+	2.956e-17	2.641e-17	-16.529	-16.578	-0.049	(0)
UO2F2	2.347e-17	2.347e-17	-16.629	-16.629	0.000	(0)
FeF3	8.496e-19	8.496e-19	-18.071	-18.071	0.000	(0)
VO2F	5.904e-19	5.904e-19	-18.229	-18.229	0.000	(0)
H2F2	2.208e-19	2.208e-19	-18.656	-18.656	0.000	(0)
UO2F3-	1.536e-19	1.344e-19	-18.814	-18.872	-0.058	(0)
PbF3-	4.948e-20	4.330e-20	-19.306	-19.364	-0.058	(0)
VOF+	6.248e-21	5.467e-21	-20.204	-20.262	-0.058	(0)
VO2F2-	5.584e-21	4.887e-21	-20.253	-20.311	-0.058	(0)

BF3OH-	6.049e-23	5.354e-23	-22.218	-22.271	-0.053	(0)
VOF2	4.674e-23	4.674e-23	-22.330	-22.330	0.000	(0)
UO2F4-2	4.152e-23	2.434e-23	-22.382	-22.614	-0.232	(0)
VO2F3-2	2.370e-24	1.390e-24	-23.625	-23.857	-0.232	(0)
PbF4-2	8.058e-25	4.724e-25	-24.094	-24.326	-0.232	(0)
VOF3-	4.320e-26	3.780e-26	-25.364	-25.422	-0.058	(0)
BF4-	5.777e-29	5.113e-29	-28.238	-28.291	-0.053	(0)
VO2F4-3	5.182e-29	1.559e-29	-28.285	-28.807	-0.522	(0)
VOF4-2	5.933e-30	3.479e-30	-29.227	-29.459	-0.232	(0)
UF3+	1.153e-38	1.009e-38	-37.938	-37.996	-0.058	(0)
UF2+2	4.762e-39	2.792e-39	-38.322	-38.554	-0.232	(0)
UF+3	0.000e+00	0.000e+00	-40.490	-41.012	-0.522	(0)
UF4	0.000e+00	0.000e+00	-40.598	-40.598	0.000	(0)
UF5-	0.000e+00	0.000e+00	-43.585	-43.642	-0.058	(0)
UF6-2	0.000e+00	0.000e+00	-45.573	-45.805	-0.232	(0)
Fe(2)	1.828e-08					
Fe+2	1.485e-08	8.708e-09	-7.828	-8.060	-0.232	(0)
FeSO4	2.666e-09	2.666e-09	-8.574	-8.574	0.000	(0)
FeOH+	4.588e-10	4.100e-10	-9.338	-9.387	-0.049	(0)
FeHCO3+	3.038e-10	2.724e-10	-9.517	-9.565	-0.047	(0)
Fe(OH)2	3.851e-13	3.851e-13	-12.414	-12.414	0.000	(0)
Fe(OH)3-	1.611e-13	1.440e-13	-12.793	-12.842	-0.049	(0)
Fe(HS)2	0.000e+00	0.000e+00	-136.146	-136.146	0.000	(0)
Fe(HS)3-	0.000e+00	0.000e+00	-202.569	-202.627	-0.058	(0)
Fe(3)	1.548e-06					
Fe(OH)3	7.727e-07	7.727e-07	-6.112	-6.112	0.000	(0)
Fe(OH)2+	6.799e-07	6.084e-07	-6.168	-6.216	-0.048	(0)
Fe(OH)4-	9.507e-08	8.508e-08	-7.022	-7.070	-0.048	(0)
FeOH+2	2.074e-12	1.322e-12	-11.683	-11.879	-0.195	(0)
FeF+2	6.790e-17	4.330e-17	-16.168	-16.364	-0.195	(0)
FeF2+	2.956e-17	2.641e-17	-16.529	-16.578	-0.049	(0)
FeSO4+	2.712e-17	2.424e-17	-16.567	-16.616	-0.049	(0)
Fe+3	4.890e-18	1.732e-18	-17.311	-17.761	-0.451	(0)
FeF3	8.496e-19	8.496e-19	-18.071	-18.071	0.000	(0)
Fe(SO4)2-	7.385e-19	6.462e-19	-18.132	-18.190	-0.058	(0)
FeCl+2	3.565e-20	2.273e-20	-19.448	-19.643	-0.195	(0)
Fe2(OH)2+4	4.901e-22	5.791e-23	-21.310	-22.237	-0.928	(0)
FeHSeO3+2	1.500e-22	8.795e-23	-21.824	-22.056	-0.232	(0)
FeCl2+	4.937e-23	4.412e-23	-22.306	-22.355	-0.049	(0)
Fe3(OH)4+5	1.433e-26	5.093e-28	-25.844	-27.293	-1.449	(0)
FeCl3	1.917e-27	1.917e-27	-26.717	-26.717	0.000	(0)
H(0)	2.232e-26					
H2	1.116e-26	1.119e-26	-25.952	-25.951	0.001	(0)
K	5.694e-04					
K+	5.644e-04	5.030e-04	-3.248	-3.298	-0.050	(0)
KSO4-	4.962e-06	4.441e-06	-5.304	-5.353	-0.048	(0)
KCrO4-	7.009e-20	6.133e-20	-19.154	-19.212	-0.058	(0)
Mg	9.788e-04					
Mg+2	8.363e-04	5.273e-04	-3.078	-3.278	-0.200	(0)
MgSO4	1.197e-04	1.197e-04	-3.922	-3.922	0.000	(0)
MgHCO3+	1.506e-05	1.340e-05	-4.822	-4.873	-0.050	(0)
MgCO3	6.000e-06	6.000e-06	-5.222	-5.222	0.000	(0)
MgF+	1.512e-06	1.349e-06	-5.820	-5.870	-0.050	(0)
MgOH+	2.764e-07	2.482e-07	-6.558	-6.605	-0.047	(0)
MgH2BO3+	5.292e-09	4.683e-09	-8.276	-8.329	-0.053	(0)
Mn(2)	1.614e-06					
Mn+2	1.385e-06	8.121e-07	-5.858	-6.090	-0.232	(0)
MnSO4	1.801e-07	1.801e-07	-6.744	-6.744	0.000	(0)
MnHCO3+	4.505e-08	4.026e-08	-7.346	-7.395	-0.049	(0)
MnOH+	2.700e-09	2.412e-09	-8.569	-8.618	-0.049	(0)
MnF+	8.248e-10	7.371e-10	-9.084	-9.133	-0.049	(0)
MnCl+	4.972e-10	4.443e-10	-9.303	-9.352	-0.049	(0)
MnCl2	2.727e-13	2.727e-13	-12.564	-12.564	0.000	(0)
MnCl3-	3.653e-17	3.264e-17	-16.437	-16.486	-0.049	(0)
Mn(OH)3-	2.333e-17	2.085e-17	-16.632	-16.681	-0.049	(0)
MnSeO4	1.535e-17	1.535e-17	-16.814	-16.814	0.000	(0)
Mn(OH)4-2	1.248e-22	7.959e-23	-21.904	-22.099	-0.195	(0)
MnSe	2.164e-35	2.164e-35	-34.665	-34.665	0.000	(0)
Mn(3)	2.193e-28					
Mn+3	2.193e-28	7.767e-29	-27.659	-28.110	-0.451	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-46.436	-46.631	-0.195	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-52.620	-52.672	-0.052	(0)
Mo	5.599e-08					
MoO4-2	5.598e-08	3.530e-08	-7.252	-7.452	-0.200	(0)
HMoO4-	6.833e-12	5.979e-12	-11.165	-11.223	-0.058	(0)
H2MoO4	3.728e-16	3.728e-16	-15.428	-15.428	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-52.760	-53.281	-0.522	(0)
Mo7O24-6	0.000e+00	0.000e+00	-61.648	-63.735	-2.087	(0)
HMo7O24-5	0.000e+00	0.000e+00	-63.969	-65.418	-1.449	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-67.778	-68.706	-0.928	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-73.008	-73.529	-0.522	(0)
Na	2.773e-03					
Na+	2.751e-03	2.451e-03	-2.561	-2.611	-0.050	(0)
NaSO4-	1.834e-05	1.642e-05	-4.736	-4.785	-0.048	(0)
NaHCO3	3.424e-06	3.424e-06	-5.465	-5.465	0.000	(0)
NaCO3-	6.978e-07	6.244e-07	-6.156	-6.205	-0.048	(0)
NaF	3.526e-08	3.526e-08	-7.453	-7.453	0.000	(0)
NaH2BO3	9.952e-10	9.952e-10	-9.002	-9.002	0.000	(0)
NaCrO4-	4.568e-19	3.997e-19	-18.340	-18.398	-0.058	(0)
Ni	5.751e-08					
Ni+2	3.359e-08	2.118e-08	-7.474	-7.674	-0.200	(0)
NiCO3	1.081e-08	1.081e-08	-7.966	-7.966	0.000	(0)
NiHCO3+	7.413e-09	6.487e-09	-8.130	-8.188	-0.058	(0)
NiSO4	5.270e-09	5.270e-09	-8.278	-8.278	0.000	(0)
NiOH+	3.603e-10	3.153e-10	-9.443	-9.501	-0.058	(0)
Ni(OH)2	2.962e-11	2.962e-11	-10.528	-10.528	0.000	(0)
NiCl+	2.691e-11	2.355e-11	-10.570	-10.628	-0.058	(0)
NiF+	1.386e-11	1.213e-11	-10.858	-10.916	-0.058	(0)
Ni(SO4)2-2	3.712e-13	2.176e-13	-12.430	-12.662	-0.232	(0)
Ni(OH)3-	4.002e-14	3.502e-14	-13.398	-13.456	-0.058	(0)
NiCl2	5.152e-17	5.152e-17	-16.288	-16.288	0.000	(0)
NiSeO4	6.958e-19	6.958e-19	-18.158	-18.158	0.000	(0)
O(0)	0.000e+00					
O2	0.000e+00	0.000e+00	-40.394	-40.393	0.001	(0)
Pb	7.188e-08					
PbCO3	5.714e-08	5.714e-08	-7.243	-7.243	0.000	(0)
PbOH+	4.716e-09	4.127e-09	-8.326	-8.384	-0.058	(0)
Pb(CO3)2-2	3.845e-09	2.254e-09	-8.415	-8.647	-0.232	(0)
PbHCO3+	2.931e-09	2.565e-09	-8.533	-8.591	-0.058	(0)
Pb+2	2.204e-09	1.389e-09	-8.657	-8.857	-0.200	(0)
PbSO4	8.486e-10	8.486e-10	-9.071	-9.071	0.000	(0)
Pb(OH)2	1.543e-10	1.543e-10	-9.812	-9.812	0.000	(0)
PbCl+	2.448e-11	2.142e-11	-10.611	-10.669	-0.058	(0)
Pb(SO4)2-2	1.088e-11	6.377e-12	-10.963	-11.195	-0.232	(0)
PbF+	2.551e-12	2.232e-12	-11.593	-11.651	-0.058	(0)
Pb(OH)3-	2.085e-13	1.825e-13	-12.681	-12.739	-0.058	(0)
PbCl2	4.158e-14	4.158e-14	-13.381	-13.381	0.000	(0)
PbF2	1.001e-15	1.001e-15	-14.999	-14.999	0.000	(0)
Pb2OH+3	3.021e-16	9.087e-17	-15.520	-16.042	-0.522	(0)
Pb(OH)4-2	9.014e-17	5.285e-17	-16.045	-16.277	-0.232	(0)
PbCl3-	8.221e-18	7.193e-18	-17.085	-17.143	-0.058	(0)
Pb3(OH)4+2	1.126e-18	6.602e-19	-17.948	-18.180	-0.232	(0)
PbF3-	4.948e-20	4.330e-20	-19.306	-19.364	-0.058	(0)
PbCl4-2	2.437e-21	1.429e-21	-20.613	-20.845	-0.232	(0)
Pb4(OH)4+4	6.167e-23	7.286e-24	-22.210	-23.138	-0.928	(0)
PbF4-2	8.058e-25	4.724e-25	-24.094	-24.326	-0.232	(0)
Pb(HS)2	0.000e+00	0.000e+00	-130.623	-130.623	0.000	(0)
Pb(HS)3-	0.000e+00	0.000e+00	-197.783	-197.841	-0.058	(0)
S(-2)	0.000e+00					
HS-	0.000e+00	0.000e+00	-68.460	-68.518	-0.058	(0)
CdHS+	0.000e+00	0.000e+00	-68.479	-68.537	-0.058	(0)
H2S	0.000e+00	0.000e+00	-69.568	-69.568	0.000	(0)
S5-2	0.000e+00	0.000e+00	-69.581	-69.813	-0.232	(0)
S6-2	0.000e+00	0.000e+00	-70.097	-70.329	-0.232	(0)
S4-2	0.000e+00	0.000e+00	-70.177	-70.409	-0.232	(0)
S3-2	0.000e+00	0.000e+00	-70.983	-71.215	-0.232	(0)
S2-2	0.000e+00	0.000e+00	-71.999	-72.231	-0.232	(0)
S-2	0.000e+00	0.000e+00	-77.553	-77.748	-0.195	(0)
Cu(S4)2-3	0.000e+00	0.000e+00	-126.056	-126.337	-0.281	(0)
CuS4S5-3	0.000e+00	0.000e+00	-126.797	-127.067	-0.270	(0)
ZnS(HS)-	0.000e+00	0.000e+00	-128.564	-128.622	-0.058	(0)
Cd(HS)2	0.000e+00	0.000e+00	-129.851	-129.851	0.000	(0)
Pb(HS)2	0.000e+00	0.000e+00	-130.623	-130.623	0.000	(0)
Zn(HS)2	0.000e+00	0.000e+00	-130.682	-130.682	0.000	(0)
Fe(HS)2	0.000e+00	0.000e+00	-136.146	-136.146	0.000	(0)
Cu(HS)3-	0.000e+00	0.000e+00	-187.787	-187.845	-0.058	(0)
Zn(HS)3-	0.000e+00	0.000e+00	-195.862	-195.920	-0.058	(0)
Cd(HS)3-	0.000e+00	0.000e+00	-196.411	-196.469	-0.058	(0)
ZnS(HS)2-2	0.000e+00	0.000e+00	-197.598	-197.830	-0.232	(0)
Pb(HS)3-	0.000e+00	0.000e+00	-197.783	-197.841	-0.058	(0)
Fe(HS)3-	0.000e+00	0.000e+00	-202.569	-202.627	-0.058	(0)
Cd(HS)4-2	0.000e+00	0.000e+00	-262.559	-262.791	-0.232	(0)
Zn(HS)4-2	0.000e+00	0.000e+00	-265.666	-265.897	-0.232	(0)
S(6)	2.471e-03					
SO4-2	1.978e-03	1.247e-03	-2.704	-2.904	-0.200	(0)
CaSO4	3.499e-04	3.499e-04	-3.456	-3.456	0.000	(0)
MgSO4	1.197e-04	1.197e-04	-3.922	-3.922	0.000	(0)
NaSO4-	1.834e-05	1.642e-05	-4.736	-4.785	-0.048	(0)
KSO4-	4.962e-06	4.441e-06	-5.304	-5.353	-0.048	(0)
MnSO4	1.801e-07	1.801e-07	-6.744	-6.744	0.000	(0)
ZnSO4	9.333e-08	9.333e-08	-7.030	-7.030	0.000	(0)
CoSO4	6.940e-09	6.940e-09	-8.159	-8.159	0.000	(0)
NiSO4	5.270e-09	5.270e-09	-8.278	-8.278	0.000	(0)
CdSO4	2.744e-09	2.744e-09	-8.562	-8.562	0.000	(0)
FeSO4	2.666e-09	2.666e-09	-8.574	-8.574	0.000	(0)
CuSO4	1.845e-09	1.845e-09	-8.734	-8.734	0.000	(0)
Zn(SO4)2-2	1.729e-09	1.014e-09	-8.762	-8.994	-0.232	(0)
HSO4-	1.163e-09	1.038e-09	-8.934	-8.984	-0.050	(0)
PbSO4	8.486e-10	8.486e-10	-9.071	-9.071	0.000	(0)
Cd(SO4)2-2	7.874e-11	4.617e-11	-10.104	-10.336	-0.232	(0)
CrOHSO4	6.226e-11	6.226e-11	-10.206	-10.206	0.000	(0)
Pb(SO4)2-2	1.088e-11	6.377e-12	-10.963	-11.195	-0.232	(0)
Ni(SO4)2-2	3.712e-13	2.176e-13	-12.430	-12.662	-0.232	(0)
CrSO4+	2.706e-14	2.368e-14	-13.568	-13.626	-0.058	(0)
AlSO4+	7.841e-15	6.994e-15	-14.106	-14.155	-0.050	(0)
UO2SO4	2.142e-16	2.142e-16	-15.669	-15.669	0.000	(0)
Al(SO4)2-	1.048e-16	9.347e-17	-15.980	-16.029	-0.050	(0)
FeSO4+	2.712e-17	2.424e-17	-16.567	-16.616	-0.049	(0)
UO2(SO4)2-2	6.005e-18	3.521e-18	-17.221	-17.453	-0.232	(0)
Cr2(OH)2SO4+2	2.019e-18	1.184e-18	-17.695	-17.927	-0.232	(0)
Fe(SO4)2-	7.385e-19	6.462e-19	-18.132	-18.190	-0.058	(0)
VO2SO4-	5.025e-19	4.397e-19	-18.299	-18.357	-0.058	(0)
Cr2(OH)2(SO4)2	8.770e-20	8.770e-20	-19.057	-19.057	0.000	(0)
VOSO4	1.373e-20	1.373e-20	-19.862	-19.862	0.000	(0)
CrO3SO4-2	4.988e-27	2.924e-27	-26.302	-26.534	-0.232	(0)
VSO4+	4.523e-34	3.958e-34	-33.345	-33.403	-0.058	(0)
U(SO4)2	0.000e+00	0.000e+00	-40.978	-40.978	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-41.742	-41.974	-0.232	(0)
Se(-2)	6.294e-32					
HSe-	6.291e-32	5.505e-32	-31.201	-31.259	-0.058	(0)
MnSe	2.164e-35	2.164e-35	-34.665	-34.665	0.000	(0)
H2Se	3.638e-36	3.638e-36	-35.439	-35.439	0.000	(0)
Se-2	1.103e-38	6.466e-39	-37.957	-38.189	-0.232	(0)
Se(4)	3.729e-08					
HSeO3-	2.196e-08	1.922e-08	-7.658	-7.716	-0.058	(0)
SeO3-2	1.533e-08	8.986e-09	-7.815	-8.046	-0.232	(0)
H2SeO3	6.979e-14	6.979e-14	-13.156	-13.156	0.000	(0)
Cd(SeO3)2-2	1.066e-18	6.247e-19	-17.972	-18.204	-0.232	(0)
FeHSeO3+2	1.500e-22	8.795e-23	-21.824	-22.056	-0.232	(0)
Se(6)	1.114e-13					
SeO4-2	1.114e-13	7.023e-14	-12.953	-13.153	-0.200	(0)
MnSeO4	1.535e-17	1.535e-17	-16.814	-16.814	0.000	(0)
ZnSeO4	3.721e-18	3.721e-18	-17.429	-17.429	0.000	(0)
CoSeO4	9.818e-19	9.818e-19	-18.008	-18.008	0.000	(0)
NiSeO4	6.958e-19	6.958e-19	-18.158	-18.158	0.000	(0)
CdSeO4	1.228e-19	1.228e-19	-18.911	-18.911	0.000	(0)
HSeO4-	3.425e-20	2.997e-20	-19.465	-19.523	-0.058	(0)
Zn(SeO4)2-2	4.520e-31	2.650e-31	-30.345	-30.577	-0.232	(0)
U(3)	0.000e+00					
U+3	0.000e+00	0.000e+00	-57.275	-57.796	-0.522	(0)
U(4)	4.143e-19					
U(OH)5-	4.141e-19	3.624e-19	-18.383	-18.441	-0.058	(0)
U(OH)4	1.292e-22	1.292e-22	-21.889	-21.889	0.000	(0)
U(OH)3+	4.598e-27	4.023e-27	-26.337	-26.395	-0.058	(0)
U(OH)2+2	2.702e-32	1.584e-32	-31.568	-31.800	-0.232	(0)
UOH+3	2.112e-38	6.353e-39	-37.675	-38.197	-0.522	(0)
UF3+	1.153e-38	1.009e-38	-37.938	-37.996	-0.058	(0)
UF2+2	4.762e-39	2.792e-39	-38.322	-38.554	-0.232	(0)
UF+3	0.000e+00	0.000e+00	-40.490	-41.012	-0.522	(0)
UF4	0.000e+00	0.000e+00	-40.598	-40.598	0.000	(0)
U(SO4)2	0.000e+00	0.000e+00	-40.978	-40.978	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-41.742	-41.974	-0.232	(0)
UF5-	0.000e+00	0.000e+00	-43.585	-43.642	-0.058	(0)
U+4	0.000e+00	0.000e+00	-44.742	-45.670	-0.928	(0)
UF6-2	0.000e+00	0.000e+00	-45.573	-45.805	-0.232	(0)
UCl+3	0.000e+00	0.000e+00	-46.810	-47.332	-0.522	(0)
U6(OH)15+9	0.000e+00	0.000e+00	-165.431	-170.127	-4.696	(0)
U(5)	3.691e-17					
UO2+	3.691e-17	3.230e-17	-16.433	-16.491	-0.058	(0)
U(6)	1.267e-08					
UO2(CO3)3-4	9.789e-09	1.157e-09	-8.009	-8.937	-0.928	(0)
UO2(CO3)2-2	2.877e-09	1.687e-09	-8.541	-8.773	-0.232	(0)
UO2CO3	6.179e-12	6.179e-12	-11.209	-11.209	0.000	(0)
UO2OH+	1.930e-14	1.689e-14	-13.714	-13.772	-0.058	(0)
UO2F+	4.080e-16	3.570e-16	-15.389	-15.447	-0.058	(0)
UO2SO4	2.142e-16	2.142e-16	-15.669	-15.669	0.000	(0)
UO2+2	1.799e-16	1.135e-16	-15.745	-15.945	-0.200	(0)
UO2F2	2.347e-17	2.347e-17	-16.629	-16.629	0.000	(0)
UO2(SO4)2-2	6.005e-18	3.521e-18	-17.221	-17.453	-0.232	(0)
UO2F3-	1.536e-19	1.344e-19	-18.814	-18.872	-0.058	(0)
UO2Cl+	9.138e-20	7.996e-20	-19.039	-19.097	-0.058	(0)
(UO2)2(OH)2+2	8.075e-22	4.734e-22	-21.093	-21.325	-0.232	(0)
UO2F4-2	4.152e-23	2.434e-23	-22.382	-22.614	-0.232	(0)
(UO2)3(OH)5+	9.694e-24	8.482e-24	-23.014	-23.071	-0.058	(0)
V(2)	6.725e-40					
VOH+	6.725e-40	5.885e-40	-39.172	-39.230	-0.058	(0)
V+2	0.000e+00	0.000e+00	-40.581	-40.813	-0.232	(0)
V(3)	8.968e-13					
V(OH)3	8.968e-13	8.968e-13	-12.047	-12.047	0.000	(0)
V(OH)2+	5.638e-24	4.934e-24	-23.249	-23.307	-0.058	(0)
VOH+2	6.796e-28	3.985e-28	-27.168	-27.400	-0.232	(0)
V+3	2.235e-33	6.723e-34	-32.651	-33.172	-0.522	(0)
VSO4+	4.523e-34	3.958e-34	-33.345	-33.403	-0.058	(0)
V2(OH)3+3	0.000e+00	0.000e+00	-51.733	-52.255	-0.522	(0)
V2(OH)2+4	0.000e+00	0.000e+00	-53.072	-53.999	-0.928	(0)
V(4)	1.087e-17					
V(OH)3+	1.078e-17	9.433e-18	-16.967	-17.025	-0.058	(0)
VO+2	6.820e-20	3.999e-20	-19.166	-19.398	-0.232	(0)
VOSO4	1.373e-20	1.373e-20	-19.862	-19.862	0.000	(0)
VOF+	6.248e-21	5.467e-21	-20.204	-20.262	-0.058	(0)
VOCl+	5.571e-23	4.875e-23	-22.254	-22.312	-0.058	(0)
VOF2	4.674e-23	4.674e-23	-22.330	-22.330	0.000	(0)

VOF3-	4.320e-26	3.780e-26	-25.364	-25.422	-0.058 (0)
H2V2O4+2	7.609e-30	4.461e-30	-29.119	-29.351	-0.232 (0)
VOF4-2	5.933e-30	3.479e-30	-29.227	-29.459	-0.232 (0)
V(5)	1.680e-08				
H2VO4-	1.166e-08	1.021e-08	-7.933	-7.991	-0.058 (0)
HVO4-2	5.136e-09	3.011e-09	-8.289	-8.521	-0.232 (0)
H3VO4	8.689e-13	8.689e-13	-12.061	-12.061	0.000 (0)
H3V2O7-	6.545e-14	5.727e-14	-13.184	-13.242	-0.058 (0)
HV2O7-3	3.463e-14	1.042e-14	-13.461	-13.982	-0.522 (0)
VO4-3	5.894e-15	1.773e-15	-14.230	-14.751	-0.522 (0)
V2O7-4	2.787e-16	3.293e-17	-15.555	-16.482	-0.928 (0)
VO2+	1.657e-17	1.477e-17	-16.781	-16.831	-0.050 (0)
V3O9-3	3.704e-18	1.114e-18	-17.431	-17.953	-0.522 (0)
VO2F	5.904e-19	5.904e-19	-18.229	-18.229	0.000 (0)
VO2SO4-	5.025e-19	4.397e-19	-18.299	-18.357	-0.058 (0)
VO2F2-	5.584e-21	4.887e-21	-20.253	-20.311	-0.058 (0)
V4O12-4	4.012e-23	4.741e-24	-22.397	-23.324	-0.928 (0)
VO2F3-2	2.370e-24	1.390e-24	-23.625	-23.857	-0.232 (0)
VO2F4-3	5.182e-29	1.559e-29	-28.285	-28.807	-0.522 (0)
V10O28-6	0.000e+00	0.000e+00	-61.197	-63.284	-2.087 (0)
HV10O28-5	0.000e+00	0.000e+00	-61.718	-63.167	-1.449 (0)
H2V10O28-4	0.000e+00	0.000e+00	-65.102	-66.030	-0.928 (0)
Zn	9.927e-07				
Zn+2	5.426e-07	3.421e-07	-6.266	-6.466	-0.200 (0)
ZnCO3	2.693e-07	2.693e-07	-6.570	-6.570	0.000 (0)
ZnSO4	9.333e-08	9.333e-08	-7.030	-7.030	0.000 (0)
ZnOH+	4.623e-08	4.045e-08	-7.335	-7.393	-0.058 (0)
ZnHCO3+	3.071e-08	2.688e-08	-7.513	-7.571	-0.058 (0)
Zn(OH)2	7.581e-09	7.581e-09	-8.120	-8.120	0.000 (0)
Zn(SO4)2-2	1.729e-09	1.014e-09	-8.762	-8.994	-0.232 (0)
ZnOHCl	5.781e-10	5.781e-10	-9.238	-9.238	0.000 (0)
ZnCl+	4.194e-10	3.734e-10	-9.377	-9.428	-0.050 (0)
ZnF+	1.778e-10	1.556e-10	-9.750	-9.808	-0.058 (0)
Zn(OH)3-	5.135e-11	4.493e-11	-10.289	-10.347	-0.058 (0)
ZnCl2	2.572e-13	2.572e-13	-12.590	-12.590	0.000 (0)
Zn(OH)4-2	3.608e-15	2.115e-15	-14.443	-14.675	-0.232 (0)
ZnCl3-	9.970e-17	8.877e-17	-16.001	-16.052	-0.050 (0)
ZnSeO4	3.721e-18	3.721e-18	-17.429	-17.429	0.000 (0)
ZnCl4-2	3.025e-20	1.929e-20	-19.519	-19.715	-0.195 (0)
Zn(SeO4)2-2	4.520e-31	2.650e-31	-30.345	-30.577	-0.232 (0)
ZnS(HS)-	0.000e+00	0.000e+00	-128.564	-128.622	-0.058 (0)
Zn(HS)2	0.000e+00	0.000e+00	-130.682	-130.682	0.000 (0)
Zn(HS)3-	0.000e+00	0.000e+00	-195.862	-195.920	-0.058 (0)
ZnS(HS)2-2	0.000e+00	0.000e+00	-197.598	-197.830	-0.232 (0)
Zn(HS)4-2	0.000e+00	0.000e+00	-265.666	-265.897	-0.232 (0)

-------------------------------Saturation indices-------------------------------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.73	9.07	10.80	Al(OH)3
Al2(MoO4)3	-55.01	-52.64	2.37	Al2(MoO4)3
Al2O3	-1.52	18.14	19.65	Al2O3
Al4(OH)10SO4	-5.47	17.23	22.70	Al4(OH)10SO4
AlAsO4:2H2O	-9.72	-4.92	4.80	AlAsO4:2H2O
AlOHSO4	-6.75	-9.98	-3.23	AlOHSO4
Alunite	-4.71	-6.11	-1.40	KAl3(SO4)2(OH)6
Anglesite	-3.97	-11.76	-7.79	PbSO4
Anhydrite	-1.46	-5.82	-4.36	CaSO4
Anilite	-43.86	-75.74	-31.88	Cu0.25Cu1.5S
Antlerite	-3.98	4.81	8.79	Cu3(OH)4SO4
Aragonite	0.52	-7.78	-8.30	CaCO3
Arsenolite	-68.82	-71.58	-2.76	As4O6
Artinite	-4.88	4.72	9.60	MgCO3:Mg(OH)2:3H2O
As2O5	-34.69	-27.98	6.71	As2O5
Atacamite	-2.92	4.47	7.39	Cu2(OH)3Cl
Azurite	-1.25	-18.16	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-14.73	9.66	24.39	Ba(OH)2:8H2O
Ba2V2O7:2H2O	-14.06	1.81	15.87	Ba2V2O7:2H2O
Ba3(AsO4)2	9.92	1.01	-8.91	Ba3(AsO4)2
Ba3(VO4)2:4H2O	-21.46	11.48	32.94	Ba3(VO4)2:4H2O
BaCrO4	-13.29	-22.96	-9.67	BaCrO4
BaF2	-9.94	-15.76	-5.82	BaF2
BaMoO4	-6.97	-13.93	-6.96	BaMoO4
Barite	0.60	-9.38	-9.98	BaSO4
BaS	-83.10	-66.92	16.18	BaS
BaSeO3	-7.95	-6.12	1.83	BaSeO3
BaSeO4	-12.17	-19.63	-7.46	BaSeO4
Bianchite	-7.61	-9.37	-1.76	ZnSO4:6H2O
Birnessite	-10.59	7.50	18.09	MnO2
Bixbyite	-7.16	-7.80	-0.64	Mn2O3
BlaubleiI	-45.42	-69.59	-24.16	Cu0.9Cu0.2S
BlaubleiII	-45.15	-72.43	-27.28	Cu0.6Cu0.8S
Boehmite	0.49	9.07	8.58	AlOOH
Brochantite	-2.47	12.75	15.22	Cu4(OH)6SO4
Brucite	-3.98	12.86	16.84	Mg(OH)2
Bunsenite	-3.98	8.47	12.45	NiO
Ca(VO3)2	-9.95	-4.29	5.66	Ca(VO3)2
Ca2V2O7	-8.57	8.93	17.50	Ca2V2O7
Ca2V2O7:2H2O	-12.62	8.93	21.55	Ca2V2O7:2H2O
Ca3(AsO4)2:4H2O	-10.60	11.70	22.30	Ca3(AsO4)2:4H2O
Ca3(VO4)2	-16.80	22.16	38.96	Ca3(VO4)2
Ca3(VO4)2:4H2O	-17.70	22.16	39.86	Ca3(VO4)2:4H2O
CaCrO4	-17.13	-19.40	-2.27	CaCrO4
Calcite	0.70	-7.78	-8.48	CaCO3
CaMoO4	-2.41	-10.36	-7.95	CaMoO4
Carnotite	-4.02	-3.79	0.23	KUO2VO4
CaSeO3:2H2O	-5.37	-2.56	2.81	CaSeO3:2H2O
CaSeO4:2H2O	-13.05	-16.07	-3.02	CaSeO4:2H2O
Cd(BO2)2	-12.58	-2.74	9.84	Cd(BO2)2
Cd(OH)2	-5.53	8.11	13.64	Cd(OH)2
Cd(OH)2(am)	-5.62	8.11	13.73	Cd(OH)2
Cd3(OH)2(SO4)2	-20.46	-13.75	6.71	Cd3(OH)2(SO4)2
Cd3(OH)4SO4	-17.27	5.29	22.56	Cd3(OH)4SO4
Cd4(OH)6SO4	-15.00	13.40	28.40	Cd4(OH)6SO4
CdCl2	-14.09	-14.75	-0.66	CdCl2
CdCl2:1H2O	-13.06	-14.75	-1.69	CdCl2:1H2O
CdCl2:2.5H2O	-12.84	-14.75	-1.91	CdCl2:2.5H2O
CdF2	-16.10	-17.31	-1.21	CdF2
Cdmetal(alpha)	-28.20	-14.69	13.51	Cd
Cdmetal(gamma)	-28.31	-14.69	13.62	Cd
CdMoO4	-1.33	-15.48	-14.15	CdMoO4
CdOHCl	-6.86	-3.32	3.54	CdOHCl
CdSe	-11.02	-31.22	-20.20	CdSe
CdSeO4:2H2O	-19.33	-21.18	-1.85	CdSeO4:2H2O
CdSO4	-10.76	-10.93	-0.17	CdSO4
CdSO4:1H2O	-9.21	-10.93	-1.73	CdSO4:1H2O
CdSO4:2.67H2O	-9.06	-10.93	-1.87	CdSO4:2.67H2O
Cerussite	-0.59	-13.72	-13.13	PbCO3
CH4(g)	-71.16	-112.21	-41.05	CH4
Chalcanthite	-8.45	-11.09	-2.64	CuSO4:5H2O
Chalcocite	-43.19	-78.11	-34.92	Cu2S
Chalcopyrite	-101.88	-137.15	-35.27	CuFeS2
Claudetite	-68.52	-71.58	-3.06	As4O6
Clausthalite	-4.95	-32.05	-27.10	PbSe
Co(BO2)2	-29.34	-2.27	27.07	Co(BO2)2
Co(OH)2	-4.51	8.59	13.09	Co(OH)2
Co(OH)3	-10.11	-12.41	-2.31	Co(OH)3
CO2(g)	-2.86	-21.00	-18.15	CO2
Co3(AsO4)2	-15.26	-2.23	13.03	Co3(AsO4)2
Co3O4	-5.75	-16.24	-10.50	Co3O4
CoCl2	-22.55	-14.28	8.27	CoCl2
CoCl2:6H2O	-16.82	-14.28	2.54	CoCl2:6H2O
CoCO3	-2.44	-12.42	-9.98	CoCO3
CoF2	-15.24	-16.84	-1.60	CoF2
CoF3	-49.09	-50.55	-1.46	CoF3
CoFe2O4	25.01	21.48	-3.53	CoFe2O4
CoMoO4	-7.25	-15.01	-7.76	CoMoO4
CoO	-5.00	8.59	13.59	CoO
CoS(alpha)	-60.56	-68.00	-7.44	CoS
CoS(beta)	-56.93	-68.00	-11.07	CoS
CoSe	-14.54	-30.74	-16.20	CoSe
CoSeO3	-8.52	-7.20	1.32	CoSeO3
CoSeO4:6H2O	-19.18	-20.71	-1.53	CoSeO4:6H2O
CoSO4	-13.26	-10.46	2.80	CoSO4
CoSO4:6H2O	-7.99	-10.46	-2.47	CoSO4:6H2O
Cotunnite	-10.80	-15.58	-4.78	PbCl2
Covellite	-46.34	-68.64	-22.30	CuS
Cr(OH)2	-18.72	-7.90	10.82	Cr(OH)2
Cr(OH)3	-0.78	0.55	1.34	Cr(OH)3
Cr(OH)3(am)	1.30	0.55	-0.75	Cr(OH)3
Cr2O3	3.46	1.10	-2.36	Cr2O3
CrCl2	-44.86	-30.77	14.09	CrCl2
CrCl3	-48.86	-33.74	15.11	CrCl3
CrF3	-26.25	-37.58	-11.34	CrF3
Crmetal	-61.19	-30.70	30.48	Cr
CrO3	-29.41	-32.62	-3.21	CrO3
Cryolite	-16.99	-50.83	-33.84	Na3AlF6
Cu(OH)2	-0.72	7.95	8.67	Cu(OH)2
Cu2Se(alpha)	4.95	-40.85	-45.80	Cu2Se
Cu2SO4	-18.62	-20.57	-1.95	Cu2SO4
Cu3(AsO4)2:2H2O	-10.24	-4.14	6.10	Cu3(AsO4)2:2H2O
Cu3Se2	-8.74	-72.23	-63.49	Cu3Se2
CuCO3	-1.55	-13.05	-11.50	CuCO3
CuCr2O4	-19.23	-24.67	-5.44	CuCr2O4
CuF	-8.57	-13.47	-4.91	CuF
CuF2	-18.59	-17.47	1.12	CuF2
CuF2:2H2O	-12.92	-17.47	-4.55	CuF2:2H2O
Cumetal	-3.41	-12.16	-8.76	Cu
CuMoO4	-2.57	-15.64	-13.08	CuMoO4
CuOCuSO4	-13.45	-3.14	10.30	CuOCuSO4
Cupricferrite	14.86	20.85	5.99	CuFe2O4
Cuprite	-0.12	-1.52	-1.41	Cu2O
Cuprousferrite	14.60	5.69	-8.92	CuFeO2
CuSe	1.72	-31.38	-33.10	CuSe
CuSe2	-14.54	-47.91	-33.37	CuSe2
CuSeO3:2H2O	-8.35	-7.84	0.51	CuSeO3:2H2O
CuSeO4:5H2O	-18.90	-21.34	-2.44	CuSeO4:5H2O
CuSO4	-14.03	-11.09	2.94	CuSO4
Diaspore	2.20	9.07	6.87	AlOOH
Djurleite	-43.56	-77.48	-33.92	Cu0.066Cu1.868S
Dolomite(disordered)	0.62	-15.92	-16.54	CaMg(CO3)2
Dolomite(ordered)	1.17	-15.92	-17.09	CaMg(CO3)2
Epsomite	-4.06	-6.18	-2.13	MgSO4:7H2O
Fe(OH)2	-5.48	8.08	13.56	Fe(OH)2
Fe(OH)2.7Cl.3	6.06	3.02	-3.04	Fe(OH)2.7Cl.3
Fe(VO3)2	-5.72	-9.44	-3.72	Fe(VO3)2
Fe2(OH)4SeO3	-4.44	-2.89	1.55	Fe2(OH)4SeO3
Fe2(SeO3)3:2H2O	-13.84	-34.46	-20.63	Fe2(SeO3)3:2H2O
Fe2(SO4)3	-40.50	-44.24	-3.73	Fe2(SO4)3
Fe3(OH)8	0.75	20.98	20.22	Fe3(OH)8
FeAsO4:2H2O	-7.94	-7.54	0.40	FeAsO4:2H2O
FeCr2O4	1.98	9.18	7.20	FeCr2O4
FeMoO4	-5.42	-15.51	-10.09	FeMoO4
Ferrihydrite	3.26	6.45	3.19	Fe(OH)3
Ferroselite	-29.18	-47.78	-18.60	FeSe2
FeS(ppt)	-65.56	-68.51	-2.95	FeS
FeSe	-20.25	-31.25	-11.00	FeSe
Fluorite	-1.70	-12.20	-10.50	CaF2
Galena	-55.34	-69.31	-13.97	PbS
Gibbsite	0.78	9.07	8.29	Al(OH)3
Goethite	5.96	6.45	0.49	FeOOH
Goslarite	-7.36	-9.37	-2.01	ZnSO4:7H2O
Greenockite	-54.12	-68.48	-14.36	CdS
Greigite	-240.34	-285.37	-45.03	Fe3S4
Gummite	-7.48	0.19	7.67	UO3
Gypsum	-1.21	-5.82	-4.61	CaSO4:2H2O
H-Jarosite	-6.64	-18.74	-12.10	(H3O)Fe3(SO4)2(OH)6
H2MoO4	-10.72	-23.59	-12.88	H2MoO4
H2S(g)	-68.58	-76.59	-8.01	H2S
H2Se(g)	-34.37	-39.33	-4.96	H2Se
Halite	-7.58	-5.97	1.60	NaCl
Hausmannite	-8.08	52.95	61.03	Mn3O4
Hematite	14.31	12.90	-1.42	Fe2O3
Hercynite	3.32	26.22	22.89	FeAl2O4
Huntite	-2.23	-32.20	-29.97	CaMg3(CO3)4
Hydrocerussite	-1.39	-20.16	-18.77	Pb3(OH)2(CO3)2
Hydromagnesite	-10.94	-19.71	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-19.08	-24.25	-5.17	KAl(SO4)2:12H2O
K-Jarosite	0.83	-13.97	-14.80	KFe3(SO4)2(OH)6
K2Cr2O7	-38.46	-55.70	-17.24	K2Cr2O7
K2CrO4	-22.57	-23.08	-0.51	K2CrO4
K2MoO4	-17.31	-14.05	3.26	K2MoO4
K2SeO4	-19.02	-19.75	-0.73	K2SeO4
Langite	-4.73	12.75	17.49	Cu4(OH)6SO4:H2O
Larnakite	-4.04	-4.48	-0.43	PbO:PbSO4
Laurionite	-4.77	-4.15	0.62	PbOHCl
Lepidocrocite	5.08	6.45	1.37	FeOOH
Lime	-19.47	13.23	32.70	CaO
Litharge	-5.41	7.28	12.69	PbO
Mackinawite	-64.91	-68.51	-3.60	FeS
Maghemite	6.51	12.90	6.39	Fe2O3
Magnesioferrite	8.90	25.76	16.86	Fe2MgO4
Magnesite	-0.68	-8.14	-7.46	MgCO3
Magnetite	17.57	20.98	3.40	Fe3O4
Malachite	0.20	-5.10	-5.31	Cu2(OH)2CO3
Manganite	-3.89	21.45	25.34	MnOOH
Massicot	-5.61	7.28	12.89	PbO
Matlockite	-7.89	-16.86	-8.97	PbClF
Melanothallite	-21.17	-14.91	6.26	CuCl2
Melanterite	-8.76	-10.96	-2.21	FeSO4:7H2O
Mg(OH)2(active)	-5.93	12.86	18.79	Mg(OH)2
Mg(VO3)2	-15.94	-4.66	11.28	Mg(VO3)2
Mg2V2O7	-18.16	8.20	26.36	Mg2V2O7
MgCr2O4	-2.24	13.96	16.20	MgCr2O4
MgCrO4	-25.14	-19.76	5.38	MgCrO4
MgF2	-4.43	-12.56	-8.13	MgF2
MgMoO4	-8.88	-10.73	-1.85	MgMoO4
MgSeO3:6H2O	-5.98	-2.92	3.06	MgSeO3:6H2O
MgSeO4:6H2O	-15.23	-16.43	-1.20	MgSeO4:6H2O
Minium	-28.87	44.65	73.52	Pb3O4
Mirabilite	-7.01	-8.13	-1.11	Na2SO4:10H2O
Mn(VO3)2	-12.37	-7.47	4.90	Mn(VO3)2
Mn2(SO4)3	-59.22	-64.93	-5.71	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-10.34	2.16	12.50	Mn3(AsO4)2:8H2O
MnCl2:4H2O	-15.53	-12.81	2.72	MnCl2:4H2O
MnS(grn)	-66.71	-66.54	0.17	MnS
MnS(pnk)	-69.88	-66.54	3.34	MnS
MnSe	-32.78	-29.28	3.50	MnSe
MnSeO3	-6.87	-5.74	1.13	MnSeO3
MnSeO3:2H2O	-6.72	-5.74	0.98	MnSeO3:2H2O
MnSeO4:5H2O	-17.19	-19.24	-2.05	MnSeO4:5H2O
MnSO4	-11.58	-8.99	2.58	MnSO4
Monteponite	-6.99	8.11	15.10	CdO

```
MoO3            -15.59    -23.59   -8.00  MoO3
Morenosite       -8.43    -10.58   -2.14  NiSO4:7H2O
MoS2           -129.31   -199.57  -70.26  MoS2
Na-Jarosite      -2.08    -13.28  -11.20  NaFe3(SO4)2(OH)6
Na2Cr2O7        -44.43    -54.33   -9.90  Na2Cr2O7
Na2CrO4         -24.64    -21.71    2.93  Na2CrO4
Na2Mo2O7        -19.67    -36.27  -16.60  Na2Mo2O7
Na2MoO4         -14.16    -12.67    1.49  Na2MoO4
Na2MoO4:2H2O    -13.90    -12.67    1.22  Na2MoO4:2H2O
Na2SeO3:5H2O    -15.17     -4.87   10.30  Na2SeO3:5H2O
Na2SeO4         -19.65    -18.37    1.28  Na2SeO4
Na3VO4          -29.06      7.62   36.68  Na3VO4
Na4V2O7         -33.08      4.32   37.40  Na4V2O7
Nantokite        -5.46    -12.19   -6.73  CuCl
Natron           -8.78    -10.09   -1.31  Na2CO3:10H2O
NaVO3            -7.16     -3.30    3.86  NaVO3
Nesquehonite     -3.47     -8.14   -4.67  MgCO3:3H2O
Ni(OH)2          -4.33      8.47   12.79  Ni(OH)2
Ni3(AsO4)2:8H2O -18.29     -2.59   15.70  Ni3(AsO4)2:8H2O
Ni4(OH)6SO4     -17.18     14.82   32.00  Ni4(OH)6SO4
NiCO3            -5.67    -12.54   -6.87  NiCO3
NiMoO4           -3.98    -15.13  -11.14  NiMoO4
NiS(alpha)      -62.52    -68.12   -5.60  NiS
NiS(beta)       -57.02    -68.12  -11.10  NiS
NiS(gamma)      -55.32    -68.12  -12.80  NiS
NiSe            -13.16    -30.86  -17.70  NiSe
NiSeO3:2H2O     -10.14     -7.32    2.81  NiSeO3:2H2O
NiSeO4:6H2O     -19.31    -20.83   -1.52  NiSeO4:6H2O
Nsutite         -10.00      7.50   17.50  MnO2
O2(g)           -37.49     45.60   83.09  O2
Orpiment       -204.49   -265.55  -61.07  As2S3
Otavite          -0.89    -12.89  -12.00  CdCO3
Pb(BO2)2        -10.09     -3.57    6.52  Pb(BO2)2
Pb(OH)2          -0.87      7.28    8.15  Pb(OH)2
Pb10(OH)6O(CO3)6 -44.44    -53.20   -8.76  Pb10(OH)6O(CO3)6
Pb2(OH)3Cl       -5.66      3.13    8.79  Pb2(OH)3Cl
Pb2O(OH)2       -11.62     14.56   26.19  Pb2O(OH)2
Pb2O3           -23.67     37.37   61.04  Pb2O3
Pb2OCO3          -5.88     -6.44   -0.56  Pb2OCO3
Pb2V2O7          -1.06     -2.96   -1.90  Pb2V2O7
Pb3(AsO4)2      -11.94     -6.14    5.80  Pb3(AsO4)2
Pb3(VO4)2        -1.81      4.33    6.14  Pb3(VO4)2
Pb3O2CO3        -10.18      0.84   11.02  Pb3O2CO3
Pb3O2SO4         -7.88      2.80   10.69  Pb3O2SO4
Pb4(OH)6SO4     -11.01     10.09   21.10  Pb4(OH)6SO4
Pb4O3SO4        -11.79     10.09   21.88  Pb4O3SO4
PbCrO4          -12.74    -25.34  -12.60  PbCrO4
PbF2            -10.70    -18.14   -7.44  PbF2
Pbmetal         -19.76    -15.52    4.25  Pb
PbMoO4           -0.69    -16.31  -15.62  PbMoO4
PbO:0.3H2O       -5.70      7.28   12.98  PbO:0.33H2O
PbSeO4          -15.17    -22.01   -6.84  PbSeO4
Periclase        -8.72     12.86   21.58  MgO
Phosgenite       -9.49    -29.30  -19.81  PbCl2:PbCO3
Plattnerite     -19.52     30.08   49.60  PbO2
Portlandite      -9.58     13.23   22.80  Ca(OH)2
Pyrite         -103.79   -122.29  -18.51  FeS2
Pyrochroite      -5.14     10.05   15.19  Mn(OH)2
Pyrolusite       -8.53     32.85   41.38  MnO2
Realgar         -86.14   -105.88  -19.75  AsS
Retgersite       -8.54    -10.58   -2.04  NiSO4:6H2O
Rhodochrosite    -0.37    -10.95  -10.58  MnCO3
Rutherfordine    -6.31    -20.81  -14.50  UO2CO3
Schoepite        -5.80      0.19    5.99  UO2(OH)2:H2O
Semetal(am)      -9.42    -16.53   -7.11  Se
Semetal(hex      -8.82    -16.53   -7.71  Se
```

```
SeO2            -15.91    -15.79    0.12  SeO2
SeO3            -50.34    -29.29   21.04  SeO3
Siderite         -2.68    -12.92  -10.24  FeCO3
Smithsonite      -1.33    -11.33  -10.00  ZnCO3
Sphalerite      -55.46    -66.91  -11.45  ZnS
Spinel           -5.85     31.00   36.85  MgAl2O4
Sulfur          -51.64    -53.79   -2.14  S
Tenorite          0.31      7.95    7.64  CuO
Thenardite       -8.45     -8.13    0.32  Na2SO4
Thermonatrite   -10.72    -10.09    0.64  Na2CO3:H2O
Tyuyamunite      -7.98     -3.90    4.08  Ca(UO2)2(VO4)2
U3O8            -15.65      5.43   21.08  U3O8
U4O9            -27.74    -30.76   -3.02  U4O9
UF4             -34.70    -64.24  -29.54  UF4
UF4:2.5H2O      -31.52    -64.24  -32.72  UF4:2.5H2O
UO2(am)         -14.32    -13.39    0.93  UO2
UO2(OH)2(beta)   -5.42      0.19    5.61  UO2(OH)2
UO2SeO4:4H2O    -26.85    -29.10   -2.25  UO2SeO4:4H2O
UO3              -7.51      0.19    7.70  UO3
Uraninite        -8.72    -13.39   -4.67  UO2
V(OH)3          -16.55     -8.96    7.59  V(OH)3
V2O5            -16.16    -17.52   -1.36  V2O5
V3O5            -34.41    -32.58    1.84  V3O5
V4O7            -43.02    -35.83    7.19  V4O7
V6O13           -37.31    -98.17  -60.86  V6O13
VCl2            -62.10    -43.23   18.87  VCl2
VCl3            -66.69    -43.26   23.43  VCl3
VF4             -69.04    -54.11   14.93  VF4
Vmetal          -87.19    -43.16   44.03  V
VO              -35.12    -20.36   14.76  VO
VO(OH)2          -8.41     -3.26    5.15  VO(OH)2
VO2Cl           -23.03    -20.19    2.84  VO2Cl
VOCl            -31.55    -20.39   11.15  VOCl
VOCl2           -38.88    -26.12   12.76  VOCl2
VOSO4           -25.91    -22.30    3.61  VOSO4
Witherite        -2.77    -11.34   -8.57  BaCO3
Wurtzite        -57.96    -66.91   -8.95  ZnS
Zincite          -1.66      9.67   11.33  ZnO
Zincosite       -13.30     -9.37    3.93  ZnSO4
Zn(BO2)2         -9.47     -1.18    8.29  Zn(BO2)2
Zn(OH)2          -2.53      9.67   12.20  Zn(OH)2
Zn(OH)2(am)      -2.80      9.67   12.47  Zn(OH)2
Zn(OH)2(beta)    -2.08      9.67   11.75  Zn(OH)2
Zn(OH)2(epsilon)  -1.86      9.67   11.53  Zn(OH)2
Zn(OH)2(gamma)   -2.06      9.67   11.73  Zn(OH)2
Zn2(OH)2SO4      -7.20      0.30    7.50  Zn2(OH)2SO4
Zn2(OH)3Cl       -7.28      7.92   15.19  Zn2(OH)3Cl
Zn3(AsO4)2:2.5H2O -12.61      1.04   13.65  Zn3(AsO4)2:2.5H2O
Zn3O(SO4)2      -27.98     -9.07   18.91  Zn3O(SO4)2
Zn4(OH)6SO4      -8.75     19.65   28.40  Zn4(OH)6SO4
Zn5(OH)8Cl2     -12.99     25.51   38.50  Zn5(OH)8Cl2
ZnCl2           -20.24    -13.19    7.05  ZnCl2
ZnCO3:1H2O       -1.07    -11.33  -10.26  ZnCO3:1H2O
ZnF2            -15.22    -15.75   -0.53  ZnF2
Znmetal         -38.92    -13.13   25.79  Zn
ZnMoO4           -3.79    -13.92  -10.13  ZnMoO4
ZnO(active)      -1.51      9.67   11.19  ZnO
ZnS(am)         -57.86    -66.91   -9.05  ZnS
ZnSe            -15.26    -29.66  -14.40  ZnSe
ZnSeO4:6H2O     -18.10    -19.62   -1.52  ZnSeO4:6H2O
ZnSO4:1H2O       -8.73     -9.37   -0.64  ZnSO4:1H2O

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
  For ideal gases, phi = 1.

------------------
```

```
End of simulation.
------------------

------------------------------------
Reading input data for simulation 2.
------------------------------------

--------------------------------
End of Run after 0.688 Seconds.
--------------------------------
```

```
# P25 Scenario

SOLUTION 1 UG Water P25
    temp      25
    pH        8.112
    units     mg/L
    density   1
Al    0.0776
As    0.0027
Ba    0.1797
B     0.1302
Ca    101.7
Cl    53.6
Mg    52.5
Na    206.2
K     37.9
F     0.9956
S(6)  246.5
Cd    0.0077
Cr    0.0078
Co    0.0039
Cu    0.0722
Fe    0.1879
Pb    0.0477
Mn    0.0895
Mo    0.0110
Ni    0.0056
Se    0.0150
U     0.0082
V     0.0024
Zn    0.2006
      Alkalinity 553.3 as HCO3
    -water    1 # kg

SOLUTION 2 PAF Material
    temp      25
    pH        7.5
    units     mg/L
    density   1
      Al    0.020
      As    0
      Ba    0.020
      B     0
      Ca    67.0
      Cl    0
      Mg    8.0
      Na    1.0
      K     13.0
      F     0.300
      S(6)  197.0
      Cd    0.000
      Cr    0
      Co    0.007
      Cu    0.028
      Fe    0
      Pb    0
      Mn    0.040
      Mo    0.003
      Ni    0.004
      Se    0
      U     0
      V     0
      Zn    0
      Alkalinity 22 as HCO3
    -water    1 # kg
```

```
SOLUTION 3 NAF Material
    temp      25
    pH        7.6
    units     mg/L
    density   1
      Al    0.140
      As    0.029
      Ba    0.020
      B     0
      Ca    122.0
      Cl    0
      Mg    18.0
      Na    1.0
      K     16.0
      F     0.300
      S(6)  331.0
      Cd    0.000
      Cr    0
      Co    0.002
      Cu    0.019
      Fe    0.070
      Pb    0
      Mn    0.130
      Mo    0.005
      Ni    0.001
      Se    0
      U     0.001
      V     0
      Zn    0
      Alkalinity 28 as HCO3
    -water    1 # kg


SOLUTION 4 Make-up Material
    temp      25
    pH        7.7
    units     mg/L
    density   1
      Al    0.020
      As    0
      Ba    0.020
      B     0
      Ca    67.0
      Cl    0
      Mg    8.0
      Na    1.0
      K     13.0
      F     0.300
      S(6)  197.0
      Cd    0.000
      Cr    0
      Co    0.007
      Cu    0.028
      Fe    0
      Pb    0
      Mn    0.040
      Mo    0.003
      Ni    0.004
      Se    0
      U     0
      V     0
      Zn    0
      Alkalinity 22 as HCO3
    -water    1 # kg

# Mix the three solutions together
```

```
MIX 1 Mix within UG Works
    1    0.312
    2    0.109
    3    0.398
    4    0.181

SAVE Solution 5

SELECTED_OUTPUT 2
    -file                D:\selected_output_3.txt
    -high_precision      true
    -reset               true
    -distance            false
    -time                false
    -temperature         false
    -ionic_strength      false
    -water               false
    -totals              pH Al As Ba B Ca Cl Mg
                         Na K  F  S(6) Cd Cr Co
                         Cu Fe Pb Mn Mo  Ni Se
                         U V Zn Alkalinity
END
```

```
   Input file: P:\J23011 - BCP Underground EA (Aeris)\2. Tech Work Area\2.08 Water Quality
Model\2.08.02 PAF Assessment\BPC_UG_PAF_Disposal_P25.pqi
  Output file: P:\J23011 - BCP Underground EA (Aeris)\2. Tech Work Area\2.08 Water Quality
Model\2.08.02 PAF Assessment\BPC_UG_PAF_Disposal_P25.pqo
Database file: c:\phreeqc\database\minteq.v4.dat

------------------
Reading data base.
------------------

      SOLUTION_MASTER_SPECIES
      SOLUTION_SPECIES
      SOLUTION_SPECIES
      PHASES
      PHASES
      SURFACE_MASTER_SPECIES
      SURFACE_SPECIES
      END
------------------------------------
Reading input data for simulation 1.
------------------------------------

      DATABASE c:\phreeqc\database\minteq.v4.dat
      SOLUTION 1 UG Water P25
          temp      25
          pH        8.112
          units     mg/L
          density   1
      Al    0.0776
      As    0.0027
      Ba    0.1797
      B     0.1302
      Ca    101.7
      Cl    53.6
      Mg    52.5
      Na    206.2
      K     37.9
      F     0.9956
      S(6)  246.5
      Cd    0.0077
      Cr    0.0078
      Co    0.0039
      Cu    0.0722
      Fe    0.1879
      Pb    0.0477
      Mn    0.0895
      Mo    0.0110
      Ni    0.0056
      Se    0.0150
      U     0.0082
      V     0.0024
      Zn    0.2006
            Alkalinity 553.3 as HCO3
          water    1 # kg
      SOLUTION 2 PAF Material
          temp      25
          pH        7.5
          units     mg/L
          density   1
            Al    0.020
            As    0
            Ba    0.020
            B     0
            Ca    67.0
            Cl    0
            Mg    8.0
            Na    1.0
            K     13.0
            F     0.300
            S(6)  197.0
            Cd    0.000
            Cr    0
            Co    0.007
            Cu    0.028
            Fe    0
            Pb    0
            Mn    0.040
            Mo    0.003
            Ni    0.004
            Se    0
            U     0
            V     0
            Zn    0
            Alkalinity 22 as HCO3
          water    1 # kg
      SOLUTION 3 NAF Material
          temp      25
          pH        7.6
          units     mg/L
          density   1
            Al    0.140
            As    0.029
            Ba    0.020
            B     0
            Ca    122.0
            Cl    0
            Mg    18.0
            Na    1.0
            K     16.0
            F     0.300
            S(6)  331.0
            Cd    0.000
            Cr    0
            Co    0.002
            Cu    0.019
            Fe    0.070
            Pb    0
            Mn    0.130
            Mo    0.005
            Ni    0.001
            Se    0
            U     0.001
            V     0
            Zn    0
            Alkalinity 28 as HCO3
          water    1 # kg
      SOLUTION 4 Make-up Material
          temp      25
          pH        7.7
          units     mg/L
          density   1
            Al    0.020
            As    0
            Ba    0.020
            B     0
            Ca    67.0
            Cl    0
            Mg    8.0
            Na    1.0
            K     13.0
            F     0.300
            S(6)  197.0
```

```
           Cd    0.000
           Cr    0
           Co    0.007
           Cu    0.028
           Fe    0
           Pb    0
           Mn    0.040
           Mo    0.003
           Ni    0.004
           Se    0
           U     0
           V     0
           Zn    0
           Alkalinity 22 as HCO3
         water    1 # kg
     MIX 1 Mix within UG Works
         1    0.312
         2    0.109
         3    0.398
         4    0.181
     SAVE Solution 5
     SELECTED_OUTPUT 2
         file                  D:\selected_output_3.txt
         high_precision        true
         reset                 true
         distance              false
         time                  false
         temperature           false
         ionic_strength        false
         water                 false
         totals                pH Al As Ba B Ca Cl Mg
WARNING: Expected element name to begin with upper case letter.
                               Na K  F  S(6) Cd Cr Co
                               Cu Fe Pb Mn Mo  Ni Se
                               U V Zn Alkalinity
     END
-------------------------------------------
Beginning of initial solution calculations.
-------------------------------------------

Initial solution 1.     UG Water P25

-----------------------------Solution composition------------------------------

      Elements           Molality       Moles

      Al                 2.880e-06   2.880e-06
      Alkalinity         9.079e-03   9.079e-03
      As                 3.608e-08   3.608e-08
      B                  1.206e-05   1.206e-05
      Ba                 1.310e-06   1.310e-06
      Ca                 2.541e-03   2.541e-03
      Cd                 6.859e-08   6.859e-08
      Cl                 1.514e-03   1.514e-03
      Co                 6.626e-08   6.626e-08
      Cr                 1.502e-07   1.502e-07
      Cu                 1.138e-06   1.138e-06
      F                  5.247e-05   5.247e-05
      Fe                 3.369e-06   3.369e-06
      K                  9.706e-04   9.706e-04
      Mg                 2.163e-03   2.163e-03
      Mn                 1.631e-06   1.631e-06
      Mo                 1.148e-07   1.148e-07
      Na                 8.980e-03   8.980e-03
      Ni                 9.554e-08   9.554e-08
      Pb                 2.305e-07   2.305e-07
```

```
      S(6)               2.569e-03   2.569e-03
      Se                 1.902e-07   1.902e-07
      U                  3.449e-08   3.449e-08
      V                  4.717e-08   4.717e-08
      Zn                 3.072e-06   3.072e-06

----------------------------Description of solution----------------------------

                                    pH  =   8.112
                                    pe  =   4.000
                          Activity of water  =   1.000
                 Ionic strength (mol/kgw)  =   2.187e-02
                      Mass of water (kg)  =   1.000e+00
                 Total carbon (mol/kg)  =   8.983e-03
                    Total CO2 (mol/kg)  =   8.983e-03
                      Temperature (°C)  =  25.00
                Electrical balance (eq)  =   3.601e-03
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  11.28
                               Iterations  =  10
                                  Total H  = 1.110226e+02
                                  Total O  = 5.554412e+01

----------------------------Distribution of species----------------------------

                                                  Log       Log       Log    mole V
   Species          Molality    Activity  Molality  Activity     Gamma    cm³/mol

   OH-            1.511e-06   1.303e-06    -5.821    -5.885    -0.064     (0)
   H+             8.920e-09   7.727e-09    -8.050    -8.112    -0.062      0.00
   H2O            5.551e+01   9.995e-01     1.744    -0.000     0.000    18.07
Al             2.880e-06
   Al(OH)4-       2.864e-06   2.483e-06    -5.543    -5.605    -0.062     (0)
   Al(OH)3        1.514e-08   1.514e-08    -7.820    -7.820     0.000     (0)
   Al(OH)2+       6.687e-10   5.827e-10    -9.175    -9.235    -0.060     (0)
   AlF2+          3.188e-12   2.778e-12   -11.496   -11.556    -0.060     (0)
   AlF3           1.405e-12   1.405e-12   -11.852   -11.852     0.000     (0)
   AlOH+2         9.764e-13   5.632e-13   -12.010   -12.249    -0.239     (0)
   AlF+2          3.012e-13   1.737e-13   -12.521   -12.760    -0.239     (0)
   AlF4-          3.263e-14   2.829e-14   -13.486   -13.548    -0.062     (0)
   AlSO4+         4.372e-15   3.791e-15   -14.359   -14.421    -0.062     (0)
   Al+3           1.574e-15   4.324e-16   -14.803   -15.364    -0.561     (0)
   Al(SO4)2-      5.291e-17   4.589e-17   -16.276   -16.338    -0.062     (0)
   AlMo6O21-3     0.000e+00   0.000e+00   -51.502   -52.180    -0.679     (0)
As(3)          8.330e-21
   H3AsO3         7.720e-21   7.720e-21   -20.112   -20.112     0.000     (0)
   H2AsO3-        6.096e-22   5.124e-22   -21.215   -21.290    -0.075     (0)
   HAsO3-2        1.211e-25   6.048e-26   -24.917   -25.218    -0.302     (0)
   H4AsO3+        3.516e-29   2.955e-29   -28.454   -28.529    -0.075     (0)
   AsO3-3         1.440e-30   3.017e-31   -29.842   -30.520    -0.679     (0)
As(5)          3.608e-08
   HAsO4-2        3.460e-08   1.727e-08    -7.461    -7.763    -0.302     (0)
   H2AsO4-        1.448e-09   1.217e-09    -8.839    -8.915    -0.075     (0)
   AsO4-3         3.374e-11   7.070e-12   -10.472   -11.151    -0.679     (0)
   H3AsO4         1.626e-15   1.635e-15   -14.789   -14.787     0.002     (0)
B              1.206e-05
   H3BO3          1.098e-05   1.104e-05    -4.959    -4.957     0.002     (0)
   H2BO3-         9.687e-07   8.297e-07    -6.014    -6.081    -0.067     (0)
   CaH2BO3+       6.265e-08   5.366e-08    -7.203    -7.270    -0.067     (0)
   MgH2BO3+       3.442e-08   2.948e-08    -7.463    -7.530    -0.067     (0)
   NaH2BO3        1.012e-08   1.012e-08    -7.995    -7.995     0.000     (0)
   BF(OH)3-       2.066e-10   1.770e-10    -9.685    -9.752    -0.067     (0)
   BaH2BO3+       2.088e-11   1.789e-11   -10.680   -10.747    -0.067     (0)
   H5(BO3)2-      9.101e-12   7.796e-12   -11.041   -11.108    -0.067     (0)
   H8(BO3)3-      1.005e-14   8.605e-15   -13.998   -14.065    -0.067     (0)
   BF2(OH)2-      6.859e-15   5.875e-15   -14.164   -14.231    -0.067     (0)
   BF3OH-         8.288e-22   7.099e-22   -21.082   -21.149    -0.067     (0)
```

```
   BF4-           1.266e-27   1.085e-27   -26.897   -26.965    -0.067     (0)
Ba             1.310e-06
   Ba+2           1.239e-06   6.976e-07    -5.907    -6.156    -0.249     (0)
   BaHCO3+        5.549e-08   4.851e-08    -7.256    -7.314    -0.058     (0)
   BaCO3          1.581e-08   1.581e-08    -7.801    -7.801     0.000     (0)
   BaH2BO3+       2.088e-11   1.789e-11   -10.680   -10.747    -0.067     (0)
   BaOH+          4.561e-12   3.966e-12   -11.341   -11.402    -0.061     (0)
C(4)           8.983e-03
   HCO3-          8.356e-03   7.282e-03    -2.078    -2.138    -0.060     (0)
   CaHCO3+        1.744e-04   1.524e-04    -3.759    -3.817    -0.058     (0)
   H2CO3          1.266e-04   1.266e-04    -3.898    -3.898     0.000     (0)
   MgHCO3+        8.833e-05   7.637e-05    -4.054    -4.117    -0.063     (0)
   CaCO3          7.871e-05   7.871e-05    -4.104    -4.104     0.000     (0)
   CO3-2          7.847e-05   4.418e-05    -4.105    -4.355    -0.249     (0)
   MgCO3          3.767e-05   3.767e-05    -4.424    -4.424     0.000     (0)
   NaHCO3         3.153e-05   3.153e-05    -4.501    -4.501     0.000     (0)
   NaCO3-         7.269e-06   6.334e-06    -5.139    -5.198    -0.060     (0)
   ZnCO3          1.550e-06   1.550e-06    -5.810    -5.810     0.000     (0)
   CuCO3          8.949e-07   8.949e-07    -6.048    -6.048     0.000     (0)
   Cu(CO3)2-2     2.132e-07   1.064e-07    -6.671    -6.973    -0.302     (0)
   PbCO3          1.705e-07   1.705e-07    -6.768    -6.768     0.000     (0)
   ZnHCO3+        1.671e-07   1.404e-07    -6.777    -6.853    -0.075     (0)
   MnHCO3+        1.146e-07   9.965e-08    -6.941    -7.002    -0.061     (0)
   BaHCO3+        5.549e-08   4.851e-08    -7.256    -7.314    -0.058     (0)
   Pb(CO3)2-2     4.351e-08   2.172e-08    -7.361    -7.663    -0.302     (0)
   NiCO3          3.319e-08   3.319e-08    -7.479    -7.479     0.000     (0)
   UO2(CO3)3-4    3.266e-08   2.029e-09    -7.486    -8.693    -1.207     (0)
   NiHCO3+        2.151e-08   1.808e-08    -7.667    -7.743    -0.075     (0)
   CdCO3          2.086e-08   2.086e-08    -7.681    -7.681     0.000     (0)
   BaCO3          1.581e-08   1.581e-08    -7.801    -7.801     0.000     (0)
   CoCO3          1.341e-08   1.341e-08    -7.872    -7.872     0.000     (0)
   CoHCO3+        1.210e-08   1.017e-08    -7.917    -7.993    -0.075     (0)
   PbHCO3+        8.262e-09   6.945e-09    -8.083    -8.158    -0.075     (0)
   CuHCO3+        1.880e-09   1.580e-09    -8.726    -8.801    -0.075     (0)
   UO2(CO3)2-2    1.835e-09   9.162e-10    -8.736    -9.038    -0.302     (0)
   Cd(CO3)2-2     1.369e-09   6.832e-10    -8.864    -9.165    -0.302     (0)
   CdHCO3+        4.085e-10   3.434e-10    -9.389    -9.464    -0.075     (0)
   FeHCO3+        3.248e-10   2.839e-10    -9.488    -9.547    -0.058     (0)
   UO2CO3         1.039e-12   1.039e-12   -11.983   -11.983     0.000     (0)
Ca             2.541e-03
   Ca+2           1.996e-03   1.124e-03    -2.700    -2.949    -0.249     (0)
   CaSO4          2.909e-04   2.909e-04    -3.536    -3.536     0.000     (0)
   CaHCO3+        1.744e-04   1.524e-04    -3.759    -3.817    -0.058     (0)
   CaCO3          7.871e-05   7.871e-05    -4.104    -4.104     0.000     (0)
   CaF+           5.668e-07   4.929e-07    -6.247    -6.307    -0.061     (0)
   CaH2BO3+       6.265e-08   5.366e-08    -7.203    -7.270    -0.067     (0)
   CaOH+          3.342e-08   2.921e-08    -7.476    -7.534    -0.058     (0)
Cd             6.859e-08
   Cd+2           3.679e-08   2.071e-08    -7.434    -7.684    -0.249     (0)
   CdCO3          2.086e-08   2.086e-08    -7.681    -7.681     0.000     (0)
   CdSO4          5.485e-09   5.485e-09    -8.261    -8.261     0.000     (0)
   CdCl+          3.086e-09   2.594e-09    -8.511    -8.586    -0.075     (0)
   Cd(CO3)2-2     1.369e-09   6.832e-10    -8.864    -9.165    -0.302     (0)
   CdHCO3+        4.085e-10   3.434e-10    -9.389    -9.464    -0.075     (0)
   CdOH+          2.550e-10   2.143e-10    -9.594    -9.669    -0.075     (0)
   Cd(SO4)2-2     1.674e-10   8.357e-11    -9.776   -10.078    -0.302     (0)
   CdOHCl         1.386e-10   1.386e-10    -9.858    -9.858     0.000     (0)
   CdF+           1.569e-11   1.319e-11   -10.804   -10.880    -0.075     (0)
   CdCl2          1.418e-11   1.418e-11   -10.848   -10.848     0.000     (0)
   Cd(OH)2        1.761e-12   1.761e-12   -11.754   -11.754     0.000     (0)
   CdCl3-         1.396e-14   1.173e-14   -13.855   -13.931    -0.075     (0)
   CdF2           1.057e-15   1.057e-15   -14.976   -14.976     0.000     (0)
   Cd(OH)3-       1.668e-16   1.402e-16   -15.778   -15.853    -0.075     (0)
   Cd2OH+3        1.062e-16   2.225e-17   -15.974   -16.653    -0.679     (0)
   Cd(SeO3)2-2    6.652e-17   3.321e-17   -16.177   -16.479    -0.302     (0)
   CdSeO4         3.520e-17   3.520e-17   -16.453   -16.453     0.000     (0)
```

```
   Cd(OH)4-2      5.986e-23   2.988e-23   -22.223   -22.525    -0.302     (0)
Cl             1.514e-03
   Cl-            1.514e-03   1.311e-03    -2.820    -2.882    -0.062     (0)
   ZnOHCl         3.425e-09   3.425e-09    -8.465    -8.465     0.000     (0)
   CdCl+          3.086e-09   2.594e-09    -8.511    -8.586    -0.075     (0)
   ZnCl+          2.323e-09   2.009e-09    -8.634    -8.697    -0.063     (0)
   MnCl+          1.302e-09   1.132e-09    -8.885    -8.946    -0.061     (0)
   CuCl           2.781e-10   2.781e-10    -9.556    -9.556     0.000     (0)
   CdOHCl         1.386e-10   1.386e-10    -9.858    -9.858     0.000     (0)
   CoCl+          9.691e-11   8.146e-11   -10.014   -10.089    -0.075     (0)
   CuCl2-         8.811e-11   7.619e-11   -10.055   -10.118    -0.063     (0)
   NiCl+          8.037e-11   6.756e-11   -10.095   -10.170    -0.075     (0)
   PbCl+          7.104e-11   5.972e-11   -10.148   -10.224    -0.075     (0)
   CdCl2          1.418e-11   1.418e-11   -10.848   -10.848     0.000     (0)
   CuCl+          8.267e-12   7.148e-12   -11.083   -11.146    -0.063     (0)
   ZnCl2          4.174e-12   4.174e-12   -11.379   -11.379     0.000     (0)
   MnCl2          2.097e-12   2.097e-12   -11.678   -11.678     0.000     (0)
   PbCl2          3.498e-13   3.498e-13   -12.456   -12.456     0.000     (0)
   CuCl3-2        3.735e-14   2.136e-14   -13.428   -13.670    -0.243     (0)
   CdCl3-         1.396e-14   1.173e-14   -13.855   -13.931    -0.075     (0)
   ZnCl3-         5.028e-15   4.348e-15   -14.299   -14.362    -0.063     (0)
   CuCl2          3.250e-15   3.250e-15   -14.488   -14.488     0.000     (0)
   MnCl3-         8.709e-16   7.573e-16   -15.060   -15.121    -0.061     (0)
   NiCl2          4.461e-16   4.461e-16   -15.351   -15.351     0.000     (0)
   PbCl3-         2.172e-16   1.826e-16   -15.663   -15.739    -0.075     (0)
   CrCl+2         6.425e-17   3.208e-17   -16.192   -16.494    -0.302     (0)
   ZnCl4-2        4.986e-18   2.851e-18   -17.302   -17.545    -0.243     (0)
   CrOHCl2        1.041e-18   1.041e-18   -17.982   -17.982     0.000     (0)
   PbCl4-2        2.192e-19   1.094e-19   -18.659   -18.961    -0.302     (0)
   FeCl+2         1.992e-19   1.139e-19   -18.701   -18.943    -0.243     (0)
   CuCl3-         4.600e-20   3.977e-20   -19.337   -19.400    -0.063     (0)
   UO2Cl+         1.495e-20   1.256e-20   -19.825   -19.901    -0.075     (0)
   CrCl2+         4.748e-21   3.991e-21   -20.323   -20.399    -0.075     (0)
   FeCl2+         7.674e-22   6.673e-22   -21.115   -21.176    -0.061     (0)
   VOCl+          6.388e-23   5.370e-23   -22.195   -22.270    -0.075     (0)
   CuCl4-2        4.571e-25   2.614e-25   -24.340   -24.583    -0.243     (0)
   FeCl3          8.751e-26   8.751e-26   -25.058   -25.058     0.000     (0)
   CrO3Cl-        3.198e-26   2.688e-26   -25.495   -25.571    -0.075     (0)
   CoCl+2         3.821e-37   1.907e-37   -36.418   -36.720    -0.302     (0)
   UCl+3          0.000e+00   0.000e+00   -48.964   -49.642    -0.679     (0)
Co(2)          6.626e-08
   Co+2           3.597e-08   1.796e-08    -7.444    -7.746    -0.302     (0)
   CoCO3          1.341e-08   1.341e-08    -7.872    -7.872     0.000     (0)
   CoHCO3+        1.210e-08   1.017e-08    -7.917    -7.993    -0.075     (0)
   CoSO4          4.047e-09   4.047e-09    -8.393    -8.393     0.000     (0)
   CoOH+          5.552e-10   4.667e-10    -9.256    -9.331    -0.075     (0)
   CoCl+          9.691e-11   8.146e-11   -10.014   -10.089    -0.075     (0)
   Co(OH)2        4.829e-11   4.829e-11   -10.316   -10.316     0.000     (0)
   CoF+           2.714e-11   2.281e-11   -10.566   -10.642    -0.075     (0)
   Co(OH)3-       1.493e-15   1.255e-15   -14.826   -14.901    -0.075     (0)
   CoOOH-         3.748e-16   3.150e-16   -15.426   -15.502    -0.075     (0)
   CoSeO4         8.214e-17   8.214e-17   -16.085   -16.085     0.000     (0)
   Co2OH+3        2.005e-18   4.201e-19   -17.698   -18.377    -0.679     (0)
   Co(OH)4-2      5.190e-22   2.591e-22   -21.285   -21.587    -0.302     (0)
   Co4(OH)4+4     1.524e-28   9.468e-30   -27.817   -29.024    -1.207     (0)
Co(3)          9.479e-30
   CoOH+2         9.479e-30   4.732e-30   -29.023   -29.325    -0.302     (0)
   Co+3           2.603e-36   7.149e-37   -35.585   -36.146    -0.561     (0)
   CoCl+2         3.821e-37   1.907e-37   -36.418   -36.720    -0.302     (0)
Cr(2)          9.045e-25
   Cr+2           9.045e-25   4.516e-25   -24.044   -24.345    -0.302     (0)
Cr(3)          1.502e-07
   Cr(OH)2+       1.016e-07   8.537e-08    -6.993    -7.069    -0.075     (0)
   Cr(OH)3        4.178e-08   4.178e-08    -7.379    -7.379     0.000     (0)
   CrO2-          3.056e-09   2.569e-09    -8.515    -8.590    -0.075     (0)
   Cr(OH)4-       2.577e-09   2.166e-09    -8.589    -8.664    -0.075     (0)
```

Cr(OH)+2	1.079e-09	5.387e-10	-8.967	-9.269	-0.302	(0)
CrOHSO4	1.444e-10	1.444e-10	-9.840	-9.840	0.000	(0)
CrF+2	2.411e-13	1.204e-13	-12.618	-12.920	-0.302	(0)
Cr+3	9.022e-14	1.890e-14	-13.045	-13.723	-0.679	(0)
CrSO4+	5.931e-14	4.986e-14	-13.227	-13.302	-0.075	(0)
CrCl+2	6.425e-17	3.208e-17	-16.192	-16.494	-0.302	(0)
Cr2(OH)2SO4+2	1.408e-17	7.030e-18	-16.851	-17.153	-0.302	(0)
CrOHCl2	1.041e-18	1.041e-18	-17.982	-17.982	0.000	(0)
Cr2(OH)2(SO4)2	4.717e-19	4.717e-19	-18.326	-18.326	0.000	(0)
CrCl2+	4.748e-21	3.991e-21	-20.323	-20.399	-0.075	(0)
Cr(6)	3.128e-14					
CrO4-2	2.995e-14	1.686e-14	-13.524	-13.773	-0.249	(0)
NaCrO4-	7.675e-16	6.452e-16	-15.115	-15.190	-0.075	(0)
HCrO4-	5.016e-16	4.216e-16	-15.300	-15.375	-0.075	(0)
KCrO4-	6.217e-17	5.226e-17	-16.206	-16.282	-0.075	(0)
H2CrO4	2.641e-24	2.641e-24	-23.578	-23.578	0.000	(0)
CrO3SO4-2	2.246e-24	1.121e-24	-23.649	-23.950	-0.302	(0)
CrO3Cl-	3.198e-26	2.688e-26	-25.495	-25.571	-0.075	(0)
Cr2O7-2	1.235e-29	6.167e-30	-28.908	-29.210	-0.302	(0)
Cu(1)	5.667e-10					
CuCl	2.781e-10	2.781e-10	-9.556	-9.556	0.000	(0)
Cu+	2.004e-10	1.685e-10	-9.698	-9.774	-0.075	(0)
CuCl2-	8.811e-11	7.619e-11	-10.055	-10.118	-0.063	(0)
CuCl3-2	3.735e-14	2.136e-14	-13.428	-13.670	-0.243	(0)
Cu(2)	1.137e-06					
CuCO3	8.949e-07	8.949e-07	-6.048	-6.048	0.000	(0)
Cu(CO3)2-2	2.132e-07	1.064e-07	-6.671	-6.973	-0.302	(0)
CuOH+	1.639e-08	1.417e-08	-7.786	-7.849	-0.063	(0)
Cu+2	6.108e-09	3.440e-09	-8.214	-8.464	-0.249	(0)
Cu(OH)2	3.682e-09	3.682e-09	-8.434	-8.434	0.000	(0)
CuHCO3+	1.880e-09	1.580e-09	-8.726	-8.801	-0.075	(0)
CuSO4	8.901e-10	8.901e-10	-9.051	-9.051	0.000	(0)
Cu(OH)3-	1.170e-11	9.838e-12	-10.932	-11.007	-0.075	(0)
CuF+	1.037e-11	8.719e-12	-10.984	-11.060	-0.075	(0)
Cu2(OH)2+2	1.010e-11	5.042e-12	-10.996	-11.297	-0.302	(0)
CuCl+	8.267e-12	7.148e-12	-11.083	-11.146	-0.063	(0)
CuCl2	3.250e-15	3.250e-15	-14.488	-14.488	0.000	(0)
Cu(OH)4-2	2.020e-16	1.009e-16	-15.695	-15.996	-0.302	(0)
CuCl3-	4.600e-20	3.977e-20	-19.337	-19.400	-0.063	(0)
CuCl4-2	4.571e-25	2.614e-25	-24.340	-24.583	-0.243	(0)
F	5.247e-05					
F-	4.638e-05	4.018e-05	-4.334	-4.396	-0.062	(0)
MgF+	5.327e-06	4.620e-06	-5.273	-5.335	-0.062	(0)
CaF+	5.668e-07	4.929e-07	-6.247	-6.307	-0.061	(0)
NaF	1.952e-07	1.952e-07	-6.710	-6.710	0.000	(0)
MnF+	1.261e-09	1.097e-09	-8.899	-8.960	-0.061	(0)
ZnF+	5.815e-10	4.888e-10	-9.235	-9.311	-0.075	(0)
HF	4.592e-10	4.592e-10	-9.338	-9.338	0.000	(0)
BF(OH)3-	2.066e-10	1.770e-10	-9.685	-9.752	-0.067	(0)
CoF+	2.714e-11	2.281e-11	-10.566	-10.642	-0.075	(0)
NiF+	2.418e-11	2.032e-11	-10.617	-10.692	-0.075	(0)
CdF+	1.569e-11	1.319e-11	-10.804	-10.880	-0.075	(0)
CuF+	1.037e-11	8.719e-12	-10.984	-11.060	-0.075	(0)
PbF+	4.323e-12	3.634e-12	-11.364	-11.440	-0.075	(0)
AlF2+	3.188e-12	2.778e-12	-11.496	-11.556	-0.060	(0)
AlF3	1.405e-12	1.405e-12	-11.852	-11.852	0.000	(0)
AlF+2	3.012e-13	1.737e-13	-12.521	-12.760	-0.239	(0)
CrF+2	2.411e-13	1.204e-13	-12.618	-12.920	-0.302	(0)
HF2-	8.135e-14	7.013e-14	-13.090	-13.154	-0.064	(0)
AlF4-	3.263e-14	2.829e-14	-13.486	-13.548	-0.062	(0)
BF2(OH)2-	6.859e-15	5.875e-15	-14.164	-14.231	-0.067	(0)
PbF2	2.873e-15	2.873e-15	-14.542	-14.542	0.000	(0)
CdF2	1.057e-15	1.057e-15	-14.976	-14.976	0.000	(0)
FeF+2	2.216e-16	1.267e-16	-15.654	-15.897	-0.243	(0)
FeF2+	1.567e-16	1.363e-16	-15.805	-15.866	-0.061	(0)
UO2F+	3.898e-17	3.276e-17	-16.409	-16.485	-0.075	(0)
FeF3	7.724e-18	7.724e-18	-17.112	-17.112	0.000	(0)
UO2F2	3.796e-18	3.796e-18	-17.421	-17.421	0.000	(0)
VO2F	2.153e-18	2.153e-18	-17.667	-17.667	0.000	(0)
H2F2	5.648e-19	5.648e-19	-18.248	-18.248	0.000	(0)
PbF3-	2.604e-19	2.189e-19	-18.584	-18.660	-0.075	(0)
UO2F3-	4.558e-20	3.831e-20	-19.341	-19.417	-0.075	(0)
VO2F2-	3.736e-20	3.140e-20	-19.428	-19.503	-0.075	(0)
VOF+	4.184e-21	3.517e-21	-20.378	-20.454	-0.075	(0)
BF3OH-	8.288e-22	7.099e-22	-21.082	-21.149	-0.067	(0)
VOF2	5.299e-23	5.299e-23	-22.276	-22.276	0.000	(0)
VO2F3-2	3.152e-23	1.574e-23	-22.501	-22.803	-0.302	(0)
UO2F4-2	2.449e-23	1.223e-23	-22.611	-22.913	-0.302	(0)
PbF4-2	8.432e-24	4.210e-24	-23.074	-23.376	-0.302	(0)
VOF3-	8.985e-26	7.553e-26	-25.046	-25.122	-0.075	(0)
VO2F4-3	1.485e-27	3.111e-28	-26.828	-27.507	-0.679	(0)
BF4-	1.266e-27	1.085e-27	-26.897	-26.965	-0.067	(0)
VOF4-2	2.453e-29	1.225e-29	-28.610	-28.912	-0.302	(0)
UF3+	1.064e-40	0.000e+00	-39.973	-40.048	-0.075	(0)
UF2+2	0.000e+00	0.000e+00	-40.551	-40.852	-0.302	(0)
UF4	0.000e+00	0.000e+00	-42.404	-42.404	0.000	(0)
UF+3	0.000e+00	0.000e+00	-42.877	-43.556	-0.679	(0)
UF5-	0.000e+00	0.000e+00	-45.127	-45.202	-0.075	(0)
UF6-2	0.000e+00	0.000e+00	-46.817	-47.118	-0.302	(0)
Fe(2)	7.572e-09					
Fe+2	6.204e-09	3.097e-09	-8.207	-8.509	-0.302	(0)
FeSO4	8.588e-10	8.588e-10	-9.066	-9.066	0.000	(0)
FeHCO3+	3.248e-10	2.839e-10	-9.488	-9.547	-0.058	(0)
FeOH+	1.847e-10	1.606e-10	-9.734	-9.794	-0.061	(0)
Fe(OH)2	1.662e-13	1.662e-13	-12.779	-12.779	0.000	(0)
Fe(OH)3-	7.871e-14	6.845e-14	-13.104	-13.165	-0.061	(0)
Fe(3)	3.361e-06					
Fe(OH)3	1.715e-06	1.715e-06	-5.766	-5.766	0.000	(0)
Fe(OH)2+	1.407e-06	1.226e-06	-5.852	-5.911	-0.060	(0)
Fe(OH)4-	2.387e-07	2.081e-07	-6.622	-6.682	-0.060	(0)
FeOH+2	4.231e-12	2.420e-12	-11.374	-11.616	-0.243	(0)
FeF+2	2.216e-16	1.267e-16	-15.654	-15.897	-0.243	(0)
FeF2+	1.567e-16	1.363e-16	-15.805	-15.866	-0.061	(0)
FeSO4+	4.193e-17	3.647e-17	-16.377	-16.438	-0.061	(0)
Fe+3	1.048e-17	2.877e-18	-16.980	-17.541	-0.561	(0)
FeF3	7.724e-18	7.724e-18	-17.112	-17.112	0.000	(0)
Fe(SO4)2-	1.048e-18	8.806e-19	-17.980	-18.055	-0.075	(0)
FeCl+2	1.992e-19	1.139e-19	-18.701	-18.943	-0.243	(0)
Fe2(OH)2+4	3.121e-21	1.939e-22	-20.506	-21.712	-1.207	(0)
FeHSeO3+2	1.304e-21	6.508e-22	-20.885	-21.187	-0.302	(0)
FeCl2+	7.674e-22	6.673e-22	-21.115	-21.176	-0.061	(0)
Fe3(OH)4+5	2.640e-25	3.436e-27	-24.578	-26.464	-1.885	(0)
FeCl3	8.751e-26	8.751e-26	-25.058	-25.058	0.000	(0)
H(0)	8.411e-28					
H2	4.205e-28	4.227e-28	-27.376	-27.374	0.002	(0)
K	9.706e-04					
K+	9.629e-04	8.341e-04	-3.016	-3.079	-0.062	(0)
KSO4-	7.654e-06	6.670e-06	-5.116	-5.176	-0.060	(0)
KCrO4-	6.217e-17	5.226e-17	-16.206	-16.282	-0.075	(0)
Mg	2.163e-03					
Mg+2	1.820e-03	1.025e-03	-2.740	-2.989	-0.249	(0)
MgSO4	2.107e-04	2.107e-04	-3.676	-3.676	0.000	(0)
MgHCO3+	8.833e-05	7.637e-05	-4.054	-4.117	-0.063	(0)
MgCO3	3.767e-05	3.767e-05	-4.424	-4.424	0.000	(0)
MgF+	5.327e-06	4.620e-06	-5.273	-5.335	-0.062	(0)
MgOH+	6.064e-07	5.315e-07	-6.217	-6.275	-0.057	(0)
MgH2BO3+	3.442e-08	2.948e-08	-7.463	-7.530	-0.067	(0)
Mn(2)	1.631e-06					
Mn+2	1.374e-06	6.858e-07	-5.862	-6.164	-0.302	(0)
MnSO4	1.378e-07	1.378e-07	-6.861	-6.861	0.000	(0)
MnHCO3+	1.146e-07	9.965e-08	-6.941	-7.002	-0.061	(0)
MnOH+	2.580e-09	2.244e-09	-8.588	-8.649	-0.061	(0)
MnCl+	1.302e-09	1.132e-09	-8.885	-8.946	-0.061	(0)
MnF+	1.261e-09	1.097e-09	-8.899	-8.960	-0.061	(0)
MnCl2	2.097e-12	2.097e-12	-11.678	-11.678	0.000	(0)
MnSeO4	1.685e-15	1.685e-15	-14.773	-14.773	0.000	(0)
MnCl3-	8.709e-16	7.573e-16	-15.060	-15.121	-0.061	(0)
Mn(OH)3-	2.706e-17	2.353e-17	-16.568	-16.628	-0.061	(0)
Mn(OH)4-2	1.730e-22	9.895e-23	-21.762	-22.005	-0.243	(0)
MnSe	4.834e-39	4.834e-39	-38.316	-38.316	0.000	(0)
Mn(3)	1.115e-27					
Mn+3	1.115e-27	3.063e-28	-26.953	-27.514	-0.561	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-43.448	-43.691	-0.243	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-48.997	-49.063	-0.066	(0)
Mo	1.148e-07					
MoO4-2	1.148e-07	6.463e-08	-6.940	-7.190	-0.249	(0)
HMoO4-	1.182e-11	9.937e-12	-10.927	-11.003	-0.075	(0)
H2MoO4	5.624e-16	5.624e-16	-15.250	-15.250	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-51.502	-52.180	-0.679	(0)
Mo7O24-6	0.000e+00	0.000e+00	-59.517	-62.232	-2.715	(0)
HMo7O24-5	0.000e+00	0.000e+00	-62.072	-63.957	-1.885	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-66.080	-67.287	-1.207	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-71.474	-72.153	-0.679	(0)
Na	8.980e-03					
Na+	8.888e-03	7.699e-03	-2.051	-2.114	-0.062	(0)
NaSO4-	5.359e-05	4.670e-05	-4.271	-4.331	-0.060	(0)
NaHCO3	3.153e-05	3.153e-05	-4.501	-4.501	0.000	(0)
NaCO3-	7.269e-06	6.334e-06	-5.139	-5.198	-0.060	(0)
NaF	1.952e-07	1.952e-07	-6.710	-6.710	0.000	(0)
NaH2BO3	1.012e-08	1.012e-08	-7.995	-7.995	0.000	(0)
NaCrO4-	7.675e-16	6.452e-16	-15.115	-15.190	-0.075	(0)
Ni	9.554e-08					
Ni+2	3.576e-08	2.014e-08	-7.447	-7.696	-0.249	(0)
NiCO3	3.319e-08	3.319e-08	-7.479	-7.479	0.000	(0)
NiHCO3+	2.151e-08	1.808e-08	-7.667	-7.743	-0.075	(0)
NiSO4	4.539e-09	4.539e-09	-8.343	-8.343	0.000	(0)
NiOH+	3.928e-10	3.302e-10	-9.406	-9.481	-0.075	(0)
NiCl+	8.037e-11	6.756e-11	-10.095	-10.170	-0.075	(0)
Ni(OH)2	3.417e-11	3.417e-11	-10.466	-10.466	0.000	(0)
NiF+	2.418e-11	2.032e-11	-10.617	-10.692	-0.075	(0)
Ni(SO4)2-2	3.400e-13	1.698e-13	-12.468	-12.770	-0.302	(0)
Ni(OH)3-	5.295e-14	4.451e-14	-13.276	-13.352	-0.075	(0)
NiCl2	4.461e-16	4.461e-16	-15.351	-15.351	0.000	(0)
NiSeO4	8.596e-17	8.596e-17	-16.066	-16.066	0.000	(0)
O(0)	5.641e-38					
O2	2.821e-38	2.835e-38	-37.550	-37.547	0.002	(0)
Pb	2.305e-07					
PbCO3	1.705e-07	1.705e-07	-6.768	-6.768	0.000	(0)
Pb(CO3)2-2	4.351e-08	2.172e-08	-7.361	-7.663	-0.302	(0)
PbHCO3+	8.262e-09	6.945e-09	-8.083	-8.158	-0.075	(0)
PbOH+	4.996e-09	4.200e-09	-8.301	-8.377	-0.075	(0)
Pb+2	2.280e-09	1.284e-09	-8.642	-8.892	-0.249	(0)
PbSO4	7.101e-10	7.101e-10	-9.149	-9.149	0.000	(0)
Pb(OH)2	1.730e-10	1.730e-10	-9.762	-9.762	0.000	(0)
PbCl+	7.104e-11	5.972e-11	-10.148	-10.224	-0.075	(0)
Pb(SO4)2-2	9.681e-12	4.833e-12	-11.014	-11.316	-0.302	(0)
PbF+	4.323e-12	3.634e-12	-11.364	-11.440	-0.075	(0)
PbCl2	3.498e-13	3.498e-13	-12.456	-12.456	0.000	(0)
Pb(OH)3-	2.681e-13	2.253e-13	-12.572	-12.647	-0.075	(0)
PbF2	2.873e-15	2.873e-15	-14.542	-14.542	0.000	(0)
Pb2OH+3	4.078e-16	8.543e-17	-15.390	-16.068	-0.679	(0)
PbCl3-	2.172e-16	1.826e-16	-15.663	-15.739	-0.075	(0)
Pb(OH)4-2	1.440e-16	7.188e-17	-15.842	-16.143	-0.302	(0)
Pb3(OH)4+2	1.535e-18	7.664e-19	-17.814	-18.116	-0.302	(0)
PbF3-	2.604e-19	2.189e-19	-18.584	-18.660	-0.075	(0)
PbCl4-2	2.192e-19	1.094e-19	-18.659	-18.961	-0.302	(0)
Pb4(OH)4+4	1.258e-22	7.813e-24	-21.900	-23.107	-1.207	(0)
PbF4-2	8.432e-24	4.210e-24	-23.074	-23.376	-0.302	(0)
S(6)	2.569e-03					
SO4-2	2.006e-03	1.130e-03	-2.698	-2.947	-0.249	(0)
CaSO4	2.909e-04	2.909e-04	-3.536	-3.536	0.000	(0)
MgSO4	2.107e-04	2.107e-04	-3.676	-3.676	0.000	(0)
NaSO4-	5.359e-05	4.670e-05	-4.271	-4.331	-0.060	(0)
KSO4-	7.654e-06	6.670e-06	-5.116	-5.176	-0.060	(0)
ZnSO4	1.507e-07	1.507e-07	-6.822	-6.822	0.000	(0)
MnSO4	1.378e-07	1.378e-07	-6.861	-6.861	0.000	(0)
CdSO4	5.485e-09	5.485e-09	-8.261	-8.261	0.000	(0)
NiSO4	4.539e-09	4.539e-09	-8.343	-8.343	0.000	(0)
CoSO4	4.047e-09	4.047e-09	-8.393	-8.393	0.000	(0)
Zn(SO4)2-2	2.970e-09	1.483e-09	-8.527	-8.829	-0.302	(0)
HSO4-	9.836e-10	8.529e-10	-9.007	-9.069	-0.062	(0)
CuSO4	8.901e-10	8.901e-10	-9.051	-9.051	0.000	(0)
FeSO4	8.588e-10	8.588e-10	-9.066	-9.066	0.000	(0)
PbSO4	7.101e-10	7.101e-10	-9.149	-9.149	0.000	(0)
Cd(SO4)2-2	1.674e-10	8.357e-11	-9.776	-10.078	-0.302	(0)
CrOHSO4	1.444e-10	1.444e-10	-9.840	-9.840	0.000	(0)
Pb(SO4)2-2	9.681e-12	4.833e-12	-11.014	-11.316	-0.302	(0)
Ni(SO4)2-2	3.400e-13	1.698e-13	-12.468	-12.770	-0.302	(0)
CrSO4+	5.931e-14	4.986e-14	-13.227	-13.302	-0.075	(0)
AlSO4+	4.372e-15	3.791e-15	-14.359	-14.421	-0.062	(0)
Al(SO4)2-	5.291e-17	4.589e-17	-16.276	-16.338	-0.062	(0)
FeSO4+	4.193e-17	3.647e-17	-16.377	-16.438	-0.061	(0)
Cr2(OH)2SO4+2	1.408e-17	7.030e-18	-16.851	-17.153	-0.302	(0)
UO2SO4	1.010e-17	1.010e-17	-16.996	-16.996	0.000	(0)
Fe(SO4)2-	1.048e-18	8.806e-19	-17.980	-18.055	-0.075	(0)
VO2SO4-	9.804e-19	8.241e-19	-18.009	-18.084	-0.075	(0)
Cr2(OH)2(SO4)2	4.717e-19	4.717e-19	-18.326	-18.326	0.000	(0)
UO2(SO4)2-2	3.013e-19	1.504e-19	-18.521	-18.823	-0.302	(0)
VOSO4	4.541e-21	4.541e-21	-20.343	-20.343	0.000	(0)
CrO3SO4-2	2.246e-24	1.121e-24	-23.649	-23.950	-0.302	(0)
VSO4+	2.747e-35	2.309e-35	-34.561	-34.637	-0.075	(0)
U(SO4)2	0.000e+00	0.000e+00	-43.854	-43.854	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-44.506	-44.807	-0.302	(0)
Se(-2)	1.573e-35					
HSe-	1.572e-35	1.322e-35	-34.803	-34.879	-0.075	(0)
MnSe	4.834e-39	4.834e-39	-38.316	-38.316	0.000	(0)
H2Se	7.927e-40	7.927e-40	-39.101	-39.101	0.000	(0)
Se-2	0.000e+00	0.000e+00	-41.465	-41.767	-0.302	(0)
Se(4)	1.902e-07					
HSeO3-	1.018e-07	8.561e-08	-6.992	-7.067	-0.075	(0)
SeO3-2	8.835e-08	4.411e-08	-7.054	-7.355	-0.302	(0)
H2SeO3	2.822e-13	2.822e-13	-12.549	-12.549	0.000	(0)
Cd(SeO3)2-2	6.652e-17	3.321e-17	-16.177	-16.479	-0.302	(0)
FeHSeO3+2	1.304e-21	6.508e-22	-20.885	-21.187	-0.302	(0)
Se(6)	1.621e-11					
SeO4-2	1.621e-11	9.127e-12	-10.790	-11.040	-0.249	(0)
MnSeO4	1.685e-15	1.685e-15	-14.773	-14.773	0.000	(0)
ZnSeO4	8.620e-16	8.620e-16	-15.064	-15.064	0.000	(0)
NiSeO4	8.596e-17	8.596e-17	-16.066	-16.066	0.000	(0)
CoSeO4	8.214e-17	8.214e-17	-16.085	-16.085	0.000	(0)
CdSeO4	3.520e-17	3.520e-17	-16.453	-16.453	0.000	(0)
HSeO4-	4.205e-18	3.534e-18	-17.376	-17.452	-0.075	(0)
Zn(SeO4)2-2	1.598e-26	7.977e-27	-25.796	-26.098	-0.302	(0)
U(3)	0.000e+00					
U+3	0.000e+00	0.000e+00	-60.577	-61.256	-0.679	(0)
U(4)	1.133e-21					
U(OH)5-	1.133e-21	9.525e-22	-20.946	-21.021	-0.075	(0)
U(OH)4	3.084e-25	3.084e-25	-24.511	-24.511	0.000	(0)
U(OH)3+	1.037e-29	8.715e-30	-28.984	-29.060	-0.075	(0)
U(OH)2+2	6.239e-35	3.115e-35	-34.205	-34.507	-0.302	(0)
UF3+	1.064e-40	0.000e+00	-39.973	-40.048	-0.075	(0)
UOH+3	0.000e+00	0.000e+00	-40.267	-40.945	-0.679	(0)

UF2+2	0.000e+00	0.000e+00	-40.551	-40.852	-0.302	(0)
UF4	0.000e+00	0.000e+00	-42.404	-42.404	0.000	(0)
UF+3	0.000e+00	0.000e+00	-42.877	-43.556	-0.679	(0)
U(SO4)2	0.000e+00	0.000e+00	-43.854	-43.854	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-44.506	-44.807	-0.302	(0)
UF5-	0.000e+00	0.000e+00	-45.127	-45.202	-0.075	(0)
UF6-2	0.000e+00	0.000e+00	-46.817	-47.118	-0.302	(0)
U+4	0.000e+00	0.000e+00	-47.253	-48.460	-1.207	(0)
UCl+3	0.000e+00	0.000e+00	-48.964	-49.642	-0.679	(0)
U6(OH)15+9	0.000e+00	0.000e+00	-180.130	-186.239	-6.109	(0)
U(5)	4.284e-19					
UO2+	4.284e-19	3.601e-19	-18.368	-18.444	-0.075	(0)
U(6)	3.449e-08					
UO2(CO3)3-4	3.266e-08	2.029e-09	-7.486	-8.693	-1.207	(0)
UO2(CO3)2-2	1.835e-09	9.162e-10	-8.736	-9.038	-0.302	(0)
UO2CO3	1.039e-12	1.039e-12	-11.983	-11.983	0.000	(0)
UO2OH+	1.153e-15	9.688e-16	-14.938	-15.014	-0.075	(0)
UO2F+	3.898e-17	3.276e-17	-16.409	-16.485	-0.075	(0)
UO2+2	1.049e-17	5.908e-18	-16.979	-17.229	-0.249	(0)
UO2SO4	1.010e-17	1.010e-17	-16.996	-16.996	0.000	(0)
UO2F2	3.796e-18	3.796e-18	-17.421	-17.421	0.000	(0)
UO2(SO4)2-2	3.013e-19	1.504e-19	-18.521	-18.823	-0.302	(0)
UO2F3-	4.558e-20	3.831e-20	-19.341	-19.417	-0.075	(0)
UO2Cl+	1.495e-20	1.256e-20	-19.825	-19.901	-0.075	(0)
UO2F4-2	2.449e-23	1.223e-23	-22.611	-22.913	-0.302	(0)
(UO2)2(OH)2+2	3.120e-24	1.558e-24	-23.506	-23.807	-0.302	(0)
(UO2)3(OH)5+	2.311e-27	1.942e-27	-26.636	-26.712	-0.075	(0)
V(2)	0.000e+00					
VOH+	0.000e+00	0.000e+00	-40.973	-41.049	-0.075	(0)
V+2	0.000e+00	0.000e+00	-42.372	-42.674	-0.302	(0)
V(3)	7.719e-14					
V(OH)3	7.719e-14	7.719e-14	-13.112	-13.112	0.000	(0)
V(OH)2+	4.586e-25	3.855e-25	-24.339	-24.414	-0.075	(0)
VOH+2	5.661e-29	2.827e-29	-28.247	-28.549	-0.302	(0)
V+3	2.066e-34	4.330e-35	-33.685	-34.364	-0.679	(0)
VSO4+	2.747e-35	2.309e-35	-34.561	-34.637	-0.075	(0)
V2(OH)3+3	0.000e+00	0.000e+00	-53.832	-54.511	-0.679	(0)
V2(OH)2+4	0.000e+00	0.000e+00	-55.091	-56.297	-1.207	(0)
V(4)	4.549e-18					
V(OH)3+	4.511e-18	3.792e-18	-17.346	-17.421	-0.075	(0)
VO+2	2.924e-20	1.460e-20	-19.534	-19.836	-0.302	(0)
VOSO4	4.541e-21	4.541e-21	-20.343	-20.343	0.000	(0)
VOF+	4.184e-21	3.517e-21	-20.378	-20.454	-0.075	(0)
VOCl+	6.388e-23	5.370e-23	-22.195	-22.270	-0.075	(0)
VOF2	5.299e-23	5.299e-23	-22.276	-22.276	0.000	(0)
VOF3-	8.985e-26	7.553e-26	-25.046	-25.122	-0.075	(0)
VOF4-2	2.453e-29	1.225e-29	-28.610	-28.912	-0.302	(0)
H2V2O4+2	1.445e-30	7.213e-31	-29.840	-30.142	-0.302	(0)
V(5)	4.717e-08					
H2VO4-	3.048e-08	2.562e-08	-7.516	-7.591	-0.075	(0)
HVO4-2	1.669e-08	8.330e-09	-7.778	-8.079	-0.302	(0)
H3VO4	1.980e-12	1.980e-12	-11.703	-11.703	0.000	(0)
H3V2O7-	3.899e-13	3.277e-13	-12.409	-12.484	-0.075	(0)
HV2O7-3	3.454e-13	7.236e-14	-12.462	-13.140	-0.679	(0)
VO4-3	2.579e-14	5.403e-15	-13.589	-14.267	-0.679	(0)
V2O7-4	4.057e-15	2.521e-16	-14.392	-15.598	-1.207	(0)
V3O9-3	8.421e-17	1.764e-17	-16.075	-16.753	-0.679	(0)
VO2+	3.527e-17	3.055e-17	-16.453	-16.515	-0.062	(0)
VO2F	2.153e-18	2.153e-18	-17.667	-17.667	0.000	(0)
VO2SO4-	9.804e-19	8.241e-19	-18.009	-18.084	-0.075	(0)
VO2F2-	3.736e-20	3.140e-20	-19.428	-19.503	-0.075	(0)
V4O12-4	3.035e-21	1.885e-22	-20.518	-21.725	-1.207	(0)
VO2F3-2	3.152e-23	1.574e-23	-22.501	-22.803	-0.302	(0)
VO2F4-3	1.485e-27	3.111e-28	-26.828	-27.507	-0.679	(0)
V10O28-6	0.000e+00	0.000e+00	-56.738	-59.453	-2.715	(0)
HV10O28-5	0.000e+00	0.000e+00	-57.493	-59.379	-1.885	(0)
H2V10O28-4	0.000e+00	0.000e+00	-61.076	-62.283	-1.207	(0)
Zn	3.072e-06					
ZnCO3	1.550e-06	1.550e-06	-5.810	-5.810	0.000	(0)
Zn+2	1.083e-06	6.098e-07	-5.965	-6.215	-0.249	(0)
ZnHCO3+	1.671e-07	1.404e-07	-6.777	-6.853	-0.075	(0)
ZnSO4	1.507e-07	1.507e-07	-6.822	-6.822	0.000	(0)
ZnOH+	9.450e-08	7.943e-08	-7.025	-7.100	-0.075	(0)
Zn(OH)2	1.640e-08	1.640e-08	-7.785	-7.785	0.000	(0)
ZnOHCl	3.425e-09	3.425e-09	-8.465	-8.465	0.000	(0)
Zn(SO4)2-2	2.970e-09	1.483e-09	-8.527	-8.829	-0.302	(0)
ZnCl+	2.323e-09	2.009e-09	-8.634	-8.697	-0.063	(0)
ZnF+	5.815e-10	4.888e-10	-9.235	-9.311	-0.075	(0)
Zn(OH)3-	1.274e-10	1.071e-10	-9.895	-9.970	-0.075	(0)
ZnCl2	4.174e-12	4.174e-12	-11.379	-11.379	0.000	(0)
Zn(OH)4-2	1.112e-14	5.551e-15	-13.954	-14.256	-0.302	(0)
ZnCl3-	5.028e-15	4.348e-15	-14.299	-14.362	-0.063	(0)
ZnSeO4	8.620e-16	8.620e-16	-15.064	-15.064	0.000	(0)
ZnCl4-2	4.986e-18	2.851e-18	-17.302	-17.545	-0.243	(0)
Zn(SeO4)2-2	1.598e-26	7.977e-27	-25.796	-26.098	-0.302	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.83	8.97	10.80	Al(OH)3
Al2(MoO4)3	-54.66	-52.30	2.37	Al2(MoO4)3
Al2O3	-1.71	17.94	19.65	Al2O3
Al4(OH)10SO4	-5.99	16.71	22.70	Al4(OH)10SO4
AlAsO4:2H2O	-10.62	-5.82	4.80	AlAsO4:2H2O
AlOHSO4	-6.97	-10.20	-3.23	AlOHSO4
Alunite	-4.99	-6.39	-1.40	KAl3(SO4)2(OH)6
Anglesite	-4.05	-11.84	-7.79	PbSO4
Anhydrite	-1.54	-5.90	-4.36	CaSO4
Antlerite	-4.68	4.11	8.79	Cu3(OH)4SO4
Aragonite	1.00	-7.30	-8.30	CaCO3
Arsenolite	-77.69	-80.45	-2.76	As4O6
Artinite	-3.71	5.89	9.60	MgCO3:Mg(OH)2:3H2O
As2O5	-36.28	-29.57	6.71	As2O5
Atacamite	-2.86	4.53	7.39	Cu2(OH)3Cl
Azurite	-0.97	-17.88	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-14.33	10.07	24.39	Ba(OH)2:8H2O
Ba2V2O7:2H2O	-12.54	3.33	15.87	Ba2V2O7:2H2O
Ba3(AsO4)2	9.54	0.63	-8.91	Ba3(AsO4)2
Ba3(VO4)2:4H2O	-19.54	13.40	32.94	Ba3(VO4)2:4H2O
BaCrO4	-10.26	-19.93	-9.67	BaCrO4
BaF2	-9.13	-14.95	-5.82	BaF2
BaMoO4	-6.39	-13.35	-6.96	BaMoO4
Barite	0.88	-9.10	-9.98	BaSO4
BaSeO3	-6.94	-5.11	1.83	BaSeO3
BaSeO4	-9.74	-17.20	-7.46	BaSeO4
Bianchite	-7.40	-9.16	-1.76	ZnSO4:6H2O
Birnessite	-9.16	8.93	18.09	MnO2
Bixbyite	-5.71	-6.36	-0.64	Mn2O3
Boehmite	0.39	8.97	8.58	AlOOH
Brochantite	-3.35	11.87	15.22	Cu4(OH)6SO4
Brucite	-3.61	13.23	16.84	Mg(OH)2
Bunsenite	-3.92	8.53	12.45	NiO
Ca(VO3)2	-9.19	-3.53	5.66	Ca(VO3)2
Ca2V2O7	-7.76	9.74	17.50	Ca2V2O7
Ca2V2O7:2H2O	-11.81	9.74	21.55	Ca2V2O7:2H2O
Ca3(AsO4)2:4H2O	-12.05	10.25	22.30	Ca3(AsO4)2:4H2O
Ca3(VO4)2	-15.94	23.02	38.96	Ca3(VO4)2
Ca3(VO4)2:4H2O	-16.84	23.02	39.86	Ca3(VO4)2:4H2O
CaCrO4	-14.46	-16.72	-2.27	CaCrO4
Calcite	1.18	-7.30	-8.48	CaCO3
CaMoO4	-2.19	-10.14	-7.95	CaMoO4
Carnotite	-4.60	-4.37	0.23	KUO2VO4
CaSeO3:2H2O	-4.72	-1.91	2.81	CaSeO3:2H2O
CaSeO4:2H2O	-10.97	-13.99	-3.02	CaSeO4:2H2O
Cd(BO2)2	-11.21	-1.37	9.84	Cd(BO2)2
Cd(OH)2	-5.10	8.54	13.64	Cd(OH)2
Cd(OH)2(am)	-5.19	8.54	13.73	Cd(OH)2
Cd3(OH)2(SO4)2	-19.43	-12.72	6.71	Cd3(OH)2(SO4)2
Cd3(OH)4SO4	-16.11	6.45	22.56	Cd3(OH)4SO4
Cd4(OH)6SO4	-13.41	14.99	28.40	Cd4(OH)6SO4
CdCl2	-12.79	-13.45	-0.66	CdCl2
CdCl2:1H2O	-11.76	-13.45	-1.69	CdCl2:1H2O
CdCl2:2.5H2O	-11.54	-13.45	-1.91	CdCl2:2.5H2O
CdF2	-15.26	-16.48	-1.21	CdF2
Cdmetal(alpha)	-29.20	-15.68	13.51	Cd
Cdmetal(gamma)	-29.30	-15.68	13.62	Cd
CdMoO4	-0.72	-14.87	-14.15	CdMoO4
CdOHCl	-5.99	-2.45	3.54	CdOHCl
CdSe	-14.25	-34.45	-20.20	CdSe
CdSeO4:2H2O	-16.87	-18.72	-1.85	CdSeO4:2H2O
CdSO4	-10.46	-10.63	-0.17	CdSO4
CdSO4:1H2O	-8.90	-10.63	-1.73	CdSO4:1H2O
CdSO4:2.67H2O	-8.76	-10.63	-1.87	CdSO4:2.67H2O
Cerussite	-0.12	-13.25	-13.13	PbCO3
CH4(g)	-76.43	-117.47	-41.05	CH4
Chalcanthite	-8.77	-11.41	-2.64	CuSO4:5H2O
Claudetite	-77.38	-80.45	-3.06	As4O6
Clausthalite	-8.56	-35.66	-27.10	PbSe
Co(BO2)2	-28.51	-1.44	27.07	Co(BO2)2
Co(OH)2	-4.62	8.48	13.09	Co(OH)2
Co(OH)3	-9.50	-11.81	-2.31	Co(OH)3
CO2(g)	-2.43	-20.58	-18.15	CO2
Co3(AsO4)2	-17.17	-4.14	13.03	Co3(AsO4)2
Co3O4	-4.65	-15.14	-10.50	Co3O4
CoCl2	-21.78	-13.51	8.27	CoCl2
CoCl2:6H2O	-16.05	-13.51	2.54	CoCl2:6H2O
CoCO3	-2.12	-12.10	-9.98	CoCO3
CoF2	-14.94	-16.54	-1.60	CoF2
CoF3	-47.88	-49.33	-1.46	CoF3
CoFe2O4	25.60	22.07	-3.53	CoFe2O4
CoMoO4	-7.17	-14.94	-7.76	CoMoO4
CoO	-5.11	8.48	13.59	CoO
CoSe	-18.31	-34.51	-16.20	CoSe
CoSeO3	-8.02	-6.70	1.32	CoSeO3
CoSeO4:6H2O	-17.26	-18.79	-1.53	CoSeO4:6H2O
CoSO4	-13.50	-10.69	2.80	CoSO4
CoSO4:6H2O	-8.22	-10.69	-2.47	CoSO4:6H2O
Cotunnite	-9.88	-14.66	-4.78	PbCl2
Cr(OH)2	-18.94	-8.12	10.82	Cr(OH)2
Cr(OH)3	-0.29	1.04	1.34	Cr(OH)3
Cr(OH)3(am)	1.79	1.04	-0.75	Cr(OH)3
Cr2O3	4.44	2.09	-2.36	Cr2O3
CrCl2	-44.20	-30.11	14.09	CrCl2
CrCl3	-47.05	-31.94	15.11	CrCl3
CrF3	-25.14	-36.48	-11.34	CrF3
Crmetal	-62.83	-32.35	30.48	Cr
CrO3	-26.79	-30.00	-3.21	CrO3
Cryolite	-14.24	-48.08	-33.84	Na3AlF6
Cu(OH)2	-0.91	7.76	8.67	Cu(OH)2
Cu2Se(alpha)	-0.51	-46.31	-45.80	Cu2Se
Cu2SO4	-20.54	-22.49	-1.95	Cu2SO4
Cu3(AsO4)2:2H2O	-12.39	-6.29	6.10	Cu3(AsO4)2:2H2O
Cu3Se2	-18.05	-81.54	-63.49	Cu3Se2
CuCO3	-1.32	-12.82	-11.50	CuCO3
CuCr2O4	-16.80	-22.24	-5.44	CuCr2O4
CuF	-9.26	-14.17	-4.91	CuF
CuF2	-18.37	-17.26	1.12	CuF2
CuF2:2H2O	-12.71	-17.26	-4.55	CuF2:2H2O
Cumetal	-5.02	-13.77	-8.76	Cu
CuMoO4	-2.58	-15.65	-13.08	CuMoO4
CuOCuSO4	-13.95	-3.65	10.30	CuOCuSO4
Cupricferrite	15.36	21.35	5.99	CuFe2O4
Cuprite	-1.92	-3.32	-1.41	Cu2O
Cuprousferrite	14.05	5.13	-8.92	CuFeO2
CuSe	-2.13	-35.23	-33.10	CuSe
CuSe2	-20.63	-54.00	-33.37	CuSe2
CuSeO3:2H2O	-7.93	-7.42	0.51	CuSeO3:2H2O
CuSeO4:5H2O	-17.06	-19.50	-2.44	CuSeO4:5H2O
CuSO4	-14.35	-11.41	2.94	CuSO4
Diaspore	2.10	8.97	6.87	AlOOH
Dolomite(disordered)	1.89	-14.65	-16.54	CaMg(CO3)2
Dolomite(ordered)	2.44	-14.65	-17.09	CaMg(CO3)2
Epsomite	-3.81	-5.94	-2.13	MgSO4:7H2O
Fe(OH)2	-5.85	7.71	13.56	Fe(OH)2
Fe(OH)2.7Cl.3	6.54	3.50	-3.04	Fe(OH)2.7Cl.3
Fe(VO3)2	-5.37	-9.09	-3.72	Fe(VO3)2
Fe2(OH)4SeO3	-3.14	-1.59	1.55	Fe2(OH)4SeO3
Fe2(SeO3)3:2H2O	-11.32	-31.95	-20.63	Fe2(SeO3)3:2H2O
Fe2(SO4)3	-40.19	-43.92	-3.73	Fe2(SO4)3
Fe3(OH)8	1.08	21.30	20.22	Fe3(OH)8
FeAsO4:2H2O	-8.39	-7.99	0.40	FeAsO4:2H2O
FeCr2O4	2.60	9.80	7.20	FeCr2O4
FeMoO4	-5.61	-15.70	-10.09	FeMoO4
Ferrihydrite	3.60	6.79	3.19	Fe(OH)3
Ferroselite	-35.45	-54.04	-18.60	FeSe2
FeSe	-24.28	-35.28	-11.00	FeSe
Fluorite	-1.24	-11.74	-10.50	CaF2
Gibbsite	0.68	8.97	8.29	Al(OH)3
Goethite	6.30	6.79	0.49	FeOOH
Goslarite	-7.15	-9.16	-2.01	ZnSO4:7H2O
Gummite	-8.68	-1.00	7.67	UO3
Gypsum	-1.29	-5.90	-4.61	CaSO4:2H2O
H-Jarosite	-5.86	-17.96	-12.10	(H3O)Fe3(SO4)2(OH)6
H2MoO4	-10.54	-23.41	-12.88	H2MoO4
H2Se(g)	-38.03	-42.99	-4.96	H2Se
Halite	-6.60	-5.00	1.60	NaCl
Hausmannite	-6.63	54.40	61.03	Mn3O4
Hematite	15.01	13.59	-1.42	Fe2O3
Hercynite	2.76	25.66	22.89	FeAl2O4
Huntite	0.63	-29.34	-29.97	CaMg3(CO3)4
Hydrocerussite	-0.39	-19.16	-18.77	Pb3(OH)2(CO3)2
Hydromagnesite	-7.38	-16.14	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-19.17	-24.34	-5.17	KAl(SO4)2:12H2O
K-Jarosite	1.87	-12.93	-14.80	KFe3(SO4)2(OH)6
K2Cr2O7	-32.69	-49.93	-17.24	K2Cr2O7
K2CrO4	-19.42	-19.93	-0.51	K2CrO4
K2MoO4	-16.61	-13.35	3.26	K2MoO4
K2SeO4	-16.47	-17.20	-0.73	K2SeO4
Langite	-5.62	11.87	17.49	Cu4(OH)6SO4:H2O
Larnakite	-4.07	-4.51	-0.43	PbO:PbSO4
Laurionite	-4.29	-3.66	0.62	PbOHCl
Lepidocrocite	5.42	6.79	1.37	FeOOH
Lime	-19.42	13.27	32.70	CaO
Litharge	-5.36	7.33	12.69	PbO
Maghemite	7.20	13.59	6.39	Fe2O3
Magnesioferrite	9.96	26.82	16.86	Fe2MgO4
Magnesite	0.12	-7.34	-7.46	MgCO3
Magnetite	17.90	21.30	3.40	Fe3O4
Malachite	0.25	-5.06	-5.31	Cu2(OH)2CO3
Manganite	-3.17	22.17	25.34	MnOOH
Massicot	-5.56	7.33	12.89	PbO
Matlockite	-7.20	-16.17	-8.97	PbClF
Melanothallite	-20.49	-14.23	6.26	CuCl2

Melanterite	-9.25	-11.46	-2.21	FeSO4:7H2O
Mg(OH)2(active)	-5.56	13.23	18.79	Mg(OH)2
Mg(VO3)2	-14.85	-3.57	11.28	Mg(VO3)2
Mg2V2O7	-16.70	9.66	26.36	Mg2V2O7
MgCr2O4	0.88	15.32	16.20	MgCr2O4
MgCrO4	-22.14	-16.76	5.38	MgCrO4
MgF2	-3.65	-11.78	-8.13	MgF2
MgMoO4	-8.33	-10.18	-1.85	MgMoO4
MgSeO3:6H2O	-5.00	-1.95	3.06	MgSeO3:6H2O
MgSeO4:6H2O	-12.83	-14.03	-1.20	MgSeO4:6H2O
Minium	-27.30	46.22	73.52	Pb3O4
Mirabilite	-6.06	-7.18	-1.11	Na2SO4:10H2O
Mn(VO3)2	-11.65	-6.75	4.90	Mn(VO3)2
Mn2(SO4)3	-58.16	-63.87	-5.71	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-11.89	0.61	12.50	Mn3(AsO4)2:8H2O
MnCl2:4H2O	-14.64	-11.93	2.72	MnCl2:4H2O
MnSe	-36.43	-32.93	3.50	MnSe
MnSeO3	-6.25	-5.12	1.13	MnSeO3
MnSeO3:2H2O	-6.10	-5.12	0.98	MnSeO3:2H2O
MnSeO4:5H2O	-15.15	-17.20	-2.05	MnSeO4:5H2O
MnSO4	-11.69	-9.11	2.58	MnSO4
Monteponite	-6.56	8.54	15.10	CdO
MoO3	-15.41	-23.41	-8.00	MoO3
Morenosite	-8.50	-10.64	-2.14	NiSO4:7H2O
Na-Jarosite	-0.76	-11.96	-11.20	NaFe3(SO4)2(OH)6
Na2Cr2O7	-38.10	-48.00	-9.90	Na2Cr2O7
Na2CrO4	-20.93	-18.00	2.93	Na2CrO4
Na2Mo2O7	-18.23	-34.83	-16.60	Na2Mo2O7
Na2MoO4	-12.91	-11.42	1.49	Na2MoO4
Na2MoO4:2H2O	-12.64	-11.42	1.22	Na2MoO4:2H2O
Na2SeO3:5H2O	-13.48	-3.18	10.30	Na2SeO3:5H2O
Na2SeO4	-16.55	-15.27	1.28	Na2SeO4
Na3VO4	-27.09	9.59	36.68	Na3VO4
Na4V2O7	-30.21	7.19	37.40	Na4V2O7
Nantokite	-5.93	-12.66	-6.73	CuCl
Natron	-7.27	-8.58	-1.31	Na2CO3:10H2O
NaVO3	-6.26	-2.40	3.86	NaVO3
Nesquehonite	-2.67	-7.34	-4.67	MgCO3:3H2O
Ni(OH)2	-4.27	8.53	12.79	Ni(OH)2
Ni3(AsO4)2:8H2O	-19.69	-3.99	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-17.06	14.94	32.00	Ni4(OH)6SO4
NiCO3	-5.18	-12.05	-6.87	NiCO3
NiMoO4	-3.74	-14.89	-11.14	NiMoO4
NiSe	-16.76	-34.46	-17.70	NiSe
NiSeO3:2H2O	-9.47	-6.65	2.81	NiSeO3:2H2O
NiSeO4:6H2O	-17.22	-18.74	-1.52	NiSeO4:6H2O
Nsutite	-8.57	8.93	17.50	MnO2
O2(g)	-34.64	48.45	83.09	O2
Otavite	-0.04	-12.04	-12.00	CdCO3
Pb(BO2)2	-9.10	-2.58	6.52	Pb(BO2)2
Pb(OH)2	-0.82	7.33	8.15	Pb(OH)2
Pb10(OH)6O(CO3)6	-41.39	-50.15	-8.76	Pb10(OH)6O(CO3)6
Pb2(OH)3Cl	-5.12	3.67	8.79	Pb2(OH)3Cl
Pb2O(OH)2	-11.52	14.66	26.19	Pb2O(OH)2
Pb2O3	-22.15	38.89	61.04	Pb2O3
Pb2OCO3	-5.36	-5.91	-0.56	Pb2OCO3
Pb2V2O7	-0.24	-2.14	-1.90	Pb2V2O7
Pb3(AsO4)2	-13.38	-7.58	5.80	Pb3(AsO4)2
Pb3(VO4)2	-0.95	5.19	6.14	Pb3(VO4)2
Pb3O2CO3	-9.60	1.42	11.02	Pb3O2CO3
Pb3O2SO4	-7.86	2.83	10.69	Pb3O2SO4
Pb4(OH)6SO4	-10.94	10.16	21.10	Pb4(OH)6SO4
Pb4O3SO4	-11.72	10.16	21.88	Pb4O3SO4
PbCrO4	-10.06	-22.66	-12.60	PbCrO4
PbF2	-10.24	-17.68	-7.44	PbF2
Pbmetal	-21.14	-16.89	4.25	Pb
PbMoO4	-0.46	-16.08	-15.62	PbMoO4
PbO:0.3H2O	-5.65	7.33	12.98	PbO:0.33H2O
PbSeO4	-13.09	-19.93	-6.84	PbSeO4
Periclase	-8.35	13.23	21.58	MgO
Phosgenite	-8.09	-27.90	-19.81	PbCl2:PbCO3
Plattnerite	-18.04	31.56	49.60	PbO2
Portlandite	-9.53	13.27	22.80	Ca(OH)2
Pyrochroite	-5.13	10.06	15.19	Mn(OH)2
Pyrolusite	-7.10	34.28	41.38	MnO2
Retgersite	-8.60	-10.64	-2.04	NiSO4:6H2O
Rhodochrosite	0.06	-10.52	-10.58	MnCO3
Rutherfordine	-7.08	-21.58	-14.50	UO2CO3
Schoepite	-7.00	-1.01	5.99	UO2(OH)2:H2O
Semetal(am)	-11.66	-18.77	-7.11	Se
Semetal(hex	-11.06	-18.77	-7.71	Se
SeO2	-15.30	-15.18	0.12	SeO2
SeO3	-48.31	-27.26	21.04	SeO3
Siderite	-2.62	-12.86	-10.24	FeCO3
Smithsonite	-0.57	-10.57	-10.00	ZnCO3
Spinel	-5.67	31.18	36.85	MgAl2O4
Tenorite	0.12	7.76	7.64	CuO
Thenardite	-7.50	-7.17	0.32	Na2SO4
Thermonatrite	-9.22	-8.58	0.64	Na2CO3:H2O
Tyuyamunite	-9.62	-5.54	4.08	Ca(UO2)2(VO4)2
U3O8	-20.67	0.41	21.08	U3O8
U4O9	-36.81	-39.83	-3.02	U4O9
UF4	-36.51	-66.04	-29.54	UF4
UF4:2.5H2O	-33.33	-66.04	-32.72	UF4:2.5H2O
UO2(am)	-16.95	-16.01	0.93	UO2
UO2(OH)2(beta)	-6.62	-1.00	5.61	UO2(OH)2
UO2SeO4:4H2O	-26.02	-28.27	-2.25	UO2SeO4:4H2O
UO3	-8.70	-1.00	7.70	UO3
Uraninite	-11.34	-16.01	-4.67	UO2
V(OH)3	-17.62	-10.03	7.59	V(OH)3
V2O5	-15.45	-16.81	-1.36	V2O5
V3O5	-36.90	-35.06	1.84	V3O5
V4O7	-45.86	-38.67	7.19	V4O7
V6O13	-38.01	-98.87	-60.86	V6O13
VCl2	-63.00	-44.13	18.87	VCl2
VCl3	-66.44	-43.01	23.43	VCl3
VF4	-68.57	-53.64	14.93	VF4
Vmetal	-90.39	-46.36	44.03	V
VO	-36.90	-22.14	14.76	VO
VO(OH)2	-8.76	-3.61	5.15	VO(OH)2
VO2Cl	-22.24	-19.40	2.84	VO2Cl
VOCl	-32.17	-21.02	11.15	VOCl
VOCl2	-38.36	-25.60	12.76	VOCl2
VOSO4	-26.39	-22.78	3.61	VOSO4
Witherite	-1.94	-10.51	-8.57	BaCO3
Zincite	-1.32	10.01	11.33	ZnO
Zincosite	-13.09	-9.16	3.93	ZnSO4
Zn(BO2)2	-8.19	0.10	8.29	Zn(BO2)2
Zn(OH)2	-2.19	10.01	12.20	Zn(OH)2
Zn(OH)2(am)	-2.47	10.01	12.47	Zn(OH)2
Zn(OH)2(beta)	-1.75	10.01	11.75	Zn(OH)2
Zn(OH)2(epsilon)	-1.53	10.01	11.53	Zn(OH)2
Zn(OH)2(gamma)	-1.73	10.01	11.73	Zn(OH)2
Zn2(OH)2SO4	-6.65	0.85	7.50	Zn2(OH)2SO4
Zn2(OH)3Cl	-6.17	9.02	15.19	Zn2(OH)3Cl
Zn3(AsO4)2:2.5H2O	-13.20	0.45	13.65	Zn3(AsO4)2:2.5H2O
Zn3O(SO4)2	-27.23	-8.31	18.91	Zn3O(SO4)2
Zn4(OH)6SO4	-7.54	20.86	28.40	Zn4(OH)6SO4
Zn5(OH)8Cl2	-10.44	28.06	38.50	Zn5(OH)8Cl2
ZnCl2	-19.03	-11.98	7.05	ZnCl2
ZnCO3:1H2O	-0.31	-10.57	-10.26	ZnCO3:1H2O
ZnF2	-14.47	-15.01	-0.53	ZnF2
Znmetal	-40.00	-14.21	25.79	Zn
ZnMoO4	-3.28	-13.40	-10.13	ZnMoO4
ZnO(active)	-1.18	10.01	11.19	ZnO
ZnSe	-18.58	-32.98	-14.40	ZnSe
ZnSeO4:6H2O	-15.74	-17.26	-1.52	ZnSeO4:6H2O
ZnSO4:1H2O	-8.52	-9.16	-0.64	ZnSO4:1H2O

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Initial solution 2. PAF Material

----------Solution composition----------

Elements	Molality	Moles
Al	7.415e-07	7.415e-07
Alkalinity	3.607e-04	3.607e-04
Ba	1.457e-07	1.457e-07
Ca	1.672e-03	1.672e-03
Co	1.188e-07	1.188e-07
Cu	4.408e-07	4.408e-07
F	1.580e-05	1.580e-05
K	3.326e-04	3.326e-04
Mg	3.293e-04	3.293e-04
Mn	7.283e-07	7.283e-07
Mo	3.128e-08	3.128e-08
Na	4.351e-05	4.351e-05
Ni	6.818e-08	6.818e-08
S(6)	2.051e-03	2.051e-03

----------Description of solution----------

pH	=	7.500
pe	=	4.000
Activity of water	=	1.000
Ionic strength (mol/kgw)	=	7.200e-03
Mass of water (kg)	=	1.000e+00
Total carbon (mol/kg)	=	3.782e-04
Total CO2 (mol/kg)	=	3.782e-04
Temperature (°C)	=	25.00
Electrical balance (eq)	=	-9.478e-05
Percent error, 100*(Cat-|An|)/(Cat+|An|)	=	-1.25
Iterations	=	13 (23 overall)
Total H	=	1.110141e+02
Total O	=	5.551618e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
OH-	3.487e-07	3.184e-07	-6.458	-6.497	-0.039	(0)
H+	3.458e-08	3.162e-08	-7.461	-7.500	-0.039	0.00
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000	18.07
Al	7.415e-07					
Al(OH)4-	7.221e-07	6.609e-07	-6.141	-6.180	-0.038	(0)
Al(OH)3	1.649e-08	1.649e-08	-7.783	-7.783	0.000	(0)
Al(OH)2+	2.830e-09	2.595e-09	-8.548	-8.586	-0.038	(0)
AlF2+	2.736e-11	2.509e-11	-10.563	-10.600	-0.038	(0)
AlOH+2	1.451e-11	1.026e-11	-10.838	-10.989	-0.150	(0)
AlF+2	6.374e-12	4.507e-12	-11.196	-11.346	-0.150	(0)
AlF3	4.418e-12	4.418e-12	-11.355	-11.355	0.000	(0)
AlSO4+	3.315e-13	3.034e-13	-12.480	-12.518	-0.038	(0)
Al+3	7.201e-14	3.223e-14	-13.143	-13.492	-0.349	(0)
AlF4-	3.383e-14	3.096e-14	-13.471	-13.509	-0.038	(0)
Al(SO4)2-	4.307e-15	3.942e-15	-14.366	-14.404	-0.038	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-49.070	-49.460	-0.390	(0)
Ba	1.457e-07					
Ba+2	1.453e-07	1.017e-07	-6.838	-6.993	-0.155	(0)
BaHCO3+	3.363e-10	3.088e-10	-9.473	-9.510	-0.037	(0)
BaCO3	2.459e-11	2.459e-11	-10.609	-10.609	0.000	(0)
BaOH+	1.542e-13	1.413e-13	-12.812	-12.850	-0.038	(0)
C(4)	3.782e-04					
HCO3-	3.469e-04	3.181e-04	-3.460	-3.497	-0.038	(0)
H2CO3	2.262e-05	2.262e-05	-4.645	-4.645	0.000	(0)
CaHCO3+	6.292e-06	5.777e-06	-5.201	-5.238	-0.037	(0)
CaCO3	7.289e-07	7.289e-07	-6.137	-6.137	0.000	(0)
MgHCO3+	7.079e-07	6.472e-07	-6.150	-6.189	-0.039	(0)
CO3-2	6.741e-07	4.716e-07	-6.171	-6.326	-0.155	(0)
CuCO3	2.133e-07	2.133e-07	-6.671	-6.671	0.000	(0)
MgCO3	7.799e-08	7.799e-08	-7.108	-7.108	0.000	(0)
NaHCO3	7.071e-09	7.071e-09	-8.151	-8.151	0.000	(0)
MnHCO3+	2.944e-09	2.697e-09	-8.531	-8.569	-0.038	(0)
CoHCO3+	1.830e-09	1.657e-09	-8.738	-8.781	-0.043	(0)
CuHCO3+	1.703e-09	1.542e-09	-8.769	-8.812	-0.043	(0)
NiHCO3+	1.700e-09	1.539e-09	-8.770	-8.813	-0.043	(0)
NiCO3	6.904e-10	6.904e-10	-9.161	-9.161	0.000	(0)
CoCO3	5.337e-10	5.337e-10	-9.273	-9.273	0.000	(0)
Cu(CO3)2-2	4.033e-10	2.707e-10	-9.394	-9.567	-0.173	(0)
NaCO3-	3.785e-10	3.471e-10	-9.422	-9.460	-0.038	(0)
BaHCO3+	3.363e-10	3.088e-10	-9.473	-9.510	-0.037	(0)
BaCO3	2.459e-11	2.459e-11	-10.609	-10.609	0.000	(0)
Ca	1.672e-03					
Ca+2	1.394e-03	9.753e-04	-2.856	-3.011	-0.155	(0)
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)
CaHCO3+	6.292e-06	5.777e-06	-5.201	-5.238	-0.037	(0)
CaCO3	7.289e-07	7.289e-07	-6.137	-6.137	0.000	(0)
CaF+	1.625e-07	1.489e-07	-6.789	-6.827	-0.038	(0)
CaOH+	6.748e-09	6.196e-09	-8.171	-8.208	-0.037	(0)
Co(2)	1.188e-07					
Co+2	9.974e-08	6.695e-08	-7.001	-7.174	-0.173	(0)
CoSO4	1.620e-08	1.620e-08	-7.791	-7.791	0.000	(0)
CoHCO3+	1.830e-09	1.657e-09	-8.738	-8.781	-0.043	(0)
CoCO3	5.337e-10	5.337e-10	-9.273	-9.273	0.000	(0)
CoOH+	4.699e-10	4.253e-10	-9.328	-9.371	-0.043	(0)
CoF+	3.271e-11	2.961e-11	-10.485	-10.529	-0.043	(0)
Co(OH)2	1.076e-11	1.076e-11	-10.968	-10.968	0.000	(0)
Co(OH)3-	7.550e-17	6.834e-17	-16.122	-16.165	-0.043	(0)
CoOOH-	1.894e-17	1.715e-17	-16.723	-16.766	-0.043	(0)
Co2OH+3	3.499e-18	1.427e-18	-17.456	-17.846	-0.390	(0)
Co(OH)4-2	5.137e-24	3.448e-24	-23.289	-23.462	-0.173	(0)
Co4(OH)4+4	3.216e-29	6.530e-30	-28.493	-29.185	-0.692	(0)
Co(3)	6.424e-30					
CoOH+2	6.424e-30	4.312e-30	-29.192	-29.365	-0.173	(0)
Co+3	5.955e-36	2.665e-36	-35.225	-35.574	-0.349	(0)
Cu(1)	4.157e-09					
Cu+	4.157e-09	3.762e-09	-8.381	-8.425	-0.043	(0)
Cu(2)	4.366e-07					
CuCO3	2.133e-07	2.133e-07	-6.671	-6.671	0.000	(0)
Cu+2	1.098e-07	7.682e-08	-6.959	-7.115	-0.155	(0)
CuOH+	8.460e-08	7.735e-08	-7.073	-7.112	-0.039	(0)
CuSO4	2.134e-08	2.134e-08	-7.671	-7.671	0.000	(0)
Cu(OH)2	4.914e-09	4.914e-09	-8.309	-8.309	0.000	(0)
CuHCO3+	1.703e-09	1.542e-09	-8.769	-8.812	-0.043	(0)
Cu(CO3)2-2	4.033e-10	2.707e-10	-9.394	-9.567	-0.173	(0)
Cu2(OH)2+2	2.239e-10	1.503e-10	-9.650	-9.823	-0.173	(0)
CuF+	7.488e-11	6.778e-11	-10.126	-10.169	-0.043	(0)
Cu(OH)3-	3.545e-12	3.209e-12	-11.450	-11.494	-0.043	(0)
Cu(OH)4-2	1.198e-17	8.042e-18	-16.922	-17.095	-0.173	(0)
F	1.580e-05					
F-	1.529e-05	1.398e-05	-4.816	-4.854	-0.039	(0)

MgF+	3.409e-07	3.120e-07	-6.467	-6.506	-0.038	(0)
CaF+	1.625e-07	1.489e-07	-6.789	-6.827	-0.038	(0)
HF	6.541e-10	6.541e-10	-9.184	-9.184	0.000	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
MnF+	2.582e-10	2.366e-10	-9.588	-9.626	-0.038	(0)
CuF+	7.488e-11	6.778e-11	-10.126	-10.169	-0.043	(0)
CoF+	3.271e-11	2.961e-11	-10.485	-10.529	-0.043	(0)
AlF2+	2.736e-11	2.509e-11	-10.563	-10.600	-0.038	(0)
NiF+	1.523e-11	1.379e-11	-10.817	-10.861	-0.043	(0)
AlF+2	6.374e-12	4.507e-12	-11.196	-11.346	-0.150	(0)
AlF3	4.418e-12	4.418e-12	-11.355	-11.355	0.000	(0)
HF2-	3.808e-14	3.478e-14	-13.419	-13.459	-0.039	(0)
AlF4-	3.383e-14	3.096e-14	-13.471	-13.509	-0.038	(0)
H2F2	1.146e-18	1.146e-18	-17.941	-17.941	0.000	(0)
H(0)	1.414e-26					
H2	7.068e-27	7.079e-27	-26.151	-26.150	0.001	(0)
K	3.326e-04					
K+	3.298e-04	3.016e-04	-3.482	-3.521	-0.039	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
Mg	3.293e-04					
Mg+2	2.842e-04	1.988e-04	-3.546	-3.702	-0.155	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
MgHCO3+	7.079e-07	6.472e-07	-6.150	-6.189	-0.039	(0)
MgF+	3.409e-07	3.120e-07	-6.467	-6.506	-0.038	(0)
MgCO3	7.799e-08	7.799e-08	-7.108	-7.108	0.000	(0)
MgOH+	2.742e-08	2.520e-08	-7.562	-7.599	-0.037	(0)
Mn(2)	7.283e-07					
Mn+2	6.331e-07	4.250e-07	-6.199	-6.372	-0.173	(0)
MnSO4	9.164e-08	9.164e-08	-7.038	-7.038	0.000	(0)
MnHCO3+	2.944e-09	2.697e-09	-8.531	-8.569	-0.038	(0)
MnOH+	3.710e-10	3.399e-10	-9.431	-9.469	-0.038	(0)
MnF+	2.582e-10	2.366e-10	-9.588	-9.626	-0.038	(0)
Mn(OH)3-	2.324e-19	2.129e-19	-18.634	-18.672	-0.038	(0)
Mn(OH)4-2	3.106e-25	2.189e-25	-24.508	-24.660	-0.152	(0)
Mn(3)	4.241e-28					
Mn+3	4.241e-28	1.898e-28	-27.373	-27.722	-0.349	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-48.642	-48.794	-0.152	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-54.126	-54.166	-0.040	(0)
Mo	3.128e-08					
MoO4-2	3.126e-08	2.187e-08	-7.505	-7.660	-0.155	(0)
HMoO4-	1.520e-11	1.376e-11	-10.818	-10.861	-0.043	(0)
H2MoO4	3.188e-15	3.188e-15	-14.497	-14.497	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-49.070	-49.460	-0.390	(0)
Mo7O24-6	0.000e+00	0.000e+00	-59.073	-60.631	-1.558	(0)
HMo7O24-5	0.000e+00	0.000e+00	-60.662	-61.744	-1.082	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-63.769	-64.462	-0.692	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-68.326	-68.716	-0.390	(0)
Na	4.351e-05					
Na+	4.322e-05	3.953e-05	-4.364	-4.403	-0.039	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
NaHCO3	7.071e-09	7.071e-09	-8.151	-8.151	0.000	(0)
NaCO3-	3.785e-10	3.471e-10	-9.422	-9.460	-0.038	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
Ni	6.818e-08					
Ni+2	5.610e-08	3.924e-08	-7.251	-7.406	-0.155	(0)
NiSO4	9.495e-09	9.495e-09	-8.023	-8.023	0.000	(0)
NiHCO3+	1.700e-09	1.539e-09	-8.770	-8.813	-0.043	(0)
NiCO3	6.904e-10	6.904e-10	-9.161	-9.161	0.000	(0)
NiOH+	1.738e-10	1.573e-10	-9.760	-9.803	-0.043	(0)
NiF+	1.523e-11	1.379e-11	-10.817	-10.861	-0.043	(0)
Ni(OH)2	3.978e-12	3.978e-12	-11.400	-11.400	0.000	(0)
Ni(SO4)2-2	5.679e-13	3.812e-13	-12.246	-12.419	-0.173	(0)
Ni(OH)3-	1.399e-15	1.267e-15	-14.854	-14.897	-0.043	(0)
O(0)	2.019e-40					
O2	1.010e-40	1.011e-40	-39.996	-39.995	0.001	(0)
S(6)	2.051e-03					
SO4-2	1.733e-03	1.213e-03	-2.761	-2.916	-0.155	(0)
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
MnSO4	9.164e-08	9.164e-08	-7.038	-7.038	0.000	(0)
CuSO4	2.134e-08	2.134e-08	-7.671	-7.671	0.000	(0)
CoSO4	1.620e-08	1.620e-08	-7.791	-7.791	0.000	(0)
NiSO4	9.495e-09	9.495e-09	-8.023	-8.023	0.000	(0)
HSO4-	4.094e-09	3.747e-09	-8.388	-8.426	-0.038	(0)
Ni(SO4)2-2	5.679e-13	3.812e-13	-12.246	-12.419	-0.173	(0)
AlSO4+	3.315e-13	3.034e-13	-12.480	-12.518	-0.038	(0)
Al(SO4)2-	4.307e-15	3.942e-15	-14.366	-14.404	-0.038	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.79	9.01	10.80	Al(OH)3
Al2(MoO4)3	-52.33	-49.96	2.37	Al2(MoO4)3
Al2O3	-1.64	18.02	19.65	Al2O3
Al4(OH)10SO4	-4.58	18.12	22.70	Al4(OH)10SO4
AlOHSO4	-5.68	-8.91	-3.23	AlOHSO4
Alunite	-3.43	-4.83	-1.40	KAl3(SO4)2(OH)6
Anhydrite	-1.57	-5.93	-4.36	CaSO4
Antlerite	-3.05	5.74	8.79	Cu3(OH)4SO4
Aragonite	-1.04	-9.34	-8.30	CaCO3
Artinite	-8.33	1.27	9.60	MgCO3:Mg(OH)2:3H2O
Azurite	-2.09	-19.00	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-16.39	8.01	24.39	Ba(OH)2:8H2O
BaF2	-10.88	-16.70	-5.82	BaF2
BaMoO4	-7.69	-14.65	-6.96	BaMoO4
Barite	0.07	-9.91	-9.98	BaSO4
Birnessite	-11.81	6.28	18.09	MnO2
Bixbyite	-9.80	-10.44	-0.64	Mn2O3
Boehmite	0.43	9.01	8.58	AlOOH
Brochantite	-1.60	13.63	15.22	Cu4(OH)6SO4
Brucite	-5.55	11.30	16.84	Mg(OH)2
Bunsenite	-4.85	7.59	12.45	NiO
Calcite	-0.86	-9.34	-8.48	CaCO3
CaMoO4	-2.72	-10.67	-7.95	CaMoO4
CH4(g)	-72.28	-113.33	-41.05	CH4
Chalcanthite	-7.39	-10.03	-2.64	CuSO4:5H2O
Co(OH)2	-5.27	7.83	13.09	Co(OH)2
Co(OH)3	-10.77	-13.07	-2.31	Co(OH)3
CO2(g)	-3.18	-21.33	-18.15	CO2
Co3O4	-7.83	-18.32	-10.50	Co3O4
CoCO3	-3.52	-13.50	-9.98	CoCO3
CoF2	-15.29	-16.88	-1.60	CoF2
CoF3	-48.68	-50.14	-1.46	CoF3
CoMoO4	-7.07	-14.83	-7.76	CoMoO4
CoO	-5.76	7.83	13.59	CoO
CoSO4	-12.89	-10.09	2.80	CoSO4
CoSO4:6H2O	-7.62	-10.09	-2.47	CoSO4:6H2O
Cryolite	-21.99	-55.83	-33.84	Na3AlF6
Cu(OH)2	-0.79	7.89	8.67	Cu(OH)2
Cu2SO4	-17.82	-19.77	-1.95	Cu2SO4
CuCO3	-1.94	-13.44	-11.50	CuCO3
CuF	-8.37	-13.28	-4.91	CuF
CuF2	-17.94	-16.82	1.12	CuF2
CuF2:2H2O	-12.27	-16.82	-4.55	CuF2:2H2O
Cumetal	-3.67	-12.42	-8.76	Cu
CuMoO4	-1.70	-14.77	-13.08	CuMoO4
CuOCuSO4	-12.45	-2.15	10.30	CuOCuSO4
Cuprite	-0.44	-1.85	-1.41	Cu2O
CuSO4	-12.97	-10.03	2.94	CuSO4
Diaspore	2.14	9.01	6.87	AlOOH
Dolomite(disordered)	-2.83	-19.37	-16.54	CaMg(CO3)2
Dolomite(ordered)	-2.28	-19.37	-17.09	CaMg(CO3)2
Epsomite	-4.49	-6.62	-2.13	MgSO4:7H2O
Fluorite	-2.22	-12.72	-10.50	CaF2
Gibbsite	0.72	9.01	8.29	Al(OH)3
Gypsum	-1.32	-5.93	-4.61	CaSO4:2H2O
H2MoO4	-9.78	-22.66	-12.88	H2MoO4
Hausmannite	-12.15	48.88	61.03	Mn3O4
Huntite	-9.45	-39.42	-29.97	CaMg3(CO3)4
Hydromagnesite	-20.05	-28.81	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-17.68	-22.85	-5.17	KAl(SO4)2:12H2O
K2MoO4	-17.96	-14.70	3.26	K2MoO4
Langite	-3.86	13.63	17.49	Cu4(OH)6SO4:H2O
Lime	-20.71	11.99	32.70	CaO
Magnesite	-2.57	-10.03	-7.46	MgCO3
Malachite	-0.25	-5.56	-5.31	Cu2(OH)2CO3
Manganite	-5.21	20.13	25.34	MnOOH
Mg(OH)2(active)	-7.50	11.30	18.79	Mg(OH)2
MgF2	-5.28	-13.41	-8.13	MgF2
MgMoO4	-9.51	-11.36	-1.85	MgMoO4
Mirabilite	-10.61	-11.72	-1.11	Na2SO4:10H2O
Mn2(SO4)3	-58.48	-64.19	-5.71	Mn2(SO4)3
MnSO4	-11.87	-9.29	2.58	MnSO4
MoO3	-14.66	-22.66	-8.00	MoO3
Morenosite	-8.18	-10.32	-2.14	NiSO4:7H2O
Na2Mo2O7	-22.53	-39.13	-16.60	Na2Mo2O7
Na2MoO4	-17.96	-16.47	1.49	Na2MoO4
Na2MoO4:2H2O	-17.69	-16.47	1.22	Na2MoO4:2H2O
Natron	-13.82	-15.13	-1.31	Na2CO3:10H2O
Nesquehonite	-5.36	-10.03	-4.67	MgCO3:3H2O
Ni(OH)2	-5.20	7.59	12.79	Ni(OH)2
Ni4(OH)6SO4	-19.54	12.46	32.00	Ni4(OH)6SO4
NiCO3	-6.86	-13.73	-6.87	NiCO3
NiMoO4	-3.92	-15.07	-11.14	NiMoO4
Nsutite	-11.23	6.28	17.50	MnO2
O2(g)	-37.09	46.00	83.09	O2
Periclase	-10.29	11.30	21.58	MgO
Portlandite	-10.81	11.99	22.80	Ca(OH)2
Pyrochroite	-6.57	8.63	15.19	Mn(OH)2
Pyrolusite	-9.75	31.63	41.38	MnO2
Retgersite	-8.28	-10.32	-2.04	NiSO4:6H2O
Rhodochrosite	-2.12	-12.70	-10.58	MnCO3
Spinel	-7.53	29.31	36.85	MgAl2O4
Tenorite	0.24	7.89	7.64	CuO
Thenardite	-12.04	-11.72	0.32	Na2SO4
Thermonatrite	-15.77	-15.13	0.64	Na2CO3:H2O
Witherite	-4.75	-13.32	-8.57	BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Initial solution 3. NAF Material

----------Solution composition----------

Elements	Molality	Moles
Al	5.191e-06	5.191e-06
Alkalinity	4.591e-04	4.591e-04
As	3.873e-07	3.873e-07
Ba	1.457e-07	1.457e-07
Ca	3.046e-03	3.046e-03
Co	3.395e-08	3.395e-08
Cu	2.992e-07	2.992e-07
F	1.580e-05	1.580e-05
Fe	1.254e-06	1.254e-06
K	4.094e-04	4.094e-04
Mg	7.410e-04	7.410e-04
Mn	2.368e-06	2.368e-06
Mo	5.214e-08	5.214e-08
Na	4.352e-05	4.352e-05
Ni	1.705e-08	1.705e-08
S(6)	3.447e-03	3.447e-03
U	4.203e-09	4.203e-09

----------Description of solution----------

pH	=	7.600
pe	=	4.000
Activity of water	=	1.000
Ionic strength (mol/kgw)	=	1.193e-02
Mass of water (kg)	=	1.000e+00
Total carbon (mol/kg)	=	4.552e-04
Total CO2 (mol/kg)	=	4.552e-04
Temperature (°C)	=	25.00
Electrical balance (eq)	=	6.787e-04
Percent error, 100*(Cat-|An|)/(Cat+|An|)	=	5.48
Iterations	=	11 (34 overall)
Total H	=	1.110142e+02
Total O	=	5.552201e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
OH-	4.492e-07	4.008e-07	-6.348	-6.397	-0.049	(0)
H+	2.808e-08	2.512e-08	-7.552	-7.600	-0.048	0.00
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000	18.07
Al	5.191e-06					
Al(OH)4-	5.088e-06	4.556e-06	-5.293	-5.341	-0.048	(0)
Al(OH)3	9.030e-08	9.030e-08	-7.044	-7.044	0.000	(0)
Al(OH)2+	1.257e-08	1.129e-08	-7.901	-7.947	-0.047	(0)
AlF2+	6.958e-11	6.249e-11	-10.158	-10.204	-0.047	(0)
AlOH+2	5.451e-11	3.546e-11	-10.264	-10.450	-0.187	(0)
AlF+2	1.811e-11	1.178e-11	-10.742	-10.929	-0.187	(0)
AlF3	1.048e-11	1.048e-11	-10.980	-10.980	0.000	(0)
AlSO4+	1.328e-12	1.189e-12	-11.877	-11.925	-0.048	(0)
Al+3	2.412e-13	8.848e-14	-12.618	-13.053	-0.436	(0)
AlF4-	7.812e-14	6.995e-14	-13.107	-13.155	-0.048	(0)
Al(SO4)2-	2.463e-14	2.206e-14	-13.608	-13.656	-0.048	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-48.018	-48.520	-0.501	(0)
As(3)	1.024e-17					
H3AsO3	1.000e-17	1.000e-17	-17.000	-17.000	0.000	(0)
H2AsO3-	2.322e-19	2.043e-19	-18.634	-18.690	-0.056	(0)
HAsO3-2	1.239e-23	7.417e-24	-22.907	-23.130	-0.223	(0)
H4AsO3+	1.416e-25	1.245e-25	-24.849	-24.905	-0.056	(0)
AsO3-3	3.611e-29	1.138e-29	-28.442	-28.944	-0.501	(0)
As(5)	3.873e-07					
HAsO4-2	3.350e-07	2.005e-07	-6.475	-6.698	-0.223	(0)
H2AsO4-	5.222e-08	4.594e-08	-7.282	-7.338	-0.056	(0)
AsO4-3	8.009e-11	2.524e-11	-10.096	-10.598	-0.501	(0)
H3AsO4	2.000e-13	2.005e-13	-12.699	-12.698	0.001	(0)
Ba	1.457e-07					
Ba+2	1.453e-07	9.304e-08	-6.838	-7.031	-0.194	(0)
BaHCO3+	3.699e-10	3.328e-10	-9.432	-9.478	-0.046	(0)
BaCO3	3.336e-11	3.336e-11	-10.477	-10.477	0.000	(0)
BaOH+	1.815e-13	1.628e-13	-12.741	-12.788	-0.047	(0)
C(4)	4.552e-04					

HCO3-	4.171e-04	3.746e-04	-3.380	-3.426	-0.047	(0)
H2CO3	2.116e-05	2.116e-05	-4.674	-4.674	0.000	(0)
CaHCO3+	1.200e-05	1.080e-05	-4.921	-4.967	-0.046	(0)
CaCO3	1.715e-06	1.715e-06	-5.766	-5.766	0.000	(0)
MgHCO3+	1.687e-06	1.508e-06	-5.773	-5.822	-0.049	(0)
CO3-2	1.092e-06	6.991e-07	-5.962	-6.155	-0.194	(0)
MgCO3	2.288e-07	2.288e-07	-6.641	-6.641	0.000	(0)
CuCO3	1.600e-07	1.600e-07	-6.796	-6.796	0.000	(0)
MnHCO3+	9.921e-09	8.899e-09	-8.003	-8.051	-0.047	(0)
NaHCO3	8.124e-09	8.124e-09	-8.090	-8.090	0.000	(0)
UO2(CO3)2-2	3.482e-09	2.084e-09	-8.458	-8.681	-0.223	(0)
CuHCO3+	1.044e-09	9.187e-10	-8.981	-9.037	-0.056	(0)
UO2(CO3)3-4	5.687e-10	7.303e-11	-9.245	-10.136	-0.891	(0)
NaCO3-	5.590e-10	5.020e-10	-9.253	-9.299	-0.047	(0)
CoHCO3+	5.432e-10	4.778e-10	-9.265	-9.321	-0.056	(0)
Cu(CO3)2-2	5.030e-10	3.011e-10	-9.298	-9.521	-0.223	(0)
NiHCO3+	4.493e-10	3.952e-10	-9.347	-9.403	-0.056	(0)
BaHCO3+	3.699e-10	3.328e-10	-9.432	-9.478	-0.046	(0)
NiCO3	2.232e-10	2.232e-10	-9.651	-9.651	0.000	(0)
CoCO3	1.938e-10	1.938e-10	-9.713	-9.713	0.000	(0)
UO2CO3	1.494e-10	1.494e-10	-9.826	-9.826	0.000	(0)
FeHCO3+	1.083e-10	9.748e-11	-9.965	-10.011	-0.046	(0)
BaCO3	3.336e-11	3.336e-11	-10.477	-10.477	0.000	(0)
Ca	**3.046e-03**					
Ca+2	2.418e-03	1.548e-03	-2.617	-2.810	-0.194	(0)
CaSO4	6.140e-04	6.140e-04	-3.212	-3.212	0.000	(0)
CaHCO3+	1.200e-05	1.080e-05	-4.921	-4.967	-0.046	(0)
CaCO3	1.715e-06	1.715e-06	-5.766	-5.766	0.000	(0)
CaF+	2.509e-07	2.251e-07	-6.600	-6.648	-0.047	(0)
CaOH+	1.376e-08	1.238e-08	-7.861	-7.907	-0.046	(0)
Co(2)	**3.395e-08**					
Co+2	2.739e-08	1.640e-08	-7.562	-7.785	-0.223	(0)
CoSO4	5.664e-09	5.664e-09	-8.247	-8.247	0.000	(0)
CoHCO3+	5.432e-10	4.778e-10	-9.265	-9.321	-0.056	(0)
CoCO3	1.938e-10	1.938e-10	-9.713	-9.713	0.000	(0)
CoOH+	1.491e-10	1.311e-10	-9.827	-9.882	-0.056	(0)
CoF+	7.852e-12	6.907e-12	-11.105	-11.161	-0.056	(0)
Co(OH)2	4.175e-12	4.175e-12	-11.379	-11.379	0.000	(0)
Co(OH)3-	3.796e-17	3.339e-17	-16.421	-16.476	-0.056	(0)
CoOOH-	9.525e-18	8.379e-18	-17.021	-17.077	-0.056	(0)
Co2OH+3	3.419e-19	1.078e-19	-18.466	-18.968	-0.501	(0)
Co(OH)4-2	3.543e-24	2.121e-24	-23.451	-23.673	-0.223	(0)
Co4(OH)4+4	4.595e-31	5.900e-32	-30.338	-31.229	-0.891	(0)
Co(3)	**2.221e-30**					
CoOH+2	2.221e-30	1.330e-30	-29.653	-29.876	-0.223	(0)
Co+3	1.780e-36	6.528e-37	-35.750	-36.185	-0.436	(0)
Cu(1)	**2.164e-09**					
Cu+	2.164e-09	1.904e-09	-8.665	-8.720	-0.056	(0)
Cu(2)	**2.970e-07**					
CuCO3	1.600e-07	1.600e-07	-6.796	-6.796	0.000	(0)
Cu+2	6.070e-08	3.887e-08	-7.217	-7.410	-0.194	(0)
CuOH+	5.512e-08	4.927e-08	-7.259	-7.307	-0.049	(0)
CuSO4	1.542e-08	1.542e-08	-7.812	-7.812	0.000	(0)
Cu(OH)2	3.940e-09	3.940e-09	-8.404	-8.404	0.000	(0)
CuHCO3+	1.044e-09	9.187e-10	-8.981	-9.037	-0.056	(0)
Cu(CO3)2-2	5.030e-10	3.011e-10	-9.298	-9.521	-0.223	(0)
Cu2(OH)2+2	1.019e-10	6.097e-11	-9.992	-10.215	-0.223	(0)
CuF+	3.714e-11	3.267e-11	-10.430	-10.486	-0.056	(0)
Cu(OH)3-	3.683e-12	3.239e-12	-11.434	-11.490	-0.056	(0)
Cu(OH)4-2	1.707e-17	1.022e-17	-16.768	-16.991	-0.223	(0)
F	**1.580e-05**					
F-	1.489e-05	1.332e-05	-4.827	-4.876	-0.048	(0)
MgF+	6.566e-07	5.879e-07	-6.183	-6.231	-0.048	(0)
CaF+	2.509e-07	2.251e-07	-6.600	-6.648	-0.047	(0)
MnF+	7.039e-10	6.314e-10	-9.152	-9.200	-0.047	(0)
HF	4.949e-10	4.949e-10	-9.306	-9.306	0.000	(0)

NaF	3.241e-10	3.241e-10	-9.489	-9.489	0.000	(0)
AlF2+	6.958e-11	6.249e-11	-10.158	-10.204	-0.047	(0)
CuF+	3.714e-11	3.267e-11	-10.430	-10.486	-0.056	(0)
AlF+2	1.811e-11	1.178e-11	-10.742	-10.929	-0.187	(0)
AlF3	1.048e-11	1.048e-11	-10.980	-10.980	0.000	(0)
CoF+	7.852e-12	6.907e-12	-11.105	-11.161	-0.056	(0)
NiF+	3.255e-12	2.863e-12	-11.487	-11.543	-0.056	(0)
UO2F+	1.122e-13	9.871e-14	-12.950	-13.006	-0.056	(0)
AlF4-	7.812e-14	6.995e-14	-13.107	-13.155	-0.048	(0)
HF2-	2.808e-14	2.506e-14	-13.552	-13.601	-0.049	(0)
UO2F2	3.792e-15	3.792e-15	-14.421	-14.421	0.000	(0)
FeF+2	4.333e-16	2.804e-16	-15.363	-15.552	-0.189	(0)
FeF2+	1.114e-16	9.996e-17	-15.953	-16.000	-0.047	(0)
UO2F3-	1.442e-17	1.269e-17	-16.841	-16.897	-0.056	(0)
FeF3	1.879e-18	1.879e-18	-17.726	-17.726	0.000	(0)
H2F2	6.561e-19	6.561e-19	-18.183	-18.183	0.000	(0)
UO2F4-2	2.242e-21	1.342e-21	-20.649	-20.872	-0.223	(0)
UF3+	3.760e-36	3.307e-36	-35.425	-35.481	-0.056	(0)
UF2+2	2.617e-36	1.567e-36	-35.582	-35.805	-0.223	(0)
UF+3	2.964e-38	9.342e-39	-37.528	-38.030	-0.501	(0)
UF4	4.830e-39	4.830e-39	-38.316	-38.316	0.000	(0)
UF5-	0.000e+00	0.000e+00	-41.538	-41.594	-0.056	(0)
UF6-2	0.000e+00	0.000e+00	-43.766	-43.989	-0.223	(0)
Fe(2)	**4.379e-08**					
Fe+2	3.453e-08	2.067e-08	-7.462	-7.685	-0.223	(0)
FeSO4	8.785e-09	8.785e-09	-8.056	-8.056	0.000	(0)
FeOH+	3.677e-10	3.298e-10	-9.434	-9.482	-0.047	(0)
FeHCO3+	1.083e-10	9.748e-11	-9.965	-10.011	-0.046	(0)
Fe(OH)2	1.050e-13	1.050e-13	-12.979	-12.979	0.000	(0)
Fe(OH)3-	1.484e-14	1.331e-14	-13.829	-13.876	-0.047	(0)
Fe(3)	**1.210e-06**					
Fe(OH)2+	8.628e-07	7.749e-07	-6.064	-6.111	-0.047	(0)
Fe(OH)3	3.336e-07	3.336e-07	-6.477	-6.477	0.000	(0)
Fe(OH)4-	1.386e-08	1.245e-08	-7.858	-7.905	-0.047	(0)
FeOH+2	7.678e-12	4.969e-12	-11.115	-11.304	-0.189	(0)
FeF+2	4.333e-16	2.804e-16	-15.363	-15.552	-0.189	(0)
FeSO4+	4.159e-16	3.730e-16	-15.381	-15.428	-0.047	(0)
FeF2+	1.114e-16	9.996e-17	-15.953	-16.000	-0.047	(0)
Fe+3	5.236e-17	1.920e-17	-16.281	-16.717	-0.436	(0)
Fe(SO4)2-	1.570e-17	1.381e-17	-16.804	-16.860	-0.056	(0)
FeF3	1.879e-18	1.879e-18	-17.726	-17.726	0.000	(0)
Fe2(OH)2+4	6.368e-21	8.178e-22	-20.196	-21.087	-0.891	(0)
Fe3(OH)4+5	2.263e-25	9.160e-27	-24.645	-26.038	-1.393	(0)
H(0)	**8.909e-27**					
H2	4.455e-27	4.467e-27	-26.351	-26.350	0.001	(0)
K	**4.094e-04**					
K+	4.045e-04	3.618e-04	-3.393	-3.441	-0.048	(0)
KSO4-	4.938e-06	4.435e-06	-5.306	-5.353	-0.047	(0)
Mg	**7.410e-04**					
Mg+2	6.144e-04	3.934e-04	-3.212	-3.405	-0.194	(0)
MgSO4	1.239e-04	1.239e-04	-3.907	-3.907	0.000	(0)
MgHCO3+	1.687e-06	1.508e-06	-5.773	-5.822	-0.049	(0)
MgF+	6.566e-07	5.879e-07	-6.183	-6.231	-0.048	(0)
MgCO3	2.288e-07	2.288e-07	-6.641	-6.641	0.000	(0)
MgOH+	6.966e-08	6.278e-08	-7.157	-7.202	-0.045	(0)
Mn(2)	**2.368e-06**					
Mn+2	1.989e-06	1.191e-06	-5.701	-5.924	-0.223	(0)
MnSO4	3.666e-07	3.666e-07	-6.436	-6.436	0.000	(0)
MnHCO3+	9.921e-09	8.899e-09	-8.003	-8.051	-0.047	(0)
MnOH+	1.337e-09	1.199e-09	-8.874	-8.921	-0.047	(0)
MnF+	7.039e-10	6.314e-10	-9.152	-9.200	-0.047	(0)
Mn(OH)3-	1.327e-18	1.190e-18	-17.877	-17.924	-0.047	(0)
Mn(OH)4-2	2.380e-24	1.540e-24	-23.623	-23.812	-0.189	(0)
Mn(3)	**1.450e-27**					
Mn+3	1.450e-27	5.318e-28	-26.839	-27.274	-0.436	(0)
Mn(6)	**0.000e+00**					

MnO4-2	0.000e+00	0.000e+00	-47.357	-47.546	-0.189	(0)
Mn(7)	**0.000e+00**					
MnO4-	0.000e+00	0.000e+00	-52.868	-52.918	-0.050	(0)
Mo	**5.214e-08**					
MoO4-2	5.212e-08	3.338e-08	-7.283	-7.477	-0.194	(0)
HMoO4-	1.896e-11	1.668e-11	-10.722	-10.778	-0.056	(0)
H2MoO4	3.069e-15	3.069e-15	-14.513	-14.513	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-48.018	-48.520	-0.501	(0)
Mo7O24-6	0.000e+00	0.000e+00	-58.140	-60.146	-2.006	(0)
HMo7O24-5	0.000e+00	0.000e+00	-59.966	-61.359	-1.393	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-63.285	-64.177	-0.891	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-68.029	-68.531	-0.501	(0)
Na	**4.352e-05**					
Na+	4.311e-05	3.857e-05	-4.365	-4.414	-0.048	(0)
NaSO4-	3.992e-07	3.586e-07	-6.399	-6.445	-0.047	(0)
NaHCO3	8.124e-09	8.124e-09	-8.090	-8.090	0.000	(0)
NaCO3-	5.590e-10	5.020e-10	-9.253	-9.299	-0.047	(0)
NaF	3.241e-10	3.241e-10	-9.489	-9.489	0.000	(0)
Ni	**1.705e-08**					
Ni+2	1.336e-08	8.558e-09	-7.874	-8.068	-0.194	(0)
NiSO4	2.956e-09	2.956e-09	-8.529	-8.529	0.000	(0)
NiHCO3+	4.493e-10	3.952e-10	-9.347	-9.403	-0.056	(0)
NiCO3	2.232e-10	2.232e-10	-9.651	-9.651	0.000	(0)
NiOH+	4.909e-11	4.318e-11	-10.309	-10.365	-0.056	(0)
NiF+	3.255e-12	2.863e-12	-11.487	-11.543	-0.056	(0)
Ni(OH)2	1.375e-12	1.375e-12	-11.862	-11.862	0.000	(0)
Ni(SO4)2-2	2.831e-13	1.695e-13	-12.548	-12.771	-0.223	(0)
Ni(OH)3-	6.265e-16	5.511e-16	-15.203	-15.259	-0.056	(0)
O(0)	**5.066e-40**					
O2	2.533e-40	2.540e-40	-39.596	-39.595	0.001	(0)
S(6)	**3.447e-03**					
SO4-2	2.704e-03	1.731e-03	-2.568	-2.762	-0.194	(0)
CaSO4	6.140e-04	6.140e-04	-3.212	-3.212	0.000	(0)
MgSO4	1.239e-04	1.239e-04	-3.907	-3.907	0.000	(0)
KSO4-	4.938e-06	4.435e-06	-5.306	-5.353	-0.047	(0)
NaSO4-	3.992e-07	3.586e-07	-6.399	-6.445	-0.047	(0)
MnSO4	3.666e-07	3.666e-07	-6.436	-6.436	0.000	(0)
CuSO4	1.542e-08	1.542e-08	-7.812	-7.812	0.000	(0)
FeSO4	8.785e-09	8.785e-09	-8.056	-8.056	0.000	(0)
CoSO4	5.664e-09	5.664e-09	-8.247	-8.247	0.000	(0)
HSO4-	4.746e-09	4.250e-09	-8.324	-8.372	-0.048	(0)
NiSO4	2.956e-09	2.956e-09	-8.529	-8.529	0.000	(0)
AlSO4+	1.328e-12	1.189e-12	-11.877	-11.925	-0.048	(0)
Ni(SO4)2-2	2.831e-13	1.695e-13	-12.548	-12.771	-0.223	(0)
UO2SO4	1.407e-13	1.407e-13	-12.852	-12.852	0.000	(0)
Al(SO4)2-	2.463e-14	2.206e-14	-13.608	-13.656	-0.048	(0)
UO2(SO4)2-2	5.363e-15	3.210e-15	-14.271	-14.493	-0.223	(0)
FeSO4+	4.159e-16	3.730e-16	-15.381	-15.428	-0.047	(0)
Fe(SO4)2-	1.570e-17	1.381e-17	-16.804	-16.860	-0.056	(0)
U(SO4)2	3.332e-38	3.332e-38	-37.477	-37.477	0.000	(0)
USO4+2	4.047e-39	2.423e-39	-38.393	-38.616	-0.223	(0)
U(3)	**0.000e+00**					
U+3	0.000e+00	0.000e+00	-54.749	-55.250	-0.501	(0)
U(4)	**3.033e-18**					
U(OH)5-	3.030e-18	2.665e-18	-17.519	-17.574	-0.056	(0)
U(OH)4	2.804e-21	2.804e-21	-20.552	-20.552	0.000	(0)
U(OH)3+	2.928e-25	2.575e-25	-24.533	-24.589	-0.056	(0)
U(OH)2+2	4.997e-30	2.991e-30	-29.301	-29.524	-0.223	(0)
UOH+3	1.123e-35	3.539e-36	-34.950	-35.451	-0.501	(0)
UF3+	3.760e-36	3.307e-36	-35.425	-35.481	-0.056	(0)
UF2+2	2.617e-36	1.567e-36	-35.582	-35.805	-0.223	(0)
U(SO4)2	3.332e-38	3.332e-38	-37.477	-37.477	0.000	(0)
UF+3	2.964e-38	9.342e-39	-37.528	-38.030	-0.501	(0)
UF4	4.830e-39	4.830e-39	-38.316	-38.316	0.000	(0)
USO4+2	4.047e-39	2.423e-39	-38.393	-38.616	-0.223	(0)
UF5-	0.000e+00	0.000e+00	-41.538	-41.594	-0.056	(0)

U+4	0.000e+00	0.000e+00	-41.563	-42.454	-0.891	(0)
UF6-2	0.000e+00	0.000e+00	-43.766	-43.989	-0.223	(0)
U6(OH)15+9	0.000e+00	0.000e+00	-153.367	-157.880	-4.513	(0)
U(5)	**3.720e-15**					
UO2+	3.720e-15	3.272e-15	-14.429	-14.485	-0.056	(0)
U(6)	**4.203e-09**					
UO2(CO3)2-2	3.482e-09	2.084e-09	-8.458	-8.681	-0.223	(0)
UO2(CO3)3-4	5.687e-10	7.303e-11	-9.245	-10.136	-0.891	(0)
UO2CO3	1.494e-10	1.494e-10	-9.826	-9.826	0.000	(0)
UO2OH+	3.080e-12	2.709e-12	-11.511	-11.567	-0.056	(0)
UO2SO4	1.407e-13	1.407e-13	-12.852	-12.852	0.000	(0)
UO2F+	1.122e-13	9.871e-14	-12.950	-13.006	-0.056	(0)
UO2+2	8.384e-14	5.369e-14	-13.077	-13.270	-0.194	(0)
UO2(SO4)2-2	5.363e-15	3.210e-15	-14.271	-14.493	-0.223	(0)
UO2F2	3.792e-15	3.792e-15	-14.421	-14.421	0.000	(0)
(UO2)2(OH)2+2	2.034e-17	1.218e-17	-16.692	-16.914	-0.223	(0)
UO2F3-	1.442e-17	1.269e-17	-16.841	-16.897	-0.056	(0)
(UO2)3(OH)5+	4.571e-18	4.021e-18	-17.340	-17.396	-0.056	(0)
UO2F4-2	2.242e-21	1.342e-21	-20.649	-20.872	-0.223	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.05	9.75	10.80	Al(OH)3
Al2(MoO4)3	-50.90	-48.54	2.37	Al2(MoO4)3
Al2O3	-0.16	19.49	19.65	Al2O3
Al4(OH)10SO4	-1.67	21.03	22.70	Al4(OH)10SO4
AlAsO4:2H2O	-7.75	-2.95	4.80	AlAsO4:2H2O
AlOHSO4	-4.98	-8.21	-3.23	AlOHSO4
Alunite	-1.12	-2.52	-1.40	KAl3(SO4)2(OH)6
Anhydrite	-1.21	-5.57	-4.36	CaSO4
Antlerite	-3.38	5.41	8.79	Cu3(OH)4SO4
Aragonite	-0.67	-8.97	-8.30	CaCO3
Arsenolite	-65.24	-68.00	-2.76	As4O6
Artinite	-7.37	2.23	9.60	MgCO3:Mg(OH)2:3H2O
As2O5	-32.10	-25.40	6.71	As2O5
Azurite	-2.44	-19.34	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-16.23	8.17	24.39	Ba(OH)2:8H2O
Ba3(AsO4)2	8.02	-0.89	-8.91	Ba3(AsO4)2
BaF2	-10.96	-16.78	-5.82	BaF2
BaMoO4	-7.55	-14.51	-6.96	BaMoO4
Barite	0.19	-9.79	-9.98	BaSO4
Birnessite	-10.97	7.13	18.09	MnO2
Bixbyite	-8.30	-8.95	-0.64	Mn2O3
Boehmite	1.17	9.75	8.58	AlOOH
Brochantite	-2.03	13.20	15.22	Cu4(OH)6SO4
Brucite	-5.05	11.79	16.84	Mg(OH)2
Bunsenite	-5.31	7.13	12.45	NiO
Ca3(AsO4)2:4H2O	-10.53	11.77	22.30	Ca3(AsO4)2:4H2O
Calcite	-0.49	-8.97	-8.48	CaCO3
CaMoO4	-2.34	-10.29	-7.95	CaMoO4
CH4(g)	-73.11	-114.16	-41.05	CH4
Chalcanthite	-7.53	-10.17	-2.64	CuSO4:5H2O
Claudetite	-64.93	-68.00	-3.06	As4O6
Co(OH)2	-5.68	7.41	13.09	Co(OH)2
Co(OH)3	-11.08	-13.39	-2.31	Co(OH)3
CO2(g)	-3.21	-21.36	-18.15	CO2
Co3(AsO4)2	-16.19	-3.15	13.03	Co3(AsO4)2
Co3O4	-8.86	-19.36	-10.50	Co3O4
CoCO3	-3.96	-13.94	-9.98	CoCO3
CoF2	-15.94	-17.54	-1.60	CoF2
CoF3	-49.35	-50.81	-1.46	CoF3
CoFe2O4	23.11	19.58	-3.53	CoFe2O4
CoMoO4	-7.50	-15.26	-7.76	CoMoO4
CoO	-6.17	7.41	13.59	CoO

CoSO4	-13.35	-10.55	2.80	CoSO4
CoSO4:6H2O	-8.07	-10.55	-2.47	CoSO4:6H2O
Cryolite	-21.71	-55.55	-33.84	Na3AlF6
Cu(OH)2	-0.88	7.79	8.67	Cu(OH)2
Cu2SO4	-18.25	-20.20	-1.95	Cu2SO4
Cu3(AsO4)2:2H2O	-8.13	-2.03	6.10	Cu3(AsO4)2:2H2O
CuCO3	-2.07	-13.57	-11.50	CuCO3
CuF	-8.69	-13.60	-4.91	CuF
CuF2	-18.28	-17.16	1.12	CuF2
CuF2:2H2O	-12.61	-17.16	-4.55	CuF2:2H2O
Cumetal	-3.96	-12.72	-8.76	Cu
CuMoO4	-1.81	-14.89	-13.08	CuMoO4
CuOCuSO4	-12.69	-2.38	10.30	CuOCuSO4
Cupricferrite	13.97	19.96	5.99	CuFe2O4
Cuprite	-0.83	-2.24	-1.41	Cu2O
Cuprousferrite	13.88	4.96	-8.92	CuFeO2
CuSO4	-13.11	-10.17	2.94	CuSO4
Diaspore	2.87	9.75	6.87	AlOOH
Dolomite(disordered)	-1.99	-18.53	-16.54	CaMg(CO3)2
Dolomite(ordered)	-1.44	-18.53	-17.09	CaMg(CO3)2
Epsomite	-4.04	-6.17	-2.13	MgSO4:7H2O
Fe(OH)2	-6.05	7.52	13.56	Fe(OH)2
Fe2(SO4)3	-37.98	-41.72	-3.73	Fe2(SO4)3
Fe3(OH)8	-0.54	19.68	20.22	Fe3(OH)8
FeAsO4:2H2O	-7.01	-6.61	0.40	FeAsO4:2H2O
FeMoO4	-5.07	-15.16	-10.09	FeMoO4
Ferrihydrite	2.89	6.08	3.19	Fe(OH)3
Fluorite	-2.06	-12.56	-10.50	CaF2
Gibbsite	1.46	9.75	8.29	Al(OH)3
Goethite	5.59	6.08	0.49	FeOOH
Gummite	-5.74	1.93	7.67	UO3
Gypsum	-0.96	-5.57	-4.61	CaSO4:2H2O
H-Jarosite	-5.57	-17.67	-12.10	(H3O)Fe3(SO4)2(OH)6
H2MoO4	-9.80	-22.68	-12.88	H2MoO4
Hausmannite	-10.00	51.03	61.03	Mn3O4
Hematite	13.58	12.17	-1.42	Fe2O3
Hercynite	4.12	27.01	22.89	FeAl2O4
Huntite	-7.68	-37.65	-29.97	CaMg3(CO3)4
Hydromagnesite	-17.68	-26.45	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-16.85	-22.02	-5.17	KAl(SO4)2:12H2O
K-Jarosite	1.28	-13.52	-14.80	KFe3(SO4)2(OH)6
K2MoO4	-17.62	-14.36	3.26	K2MoO4
Langite	-4.29	13.20	17.49	Cu4(OH)6SO4:H2O
Lepidocrocite	4.71	6.08	1.37	FeOOH
Lime	-20.31	12.39	32.70	CaO
Maghemite	5.78	12.17	6.39	Fe2O3
Magnesioferrite	7.10	23.96	16.86	Fe2MgO4
Magnesite	-2.10	-9.56	-7.46	MgCO3
Magnetite	16.28	19.68	3.40	Fe3O4
Malachite	-0.47	-5.78	-5.31	Cu2(OH)2CO3
Manganite	-4.46	20.88	25.34	MnOOH
Melanterite	-8.24	-10.45	-2.21	FeSO4:7H2O
Mg(OH)2(active)	-7.00	11.79	18.79	Mg(OH)2
MgF2	-5.03	-13.16	-8.13	MgF2
MgMoO4	-9.03	-10.88	-1.85	MgMoO4
Mirabilite	-10.48	-11.59	-1.11	Na2SO4:10H2O
Mn2(SO4)3	-57.12	-62.83	-5.71	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-10.07	2.43	12.50	Mn3(AsO4)2:8H2O
MnSO4	-11.27	-8.69	2.58	MnSO4
MoO3	-14.68	-22.68	-8.00	MoO3
Morenosite	-8.68	-10.83	-2.14	NiSO4:7H2O
Na-Jarosite	-3.29	-14.49	-11.20	NaFe3(SO4)2(OH)6
Na2Mo2O7	-22.38	-38.98	-16.60	Na2Mo2O7
Na2MoO4	-17.79	-16.30	1.49	Na2MoO4
Na2MoO4:2H2O	-17.53	-16.30	1.22	Na2MoO4:2H2O
Natron	-13.67	-14.98	-1.31	Na2CO3:10H2O
Nesquehonite	-4.89	-9.56	-4.67	MgCO3:3H2O
Ni(OH)2	-5.66	7.13	12.79	Ni(OH)2
Ni3(AsO4)2:8H2O	-19.70	-4.00	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-21.43	10.57	32.00	Ni4(OH)6SO4
NiCO3	-7.35	-14.22	-6.87	NiCO3
NiMoO4	-4.40	-15.54	-11.14	NiMoO4
Nsutite	-10.38	7.13	17.50	MnO2
O2(g)	-36.69	46.40	83.09	O2
Periclase	-9.79	11.79	21.58	MgO
Portlandite	-10.41	12.39	22.80	Ca(OH)2
Pyrochroite	-5.92	9.28	15.19	Mn(OH)2
Pyrolusite	-8.90	32.48	41.38	MnO2
Retgersite	-8.79	-10.83	-2.04	NiSO4:6H2O
Rhodochrosite	-1.50	-12.08	-10.58	MnCO3
Rutherfordine	-4.93	-19.43	-14.50	UO2CO3
Schoepite	-4.06	1.93	5.99	UO2(OH)2:H2O
Siderite	-3.60	-13.84	-10.24	FeCO3
Spinel	-5.56	31.29	36.85	MgAl2O4
Tenorite	0.15	7.79	7.64	CuO
Thenardite	-11.91	-11.59	0.32	Na2SO4
Thermonatrite	-15.62	-14.98	0.64	Na2CO3:H2O
U3O8	-10.85	10.24	21.08	U3O8
U4O9	-22.00	-25.02	-3.02	U4O9
UF4	-32.42	-61.96	-29.54	UF4
UF4:2.5H2O	-29.24	-61.96	-32.72	UF4:2.5H2O
UO2(am)	-12.99	-12.05	0.93	UO2
UO2(OH)2(beta)	-3.68	1.93	5.61	UO2(OH)2
UO3	-5.77	1.93	7.70	UO3
Uraninite	-7.38	-12.05	-4.67	UO2
Witherite	-4.62	-13.19	-8.57	BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Initial solution 4. Make-up Material

----------Solution composition----------

Elements	Molality	Moles
Al	7.415e-07	7.415e-07
Alkalinity	3.607e-04	3.607e-04
Ba	1.457e-07	1.457e-07
Ca	1.672e-03	1.672e-03
Co	1.188e-07	1.188e-07
Cu	4.408e-07	4.408e-07
F	1.580e-05	1.580e-05
K	3.326e-04	3.326e-04
Mg	3.293e-04	3.293e-04
Mn	7.283e-07	7.283e-07
Mo	3.128e-08	3.128e-08
Na	4.351e-05	4.351e-05
Ni	6.818e-08	6.818e-08
S(6)	2.051e-03	2.051e-03

----------Description of solution----------

pH	=	7.700
pe	=	4.000
Activity of water	=	1.000
Ionic strength (mol/kgw)	=	7.199e-03
Mass of water (kg)	=	1.000e+00
Total carbon (mol/kg)	=	3.686e-04
Total CO2 (mol/kg)	=	3.686e-04
Temperature (°C)	=	25.00
Electrical balance (eq)	=	-9.478e-05

Percent error, 100*(Cat-|An|)/(Cat+|An|) = -1.25
Iterations = 12 (46 overall)
Total H = 1.110140e+02
Total O = 5.551615e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol	
OH-	5.526e-07	5.046e-07	-6.258	-6.297	-0.039	(0)	
H+	2.182e-08	1.995e-08	-7.661	-7.700	-0.039	0.00	
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000	18.07	
Al	7.415e-07						
Al(OH)4-	7.298e-07	6.680e-07	-6.137	-6.175	-0.038	(0)	
Al(OH)3	1.051e-08	1.051e-08	-7.978	-7.978	0.000	(0)	
Al(OH)2+	1.139e-09	1.044e-09	-8.944	-8.981	-0.038	(0)	
AlF2+	4.383e-12	4.020e-12	-11.358	-11.396	-0.038	(0)	
AlOH+2	3.684e-12	2.605e-12	-11.434	-11.584	-0.150	(0)	
AlF+2	1.021e-12	7.220e-13	-11.991	-12.141	-0.150	(0)	
AlF3	7.077e-13	7.077e-13	-12.150	-12.150	0.000	(0)	
AlSO4+	5.310e-14	4.860e-14	-13.275	-13.313	-0.038	(0)	
Al+3	1.153e-14	5.163e-15	-13.938	-14.287	-0.349	(0)	
AlF4-	5.420e-15	4.960e-15	-14.266	-14.304	-0.038	(0)	
Al(SO4)2-	6.899e-16	6.315e-16	-15.161	-15.200	-0.038	(0)	
AlMo6O21-3	0.000e+00	0.000e+00	-51.065	-51.455	-0.389	(0)	
Ba	1.457e-07						
Ba+2	1.453e-07	1.017e-07	-6.838	-6.993	-0.155	(0)	
BaHCO3+	3.344e-10	3.070e-10	-9.476	-9.513	-0.037	(0)	
BaCO3	3.874e-11	3.874e-11	-10.412	-10.412	0.000	(0)	
BaOH+	2.444e-13	2.239e-13	-12.612	-12.650	-0.038	(0)	
C(4)	3.686e-04						
HCO3-	3.449e-04	3.163e-04	-3.462	-3.500	-0.038	(0)	
H2CO3	1.419e-05	1.419e-05	-4.848	-4.848	0.000	(0)	
CaHCO3+	6.254e-06	5.742e-06	-5.204	-5.241	-0.037	(0)	
CaCO3	1.148e-06	1.148e-06	-5.940	-5.940	0.000	(0)	
CO3-2	1.062e-06	7.431e-07	-5.974	-6.129	-0.155	(0)	
MgHCO3+	7.037e-07	6.434e-07	-6.153	-6.192	-0.039	(0)	
CuCO3	2.384e-07	2.384e-07	-6.623	-6.623	0.000	(0)	
MgCO3	1.229e-07	1.229e-07	-6.911	-6.911	0.000	(0)	
NaHCO3	7.030e-09	7.030e-09	-8.153	-8.153	0.000	(0)	
MnHCO3+	2.926e-09	2.681e-09	-8.534	-8.572	-0.038	(0)	
CoHCO3+	1.811e-09	1.639e-09	-8.742	-8.785	-0.043	(0)	
NiHCO3+	1.678e-09	1.519e-09	-8.775	-8.818	-0.043	(0)	
CuHCO3+	1.201e-09	1.087e-09	-8.920	-8.964	-0.043	(0)	
NiCO3	1.080e-09	1.080e-09	-8.967	-8.967	0.000	(0)	
CoCO3	8.369e-10	8.369e-10	-9.077	-9.077	0.000	(0)	
Cu(CO3)2-2	7.104e-10	4.768e-10	-9.149	-9.322	-0.173	(0)	
NaCO3-	5.965e-10	5.470e-10	-9.224	-9.262	-0.038	(0)	
BaHCO3+	3.344e-10	3.070e-10	-9.476	-9.513	-0.037	(0)	
BaCO3	3.874e-11	3.874e-11	-10.412	-10.412	0.000	(0)	
Ca	1.672e-03						
Ca+2	1.394e-03	9.751e-04	-2.856	-3.011	-0.155	(0)	
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)	
CaHCO3+	6.254e-06	5.742e-06	-5.204	-5.241	-0.037	(0)	
CaCO3	1.148e-06	1.148e-06	-5.940	-5.940	0.000	(0)	
CaF+	1.624e-07	1.488e-07	-6.789	-6.827	-0.038	(0)	
CaOH+	1.069e-08	9.818e-09	-7.971	-8.008	-0.037	(0)	
Co(2)	1.188e-07						
Co+2	9.925e-08	6.662e-08	-7.003	-7.176	-0.173	(0)	
CoSO4	1.612e-08	1.612e-08	-7.793	-7.793	0.000	(0)	
CoHCO3+	1.811e-09	1.639e-09	-8.742	-8.785	-0.043	(0)	
CoCO3	8.369e-10	8.369e-10	-9.077	-9.077	0.000	(0)	
CoOH+	7.411e-10	6.708e-10	-9.130	-9.173	-0.043	(0)	
CoF+	3.255e-11	2.946e-11	-10.487	-10.531	-0.043	(0)	
Co(OH)2	2.689e-11	2.689e-11	-10.570	-10.570	0.000	(0)	
Co(OH)3-	2.991e-16	2.707e-16	-15.524	-15.567	-0.043	(0)	
CoOOH-	7.505e-17	6.793e-17	-16.125	-16.168	-0.043	(0)	
Co2OH+3	5.491e-18	2.240e-18	-17.260	-17.650	-0.389	(0)	
Co(OH)4-2	3.225e-23	2.165e-23	-22.491	-22.665	-0.173	(0)	
Co4(OH)4+4	1.990e-28	4.040e-29	-27.701	-28.394	-0.692	(0)	
Co(3)	1.013e-29						
CoOH+2	1.013e-29	6.801e-30	-28.994	-29.167	-0.173	(0)	
Co+3	5.925e-36	2.652e-36	-35.227	-35.576	-0.349	(0)	
Cu(1)	2.948e-09						
Cu+	2.948e-09	2.668e-09	-8.530	-8.574	-0.043	(0)	
Cu(2)	4.378e-07						
CuCO3	2.384e-07	2.384e-07	-6.623	-6.623	0.000	(0)	
CuOH+	9.510e-08	8.694e-08	-7.022	-7.061	-0.039	(0)	
Cu+2	7.788e-08	5.448e-08	-7.109	-7.264	-0.155	(0)	
CuSO4	1.514e-08	1.514e-08	-7.820	-7.820	0.000	(0)	
Cu(OH)2	8.754e-09	8.754e-09	-8.058	-8.058	0.000	(0)	
CuHCO3+	1.201e-09	1.087e-09	-8.920	-8.964	-0.043	(0)	
Cu(CO3)2-2	7.104e-10	4.768e-10	-9.149	-9.322	-0.173	(0)	
Cu2(OH)2+2	2.829e-10	1.899e-10	-9.548	-9.722	-0.173	(0)	
CuF+	5.311e-11	4.808e-11	-10.275	-10.318	-0.043	(0)	
Cu(OH)3-	1.001e-11	9.061e-12	-11.000	-11.043	-0.043	(0)	
Cu(OH)4-2	5.361e-17	3.599e-17	-16.271	-16.444	-0.173	(0)	
F	1.580e-05						
F-	1.529e-05	1.398e-05	-4.816	-4.854	-0.039	(0)	
MgF+	3.408e-07	3.119e-07	-6.467	-6.506	-0.038	(0)	
CaF+	1.624e-07	1.488e-07	-6.789	-6.827	-0.038	(0)	
HF	4.127e-10	4.127e-10	-9.384	-9.384	0.000	(0)	
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)	
MnF+	2.582e-10	2.365e-10	-9.588	-9.626	-0.038	(0)	
CuF+	5.311e-11	4.808e-11	-10.275	-10.318	-0.043	(0)	
CoF+	3.255e-11	2.946e-11	-10.487	-10.531	-0.043	(0)	
NiF+	1.512e-11	1.369e-11	-10.820	-10.864	-0.043	(0)	
AlF2+	4.383e-12	4.020e-12	-11.358	-11.396	-0.038	(0)	
AlF+2	1.021e-12	7.220e-13	-11.991	-12.141	-0.150	(0)	
AlF3	7.077e-13	7.077e-13	-12.150	-12.150	0.000	(0)	
HF2-	2.403e-14	2.194e-14	-13.619	-13.659	-0.039	(0)	
AlF4-	5.420e-15	4.960e-15	-14.266	-14.304	-0.038	(0)	
H2F2	4.564e-19	4.564e-19	-18.341	-18.341	0.000	(0)	
H(0)	5.627e-27						
H2	2.814e-27	2.818e-27	-26.551	-26.550	0.001	(0)	
K	3.326e-04						
K+	3.298e-04	3.016e-04	-3.482	-3.521	-0.039	(0)	
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)	
Mg	3.293e-04						
Mg+2	2.842e-04	1.988e-04	-3.546	-3.702	-0.155	(0)	
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)	
MgHCO3+	7.037e-07	6.434e-07	-6.153	-6.192	-0.039	(0)	
MgF+	3.408e-07	3.119e-07	-6.467	-6.506	-0.038	(0)	
MgCO3	1.229e-07	1.229e-07	-6.911	-6.911	0.000	(0)	
MgOH+	4.345e-08	3.994e-08	-7.362	-7.399	-0.037	(0)	
Mn(2)	7.283e-07						
Mn+2	6.329e-07	4.249e-07	-6.199	-6.372	-0.173	(0)	
MnSO4	9.162e-08	9.162e-08	-7.038	-7.038	0.000	(0)	
MnHCO3+	2.926e-09	2.681e-09	-8.534	-8.572	-0.038	(0)	
MnOH+	5.878e-10	5.385e-10	-9.231	-9.269	-0.038	(0)	
MnF+	2.582e-10	2.365e-10	-9.588	-9.626	-0.038	(0)	
Mn(OH)3-	9.250e-19	8.475e-19	-18.034	-18.072	-0.038	(0)	
Mn(OH)4-2	1.959e-24	1.381e-24	-23.708	-23.860	-0.152	(0)	
Mn(3)	4.240e-28						
Mn+3	4.240e-28	1.898e-28	-27.373	-27.722	-0.349	(0)	
Mn(6)	0.000e+00						
MnO4-2	0.000e+00	0.000e+00	-47.042	-47.194	-0.152	(0)	
Mn(7)	0.000e+00						
MnO4-	0.000e+00	0.000e+00	-52.526	-52.566	-0.040	(0)	
Mo	3.128e-08						
MoO4-2	3.127e-08	2.188e-08	-7.505	-7.660	-0.155	(0)	

HMoO4-	9.595e-12	8.685e-12	-11.018	-11.061	-0.043	(0)
H2MoO4	1.269e-15	1.269e-15	-14.896	-14.896	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-51.065	-51.455	-0.389	(0)
Mo7O24-6	0.000e+00	0.000e+00	-60.672	-62.230	-1.558	(0)
HMo7O24-5	0.000e+00	0.000e+00	-62.461	-63.543	-1.082	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-65.769	-66.461	-0.692	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-70.526	-70.915	-0.389	(0)
Na	4.351e-05					
Na+	4.322e-05	3.953e-05	-4.364	-4.403	-0.039	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
NaHCO3	7.030e-09	7.030e-09	-8.153	-8.153	0.000	(0)
NaCO3-	5.965e-10	5.470e-10	-9.224	-9.262	-0.038	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
Ni	6.818e-08					
Ni+2	5.569e-08	3.896e-08	-7.254	-7.409	-0.155	(0)
NiSO4	9.427e-09	9.427e-09	-8.026	-8.026	0.000	(0)
NiHCO3+	1.678e-09	1.519e-09	-8.775	-8.818	-0.043	(0)
NiCO3	1.080e-09	1.080e-09	-8.967	-8.967	0.000	(0)
NiOH+	2.734e-10	2.475e-10	-9.563	-9.606	-0.043	(0)
NiF+	1.512e-11	1.369e-11	-10.820	-10.864	-0.043	(0)
Ni(OH)2	9.921e-12	9.921e-12	-11.003	-11.003	0.000	(0)
Ni(SO4)2-2	5.639e-13	3.785e-13	-12.249	-12.422	-0.173	(0)
Ni(OH)3-	5.531e-15	5.006e-15	-14.257	-14.300	-0.043	(0)
O(0)	1.274e-39					
O2	6.370e-40	6.381e-40	-39.196	-39.195	0.001	(0)
S(6)	2.051e-03					
SO4-2	1.733e-03	1.213e-03	-2.761	-2.916	-0.155	(0)
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
MnSO4	9.162e-08	9.162e-08	-7.038	-7.038	0.000	(0)
CoSO4	1.612e-08	1.612e-08	-7.793	-7.793	0.000	(0)
CuSO4	1.514e-08	1.514e-08	-7.820	-7.820	0.000	(0)
NiSO4	9.427e-09	9.427e-09	-8.026	-8.026	0.000	(0)
HSO4-	2.583e-09	2.364e-09	-8.588	-8.626	-0.038	(0)
Ni(SO4)2-2	5.639e-13	3.785e-13	-12.249	-12.422	-0.173	(0)
AlSO4+	5.310e-14	4.860e-14	-13.275	-13.313	-0.038	(0)
Al(SO4)2-	6.899e-16	6.315e-16	-15.161	-15.200	-0.038	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.99	8.81	10.80	Al(OH)3
Al2(MoO4)3	-53.92	-51.55	2.37	Al2(MoO4)3
Al2O3	-2.03	17.63	19.65	Al2O3
Al4(OH)10SO4	-5.77	16.93	22.70	Al4(OH)10SO4
AlOHSO4	-6.27	-9.50	-3.23	AlOHSO4
Alunite	-4.61	-6.01	-1.40	KAl3(SO4)2(OH)6
Anhydrite	-1.57	-5.93	-4.36	CaSO4
Antlerite	-2.70	6.09	8.79	Cu3(OH)4SO4
Aragonite	-0.84	-9.14	-8.30	CaCO3
Artinite	-7.73	1.87	9.60	MgCO3:Mg(OH)2:3H2O
Azurite	-1.74	-18.65	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-15.99	8.41	24.39	Ba(OH)2:8H2O
BaF2	-10.88	-16.70	-5.82	BaF2
BaMoO4	-7.69	-14.65	-6.96	BaMoO4
Barite	0.07	-9.91	-9.98	BaSO4
Birnessite	-11.01	7.08	18.09	MnO2
Bixbyite	-8.60	-9.24	-0.64	Mn2O3
Boehmite	0.23	8.81	8.58	AlOOH
Brochantite	-0.99	14.23	15.22	Cu4(OH)6SO4
Brucite	-5.15	11.70	16.84	Mg(OH)2
Bunsenite	-4.45	7.99	12.45	NiO
Calcite	-0.66	-9.14	-8.48	CaCO3
CaMoO4	-2.72	-10.67	-7.95	CaMoO4
CH4(g)	-74.08	-115.13	-41.05	CH4
Chalcanthite	-7.54	-10.18	-2.64	CuSO4:5H2O
Co(OH)2	-4.87	8.22	13.09	Co(OH)2
Co(OH)3	-10.17	-12.48	-2.31	Co(OH)3
CO2(g)	-3.38	-21.53	-18.15	CO2
Co3O4	-6.23	-16.73	-10.50	Co3O4
CoCO3	-3.33	-13.31	-9.98	CoCO3
CoF2	-15.29	-16.89	-1.60	CoF2
CoF3	-48.68	-50.14	-1.46	CoF3
CoMoO4	-7.08	-14.84	-7.76	CoMoO4
CoO	-5.36	8.22	13.59	CoO
CoSO4	-12.90	-10.09	2.80	CoSO4
CoSO4:6H2O	-7.62	-10.09	-2.47	CoSO4:6H2O
Cryolite	-22.78	-56.62	-33.84	Na3AlF6
Cu(OH)2	-0.54	8.14	8.67	Cu(OH)2
Cu2SO4	-18.11	-20.06	-1.95	Cu2SO4
CuCO3	-1.89	-13.39	-11.50	CuCO3
CuF	-8.52	-13.43	-4.91	CuF
CuF2	-18.09	-16.97	1.12	CuF2
CuF2:2H2O	-12.42	-16.97	-4.55	CuF2:2H2O
Cumetal	-3.82	-12.57	-8.76	Cu
CuMoO4	-1.85	-14.92	-13.08	CuMoO4
CuOCuSO4	-12.35	-2.04	10.30	CuOCuSO4
Cuprite	-0.34	-1.75	-1.41	Cu2O
CuSO4	-13.12	-10.18	2.94	CuSO4
Diaspore	1.94	8.81	6.87	AlOOH
Dolomite(disordered)	-2.43	-18.97	-16.54	CaMg(CO3)2
Dolomite(ordered)	-1.88	-18.97	-17.09	CaMg(CO3)2
Epsomite	-4.49	-6.62	-2.13	MgSO4:7H2O
Fluorite	-2.22	-12.72	-10.50	CaF2
Gibbsite	0.52	8.81	8.29	Al(OH)3
Gypsum	-1.32	-5.93	-4.61	CaSO4:2H2O
H2MoO4	-10.18	-23.06	-12.88	H2MoO4
Hausmannite	-10.55	50.48	61.03	Mn3O4
Huntite	-8.66	-38.63	-29.97	CaMg3(CO3)4
Hydromagnesite	-18.86	-27.62	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-18.47	-23.64	-5.17	KAl(SO4)2:12H2O
K2MoO4	-17.96	-14.70	3.26	K2MoO4
Langite	-3.26	14.23	17.49	Cu4(OH)6SO4:H2O
Lime	-20.31	12.39	32.70	CaO
Magnesite	-2.37	-9.83	-7.46	MgCO3
Malachite	0.05	-5.26	-5.31	Cu2(OH)2CO3
Manganite	-4.61	20.73	25.34	MnOOH
Mg(OH)2(active)	-7.10	11.70	18.79	Mg(OH)2
MgF2	-5.28	-13.41	-8.13	MgF2
MgMoO4	-9.51	-11.36	-1.85	MgMoO4
Mirabilite	-10.61	-11.72	-1.11	Na2SO4:10H2O
Mn2(SO4)3	-58.48	-64.19	-5.71	Mn2(SO4)3
MnSO4	-11.87	-9.29	2.58	MnSO4
MoO3	-15.06	-23.06	-8.00	MoO3
Morenosite	-8.18	-10.33	-2.14	NiSO4:7H2O
Na2Mo2O7	-22.93	-39.53	-16.60	Na2Mo2O7
Na2MoO4	-17.96	-16.47	1.49	Na2MoO4
Na2MoO4:2H2O	-17.69	-16.47	1.22	Na2MoO4:2H2O
Natron	-13.62	-14.94	-1.31	Na2CO3:10H2O
Nesquehonite	-5.16	-9.83	-4.67	MgCO3:3H2O
Ni(OH)2	-4.80	7.99	12.79	Ni(OH)2
Ni4(OH)6SO4	-18.35	13.65	32.00	Ni4(OH)6SO4
NiCO3	-6.67	-13.54	-6.87	NiCO3
NiMoO4	-3.93	-15.07	-11.14	NiMoO4
Nsutite	-10.43	7.08	17.50	MnO2
O2(g)	-36.29	46.80	83.09	O2
Periclase	-9.89	11.70	21.58	MgO
Portlandite	-10.42	12.39	22.80	Ca(OH)2
Pyrochroite	-6.17	9.03	15.19	Mn(OH)2
Pyrolusite	-8.95	32.43	41.38	MnO2
Retgersite	-8.29	-10.33	-2.04	NiSO4:6H2O
Rhodochrosite	-1.92	-12.50	-10.58	MnCO3
Spinel	-7.52	29.32	36.85	MgAl2O4
Tenorite	0.49	8.14	7.64	CuO
Thenardite	-12.04	-11.72	0.32	Na2SO4
Thermonatrite	-15.57	-14.94	0.64	Na2CO3:H2O
Witherite	-4.55	-13.12	-8.57	BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Beginning of batch-reaction calculations.

Reaction step 1.

Using mix 1. Mix within UG Works

Mixture 1. Mix within UG Works

3.120e-01 Solution 1 UG Water P25
1.090e-01 Solution 2 PAF Material
3.980e-01 Solution 3 NAF Material
1.810e-01 Solution 4 Make-up Material

----------Solution composition----------

Elements	Molality	Moles
Al	3.180e-06	3.180e-06
As	1.654e-07	1.654e-07
B	3.763e-06	3.763e-06
Ba	5.090e-07	5.090e-07
C	3.092e-03	3.092e-03
Ca	2.490e-03	2.490e-03
Cd	2.140e-08	2.140e-08
Cl	4.723e-04	4.723e-04
Co	6.864e-08	6.864e-08
Cr	4.686e-08	4.686e-08
Cu	6.018e-07	6.018e-07
F	2.724e-05	2.724e-05
Fe	1.550e-06	1.550e-06
K	5.622e-04	5.622e-04
Mg	1.065e-03	1.065e-03
Mn	1.662e-06	1.662e-06
Mo	6.564e-08	6.564e-08
Na	2.832e-03	2.832e-03
Ni	5.636e-08	5.636e-08
Pb	7.192e-08	7.192e-08
S	2.768e-03	2.768e-03
Se	5.934e-08	5.934e-08
U	1.243e-08	1.243e-08
V	1.472e-08	1.472e-08
Zn	9.583e-07	9.583e-07

----------Description of solution----------

pH	=	8.080	Charge balance
pe	=	3.291	Adjusted to redox equilibrium
Activity of water	=	1.000	
Ionic strength (mol/kgw)	=	1.371e-02	
Mass of water (kg)	=	1.000e+00	
Total alkalinity (eq/kg)	=	3.120e-03	
Total CO2 (mol/kg)	=	3.092e-03	
Temperature (°C)	=	25.00	
Electrical balance (eq)	=	1.366e-03	
Percent error, 100*(Cat-|An|)/(Cat+|An|)	=	7.97	
Iterations	=	10	
Total H	=	1.110168e+02	
Total O	=	5.552721e+01	

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
OH-	1.365e-06	1.209e-06	-5.865	-5.917	-0.053	(0)
H+	9.369e-09	8.324e-09	-8.028	-8.080	-0.051	0.00
H2O	5.551e+01	9.998e-01	1.744	-0.000	0.000	18.07
Al	3.180e-06					
Al(OH)4-	3.160e-06	2.811e-06	-5.500	-5.551	-0.051	(0)
Al(OH)3	1.846e-08	1.846e-08	-7.734	-7.734	0.000	(0)
Al(OH)2+	8.573e-10	7.650e-10	-9.067	-9.116	-0.049	(0)
AlF2+	1.481e-12	1.322e-12	-11.829	-11.879	-0.049	(0)
AlOH+2	1.256e-12	7.963e-13	-11.901	-12.099	-0.198	(0)
AlF3	3.736e-13	3.736e-13	-12.428	-12.428	0.000	(0)
AlF+2	2.331e-13	1.478e-13	-12.632	-12.830	-0.198	(0)
AlSO4+	7.909e-15	7.034e-15	-14.102	-14.153	-0.051	(0)
AlF4-	4.727e-15	4.204e-15	-14.325	-14.376	-0.051	(0)
Al+3	1.909e-15	6.584e-16	-14.719	-15.181	-0.462	(0)
Al(SO4)2-	1.166e-16	1.037e-16	-15.933	-15.984	-0.051	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-52.459	-52.997	-0.537	(0)
As(3)	1.528e-18					
H3AsO3	1.427e-18	1.427e-18	-17.845	-17.845	0.000	(0)
H2AsO3-	1.009e-19	8.795e-20	-18.996	-19.056	-0.060	(0)
HAsO3-2	1.670e-23	9.636e-24	-22.777	-23.016	-0.239	(0)
H4AsO3+	6.754e-27	5.887e-27	-26.170	-26.230	-0.060	(0)
AsO3-3	1.538e-28	4.462e-29	-27.813	-28.350	-0.537	(0)
As(5)	1.654e-07					
HAsO4-2	1.574e-07	9.079e-08	-6.803	-7.042	-0.239	(0)
H2AsO4-	7.908e-09	6.893e-09	-8.102	-8.162	-0.060	(0)
AsO4-3	1.189e-10	3.449e-11	-9.925	-10.462	-0.537	(0)
H3AsO4	9.939e-15	9.970e-15	-14.003	-14.001	0.001	(0)
B	3.763e-06					
H3BO3	3.462e-06	3.473e-06	-5.461	-5.459	0.001	(0)
H2BO3-	2.747e-07	2.423e-07	-6.561	-6.616	-0.054	(0)
CaH2BO3+	1.970e-08	1.738e-08	-7.705	-7.760	-0.054	(0)
MgH2BO3+	5.338e-09	4.709e-09	-8.273	-8.327	-0.054	(0)
NaH2BO3	9.576e-10	9.576e-10	-9.019	-9.019	0.000	(0)
BF(OH)3-	3.527e-11	3.111e-11	-10.453	-10.507	-0.054	(0)
BaH2BO3+	2.635e-12	2.324e-12	-11.579	-11.634	-0.054	(0)
H5(BO3)2-	8.119e-13	7.162e-13	-12.090	-12.145	-0.054	(0)
BF2(OH)2-	7.049e-16	6.218e-16	-15.152	-15.206	-0.054	(0)
H8(BO3)3-	2.820e-16	2.487e-16	-15.550	-15.604	-0.054	(0)
BF3OH-	5.127e-23	4.523e-23	-22.290	-22.345	-0.054	(0)
BF4-	4.716e-29	4.160e-29	-28.326	-28.381	-0.054	(0)
Ba	5.090e-07					
Ba+2	4.981e-07	3.104e-07	-6.303	-6.508	-0.205	(0)
BaHCO3+	8.564e-09	7.659e-09	-8.067	-8.116	-0.049	(0)
BaCO3	2.316e-09	2.316e-09	-8.635	-8.635	0.000	(0)
BaH2BO3+	2.635e-12	2.324e-12	-11.579	-11.634	-0.054	(0)
BaOH+	1.839e-12	1.639e-12	-11.735	-11.786	-0.050	(0)
C(4)	3.092e-03					
HCO3-	2.895e-03	2.584e-03	-2.538	-2.588	-0.049	(0)
CaHCO3+	6.706e-05	5.998e-05	-4.174	-4.222	-0.049	(0)
H2CO3	4.837e-05	4.837e-05	-4.315	-4.315	0.000	(0)
CaCO3	2.875e-05	2.875e-05	-4.541	-4.541	0.000	(0)
CO3-2	2.335e-05	1.455e-05	-4.632	-4.837	-0.205	(0)
MgHCO3+	1.669e-05	1.482e-05	-4.777	-4.829	-0.052	(0)
MgCO3	6.784e-06	6.784e-06	-5.169	-5.169	0.000	(0)

NaHCO3	3.623e-06	3.623e-06	-5.441	-5.441	0.000	(0)
NaCO3-	7.572e-07	6.757e-07	-6.121	-6.170	-0.049	(0)
CuCO3	5.194e-07	5.194e-07	-6.285	-6.285	0.000	(0)
ZnCO3	2.667e-07	2.667e-07	-6.574	-6.574	0.000	(0)
PbCO3	5.716e-08	5.716e-08	-7.243	-7.243	0.000	(0)
MnHCO3+	4.713e-08	4.199e-08	-7.327	-7.377	-0.050	(0)
Cu(CO3)2-2	3.526e-08	2.034e-08	-7.453	-7.692	-0.239	(0)
ZnHCO3+	2.986e-08	2.602e-08	-7.525	-7.585	-0.060	(0)
NiCO3	1.089e-08	1.089e-08	-7.963	-7.963	0.000	(0)
UO2(CO3)3-4	9.839e-09	1.090e-09	-8.007	-8.962	-0.955	(0)
BaHCO3+	8.564e-09	7.659e-09	-8.067	-8.116	-0.049	(0)
NiHCO3+	7.334e-09	6.392e-09	-8.135	-8.194	-0.060	(0)
CoCO3	6.709e-09	6.709e-09	-8.173	-8.173	0.000	(0)
CoHCO3+	6.289e-09	5.481e-09	-8.201	-8.261	-0.060	(0)
Pb(CO3)2-2	4.158e-09	2.399e-09	-8.381	-8.620	-0.239	(0)
CdCO3	3.031e-09	3.031e-09	-8.518	-8.518	0.000	(0)
PbHCO3+	2.878e-09	2.508e-09	-8.541	-8.601	-0.060	(0)
UO2(CO3)2-2	2.591e-09	1.495e-09	-8.587	-8.825	-0.239	(0)
BaCO3	2.316e-09	2.316e-09	-8.635	-8.635	0.000	(0)
CuHCO3+	1.134e-09	9.881e-10	-8.945	-9.005	-0.060	(0)
FeHCO3+	3.228e-10	2.887e-10	-9.491	-9.540	-0.049	(0)
CdHCO3+	6.167e-11	5.375e-11	-10.210	-10.270	-0.060	(0)
Cd(CO3)2-2	5.666e-11	3.269e-11	-10.247	-10.486	-0.239	(0)
UO2CO3	5.149e-12	5.149e-12	-11.288	-11.288	0.000	(0)
Ca	**2.490e-03**					
Ca+2	2.001e-03	1.247e-03	-2.699	-2.904	-0.205	(0)
CaSO4	3.930e-04	3.930e-04	-3.406	-3.406	0.000	(0)
CaHCO3+	6.706e-05	5.998e-05	-4.174	-4.222	-0.049	(0)
CaCO3	2.875e-05	2.875e-05	-4.541	-4.541	0.000	(0)
CaF+	3.428e-07	3.055e-07	-6.465	-6.515	-0.050	(0)
CaOH+	3.364e-08	3.008e-08	-7.473	-7.522	-0.049	(0)
CaH2BO3+	1.970e-08	1.738e-08	-7.705	-7.760	-0.054	(0)
Cd	**2.140e-08**					
Cd+2	1.466e-08	9.137e-09	-7.834	-8.039	-0.205	(0)
CdCO3	3.031e-09	3.031e-09	-8.518	-8.518	0.000	(0)
CdSO4	2.948e-09	2.948e-09	-8.530	-8.530	0.000	(0)
CdCl+	4.201e-10	3.661e-10	-9.377	-9.436	-0.060	(0)
CdOH+	1.007e-10	8.778e-11	-9.997	-10.057	-0.060	(0)
Cd(SO4)2-2	9.486e-11	5.473e-11	-10.023	-10.262	-0.239	(0)
CdHCO3+	6.167e-11	5.375e-11	-10.210	-10.270	-0.060	(0)
Cd(CO3)2-2	5.666e-11	3.269e-11	-10.247	-10.486	-0.239	(0)
CdOHCl	1.816e-11	1.816e-11	-10.741	-10.741	0.000	(0)
CdF+	3.731e-12	3.251e-12	-11.428	-11.488	-0.060	(0)
Cd(OH)2	6.698e-13	6.698e-13	-12.174	-12.174	0.000	(0)
CdCl2	6.405e-13	6.405e-13	-12.194	-12.194	0.000	(0)
CdCl3-	1.946e-16	1.696e-16	-15.711	-15.771	-0.060	(0)
CdF2	1.457e-16	1.457e-16	-15.837	-15.837	0.000	(0)
Cd(OH)3-	5.679e-17	4.949e-17	-16.246	-16.305	-0.060	(0)
Cd2OH+3	1.385e-17	4.019e-18	-16.858	-17.396	-0.537	(0)
Cd(SeO3)2-2	2.692e-18	1.553e-18	-17.570	-17.809	-0.239	(0)
CdSeO4	1.668e-19	1.668e-19	-18.778	-18.778	0.000	(0)
Cd(OH)4-2	1.698e-23	9.798e-24	-22.770	-23.009	-0.239	(0)
CdHS+	0.000e+00	0.000e+00	-68.221	-68.281	-0.060	(0)
Cd(HS)2	0.000e+00	0.000e+00	-129.326	-129.326	0.000	(0)
Cd(HS)3-	0.000e+00	0.000e+00	-195.616	-195.676	-0.060	(0)
Cd(HS)4-2	0.000e+00	0.000e+00	-261.491	-261.730	-0.239	(0)
Cl	**4.723e-04**					
Cl-	4.723e-04	4.196e-04	-3.326	-3.377	-0.051	(0)
CuCl	8.016e-10	8.016e-10	-9.096	-9.096	0.000	(0)
ZnOHCl	5.316e-10	5.316e-10	-9.274	-9.274	0.000	(0)
MnCl+	4.829e-10	4.303e-10	-9.316	-9.366	-0.050	(0)
CdCl+	4.201e-10	3.661e-10	-9.377	-9.436	-0.060	(0)
ZnCl+	3.782e-10	3.357e-10	-9.422	-9.474	-0.052	(0)
CuCl2-	7.917e-11	7.028e-11	-10.101	-10.153	-0.052	(0)
CoCl+	4.543e-11	3.959e-11	-10.343	-10.402	-0.060	(0)
NiCl+	2.472e-11	2.155e-11	-10.607	-10.667	-0.060	(0)
PbCl+	2.232e-11	1.945e-11	-10.651	-10.711	-0.060	(0)
CdOHCl	1.816e-11	1.816e-11	-10.741	-10.741	0.000	(0)
CuCl+	4.541e-12	4.031e-12	-11.343	-11.395	-0.052	(0)
CdCl2	6.405e-13	6.405e-13	-12.194	-12.194	0.000	(0)
MnCl2	2.551e-13	2.551e-13	-12.593	-12.593	0.000	(0)
ZnCl2	2.233e-13	2.233e-13	-12.651	-12.651	0.000	(0)
PbCl2	3.646e-14	3.646e-14	-13.438	-13.438	0.000	(0)
CuCl3-2	1.000e-14	6.305e-15	-14.000	-14.200	-0.200	(0)
CuCl2	5.865e-16	5.865e-16	-15.232	-15.232	0.000	(0)
CdCl3-	1.946e-16	1.696e-16	-15.711	-15.771	-0.060	(0)
ZnCl3-	8.384e-17	7.442e-17	-16.077	-16.128	-0.052	(0)
NiCl2	4.552e-17	4.552e-17	-16.342	-16.342	0.000	(0)
MnCl3-	3.308e-17	2.948e-17	-16.480	-16.531	-0.050	(0)
PbCl3-	6.989e-18	6.091e-18	-17.156	-17.215	-0.060	(0)
CrCl+2	6.781e-18	3.912e-18	-17.169	-17.408	-0.239	(0)
UO2Cl+	6.939e-20	6.048e-20	-19.159	-19.218	-0.060	(0)
CrOHCl2	3.774e-20	3.774e-20	-19.423	-19.423	0.000	(0)
FeCl+2	3.242e-20	2.044e-20	-19.489	-19.690	-0.200	(0)
ZnCl4-2	2.477e-20	1.561e-20	-19.606	-19.806	-0.200	(0)
CuCl3-	2.587e-21	2.297e-21	-20.587	-20.639	-0.052	(0)
PbCl4-2	2.025e-21	1.168e-21	-20.694	-20.932	-0.239	(0)
CrCl2+	1.787e-22	1.558e-22	-21.748	-21.808	-0.060	(0)
VOCl+	4.663e-23	4.064e-23	-22.331	-22.391	-0.060	(0)
FeCl2+	4.299e-23	3.831e-23	-22.367	-22.417	-0.050	(0)
CuCl4-2	7.661e-27	4.830e-27	-26.116	-26.316	-0.200	(0)
FeCl3	1.608e-27	1.608e-27	-26.794	-26.794	0.000	(0)
CrO3Cl-	1.803e-29	1.572e-29	-28.744	-28.804	-0.060	(0)
CoCl+2	3.143e-38	1.814e-38	-37.503	-37.741	-0.239	(0)
UCl+3	0.000e+00	0.000e+00	-46.876	-47.414	-0.537	(0)
Co(2)	**6.864e-08**					
Co+2	4.727e-08	2.727e-08	-7.325	-7.564	-0.239	(0)
CoSO4	7.489e-09	7.489e-09	-8.126	-8.126	0.000	(0)
CoCO3	6.709e-09	6.709e-09	-8.173	-8.173	0.000	(0)
CoHCO3+	6.289e-09	5.481e-09	-8.201	-8.261	-0.060	(0)
CoOH+	7.551e-10	6.581e-10	-9.122	-9.182	-0.060	(0)
Co(OH)2	6.323e-11	6.323e-11	-10.199	-10.199	0.000	(0)
CoCl+	4.543e-11	3.959e-11	-10.343	-10.402	-0.060	(0)
CoF+	2.222e-11	1.937e-11	-10.653	-10.713	-0.060	(0)
Co(OH)3-	1.751e-15	1.526e-15	-14.757	-14.817	-0.060	(0)
CoOOH-	4.393e-16	3.829e-16	-15.357	-15.417	-0.060	(0)
Co2OH+3	3.101e-18	8.996e-19	-17.509	-18.046	-0.537	(0)
CoSeO4	1.340e-18	1.340e-18	-17.873	-17.873	0.000	(0)
Co(OH)4-2	5.069e-22	2.925e-22	-21.295	-21.534	-0.239	(0)
Co4(OH)4+4	3.378e-28	3.743e-29	-27.471	-28.427	-0.955	(0)
Co(3)	**2.263e-30**					
CoOH+2	2.263e-30	1.305e-30	-29.645	-29.884	-0.239	(0)
Co+3	6.158e-37	2.124e-37	-36.211	-36.673	-0.462	(0)
CoCl+2	3.143e-38	1.814e-38	-37.503	-37.741	-0.239	(0)
Cr(2)	**1.525e-24**					
Cr+2	1.525e-24	8.797e-25	-23.817	-24.056	-0.239	(0)
Cr(3)	**4.686e-08**					
Cr(OH)2+	3.219e-08	2.805e-08	-7.492	-7.552	-0.060	(0)
Cr(OH)3	1.274e-08	1.274e-08	-7.895	-7.895	0.000	(0)
CrO2-	8.345e-10	7.273e-10	-9.079	-9.138	-0.060	(0)
Cr(OH)4-	7.041e-10	6.136e-10	-9.152	-9.212	-0.060	(0)
Cr(OH)+2	3.304e-10	1.906e-10	-9.481	-9.720	-0.239	(0)
CrOHSO4	6.226e-11	6.226e-11	-10.206	-10.206	0.000	(0)
CrF+2	4.444e-14	2.564e-14	-13.352	-13.591	-0.239	(0)
CrSO4+	2.657e-14	2.315e-14	-13.576	-13.635	-0.060	(0)
Cr+3	2.483e-14	7.204e-15	-13.605	-14.142	-0.537	(0)
CrCl+2	6.781e-18	3.912e-18	-17.169	-17.408	-0.239	(0)
Cr2(OH)2SO4+2	1.859e-18	1.073e-18	-17.731	-17.970	-0.239	(0)
Cr2(OH)2(SO4)2	8.769e-20	8.769e-20	-19.057	-19.057	0.000	(0)
CrOHCl2	3.774e-20	3.774e-20	-19.423	-19.423	0.000	(0)
CrCl2+	1.787e-22	1.558e-22	-21.748	-21.808	-0.060	(0)
Cr(6)	**4.387e-17**					
CrO4-2	4.262e-17	2.656e-17	-16.370	-16.576	-0.205	(0)
HCrO4-	8.208e-19	7.153e-19	-18.086	-18.145	-0.060	(0)
NaCrO4-	3.776e-19	3.291e-19	-18.423	-18.483	-0.060	(0)
KCrO4-	5.601e-20	4.881e-20	-19.252	-19.311	-0.060	(0)
H2CrO4	4.827e-27	4.827e-27	-26.316	-26.316	0.000	(0)
CrO3SO4-2	4.327e-27	2.497e-27	-26.364	-26.603	-0.239	(0)
CrO3Cl-	1.803e-29	1.572e-29	-28.744	-28.804	-0.060	(0)
Cr2O7-2	3.076e-35	1.775e-35	-34.512	-34.751	-0.239	(0)
Cu(1)	**2.622e-09**					
Cu+	1.741e-09	1.517e-09	-8.759	-8.819	-0.060	(0)
CuCl	8.016e-10	8.016e-10	-9.096	-9.096	0.000	(0)
CuCl2-	7.917e-11	7.028e-11	-10.101	-10.153	-0.052	(0)
CuCl3-2	1.000e-14	6.305e-15	-14.000	-14.200	-0.200	(0)
Cu(S4)2-3	0.000e+00	0.000e+00	-125.484	-125.769	-0.285	(0)
CuS4S5-3	0.000e+00	0.000e+00	-126.225	-126.499	-0.274	(0)
Cu(2)	**5.992e-07**					
CuCO3	5.194e-07	5.194e-07	-6.285	-6.285	0.000	(0)
Cu(CO3)2-2	3.526e-08	2.034e-08	-7.453	-7.692	-0.239	(0)
CuOH+	2.612e-08	2.318e-08	-7.583	-7.635	-0.052	(0)
Cu+2	9.727e-09	6.061e-09	-8.012	-8.217	-0.205	(0)
Cu(OH)2	5.594e-09	5.594e-09	-8.252	-8.252	0.000	(0)
CuSO4	1.911e-09	1.911e-09	-8.719	-8.719	0.000	(0)
CuHCO3+	1.134e-09	9.881e-10	-8.945	-9.005	-0.060	(0)
Cu2(OH)2+2	2.340e-11	1.350e-11	-10.631	-10.870	-0.239	(0)
Cu(OH)3-	1.592e-11	1.388e-11	-10.798	-10.858	-0.060	(0)
CuF+	9.853e-12	8.587e-12	-11.006	-11.066	-0.060	(0)
CuCl+	4.541e-12	4.031e-12	-11.343	-11.395	-0.052	(0)
CuCl2	5.865e-16	5.865e-16	-15.232	-15.232	0.000	(0)
Cu(OH)4-2	2.289e-16	1.321e-16	-15.640	-15.879	-0.239	(0)
CuCl3-	2.587e-21	2.297e-21	-20.587	-20.639	-0.052	(0)
CuCl4-2	7.661e-27	4.830e-27	-26.116	-26.316	-0.200	(0)
Cu(HS)3-	0.000e+00	0.000e+00	-187.008	-187.067	-0.060	(0)
F	**2.724e-05**					
F-	2.527e-05	2.245e-05	-4.597	-4.649	-0.051	(0)
MgF+	1.588e-06	1.412e-06	-5.799	-5.850	-0.051	(0)
CaF+	3.428e-07	3.055e-07	-6.465	-6.515	-0.050	(0)
NaF	3.533e-08	3.533e-08	-7.452	-7.452	0.000	(0)
MnF+	8.172e-10	7.282e-10	-9.088	-9.138	-0.050	(0)
HF	2.764e-10	2.764e-10	-9.558	-9.558	0.000	(0)
ZnF+	1.637e-10	1.427e-10	-9.786	-9.846	-0.060	(0)
BF(OH)3-	3.527e-11	3.111e-11	-10.453	-10.507	-0.054	(0)
CoF+	2.222e-11	1.937e-11	-10.653	-10.713	-0.060	(0)
NiF+	1.299e-11	1.132e-11	-10.887	-10.946	-0.060	(0)
CuF+	9.853e-12	8.587e-12	-11.006	-11.066	-0.060	(0)
CdF+	3.731e-12	3.251e-12	-11.428	-11.488	-0.060	(0)
PbF+	2.372e-12	2.068e-12	-11.625	-11.685	-0.060	(0)
AlF2+	1.481e-12	1.322e-12	-11.829	-11.879	-0.049	(0)
AlF3	3.736e-13	3.736e-13	-12.428	-12.428	0.000	(0)
AlF+2	2.331e-13	1.478e-13	-12.632	-12.830	-0.198	(0)
CrF+2	4.444e-14	2.564e-14	-13.352	-13.591	-0.239	(0)
HF2-	2.664e-14	2.360e-14	-13.574	-13.627	-0.053	(0)
AlF4-	4.727e-15	4.204e-15	-14.325	-14.376	-0.051	(0)
PbF2	9.136e-16	9.136e-16	-15.039	-15.039	0.000	(0)
BF2(OH)2-	7.049e-16	6.218e-16	-15.152	-15.206	-0.054	(0)
UO2F+	3.161e-16	2.755e-16	-15.500	-15.560	-0.060	(0)
CdF2	1.457e-16	1.457e-16	-15.837	-15.837	0.000	(0)
FeF+2	6.298e-17	3.971e-17	-16.201	-16.401	-0.200	(0)
FeF2+	2.678e-17	2.386e-17	-16.572	-16.622	-0.050	(0)
UO2F2	1.784e-17	1.784e-17	-16.749	-16.749	0.000	(0)
FeF3	7.559e-19	7.559e-19	-18.122	-18.122	0.000	(0)
VO2F	4.798e-19	4.798e-19	-18.319	-18.319	0.000	(0)
H2F2	2.048e-19	2.048e-19	-18.689	-18.689	0.000	(0)
UO2F3-	1.154e-19	1.006e-19	-18.938	-18.997	-0.060	(0)
PbF3-	4.464e-20	3.891e-20	-19.350	-19.410	-0.060	(0)
VOF+	5.335e-21	4.649e-21	-20.273	-20.333	-0.060	(0)
VO2F2-	4.488e-21	3.912e-21	-20.348	-20.408	-0.060	(0)
BF3OH-	5.127e-23	4.523e-23	-22.290	-22.345	-0.054	(0)
VOF2	3.915e-23	3.915e-23	-22.407	-22.407	0.000	(0)
UO2F4-2	3.110e-23	1.794e-23	-22.507	-22.746	-0.239	(0)
VO2F3-2	1.899e-24	1.096e-24	-23.721	-23.960	-0.239	(0)
PbF4-2	7.247e-25	4.181e-25	-24.140	-24.379	-0.239	(0)
VOF3-	3.578e-26	3.119e-26	-25.446	-25.506	-0.060	(0)
BF4-	4.716e-29	4.160e-29	-28.326	-28.381	-0.054	(0)
VO2F4-3	4.172e-29	1.210e-29	-28.380	-28.917	-0.537	(0)
VOF4-2	4.899e-30	2.827e-30	-29.310	-29.549	-0.239	(0)
UF3+	9.482e-39	8.264e-39	-38.023	-38.083	-0.060	(0)
UF2+2	4.025e-39	2.322e-39	-38.395	-38.634	-0.239	(0)
UF+3	0.000e+00	0.000e+00	-40.548	-41.085	-0.537	(0)
UF4	0.000e+00	0.000e+00	-40.692	-40.692	0.000	(0)
UF5-	0.000e+00	0.000e+00	-43.683	-43.742	-0.060	(0)
UF6-2	0.000e+00	0.000e+00	-45.672	-45.911	-0.239	(0)
Fe(2)	**1.918e-08**					
Fe+2	1.538e-08	8.875e-09	-7.813	-8.052	-0.239	(0)
FeSO4	2.998e-09	2.998e-09	-8.523	-8.523	0.000	(0)
FeOH+	4.795e-10	4.273e-10	-9.319	-9.369	-0.050	(0)
FeHCO3+	3.228e-10	2.887e-10	-9.491	-9.540	-0.049	(0)
Fe(OH)2	4.105e-13	4.105e-13	-12.387	-12.387	0.000	(0)
Fe(OH)3-	1.762e-13	1.570e-13	-12.754	-12.804	-0.050	(0)
Fe(HS)2	0.000e+00	0.000e+00	-135.601	-135.601	0.000	(0)
Fe(HS)3-	0.000e+00	0.000e+00	-201.754	-201.814	-0.060	(0)
Fe(3)	**1.531e-06**					
Fe(OH)3	7.698e-07	7.698e-07	-6.114	-6.114	0.000	(0)
Fe(OH)2+	6.641e-07	5.926e-07	-6.178	-6.227	-0.049	(0)
Fe(OH)4-	9.714e-08	8.668e-08	-7.013	-7.062	-0.049	(0)
FeOH+2	1.998e-12	1.260e-12	-11.699	-11.900	-0.200	(0)
FeF+2	6.298e-17	3.971e-17	-16.201	-16.401	-0.200	(0)
FeSO4+	2.795e-17	2.491e-17	-16.554	-16.604	-0.050	(0)
FeF2+	2.678e-17	2.386e-17	-16.572	-16.622	-0.050	(0)
Fe+3	4.676e-18	1.613e-18	-17.330	-17.792	-0.462	(0)
Fe(SO4)2-	8.409e-19	7.329e-19	-18.075	-18.135	-0.060	(0)
FeF3	7.559e-19	7.559e-19	-18.122	-18.122	0.000	(0)
FeCl+2	3.242e-20	2.044e-20	-19.489	-19.690	-0.200	(0)
Fe2(OH)2+4	4.740e-22	5.253e-23	-21.324	-22.280	-0.955	(0)
FeHSeO3+2	2.218e-22	1.280e-22	-21.654	-21.893	-0.239	(0)
FeCl2+	4.299e-23	3.831e-23	-22.367	-22.417	-0.050	(0)
Fe3(OH)4+5	1.400e-26	4.500e-28	-25.854	-27.347	-1.493	(0)
FeCl3	1.608e-27	1.608e-27	-26.794	-26.794	0.000	(0)
H(0)	**2.555e-26**					
H2	1.278e-26	1.282e-26	-25.894	-25.892	0.001	(0)
K	**5.622e-04**					
K+	5.568e-04	4.947e-04	-3.254	-3.306	-0.051	(0)
KSO4-	5.402e-06	4.820e-06	-5.267	-5.317	-0.049	(0)
KCrO4-	5.601e-20	4.881e-20	-19.252	-19.311	-0.060	(0)
Mg	**1.065e-03**					
Mg+2	8.994e-04	5.605e-04	-3.046	-3.251	-0.205	(0)
MgSO4	1.404e-04	1.404e-04	-3.853	-3.853	0.000	(0)
MgHCO3+	1.669e-05	1.482e-05	-4.777	-4.829	-0.052	(0)
MgCO3	6.784e-06	6.784e-06	-5.169	-5.169	0.000	(0)
MgF+	1.588e-06	1.412e-06	-5.799	-5.850	-0.051	(0)
MgOH+	3.012e-07	2.698e-07	-6.521	-6.569	-0.048	(0)
MgH2BO3+	5.338e-09	4.709e-09	-8.273	-8.327	-0.054	(0)
Mn(2)	**1.662e-06**					
Mn+2	1.412e-06	8.146e-07	-5.850	-6.089	-0.239	(0)
MnSO4	1.994e-07	1.994e-07	-6.700	-6.700	0.000	(0)
MnHCO3+	4.713e-08	4.199e-08	-7.327	-7.377	-0.050	(0)
MnOH+	2.777e-09	2.475e-09	-8.556	-8.606	-0.050	(0)
MnF+	8.172e-10	7.282e-10	-9.088	-9.138	-0.050	(0)
MnCl+	4.829e-10	4.303e-10	-9.316	-9.366	-0.050	(0)
MnCl2	2.551e-13	2.551e-13	-12.593	-12.593	0.000	(0)
MnCl3-	3.308e-17	2.948e-17	-16.480	-16.531	-0.050	(0)
Mn(OH)3-	2.510e-17	2.237e-17	-16.600	-16.650	-0.050	(0)
MnSeO4	2.149e-17	2.149e-17	-16.668	-16.668	0.000	(0)

Mn(OH)4-2	1.385e-22	8.735e-23	-21.858	-22.059	-0.200	(0)
MnSe	5.207e-35	5.207e-35	-34.283	-34.283	0.000	(0)
Mn(3)	2.064e-28					
Mn+3	2.064e-28	7.119e-29	-27.685	-28.148	-0.462	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-46.508	-46.708	-0.200	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-52.735	-52.789	-0.054	(0)
Mo	6.564e-08					
MoO4-2	6.563e-08	4.090e-08	-7.183	-7.388	-0.205	(0)
HMoO4-	7.772e-12	6.774e-12	-11.109	-11.169	-0.060	(0)
H2MoO4	4.130e-16	4.130e-16	-15.384	-15.384	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-52.459	-52.997	-0.537	(0)
Mo7O24-6	0.000e+00	0.000e+00	-61.215	-63.365	-2.150	(0)
HMo7O24-5	0.000e+00	0.000e+00	-63.565	-65.058	-1.493	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-67.400	-68.356	-0.955	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-72.652	-73.189	-0.537	(0)
Na	2.832e-03					
Na+	2.807e-03	2.494e-03	-2.552	-2.603	-0.051	(0)
NaSO4-	2.065e-05	1.843e-05	-4.685	-4.734	-0.049	(0)
NaHCO3	3.623e-06	3.623e-06	-5.441	-5.441	0.000	(0)
NaCO3-	7.572e-07	6.757e-07	-6.121	-6.170	-0.049	(0)
NaF	3.533e-08	3.533e-08	-7.452	-7.452	0.000	(0)
NaH2BO3	9.576e-10	9.576e-10	-9.019	-9.019	0.000	(0)
NaCrO4-	3.776e-19	3.291e-19	-18.423	-18.483	-0.060	(0)
Ni	5.636e-08					
Ni+2	3.221e-08	2.007e-08	-7.492	-7.698	-0.205	(0)
NiCO3	1.089e-08	1.089e-08	-7.963	-7.963	0.000	(0)
NiHCO3+	7.334e-09	6.392e-09	-8.135	-8.194	-0.060	(0)
NiSO4	5.511e-09	5.511e-09	-8.259	-8.259	0.000	(0)
NiOH+	3.506e-10	3.055e-10	-9.455	-9.515	-0.060	(0)
Ni(OH)2	2.935e-11	2.935e-11	-10.532	-10.532	0.000	(0)
NiCl+	2.472e-11	2.155e-11	-10.607	-10.667	-0.060	(0)
NiF+	1.299e-11	1.132e-11	-10.887	-10.946	-0.060	(0)
Ni(SO4)2-2	4.353e-13	2.511e-13	-12.361	-12.600	-0.239	(0)
Ni(OH)3-	4.073e-14	3.550e-14	-13.390	-13.450	-0.060	(0)
NiCl2	4.552e-17	4.552e-17	-16.342	-16.342	0.000	(0)
NiSeO4	9.202e-19	9.202e-19	-18.036	-18.036	0.000	(0)
O(0)	0.000e+00					
O2	0.000e+00	0.000e+00	-40.512	-40.511	0.001	(0)
Pb	7.192e-08					
PbCO3	5.716e-08	5.716e-08	-7.243	-7.243	0.000	(0)
PbOH+	4.555e-09	3.970e-09	-8.342	-8.401	-0.060	(0)
Pb(CO3)2-2	4.158e-09	2.399e-09	-8.381	-8.620	-0.239	(0)
PbHCO3+	2.878e-09	2.508e-09	-8.541	-8.601	-0.060	(0)
Pb+2	2.097e-09	1.307e-09	-8.678	-8.884	-0.205	(0)
PbSO4	8.808e-10	8.808e-10	-9.055	-9.055	0.000	(0)
Pb(OH)2	1.518e-10	1.518e-10	-9.819	-9.819	0.000	(0)
PbCl+	2.232e-11	1.945e-11	-10.651	-10.711	-0.060	(0)
Pb(SO4)2-2	1.266e-11	7.304e-12	-10.898	-11.136	-0.239	(0)
PbF+	2.372e-12	2.068e-12	-11.625	-11.685	-0.060	(0)
Pb(OH)3-	2.107e-13	1.836e-13	-12.676	-12.736	-0.060	(0)
PbCl2	3.646e-14	3.646e-14	-13.438	-13.438	0.000	(0)
PbF2	9.136e-16	9.136e-16	-15.039	-15.039	0.000	(0)
Pb2OH+3	2.833e-16	8.221e-17	-15.548	-16.085	-0.537	(0)
Pb(OH)4-2	9.426e-17	5.439e-17	-16.026	-16.265	-0.239	(0)
PbCl3-	6.989e-18	6.091e-18	-17.156	-17.215	-0.060	(0)
Pb3(OH)4+2	1.042e-18	6.009e-19	-17.982	-18.221	-0.239	(0)
PbF3-	4.464e-20	3.891e-20	-19.350	-19.410	-0.060	(0)
PbCl4-2	2.025e-21	1.168e-21	-20.694	-20.932	-0.239	(0)
Pb4(OH)4+4	5.628e-23	6.237e-24	-22.250	-23.205	-0.955	(0)
PbF4-2	7.247e-25	4.181e-25	-24.140	-24.379	-0.239	(0)
Pb(HS)2	0.000e+00	0.000e+00	-130.113	-130.113	0.000	(0)
Pb(HS)3-	0.000e+00	0.000e+00	-197.003	-197.063	-0.060	(0)
S(-2)	0.000e+00					
HS-	0.000e+00	0.000e+00	-68.190	-68.250	-0.060	(0)
CdHS+	0.000e+00	0.000e+00	-68.221	-68.281	-0.060	(0)
S5-2	0.000e+00	0.000e+00	-69.296	-69.535	-0.239	(0)
H2S	0.000e+00	0.000e+00	-69.309	-69.309	0.000	(0)
S6-2	0.000e+00	0.000e+00	-69.812	-70.051	-0.239	(0)
S4-2	0.000e+00	0.000e+00	-69.892	-70.131	-0.239	(0)
S3-2	0.000e+00	0.000e+00	-70.698	-70.937	-0.239	(0)
S2-2	0.000e+00	0.000e+00	-71.714	-71.953	-0.239	(0)
S-2	0.000e+00	0.000e+00	-77.270	-77.470	-0.200	(0)
Cu(S4)2-3	0.000e+00	0.000e+00	-125.484	-125.769	-0.285	(0)
CuS4S5-3	0.000e+00	0.000e+00	-126.225	-126.499	-0.274	(0)
ZnS(HS)-	0.000e+00	0.000e+00	-128.047	-128.106	-0.060	(0)
Cd(HS)2	0.000e+00	0.000e+00	-129.326	-129.326	0.000	(0)
Pb(HS)2	0.000e+00	0.000e+00	-130.113	-130.113	0.000	(0)
Zn(HS)2	0.000e+00	0.000e+00	-130.176	-130.176	0.000	(0)
Fe(HS)2	0.000e+00	0.000e+00	-135.601	-135.601	0.000	(0)
Cu(HS)3-	0.000e+00	0.000e+00	-187.008	-187.067	-0.060	(0)
Zn(HS)3-	0.000e+00	0.000e+00	-195.086	-195.146	-0.060	(0)
Cd(HS)3-	0.000e+00	0.000e+00	-195.616	-195.676	-0.060	(0)
ZnS(HS)2-2	0.000e+00	0.000e+00	-196.807	-197.046	-0.239	(0)
Pb(HS)3-	0.000e+00	0.000e+00	-197.003	-197.063	-0.060	(0)
Fe(HS)3-	0.000e+00	0.000e+00	-201.754	-201.814	-0.060	(0)
Cd(HS)4-2	0.000e+00	0.000e+00	-261.491	-261.730	-0.239	(0)
Zn(HS)4-2	0.000e+00	0.000e+00	-264.617	-264.855	-0.239	(0)
S(6)	2.768e-03					
SO4-2	2.209e-03	1.376e-03	-2.656	-2.861	-0.205	(0)
CaSO4	3.930e-04	3.930e-04	-3.406	-3.406	0.000	(0)
MgSO4	1.404e-04	1.404e-04	-3.853	-3.853	0.000	(0)
NaSO4-	2.065e-05	1.843e-05	-4.685	-4.734	-0.049	(0)
KSO4-	5.402e-06	4.820e-06	-5.267	-5.317	-0.049	(0)
MnSO4	1.994e-07	1.994e-07	-6.700	-6.700	0.000	(0)
ZnSO4	9.590e-08	9.590e-08	-7.018	-7.018	0.000	(0)
CoSO4	7.489e-09	7.489e-09	-8.126	-8.126	0.000	(0)
NiSO4	5.511e-09	5.511e-09	-8.259	-8.259	0.000	(0)
FeSO4	2.998e-09	2.998e-09	-8.523	-8.523	0.000	(0)
CdSO4	2.948e-09	2.948e-09	-8.530	-8.530	0.000	(0)
Zn(SO4)2-2	1.993e-09	1.150e-09	-8.701	-8.939	-0.239	(0)
CuSO4	1.911e-09	1.911e-09	-8.719	-8.719	0.000	(0)
HSO4-	1.259e-09	1.120e-09	-8.900	-8.951	-0.051	(0)
PbSO4	8.808e-10	8.808e-10	-9.055	-9.055	0.000	(0)
Cd(SO4)2-2	9.486e-11	5.473e-11	-10.023	-10.262	-0.239	(0)
CrOHSO4	6.226e-11	6.226e-11	-10.206	-10.206	0.000	(0)
Pb(SO4)2-2	1.266e-11	7.304e-12	-10.898	-11.136	-0.239	(0)
Ni(SO4)2-2	4.353e-13	2.511e-13	-12.361	-12.600	-0.239	(0)
CrSO4+	2.657e-14	2.315e-14	-13.576	-13.635	-0.060	(0)
AlSO4+	7.909e-15	7.034e-15	-14.102	-14.153	-0.051	(0)
UO2SO4	1.851e-16	1.851e-16	-15.733	-15.733	0.000	(0)
Al(SO4)2-	1.166e-16	1.037e-16	-15.933	-15.984	-0.051	(0)
FeSO4+	2.795e-17	2.491e-17	-16.554	-16.604	-0.050	(0)
UO2(SO4)2-2	5.821e-18	3.359e-18	-17.235	-17.474	-0.239	(0)
Cr2(OH)2SO4+2	1.859e-18	1.073e-18	-17.731	-17.970	-0.239	(0)
Fe(SO4)2-	8.409e-19	7.329e-19	-18.075	-18.135	-0.060	(0)
VO2SO4-	4.594e-19	4.004e-19	-18.338	-18.397	-0.060	(0)
Cr2(OH)2(SO4)2	8.769e-20	8.769e-20	-19.057	-19.057	0.000	(0)
VOSO4	1.309e-20	1.309e-20	-19.883	-19.883	0.000	(0)
CrO3SO4-2	4.327e-27	2.497e-27	-26.364	-26.603	-0.239	(0)
VSO4+	4.527e-34	3.945e-34	-33.344	-33.404	-0.060	(0)
U(SO4)2	0.000e+00	0.000e+00	-40.959	-40.959	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-41.759	-41.998	-0.239	(0)
Se(-2)	1.482e-31					
HSe-	1.482e-31	1.291e-31	-30.829	-30.889	-0.060	(0)
MnSe	5.207e-35	5.207e-35	-34.283	-34.283	0.000	(0)
H2Se	8.343e-36	8.343e-36	-35.079	-35.079	0.000	(0)
Se-2	2.689e-38	1.551e-38	-37.570	-37.809	-0.239	(0)
Se(4)	5.934e-08					
HSeO3-	3.445e-08	3.003e-08	-7.463	-7.522	-0.060	(0)
SeO3-2	2.489e-08	1.436e-08	-7.604	-7.843	-0.239	(0)
H2SeO3	1.066e-13	1.066e-13	-12.972	-12.972	0.000	(0)
Cd(SeO3)2-2	2.692e-18	1.553e-18	-17.570	-17.809	-0.239	(0)
FeHSeO3+2	2.218e-22	1.280e-22	-21.654	-21.893	-0.239	(0)
Se(6)	1.574e-13					
SeO4-2	1.573e-13	9.803e-14	-12.803	-13.009	-0.205	(0)
MnSeO4	2.149e-17	2.149e-17	-16.668	-16.668	0.000	(0)
ZnSeO4	4.836e-18	4.836e-18	-17.316	-17.316	0.000	(0)
CoSeO4	1.340e-18	1.340e-18	-17.873	-17.873	0.000	(0)
NiSeO4	9.202e-19	9.202e-19	-18.036	-18.036	0.000	(0)
CdSeO4	1.668e-19	1.668e-19	-18.778	-18.778	0.000	(0)
HSeO4-	4.692e-20	4.090e-20	-19.329	-19.388	-0.060	(0)
Zn(SeO4)2-2	8.331e-31	4.807e-31	-30.079	-30.318	-0.239	(0)
U(3)	0.000e+00					
U+3	0.000e+00	0.000e+00	-57.287	-57.824	-0.537	(0)
U(4)	3.991e-19					
U(OH)5-	3.990e-19	3.477e-19	-18.399	-18.459	-0.060	(0)
U(OH)4	1.212e-22	1.212e-22	-21.916	-21.916	0.000	(0)
U(OH)3+	4.234e-27	3.690e-27	-26.373	-26.433	-0.060	(0)
U(OH)2+2	2.462e-32	1.421e-32	-31.609	-31.848	-0.239	(0)
UOH+3	1.920e-38	5.571e-39	-37.717	-38.254	-0.537	(0)
UF3+	9.482e-39	8.264e-39	-38.023	-38.083	-0.060	(0)
UF2+2	4.025e-39	2.322e-39	-38.395	-38.634	-0.239	(0)
UF+3	0.000e+00	0.000e+00	-40.548	-41.085	-0.537	(0)
UF4	0.000e+00	0.000e+00	-40.692	-40.692	0.000	(0)
U(SO4)2	0.000e+00	0.000e+00	-40.959	-40.959	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-41.759	-41.998	-0.239	(0)
UF5-	0.000e+00	0.000e+00	-43.683	-43.742	-0.060	(0)
U+4	0.000e+00	0.000e+00	-44.781	-45.737	-0.955	(0)
UF6-2	0.000e+00	0.000e+00	-45.672	-45.911	-0.239	(0)
UCl+3	0.000e+00	0.000e+00	-46.876	-47.414	-0.537	(0)
U6(OH)15+9	0.000e+00	0.000e+00	-165.544	-170.381	-4.837	(0)
U(5)	3.177e-17					
UO2+	3.177e-17	2.769e-17	-16.498	-16.558	-0.060	(0)
U(6)	1.243e-08					
UO2(CO3)3-4	9.839e-09	1.090e-09	-8.007	-8.962	-0.955	(0)
UO2(CO3)2-2	2.591e-09	1.495e-09	-8.587	-8.825	-0.239	(0)
UO2CO3	5.149e-12	5.149e-12	-11.288	-11.288	0.000	(0)
UO2OH+	1.553e-14	1.353e-14	-13.809	-13.869	-0.060	(0)
UO2F+	3.161e-16	2.755e-16	-15.500	-15.560	-0.060	(0)
UO2SO4	1.851e-16	1.851e-16	-15.733	-15.733	0.000	(0)
UO2+2	1.426e-16	8.887e-17	-15.846	-16.051	-0.205	(0)
UO2F2	1.784e-17	1.784e-17	-16.749	-16.749	0.000	(0)
UO2(SO4)2-2	5.821e-18	3.359e-18	-17.235	-17.474	-0.239	(0)
UO2F3-	1.154e-19	1.006e-19	-18.938	-18.997	-0.060	(0)
UO2Cl+	6.939e-20	6.048e-20	-19.159	-19.218	-0.060	(0)
(UO2)2(OH)2+2	5.267e-22	3.039e-22	-21.278	-21.517	-0.239	(0)
UO2F4-2	3.110e-23	1.794e-23	-22.507	-22.746	-0.239	(0)
(UO2)3(OH)5+	5.235e-24	4.562e-24	-23.281	-23.341	-0.060	(0)
V(2)	6.827e-40					
VOH+	6.827e-40	5.950e-40	-39.166	-39.225	-0.060	(0)
V+2	0.000e+00	0.000e+00	-40.579	-40.818	-0.239	(0)
V(3)	8.666e-13					
V(OH)3	8.666e-13	8.666e-13	-12.062	-12.062	0.000	(0)
V(OH)2+	5.349e-24	4.662e-24	-23.272	-23.331	-0.060	(0)
VOH+2	6.380e-28	3.681e-28	-27.195	-27.434	-0.239	(0)
V+3	2.093e-33	6.073e-34	-32.679	-33.217	-0.537	(0)
VSO4+	4.527e-34	3.945e-34	-33.344	-33.404	-0.060	(0)
V2(OH)3+3	0.000e+00	0.000e+00	-51.776	-52.314	-0.537	(0)
V2(OH)2+4	0.000e+00	0.000e+00	-53.113	-54.068	-0.955	(0)
V(4)	9.635e-18					
V(OH)3+	9.557e-18	8.329e-18	-17.020	-17.079	-0.060	(0)
VO+2	5.983e-20	3.452e-20	-19.223	-19.462	-0.239	(0)
VOSO4	1.309e-20	1.309e-20	-19.883	-19.883	0.000	(0)
VOF+	5.335e-21	4.649e-21	-20.273	-20.333	-0.060	(0)
VOCl+	4.663e-23	4.064e-23	-22.331	-22.391	-0.060	(0)
VOF2	3.915e-23	3.915e-23	-22.407	-22.407	0.000	(0)
VOF3-	3.578e-26	3.119e-26	-25.446	-25.506	-0.060	(0)
H2V2O4+2	6.029e-30	3.478e-30	-29.220	-29.459	-0.239	(0)
VOF4-2	4.899e-30	2.827e-30	-29.310	-29.549	-0.239	(0)
V(5)	1.472e-08					
H2VO4-	1.011e-08	8.810e-09	-7.995	-8.055	-0.060	(0)
HVO4-2	4.608e-09	2.659e-09	-8.337	-8.575	-0.239	(0)
H3VO4	7.333e-13	7.333e-13	-12.135	-12.135	0.000	(0)
H3V2O7-	4.787e-14	4.172e-14	-13.320	-13.380	-0.060	(0)
HV2O7-3	2.736e-14	7.938e-15	-13.563	-14.100	-0.537	(0)
VO4-3	5.517e-15	1.601e-15	-14.258	-14.796	-0.537	(0)
V2O7-4	2.316e-16	2.567e-17	-15.635	-16.591	-0.955	(0)
VO2+	1.371e-17	1.218e-17	-16.863	-16.914	-0.051	(0)
V3O9-3	2.470e-18	7.165e-19	-17.607	-18.145	-0.537	(0)
VO2F	4.798e-19	4.798e-19	-18.319	-18.319	0.000	(0)
VO2SO4-	4.594e-19	4.004e-19	-18.338	-18.397	-0.060	(0)
VO2F2-	4.488e-21	3.912e-21	-20.348	-20.408	-0.060	(0)
V4O12-4	2.375e-23	2.632e-24	-22.624	-23.580	-0.955	(0)
VO2F3-2	1.899e-24	1.096e-24	-23.721	-23.960	-0.239	(0)
VO2F4-3	4.172e-29	1.210e-29	-28.380	-28.917	-0.537	(0)
V10O28-6	0.000e+00	0.000e+00	-61.812	-63.962	-2.150	(0)
HV10O28-5	0.000e+00	0.000e+00	-62.362	-63.855	-1.493	(0)
H2V10O28-4	0.000e+00	0.000e+00	-65.772	-66.727	-0.955	(0)
Zn	9.583e-07					
Zn+2	5.112e-07	3.185e-07	-6.291	-6.497	-0.205	(0)
ZnCO3	2.667e-07	2.667e-07	-6.574	-6.574	0.000	(0)
ZnSO4	9.590e-08	9.590e-08	-7.018	-7.018	0.000	(0)
ZnOH+	4.420e-08	3.852e-08	-7.355	-7.414	-0.060	(0)
ZnHCO3+	2.986e-08	2.602e-08	-7.525	-7.585	-0.060	(0)
Zn(OH)2	7.384e-09	7.384e-09	-8.132	-8.132	0.000	(0)
Zn(SO4)2-2	1.993e-09	1.150e-09	-8.701	-8.939	-0.239	(0)
ZnOHCl	5.316e-10	5.316e-10	-9.274	-9.274	0.000	(0)
ZnCl+	3.782e-10	3.357e-10	-9.422	-9.474	-0.052	(0)
ZnF+	1.637e-10	1.427e-10	-9.786	-9.846	-0.060	(0)
Zn(OH)3-	5.135e-11	4.476e-11	-10.289	-10.349	-0.060	(0)
ZnCl2	2.233e-13	2.233e-13	-12.651	-12.651	0.000	(0)
Zn(OH)4-2	3.735e-15	2.155e-15	-14.428	-14.667	-0.239	(0)
ZnCl3-	8.384e-17	7.442e-17	-16.077	-16.128	-0.052	(0)
ZnSeO4	4.836e-18	4.836e-18	-17.316	-17.316	0.000	(0)
ZnCl4-2	2.477e-20	1.561e-20	-19.606	-19.806	-0.200	(0)
Zn(SeO4)2-2	8.331e-31	4.807e-31	-30.079	-30.318	-0.239	(0)
ZnS(HS)-	0.000e+00	0.000e+00	-128.047	-128.106	-0.060	(0)
Zn(HS)2	0.000e+00	0.000e+00	-130.176	-130.176	0.000	(0)
Zn(HS)3-	0.000e+00	0.000e+00	-195.086	-195.146	-0.060	(0)
ZnS(HS)2-2	0.000e+00	0.000e+00	-196.807	-197.046	-0.239	(0)
Zn(HS)4-2	0.000e+00	0.000e+00	-264.617	-264.855	-0.239	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.74	9.06	10.80	Al(OH)3
Al2(MoO4)3	-54.90	-52.53	2.37	Al2(MoO4)3
Al2O3	-1.54	18.11	19.65	Al2O3
Al4(OH)10SO4	-5.49	17.21	22.70	Al4(OH)10SO4
AlAsO4:2H2O	-9.74	-4.94	4.80	AlAsO4:2H2O
AlOHSO4	-6.73	-9.96	-3.23	AlOHSO4
Alunite	-4.70	-6.10	-1.40	KAl3(SO4)2(OH)6
Anglesite	-3.96	-11.75	-7.79	PbSO4
Anhydrite	-1.41	-5.77	-4.36	CaSO4
Anilite	-43.57	-75.45	-31.88	Cu0.25Cu1.5S
Antlerite	-3.98	4.80	8.79	Cu3(OH)4SO4
Aragonite	0.56	-7.74	-8.30	CaCO3
Arsenolite	-68.62	-71.38	-2.76	As4O6
Artinite	-4.78	4.82	9.60	MgCO3:Mg(OH)2:3H2O
As2O5	-34.71	-28.00	6.71	As2O5
Atacamite	-2.96	4.43	7.39	Cu2(OH)3Cl

Azurite	-1.26	-18.17	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-14.74	9.65	24.39	Ba(OH)2:8H2O
Ba2V2O7:2H2O	-14.24	1.63	15.87	Ba2V2O7:2H2O
Ba3(AsO4)2	9.86	0.95	-8.91	Ba3(AsO4)2
Ba3(VO4)2:4H2O	-21.66	11.28	32.94	Ba3(VO4)2:4H2O
BaCrO4	-13.41	-23.08	-9.67	BaCrO4
BaF2	-9.99	-15.81	-5.82	BaF2
BaMoO4	-6.94	-13.90	-6.96	BaMoO4
Barite	0.61	-9.37	-9.98	BaSO4
BaS	-82.86	-66.68	16.18	BaS
BaSeO3	-7.78	-5.95	1.83	BaSeO3
BaSeO4	-12.06	-19.52	-7.46	BaSeO4
Bianchite	-7.59	-9.36	-1.76	ZnSO4:6H2O
Birnessite	-10.63	7.46	18.09	MnO2
Bixbyite	-7.17	-7.82	-0.64	Mn2O3
BlaubleiI	-45.17	-69.33	-24.16	Cu0.9Cu0.2S
BlaubleiII	-44.88	-72.16	-27.28	Cu0.6Cu0.8S
Boehmite	0.48	9.06	8.58	AlOOH
Brochantite	-2.48	12.75	15.22	Cu4(OH)6SO4
Brucite	-3.94	12.91	16.84	Mg(OH)2
Bunsenite	-3.98	8.46	12.45	NiO
Ca(VO3)2	-10.07	-4.41	5.66	Ca(VO3)2
Ca2V2O7	-8.66	8.84	17.50	Ca2V2O7
Ca2V2O7:2H2O	-12.71	8.84	21.55	Ca2V2O7:2H2O
Ca3(AsO4)2:4H2O	-10.54	11.76	22.30	Ca3(AsO4)2:4H2O
Ca3(VO4)2	-16.86	22.10	38.96	Ca3(VO4)2
Ca3(VO4)2:4H2O	-17.76	22.10	39.86	Ca3(VO4)2:4H2O
CaCrO4	-17.21	-19.48	-2.27	CaCrO4
Calcite	0.74	-7.74	-8.48	CaCO3
CaMoO4	-2.34	-10.29	-7.95	CaMoO4
Carnotite	-4.18	-3.95	0.23	KUO2VO4
CaSeO3:2H2O	-5.16	-2.35	2.81	CaSeO3:2H2O
CaSeO4:2H2O	-12.89	-15.91	-3.02	CaSeO4:2H2O
Cd(BO2)2	-12.64	-2.80	9.84	Cd(BO2)2
Cd(OH)2	-5.52	8.12	13.64	Cd(OH)2
Cd(OH)2(am)	-5.61	8.12	13.73	Cd(OH)2
Cd3(OH)2(SO4)2	-20.39	-13.68	6.71	Cd3(OH)2(SO4)2
Cd3(OH)4SO4	-17.22	5.34	22.56	Cd3(OH)4SO4
Cd4(OH)6SO4	-14.94	13.46	28.40	Cd4(OH)6SO4
CdCl2	-14.13	-14.79	-0.66	CdCl2
CdCl2:1H2O	-13.10	-14.79	-1.69	CdCl2:1H2O
CdCl2:2.5H2O	-12.88	-14.79	-1.91	CdCl2:2.5H2O
CdF2	-16.12	-17.34	-1.21	CdF2
Cdmetal(alpha)	-28.14	-14.62	13.51	Cd
Cdmetal(gamma)	-28.24	-14.62	13.62	Cd
CdMoO4	-1.28	-15.43	-14.15	CdMoO4
CdOHCl	-6.87	-3.34	3.54	CdOHCl
CdSe	-10.65	-30.85	-20.20	CdSe
CdSeO4:2H2O	-19.20	-21.05	-1.85	CdSeO4:2H2O
CdSO4	-10.73	-10.90	-0.17	CdSO4
CdSO4:1H2O	-9.17	-10.90	-1.73	CdSO4:1H2O
CdSO4:2.67H2O	-9.03	-10.90	-1.87	CdSO4:2.67H2O
Cerussite	-0.59	-13.72	-13.13	PbCO3
CH4(g)	-70.92	-111.97	-41.05	CH4
Chalcanthite	-8.44	-11.08	-2.64	CuSO4:5H2O
Chalcocite	-42.89	-77.81	-34.92	Cu2S
Chalcopyrite	-101.34	-136.61	-35.27	CuFeS2
Claudetite	-68.32	-71.38	-3.06	As4O6
Clausthalite	-4.59	-31.69	-27.10	PbSe
Co(BO2)2	-29.39	-2.32	27.07	Co(BO2)2
Co(OH)2	-4.50	8.59	13.09	Co(OH)2
Co(OH)3	-10.13	-12.43	-2.31	Co(OH)3
CO2(g)	-2.85	-21.00	-18.15	CO2
Co3(AsO4)2	-15.25	-2.22	13.03	Co3(AsO4)2
Co3O4	-5.78	-16.27	-10.50	Co3O4
CoCl2	-22.59	-14.32	8.27	CoCl2

CoCl2:6H2O	-16.86	-14.32	2.54	CoCl2:6H2O
CoCO3	-2.42	-12.40	-9.98	CoCO3
CoF2	-15.26	-16.86	-1.60	CoF2
CoF3	-49.16	-50.62	-1.46	CoF3
CoFe2O4	25.02	21.49	-3.53	CoFe2O4
CoMoO4	-7.19	-14.95	-7.76	CoMoO4
CoO	-4.99	8.59	13.59	CoO
CoS(alpha)	-60.29	-67.73	-7.44	CoS
CoS(beta)	-56.66	-67.73	-11.07	CoS
CoSe	-14.17	-30.37	-16.20	CoSe
CoSeO3	-8.33	-7.01	1.32	CoSeO3
CoSeO4:6H2O	-19.04	-20.57	-1.53	CoSeO4:6H2O
CoSO4	-13.23	-10.43	2.80	CoSO4
CoSO4:6H2O	-7.95	-10.43	-2.47	CoSO4:6H2O
Cotunnite	-10.86	-15.64	-4.78	PbCl2
Covellite	-46.09	-68.39	-22.30	CuS
Cr(OH)2	-18.72	-7.90	10.82	Cr(OH)2
Cr(OH)3	-0.81	0.53	1.34	Cr(OH)3
Cr(OH)3(am)	1.28	0.53	-0.75	Cr(OH)3
Cr2O3	3.41	1.06	-2.36	Cr2O3
CrCl2	-44.90	-30.81	14.09	CrCl2
CrCl3	-48.96	-33.84	15.11	CrCl3
CrF3	-26.32	-37.66	-11.34	CrF3
Crmetal	-61.12	-30.64	30.48	Cr
CrO3	-29.52	-32.74	-3.21	CrO3
Cryolite	-17.04	-50.88	-33.84	Na3AlF6
Cu(OH)2	-0.73	7.94	8.67	Cu(OH)2
Cu2Se(alpha)	5.35	-40.45	-45.80	Cu2Se
Cu2SO4	-18.55	-20.50	-1.95	Cu2SO4
Cu3(AsO4)2:2H2O	-10.28	-4.18	6.10	Cu3(AsO4)2:2H2O
Cu3Se2	-7.98	-71.47	-63.49	Cu3Se2
CuCO3	-1.55	-13.05	-11.50	CuCO3
CuCrO4	-19.35	-24.79	-5.44	CuCrO4
CuF	-8.56	-13.47	-4.91	CuF
CuF2	-18.63	-17.51	1.12	CuF2
CuF2:2H2O	-12.97	-17.52	-4.55	CuF2:2H2O
Cumetal	-3.35	-12.11	-8.76	Cu
CuMoO4	-2.53	-15.61	-13.08	CuMoO4
CuOCuSO4	-13.44	-3.14	10.30	CuOCuSO4
Cupricferrite	14.85	20.83	5.99	CuFe2O4
Cuprite	-0.07	-1.48	-1.41	Cu2O
Cuprousferrite	14.62	5.71	-8.92	CuFeO2
CuSe	2.07	-31.03	-33.10	CuSe
CuSe2	-13.89	-47.25	-33.37	CuSe2
CuSeO3:2H2O	-8.17	-7.66	0.51	CuSeO3:2H2O
CuSeO4:5H2O	-18.79	-21.23	-2.44	CuSeO4:5H2O
CuSO4	-14.02	-11.08	2.94	CuSO4
Diaspore	2.18	9.06	6.87	AlOOH
Djurleite	-43.27	-77.19	-33.92	Cu0.066Cu1.868S
Dolomite(disordered)	0.71	-15.83	-16.54	CaMg(CO3)2
Dolomite(ordered)	1.26	-15.83	-17.09	CaMg(CO3)2
Epsomite	-3.99	-6.11	-2.13	MgSO4:7H2O
Fe(OH)2	-5.46	8.11	13.56	Fe(OH)2
Fe(OH)2.7Cl.3	6.05	3.01	-3.04	Fe(OH)2.7Cl.3
Fe(VO3)2	-5.84	-9.56	-3.72	Fe(VO3)2
Fe2(OH)4SeO3	-4.26	-2.71	1.55	Fe2(OH)4SeO3
Fe2(SeO3)3:2H2O	-13.29	-33.91	-20.63	Fe2(SeO3)3:2H2O
Fe2(SO4)3	-40.43	-44.17	-3.73	Fe2(SO4)3
Fe3(OH)8	0.78	21.00	20.22	Fe3(OH)8
FeAsO4:2H2O	-7.95	-7.55	0.40	FeAsO4:2H2O
FeCr2O4	1.96	9.16	7.20	FeCr2O4
FeMoO4	-5.35	-15.44	-10.09	FeMoO4
Ferrihydrite	3.26	6.45	3.19	Fe(OH)3
Ferroselite	-28.49	-47.09	-18.60	FeSe2
FeS(ppt)	-65.27	-68.22	-2.95	FeS
FeSe	-19.86	-30.86	-11.00	FeSe

Fluorite	-1.70	-12.20	-10.50	CaF2
Galena	-55.08	-69.05	-13.97	PbS
Gibbsite	0.77	9.06	8.29	Al(OH)3
Goethite	5.96	6.45	0.49	FeOOH
Goslarite	-7.35	-9.36	-2.01	ZnSO4:7H2O
Greenockite	-53.85	-68.21	-14.36	CdS
Greigite	-239.28	-284.32	-45.03	Fe3S4
Gummite	-7.56	0.11	7.67	UO3
Gypsum	-1.16	-5.77	-4.61	CaSO4:2H2O
H-Jarosite	-6.60	-18.70	-12.10	(H3O)Fe3(SO4)2(OH)6
H2MoO4	-10.67	-23.55	-12.88	H2MoO4
H2S(g)	-68.32	-76.33	-8.01	H2S
H2Se(g)	-34.01	-38.97	-4.96	H2Se
Halite	-7.58	-5.98	1.60	NaCl
Hausmannite	-8.08	52.95	61.03	Mn3O4
Hematite	14.31	12.89	-1.42	Fe2O3
Hercynite	3.33	26.22	22.89	FeAl2O4
Huntite	-2.04	-32.01	-29.97	CaMg3(CO3)4
Hydrocerussite	-1.40	-20.17	-18.77	Pb3(OH)2(CO3)2
Hydromagnesite	-10.68	-19.45	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-19.04	-24.21	-5.17	KAl(SO4)2:12H2O
K-Jarosite	0.87	-13.93	-14.80	KFe3(SO4)2(OH)6
K2Cr2O7	-38.68	-55.92	-17.24	K2Cr2O7
K2CrO4	-22.67	-23.19	-0.51	K2CrO4
K2MoO4	-17.26	-14.00	3.26	K2MoO4
K2SeO4	-18.89	-19.62	-0.73	K2SeO4
Langite	-4.74	12.75	17.49	Cu4(OH)6SO4:H2O
Larnakite	-4.04	-4.47	-0.43	PbO:PbSO4
Laurionite	-4.80	-4.18	0.62	PbOHCl
Lepidocrocite	5.08	6.45	1.37	FeOOH
Lime	-19.44	13.25	32.70	CaO
Litharge	-5.42	7.28	12.69	PbO
Mackinawite	-64.62	-68.22	-3.60	FeS
Maghemite	6.51	12.89	6.39	Fe2O3
Magnesioferrite	8.94	25.80	16.86	Fe2MgO4
Magnesite	-0.63	-8.09	-7.46	MgCO3
Magnetite	17.60	21.00	3.40	Fe3O4
Malachite	0.19	-5.11	-5.31	Cu2(OH)2CO3
Manganite	-3.90	21.44	25.34	MnOOH
Massicot	-5.62	7.28	12.89	PbO
Matlockite	-7.94	-16.91	-8.97	PbClF
Melanothallite	-21.23	-14.97	6.26	CuCl2
Melanterite	-8.70	-10.91	-2.21	FeSO4:7H2O
Mg(OH)2(active)	-5.89	12.91	18.79	Mg(OH)2
Mg(VO3)2	-16.04	-4.76	11.28	Mg(VO3)2
Mg2V2O7	-18.21	8.15	26.36	Mg2V2O7
MgCr2O4	-2.24	13.96	16.20	MgCr2O4
MgCrO4	-25.21	-19.83	5.38	MgCrO4
MgF2	-4.42	-12.55	-8.13	MgF2
MgMoO4	-8.79	-10.64	-1.85	MgMoO4
MgSeO3:6H2O	-5.75	-2.69	3.06	MgSeO3:6H2O
MgSeO4:6H2O	-15.06	-16.26	-1.20	MgSeO4:6H2O
Minium	-28.95	44.57	73.52	Pb3O4
Mirabilite	-6.95	-8.07	-1.11	Na2SO4:10H2O
Mn(VO3)2	-12.50	-7.60	4.90	Mn(VO3)2
Mn2(SO4)3	-59.17	-64.88	-5.71	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-10.29	2.21	12.50	Mn3(AsO4)2:8H2O
MnCl2:4H2O	-15.56	-12.84	2.72	MnCl2:4H2O
MnS(grn)	-66.43	-66.26	0.17	MnS
MnS(pnk)	-69.60	-66.26	3.34	MnS
MnSe	-32.40	-28.90	3.50	MnSe
MnSeO3	-6.66	-5.53	1.13	MnSeO3
MnSeO3:2H2O	-6.51	-5.53	0.98	MnSeO3:2H2O
MnSeO4:5H2O	-17.05	-19.10	-2.05	MnSeO4:5H2O
MnSO4	-11.53	-8.95	2.58	MnSO4
Monteponite	-6.98	8.12	15.10	CdO

MoO3	-15.55	-23.55	-8.00	MoO3
Morenosite	-8.41	-10.56	-2.14	NiSO4:7H2O
MoS2	-128.69	-198.95	-70.26	MoS2
Na-Jarosite	-2.03	-13.23	-11.20	NaFe3(SO4)2(OH)6
Na2Cr2O7	-44.62	-54.52	-9.90	Na2Cr2O7
Na2CrO4	-24.71	-21.78	2.93	Na2CrO4
Na2Mo2O7	-19.55	-36.14	-16.60	Na2Mo2O7
Na2MoO4	-14.08	-12.59	1.49	Na2MoO4
Na2MoO4:2H2O	-13.82	-12.59	1.22	Na2MoO4:2H2O
Na2SeO3:5H2O	-14.95	-4.65	10.30	Na2SeO3:5H2O
Na2SeO4	-19.49	-18.21	1.28	Na2SeO4
Na3VO4	-29.09	7.59	36.68	Na3VO4
Na4V2O7	-33.16	4.24	37.40	Na4V2O7
Nantokite	-5.47	-12.20	-6.73	CuCl
Natron	-8.73	-10.04	-1.31	Na2CO3:10H2O
NaVO3	-7.22	-3.36	3.86	NaVO3
Nesquehonite	-3.42	-8.09	-4.67	MgCO3:3H2O
Ni(OH)2	-4.33	8.46	12.79	Ni(OH)2
Ni3(AsO4)2:8H2O	-18.32	-2.62	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-17.17	14.83	32.00	Ni4(OH)6SO4
NiCO3	-5.66	-12.53	-6.87	NiCO3
NiMoO4	-3.94	-15.09	-11.14	NiMoO4
NiS(alpha)	-62.27	-67.87	-5.60	NiS
NiS(beta)	-56.77	-67.87	-11.10	NiS
NiS(gamma)	-55.07	-67.87	-12.80	NiS
NiSe	-12.81	-30.51	-17.70	NiSe
NiSeO3:2H2O	-9.96	-7.14	2.81	NiSeO3:2H2O
NiSeO4:6H2O	-19.19	-20.71	-1.52	NiSeO4:6H2O
Nsutite	-10.04	7.46	17.50	MnO2
O2(g)	-37.61	45.48	83.09	O2
Orpiment	-203.61	-264.68	-61.07	As2S3
Otavite	-0.88	-12.88	-12.00	CdCO3
Pb(BO2)2	-10.16	-3.64	6.52	Pb(BO2)2
Pb(OH)2	-0.87	7.28	8.15	Pb(OH)2
Pb10(OH)6O(CO3)6	-44.46	-53.22	-8.76	Pb10(OH)6O(CO3)6
Pb2(OH)3Cl	-5.70	3.09	8.79	Pb2(OH)3Cl
Pb2O(OH)2	-11.64	14.55	26.19	Pb2O(OH)2
Pb2O3	-23.75	37.29	61.04	Pb2O3
Pb2OCO3	-5.89	-6.45	-0.56	Pb2OCO3
Pb2V2O7	-1.22	-3.12	-1.90	Pb2V2O7
Pb3(AsO4)2	-11.98	-6.18	5.80	Pb3(AsO4)2
Pb3(VO4)2	-1.98	4.16	6.14	Pb3(VO4)2
Pb3O2CO3	-10.19	0.83	11.02	Pb3O2CO3
Pb3O2SO4	-7.88	2.81	10.69	Pb3O2SO4
Pb4(OH)6SO4	-11.02	10.08	21.10	Pb4(OH)6SO4
Pb4O3SO4	-11.80	10.08	21.88	Pb4O3SO4
PbCrO4	-12.86	-25.46	-12.60	PbCrO4
PbF2	-10.74	-18.18	-7.44	PbF2
Pbmetal	-19.71	-15.47	4.25	Pb
PbMoO4	-0.65	-16.27	-15.62	PbMoO4
PbO:0.3H2O	-5.70	7.28	12.98	PbO:0.33H2O
PbSeO4	-15.05	-21.89	-6.84	PbSeO4
Periclase	-8.68	12.91	21.58	MgO
Phosgenite	-9.55	-29.36	-19.81	PbCl2:PbCO3
Plattnerite	-19.58	30.02	49.60	PbO2
Portlandite	-9.55	13.25	22.80	Ca(OH)2
Pyrite	-103.30	-121.81	-18.51	FeS2
Pyrochroite	-5.12	10.07	15.19	Mn(OH)2
Pyrolusite	-8.57	32.81	41.38	MnO2
Realgar	-85.80	-105.55	-19.75	AsS
Retgersite	-8.52	-10.56	-2.04	NiSO4:6H2O
Rhodochrosite	-0.35	-10.93	-10.58	MnCO3
Rutherfordine	-6.39	-20.89	-14.50	UO2CO3
Schoepite	-5.89	0.11	5.99	UO2(OH)2:H2O
Semetal(am)	-9.12	-16.23	-7.11	Se
Semetal(hex	-8.52	-16.23	-7.71	Se

```
  SeO2            -15.73    -15.60    0.12  SeO2
  SeO3            -50.21    -29.17   21.04  SeO3
  Siderite         -2.65    -12.89  -10.24  FeCO3
  Smithsonite      -1.33    -11.33  -10.00  ZnCO3
  Sphalerite      -55.22    -66.67  -11.45  ZnS
  Spinel           -5.83     31.02   36.85  MgAl2O4
  Sulfur          -51.44    -53.59   -2.14  S
  Tenorite          0.30      7.94    7.64  CuO
  Thenardite       -8.39     -8.07    0.32  Na2SO4
  Thermonatrite   -10.68    -10.04    0.64  Na2CO3:H2O
  Tyuyamunite      -8.28     -4.20    4.08  Ca(UO2)2(VO4)2
  U3O8            -15.85      5.23   21.08  U3O8
  U4O9            -27.91    -30.93   -3.02  U4O9
  UF4             -34.79    -64.33  -29.54  UF4
  UF4:2.5H2O      -31.61    -64.33  -32.72  UF4:2.5H2O
  UO2(am)         -14.35    -13.42    0.93  UO2
  UO2(OH)2(beta)   -5.50      0.11    5.61  UO2(OH)2
  UO2SeO4:4H2O    -26.81    -29.06   -2.25  UO2SeO4:4H2O
  UO3              -7.59      0.11    7.70  UO3
  Uraninite        -8.75    -13.42   -4.67  UO2
  V(OH)3          -16.57     -8.98    7.59  V(OH)3
  V2O5            -16.31    -17.67   -1.36  V2O5
  V3O5            -34.49    -32.65    1.84  V3O5
  V4O7            -43.14    -35.95    7.19  V4O7
  V6O13           -37.63    -98.49  -60.86  V6O13
  VCl2            -62.14    -43.26   18.87  VCl2
  VCl3            -66.78    -43.35   23.43  VCl3
  VF4             -69.15    -54.22   14.93  VF4
  Vmetal          -87.12    -43.09   44.03  V
  VO              -35.11    -20.35   14.76  VO
  VO(OH)2          -8.45     -3.30    5.15  VO(OH)2
  VO2Cl           -23.13    -20.29    2.84  VO2Cl
  VOCl            -31.59    -20.43   11.15  VOCl
  VOCl2           -38.98    -26.22   12.76  VOCl2
  VOSO4           -25.93    -22.32    3.61  VOSO4
  Witherite        -2.78    -11.35   -8.57  BaCO3
  Wurtzite        -57.72    -66.67   -8.95  ZnS
  Zincite          -1.67      9.66   11.33  ZnO
  Zincosite       -13.29     -9.36    3.93  ZnSO4
  Zn(BO2)2         -9.55     -1.26    8.29  Zn(BO2)2
  Zn(OH)2          -2.54      9.66   12.20  Zn(OH)2
  Zn(OH)2(am)      -2.81      9.66   12.47  Zn(OH)2
  Zn(OH)2(beta)    -2.09      9.66   11.75  Zn(OH)2
  Zn(OH)2(epsilon)  -1.87      9.66   11.53  Zn(OH)2
  Zn(OH)2(gamma)   -2.07      9.66   11.73  Zn(OH)2
  Zn2(OH)2SO4      -7.20      0.30    7.50  Zn2(OH)2SO4
  Zn2(OH)3Cl       -7.32      7.87   15.19  Zn2(OH)3Cl
  Zn3(AsO4)2:2.5H2O -12.67      0.98   13.65  Zn3(AsO4)2:2.5H2O
  Zn3O(SO4)2      -27.97     -9.05   18.91  Zn3O(SO4)2
  Zn4(OH)6SO4      -8.77     19.63   28.40  Zn4(OH)6SO4
  Zn5(OH)8Cl2     -13.10     25.40   38.50  Zn5(OH)8Cl2
  ZnCl2           -20.30    -13.25    7.05  ZnCl2
  ZnCO3:1H2O       -1.07    -11.33  -10.26  ZnCO3:1H2O
  ZnF2            -15.26    -15.79   -0.53  ZnF2
  Znmetal         -38.87    -13.08   25.79  Zn
  ZnMoO4           -3.76    -13.89  -10.13  ZnMoO4
  ZnO(active)      -1.53      9.66   11.19  ZnO
  ZnS(am)         -57.61    -66.67   -9.05  ZnS
  ZnSe            -14.91    -29.31  -14.40  ZnSe
  ZnSeO4:6H2O     -17.99    -19.51   -1.52  ZnSeO4:6H2O
  ZnSO4:1H2O       -8.72     -9.36   -0.64  ZnSO4:1H2O

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
  For ideal gases, phi = 1.

------------------
```

```
End of simulation.
------------------

------------------------------------
Reading input data for simulation 2.
------------------------------------

------------------------------
End of Run after 0.267 Seconds.
------------------------------
```

```
# P50 Scenario

SOLUTION 1 UG Water P50
    temp      25
    pH        8.112
    units     mg/L
    density   1
Al    0.0802
As    0.0026
Ba    0.1788
B     0.1294
Ca    84.0
Cl    49.1
Mg    41.0
Na    176.2
K     35.8
F     0.9179
S(6)  141.4
Cd    0.0075
Cr    0.0074
Co    0.0037
Cu    0.0710
Fe    0.1857
Pb    0.0464
Mn    0.0875
Mo    0.0067
Ni    0.0054
Se    0.0068
U     0.0074
V     0.0025
Zn    0.1983
Alkalinity 553.3 as HCO3
    -water    1 # kg

SOLUTION 2 PAF Material
    temp      25
    pH        7.5
    units     mg/L
    density   1
      Al    0.020
      As    0
      Ba    0.020
      B     0
      Ca    67.0
      Cl    0
      Mg    8.0
      Na    1.0
      K     13.0
      F     0.300
      S(6)  197.0
      Cd    0.000
      Cr    0
      Co    0.007
      Cu    0.028
      Fe    0
      Pb    0
      Mn    0.040
      Mo    0.003
      Ni    0.004
      Se    0
      U     0
      V     0
      Zn    0
      Alkalinity 22 as HCO3
    -water    1 # kg
```

```
SOLUTION 3 NAF Material
    temp      25
    pH        7.6
    units     mg/L
    density   1
      Al    0.140
      As    0.029
      Ba    0.020
      B     0
      Ca    122.0
      Cl    0
      Mg    18.0
      Na    1.0
      K     16.0
      F     0.300
      S(6)  331.0
      Cd    0.000
      Cr    0
      Co    0.002
      Cu    0.019
      Fe    0.070
      Pb    0
      Mn    0.130
      Mo    0.005
      Ni    0.001
      Se    0
      U     0.001
      V     0
      Zn    0
      Alkalinity 28 as HCO3
    -water    1 # kg


SOLUTION 4 Make-up Material
    temp      25
    pH        7.7
    units     mg/L
    density   1
      Al    0.020
      As    0
      Ba    0.020
      B     0
      Ca    67.0
      Cl    0
      Mg    8.0
      Na    1.0
      K     13.0
      F     0.300
      S(6)  197.0
      Cd    0.000
      Cr    0
      Co    0.007
      Cu    0.028
      Fe    0
      Pb    0
      Mn    0.040
      Mo    0.003
      Ni    0.004
      Se    0
      U     0
      V     0
      Zn    0
      Alkalinity 22 as HCO3
    -water    1 # kg

# Mix the three solutions together
```

```
MIX 1 Mix within UG Works
    1    0.308
    2    0.110
    3    0.400
    4    0.182

SAVE Solution 5

SELECTED_OUTPUT 2
    -file                   D:\selected_output_3.txt
    -high_precision         true
    -reset                  true
    -distance               false
    -time                   false
    -temperature            false
    -ionic_strength         false
    -water                  false
    -totals                 pH Al As Ba B Ca Cl Mg
                            Na K  F  S(6) Cd Cr Co
                            Cu Fe Pb Mn Mo  Ni Se
                            U V Zn Alkalinity
END
```

```
   Input file: P:\J23011 - BCP Underground EA (Aeris)\2. Tech Work Area\2.08 Water Quality
Model\2.08.02 PAF Assessment\BPC_UG_PAF_Disposal_P50.pqi
  Output file: P:\J23011 - BCP Underground EA (Aeris)\2. Tech Work Area\2.08 Water Quality
Model\2.08.02 PAF Assessment\BPC_UG_PAF_Disposal_P50.pqo
Database file: c:\phreeqc\database\minteq.v4.dat

------------------
Reading data base.
------------------

      SOLUTION_MASTER_SPECIES
      SOLUTION_SPECIES
      SOLUTION_SPECIES
      PHASES
      PHASES
      SURFACE_MASTER_SPECIES
      SURFACE_SPECIES
      END
-----------------------------------
Reading input data for simulation 1.
-----------------------------------

      DATABASE c:\phreeqc\database\minteq.v4.dat
      SOLUTION 1 UG Water P50
          temp      25
          pH        8.112
          units     mg/L
          density   1
      Al    0.0802
      As    0.0026
      Ba    0.1788
      B     0.1294
      Ca    84.0
      Cl    49.1
      Mg    41.0
      Na    176.2
      K     35.8
      F     0.9179
      S(6)  141.4
      Cd    0.0075
      Cr    0.0074
      Co    0.0037
      Cu    0.0710
      Fe    0.1857
      Pb    0.0464
      Mn    0.0875
      Mo    0.0067
      Ni    0.0054
      Se    0.0068
      U     0.0074
      V     0.0025
      Zn    0.1983
      Alkalinity 553.3 as HCO3
          water    1 # kg
      SOLUTION 2 PAF Material
          temp      25
          pH        7.5
          units     mg/L
          density   1
            Al    0.020
            As    0
            Ba    0.020
            B     0
            Ca    67.0
            Cl    0
            Mg    8.0
```

```
            Na    1.0
            K     13.0
            F     0.300
            S(6)  197.0
            Cd    0.000
            Cr    0
            Co    0.007
            Cu    0.028
            Fe    0
            Pb    0
            Mn    0.040
            Mo    0.003
            Ni    0.004
            Se    0
            U     0
            V     0
            Zn    0
            Alkalinity 22 as HCO3
          water    1 # kg
      SOLUTION 3 NAF Material
          temp      25
          pH        7.6
          units     mg/L
          density   1
            Al    0.140
            As    0.029
            Ba    0.020
            B     0
            Ca    122.0
            Cl    0
            Mg    18.0
            Na    1.0
            K     16.0
            F     0.300
            S(6)  331.0
            Cd    0.000
            Cr    0
            Co    0.002
            Cu    0.019
            Fe    0.070
            Pb    0
            Mn    0.130
            Mo    0.005
            Ni    0.001
            Se    0
            U     0.001
            V     0
            Zn    0
            Alkalinity 28 as HCO3
          water    1 # kg
      SOLUTION 4 Make-up Material
          temp      25
          pH        7.7
          units     mg/L
          density   1
            Al    0.020
            As    0
            Ba    0.020
            B     0
            Ca    67.0
            Cl    0
            Mg    8.0
            Na    1.0
            K     13.0
            F     0.300
            S(6)  197.0
```

```
            Cd    0.000
            Cr    0
            Co    0.007
            Cu    0.028
            Fe    0
            Pb    0
            Mn    0.040
            Mo    0.003
            Ni    0.004
            Se    0
            U     0
            V     0
            Zn    0
            Alkalinity 22 as HCO3
          water    1 # kg
      MIX 1 Mix within UG Works
          1    0.308
          2    0.110
          3    0.400
          4    0.182
      SAVE Solution 5
      SELECTED_OUTPUT 2
          file                  D:\selected_output_3.txt
          high_precision        true
          reset                 true
          distance              false
          time                  false
          temperature           false
          ionic_strength        false
          water                 false
          totals                pH Al As Ba B Ca Cl Mg
WARNING: Expected element name to begin with upper case letter.
                                 Na K  F  S(6) Cd Cr Co
                                 Cu Fe Pb Mn Mo  Ni Se
                                 U V Zn Alkalinity
      END
-------------------------------------------
Beginning of initial solution calculations.
-------------------------------------------

Initial solution 1.     UG Water P50

-----------------------------Solution composition------------------------------

      Elements           Molality       Moles

      Al                 2.976e-06   2.976e-06
      Alkalinity         9.077e-03   9.077e-03
      As                 3.474e-08   3.474e-08
      B                  1.198e-05   1.198e-05
      Ba                 1.303e-06   1.303e-06
      Ca                 2.098e-03   2.098e-03
      Cd                 6.679e-08   6.679e-08
      Cl                 1.386e-03   1.386e-03
      Co                 6.285e-08   6.285e-08
      Cr                 1.425e-07   1.425e-07
      Cu                 1.119e-06   1.119e-06
      F                  4.837e-05   4.837e-05
      Fe                 3.329e-06   3.329e-06
      K                  9.166e-04   9.166e-04
      Mg                 1.689e-03   1.689e-03
      Mn                 1.594e-06   1.594e-06
      Mo                 6.991e-08   6.991e-08
      Na                 7.673e-03   7.673e-03
      Ni                 9.211e-08   9.211e-08
      Pb                 2.242e-07   2.242e-07
```

```
      S(6)              1.474e-03   1.474e-03
      Se                8.621e-08   8.621e-08
      U                 3.112e-08   3.112e-08
      V                 4.913e-08   4.913e-08
      Zn                3.036e-06   3.036e-06

----------------------------Description of solution----------------------------

                                    pH  =   8.112
                                    pe  =   4.000
                          Activity of water  =   1.000
                       Ionic strength (mol/kgw)  =   1.820e-02
                            Mass of water (kg)  =   1.000e+00
                        Total carbon (mol/kg)  =   8.999e-03
                           Total CO2 (mol/kg)  =   8.999e-03
                             Temperature (°C)  =  25.00
                       Electrical balance (eq)  =   2.731e-03
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =   9.92
                                  Iterations  =  11
                                     Total H  = 1.110227e+02
                                     Total O  = 5.553978e+01

----------------------------Distribution of species----------------------------

                                                Log       Log       Log    mole V
   Species          Molality    Activity  Molality  Activity     Gamma    cm³/mol

   OH-            1.494e-06   1.303e-06    -5.826    -5.885    -0.060     (0)
   H+             8.828e-09   7.727e-09    -8.054    -8.112    -0.058      0.00
   H2O            5.551e+01   9.996e-01     1.744    -0.000     0.000     18.07
Al              2.976e-06
   Al(OH)4-       2.959e-06   2.593e-06    -5.529    -5.586    -0.057     (0)
   Al(OH)3        1.581e-08   1.581e-08    -7.801    -7.801     0.000     (0)
   Al(OH)2+       6.913e-10   6.083e-10    -9.160    -9.216    -0.056     (0)
   AlF2+          2.963e-12   2.608e-12   -11.528   -11.584    -0.056     (0)
   AlF3           1.251e-12   1.251e-12   -11.903   -11.903     0.000     (0)
   AlOH+2         9.804e-13   5.879e-13   -12.009   -12.231    -0.222     (0)
   AlF+2          2.867e-13   1.719e-13   -12.543   -12.765    -0.222     (0)
   AlF4-          2.725e-14   2.388e-14   -13.565   -13.622    -0.057     (0)
   AlSO4+         2.756e-15   2.415e-15   -14.560   -14.617    -0.057     (0)
   Al+3           1.496e-15   4.513e-16   -14.825   -15.346    -0.521     (0)
   Al(SO4)2-      2.035e-17   1.783e-17   -16.691   -16.749    -0.057     (0)
   AlMo6O21-3     0.000e+00   0.000e+00   -52.726   -53.346    -0.619     (0)
As(3)           8.499e-21
   H3AsO3         7.885e-21   7.885e-21   -20.103   -20.103     0.000     (0)
   H2AsO3-        6.132e-22   5.234e-22   -21.212   -21.281    -0.069     (0)
   HAsO3-2        1.164e-25   6.177e-26   -24.934   -25.209    -0.275     (0)
   H4AsO3+        3.537e-29   3.019e-29   -28.451   -28.520    -0.069     (0)
   AsO3-3         1.282e-30   3.082e-31   -29.892   -30.511    -0.619     (0)
As(5)           3.474e-08
   HAsO4-2        3.325e-08   1.765e-08    -7.478    -7.753    -0.275     (0)
   H2AsO4-        1.457e-09   1.243e-09    -8.837    -8.905    -0.069     (0)
   AsO4-3         3.005e-11   7.222e-12   -10.522   -11.141    -0.619     (0)
   H3AsO4         1.663e-15   1.670e-15   -14.779   -14.777     0.002     (0)
B               1.198e-05
   H3BO3          1.094e-05   1.098e-05    -4.961    -4.959     0.002     (0)
   H2BO3-         9.522e-07   8.256e-07    -6.021    -6.083    -0.062     (0)
   CaH2BO3+       5.502e-08   4.771e-08    -7.259    -7.321    -0.062     (0)
   MgH2BO3+       2.847e-08   2.468e-08    -7.546    -7.608    -0.062     (0)
   NaH2BO3        8.717e-09   8.717e-09    -8.060    -8.060     0.000     (0)
   BF(OH)3-       1.926e-10   1.670e-10    -9.715    -9.777    -0.062     (0)
   BaH2BO3+       2.123e-11   1.841e-11   -10.673   -10.735    -0.062     (0)
   H5(BO3)2-      8.903e-12   7.719e-12   -11.050   -11.112    -0.062     (0)
   H8(BO3)3-      9.779e-15   8.479e-15   -14.010   -14.072    -0.062     (0)
   BF2(OH)2-      6.063e-15   5.257e-15   -14.217   -14.279    -0.062     (0)
   BF3OH-         6.946e-22   6.023e-22   -21.158   -21.220    -0.062     (0)
   BF4-           1.006e-27   8.726e-28   -26.997   -27.059    -0.062     (0)
Ba              1.303e-06
   Ba+2           1.229e-06   7.214e-07    -5.910    -6.142    -0.231     (0)
   BaHCO3+        5.785e-08   5.105e-08    -7.238    -7.292    -0.054     (0)
   BaCO3          1.663e-08   1.663e-08    -7.779    -7.779     0.000     (0)
   BaH2BO3+       2.123e-11   1.841e-11   -10.673   -10.735    -0.062     (0)
   BaOH+          4.670e-12   4.102e-12   -11.331   -11.387    -0.056     (0)
C(4)            8.999e-03
   HCO3-          8.420e-03   7.410e-03    -2.075    -2.130    -0.056     (0)
   CaHCO3+        1.570e-04   1.385e-04    -3.804    -3.858    -0.054     (0)
   H2CO3          1.288e-04   1.288e-04    -3.890    -3.890     0.000     (0)
   CO3-2          7.659e-05   4.496e-05    -4.116    -4.347    -0.231     (0)
   MgHCO3+        7.479e-05   6.538e-05    -4.126    -4.185    -0.058     (0)
   CaCO3          7.154e-05   7.154e-05    -4.145    -4.145     0.000     (0)
   MgCO3          3.224e-05   3.224e-05    -4.492    -4.492     0.000     (0)
   NaHCO3         2.776e-05   2.776e-05    -4.557    -4.557     0.000     (0)
   NaCO3-         6.337e-06   5.577e-06    -5.198    -5.254    -0.056     (0)
   ZnCO3          1.601e-06   1.601e-06    -5.796    -5.796     0.000     (0)
   CuCO3          8.880e-07   8.880e-07    -6.052    -6.052     0.000     (0)
   Cu(CO3)2-2     2.025e-07   1.074e-07    -6.694    -6.969    -0.275     (0)
   ZnHCO3+        1.699e-07   1.450e-07    -6.770    -6.839    -0.069     (0)
   PbCO3          1.677e-07   1.677e-07    -6.776    -6.776     0.000     (0)
   MnHCO3+        1.230e-07   1.080e-07    -6.910    -6.967    -0.056     (0)
   BaHCO3+        5.785e-08   5.105e-08    -7.238    -7.292    -0.054     (0)
   Pb(CO3)2-2     4.097e-08   2.174e-08    -7.388    -7.663    -0.275     (0)
   NiCO3          3.348e-08   3.348e-08    -7.475    -7.475     0.000     (0)
   UO2(CO3)3-4    2.919e-08   2.314e-09    -7.535    -8.636    -1.101     (0)
   CdCO3          2.185e-08   2.185e-08    -7.661    -7.661     0.000     (0)
   NiHCO3+        2.136e-08   1.823e-08    -7.670    -7.739    -0.069     (0)
   BaCO3          1.663e-08   1.663e-08    -7.779    -7.779     0.000     (0)
   CoCO3          1.366e-08   1.366e-08    -7.865    -7.865     0.000     (0)
   CoHCO3+        1.214e-08   1.036e-08    -7.916    -7.985    -0.069     (0)
   PbHCO3+        8.003e-09   6.831e-09    -8.097    -8.166    -0.069     (0)
   UO2(CO3)2-2    1.935e-09   1.027e-09    -8.713    -8.988    -0.275     (0)
   CuHCO3+        1.837e-09   1.568e-09    -8.736    -8.805    -0.069     (0)
   Cd(CO3)2-2     1.372e-09   7.282e-10    -8.863    -9.138    -0.275     (0)
   CdHCO3+        4.215e-10   3.597e-10    -9.375    -9.444    -0.069     (0)
   FeHCO3+        3.251e-10   2.869e-10    -9.488    -9.542    -0.054     (0)
   UO2CO3         1.145e-12   1.145e-12   -11.941   -11.941     0.000     (0)
Ca              2.098e-03
   Ca+2           1.711e-03   1.004e-03    -2.767    -2.998    -0.231     (0)
   CaSO4          1.585e-04   1.585e-04    -3.800    -3.800     0.000     (0)
   CaHCO3+        1.570e-04   1.385e-04    -3.804    -3.858    -0.054     (0)
   CaCO3          7.154e-05   7.154e-05    -4.145    -4.145     0.000     (0)
   CaF+           4.753e-07   4.175e-07    -6.323    -6.379    -0.056     (0)
   CaH2BO3+       5.502e-08   4.771e-08    -7.259    -7.321    -0.062     (0)
   CaOH+          2.958e-08   2.610e-08    -7.529    -7.583    -0.054     (0)
Cd              6.679e-08
   Cd+2           3.633e-08   2.132e-08    -7.440    -7.671    -0.231     (0)
   CdCO3          2.185e-08   2.185e-08    -7.661    -7.661     0.000     (0)
   CdSO4          3.445e-09   3.445e-09    -8.463    -8.463     0.000     (0)
   CdCl+          2.896e-09   2.471e-09    -8.538    -8.607    -0.069     (0)
   Cd(CO3)2-2     1.372e-09   7.282e-10    -8.863    -9.138    -0.275     (0)
   CdHCO3+        4.215e-10   3.597e-10    -9.375    -9.444    -0.069     (0)
   CdOH+          2.585e-10   2.206e-10    -9.588    -9.656    -0.069     (0)
   CdOHCl         1.321e-10   1.321e-10    -9.879    -9.879     0.000     (0)
   Cd(SO4)2-2     6.037e-11   3.204e-11   -10.219   -10.494    -0.275     (0)
   CdF+           1.509e-11   1.288e-11   -10.821   -10.890    -0.069     (0)
   CdCl2          1.250e-11   1.250e-11   -10.903   -10.903     0.000     (0)
   Cd(OH)2        1.814e-12   1.814e-12   -11.741   -11.741     0.000     (0)
   CdCl3-         1.122e-14   9.573e-15   -13.950   -14.019    -0.069     (0)
   CdF2           9.787e-16   9.787e-16   -15.009   -15.009     0.000     (0)
   Cd(OH)3-       1.691e-16   1.443e-16   -15.772   -15.841    -0.069     (0)
   Cd2OH+3        9.812e-17   2.358e-17   -16.008   -16.627    -0.619     (0)
   CdSeO4         1.703e-17   1.703e-17   -16.769   -16.769     0.000     (0)
   Cd(SeO3)2-2    1.423e-17   7.552e-18   -16.847   -17.122    -0.275     (0)
   Cd(OH)4-2      5.799e-23   3.077e-23   -22.237   -22.512    -0.275     (0)
Cl              1.386e-03
   Cl-            1.386e-03   1.214e-03    -2.858    -2.916    -0.058     (0)
   ZnOHCl         3.216e-09   3.216e-09    -8.493    -8.493     0.000     (0)
   CdCl+          2.896e-09   2.471e-09    -8.538    -8.607    -0.069     (0)
   ZnCl+          2.158e-09   1.886e-09    -8.666    -8.724    -0.058     (0)
   MnCl+          1.271e-09   1.116e-09    -8.896    -8.952    -0.056     (0)
   CuCl           2.510e-10   2.510e-10    -9.600    -9.600     0.000     (0)
   CdOHCl         1.321e-10   1.321e-10    -9.879    -9.879     0.000     (0)
   CoCl+          8.841e-11   7.546e-11   -10.054   -10.122    -0.069     (0)
   CuCl2-         7.280e-11   6.364e-11   -10.138   -10.196    -0.058     (0)
   NiCl+          7.262e-11   6.198e-11   -10.139   -10.208    -0.069     (0)
   PbCl+          6.259e-11   5.342e-11   -10.203   -10.272    -0.069     (0)
   CdCl2          1.250e-11   1.250e-11   -10.903   -10.903     0.000     (0)
   CuCl+          7.381e-12   6.452e-12   -11.132   -11.190    -0.058     (0)
   ZnCl2          3.627e-12   3.627e-12   -11.440   -11.440     0.000     (0)
   MnCl2          1.913e-12   1.913e-12   -11.718   -11.718     0.000     (0)
   PbCl2          2.896e-13   2.896e-13   -12.538   -12.538     0.000     (0)
   CuCl3-2        2.774e-14   1.651e-14   -13.557   -13.782    -0.225     (0)
   CdCl3-         1.122e-14   9.573e-15   -13.950   -14.019    -0.069     (0)
   ZnCl3-         4.000e-15   3.497e-15   -14.398   -14.456    -0.058     (0)
   CuCl2          2.715e-15   2.715e-15   -14.566   -14.566     0.000     (0)
   MnCl3-         7.280e-16   6.394e-16   -15.138   -15.194    -0.056     (0)
   NiCl2          3.787e-16   3.787e-16   -15.422   -15.422     0.000     (0)
   PbCl3-         1.639e-16   1.399e-16   -15.785   -15.854    -0.069     (0)
   CrCl+2         5.369e-17   2.849e-17   -16.270   -16.545    -0.275     (0)
   ZnCl4-2        3.564e-18   2.122e-18   -17.448   -17.673    -0.225     (0)
   CrOHCl2        8.559e-19   8.559e-19   -18.068   -18.068     0.000     (0)
   FeCl+2         1.759e-19   1.047e-19   -18.755   -18.980    -0.225     (0)
   PbCl4-2        1.463e-19   7.761e-20   -18.835   -19.110    -0.275     (0)
   CuCl3-         3.517e-20   3.075e-20   -19.454   -19.512    -0.058     (0)
   UO2Cl+         1.475e-20   1.259e-20   -19.831   -19.900    -0.069     (0)
   CrCl2+         3.843e-21   3.280e-21   -20.415   -20.484    -0.069     (0)
   FeCl2+         6.461e-22   5.675e-22   -21.190   -21.246    -0.056     (0)
   VOCl+          6.255e-23   5.339e-23   -22.204   -22.273    -0.069     (0)
   CuCl4-2        3.141e-25   1.870e-25   -24.503   -24.728    -0.225     (0)
   FeCl3          6.887e-26   6.887e-26   -25.162   -25.162     0.000     (0)
   CrO3Cl-        2.797e-26   2.387e-26   -25.553   -25.622    -0.069     (0)
   CoCl+2         3.330e-37   1.767e-37   -36.478   -36.753    -0.275     (0)
   UCl+3          0.000e+00   0.000e+00   -49.022   -49.642    -0.619     (0)
Co(2)           6.285e-08
   Co+2           3.387e-08   1.797e-08    -7.470    -7.745    -0.275     (0)
   CoCO3          1.366e-08   1.366e-08    -7.865    -7.865     0.000     (0)
   CoHCO3+        1.214e-08   1.036e-08    -7.916    -7.985    -0.069     (0)
   CoSO4          2.472e-09   2.472e-09    -8.607    -8.607     0.000     (0)
   CoOH+          5.474e-10   4.672e-10    -9.262    -9.331    -0.069     (0)
   CoCl+          8.841e-11   7.546e-11   -10.054   -10.122    -0.069     (0)
   Co(OH)2        4.834e-11   4.834e-11   -10.316   -10.316     0.000     (0)
   CoF+           2.537e-11   2.165e-11   -10.596   -10.664    -0.069     (0)
   Co(OH)3-       1.472e-15   1.256e-15   -14.832   -14.901    -0.069     (0)
   CoOOH-         3.695e-16   3.154e-16   -15.432   -15.501    -0.069     (0)
   CoSeO4         3.864e-17   3.864e-17   -16.413   -16.413     0.000     (0)
   Co2OH+3        1.751e-18   4.208e-19   -17.757   -18.376    -0.619     (0)
   Co(OH)4-2      4.888e-22   2.594e-22   -21.311   -21.586    -0.275     (0)
   Co4(OH)4+4     1.199e-28   9.503e-30   -27.921   -29.022    -1.101     (0)
Co(3)           8.926e-30
   CoOH+2         8.926e-30   4.737e-30   -29.049   -29.325    -0.275     (0)
   Co+3           2.372e-36   7.156e-37   -35.625   -36.145    -0.521     (0)
   CoCl+2         3.330e-37   1.767e-37   -36.478   -36.753    -0.275     (0)
Cr(2)           8.166e-25
   Cr+2           8.166e-25   4.333e-25   -24.088   -24.363    -0.275     (0)
Cr(3)           1.425e-07
   Cr(OH)2+       9.600e-08   8.193e-08    -7.018    -7.087    -0.069     (0)
   Cr(OH)3        4.009e-08   4.009e-08    -7.397    -7.397     0.000     (0)
   CrO2-          2.888e-09   2.465e-09    -8.539    -8.608    -0.069     (0)
   Cr(OH)4-       2.436e-09   2.079e-09    -8.613    -8.682    -0.069     (0)
   Cr(OH)+2       9.742e-10   5.169e-10    -9.011    -9.287    -0.275     (0)
   CrOHSO4        8.455e-11   8.455e-11   -10.073   -10.073     0.000     (0)
   CrF+2          2.064e-13   1.095e-13   -12.685   -12.961    -0.275     (0)
   Cr+3           7.547e-14   1.814e-14   -13.122   -13.741    -0.619     (0)
   CrSO4+         3.420e-14   2.919e-14   -13.466   -13.535    -0.069     (0)
   CrCl+2         5.369e-17   2.849e-17   -16.270   -16.545    -0.275     (0)
   Cr2(OH)2SO4+2  7.444e-18   3.950e-18   -17.128   -17.403    -0.275     (0)
   CrOHCl2        8.559e-19   8.559e-19   -18.068   -18.068     0.000     (0)
   Cr2(OH)2(SO4)2   1.617e-19   1.617e-19   -18.791   -18.791     0.000     (0)
   CrCl2+         3.843e-21   3.280e-21   -20.415   -20.484    -0.069     (0)
Cr(6)           2.873e-14
   CrO4-2         2.757e-14   1.618e-14   -13.560   -13.791    -0.231     (0)
   NaCrO4-        6.277e-16   5.358e-16   -15.202   -15.271    -0.069     (0)
   HCrO4-         4.741e-16   4.047e-16   -15.324   -15.393    -0.069     (0)
   KCrO4-         5.625e-17   4.801e-17   -16.250   -16.319    -0.069     (0)
   H2CrO4         2.535e-24   2.535e-24   -23.596   -23.596     0.000     (0)
   CrO3SO4-2      1.238e-24   6.567e-25   -23.907   -24.183    -0.275     (0)
   CrO3Cl-        2.797e-26   2.387e-26   -25.553   -25.622    -0.069     (0)
   Cr2O7-2        1.070e-29   5.680e-30   -28.970   -29.246    -0.275     (0)
Cu(1)           5.163e-10
   CuCl           2.510e-10   2.510e-10    -9.600    -9.600     0.000     (0)
   Cu+            1.925e-10   1.643e-10    -9.716    -9.784    -0.069     (0)
   CuCl2-         7.280e-11   6.364e-11   -10.138   -10.196    -0.058     (0)
   CuCl3-2        2.774e-14   1.651e-14   -13.557   -13.782    -0.225     (0)
Cu(2)           1.118e-06
   CuCO3          8.880e-07   8.880e-07    -6.052    -6.052     0.000     (0)
   Cu(CO3)2-2     2.025e-07   1.074e-07    -6.694    -6.969    -0.275     (0)
   CuOH+          1.581e-08   1.382e-08    -7.801    -7.860    -0.058     (0)
   Cu+2           5.714e-09   3.354e-09    -8.243    -8.474    -0.231     (0)
   Cu(OH)2        3.591e-09   3.591e-09    -8.445    -8.445     0.000     (0)
   CuHCO3+        1.837e-09   1.568e-09    -8.736    -8.805    -0.069     (0)
   CuSO4          5.296e-10   5.296e-10    -9.276    -9.276     0.000     (0)
   Cu(OH)3-       1.124e-11   9.596e-12   -10.949   -11.018    -0.069     (0)
   CuF+           9.447e-12   8.063e-12   -11.025   -11.094    -0.069     (0)
   Cu2(OH)2+2     9.038e-12   4.796e-12   -11.044   -11.319    -0.275     (0)
   CuCl+          7.381e-12   6.452e-12   -11.132   -11.190    -0.058     (0)
   CuCl2          2.715e-15   2.715e-15   -14.566   -14.566     0.000     (0)
   Cu(OH)4-2      1.854e-16   9.838e-17   -15.732   -16.007    -0.275     (0)
   CuCl3-         3.517e-20   3.075e-20   -19.454   -19.512    -0.058     (0)
   CuCl4-2        3.141e-25   1.870e-25   -24.503   -24.728    -0.225     (0)
F               4.837e-05
   F-             4.352e-05   3.810e-05    -4.361    -4.419    -0.058     (0)
   MgF+           4.206e-06   3.685e-06    -5.376    -5.434    -0.057     (0)
   CaF+           4.753e-07   4.175e-07    -6.323    -6.379    -0.056     (0)
   NaF            1.601e-07   1.601e-07    -6.796    -6.796     0.000     (0)
   MnF+           1.261e-09   1.108e-09    -8.899    -8.955    -0.056     (0)
   ZnF+           5.510e-10   4.703e-10    -9.259    -9.328    -0.069     (0)
   HF             4.354e-10   4.354e-10    -9.361    -9.361     0.000     (0)
   BF(OH)3-       1.926e-10   1.670e-10    -9.715    -9.777    -0.062     (0)
   CoF+           2.537e-11   2.165e-11   -10.596   -10.664    -0.069     (0)
   NiF+           2.238e-11   1.910e-11   -10.650   -10.719    -0.069     (0)
   CdF+           1.509e-11   1.288e-11   -10.821   -10.890    -0.069     (0)
   CuF+           9.447e-12   8.063e-12   -11.025   -11.094    -0.069     (0)
   PbF+           3.903e-12   3.331e-12   -11.409   -11.477    -0.069     (0)
   AlF2+          2.963e-12   2.608e-12   -11.528   -11.584    -0.056     (0)
   AlF3           1.251e-12   1.251e-12   -11.903   -11.903     0.000     (0)
   AlF+2          2.867e-13   1.719e-13   -12.543   -12.765    -0.222     (0)
   CrF+2          2.064e-13   1.095e-13   -12.685   -12.961    -0.275     (0)
   HF2-           7.233e-14   6.306e-14   -13.141   -13.200    -0.060     (0)
   AlF4-          2.725e-14   2.388e-14   -13.565   -13.622    -0.057     (0)
   BF2(OH)2-      6.063e-15   5.257e-15   -14.217   -14.279    -0.062     (0)
   PbF2           2.497e-15   2.497e-15   -14.603   -14.603     0.000     (0)
   CdF2           9.787e-16   9.787e-16   -15.009   -15.009     0.000     (0)
   FeF+2          2.005e-16   1.193e-16   -15.698   -15.923    -0.225     (0)
   FeF2+          1.385e-16   1.217e-16   -15.859   -15.915    -0.056     (0)
   UO2F+          3.941e-17   3.364e-17   -16.404   -16.473    -0.069     (0)
```

FeF3	6.539e-18	6.539e-18	-17.184	-17.184	0.000	(0)
UO2F2	3.696e-18	3.696e-18	-17.432	-17.432	0.000	(0)
VO2F	2.193e-18	2.193e-18	-17.659	-17.659	0.000	(0)
H2F2	5.079e-19	5.079e-19	-18.294	-18.294	0.000	(0)
PbF3-	2.114e-19	1.804e-19	-18.675	-18.744	-0.069	(0)
UO2F3-	4.144e-20	3.537e-20	-19.383	-19.451	-0.069	(0)
VO2F2-	3.554e-20	3.034e-20	-19.449	-19.518	-0.069	(0)
VOF+	4.198e-21	3.583e-21	-20.377	-20.446	-0.069	(0)
BF3OH-	6.946e-22	6.023e-22	-21.158	-21.220	-0.062	(0)
VOF2	5.118e-23	5.118e-23	-22.291	-22.291	0.000	(0)
VO2F3-2	2.717e-23	1.442e-23	-22.566	-22.841	-0.275	(0)
UO2F4-2	2.017e-23	1.070e-23	-22.695	-22.971	-0.275	(0)
PbF4-2	6.200e-24	3.290e-24	-23.208	-23.483	-0.275	(0)
VOF3-	8.106e-26	6.919e-26	-25.091	-25.160	-0.069	(0)
VO2F4-3	1.124e-27	2.702e-28	-26.949	-27.568	-0.619	(0)
BF4-	1.006e-27	8.726e-28	-26.997	-27.059	-0.062	(0)
VOF4-2	2.005e-29	1.064e-29	-28.698	-28.973	-0.275	(0)
UF3+	0.000e+00	0.000e+00	-40.014	-40.083	-0.069	(0)
UF2+2	0.000e+00	0.000e+00	-40.589	-40.864	-0.275	(0)
UF4	0.000e+00	0.000e+00	-42.462	-42.462	0.000	(0)
UF+3	0.000e+00	0.000e+00	-42.926	-43.545	-0.619	(0)
UF5-	0.000e+00	0.000e+00	-45.214	-45.283	-0.069	(0)
UF6-2	0.000e+00	0.000e+00	-46.947	-47.222	-0.275	(0)
Fe(2)	6.822e-09					
Fe+2	5.795e-09	3.075e-09	-8.237	-8.512	-0.275	(0)
FeSO4	5.203e-10	5.203e-10	-9.284	-9.284	0.000	(0)
FeHCO3+	3.251e-10	2.869e-10	-9.488	-9.542	-0.054	(0)
FeOH+	1.816e-10	1.595e-10	-9.741	-9.797	-0.056	(0)
Fe(OH)2	1.650e-13	1.650e-13	-12.782	-12.782	0.000	(0)
Fe(OH)3-	7.739e-14	6.797e-14	-13.111	-13.168	-0.056	(0)
Fe(3)	3.322e-06					
Fe(OH)3	1.703e-06	1.703e-06	-5.769	-5.769	0.000	(0)
Fe(OH)2+	1.384e-06	1.218e-06	-5.859	-5.914	-0.056	(0)
Fe(OH)4-	2.348e-07	2.066e-07	-6.629	-6.685	-0.056	(0)
FeOH+2	4.036e-12	2.403e-12	-11.394	-11.619	-0.225	(0)
FeF+2	2.005e-16	1.193e-16	-15.698	-15.923	-0.225	(0)
FeF2+	1.385e-16	1.217e-16	-15.859	-15.915	-0.056	(0)
FeSO4+	2.515e-17	2.209e-17	-16.599	-16.656	-0.056	(0)
Fe+3	9.471e-18	2.857e-18	-17.024	-17.544	-0.521	(0)
FeF3	6.539e-18	6.539e-18	-17.184	-17.184	0.000	(0)
Fe(SO4)2-	3.814e-19	3.256e-19	-18.419	-18.487	-0.069	(0)
FeCl+2	1.759e-19	1.047e-19	-18.755	-18.980	-0.225	(0)
Fe2(OH)2+4	2.411e-21	1.912e-22	-20.618	-21.719	-1.101	(0)
FeCl2+	6.461e-22	5.675e-22	-21.190	-21.246	-0.056	(0)
FeHSeO3+2	5.723e-22	3.037e-22	-21.242	-21.518	-0.275	(0)
Fe3(OH)4+5	1.766e-25	3.364e-27	-24.753	-26.473	-1.720	(0)
FeCl3	6.887e-26	6.887e-26	-25.162	-25.162	0.000	(0)
H(0)	8.418e-28					
H2	4.209e-28	4.227e-28	-27.376	-27.374	0.002	(0)
K	9.166e-04					
K+	9.122e-04	7.985e-04	-3.040	-3.098	-0.058	(0)
KSO4-	4.427e-06	3.896e-06	-5.354	-5.409	-0.056	(0)
KCrO4-	5.625e-17	4.801e-17	-16.250	-16.319	-0.069	(0)
Mg	1.689e-03					
Mg+2	1.469e-03	8.622e-04	-2.833	-3.064	-0.231	(0)
MgSO4	1.081e-04	1.081e-04	-3.966	-3.966	0.000	(0)
MgHCO3+	7.479e-05	6.538e-05	-4.126	-4.185	-0.058	(0)
MgCO3	3.224e-05	3.224e-05	-4.492	-4.492	0.000	(0)
MgF+	4.206e-06	3.685e-06	-5.376	-5.434	-0.057	(0)
MgOH+	5.057e-07	4.471e-07	-6.296	-6.350	-0.053	(0)
MgH2BO3+	2.847e-08	2.468e-08	-7.546	-7.608	-0.062	(0)
Mn(2)	1.594e-06					
Mn+2	1.377e-06	7.305e-07	-5.861	-6.136	-0.275	(0)
MnHCO3+	1.230e-07	1.080e-07	-6.910	-6.967	-0.056	(0)
MnSO4	8.954e-08	8.954e-08	-7.048	-7.048	0.000	(0)
MnOH+	2.721e-09	2.390e-09	-8.565	-8.622	-0.056	(0)
MnCl+	1.271e-09	1.116e-09	-8.896	-8.952	-0.056	(0)
MnF+	1.261e-09	1.108e-09	-8.899	-8.955	-0.056	(0)
MnCl2	1.913e-12	1.913e-12	-11.718	-11.718	0.000	(0)
MnSeO4	8.434e-16	8.434e-16	-15.074	-15.074	0.000	(0)
MnCl3-	7.280e-16	6.394e-16	-15.138	-15.194	-0.056	(0)
Mn(OH)3-	2.854e-17	2.507e-17	-16.545	-16.601	-0.056	(0)
Mn(OH)4-2	1.771e-22	1.054e-22	-21.752	-21.977	-0.225	(0)
MnSe	2.420e-39	2.420e-39	-38.616	-38.616	0.000	(0)
Mn(3)	1.082e-27					
Mn+3	1.082e-27	3.263e-28	-26.966	-27.486	-0.521	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-43.438	-43.663	-0.225	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-48.974	-49.035	-0.061	(0)
Mo	6.991e-08					
MoO4-2	6.990e-08	4.103e-08	-7.156	-7.387	-0.231	(0)
HMoO4-	7.392e-12	6.309e-12	-11.131	-11.200	-0.069	(0)
H2MoO4	3.571e-16	3.571e-16	-15.447	-15.447	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-52.726	-53.346	-0.619	(0)
Mo7O24-6	0.000e+00	0.000e+00	-61.136	-63.613	-2.477	(0)
HMo7O24-5	0.000e+00	0.000e+00	-63.618	-65.338	-1.720	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-67.567	-68.668	-1.101	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-72.915	-73.534	-0.619	(0)
Na	7.673e-03					
Na+	7.610e-03	6.661e-03	-2.119	-2.176	-0.058	(0)
NaSO4-	2.802e-05	2.466e-05	-4.553	-4.608	-0.056	(0)
NaHCO3	2.776e-05	2.776e-05	-4.557	-4.557	0.000	(0)
NaCO3-	6.337e-06	5.577e-06	-5.198	-5.254	-0.056	(0)
NaF	1.601e-07	1.601e-07	-6.796	-6.796	0.000	(0)
NaH2BO3	8.717e-09	8.717e-09	-8.060	-8.060	0.000	(0)
NaCrO4-	6.277e-16	5.358e-16	-15.202	-15.271	-0.069	(0)
Ni	9.211e-08					
Ni+2	3.401e-08	1.996e-08	-7.468	-7.700	-0.231	(0)
NiCO3	3.348e-08	3.348e-08	-7.475	-7.475	0.000	(0)
NiHCO3+	2.136e-08	1.823e-08	-7.670	-7.739	-0.069	(0)
NiSO4	2.745e-09	2.745e-09	-8.561	-8.561	0.000	(0)
NiOH+	3.835e-10	3.274e-10	-9.416	-9.485	-0.069	(0)
NiCl+	7.262e-11	6.198e-11	-10.139	-10.208	-0.069	(0)
Ni(OH)2	3.387e-11	3.387e-11	-10.470	-10.470	0.000	(0)
NiF+	2.238e-11	1.910e-11	-10.650	-10.719	-0.069	(0)
Ni(SO4)2-2	1.181e-13	6.265e-14	-12.928	-13.203	-0.275	(0)
Ni(OH)3-	5.170e-14	4.412e-14	-13.287	-13.355	-0.069	(0)
NiCl2	3.787e-16	3.787e-16	-15.422	-15.422	0.000	(0)
NiSeO4	4.005e-17	4.005e-17	-16.397	-16.397	0.000	(0)
O(0)	5.647e-38					
O2	2.823e-38	2.835e-38	-37.549	-37.547	0.002	(0)
Pb	2.242e-07					
PbCO3	1.677e-07	1.677e-07	-6.776	-6.776	0.000	(0)
Pb(CO3)2-2	4.097e-08	2.174e-08	-7.388	-7.663	-0.275	(0)
PbHCO3+	8.003e-09	6.831e-09	-8.097	-8.166	-0.069	(0)
PbOH+	4.757e-09	4.060e-09	-8.323	-8.391	-0.069	(0)
Pb+2	2.114e-09	1.241e-09	-8.675	-8.906	-0.231	(0)
PbSO4	4.189e-10	4.189e-10	-9.378	-9.378	0.000	(0)
Pb(OH)2	1.672e-10	1.672e-10	-9.777	-9.777	0.000	(0)
PbCl+	6.259e-11	5.342e-11	-10.203	-10.272	-0.069	(0)
PbF+	3.903e-12	3.331e-12	-11.409	-11.477	-0.069	(0)
Pb(SO4)2-2	3.278e-12	1.740e-12	-11.484	-11.760	-0.275	(0)
PbCl2	2.896e-13	2.896e-13	-12.538	-12.538	0.000	(0)
Pb(OH)3-	2.552e-13	2.178e-13	-12.593	-12.662	-0.069	(0)
PbF2	2.497e-15	2.497e-15	-14.603	-14.603	0.000	(0)
Pb2OH+3	3.322e-16	7.983e-17	-15.479	-16.098	-0.619	(0)
PbCl3-	1.639e-16	1.399e-16	-15.785	-15.854	-0.069	(0)
Pb(OH)4-2	1.310e-16	6.950e-17	-15.883	-16.158	-0.275	(0)
Pb3(OH)4+2	1.305e-18	6.924e-19	-17.884	-18.160	-0.275	(0)
PbF3-	2.114e-19	1.804e-19	-18.675	-18.744	-0.069	(0)
PbCl4-2	1.463e-19	7.761e-20	-18.835	-19.110	-0.275	(0)
Pb4(OH)4+4	8.607e-23	6.824e-24	-22.065	-23.166	-1.101	(0)
PbF4-2	6.200e-24	3.290e-24	-23.208	-23.483	-0.275	(0)
S(6)	1.474e-03					
SO4-2	1.174e-03	6.893e-04	-2.930	-3.162	-0.231	(0)
CaSO4	1.585e-04	1.585e-04	-3.800	-3.800	0.000	(0)
MgSO4	1.081e-04	1.081e-04	-3.966	-3.966	0.000	(0)
NaSO4-	2.802e-05	2.466e-05	-4.553	-4.608	-0.056	(0)
KSO4-	4.427e-06	3.896e-06	-5.354	-5.409	-0.056	(0)
ZnSO4	9.329e-08	9.329e-08	-7.030	-7.030	0.000	(0)
MnSO4	8.954e-08	8.954e-08	-7.048	-7.048	0.000	(0)
CdSO4	3.445e-09	3.445e-09	-8.463	-8.463	0.000	(0)
NiSO4	2.745e-09	2.745e-09	-8.561	-8.561	0.000	(0)
CoSO4	2.472e-09	2.472e-09	-8.607	-8.607	0.000	(0)
Zn(SO4)2-2	1.055e-09	5.601e-10	-8.977	-9.252	-0.275	(0)
HSO4-	5.939e-10	5.204e-10	-9.226	-9.284	-0.057	(0)
CuSO4	5.296e-10	5.296e-10	-9.276	-9.276	0.000	(0)
FeSO4	5.203e-10	5.203e-10	-9.284	-9.284	0.000	(0)
PbSO4	4.189e-10	4.189e-10	-9.378	-9.378	0.000	(0)
CrOHSO4	8.455e-11	8.455e-11	-10.073	-10.073	0.000	(0)
Cd(SO4)2-2	6.037e-11	3.204e-11	-10.219	-10.494	-0.275	(0)
Pb(SO4)2-2	3.278e-12	1.740e-12	-11.484	-11.760	-0.275	(0)
Ni(SO4)2-2	1.181e-13	6.265e-14	-12.928	-13.203	-0.275	(0)
CrSO4+	3.420e-14	2.919e-14	-13.466	-13.535	-0.069	(0)
AlSO4+	2.756e-15	2.415e-15	-14.560	-14.617	-0.057	(0)
FeSO4+	2.515e-17	2.209e-17	-16.599	-16.656	-0.056	(0)
Al(SO4)2-	2.035e-17	1.783e-17	-16.691	-16.749	-0.057	(0)
Cr2(OH)2SO4+2	7.444e-18	3.950e-18	-17.128	-17.403	-0.275	(0)
UO2SO4	6.673e-18	6.673e-18	-17.176	-17.176	0.000	(0)
VO2SO4-	6.330e-19	5.402e-19	-18.199	-18.267	-0.069	(0)
Fe(SO4)2-	3.814e-19	3.256e-19	-18.419	-18.487	-0.069	(0)
Cr2(OH)2(SO4)2	1.617e-19	1.617e-19	-18.791	-18.791	0.000	(0)
UO2(SO4)2-2	1.143e-19	6.064e-20	-18.942	-19.217	-0.275	(0)
VOSO4	2.977e-21	2.977e-21	-20.526	-20.526	0.000	(0)
CrO3SO4-2	1.238e-24	6.567e-25	-23.907	-24.183	-0.275	(0)
VSO4+	1.773e-35	1.513e-35	-34.751	-34.820	-0.069	(0)
U(SO4)2	0.000e+00	0.000e+00	-44.249	-44.249	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-44.712	-44.987	-0.275	(0)
Se(-2)	7.279e-36					
HSe-	7.276e-36	6.210e-36	-35.138	-35.207	-0.069	(0)
MnSe	2.420e-39	2.420e-39	-38.616	-38.616	0.000	(0)
H2Se	3.725e-40	3.725e-40	-39.429	-39.429	0.000	(0)
Se-2	0.000e+00	0.000e+00	-41.820	-42.095	-0.275	(0)
Se(4)	8.621e-08					
HSeO3-	4.714e-08	4.023e-08	-7.327	-7.395	-0.069	(0)
SeO3-2	3.907e-08	2.073e-08	-7.408	-7.683	-0.275	(0)
H2SeO3	1.326e-13	1.326e-13	-12.877	-12.877	0.000	(0)
Cd(SeO3)2-2	1.423e-17	7.552e-18	-16.847	-17.122	-0.275	(0)
FeHSeO3+2	5.723e-22	3.037e-22	-21.242	-21.518	-0.275	(0)
Se(6)	7.309e-12					
SeO4-2	7.308e-12	4.290e-12	-11.136	-11.368	-0.231	(0)
MnSeO4	8.434e-16	8.434e-16	-15.074	-15.074	0.000	(0)
ZnSeO4	4.110e-16	4.110e-16	-15.386	-15.386	0.000	(0)
NiSeO4	4.005e-17	4.005e-17	-16.397	-16.397	0.000	(0)
CoSeO4	3.864e-17	3.864e-17	-16.413	-16.413	0.000	(0)
CdSeO4	1.703e-17	1.703e-17	-16.769	-16.769	0.000	(0)
HSeO4-	1.946e-18	1.661e-18	-17.711	-17.780	-0.069	(0)
Zn(SeO4)2-2	3.369e-27	1.788e-27	-26.472	-26.748	-0.275	(0)
U(3)	0.000e+00					
U+3	0.000e+00	0.000e+00	-60.602	-61.222	-0.619	(0)
U(4)	1.209e-21					
U(OH)5-	1.209e-21	1.031e-21	-20.918	-20.987	-0.069	(0)
U(OH)4	3.339e-25	3.339e-25	-24.476	-24.476	0.000	(0)
U(OH)3+	1.106e-29	9.436e-30	-28.956	-29.025	-0.069	(0)
U(OH)2+2	6.356e-35	3.373e-35	-34.197	-34.472	-0.275	(0)
UF3+	0.000e+00	0.000e+00	-40.014	-40.083	-0.069	(0)
UOH+3	0.000e+00	0.000e+00	-40.292	-40.911	-0.619	(0)
UF2+2	0.000e+00	0.000e+00	-40.589	-40.864	-0.275	(0)
UF4	0.000e+00	0.000e+00	-42.462	-42.462	0.000	(0)
UF+3	0.000e+00	0.000e+00	-42.926	-43.545	-0.619	(0)
U(SO4)2	0.000e+00	0.000e+00	-44.249	-44.249	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-44.712	-44.987	-0.275	(0)
UF5-	0.000e+00	0.000e+00	-45.214	-45.283	-0.069	(0)
UF6-2	0.000e+00	0.000e+00	-46.947	-47.222	-0.275	(0)
U+4	0.000e+00	0.000e+00	-47.325	-48.426	-1.101	(0)
UCl+3	0.000e+00	0.000e+00	-49.022	-49.642	-0.619	(0)
U6(OH)15+9	0.000e+00	0.000e+00	-180.459	-186.032	-5.573	(0)
U(5)	4.568e-19					
UO2+	4.568e-19	3.899e-19	-18.340	-18.409	-0.069	(0)
U(6)	3.112e-08					
UO2(CO3)3-4	2.919e-08	2.314e-09	-7.535	-8.636	-1.101	(0)
UO2(CO3)2-2	1.935e-09	1.027e-09	-8.713	-8.988	-0.275	(0)
UO2CO3	1.145e-12	1.145e-12	-11.941	-11.941	0.000	(0)
UO2OH+	1.229e-15	1.049e-15	-14.910	-14.979	-0.069	(0)
UO2F+	3.941e-17	3.364e-17	-16.404	-16.473	-0.069	(0)
UO2+2	1.090e-17	6.397e-18	-16.963	-17.194	-0.231	(0)
UO2SO4	6.673e-18	6.673e-18	-17.176	-17.176	0.000	(0)
UO2F2	3.696e-18	3.696e-18	-17.432	-17.432	0.000	(0)
UO2(SO4)2-2	1.143e-19	6.064e-20	-18.942	-19.217	-0.275	(0)
UO2F3-	4.144e-20	3.537e-20	-19.383	-19.451	-0.069	(0)
UO2Cl+	1.475e-20	1.259e-20	-19.831	-19.900	-0.069	(0)
UO2F4-2	2.017e-23	1.070e-23	-22.695	-22.971	-0.275	(0)
(UO2)2(OH)2+2	3.442e-24	1.826e-24	-23.463	-23.738	-0.275	(0)
(UO2)3(OH)5+	2.890e-27	2.466e-27	-26.539	-26.608	-0.069	(0)
V(2)	0.000e+00					
VOH+	0.000e+00	0.000e+00	-40.949	-41.018	-0.069	(0)
V+2	0.000e+00	0.000e+00	-42.367	-42.642	-0.275	(0)
V(3)	8.293e-14					
V(OH)3	8.293e-14	8.293e-14	-13.081	-13.081	0.000	(0)
V(OH)2+	4.853e-25	4.142e-25	-24.314	-24.383	-0.069	(0)
VOH+2	5.722e-29	3.037e-29	-28.242	-28.518	-0.275	(0)
V+3	1.935e-34	4.651e-35	-33.713	-34.332	-0.619	(0)
VSO4+	1.773e-35	1.513e-35	-34.751	-34.820	-0.069	(0)
V2(OH)3+3	0.000e+00	0.000e+00	-53.829	-54.449	-0.619	(0)
V2(OH)2+4	0.000e+00	0.000e+00	-55.134	-56.235	-1.101	(0)
V(4)	4.810e-18					
V(OH)3+	4.773e-18	4.074e-18	-17.321	-17.390	-0.069	(0)
VO+2	2.955e-20	1.568e-20	-19.529	-19.805	-0.275	(0)
VOF+	4.198e-21	3.583e-21	-20.377	-20.446	-0.069	(0)
VOSO4	2.977e-21	2.977e-21	-20.526	-20.526	0.000	(0)
VOCl+	6.255e-23	5.339e-23	-22.204	-22.273	-0.069	(0)
VOF2	5.118e-23	5.118e-23	-22.291	-22.291	0.000	(0)
VOF3-	8.106e-26	6.919e-26	-25.091	-25.160	-0.069	(0)
VOF4-2	2.005e-29	1.064e-29	-28.698	-28.973	-0.275	(0)
H2V2O4+2	1.569e-30	8.325e-31	-29.804	-30.080	-0.275	(0)
V(5)	4.913e-08					
H2VO4-	3.226e-08	2.753e-08	-7.491	-7.560	-0.069	(0)
HVO4-2	1.687e-08	8.951e-09	-7.773	-8.048	-0.275	(0)
H3VO4	2.127e-12	2.127e-12	-11.672	-11.672	0.000	(0)
H3V2O7-	4.433e-13	3.783e-13	-12.353	-12.422	-0.069	(0)
HV2O7-3	3.476e-13	8.354e-14	-12.459	-13.078	-0.619	(0)
VO4-3	2.416e-14	5.806e-15	-13.617	-14.236	-0.619	(0)
V2O7-4	3.670e-15	2.910e-16	-14.435	-15.536	-1.101	(0)
V3O9-3	9.105e-17	2.188e-17	-16.041	-16.660	-0.619	(0)
VO2+	3.750e-17	3.282e-17	-16.426	-16.484	-0.058	(0)
VO2F	2.193e-18	2.193e-18	-17.659	-17.659	0.000	(0)
VO2SO4-	6.330e-19	5.402e-19	-18.199	-18.267	-0.069	(0)
VO2F2-	3.554e-20	3.034e-20	-19.449	-19.518	-0.069	(0)
V4O12-4	3.169e-21	2.513e-22	-20.499	-21.600	-1.101	(0)
VO2F3-2	2.717e-23	1.442e-23	-22.566	-22.841	-0.275	(0)
VO2F4-3	1.124e-27	2.702e-28	-26.949	-27.568	-0.619	(0)
V10O28-6	0.000e+00	0.000e+00	-56.665	-59.142	-2.477	(0)
HV10O28-5	0.000e+00	0.000e+00	-57.347	-59.067	-1.720	(0)

H2V10O28-4	0.000e+00	0.000e+00	-60.871	-61.971	-1.101	(0)
Zn 3.036e-06						
ZnCO3	1.601e-06	1.601e-06	-5.796	-5.796	0.000	(0)
Zn+2	1.054e-06	6.187e-07	-5.977	-6.209	-0.231	(0)
ZnHCO3+	1.699e-07	1.450e-07	-6.770	-6.839	-0.069	(0)
ZnOH+	9.443e-08	8.059e-08	-7.025	-7.094	-0.069	(0)
ZnSO4	9.329e-08	9.329e-08	-7.030	-7.030	0.000	(0)
Zn(OH)2	1.664e-08	1.664e-08	-7.779	-7.779	0.000	(0)
ZnOHCl	3.216e-09	3.216e-09	-8.493	-8.493	0.000	(0)
ZnCl+	2.158e-09	1.886e-09	-8.666	-8.724	-0.058	(0)
Zn(SO4)2-2	1.055e-09	5.601e-10	-8.977	-9.252	-0.275	(0)
ZnF+	5.510e-10	4.703e-10	-9.259	-9.328	-0.069	(0)
Zn(OH)3-	1.273e-10	1.086e-10	-9.895	-9.964	-0.069	(0)
ZnCl2	3.627e-12	3.627e-12	-11.440	-11.440	0.000	(0)
Zn(OH)4-2	1.062e-14	5.633e-15	-13.974	-14.249	-0.275	(0)
ZnCl3-	4.000e-15	3.497e-15	-14.398	-14.456	-0.058	(0)
ZnSeO4	4.110e-16	4.110e-16	-15.386	-15.386	0.000	(0)
ZnCl4-2	3.564e-18	2.122e-18	-17.448	-17.673	-0.225	(0)
Zn(SeO4)2-2	3.369e-27	1.788e-27	-26.472	-26.748	-0.275	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.81	8.99	10.80	Al(OH)3
Al2(MoO4)3	-55.22	-52.85	2.37	Al2(MoO4)3
Al2O3	-1.67	17.98	19.65	Al2O3
Al4(OH)10SO4	-6.13	16.57	22.70	Al4(OH)10SO4
AlAsO4:2H2O	-10.59	-5.79	4.80	AlAsO4:2H2O
AlOHSO4	-7.17	-10.40	-3.23	AlOHSO4
Alunite	-5.39	-6.79	-1.40	KAl3(SO4)2(OH)6
Anglesite	-4.28	-12.07	-7.79	PbSO4
Anhydrite	-1.80	-6.16	-4.36	CaSO4
Antlerite	-4.93	3.86	8.79	Cu3(OH)4SO4
Aragonite	0.95	-7.35	-8.30	CaCO3
Arsenolite	-77.65	-80.41	-2.76	As4O6
Artinite	-3.85	5.75	9.60	MgCO3:Mg(OH)2:3H2O
As2O5	-36.26	-29.55	6.71	As2O5
Atacamite	-2.92	4.47	7.39	Cu2(OH)3Cl
Azurite	-0.99	-17.89	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-14.31	10.08	24.39	Ba(OH)2:8H2O
Ba2V2O7:2H2O	-12.45	3.42	15.87	Ba2V2O7:2H2O
Ba3(AsO4)2	9.60	0.69	-8.91	Ba3(AsO4)2
Ba3(VO4)2:4H2O	-19.44	13.50	32.94	Ba3(VO4)2:4H2O
BaCrO4	-10.26	-19.93	-9.67	BaCrO4
BaF2	-9.16	-14.98	-5.82	BaF2
BaMoO4	-6.57	-13.53	-6.96	BaMoO4
Barite	0.68	-9.30	-9.98	BaSO4
BaSeO3	-7.26	-5.43	1.83	BaSeO3
BaSeO4	-10.05	-17.51	-7.46	BaSeO4
Bianchite	-7.61	-9.37	-1.76	ZnSO4:6H2O
Birnessite	-9.13	8.96	18.09	MnO2
Bixbyite	-5.66	-6.30	-0.64	Mn2O3
Boehmite	0.41	8.99	8.58	AlOOH
Brochantite	-3.61	11.61	15.22	Cu4(OH)6SO4
Brucite	-3.68	13.16	16.84	Mg(OH)2
Bunsenite	-3.92	8.52	12.45	NiO
Ca(VO3)2	-9.18	-3.52	5.66	Ca(VO3)2
Ca2V2O7	-7.79	9.71	17.50	Ca2V2O7
Ca2V2O7:2H2O	-11.84	9.71	21.55	Ca2V2O7:2H2O
Ca3(AsO4)2:4H2O	-12.18	10.12	22.30	Ca3(AsO4)2:4H2O
Ca3(VO4)2	-16.03	22.93	38.96	Ca3(VO4)2
Ca3(VO4)2:4H2O	-16.93	22.93	39.86	Ca3(VO4)2:4H2O
CaCrO4	-14.52	-16.79	-2.27	CaCrO4
Calcite	1.13	-7.35	-8.48	CaCO3
CaMoO4	-2.44	-10.39	-7.95	CaMoO4
Carnotite	-4.56	-4.33	0.23	KUO2VO4
CaSeO3:2H2O	-5.10	-2.28	2.81	CaSeO3:2H2O
CaSeO4:2H2O	-11.35	-14.37	-3.02	CaSeO4:2H2O
Cd(BO2)2	-11.21	-1.37	9.84	Cd(BO2)2
Cd(OH)2	-5.09	8.55	13.64	Cd(OH)2
Cd(OH)2(am)	-5.18	8.55	13.73	Cd(OH)2
Cd3(OH)2(SO4)2	-19.82	-13.11	6.71	Cd3(OH)2(SO4)2
Cd3(OH)4SO4	-16.29	6.27	22.56	Cd3(OH)4SO4
Cd4(OH)6SO4	-13.58	14.82	28.40	Cd4(OH)6SO4
CdCl2	-12.84	-13.50	-0.66	CdCl2
CdCl2:1H2O	-11.81	-13.50	-1.69	CdCl2:1H2O
CdCl2:2.5H2O	-11.59	-13.50	-1.91	CdCl2:2.5H2O
CdF2	-15.30	-16.51	-1.21	CdF2
Cdmetal(alpha)	-29.19	-15.67	13.51	Cd
Cdmetal(gamma)	-29.29	-15.67	13.62	Cd
CdMoO4	-0.91	-15.06	-14.15	CdMoO4
CdOHCl	-6.01	-2.48	3.54	CdOHCl
CdSe	-14.57	-34.77	-20.20	CdSe
CdSeO4:2H2O	-17.19	-19.04	-1.85	CdSeO4:2H2O
CdSO4	-10.66	-10.83	-0.17	CdSO4
CdSO4:1H2O	-9.11	-10.83	-1.73	CdSO4:1H2O
CdSO4:2.67H2O	-8.96	-10.83	-1.87	CdSO4:2.67H2O
Cerussite	-0.12	-13.25	-13.13	PbCO3
CH4(g)	-76.42	-117.47	-41.05	CH4
Chalcanthite	-9.00	-11.64	-2.64	CuSO4:5H2O
Claudetite	-77.35	-80.41	-3.06	As4O6
Clausthalite	-8.90	-36.00	-27.10	PbSe
Co(BO2)2	-28.51	-1.44	27.07	Co(BO2)2
Co(OH)2	-4.62	8.48	13.09	Co(OH)2
Co(OH)3	-9.50	-11.81	-2.31	Co(OH)3
CO2(g)	-2.42	-20.57	-18.15	CO2
Co3(AsO4)2	-17.15	-4.12	13.03	Co3(AsO4)2
Co3O4	-4.65	-15.14	-10.50	Co3O4
CoCl2	-21.84	-13.58	8.27	CoCl2
CoCl2:6H2O	-16.11	-13.58	2.54	CoCl2:6H2O
CoCO3	-2.11	-12.09	-9.98	CoCO3
CoF2	-14.99	-16.58	-1.60	CoF2
CoF3	-47.94	-49.40	-1.46	CoF3
CoFe2O4	25.59	22.06	-3.53	CoFe2O4
CoMoO4	-7.37	-15.13	-7.76	CoMoO4
CoO	-5.11	8.48	13.59	CoO
CoSe	-18.64	-34.84	-16.20	CoSe
CoSeO3	-8.35	-7.03	1.32	CoSeO3
CoSeO4:6H2O	-17.58	-19.11	-1.53	CoSeO4:6H2O
CoSO4	-13.71	-10.91	2.80	CoSO4
CoSO4:6H2O	-8.44	-10.91	-2.47	CoSO4:6H2O
Cotunnite	-9.96	-14.74	-4.78	PbCl2
Cr(OH)2	-18.96	-8.14	10.82	Cr(OH)2
Cr(OH)3	-0.31	1.03	1.34	Cr(OH)3
Cr(OH)3(am)	1.78	1.03	-0.75	Cr(OH)3
Cr2O3	4.41	2.05	-2.36	Cr2O3
CrCl2	-44.29	-30.20	14.09	CrCl2
CrCl3	-47.17	-32.06	15.11	CrCl3
CrF3	-25.23	-36.57	-11.34	CrF3
Crmetal	-62.85	-32.36	30.48	Cr
CrO3	-26.80	-30.01	-3.21	CrO3
Cryolite	-14.55	-48.39	-33.84	Na3AlF6
Cu(OH)2	-0.92	7.75	8.67	Cu(OH)2
Cu2Se(alpha)	-0.86	-46.66	-45.80	Cu2Se
Cu2SO4	-20.78	-22.73	-1.95	Cu2SO4
Cu3(AsO4)2:2H2O	-12.41	-6.31	6.10	Cu3(AsO4)2:2H2O
Cu3Se2	-18.74	-82.23	-63.49	Cu3Se2
CuCO3	-1.32	-12.82	-11.50	CuCO3
CuCrO4	-16.83	-22.27	-5.44	CuCrO4
CuF	-9.30	-14.20	-4.91	CuF
CuF2	-18.43	-17.31	1.12	CuF2
CuF2:2H2O	-12.76	-17.31	-4.55	CuF2:2H2O
Cumetal	-5.03	-13.78	-8.76	Cu
CuMoO4	-2.79	-15.86	-13.08	CuMoO4
CuOCuSO4	-14.19	-3.89	10.30	CuOCuSO4
Cupricferrite	15.34	21.33	5.99	CuFe2O4
Cuprite	-1.94	-3.34	-1.41	Cu2O
Cuprousferrite	14.04	5.12	-8.92	CuFeO2
CuSe	-2.47	-35.57	-33.10	CuSe
CuSe2	-21.30	-54.66	-33.37	CuSe2
CuSeO3:2H2O	-8.27	-7.76	0.51	CuSeO3:2H2O
CuSeO4:5H2O	-17.40	-19.84	-2.44	CuSeO4:5H2O
CuSO4	-14.58	-11.64	2.94	CuSO4
Diaspore	2.12	8.99	6.87	AlOOH
Dolomite(disordered)	1.78	-14.76	-16.54	CaMg(CO3)2
Dolomite(ordered)	2.33	-14.76	-17.09	CaMg(CO3)2
Epsomite	-4.10	-6.23	-2.13	MgSO4:7H2O
Fe(OH)2	-5.85	7.71	13.56	Fe(OH)2
Fe(OH)2.7Cl.3	6.52	3.48	-3.04	Fe(OH)2.7Cl.3
Fe(VO3)2	-5.31	-9.03	-3.72	Fe(VO3)2
Fe2(OH)4SeO3	-3.48	-1.92	1.55	Fe2(OH)4SeO3
Fe2(SeO3)3:2H2O	-12.31	-32.94	-20.63	Fe2(SeO3)3:2H2O
Fe2(SO4)3	-40.84	-44.57	-3.73	Fe2(SO4)3
Fe3(OH)8	1.07	21.29	20.22	Fe3(OH)8
FeAsO4:2H2O	-8.39	-7.99	0.40	FeAsO4:2H2O
FeCr2O4	2.56	9.76	7.20	FeCr2O4
FeMoO4	-5.81	-15.90	-10.09	FeMoO4
Ferrihydrite	3.60	6.79	3.19	Fe(OH)3
Ferroselite	-36.11	-54.70	-18.60	FeSe2
FeSe	-24.61	-35.61	-11.00	FeSe
Fluorite	-1.34	-11.84	-10.50	CaF2
Gibbsite	0.70	8.99	8.29	Al(OH)3
Goethite	6.30	6.79	0.49	FeOOH
Goslarite	-7.36	-9.37	-2.01	ZnSO4:7H2O
Gummite	-8.64	-0.97	7.67	UO3
Gypsum	-1.55	-6.16	-4.61	CaSO4:2H2O
H-Jarosite	-6.30	-18.40	-12.10	(H3O)Fe3(SO4)2(OH)6
H2MoO4	-10.73	-23.61	-12.88	H2MoO4
H2Se(g)	-38.36	-43.32	-4.96	H2Se
Halite	-6.69	-5.09	1.60	NaCl
Hausmannite	-6.54	54.49	61.03	Mn3O4
Hematite	15.00	13.58	-1.42	Fe2O3
Hercynite	2.80	25.69	22.89	FeAl2O4
Huntite	0.39	-29.58	-29.97	CaMg3(CO3)4
Hydrocerussite	-0.42	-19.19	-18.77	Pb3(OH)2(CO3)2
Hydromagnesite	-7.72	-16.49	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-19.60	-24.77	-5.17	KAl(SO4)2:12H2O
K-Jarosite	1.42	-13.38	-14.80	KFe3(SO4)2(OH)6
K2Cr2O7	-32.76	-50.00	-17.24	K2Cr2O7
K2CrO4	-19.47	-19.99	-0.51	K2CrO4
K2MoO4	-16.84	-13.58	3.26	K2MoO4
K2SeO4	-16.83	-17.56	-0.73	K2SeO4
Langite	-5.88	11.61	17.49	Cu4(OH)6SO4:H2O
Larnakite	-4.32	-4.75	-0.43	PbO:PbSO4
Laurionite	-4.33	-3.71	0.62	PbOHCl
Lepidocrocite	5.42	6.79	1.37	FeOOH
Lime	-19.47	13.23	32.70	CaO
Litharge	-5.38	7.32	12.69	PbO
Maghemite	7.20	13.58	6.39	Fe2O3
Magnesioferrite	9.88	26.74	16.86	Fe2MgO4
Magnesite	0.05	-7.41	-7.46	MgCO3
Magnetite	17.89	21.29	3.40	Fe3O4
Malachite	0.23	-5.07	-5.31	Cu2(OH)2CO3
Manganite	-3.14	22.20	25.34	MnOOH
Massicot	-5.58	7.32	12.89	PbO
Matlockite	-7.27	-16.24	-8.97	PbClF
Melanothallite	-20.56	-14.31	6.26	CuCl2
Melanterite	-9.47	-11.67	-2.21	FeSO4:7H2O
Mg(OH)2(active)	-5.63	13.16	18.79	Mg(OH)2
Mg(VO3)2	-14.86	-3.58	11.28	Mg(VO3)2
Mg2V2O7	-16.78	9.58	26.36	Mg2V2O7
MgCr2O4	-0.99	15.21	16.20	MgCr2O4
MgCrO4	-22.24	-16.86	5.38	MgCrO4
MgF2	-3.77	-11.90	-8.13	MgF2
MgMoO4	-8.60	-10.45	-1.85	MgMoO4
MgSeO3:6H2O	-5.40	-2.35	3.06	MgSeO3:6H2O
MgSeO4:6H2O	-13.23	-14.43	-1.20	MgSeO4:6H2O
Minium	-27.35	46.18	73.52	Pb3O4
Mirabilite	-6.40	-7.52	-1.11	Na2SO4:10H2O
Mn(VO3)2	-11.56	-6.66	4.90	Mn(VO3)2
Mn2(SO4)3	-58.75	-64.46	-5.71	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-11.79	0.71	12.50	Mn3(AsO4)2:8H2O
MnCl2:4H2O	-14.68	-11.97	2.72	MnCl2:4H2O
MnSe	-36.73	-33.23	3.50	MnSe
MnSeO3	-6.55	-5.42	1.13	MnSeO3
MnSeO3:2H2O	-6.40	-5.42	0.98	MnSeO3:2H2O
MnSeO4:5H2O	-15.45	-17.50	-2.05	MnSeO4:5H2O
MnSO4	-11.88	-9.30	2.58	MnSO4
Monteponite	-6.55	8.55	15.10	CdO
MoO3	-15.61	-23.61	-8.00	MoO3
Morenosite	-8.72	-10.86	-2.14	NiSO4:7H2O
Na-Jarosite	-1.26	-12.46	-11.20	NaFe3(SO4)2(OH)6
Na2Cr2O7	-38.26	-48.16	-9.90	Na2Cr2O7
Na2CrO4	-21.07	-18.14	2.93	Na2CrO4
Na2Mo2O7	-18.75	-35.35	-16.60	Na2Mo2O7
Na2MoO4	-13.23	-11.74	1.49	Na2MoO4
Na2MoO4:2H2O	-12.96	-11.74	1.22	Na2MoO4:2H2O
Na2SeO3:5H2O	-13.94	-3.64	10.30	Na2SeO3:5H2O
Na2SeO4	-17.00	-15.72	1.28	Na2SeO4
Na3VO4	-27.25	9.43	36.68	Na3VO4
Na4V2O7	-30.40	7.00	37.40	Na4V2O7
Nantokite	-5.97	-12.70	-6.73	CuCl
Natron	-7.39	-8.70	-1.31	Na2CO3:10H2O
NaVO3	-6.29	-2.44	3.86	NaVO3
Nesquehonite	-2.74	-7.41	-4.67	MgCO3:3H2O
Ni(OH)2	-4.27	8.52	12.79	Ni(OH)2
Ni3(AsO4)2:8H2O	-19.68	-3.98	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-17.29	14.71	32.00	Ni4(OH)6SO4
NiCO3	-5.18	-12.05	-6.87	NiCO3
NiMoO4	-3.94	-15.09	-11.14	NiMoO4
NiSe	-17.09	-34.79	-17.70	NiSe
NiSeO3:2H2O	-9.80	-6.98	2.81	NiSeO3:2H2O
NiSeO4:6H2O	-17.55	-19.07	-1.52	NiSeO4:6H2O
Nsutite	-8.54	8.96	17.50	MnO2
O2(g)	-34.64	48.45	83.09	O2
Otavite	-0.02	-12.02	-12.00	CdCO3
Pb(BO2)2	-9.12	-2.60	6.52	Pb(BO2)2
Pb(OH)2	-0.83	7.32	8.15	Pb(OH)2
Pb10(OH)6O(CO3)6	-41.49	-50.25	-8.76	Pb10(OH)6O(CO3)6
Pb2(OH)3Cl	-5.19	3.61	8.79	Pb2(OH)3Cl
Pb2O(OH)2	-11.55	14.63	26.19	Pb2O(OH)2
Pb2O3	-22.18	38.86	61.04	Pb2O3
Pb2OCO3	-5.38	-5.94	-0.56	Pb2OCO3
Pb2V2O7	-0.21	-2.11	-1.90	Pb2V2O7
Pb3(AsO4)2	-13.40	-7.60	5.80	Pb3(AsO4)2
Pb3(VO4)2	-0.93	5.21	6.14	Pb3(VO4)2
Pb3O2CO3	-9.64	1.38	11.02	Pb3O2CO3
Pb3O2SO4	-8.12	2.57	10.69	Pb3O2SO4
Pb4(OH)6SO4	-11.22	9.88	21.10	Pb4(OH)6SO4
Pb4O3SO4	-11.99	9.88	21.88	Pb4O3SO4
PbCrO4	-10.10	-22.70	-12.60	PbCrO4
PbF2	-10.30	-17.74	-7.44	PbF2
Pbmetal	-21.15	-16.91	4.25	Pb

PbMoO4	-0.67	-16.29	-15.62	PbMoO4
PbO:0.3H2O	-5.66	7.32	12.98	PbO:0.33H2O
PbSeO4	-13.43	-20.27	-6.84	PbSeO4
Periclase	-8.42	13.16	21.58	MgO
Phosgenite	-8.18	-27.99	-19.81	PbCl2:PbCO3
Plattnerite	-18.06	31.54	49.60	PbO2
Portlandite	-9.58	13.23	22.80	Ca(OH)2
Pyrochroite	-5.11	10.09	15.19	Mn(OH)2
Pyrolusite	-7.07	34.31	41.38	MnO2
Retgersite	-8.82	-10.86	-2.04	NiSO4:6H2O
Rhodochrosite	0.10	-10.48	-10.58	MnCO3
Rutherfordine	-7.04	-21.54	-14.50	UO2CO3
Schoepite	-6.96	-0.97	5.99	UO2(OH)2:H2O
Semetal(am)	-11.98	-19.09	-7.11	Se
Semetal(hex	-11.39	-19.09	-7.71	Se
SeO2	-15.63	-15.51	0.12	SeO2
SeO3	-48.64	-27.59	21.04	SeO3
Siderite	-2.62	-12.86	-10.24	FeCO3
Smithsonite	-0.56	-10.56	-10.00	ZnCO3
Spinel	-5.71	31.14	36.85	MgAl2O4
Tenorite	0.11	7.75	7.64	CuO
Thenardite	-7.84	-7.51	0.32	Na2SO4
Thermonatrite	-9.34	-8.70	0.64	Na2CO3:H2O
Tyuyamunite	-9.54	-5.46	4.08	Ca(UO2)2(VO4)2
U3O8	-20.57	0.51	21.08	U3O8
U4O9	-36.67	-39.69	-3.02	U4O9
UF4	-36.57	-66.10	-29.54	UF4
UF4:2.5H2O	-33.38	-66.10	-32.72	UF4:2.5H2O
UO2(am)	-16.91	-15.98	0.93	UO2
UO2(OH)2(beta)	-6.58	-0.97	5.61	UO2(OH)2
UO2SeO4:4H2O	-26.31	-28.56	-2.25	UO2SeO4:4H2O
UO3	-8.67	-0.97	7.70	UO3
Uraninite	-11.31	-15.98	-4.67	UO2
V(OH)3	-17.59	-10.00	7.59	V(OH)3
V2O5	-15.38	-16.74	-1.36	V2O5
V3O5	-36.80	-34.97	1.84	V3O5
V4O7	-45.73	-38.55	7.19	V4O7
V6O13	-37.82	-98.68	-60.86	V6O13
VCl2	-63.04	-44.16	18.87	VCl2
VCl3	-66.51	-43.08	23.43	VCl3
VF4	-68.63	-53.70	14.93	VF4
Vmetal	-90.36	-46.33	44.03	V
VO	-36.86	-22.11	14.76	VO
VO(OH)2	-8.73	-3.58	5.15	VO(OH)2
VO2Cl	-22.24	-19.40	2.84	VO2Cl
VOCl	-32.18	-21.02	11.15	VOCl
VOCl2	-38.40	-25.64	12.76	VOCl2
VOSO4	-26.58	-22.97	3.61	VOSO4
Witherite	-1.92	-10.49	-8.57	BaCO3
Zincite	-1.32	10.02	11.33	ZnO
Zincosite	-13.30	-9.37	3.93	ZnSO4
Zn(BO2)2	-8.19	0.10	8.29	Zn(BO2)2
Zn(OH)2	-2.18	10.02	12.20	Zn(OH)2
Zn(OH)2(am)	-2.46	10.02	12.47	Zn(OH)2
Zn(OH)2(beta)	-1.74	10.02	11.75	Zn(OH)2
Zn(OH)2(epsilon)	-1.52	10.02	11.53	Zn(OH)2
Zn(OH)2(gamma)	-1.72	10.02	11.73	Zn(OH)2
Zn2(OH)2SO4	-6.86	0.64	7.50	Zn2(OH)2SO4
Zn2(OH)3Cl	-6.19	9.00	15.19	Zn2(OH)3Cl
Zn3(AsO4)2:2.5H2O	-13.16	0.49	13.65	Zn3(AsO4)2:2.5H2O
Zn3O(SO4)2	-27.64	-8.72	18.91	Zn3O(SO4)2
Zn4(OH)6SO4	-7.72	20.68	28.40	Zn4(OH)6SO4
Zn5(OH)8Cl2	-10.48	28.02	38.50	Zn5(OH)8Cl2
ZnCl2	-19.09	-12.04	7.05	ZnCl2
ZnCO3:1H2O	-0.30	-10.56	-10.26	ZnCO3:1H2O
ZnF2	-14.51	-15.05	-0.53	ZnF2
Znmetal	-40.00	-14.21	25.79	Zn
ZnMoO4	-3.47	-13.60	-10.13	ZnMoO4
ZnO(active)	-1.17	10.02	11.19	ZnO
ZnSe	-18.90	-33.30	-14.40	ZnSe
ZnSeO4:6H2O	-16.06	-17.58	-1.52	ZnSeO4:6H2O
ZnSO4:1H2O	-8.73	-9.37	-0.64	ZnSO4:1H2O

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Initial solution 2. PAF Material

----------Solution composition----------

Elements	Molality	Moles
Al	7.415e-07	7.415e-07
Alkalinity	3.607e-04	3.607e-04
Ba	1.457e-07	1.457e-07
Ca	1.672e-03	1.672e-03
Co	1.188e-07	1.188e-07
Cu	4.408e-07	4.408e-07
F	1.580e-05	1.580e-05
K	3.326e-04	3.326e-04
Mg	3.293e-04	3.293e-04
Mn	7.283e-07	7.283e-07
Mo	3.128e-08	3.128e-08
Na	4.351e-05	4.351e-05
Ni	6.818e-08	6.818e-08
S(6)	2.051e-03	2.051e-03

----------Description of solution----------

pH	=	7.500
pe	=	4.000
Activity of water	=	1.000
Ionic strength (mol/kgw)	=	7.200e-03
Mass of water (kg)	=	1.000e+00
Total carbon (mol/kg)	=	3.782e-04
Total CO2 (mol/kg)	=	3.782e-04
Temperature (°C)	=	25.00
Electrical balance (eq)	=	-9.478e-05
Percent error, 100*(Cat-|An|)/(Cat+|An|)	=	-1.25
Iterations	=	13 (24 overall)
Total H	=	1.110141e+02
Total O	=	5.551618e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
OH-	3.487e-07	3.184e-07	-6.458	-6.497	-0.039	(0)
H+	3.458e-08	3.162e-08	-7.461	-7.500	-0.039	0.00
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000	18.07
Al	7.415e-07					
Al(OH)4-	7.221e-07	6.609e-07	-6.141	-6.180	-0.038	(0)
Al(OH)3	1.649e-08	1.649e-08	-7.783	-7.783	0.000	(0)
Al(OH)2+	2.830e-09	2.595e-09	-8.548	-8.586	-0.038	(0)
AlF2+	2.736e-11	2.509e-11	-10.563	-10.600	-0.038	(0)
AlOH+2	1.451e-11	1.026e-11	-10.838	-10.989	-0.150	(0)
AlF+2	6.374e-12	4.507e-12	-11.196	-11.346	-0.150	(0)
AlF3	4.418e-12	4.418e-12	-11.355	-11.355	0.000	(0)
AlSO4+	3.315e-13	3.034e-13	-12.480	-12.518	-0.038	(0)
Al+3	7.201e-14	3.223e-14	-13.143	-13.492	-0.349	(0)
AlF4-	3.383e-14	3.096e-14	-13.471	-13.509	-0.038	(0)
Al(SO4)2-	4.307e-15	3.942e-15	-14.366	-14.404	-0.038	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-49.070	-49.460	-0.390	(0)
Ba	1.457e-07					
Ba+2	1.453e-07	1.017e-07	-6.838	-6.993	-0.155	(0)
BaHCO3+	3.363e-10	3.088e-10	-9.473	-9.510	-0.037	(0)
BaCO3	2.459e-11	2.459e-11	-10.609	-10.609	0.000	(0)
BaOH+	1.542e-13	1.413e-13	-12.812	-12.850	-0.038	(0)
C(4)	3.782e-04					
HCO3-	3.469e-04	3.181e-04	-3.460	-3.497	-0.038	(0)
H2CO3	2.262e-05	2.262e-05	-4.645	-4.645	0.000	(0)
CaHCO3+	6.292e-06	5.777e-06	-5.201	-5.238	-0.037	(0)
CaCO3	7.289e-07	7.289e-07	-6.137	-6.137	0.000	(0)
MgHCO3+	7.079e-07	6.472e-07	-6.150	-6.189	-0.039	(0)
CO3-2	6.741e-07	4.716e-07	-6.171	-6.326	-0.155	(0)
CuCO3	2.133e-07	2.133e-07	-6.671	-6.671	0.000	(0)
MgCO3	7.799e-08	7.799e-08	-7.108	-7.108	0.000	(0)
NaHCO3	7.071e-09	7.071e-09	-8.151	-8.151	0.000	(0)
MnHCO3+	2.944e-09	2.697e-09	-8.531	-8.569	-0.038	(0)
CoHCO3+	1.830e-09	1.657e-09	-8.738	-8.781	-0.043	(0)
CuHCO3+	1.703e-09	1.542e-09	-8.769	-8.812	-0.043	(0)
NiHCO3+	1.700e-09	1.539e-09	-8.770	-8.813	-0.043	(0)
NiCO3	6.904e-10	6.904e-10	-9.161	-9.161	0.000	(0)
CoCO3	5.337e-10	5.337e-10	-9.273	-9.273	0.000	(0)
Cu(CO3)2-2	4.033e-10	2.707e-10	-9.394	-9.567	-0.173	(0)
NaCO3-	3.785e-10	3.471e-10	-9.422	-9.460	-0.038	(0)
BaHCO3+	3.363e-10	3.088e-10	-9.473	-9.510	-0.037	(0)
BaCO3	2.459e-11	2.459e-11	-10.609	-10.609	0.000	(0)
Ca	1.672e-03					
Ca+2	1.394e-03	9.753e-04	-2.856	-3.011	-0.155	(0)
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)
CaHCO3+	6.292e-06	5.777e-06	-5.201	-5.238	-0.037	(0)
CaCO3	7.289e-07	7.289e-07	-6.137	-6.137	0.000	(0)
CaF+	1.625e-07	1.489e-07	-6.789	-6.827	-0.038	(0)
CaOH+	6.748e-09	6.196e-09	-8.171	-8.208	-0.037	(0)
Co(2)	1.188e-07					
Co+2	9.974e-08	6.695e-08	-7.001	-7.174	-0.173	(0)
CoSO4	1.620e-08	1.620e-08	-7.791	-7.791	0.000	(0)
CoHCO3+	1.830e-09	1.657e-09	-8.738	-8.781	-0.043	(0)
CoCO3	5.337e-10	5.337e-10	-9.273	-9.273	0.000	(0)
CoOH+	4.699e-10	4.253e-10	-9.328	-9.371	-0.043	(0)
CoF+	3.271e-11	2.961e-11	-10.485	-10.529	-0.043	(0)
Co(OH)2	1.076e-11	1.076e-11	-10.968	-10.968	0.000	(0)
Co(OH)3-	7.550e-17	6.834e-17	-16.122	-16.165	-0.043	(0)
CoOOH-	1.894e-17	1.715e-17	-16.723	-16.766	-0.043	(0)
Co2OH+3	3.499e-18	1.427e-18	-17.456	-17.846	-0.390	(0)
Co(OH)4-2	5.137e-24	3.448e-24	-23.289	-23.462	-0.173	(0)
Co4(OH)4+4	3.216e-29	6.530e-30	-28.493	-29.185	-0.692	(0)
Co(3)	6.424e-30					
CoOH+2	6.424e-30	4.312e-30	-29.192	-29.365	-0.173	(0)
Co+3	5.955e-36	2.665e-36	-35.225	-35.574	-0.349	(0)
Cu(1)	4.157e-09					
Cu+	4.157e-09	3.762e-09	-8.381	-8.425	-0.043	(0)
Cu(2)	4.366e-07					
CuCO3	2.133e-07	2.133e-07	-6.671	-6.671	0.000	(0)
Cu+2	1.098e-07	7.682e-08	-6.959	-7.115	-0.155	(0)
CuOH+	8.460e-08	7.735e-08	-7.073	-7.112	-0.039	(0)
CuSO4	2.134e-08	2.134e-08	-7.671	-7.671	0.000	(0)
Cu(OH)2	4.914e-09	4.914e-09	-8.309	-8.309	0.000	(0)
CuHCO3+	1.703e-09	1.542e-09	-8.769	-8.812	-0.043	(0)
Cu(CO3)2-2	4.033e-10	2.707e-10	-9.394	-9.567	-0.173	(0)
Cu2(OH)2+2	2.239e-10	1.503e-10	-9.650	-9.823	-0.173	(0)
CuF+	7.488e-11	6.778e-11	-10.126	-10.169	-0.043	(0)
Cu(OH)3-	3.545e-12	3.209e-12	-11.450	-11.494	-0.043	(0)
Cu(OH)4-2	1.198e-17	8.042e-18	-16.922	-17.095	-0.173	(0)
F	1.580e-05					
F-	1.529e-05	1.398e-05	-4.816	-4.854	-0.039	(0)
MgF+	3.409e-07	3.120e-07	-6.467	-6.506	-0.038	(0)
CaF+	1.625e-07	1.489e-07	-6.789	-6.827	-0.038	(0)
HF	6.541e-10	6.541e-10	-9.184	-9.184	0.000	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
MnF+	2.582e-10	2.366e-10	-9.588	-9.626	-0.038	(0)
CuF+	7.488e-11	6.778e-11	-10.126	-10.169	-0.043	(0)
CoF+	3.271e-11	2.961e-11	-10.485	-10.529	-0.043	(0)
AlF2+	2.736e-11	2.509e-11	-10.563	-10.600	-0.038	(0)
NiF+	1.523e-11	1.379e-11	-10.817	-10.861	-0.043	(0)
AlF+2	6.374e-12	4.507e-12	-11.196	-11.346	-0.150	(0)
AlF3	4.418e-12	4.418e-12	-11.355	-11.355	0.000	(0)
HF2-	3.808e-14	3.478e-14	-13.419	-13.459	-0.039	(0)
AlF4-	3.383e-14	3.096e-14	-13.471	-13.509	-0.038	(0)
H2F2	1.146e-18	1.146e-18	-17.941	-17.941	0.000	(0)
H(0)	1.414e-26					
H2	7.068e-27	7.079e-27	-26.151	-26.150	0.001	(0)
K	3.326e-04					
K+	3.298e-04	3.016e-04	-3.482	-3.521	-0.039	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
Mg	3.293e-04					
Mg+2	2.842e-04	1.988e-04	-3.546	-3.702	-0.155	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
MgHCO3+	7.079e-07	6.472e-07	-6.150	-6.189	-0.039	(0)
MgF+	3.409e-07	3.120e-07	-6.467	-6.506	-0.038	(0)
MgCO3	7.799e-08	7.799e-08	-7.108	-7.108	0.000	(0)
MgOH+	2.742e-08	2.520e-08	-7.562	-7.599	-0.037	(0)
Mn(2)	7.283e-07					
Mn+2	6.331e-07	4.250e-07	-6.199	-6.372	-0.173	(0)
MnSO4	9.164e-08	9.164e-08	-7.038	-7.038	0.000	(0)
MnHCO3+	2.944e-09	2.697e-09	-8.531	-8.569	-0.038	(0)
MnOH+	3.710e-10	3.399e-10	-9.431	-9.469	-0.038	(0)
MnF+	2.582e-10	2.366e-10	-9.588	-9.626	-0.038	(0)
Mn(OH)3-	2.324e-19	2.129e-19	-18.634	-18.672	-0.038	(0)
Mn(OH)4-2	3.106e-25	2.189e-25	-24.508	-24.660	-0.152	(0)
Mn(3)	4.241e-28					
Mn+3	4.241e-28	1.898e-28	-27.373	-27.722	-0.349	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-48.642	-48.794	-0.152	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-54.126	-54.166	-0.040	(0)
Mo	3.128e-08					
MoO4-2	3.126e-08	2.187e-08	-7.505	-7.660	-0.155	(0)
HMoO4-	1.520e-11	1.376e-11	-10.818	-10.861	-0.043	(0)
H2MoO4	3.188e-15	3.188e-15	-14.497	-14.497	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-49.070	-49.460	-0.390	(0)
Mo7O24-6	0.000e+00	0.000e+00	-59.073	-60.631	-1.558	(0)
HMo7O24-5	0.000e+00	0.000e+00	-60.662	-61.744	-1.082	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-63.769	-64.462	-0.692	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-68.326	-68.716	-0.390	(0)
Na	4.351e-05					
Na+	4.322e-05	3.953e-05	-4.364	-4.403	-0.039	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
NaHCO3	7.071e-09	7.071e-09	-8.151	-8.151	0.000	(0)
NaCO3-	3.785e-10	3.471e-10	-9.422	-9.460	-0.038	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
Ni	6.818e-08					
Ni+2	5.610e-08	3.924e-08	-7.251	-7.406	-0.155	(0)
NiSO4	9.495e-09	9.495e-09	-8.023	-8.023	0.000	(0)
NiHCO3+	1.700e-09	1.539e-09	-8.770	-8.813	-0.043	(0)
NiCO3	6.904e-10	6.904e-10	-9.161	-9.161	0.000	(0)
NiOH+	1.738e-10	1.573e-10	-9.760	-9.803	-0.043	(0)
NiF+	1.523e-11	1.379e-11	-10.817	-10.861	-0.043	(0)
Ni(OH)2	3.978e-12	3.978e-12	-11.400	-11.400	0.000	(0)
Ni(SO4)2-2	5.679e-13	3.812e-13	-12.246	-12.419	-0.173	(0)
Ni(OH)3-	1.399e-15	1.267e-15	-14.854	-14.897	-0.043	(0)
O(0)	2.019e-40					

O2	1.010e-40	1.011e-40	-39.996	-39.995	0.001	(0)
S(6)	2.051e-03					
SO4-2	1.733e-03	1.213e-03	-2.761	-2.916	-0.155	(0)
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
MnSO4	9.164e-08	9.164e-08	-7.038	-7.038	0.000	(0)
CuSO4	2.134e-08	2.134e-08	-7.671	-7.671	0.000	(0)
CoSO4	1.620e-08	1.620e-08	-7.791	-7.791	0.000	(0)
NiSO4	9.495e-09	9.495e-09	-8.023	-8.023	0.000	(0)
HSO4-	4.094e-09	3.747e-09	-8.388	-8.426	-0.038	(0)
Ni(SO4)2-2	5.679e-13	3.812e-13	-12.246	-12.419	-0.173	(0)
AlSO4+	3.315e-13	3.034e-13	-12.480	-12.518	-0.038	(0)
Al(SO4)2-	4.307e-15	3.942e-15	-14.366	-14.404	-0.038	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.79	9.01	10.80	Al(OH)3
Al2(MoO4)3	-52.33	-49.96	2.37	Al2(MoO4)3
Al2O3	-1.64	18.02	19.65	Al2O3
Al4(OH)10SO4	-4.58	18.12	22.70	Al4(OH)10SO4
AlOHSO4	-5.68	-8.91	-3.23	AlOHSO4
Alunite	-3.43	-4.83	-1.40	KAl3(SO4)2(OH)6
Anhydrite	-1.57	-5.93	-4.36	CaSO4
Antlerite	-3.05	5.74	8.79	Cu3(OH)4SO4
Aragonite	-1.04	-9.34	-8.30	CaCO3
Artinite	-8.33	1.27	9.60	MgCO3:Mg(OH)2:3H2O
Azurite	-2.09	-19.00	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-16.39	8.01	24.39	Ba(OH)2:8H2O
BaF2	-10.88	-16.70	-5.82	BaF2
BaMoO4	-7.69	-14.65	-6.96	BaMoO4
Barite	0.07	-9.91	-9.98	BaSO4
Birnessite	-11.81	6.28	18.09	MnO2
Bixbyite	-9.80	-10.44	-0.64	Mn2O3
Boehmite	0.43	9.01	8.58	AlOOH
Brochantite	-1.60	13.63	15.22	Cu4(OH)6SO4
Brucite	-5.55	11.30	16.84	Mg(OH)2
Bunsenite	-4.85	7.59	12.45	NiO
Calcite	-0.86	-9.34	-8.48	CaCO3
CaMoO4	-2.72	-10.67	-7.95	CaMoO4
CH4(g)	-72.28	-113.33	-41.05	CH4
Chalcanthite	-7.39	-10.03	-2.64	CuSO4:5H2O
Co(OH)2	-5.27	7.83	13.09	Co(OH)2
Co(OH)3	-10.77	-13.07	-2.31	Co(OH)3
CO2(g)	-3.18	-21.33	-18.15	CO2
Co3O4	-7.83	-18.32	-10.50	Co3O4
CoCO3	-3.52	-13.50	-9.98	CoCO3
CoF2	-15.29	-16.88	-1.60	CoF2
CoF3	-48.68	-50.14	-1.46	CoF3
CoMoO4	-7.07	-14.83	-7.76	CoMoO4
CoO	-5.76	7.83	13.59	CoO
CoSO4	-12.89	-10.09	2.80	CoSO4
CoSO4:6H2O	-7.62	-10.09	-2.47	CoSO4:6H2O
Cryolite	-21.99	-55.83	-33.84	Na3AlF6
Cu(OH)2	-0.79	7.89	8.67	Cu(OH)2
Cu2SO4	-17.82	-19.77	-1.95	Cu2SO4
CuCO3	-1.94	-13.44	-11.50	CuCO3
CuF	-8.37	-13.28	-4.91	CuF
CuF2	-17.94	-16.82	1.12	CuF2
CuF2:2H2O	-12.27	-16.82	-4.55	CuF2:2H2O
Cumetal	-3.67	-12.42	-8.76	Cu
CuMoO4	-1.70	-14.77	-13.08	CuMoO4
CuOCuSO4	-12.45	-2.15	10.30	CuOCuSO4
Cuprite	-0.44	-1.85	-1.41	Cu2O
CuSO4	-12.97	-10.03	2.94	CuSO4
Diaspore	2.14	9.01	6.87	AlOOH
Dolomite(disordered)	-2.83	-19.37	-16.54	CaMg(CO3)2
Dolomite(ordered)	-2.28	-19.37	-17.09	CaMg(CO3)2
Epsomite	-4.49	-6.62	-2.13	MgSO4:7H2O
Fluorite	-2.22	-12.72	-10.50	CaF2
Gibbsite	0.72	9.01	8.29	Al(OH)3
Gypsum	-1.32	-5.93	-4.61	CaSO4:2H2O
H2MoO4	-9.78	-22.66	-12.88	H2MoO4
Hausmannite	-12.15	48.88	61.03	Mn3O4
Huntite	-9.45	-39.42	-29.97	CaMg3(CO3)4
Hydromagnesite	-20.05	-28.81	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-17.68	-22.85	-5.17	KAl(SO4)2:12H2O
K2MoO4	-17.96	-14.70	3.26	K2MoO4
Langite	-3.86	13.63	17.49	Cu4(OH)6SO4:H2O
Lime	-20.71	11.99	32.70	CaO
Magnesite	-2.57	-10.03	-7.46	MgCO3
Malachite	-0.25	-5.56	-5.31	Cu2(OH)2CO3
Manganite	-5.21	20.13	25.34	MnOOH
Mg(OH)2(active)	-7.50	11.30	18.79	Mg(OH)2
MgF2	-5.28	-13.41	-8.13	MgF2
MgMoO4	-9.51	-11.36	-1.85	MgMoO4
Mirabilite	-10.61	-11.72	-1.11	Na2SO4:10H2O
Mn2(SO4)3	-58.48	-64.19	-5.71	Mn2(SO4)3
MnSO4	-11.87	-9.29	2.58	MnSO4
MoO3	-14.66	-22.66	-8.00	MoO3
Morenosite	-8.18	-10.32	-2.14	NiSO4:7H2O
Na2Mo2O7	-22.53	-39.13	-16.60	Na2Mo2O7
Na2MoO4	-17.96	-16.47	1.49	Na2MoO4
Na2MoO4:2H2O	-17.69	-16.47	1.22	Na2MoO4:2H2O
Natron	-13.82	-15.13	-1.31	Na2CO3:10H2O
Nesquehonite	-5.36	-10.03	-4.67	MgCO3:3H2O
Ni(OH)2	-5.20	7.59	12.79	Ni(OH)2
Ni4(OH)6SO4	-19.54	12.46	32.00	Ni4(OH)6SO4
NiCO3	-6.86	-13.73	-6.87	NiCO3
NiMoO4	-3.92	-15.07	-11.14	NiMoO4
Nsutite	-11.23	6.28	17.50	MnO2
O2(g)	-37.09	46.00	83.09	O2
Periclase	-10.29	11.30	21.58	MgO
Portlandite	-10.81	11.99	22.80	Ca(OH)2
Pyrochroite	-6.57	8.63	15.19	Mn(OH)2
Pyrolusite	-9.75	31.63	41.38	MnO2
Retgersite	-8.28	-10.32	-2.04	NiSO4:6H2O
Rhodochrosite	-2.12	-12.70	-10.58	MnCO3
Spinel	-7.53	29.31	36.85	MgAl2O4
Tenorite	0.24	7.89	7.64	CuO
Thenardite	-12.04	-11.72	0.32	Na2SO4
Thermonatrite	-15.77	-15.13	0.64	Na2CO3:H2O
Witherite	-4.75	-13.32	-8.57	BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Initial solution 3. NAF Material

----------Solution composition----------

Elements	Molality	Moles
Al	5.191e-06	5.191e-06
Alkalinity	4.591e-04	4.591e-04
As	3.873e-07	3.873e-07
Ba	1.457e-07	1.457e-07
Ca	3.046e-03	3.046e-03
Co	3.395e-08	3.395e-08
Cu	2.992e-07	2.992e-07
F	1.580e-05	1.580e-05
Fe	1.254e-06	1.254e-06
K	4.094e-04	4.094e-04
Mg	7.410e-04	7.410e-04
Mn	2.368e-06	2.368e-06
Mo	5.214e-08	5.214e-08
Na	4.352e-05	4.352e-05
Ni	1.705e-08	1.705e-08
S(6)	3.447e-03	3.447e-03
U	4.203e-09	4.203e-09

----------Description of solution----------

pH	= 7.600
pe	= 4.000
Activity of water	= 1.000
Ionic strength (mol/kgw)	= 1.193e-02
Mass of water (kg)	= 1.000e+00
Total carbon (mol/kg)	= 4.552e-04
Total CO2 (mol/kg)	= 4.552e-04
Temperature (°C)	= 25.00
Electrical balance (eq)	= 6.787e-04
Percent error, 100*(Cat-|An|)/(Cat+|An|)	= 5.48
Iterations	= 11 (35 overall)
Total H	= 1.110142e+02
Total O	= 5.552201e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol	
OH-	4.492e-07	4.008e-07	-6.348	-6.397	-0.049	(0)	
H+	2.808e-08	2.512e-08	-7.552	-7.600	-0.048	0.00	
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000	18.07	
Al	5.191e-06						
Al(OH)4-	5.088e-06	4.556e-06	-5.293	-5.341	-0.048	(0)	
Al(OH)3	9.030e-08	9.030e-08	-7.044	-7.044	0.000	(0)	
Al(OH)2+	1.257e-08	1.129e-08	-7.901	-7.947	-0.047	(0)	
AlF2+	6.958e-11	6.249e-11	-10.158	-10.204	-0.047	(0)	
AlOH+2	5.451e-11	3.546e-11	-10.264	-10.450	-0.187	(0)	
AlF+2	1.811e-11	1.178e-11	-10.742	-10.929	-0.187	(0)	
AlF3	1.048e-11	1.048e-11	-10.980	-10.980	0.000	(0)	
AlSO4+	1.328e-12	1.189e-12	-11.877	-11.925	-0.048	(0)	
Al+3	2.412e-13	8.848e-14	-12.618	-13.053	-0.436	(0)	
AlF4-	7.812e-14	6.995e-14	-13.107	-13.155	-0.048	(0)	
Al(SO4)2-	2.463e-14	2.206e-14	-13.608	-13.656	-0.048	(0)	
AlMo6O21-3	0.000e+00	0.000e+00	-48.018	-48.520	-0.501	(0)	
As(3)	1.024e-17						
H3AsO3	1.000e-17	1.000e-17	-17.000	-17.000	0.000	(0)	
H2AsO3-	2.322e-19	2.043e-19	-18.634	-18.690	-0.056	(0)	
HAsO3-2	1.239e-23	7.417e-24	-22.907	-23.130	-0.223	(0)	
H4AsO3+	1.416e-25	1.245e-25	-24.849	-24.905	-0.056	(0)	
AsO3-3	3.611e-29	1.138e-29	-28.442	-28.944	-0.501	(0)	
As(5)	3.873e-07						
HAsO4-2	3.350e-07	2.005e-07	-6.475	-6.698	-0.223	(0)	
H2AsO4-	5.222e-08	4.594e-08	-7.282	-7.338	-0.056	(0)	
AsO4-3	8.009e-11	2.524e-11	-10.096	-10.598	-0.501	(0)	
H3AsO4	2.000e-13	2.005e-13	-12.699	-12.698	0.001	(0)	
Ba	1.457e-07						
Ba+2	1.453e-07	9.304e-08	-6.838	-7.031	-0.194	(0)	
BaHCO3+	3.699e-10	3.328e-10	-9.432	-9.478	-0.046	(0)	
BaCO3	3.336e-11	3.336e-11	-10.477	-10.477	0.000	(0)	
BaOH+	1.815e-13	1.628e-13	-12.741	-12.788	-0.047	(0)	
C(4)	4.552e-04						
HCO3-	4.171e-04	3.746e-04	-3.380	-3.426	-0.047	(0)	
H2CO3	2.116e-05	2.116e-05	-4.674	-4.674	0.000	(0)	
CaHCO3+	1.200e-05	1.080e-05	-4.921	-4.967	-0.046	(0)	
CaCO3	1.715e-06	1.715e-06	-5.766	-5.766	0.000	(0)	
MgHCO3+	1.687e-06	1.508e-06	-5.773	-5.822	-0.049	(0)	
CO3-2	1.092e-06	6.991e-07	-5.962	-6.155	-0.194	(0)	
MgCO3	2.288e-07	2.288e-07	-6.641	-6.641	0.000	(0)	
CuCO3	1.600e-07	1.600e-07	-6.796	-6.796	0.000	(0)	
MnHCO3+	9.921e-09	8.899e-09	-8.003	-8.051	-0.047	(0)	
NaHCO3	8.124e-09	8.124e-09	-8.090	-8.090	0.000	(0)	
UO2(CO3)2-2	3.482e-09	2.084e-09	-8.458	-8.681	-0.223	(0)	
CuHCO3+	1.044e-09	9.187e-10	-8.981	-9.037	-0.056	(0)	
UO2(CO3)3-4	5.687e-10	7.303e-11	-9.245	-10.136	-0.891	(0)	
NaCO3-	5.590e-10	5.020e-10	-9.253	-9.299	-0.047	(0)	
CoHCO3+	5.432e-10	4.778e-10	-9.265	-9.321	-0.056	(0)	
Cu(CO3)2-2	5.030e-10	3.011e-10	-9.298	-9.521	-0.223	(0)	
NiHCO3+	4.493e-10	3.952e-10	-9.347	-9.403	-0.056	(0)	
BaHCO3+	3.699e-10	3.328e-10	-9.432	-9.478	-0.046	(0)	
NiCO3	2.232e-10	2.232e-10	-9.651	-9.651	0.000	(0)	
CoCO3	1.938e-10	1.938e-10	-9.713	-9.713	0.000	(0)	
UO2CO3	1.494e-10	1.494e-10	-9.826	-9.826	0.000	(0)	
FeHCO3+	1.083e-10	9.748e-11	-9.965	-10.011	-0.046	(0)	
BaCO3	3.336e-11	3.336e-11	-10.477	-10.477	0.000	(0)	
Ca	3.046e-03						
Ca+2	2.418e-03	1.548e-03	-2.617	-2.810	-0.194	(0)	
CaSO4	6.140e-04	6.140e-04	-3.212	-3.212	0.000	(0)	
CaHCO3+	1.200e-05	1.080e-05	-4.921	-4.967	-0.046	(0)	
CaCO3	1.715e-06	1.715e-06	-5.766	-5.766	0.000	(0)	
CaF+	2.509e-07	2.251e-07	-6.600	-6.648	-0.047	(0)	
CaOH+	1.376e-08	1.238e-08	-7.861	-7.907	-0.046	(0)	
Co(2)	3.395e-08						
Co+2	2.739e-08	1.640e-08	-7.562	-7.785	-0.223	(0)	
CoSO4	5.664e-09	5.664e-09	-8.247	-8.247	0.000	(0)	
CoHCO3+	5.432e-10	4.778e-10	-9.265	-9.321	-0.056	(0)	
CoCO3	1.938e-10	1.938e-10	-9.713	-9.713	0.000	(0)	
CoOH+	1.491e-10	1.311e-10	-9.827	-9.882	-0.056	(0)	
CoF+	7.852e-12	6.907e-12	-11.105	-11.161	-0.056	(0)	
Co(OH)2	4.175e-12	4.175e-12	-11.379	-11.379	0.000	(0)	
Co(OH)3-	3.796e-17	3.339e-17	-16.421	-16.476	-0.056	(0)	
CoOOH-	9.525e-18	8.379e-18	-17.021	-17.077	-0.056	(0)	
Co2OH+3	3.419e-19	1.078e-19	-18.466	-18.968	-0.501	(0)	
Co(OH)4-2	3.543e-24	2.121e-24	-23.451	-23.673	-0.223	(0)	
Co4(OH)4+4	4.595e-31	5.900e-32	-30.338	-31.229	-0.891	(0)	
Co(3)	2.221e-30						
CoOH+2	2.221e-30	1.330e-30	-29.653	-29.876	-0.223	(0)	
Co+3	1.780e-36	6.528e-37	-35.750	-36.185	-0.436	(0)	
Cu(1)	2.164e-09						
Cu+	2.164e-09	1.904e-09	-8.665	-8.720	-0.056	(0)	
Cu(2)	2.970e-07						
CuCO3	1.600e-07	1.600e-07	-6.796	-6.796	0.000	(0)	
Cu+2	6.070e-08	3.887e-08	-7.217	-7.410	-0.194	(0)	
CuOH+	5.512e-08	4.927e-08	-7.259	-7.307	-0.049	(0)	
CuSO4	1.542e-08	1.542e-08	-7.812	-7.812	0.000	(0)	
Cu(OH)2	3.940e-09	3.940e-09	-8.404	-8.404	0.000	(0)	
CuHCO3+	1.044e-09	9.187e-10	-8.981	-9.037	-0.056	(0)	
Cu(CO3)2-2	5.030e-10	3.011e-10	-9.298	-9.521	-0.223	(0)	
Cu2(OH)2+2	1.019e-10	6.097e-11	-9.992	-10.215	-0.223	(0)	
CuF+	3.714e-11	3.267e-11	-10.430	-10.486	-0.056	(0)	
Cu(OH)3-	3.683e-12	3.239e-12	-11.434	-11.490	-0.056	(0)	
Cu(OH)4-2	1.707e-17	1.022e-17	-16.768	-16.991	-0.223	(0)	
F	1.580e-05						
F-	1.489e-05	1.332e-05	-4.827	-4.876	-0.048	(0)	
MgF+	6.566e-07	5.879e-07	-6.183	-6.231	-0.048	(0)	
CaF+	2.509e-07	2.251e-07	-6.600	-6.648	-0.047	(0)	
MnF+	7.039e-10	6.314e-10	-9.152	-9.200	-0.047	(0)	
HF	4.949e-10	4.949e-10	-9.306	-9.306	0.000	(0)	

NaF	3.241e-10	3.241e-10	-9.489	-9.489	0.000	(0)
AlF2+	6.958e-11	6.249e-11	-10.158	-10.204	-0.047	(0)
CuF+	3.714e-11	3.267e-11	-10.430	-10.486	-0.056	(0)
AlF+2	1.811e-11	1.178e-11	-10.742	-10.929	-0.187	(0)
AlF3	1.048e-11	1.048e-11	-10.980	-10.980	0.000	(0)
CoF+	7.852e-12	6.907e-12	-11.105	-11.161	-0.056	(0)
NiF+	3.255e-12	2.863e-12	-11.487	-11.543	-0.056	(0)
UO2F+	1.122e-13	9.871e-14	-12.950	-13.006	-0.056	(0)
AlF4-	7.812e-14	6.995e-14	-13.107	-13.155	-0.048	(0)
HF2-	2.808e-14	2.506e-14	-13.552	-13.601	-0.049	(0)
UO2F2	3.792e-15	3.792e-15	-14.421	-14.421	0.000	(0)
FeF+2	4.333e-16	2.804e-16	-15.363	-15.552	-0.189	(0)
FeF2+	1.114e-16	9.996e-17	-15.953	-16.000	-0.047	(0)
UO2F3-	1.442e-17	1.269e-17	-16.841	-16.897	-0.056	(0)
FeF3	1.879e-18	1.879e-18	-17.726	-17.726	0.000	(0)
H2F2	6.561e-19	6.561e-19	-18.183	-18.183	0.000	(0)
UO2F4-2	2.242e-21	1.342e-21	-20.649	-20.872	-0.223	(0)
UF3+	3.760e-36	3.307e-36	-35.425	-35.481	-0.056	(0)
UF2+2	2.617e-36	1.567e-36	-35.582	-35.805	-0.223	(0)
UF+3	2.964e-38	9.342e-39	-37.528	-38.030	-0.501	(0)
UF4	4.830e-39	4.830e-39	-38.316	-38.316	0.000	(0)
UF5-	0.000e+00	0.000e+00	-41.538	-41.594	-0.056	(0)
UF6-2	0.000e+00	0.000e+00	-43.766	-43.989	-0.223	(0)
Fe(2)	4.379e-08					
Fe+2	3.453e-08	2.067e-08	-7.462	-7.685	-0.223	(0)
FeSO4	8.785e-09	8.785e-09	-8.056	-8.056	0.000	(0)
FeOH+	3.677e-10	3.298e-10	-9.434	-9.482	-0.047	(0)
FeHCO3+	1.083e-10	9.748e-11	-9.965	-10.011	-0.046	(0)
Fe(OH)2	1.050e-13	1.050e-13	-12.979	-12.979	0.000	(0)
Fe(OH)3-	1.484e-14	1.331e-14	-13.829	-13.876	-0.047	(0)
Fe(3)	1.210e-06					
Fe(OH)2+	8.628e-07	7.749e-07	-6.064	-6.111	-0.047	(0)
Fe(OH)3	3.336e-07	3.336e-07	-6.477	-6.477	0.000	(0)
Fe(OH)4-	1.386e-08	1.245e-08	-7.858	-7.905	-0.047	(0)
FeOH+2	7.678e-12	4.969e-12	-11.115	-11.304	-0.189	(0)
FeF+2	4.333e-16	2.804e-16	-15.363	-15.552	-0.189	(0)
FeSO4+	4.159e-16	3.730e-16	-15.381	-15.428	-0.047	(0)
FeF2+	1.114e-16	9.996e-17	-15.953	-16.000	-0.047	(0)
Fe+3	5.236e-17	1.920e-17	-16.281	-16.717	-0.436	(0)
Fe(SO4)2-	1.570e-17	1.381e-17	-16.804	-16.860	-0.056	(0)
FeF3	1.879e-18	1.879e-18	-17.726	-17.726	0.000	(0)
Fe2(OH)2+4	6.368e-21	8.178e-22	-20.196	-21.087	-0.891	(0)
Fe3(OH)4+5	2.263e-25	9.160e-27	-24.645	-26.038	-1.393	(0)
H(0)	8.909e-27					
H2	4.455e-27	4.467e-27	-26.351	-26.350	0.001	(0)
K	4.094e-04					
K+	4.045e-04	3.618e-04	-3.393	-3.441	-0.048	(0)
KSO4-	4.938e-06	4.435e-06	-5.306	-5.353	-0.047	(0)
Mg	7.410e-04					
Mg+2	6.144e-04	3.934e-04	-3.212	-3.405	-0.194	(0)
MgSO4	1.239e-04	1.239e-04	-3.907	-3.907	0.000	(0)
MgHCO3+	1.687e-06	1.508e-06	-5.773	-5.822	-0.049	(0)
MgF+	6.566e-07	5.879e-07	-6.183	-6.231	-0.048	(0)
MgCO3	2.288e-07	2.288e-07	-6.641	-6.641	0.000	(0)
MgOH+	6.966e-08	6.278e-08	-7.157	-7.202	-0.045	(0)
Mn(2)	2.368e-06					
Mn+2	1.989e-06	1.191e-06	-5.701	-5.924	-0.223	(0)
MnSO4	3.666e-07	3.666e-07	-6.436	-6.436	0.000	(0)
MnHCO3+	9.921e-09	8.899e-09	-8.003	-8.051	-0.047	(0)
MnOH+	1.337e-09	1.199e-09	-8.874	-8.921	-0.047	(0)
MnF+	7.039e-10	6.314e-10	-9.152	-9.200	-0.047	(0)
Mn(OH)3-	1.327e-18	1.190e-18	-17.877	-17.924	-0.047	(0)
Mn(OH)4-2	2.380e-24	1.540e-24	-23.623	-23.812	-0.189	(0)
Mn(3)	1.450e-27					
Mn+3	1.450e-27	5.318e-28	-26.839	-27.274	-0.436	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-47.357	-47.546	-0.189	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-52.868	-52.918	-0.050	(0)
Mo	5.214e-08					
MoO4-2	5.212e-08	3.338e-08	-7.283	-7.477	-0.194	(0)
HMoO4-	1.896e-11	1.668e-11	-10.722	-10.778	-0.056	(0)
H2MoO4	3.069e-15	3.069e-15	-14.513	-14.513	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-48.018	-48.520	-0.501	(0)
Mo7O24-6	0.000e+00	0.000e+00	-58.140	-60.146	-2.006	(0)
HMo7O24-5	0.000e+00	0.000e+00	-59.966	-61.359	-1.393	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-63.285	-64.177	-0.891	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-68.029	-68.531	-0.501	(0)
Na	4.352e-05					
Na+	4.311e-05	3.857e-05	-4.365	-4.414	-0.048	(0)
NaSO4-	3.992e-07	3.586e-07	-6.399	-6.445	-0.047	(0)
NaHCO3	8.124e-09	8.124e-09	-8.090	-8.090	0.000	(0)
NaCO3-	5.590e-10	5.020e-10	-9.253	-9.299	-0.047	(0)
NaF	3.241e-10	3.241e-10	-9.489	-9.489	0.000	(0)
Ni	1.705e-08					
Ni+2	1.336e-08	8.558e-09	-7.874	-8.068	-0.194	(0)
NiSO4	2.956e-09	2.956e-09	-8.529	-8.529	0.000	(0)
NiHCO3+	4.493e-10	3.952e-10	-9.347	-9.403	-0.056	(0)
NiCO3	2.232e-10	2.232e-10	-9.651	-9.651	0.000	(0)
NiOH+	4.909e-11	4.318e-11	-10.309	-10.365	-0.056	(0)
NiF+	3.255e-12	2.863e-12	-11.487	-11.543	-0.056	(0)
Ni(OH)2	1.375e-12	1.375e-12	-11.862	-11.862	0.000	(0)
Ni(SO4)2-2	2.831e-13	1.695e-13	-12.548	-12.771	-0.223	(0)
Ni(OH)3-	6.265e-16	5.511e-16	-15.203	-15.259	-0.056	(0)
O(0)	5.066e-40					
O2	2.533e-40	2.540e-40	-39.596	-39.595	0.001	(0)
S(6)	3.447e-03					
SO4-2	2.704e-03	1.731e-03	-2.568	-2.762	-0.194	(0)
CaSO4	6.140e-04	6.140e-04	-3.212	-3.212	0.000	(0)
MgSO4	1.239e-04	1.239e-04	-3.907	-3.907	0.000	(0)
KSO4-	4.938e-06	4.435e-06	-5.306	-5.353	-0.047	(0)
NaSO4-	3.992e-07	3.586e-07	-6.399	-6.445	-0.047	(0)
MnSO4	3.666e-07	3.666e-07	-6.436	-6.436	0.000	(0)
CuSO4	1.542e-08	1.542e-08	-7.812	-7.812	0.000	(0)
FeSO4	8.785e-09	8.785e-09	-8.056	-8.056	0.000	(0)
CoSO4	5.664e-09	5.664e-09	-8.247	-8.247	0.000	(0)
HSO4-	4.746e-09	4.250e-09	-8.324	-8.372	-0.048	(0)
NiSO4	2.956e-09	2.956e-09	-8.529	-8.529	0.000	(0)
AlSO4+	1.328e-12	1.189e-12	-11.877	-11.925	-0.048	(0)
Ni(SO4)2-2	2.831e-13	1.695e-13	-12.548	-12.771	-0.223	(0)
UO2SO4	1.407e-13	1.407e-13	-12.852	-12.852	0.000	(0)
Al(SO4)2-	2.463e-14	2.206e-14	-13.608	-13.656	-0.048	(0)
UO2(SO4)2-2	5.363e-15	3.210e-15	-14.271	-14.493	-0.223	(0)
FeSO4+	4.159e-16	3.730e-16	-15.381	-15.428	-0.047	(0)
Fe(SO4)2-	1.570e-17	1.381e-17	-16.804	-16.860	-0.056	(0)
U(SO4)2	3.332e-38	3.332e-38	-37.477	-37.477	0.000	(0)
USO4+2	4.047e-39	2.423e-39	-38.393	-38.616	-0.223	(0)
U(3)	0.000e+00					
U+3	0.000e+00	0.000e+00	-54.749	-55.250	-0.501	(0)
U(4)	3.033e-18					
U(OH)5-	3.030e-18	2.665e-18	-17.519	-17.574	-0.056	(0)
U(OH)4	2.804e-21	2.804e-21	-20.552	-20.552	0.000	(0)
U(OH)3+	2.928e-25	2.575e-25	-24.533	-24.589	-0.056	(0)
U(OH)2+2	4.997e-30	2.991e-30	-29.301	-29.524	-0.223	(0)
UOH+3	1.123e-35	3.539e-36	-34.950	-35.451	-0.501	(0)
UF3+	3.760e-36	3.307e-36	-35.425	-35.481	-0.056	(0)
UF2+2	2.617e-36	1.567e-36	-35.582	-35.805	-0.223	(0)
U(SO4)2	3.332e-38	3.332e-38	-37.477	-37.477	0.000	(0)
UF+3	2.964e-38	9.342e-39	-37.528	-38.030	-0.501	(0)
UF4	4.830e-39	4.830e-39	-38.316	-38.316	0.000	(0)
USO4+2	4.047e-39	2.423e-39	-38.393	-38.616	-0.223	(0)
UF5-	0.000e+00	0.000e+00	-41.538	-41.594	-0.056	(0)
U+4	0.000e+00	0.000e+00	-41.563	-42.454	-0.891	(0)
UF6-2	0.000e+00	0.000e+00	-43.766	-43.989	-0.223	(0)
U6(OH)15+9	0.000e+00	0.000e+00	-153.367	-157.880	-4.513	(0)
U(5)	3.720e-15					
UO2+	3.720e-15	3.272e-15	-14.429	-14.485	-0.056	(0)
U(6)	4.203e-09					
UO2(CO3)2-2	3.482e-09	2.084e-09	-8.458	-8.681	-0.223	(0)
UO2(CO3)3-4	5.687e-10	7.303e-11	-9.245	-10.136	-0.891	(0)
UO2CO3	1.494e-10	1.494e-10	-9.826	-9.826	0.000	(0)
UO2OH+	3.080e-12	2.709e-12	-11.511	-11.567	-0.056	(0)
UO2SO4	1.407e-13	1.407e-13	-12.852	-12.852	0.000	(0)
UO2F+	1.122e-13	9.871e-14	-12.950	-13.006	-0.056	(0)
UO2+2	8.384e-14	5.369e-14	-13.077	-13.270	-0.194	(0)
UO2(SO4)2-2	5.363e-15	3.210e-15	-14.271	-14.493	-0.223	(0)
UO2F2	3.792e-15	3.792e-15	-14.421	-14.421	0.000	(0)
(UO2)2(OH)2+2	2.034e-17	1.218e-17	-16.692	-16.914	-0.223	(0)
UO2F3-	1.442e-17	1.269e-17	-16.841	-16.897	-0.056	(0)
(UO2)3(OH)5+	4.571e-18	4.021e-18	-17.340	-17.396	-0.056	(0)
UO2F4-2	2.242e-21	1.342e-21	-20.649	-20.872	-0.223	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)
Al(OH)3(am)	-1.05	9.75	10.80 Al(OH)3
Al2(MoO4)3	-50.90	-48.54	2.37 Al2(MoO4)3
Al2O3	-0.16	19.49	19.65 Al2O3
Al4(OH)10SO4	-1.67	21.03	22.70 Al4(OH)10SO4
AlAsO4:2H2O	-7.75	-2.95	4.80 AlAsO4:2H2O
AlOHSO4	-4.98	-8.21	-3.23 AlOHSO4
Alunite	-1.12	-2.52	-1.40 KAl3(SO4)2(OH)6
Anhydrite	-1.21	-5.57	-4.36 CaSO4
Antlerite	-3.38	5.41	8.79 Cu3(OH)4SO4
Aragonite	-0.67	-8.97	-8.30 CaCO3
Arsenolite	-65.24	-68.00	-2.76 As4O6
Artinite	-7.37	2.23	9.60 MgCO3:Mg(OH)2:3H2O
As2O5	-32.10	-25.40	6.71 As2O5
Azurite	-2.44	-19.34	-16.91 Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-16.23	8.17	24.39 Ba(OH)2:8H2O
Ba3(AsO4)2	8.02	-0.89	-8.91 Ba3(AsO4)2
BaF2	-10.96	-16.78	-5.82 BaF2
BaMoO4	-7.55	-14.51	-6.96 BaMoO4
Barite	0.19	-9.79	-9.98 BaSO4
Birnessite	-10.97	7.13	18.09 MnO2
Bixbyite	-8.30	-8.95	-0.64 Mn2O3
Boehmite	1.17	9.75	8.58 AlOOH
Brochantite	-2.03	13.20	15.22 Cu4(OH)6SO4
Brucite	-5.05	11.79	16.84 Mg(OH)2
Bunsenite	-5.31	7.13	12.45 NiO
Ca3(AsO4)2:4H2O	-10.53	11.77	22.30 Ca3(AsO4)2:4H2O
Calcite	-0.49	-8.97	-8.48 CaCO3
CaMoO4	-2.34	-10.29	-7.95 CaMoO4
CH4(g)	-73.11	-114.16	-41.05 CH4
Chalcanthite	-7.53	-10.17	-2.64 CuSO4:5H2O
Claudetite	-64.93	-68.00	-3.06 As4O6
Co(OH)2	-5.68	7.41	13.09 Co(OH)2
Co(OH)3	-11.08	-13.39	-2.31 Co(OH)3
CO2(g)	-3.21	-21.36	-18.15 CO2
Co3(AsO4)2	-16.19	-3.15	13.03 Co3(AsO4)2
Co3O4	-8.86	-19.36	-10.50 Co3O4
CoCO3	-3.96	-13.94	-9.98 CoCO3
CoF2	-15.94	-17.54	-1.60 CoF2
CoF3	-49.35	-50.81	-1.46 CoF3
CoFe2O4	23.11	19.58	-3.53 CoFe2O4
CoMoO4	-7.50	-15.26	-7.76 CoMoO4
CoO	-6.17	7.41	13.59 CoO
CoSO4	-13.35	-10.55	2.80 CoSO4
CoSO4:6H2O	-8.07	-10.55	-2.47 CoSO4:6H2O
Cryolite	-21.71	-55.55	-33.84 Na3AlF6
Cu(OH)2	-0.88	7.79	8.67 Cu(OH)2
Cu2SO4	-18.25	-20.20	-1.95 Cu2SO4
Cu3(AsO4)2:2H2O	-8.13	-2.03	6.10 Cu3(AsO4)2:2H2O
CuCO3	-2.07	-13.57	-11.50 CuCO3
CuF	-8.69	-13.60	-4.91 CuF
CuF2	-18.28	-17.16	1.12 CuF2
CuF2:2H2O	-12.61	-17.16	-4.55 CuF2:2H2O
Cumetal	-3.96	-12.72	-8.76 Cu
CuMoO4	-1.81	-14.89	-13.08 CuMoO4
CuOCuSO4	-12.69	-2.38	10.30 CuOCuSO4
Cupricferrite	13.97	19.96	5.99 CuFe2O4
Cuprite	-0.83	-2.24	-1.41 Cu2O
Cuprousferrite	13.88	4.96	-8.92 CuFeO2
CuSO4	-13.11	-10.17	2.94 CuSO4
Diaspore	2.87	9.75	6.87 AlOOH
Dolomite(disordered)	-1.99	-18.53	-16.54 CaMg(CO3)2
Dolomite(ordered)	-1.44	-18.53	-17.09 CaMg(CO3)2
Epsomite	-4.04	-6.17	-2.13 MgSO4:7H2O
Fe(OH)2	-6.05	7.52	13.56 Fe(OH)2
Fe2(SO4)3	-37.98	-41.72	-3.73 Fe2(SO4)3
Fe3(OH)8	-0.54	19.68	20.22 Fe3(OH)8
FeAsO4:2H2O	-7.01	-6.61	0.40 FeAsO4:2H2O
FeMoO4	-5.07	-15.16	-10.09 FeMoO4
Ferrihydrite	2.89	6.08	3.19 Fe(OH)3
Fluorite	-2.06	-12.56	-10.50 CaF2
Gibbsite	1.46	9.75	8.29 Al(OH)3
Goethite	5.59	6.08	0.49 FeOOH
Gummite	-5.74	1.93	7.67 UO3
Gypsum	-0.96	-5.57	-4.61 CaSO4:2H2O
H-Jarosite	-5.57	-17.67	-12.10 (H3O)Fe3(SO4)2(OH)6
H2MoO4	-9.80	-22.68	-12.88 H2MoO4
Hausmannite	-10.00	51.03	61.03 Mn3O4
Hematite	13.58	12.17	-1.42 Fe2O3
Hercynite	4.12	27.01	22.89 FeAl2O4
Huntite	-7.68	-37.65	-29.97 CaMg3(CO3)4
Hydromagnesite	-17.68	-26.45	-8.77 Mg5(CO3)4(OH)2:4H2O
K-Alum	-16.85	-22.02	-5.17 KAl(SO4)2:12H2O
K-Jarosite	1.28	-13.52	-14.80 KFe3(SO4)2(OH)6
K2MoO4	-17.62	-14.36	3.26 K2MoO4
Langite	-4.29	13.20	17.49 Cu4(OH)6SO4:H2O
Lepidocrocite	4.71	6.08	1.37 FeOOH
Lime	-20.31	12.39	32.70 CaO
Maghemite	5.78	12.17	6.39 Fe2O3
Magnesioferrite	7.10	23.96	16.86 Fe2MgO4
Magnesite	-2.10	-9.56	-7.46 MgCO3
Magnetite	16.28	19.68	3.40 Fe3O4
Malachite	-0.47	-5.78	-5.31 Cu2(OH)2CO3
Manganite	-4.46	20.88	25.34 MnOOH
Melanterite	-8.24	-10.45	-2.21 FeSO4:7H2O
Mg(OH)2(active)	-7.00	11.79	18.79 Mg(OH)2
MgF2	-5.03	-13.16	-8.13 MgF2
MgMoO4	-9.03	-10.88	-1.85 MgMoO4
Mirabilite	-10.48	-11.59	-1.11 Na2SO4:10H2O
Mn2(SO4)3	-57.12	-62.83	-5.71 Mn2(SO4)3
Mn3(AsO4)2:8H2O	-10.07	2.43	12.50 Mn3(AsO4)2:8H2O
MnSO4	-11.27	-8.69	2.58 MnSO4
MoO3	-14.68	-22.68	-8.00 MoO3
Morenosite	-8.68	-10.83	-2.14 NiSO4:7H2O
Na-Jarosite	-3.29	-14.49	-11.20 NaFe3(SO4)2(OH)6
Na2Mo2O7	-22.38	-38.98	-16.60 Na2Mo2O7
Na2MoO4	-17.79	-16.30	1.49 Na2MoO4
Na2MoO4:2H2O	-17.53	-16.30	1.22 Na2MoO4:2H2O
Natron	-13.67	-14.98	-1.31 Na2CO3:10H2O

Nesquehonite	-4.89	-9.56	-4.67	MgCO3:3H2O
Ni(OH)2	-5.66	7.13	12.79	Ni(OH)2
Ni3(AsO4)2:8H2O	-19.70	-4.00	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-21.43	10.57	32.00	Ni4(OH)6SO4
NiCO3	-7.35	-14.22	-6.87	NiCO3
NiMoO4	-4.40	-15.54	-11.14	NiMoO4
Nsutite	-10.38	7.13	17.50	MnO2
O2(g)	-36.69	46.40	83.09	O2
Periclase	-9.79	11.79	21.58	MgO
Portlandite	-10.41	12.39	22.80	Ca(OH)2
Pyrochroite	-5.92	9.28	15.19	Mn(OH)2
Pyrolusite	-8.90	32.48	41.38	MnO2
Retgersite	-8.79	-10.83	-2.04	NiSO4:6H2O
Rhodochrosite	-1.50	-12.08	-10.58	MnCO3
Rutherfordine	-4.93	-19.43	-14.50	UO2CO3
Schoepite	-4.06	1.93	5.99	UO2(OH)2:H2O
Siderite	-3.60	-13.84	-10.24	FeCO3
Spinel	-5.56	31.29	36.85	MgAl2O4
Tenorite	0.15	7.79	7.64	CuO
Thenardite	-11.91	-11.59	0.32	Na2SO4
Thermonatrite	-15.62	-14.98	0.64	Na2CO3:H2O
U3O8	-10.85	10.24	21.08	U3O8
U4O9	-22.00	-25.02	-3.02	U4O9
UF4	-32.42	-61.96	-29.54	UF4
UF4:2.5H2O	-29.24	-61.96	-32.72	UF4:2.5H2O
UO2(am)	-12.99	-12.05	0.93	UO2
UO2(OH)2(beta)	-3.68	1.93	5.61	UO2(OH)2
UO3	-5.77	1.93	7.70	UO3
Uraninite	-7.38	-12.05	-4.67	UO2
Witherite	-4.62	-13.19	-8.57	BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Initial solution 4. Make-up Material

----------Solution composition----------

Elements	Molality	Moles
Al	7.415e-07	7.415e-07
Alkalinity	3.607e-04	3.607e-04
Ba	1.457e-07	1.457e-07
Ca	1.672e-03	1.672e-03
Co	1.188e-07	1.188e-07
Cu	4.408e-07	4.408e-07
F	1.580e-05	1.580e-05
K	3.326e-04	3.326e-04
Mg	3.293e-04	3.293e-04
Mn	7.283e-07	7.283e-07
Mo	3.128e-08	3.128e-08
Na	4.351e-05	4.351e-05
Ni	6.818e-08	6.818e-08
S(6)	2.051e-03	2.051e-03

----------Description of solution----------

pH	=	7.700
pe	=	4.000
Activity of water	=	1.000
Ionic strength (mol/kgw)	=	7.199e-03
Mass of water (kg)	=	1.000e+00
Total carbon (mol/kg)	=	3.686e-04
Total CO2 (mol/kg)	=	3.686e-04
Temperature (°C)	=	25.00
Electrical balance (eq)	=	-9.478e-05
Percent error, 100*(Cat-|An|)/(Cat+|An|)	=	-1.25
Iterations	=	12 (47 overall)
Total H	=	1.110140e+02
Total O	=	5.551615e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
OH-	5.526e-07	5.046e-07	-6.258	-6.297	-0.039	(0)
H+	2.182e-08	1.995e-08	-7.661	-7.700	-0.039	0.00
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000	18.07
Al	7.415e-07					
Al(OH)4-	7.298e-07	6.680e-07	-6.137	-6.175	-0.038	(0)
Al(OH)3	1.051e-08	1.051e-08	-7.978	-7.978	0.000	(0)
Al(OH)2+	1.139e-09	1.044e-09	-8.944	-8.981	-0.038	(0)
AlF2+	4.383e-12	4.020e-12	-11.358	-11.396	-0.038	(0)
AlOH+2	3.684e-12	2.605e-12	-11.434	-11.584	-0.150	(0)
AlF+2	1.021e-12	7.220e-13	-11.991	-12.141	-0.150	(0)
AlF3	7.077e-13	7.077e-13	-12.150	-12.150	0.000	(0)
AlSO4+	5.310e-14	4.860e-14	-13.275	-13.313	-0.038	(0)
Al+3	1.153e-14	5.163e-15	-13.938	-14.287	-0.349	(0)
AlF4-	5.420e-15	4.960e-15	-14.266	-14.304	-0.038	(0)
Al(SO4)2-	6.899e-16	6.315e-16	-15.161	-15.200	-0.038	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-51.065	-51.455	-0.389	(0)
Ba	1.457e-07					
Ba+2	1.453e-07	1.017e-07	-6.838	-6.993	-0.155	(0)
BaHCO3+	3.344e-10	3.070e-10	-9.476	-9.513	-0.037	(0)
BaCO3	3.874e-11	3.874e-11	-10.412	-10.412	0.000	(0)
BaOH+	2.444e-13	2.239e-13	-12.612	-12.650	-0.038	(0)
C(4)	3.686e-04					
HCO3-	3.449e-04	3.163e-04	-3.462	-3.500	-0.038	(0)
H2CO3	1.419e-05	1.419e-05	-4.848	-4.848	0.000	(0)
CaHCO3+	6.254e-06	5.742e-06	-5.204	-5.241	-0.037	(0)
CaCO3	1.148e-06	1.148e-06	-5.940	-5.940	0.000	(0)
CO3-2	1.062e-06	7.431e-07	-5.974	-6.129	-0.155	(0)
MgHCO3+	7.037e-07	6.434e-07	-6.153	-6.192	-0.039	(0)
CuCO3	2.384e-07	2.384e-07	-6.623	-6.623	0.000	(0)
MgCO3	1.229e-07	1.229e-07	-6.911	-6.911	0.000	(0)
NaHCO3	7.030e-09	7.030e-09	-8.153	-8.153	0.000	(0)
MnHCO3+	2.926e-09	2.681e-09	-8.534	-8.572	-0.038	(0)
CoHCO3+	1.811e-09	1.639e-09	-8.742	-8.785	-0.043	(0)
NiHCO3+	1.678e-09	1.519e-09	-8.775	-8.818	-0.043	(0)
CuHCO3+	1.201e-09	1.087e-09	-8.920	-8.964	-0.043	(0)
NiCO3	1.080e-09	1.080e-09	-8.967	-8.967	0.000	(0)
CoCO3	8.369e-10	8.369e-10	-9.077	-9.077	0.000	(0)
Cu(CO3)2-2	7.104e-10	4.768e-10	-9.149	-9.322	-0.173	(0)
NaCO3-	5.965e-10	5.470e-10	-9.224	-9.262	-0.038	(0)
BaHCO3+	3.344e-10	3.070e-10	-9.476	-9.513	-0.037	(0)
BaCO3	3.874e-11	3.874e-11	-10.412	-10.412	0.000	(0)
Ca	1.672e-03					
Ca+2	1.394e-03	9.751e-04	-2.856	-3.011	-0.155	(0)
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)
CaHCO3+	6.254e-06	5.742e-06	-5.204	-5.241	-0.037	(0)
CaCO3	1.148e-06	1.148e-06	-5.940	-5.940	0.000	(0)
CaF+	1.624e-07	1.488e-07	-6.789	-6.827	-0.038	(0)
CaOH+	1.069e-08	9.818e-09	-7.971	-8.008	-0.037	(0)
Co(2)	1.188e-07					
Co+2	9.925e-08	6.662e-08	-7.003	-7.176	-0.173	(0)
CoSO4	1.612e-08	1.612e-08	-7.793	-7.793	0.000	(0)
CoHCO3+	1.811e-09	1.639e-09	-8.742	-8.785	-0.043	(0)
CoCO3	8.369e-10	8.369e-10	-9.077	-9.077	0.000	(0)
CoOH+	7.411e-10	6.708e-10	-9.130	-9.173	-0.043	(0)
CoF+	3.255e-11	2.946e-11	-10.487	-10.531	-0.043	(0)
Co(OH)2	2.689e-11	2.689e-11	-10.570	-10.570	0.000	(0)
Co(OH)3-	2.991e-16	2.707e-16	-15.524	-15.567	-0.043	(0)
CoOOH-	7.505e-17	6.793e-17	-16.125	-16.168	-0.043	(0)
Co2OH+3	5.491e-18	2.240e-18	-17.260	-17.650	-0.389	(0)
Co(OH)4-2	3.225e-23	2.165e-23	-22.491	-22.665	-0.173	(0)
Co4(OH)4+4	1.990e-28	4.040e-29	-27.701	-28.394	-0.692	(0)
Co(3)	1.013e-29					
CoOH+2	1.013e-29	6.801e-30	-28.994	-29.167	-0.173	(0)
Co+3	5.925e-36	2.652e-36	-35.227	-35.576	-0.349	(0)
Cu(1)	2.948e-09					
Cu+	2.948e-09	2.668e-09	-8.530	-8.574	-0.043	(0)
Cu(2)	4.378e-07					
CuCO3	2.384e-07	2.384e-07	-6.623	-6.623	0.000	(0)
CuOH+	9.510e-08	8.694e-08	-7.022	-7.061	-0.039	(0)
Cu+2	7.788e-08	5.448e-08	-7.109	-7.264	-0.155	(0)
CuSO4	1.514e-08	1.514e-08	-7.820	-7.820	0.000	(0)
Cu(OH)2	8.754e-09	8.754e-09	-8.058	-8.058	0.000	(0)
CuHCO3+	1.201e-09	1.087e-09	-8.920	-8.964	-0.043	(0)
Cu(CO3)2-2	7.104e-10	4.768e-10	-9.149	-9.322	-0.173	(0)
Cu2(OH)2+2	2.829e-10	1.899e-10	-9.548	-9.722	-0.173	(0)
CuF+	5.311e-11	4.808e-11	-10.275	-10.318	-0.043	(0)
Cu(OH)3-	1.001e-11	9.061e-12	-11.000	-11.043	-0.043	(0)
Cu(OH)4-2	5.361e-17	3.599e-17	-16.271	-16.444	-0.173	(0)
F	1.580e-05					
F-	1.529e-05	1.398e-05	-4.816	-4.854	-0.039	(0)
MgF+	3.408e-07	3.119e-07	-6.467	-6.506	-0.038	(0)
CaF+	1.624e-07	1.488e-07	-6.789	-6.827	-0.038	(0)
HF	4.127e-10	4.127e-10	-9.384	-9.384	0.000	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
MnF+	2.582e-10	2.365e-10	-9.588	-9.626	-0.038	(0)
CuF+	5.311e-11	4.808e-11	-10.275	-10.318	-0.043	(0)
CoF+	3.255e-11	2.946e-11	-10.487	-10.531	-0.043	(0)
NiF+	1.512e-11	1.369e-11	-10.820	-10.864	-0.043	(0)
AlF2+	4.383e-12	4.020e-12	-11.358	-11.396	-0.038	(0)
AlF+2	1.021e-12	7.220e-13	-11.991	-12.141	-0.150	(0)
AlF3	7.077e-13	7.077e-13	-12.150	-12.150	0.000	(0)
HF2-	2.403e-14	2.194e-14	-13.619	-13.659	-0.039	(0)
AlF4-	5.420e-15	4.960e-15	-14.266	-14.304	-0.038	(0)
H2F2	4.564e-19	4.564e-19	-18.341	-18.341	0.000	(0)
H(0)	5.627e-27					
H2	2.814e-27	2.818e-27	-26.551	-26.550	0.001	(0)
K	3.326e-04					
K+	3.298e-04	3.016e-04	-3.482	-3.521	-0.039	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
Mg	3.293e-04					
Mg+2	2.842e-04	1.988e-04	-3.546	-3.702	-0.155	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
MgHCO3+	7.037e-07	6.434e-07	-6.153	-6.192	-0.039	(0)
MgF+	3.408e-07	3.119e-07	-6.467	-6.506	-0.038	(0)
MgCO3	1.229e-07	1.229e-07	-6.911	-6.911	0.000	(0)
MgOH+	4.345e-08	3.994e-08	-7.362	-7.399	-0.037	(0)
Mn(2)	7.283e-07					
Mn+2	6.329e-07	4.249e-07	-6.199	-6.372	-0.173	(0)
MnSO4	9.162e-08	9.162e-08	-7.038	-7.038	0.000	(0)
MnHCO3+	2.926e-09	2.681e-09	-8.534	-8.572	-0.038	(0)
MnOH+	5.878e-10	5.385e-10	-9.231	-9.269	-0.038	(0)
MnF+	2.582e-10	2.365e-10	-9.588	-9.626	-0.038	(0)
Mn(OH)3-	9.250e-19	8.475e-19	-18.034	-18.072	-0.038	(0)
Mn(OH)4-2	1.959e-24	1.381e-24	-23.708	-23.860	-0.152	(0)
Mn(3)	4.240e-28					
Mn+3	4.240e-28	1.898e-28	-27.373	-27.722	-0.349	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-47.042	-47.194	-0.152	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-52.526	-52.566	-0.040	(0)
Mo	3.128e-08					
MoO4-2	3.127e-08	2.188e-08	-7.505	-7.660	-0.155	(0)
HMoO4-	9.595e-12	8.685e-12	-11.018	-11.061	-0.043	(0)
H2MoO4	1.269e-15	1.269e-15	-14.896	-14.896	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-51.065	-51.455	-0.389	(0)
Mo7O24-6	0.000e+00	0.000e+00	-60.672	-62.230	-1.558	(0)
HMo7O24-5	0.000e+00	0.000e+00	-62.461	-63.543	-1.082	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-65.769	-66.461	-0.692	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-70.526	-70.915	-0.389	(0)
Na	4.351e-05					
Na+	4.322e-05	3.953e-05	-4.364	-4.403	-0.039	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
NaHCO3	7.030e-09	7.030e-09	-8.153	-8.153	0.000	(0)
NaCO3-	5.965e-10	5.470e-10	-9.224	-9.262	-0.038	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
Ni	6.818e-08					
Ni+2	5.569e-08	3.896e-08	-7.254	-7.409	-0.155	(0)
NiSO4	9.427e-09	9.427e-09	-8.026	-8.026	0.000	(0)
NiHCO3+	1.678e-09	1.519e-09	-8.775	-8.818	-0.043	(0)
NiCO3	1.080e-09	1.080e-09	-8.967	-8.967	0.000	(0)
NiOH+	2.734e-10	2.475e-10	-9.563	-9.606	-0.043	(0)
NiF+	1.512e-11	1.369e-11	-10.820	-10.864	-0.043	(0)
Ni(OH)2	9.921e-12	9.921e-12	-11.003	-11.003	0.000	(0)
Ni(SO4)2-2	5.639e-13	3.785e-13	-12.249	-12.422	-0.173	(0)
Ni(OH)3-	5.531e-15	5.006e-15	-14.257	-14.300	-0.043	(0)
O(0)	1.274e-39					
O2	6.370e-40	6.381e-40	-39.196	-39.195	0.001	(0)
S(6)	2.051e-03					
SO4-2	1.733e-03	1.213e-03	-2.761	-2.916	-0.155	(0)
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
MnSO4	9.162e-08	9.162e-08	-7.038	-7.038	0.000	(0)
CoSO4	1.612e-08	1.612e-08	-7.793	-7.793	0.000	(0)
CuSO4	1.514e-08	1.514e-08	-7.820	-7.820	0.000	(0)
NiSO4	9.427e-09	9.427e-09	-8.026	-8.026	0.000	(0)
HSO4-	2.583e-09	2.364e-09	-8.588	-8.626	-0.038	(0)
Ni(SO4)2-2	5.639e-13	3.785e-13	-12.249	-12.422	-0.173	(0)
AlSO4+	5.310e-14	4.860e-14	-13.275	-13.313	-0.038	(0)
Al(SO4)2-	6.899e-16	6.315e-16	-15.161	-15.200	-0.038	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.99	8.81	10.80	Al(OH)3
Al2(MoO4)3	-53.92	-51.55	2.37	Al2(MoO4)3
Al2O3	-2.03	17.63	19.65	Al2O3
Al4(OH)10SO4	-5.77	16.93	22.70	Al4(OH)10SO4
AlOHSO4	-6.27	-9.50	-3.23	AlOHSO4
Alunite	-4.61	-6.01	-1.40	KAl3(SO4)2(OH)6
Anhydrite	-1.57	-5.93	-4.36	CaSO4
Antlerite	-2.70	6.09	8.79	Cu3(OH)4SO4
Aragonite	-0.84	-9.14	-8.30	CaCO3
Artinite	-7.73	1.87	9.60	MgCO3:Mg(OH)2:3H2O
Azurite	-1.74	-18.65	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-15.99	8.41	24.39	Ba(OH)2:8H2O
BaF2	-10.88	-16.70	-5.82	BaF2
BaMoO4	-7.69	-14.65	-6.96	BaMoO4
Barite	0.07	-9.91	-9.98	BaSO4
Birnessite	-11.01	7.08	18.09	MnO2
Bixbyite	-8.60	-9.24	-0.64	Mn2O3
Boehmite	0.23	8.81	8.58	AlOOH
Brochantite	-0.99	14.23	15.22	Cu4(OH)6SO4
Brucite	-5.15	11.70	16.84	Mg(OH)2
Bunsenite	-4.45	7.99	12.45	NiO
Calcite	-0.66	-9.14	-8.48	CaCO3

CaMoO4	-2.72	-10.67	-7.95	CaMoO4
CH4(g)	-74.08	-115.13	-41.05	CH4
Chalcanthite	-7.54	-10.18	-2.64	CuSO4:5H2O
Co(OH)2	-4.87	8.22	13.09	Co(OH)2
Co(OH)3	-10.17	-12.48	-2.31	Co(OH)3
CO2(g)	-3.38	-21.53	-18.15	CO2
Co3O4	-6.23	-16.73	-10.50	Co3O4
CoCO3	-3.33	-13.31	-9.98	CoCO3
CoF2	-15.29	-16.89	-1.60	CoF2
CoF3	-48.68	-50.14	-1.46	CoF3
CoMoO4	-7.08	-14.84	-7.76	CoMoO4
CoO	-5.36	8.22	13.59	CoO
CoSO4	-12.90	-10.09	2.80	CoSO4
CoSO4:6H2O	-7.62	-10.09	-2.47	CoSO4:6H2O
Cryolite	-22.78	-56.62	-33.84	Na3AlF6
Cu(OH)2	-0.54	8.14	8.67	Cu(OH)2
Cu2SO4	-18.11	-20.06	-1.95	Cu2SO4
CuCO3	-1.89	-13.39	-11.50	CuCO3
CuF	-8.52	-13.43	-4.91	CuF
CuF2	-18.09	-16.97	1.12	CuF2
CuF2:2H2O	-12.42	-16.97	-4.55	CuF2:2H2O
Cumetal	-3.82	-12.57	-8.76	Cu
CuMoO4	-1.85	-14.92	-13.08	CuMoO4
CuOCuSO4	-12.35	-2.04	10.30	CuOCuSO4
Cuprite	-0.34	-1.75	-1.41	Cu2O
CuSO4	-13.12	-10.18	2.94	CuSO4
Diaspore	1.94	8.81	6.87	AlOOH
Dolomite(disordered)	-2.43	-18.97	-16.54	CaMg(CO3)2
Dolomite(ordered)	-1.88	-18.97	-17.09	CaMg(CO3)2
Epsomite	-4.49	-6.62	-2.13	MgSO4:7H2O
Fluorite	-2.22	-12.72	-10.50	CaF2
Gibbsite	0.52	8.81	8.29	Al(OH)3
Gypsum	-1.32	-5.93	-4.61	CaSO4:2H2O
H2MoO4	-10.18	-23.06	-12.88	H2MoO4
Hausmannite	-10.55	50.48	61.03	Mn3O4
Huntite	-8.66	-38.63	-29.97	CaMg3(CO3)4
Hydromagnesite	-18.86	-27.62	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-18.47	-23.64	-5.17	KAl(SO4)2:12H2O
K2MoO4	-17.96	-14.70	3.26	K2MoO4
Langite	-3.26	14.23	17.49	Cu4(OH)6SO4:H2O
Lime	-20.31	12.39	32.70	CaO
Magnesite	-2.37	-9.83	-7.46	MgCO3
Malachite	0.05	-5.26	-5.31	Cu2(OH)2CO3
Manganite	-4.61	20.73	25.34	MnOOH
Mg(OH)2(active)	-7.10	11.70	18.79	Mg(OH)2
MgF2	-5.28	-13.41	-8.13	MgF2
MgMoO4	-9.51	-11.36	-1.85	MgMoO4
Mirabilite	-10.61	-11.72	-1.11	Na2SO4:10H2O
Mn2(SO4)3	-58.48	-64.19	-5.71	Mn2(SO4)3
MnSO4	-11.87	-9.29	2.58	MnSO4
MoO3	-15.06	-23.06	-8.00	MoO3
Morenosite	-8.18	-10.33	-2.14	NiSO4:7H2O
Na2Mo2O7	-22.93	-39.53	-16.60	Na2Mo2O7
Na2MoO4	-17.96	-16.47	1.49	Na2MoO4
Na2MoO4:2H2O	-17.69	-16.47	1.22	Na2MoO4:2H2O
Natron	-13.62	-14.94	-1.31	Na2CO3:10H2O
Nesquehonite	-5.16	-9.83	-4.67	MgCO3:3H2O
Ni(OH)2	-4.80	7.99	12.79	Ni(OH)2
Ni4(OH)6SO4	-18.35	13.65	32.00	Ni4(OH)6SO4
NiCO3	-6.67	-13.54	-6.87	NiCO3
NiMoO4	-3.93	-15.07	-11.14	NiMoO4
Nsutite	-10.43	7.08	17.50	MnO2
O2(g)	-36.29	46.80	83.09	O2
Periclase	-9.89	11.70	21.58	MgO
Portlandite	-10.42	12.39	22.80	Ca(OH)2
Pyrochroite	-6.17	9.03	15.19	Mn(OH)2
Pyrolusite	-8.95	32.43	41.38	MnO2
Retgersite	-8.29	-10.33	-2.04	NiSO4:6H2O
Rhodochrosite	-1.92	-12.50	-10.58	MnCO3
Spinel	-7.52	29.32	36.85	MgAl2O4
Tenorite	0.49	8.14	7.64	CuO
Thenardite	-12.04	-11.72	0.32	Na2SO4
Thermonatrite	-15.57	-14.94	0.64	Na2CO3:H2O
Witherite	-4.55	-13.12	-8.57	BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Beginning of batch-reaction calculations.

Reaction step 1.

Using mix 1. Mix within UG Works

Mixture 1. Mix within UG Works

3.080e-01	Solution 1	UG Water P50
1.100e-01	Solution 2	PAF Material
4.000e-01	Solution 3	NAF Material
1.820e-01	Solution 4	Make-up Material

----------Solution composition----------

Elements	Molality	Moles
Al	3.210e-06	3.210e-06
As	1.656e-07	1.656e-07
B	3.691e-06	3.691e-06
Ba	5.023e-07	5.023e-07
C	3.062e-03	3.062e-03
Ca	2.353e-03	2.353e-03
Cd	2.057e-08	2.057e-08
Cl	4.270e-04	4.270e-04
Co	6.763e-08	6.763e-08
Cr	4.388e-08	4.388e-08
Cu	5.929e-07	5.929e-07
F	2.583e-05	2.583e-05
Fe	1.527e-06	1.527e-06
K	5.432e-04	5.432e-04
Mg	9.127e-04	9.127e-04
Mn	1.651e-06	1.651e-06
Mo	5.152e-08	5.152e-08
Na	2.393e-03	2.393e-03
Ni	5.510e-08	5.510e-08
Pb	6.905e-08	6.905e-08
S	2.432e-03	2.432e-03
Se	2.655e-08	2.655e-08
U	1.127e-08	1.127e-08
V	1.513e-08	1.513e-08
Zn	9.350e-07	9.350e-07

----------Description of solution----------

pH	=	8.065	Charge balance
pe	=	3.310	Adjusted to redox equilibrium
Activity of water	=	1.000	
Ionic strength (mol/kgw)	=	1.252e-02	
Mass of water (kg)	=	1.000e+00	
Total alkalinity (eq/kg)	=	3.085e-03	
Total CO2 (mol/kgw)	=	3.062e-03	

Temperature (°C)	=	25.00
Electrical balance (eq)	=	1.085e-03
Percent error, 100*(Cat-|An|)/(Cat+|An|)	=	6.91
Iterations	=	14
Total H	=	1.110167e+02
Total O	=	5.552578e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
OH-	1.313e-06	1.169e-06	-5.882	-5.932	-0.051	(0)
H+	9.652e-09	8.614e-09	-8.015	-8.065	-0.049	0.00
H2O	5.551e+01	9.998e-01	1.744	-0.000	0.000	18.07
Al	**3.210e-06**					
Al(OH)4-	3.189e-06	2.849e-06	-5.496	-5.545	-0.049	(0)
Al(OH)3	1.936e-08	1.936e-08	-7.713	-7.713	0.000	(0)
Al(OH)2+	9.267e-10	8.304e-10	-9.033	-9.081	-0.048	(0)
AlF2+	1.578e-12	1.415e-12	-11.802	-11.849	-0.048	(0)
AlOH+2	1.387e-12	8.945e-13	-11.858	-12.048	-0.190	(0)
AlF3	3.837e-13	3.837e-13	-12.416	-12.416	0.000	(0)
AlF+2	2.557e-13	1.649e-13	-12.592	-12.783	-0.190	(0)
AlSO4+	8.246e-15	7.366e-15	-14.084	-14.133	-0.049	(0)
AlF4-	4.638e-15	4.143e-15	-14.334	-14.383	-0.049	(0)
Al+3	2.131e-15	7.654e-16	-14.671	-15.116	-0.445	(0)
Al(SO4)2-	1.095e-16	9.786e-17	-15.960	-16.009	-0.049	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-52.913	-53.426	-0.514	(0)
As(3)	**1.645e-18**					
H3AsO3	1.540e-18	1.540e-18	-17.812	-17.812	0.000	(0)
H2AsO3-	1.046e-19	9.169e-20	-18.981	-19.038	-0.057	(0)
HAsO3-2	1.642e-23	9.708e-24	-22.785	-23.013	-0.228	(0)
H4AsO3+	7.496e-27	6.573e-27	-26.125	-26.182	-0.057	(0)
AsO3-3	1.418e-28	4.344e-29	-27.848	-28.362	-0.514	(0)
As(5)	**1.656e-07**					
HAsO4-2	1.572e-07	9.292e-08	-6.804	-7.032	-0.228	(0)
H2AsO4-	8.325e-09	7.300e-09	-8.080	-8.137	-0.057	(0)
AsO4-3	1.113e-10	3.411e-11	-9.953	-10.467	-0.514	(0)
H3AsO4	1.090e-14	1.093e-14	-13.963	-13.961	0.001	(0)
B	**3.691e-06**					
H3BO3	3.408e-06	3.417e-06	-5.468	-5.466	0.001	(0)
H2BO3-	2.599e-07	2.304e-07	-6.585	-6.638	-0.052	(0)
CaH2BO3+	1.817e-08	1.611e-08	-7.741	-7.793	-0.052	(0)
MgH2BO3+	4.454e-09	3.949e-09	-8.351	-8.404	-0.052	(0)
NaH2BO3	7.736e-10	7.736e-10	-9.111	-9.111	0.000	(0)
BF(OH)3-	3.314e-11	2.938e-11	-10.480	-10.532	-0.052	(0)
BaH2BO3+	2.504e-12	2.220e-12	-11.601	-11.654	-0.052	(0)
H5(BO3)2-	7.559e-13	6.702e-13	-12.122	-12.174	-0.052	(0)
BF2(OH)2-	6.576e-16	5.831e-16	-15.182	-15.234	-0.052	(0)
H8(BO3)3-	2.583e-16	2.290e-16	-15.588	-15.640	-0.052	(0)
BF3OH-	4.749e-23	4.211e-23	-22.323	-22.376	-0.052	(0)
BF4-	4.338e-29	3.846e-29	-28.363	-28.415	-0.052	(0)
Ba	**5.023e-07**					
Ba+2	4.915e-07	3.118e-07	-6.308	-6.506	-0.198	(0)
BaHCO3+	8.539e-09	7.667e-09	-8.069	-8.115	-0.047	(0)
BaCO3	2.241e-09	2.241e-09	-8.650	-8.650	0.000	(0)
BaH2BO3+	2.504e-12	2.220e-12	-11.601	-11.654	-0.052	(0)
BaOH+	1.777e-12	1.591e-12	-11.750	-11.798	-0.048	(0)
C(4)	**3.062e-03**					
HCO3-	2.873e-03	2.575e-03	-2.542	-2.589	-0.048	(0)
CaHCO3+	6.489e-05	5.826e-05	-4.188	-4.235	-0.047	(0)
H2CO3	4.989e-05	4.989e-05	-4.302	-4.302	0.000	(0)
CaCO3	2.699e-05	2.699e-05	-4.569	-4.569	0.000	(0)
CO3-2	2.209e-05	1.401e-05	-4.656	-4.853	-0.198	(0)
MgHCO3+	1.461e-05	1.302e-05	-4.835	-4.885	-0.050	(0)
MgCO3	5.762e-06	5.762e-06	-5.239	-5.239	0.000	(0)
NaHCO3	3.068e-06	3.068e-06	-5.513	-5.513	0.000	(0)
NaCO3-	6.169e-07	5.529e-07	-6.210	-6.257	-0.048	(0)
CuCO3	5.136e-07	5.136e-07	-6.289	-6.289	0.000	(0)
ZnCO3	2.591e-07	2.591e-07	-6.586	-6.586	0.000	(0)
PbCO3	5.503e-08	5.503e-08	-7.259	-7.259	0.000	(0)
MnHCO3+	4.801e-08	4.296e-08	-7.319	-7.367	-0.048	(0)
Cu(CO3)2-2	3.277e-08	1.937e-08	-7.484	-7.713	-0.228	(0)
ZnHCO3+	2.984e-08	2.617e-08	-7.525	-7.582	-0.057	(0)
NiCO3	1.056e-08	1.056e-08	-7.976	-7.976	0.000	(0)
UO2(CO3)3-4	8.702e-09	1.063e-09	-8.060	-8.973	-0.913	(0)
BaHCO3+	8.539e-09	7.667e-09	-8.069	-8.115	-0.047	(0)
NiHCO3+	7.311e-09	6.410e-09	-8.136	-8.193	-0.057	(0)
CoCO3	6.580e-09	6.580e-09	-8.182	-8.182	0.000	(0)
CoHCO3+	6.344e-09	5.563e-09	-8.198	-8.255	-0.057	(0)
Pb(CO3)2-2	3.763e-09	2.224e-09	-8.425	-8.653	-0.228	(0)
CdCO3	2.906e-09	2.906e-09	-8.537	-8.537	0.000	(0)
PbHCO3+	2.850e-09	2.499e-09	-8.545	-8.602	-0.057	(0)
UO2(CO3)2-2	2.560e-09	1.513e-09	-8.592	-8.820	-0.228	(0)
BaCO3	2.241e-09	2.241e-09	-8.650	-8.650	0.000	(0)
CuHCO3+	1.153e-09	1.011e-09	-8.938	-8.995	-0.057	(0)
FeHCO3+	3.317e-10	2.978e-10	-9.479	-9.526	-0.047	(0)
CdHCO3+	6.082e-11	5.333e-11	-10.216	-10.273	-0.057	(0)
Cd(CO3)2-2	5.107e-11	3.019e-11	-10.292	-10.520	-0.228	(0)
UO2CO3	5.412e-12	5.412e-12	-11.267	-11.267	0.000	(0)
Ca	**2.353e-03**					
Ca+2	1.915e-03	1.215e-03	-2.718	-2.915	-0.198	(0)
CaSO4	3.451e-04	3.451e-04	-3.462	-3.462	0.000	(0)
CaHCO3+	6.489e-05	5.826e-05	-4.188	-4.235	-0.047	(0)
CaCO3	2.699e-05	2.699e-05	-4.569	-4.569	0.000	(0)
CaF+	3.193e-07	2.857e-07	-6.496	-6.544	-0.048	(0)
CaOH+	3.156e-08	2.834e-08	-7.501	-7.548	-0.047	(0)
CaH2BO3+	1.817e-08	1.611e-08	-7.741	-7.793	-0.052	(0)
Cd	**2.057e-08**					
Cd+2	1.434e-08	9.098e-09	-7.843	-8.041	-0.198	(0)
CdCO3	2.906e-09	2.906e-09	-8.537	-8.537	0.000	(0)
CdSO4	2.644e-09	2.644e-09	-8.578	-8.578	0.000	(0)
CdCl+	3.776e-10	3.311e-10	-9.423	-9.480	-0.057	(0)
CdOH+	9.632e-11	8.446e-11	-10.016	-10.073	-0.057	(0)
Cd(SO4)2-2	7.480e-11	4.422e-11	-10.126	-10.354	-0.228	(0)
CdHCO3+	6.082e-11	5.333e-11	-10.216	-10.273	-0.057	(0)
Cd(CO3)2-2	5.107e-11	3.019e-11	-10.292	-10.520	-0.228	(0)
CdOHCl	1.587e-11	1.587e-11	-10.799	-10.799	0.000	(0)
CdF+	3.543e-12	3.107e-12	-11.451	-11.508	-0.057	(0)
Cd(OH)2	6.228e-13	6.228e-13	-12.206	-12.206	0.000	(0)
CdCl2	5.260e-13	5.260e-13	-12.279	-12.279	0.000	(0)
CdCl3-	1.442e-16	1.265e-16	-15.841	-15.898	-0.057	(0)
CdF2	1.336e-16	1.336e-16	-15.874	-15.874	0.000	(0)
Cd(OH)3-	5.071e-17	4.447e-17	-16.295	-16.352	-0.057	(0)
Cd2OH+3	1.257e-17	3.851e-18	-16.901	-17.414	-0.514	(0)
Cd(SeO3)2-2	5.169e-19	3.056e-19	-18.287	-18.515	-0.228	(0)
CdSeO4	7.499e-20	7.499e-20	-19.125	-19.125	0.000	(0)
Cd(OH)4-2	1.439e-23	8.507e-24	-22.842	-23.070	-0.228	(0)
CdHS+	0.000e+00	0.000e+00	-68.283	-68.340	-0.057	(0)
Cd(HS)2	0.000e+00	0.000e+00	-129.444	-129.444	0.000	(0)
Cd(HS)3-	0.000e+00	0.000e+00	-195.794	-195.851	-0.057	(0)
Cd(HS)4-2	0.000e+00	0.000e+00	-261.734	-261.962	-0.228	(0)
Cl	**4.270e-04**					
Cl-	4.270e-04	3.811e-04	-3.370	-3.419	-0.049	(0)
CuCl	7.168e-10	7.168e-10	-9.145	-9.145	0.000	(0)
ZnOHCl	4.706e-10	4.706e-10	-9.327	-9.327	0.000	(0)
MnCl+	4.483e-10	4.012e-10	-9.348	-9.397	-0.048	(0)
CdCl+	3.776e-10	3.311e-10	-9.423	-9.480	-0.057	(0)
ZnCl+	3.449e-10	3.076e-10	-9.462	-9.512	-0.050	(0)
CuCl2-	6.400e-11	5.707e-11	-10.194	-10.244	-0.050	(0)
CoCl+	4.176e-11	3.661e-11	-10.379	-10.436	-0.057	(0)
NiCl+	2.245e-11	1.969e-11	-10.649	-10.706	-0.057	(0)

PbCl+	2.014e-11	1.766e-11	-10.696	-10.753	-0.057	(0)
CdOHCl	1.587e-11	1.587e-11	-10.799	-10.799	0.000	(0)
CuCl+	4.216e-12	3.759e-12	-11.375	-11.425	-0.050	(0)
CdCl2	5.260e-13	5.260e-13	-12.279	-12.279	0.000	(0)
MnCl2	2.160e-13	2.160e-13	-12.666	-12.666	0.000	(0)
ZnCl2	1.858e-13	1.858e-13	-12.731	-12.731	0.000	(0)
PbCl2	3.007e-14	3.007e-14	-13.522	-13.522	0.000	(0)
CuCl3-2	7.249e-15	4.650e-15	-14.140	-14.333	-0.193	(0)
CuCl2	4.968e-16	4.968e-16	-15.304	-15.304	0.000	(0)
CdCl3-	1.442e-16	1.265e-16	-15.841	-15.898	-0.057	(0)
ZnCl3-	6.307e-17	5.624e-17	-16.200	-16.250	-0.050	(0)
NiCl2	3.778e-17	3.778e-17	-16.423	-16.423	0.000	(0)
MnCl3-	2.533e-17	2.267e-17	-16.596	-16.645	-0.048	(0)
CrCl+2	6.123e-18	3.620e-18	-17.213	-17.441	-0.228	(0)
PbCl3-	5.203e-18	4.562e-18	-17.284	-17.341	-0.057	(0)
UO2Cl+	6.837e-20	5.995e-20	-19.165	-19.222	-0.057	(0)
FeCl+2	3.125e-20	2.004e-20	-19.505	-19.698	-0.193	(0)
CrOHCl2	3.064e-20	3.064e-20	-19.514	-19.514	0.000	(0)
ZnCl4-2	1.671e-20	1.072e-20	-19.777	-19.970	-0.193	(0)
CuCl3-	1.981e-21	1.767e-21	-20.703	-20.753	-0.050	(0)
PbCl4-2	1.344e-21	7.947e-22	-20.872	-21.100	-0.228	(0)
CrCl2+	1.493e-22	1.309e-22	-21.826	-21.883	-0.057	(0)
VOCl+	4.866e-23	4.266e-23	-22.313	-22.370	-0.057	(0)
FeCl2+	3.812e-23	3.412e-23	-22.419	-22.467	-0.048	(0)
CuCl4-2	5.261e-27	3.375e-27	-26.279	-26.472	-0.193	(0)
FeCl3	1.300e-27	1.300e-27	-26.886	-26.886	0.000	(0)
CrO3Cl-	1.532e-29	1.343e-29	-28.815	-28.872	-0.057	(0)
CoCl+2	2.959e-38	1.749e-38	-37.529	-37.757	-0.228	(0)
UCl+3	0.000e+00	0.000e+00	-46.881	-47.395	-0.514	(0)
Co(2)	6.763e-08					
Co+2	4.698e-08	2.777e-08	-7.328	-7.556	-0.228	(0)
CoSO4	6.870e-09	6.870e-09	-8.163	-8.163	0.000	(0)
CoCO3	6.580e-09	6.580e-09	-8.182	-8.182	0.000	(0)
CoHCO3+	6.344e-09	5.563e-09	-8.198	-8.255	-0.057	(0)
CoOH+	7.386e-10	6.476e-10	-9.132	-9.189	-0.057	(0)
Co(OH)2	6.012e-11	6.012e-11	-10.221	-10.221	0.000	(0)
CoCl+	4.176e-11	3.661e-11	-10.379	-10.436	-0.057	(0)
CoF+	2.158e-11	1.892e-11	-10.666	-10.723	-0.057	(0)
Co(OH)3-	1.599e-15	1.402e-15	-14.796	-14.853	-0.057	(0)
CoOOH-	4.012e-16	3.518e-16	-15.397	-15.454	-0.057	(0)
Co2OH+3	2.941e-18	9.015e-19	-17.531	-18.045	-0.514	(0)
CoSeO4	6.162e-19	6.162e-19	-18.210	-18.210	0.000	(0)
Co(OH)4-2	4.393e-22	2.597e-22	-21.357	-21.586	-0.228	(0)
Co4(OH)4+4	2.873e-28	3.510e-29	-27.542	-28.455	-0.913	(0)
Co(3)	2.266e-30					
CoOH+2	2.266e-30	1.340e-30	-29.645	-29.873	-0.228	(0)
Co+3	6.281e-37	2.256e-37	-36.202	-36.647	-0.445	(0)
CoCl+2	2.959e-38	1.749e-38	-37.529	-37.757	-0.228	(0)
Cr(2)	1.453e-24					
Cr+2	1.453e-24	8.593e-25	-23.838	-24.066	-0.228	(0)
Cr(3)	4.388e-08					
Cr(OH)2+	3.043e-08	2.669e-08	-7.517	-7.574	-0.057	(0)
Cr(OH)3	1.172e-08	1.172e-08	-7.931	-7.931	0.000	(0)
CrO2-	7.368e-10	6.461e-10	-9.133	-9.190	-0.057	(0)
Cr(OH)4-	6.217e-10	5.451e-10	-9.206	-9.263	-0.057	(0)
Cr(OH)+2	3.174e-10	1.877e-10	-9.498	-9.727	-0.228	(0)
CrOHSO4	5.521e-11	5.521e-11	-10.258	-10.258	0.000	(0)
CrF+2	4.239e-14	2.506e-14	-13.373	-13.601	-0.228	(0)
CrSO4+	2.423e-14	2.125e-14	-13.616	-13.673	-0.057	(0)
Cr+3	2.395e-14	7.340e-15	-13.621	-14.134	-0.514	(0)
CrCl+2	6.123e-18	3.620e-18	-17.213	-17.441	-0.228	(0)
Cr2(OH)2SO4+2	1.584e-18	9.365e-19	-17.800	-18.028	-0.228	(0)
Cr2(OH)2(SO4)2	6.897e-20	6.897e-20	-19.161	-19.161	0.000	(0)
CrOHCl2	3.064e-20	3.064e-20	-19.514	-19.514	0.000	(0)
CrCl2+	1.493e-22	1.309e-22	-21.826	-21.883	-0.057	(0)
Cr(6)	3.786e-17					
CrO4-2	3.679e-17	2.334e-17	-16.434	-16.632	-0.198	(0)
HCrO4-	7.419e-19	6.506e-19	-18.130	-18.187	-0.057	(0)
NaCrO4-	2.802e-19	2.457e-19	-18.553	-18.610	-0.057	(0)
KCrO4-	4.753e-20	4.167e-20	-19.323	-19.380	-0.057	(0)
H2CrO4	4.542e-27	4.542e-27	-26.343	-26.343	0.000	(0)
CrO3SO4-2	3.580e-27	2.117e-27	-26.446	-26.674	-0.228	(0)
CrO3Cl-	1.532e-29	1.343e-29	-28.815	-28.872	-0.057	(0)
Cr2O7-2	2.483e-35	1.468e-35	-34.605	-34.833	-0.228	(0)
Cu(1)	2.485e-09					
Cu+	1.704e-09	1.494e-09	-8.769	-8.826	-0.057	(0)
CuCl	7.168e-10	7.168e-10	-9.145	-9.145	0.000	(0)
CuCl2-	6.400e-11	5.707e-11	-10.194	-10.244	-0.050	(0)
CuCl3-2	7.249e-15	4.650e-15	-14.140	-14.333	-0.193	(0)
Cu(S4)2-3	0.000e+00	0.000e+00	-125.642	-125.921	-0.278	(0)
CuS4S5-3	0.000e+00	0.000e+00	-126.383	-126.651	-0.268	(0)
Cu(2)	5.904e-07					
CuCO3	5.136e-07	5.136e-07	-6.289	-6.289	0.000	(0)
Cu(CO3)2-2	3.277e-08	1.937e-08	-7.484	-7.713	-0.228	(0)
CuOH+	2.580e-08	2.300e-08	-7.588	-7.638	-0.050	(0)
Cu+2	9.811e-09	6.224e-09	-8.008	-8.206	-0.198	(0)
Cu(OH)2	5.364e-09	5.364e-09	-8.270	-8.270	0.000	(0)
CuSO4	1.768e-09	1.768e-09	-8.753	-8.753	0.000	(0)
CuHCO3+	1.153e-09	1.011e-09	-8.938	-8.995	-0.057	(0)
Cu2(OH)2+2	2.248e-11	1.329e-11	-10.648	-10.876	-0.228	(0)
Cu(OH)3-	1.466e-11	1.286e-11	-10.834	-10.891	-0.057	(0)
CuF+	9.650e-12	8.461e-12	-11.015	-11.073	-0.057	(0)
CuCl+	4.216e-12	3.759e-12	-11.375	-11.425	-0.050	(0)
CuCl2	4.968e-16	4.968e-16	-15.304	-15.304	0.000	(0)
Cu(OH)4-2	2.001e-16	1.183e-16	-15.699	-15.927	-0.228	(0)
CuCl3-	1.981e-21	1.767e-21	-20.703	-20.753	-0.050	(0)
CuCl4-2	5.261e-27	3.375e-27	-26.279	-26.472	-0.193	(0)
Cu(HS)3-	0.000e+00	0.000e+00	-187.172	-187.229	-0.057	(0)
F	2.583e-05					
F-	2.414e-05	2.155e-05	-4.617	-4.667	-0.049	(0)
MgF+	1.338e-06	1.195e-06	-5.874	-5.923	-0.049	(0)
CaF+	3.193e-07	2.857e-07	-6.496	-6.544	-0.048	(0)
NaF	2.880e-08	2.880e-08	-7.541	-7.541	0.000	(0)
MnF+	8.014e-10	7.172e-10	-9.096	-9.144	-0.048	(0)
HF	2.745e-10	2.745e-10	-9.561	-9.561	0.000	(0)
ZnF+	1.575e-10	1.381e-10	-9.803	-9.860	-0.057	(0)
BF(OH)3-	3.314e-11	2.938e-11	-10.480	-10.532	-0.052	(0)
CoF+	2.158e-11	1.892e-11	-10.666	-10.723	-0.057	(0)
NiF+	1.246e-11	1.093e-11	-10.904	-10.961	-0.057	(0)
CuF+	9.650e-12	8.461e-12	-11.015	-11.073	-0.057	(0)
CdF+	3.543e-12	3.107e-12	-11.451	-11.508	-0.057	(0)
PbF+	2.262e-12	1.983e-12	-11.646	-11.703	-0.057	(0)
AlF2+	1.578e-12	1.415e-12	-11.802	-11.849	-0.048	(0)
AlF3	3.837e-13	3.837e-13	-12.416	-12.416	0.000	(0)
AlF+2	2.557e-13	1.649e-13	-12.592	-12.783	-0.190	(0)
CrF+2	4.239e-14	2.506e-14	-13.373	-13.601	-0.228	(0)
HF2-	2.526e-14	2.249e-14	-13.598	-13.648	-0.051	(0)
AlF4-	4.638e-15	4.143e-15	-14.334	-14.383	-0.049	(0)
PbF2	8.410e-16	8.410e-16	-15.075	-15.075	0.000	(0)
BF2(OH)2-	6.576e-16	5.831e-16	-15.182	-15.234	-0.052	(0)
UO2F+	3.290e-16	2.885e-16	-15.483	-15.540	-0.057	(0)
CdF2	1.336e-16	1.336e-16	-15.874	-15.874	0.000	(0)
FeF+2	6.414e-17	4.114e-17	-16.193	-16.386	-0.193	(0)
FeF2+	2.651e-17	2.372e-17	-16.577	-16.625	-0.048	(0)
UO2F2	1.793e-17	1.793e-17	-16.746	-16.746	0.000	(0)
FeF3	7.211e-19	7.211e-19	-18.142	-18.142	0.000	(0)
VO2F	5.184e-19	5.184e-19	-18.285	-18.285	0.000	(0)
H2F2	2.019e-19	2.019e-19	-18.695	-18.695	0.000	(0)
UO2F3-	1.106e-19	9.702e-20	-18.956	-19.013	-0.057	(0)
PbF3-	3.919e-20	3.437e-20	-19.407	-19.464	-0.057	(0)
VOF+	5.881e-21	5.157e-21	-20.231	-20.288	-0.057	(0)
VO2F2-	4.624e-21	4.055e-21	-20.335	-20.392	-0.057	(0)
BF3OH-	4.749e-23	4.211e-23	-22.323	-22.376	-0.052	(0)
VOF2	4.166e-23	4.166e-23	-22.380	-22.380	0.000	(0)
UO2F4-2	2.809e-23	1.660e-23	-22.551	-22.780	-0.228	(0)
VO2F3-2	1.843e-24	1.090e-24	-23.734	-23.963	-0.228	(0)
PbF4-2	5.995e-25	3.544e-25	-24.222	-24.450	-0.228	(0)
VOF3-	3.632e-26	3.185e-26	-25.440	-25.497	-0.057	(0)
BF4-	4.338e-29	3.846e-29	-28.363	-28.415	-0.052	(0)
VO2F4-3	3.770e-29	1.155e-29	-28.424	-28.937	-0.514	(0)
VOF4-2	4.685e-30	2.770e-30	-29.329	-29.558	-0.228	(0)
UF3+	9.582e-39	8.402e-39	-38.019	-38.076	-0.057	(0)
UF2+2	4.162e-39	2.461e-39	-38.381	-38.609	-0.228	(0)
UF+3	0.000e+00	0.000e+00	-40.529	-41.042	-0.514	(0)
UF4	0.000e+00	0.000e+00	-40.702	-40.702	0.000	(0)
UF5-	0.000e+00	0.000e+00	-43.714	-43.771	-0.057	(0)
UF6-2	0.000e+00	0.000e+00	-45.729	-45.958	-0.228	(0)
Fe(2)	1.915e-08					
Fe+2	1.554e-08	9.187e-09	-7.809	-8.037	-0.228	(0)
FeSO4	2.796e-09	2.796e-09	-8.553	-8.553	0.000	(0)
FeOH+	4.776e-10	4.274e-10	-9.321	-9.369	-0.048	(0)
FeHCO3+	3.317e-10	2.978e-10	-9.479	-9.526	-0.047	(0)
Fe(OH)2	3.968e-13	3.968e-13	-12.401	-12.401	0.000	(0)
Fe(OH)3-	1.639e-13	1.467e-13	-12.785	-12.834	-0.048	(0)
Fe(HS)2	0.000e+00	0.000e+00	-135.701	-135.701	0.000	(0)
Fe(HS)3-	0.000e+00	0.000e+00	-201.915	-201.972	-0.057	(0)
Fe(3)	1.508e-06					
Fe(OH)3	7.500e-07	7.500e-07	-6.125	-6.125	0.000	(0)
Fe(OH)2+	6.667e-07	5.975e-07	-6.176	-6.224	-0.048	(0)
Fe(OH)4-	9.107e-08	8.161e-08	-7.041	-7.088	-0.048	(0)
FeOH+2	2.049e-12	1.314e-12	-11.689	-11.881	-0.193	(0)
FeF+2	6.414e-17	4.114e-17	-16.193	-16.386	-0.193	(0)
FeSO4+	2.707e-17	2.423e-17	-16.568	-16.616	-0.048	(0)
FeF2+	2.651e-17	2.372e-17	-16.577	-16.625	-0.048	(0)
Fe+3	4.848e-18	1.741e-18	-17.314	-17.759	-0.445	(0)
Fe(SO4)2-	7.323e-19	6.421e-19	-18.135	-18.192	-0.057	(0)
FeF3	7.211e-19	7.211e-19	-18.142	-18.142	0.000	(0)
FeCl+2	3.125e-20	2.004e-20	-19.505	-19.698	-0.193	(0)
Fe2(OH)2+4	4.681e-22	5.718e-23	-21.330	-22.243	-0.913	(0)
FeHSeO3+2	1.075e-22	6.357e-23	-21.968	-22.197	-0.228	(0)
FeCl2+	3.812e-23	3.412e-23	-22.419	-22.467	-0.048	(0)
Fe3(OH)4+5	1.319e-26	4.938e-28	-25.880	-27.306	-1.427	(0)
FeCl3	1.300e-27	1.300e-27	-26.886	-26.886	0.000	(0)
H(0)	2.516e-26					
H2	1.258e-26	1.262e-26	-25.900	-25.899	0.001	(0)
K	5.432e-04					
K+	5.385e-04	4.806e-04	-3.269	-3.318	-0.049	(0)
KSO4-	4.707e-06	4.218e-06	-5.327	-5.375	-0.048	(0)
KCrO4-	4.753e-20	4.167e-20	-19.323	-19.380	-0.057	(0)
Mg	9.127e-04					
Mg+2	7.792e-04	4.943e-04	-3.108	-3.306	-0.198	(0)
MgSO4	1.115e-04	1.115e-04	-3.953	-3.953	0.000	(0)
MgHCO3+	1.461e-05	1.302e-05	-4.835	-4.885	-0.050	(0)
MgCO3	5.762e-06	5.762e-06	-5.239	-5.239	0.000	(0)
MgF+	1.338e-06	1.195e-06	-5.874	-5.923	-0.049	(0)
MgOH+	2.557e-07	2.300e-07	-6.592	-6.638	-0.046	(0)
MgH2BO3+	4.454e-09	3.949e-09	-8.351	-8.404	-0.052	(0)
Mn(2)	1.651e-06					
Mn+2	1.414e-06	8.362e-07	-5.849	-6.078	-0.228	(0)
MnSO4	1.844e-07	1.844e-07	-6.734	-6.734	0.000	(0)
MnHCO3+	4.801e-08	4.296e-08	-7.319	-7.367	-0.048	(0)
MnOH+	2.743e-09	2.455e-09	-8.562	-8.610	-0.048	(0)
MnF+	8.014e-10	7.172e-10	-9.096	-9.144	-0.048	(0)
MnCl+	4.483e-10	4.012e-10	-9.348	-9.397	-0.048	(0)
MnCl2	2.160e-13	2.160e-13	-12.666	-12.666	0.000	(0)
MnCl3-	2.533e-17	2.267e-17	-16.596	-16.645	-0.048	(0)
Mn(OH)3-	2.315e-17	2.072e-17	-16.635	-16.684	-0.048	(0)
MnSeO4	9.963e-18	9.963e-18	-17.002	-17.002	0.000	(0)
Mn(OH)4-2	1.219e-22	7.819e-23	-21.914	-22.107	-0.193	(0)
MnSe	2.267e-35	2.267e-35	-34.644	-34.644	0.000	(0)
Mn(3)	2.122e-28					
Mn+3	2.122e-28	7.621e-29	-27.673	-28.118	-0.445	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-46.550	-46.743	-0.193	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-52.754	-52.805	-0.051	(0)
Mo	5.152e-08					
MoO4-2	5.152e-08	3.268e-08	-7.288	-7.486	-0.198	(0)
HMoO4-	6.388e-12	5.602e-12	-11.195	-11.252	-0.057	(0)
H2MoO4	3.534e-16	3.534e-16	-15.452	-15.452	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-52.913	-53.426	-0.514	(0)
Mo7O24-6	0.000e+00	0.000e+00	-61.873	-63.928	-2.054	(0)
HMo7O24-5	0.000e+00	0.000e+00	-64.179	-65.606	-1.427	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-67.975	-68.888	-0.913	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-73.194	-73.707	-0.514	(0)
Na	2.393e-03					
Na+	2.374e-03	2.119e-03	-2.625	-2.674	-0.049	(0)
NaSO4-	1.574e-05	1.411e-05	-4.803	-4.851	-0.048	(0)
NaHCO3	3.068e-06	3.068e-06	-5.513	-5.513	0.000	(0)
NaCO3-	6.169e-07	5.529e-07	-6.210	-6.257	-0.048	(0)
NaF	2.880e-08	2.880e-08	-7.541	-7.541	0.000	(0)
NaH2BO3	7.736e-10	7.736e-10	-9.111	-9.111	0.000	(0)
NaCrO4-	2.802e-19	2.457e-19	-18.553	-18.610	-0.057	(0)
Ni	5.510e-08					
Ni+2	3.183e-08	2.019e-08	-7.497	-7.695	-0.198	(0)
NiCO3	1.056e-08	1.056e-08	-7.976	-7.976	0.000	(0)
NiHCO3+	7.311e-09	6.410e-09	-8.136	-8.193	-0.057	(0)
NiSO4	4.995e-09	4.995e-09	-8.301	-8.301	0.000	(0)
NiOH+	3.388e-10	2.971e-10	-9.470	-9.527	-0.057	(0)
Ni(OH)2	2.758e-11	2.758e-11	-10.559	-10.559	0.000	(0)
NiCl+	2.245e-11	1.969e-11	-10.649	-10.706	-0.057	(0)
NiF+	1.246e-11	1.093e-11	-10.904	-10.961	-0.057	(0)
Ni(SO4)2-2	3.469e-13	2.051e-13	-12.460	-12.688	-0.228	(0)
Ni(OH)3-	3.676e-14	3.223e-14	-13.435	-13.492	-0.057	(0)
NiCl2	3.778e-17	3.778e-17	-16.423	-16.423	0.000	(0)
NiSeO4	4.181e-19	4.181e-19	-18.379	-18.379	0.000	(0)
O(0)	0.000e+00					
O2	0.000e+00	0.000e+00	-40.498	-40.497	0.001	(0)
Pb	6.905e-08					
PbCO3	5.503e-08	5.503e-08	-7.259	-7.259	0.000	(0)
PbOH+	4.374e-09	3.835e-09	-8.359	-8.416	-0.057	(0)
Pb(CO3)2-2	3.763e-09	2.224e-09	-8.425	-8.653	-0.228	(0)
PbHCO3+	2.850e-09	2.499e-09	-8.545	-8.602	-0.057	(0)
Pb+2	2.059e-09	1.306e-09	-8.686	-8.884	-0.198	(0)
PbSO4	7.933e-10	7.933e-10	-9.101	-9.101	0.000	(0)
Pb(OH)2	1.417e-10	1.417e-10	-9.849	-9.849	0.000	(0)
PbCl+	2.014e-11	1.766e-11	-10.696	-10.753	-0.057	(0)
Pb(SO4)2-2	1.002e-11	5.926e-12	-10.999	-11.227	-0.228	(0)
PbF+	2.262e-12	1.983e-12	-11.646	-11.703	-0.057	(0)
Pb(OH)3-	1.889e-13	1.656e-13	-12.724	-12.781	-0.057	(0)
PbCl2	3.007e-14	3.007e-14	-13.522	-13.522	0.000	(0)
PbF2	8.410e-16	8.410e-16	-15.075	-15.075	0.000	(0)
Pb2OH+3	2.591e-16	7.940e-17	-15.587	-16.100	-0.514	(0)
Pb(OH)4-2	8.020e-17	4.741e-17	-16.096	-16.324	-0.228	(0)
PbCl3-	5.203e-18	4.562e-18	-17.284	-17.341	-0.057	(0)
Pb3(OH)4+2	8.857e-19	5.236e-19	-18.053	-18.281	-0.228	(0)
PbF3-	3.919e-20	3.437e-20	-19.407	-19.464	-0.057	(0)
PbCl4-2	1.344e-21	7.947e-22	-20.872	-21.100	-0.228	(0)
Pb4(OH)4+4	4.448e-23	5.433e-24	-22.352	-23.265	-0.913	(0)
PbF4-2	5.995e-25	3.544e-25	-24.222	-24.450	-0.228	(0)
Pb(HS)2	0.000e+00	0.000e+00	-130.229	-130.229	0.000	(0)
Pb(HS)3-	0.000e+00	0.000e+00	-197.179	-197.236	-0.057	(0)
S(-2)	0.000e+00					
HS-	0.000e+00	0.000e+00	-68.250	-68.307	-0.057	(0)

CdHS+	0.000e+00	0.000e+00	-68.283	-68.340	-0.057	(0)
H2S	0.000e+00	0.000e+00	-69.352	-69.352	0.000	(0)
S5-2	0.000e+00	0.000e+00	-69.379	-69.608	-0.228	(0)
S6-2	0.000e+00	0.000e+00	-69.895	-70.124	-0.228	(0)
S4-2	0.000e+00	0.000e+00	-69.975	-70.203	-0.228	(0)
S3-2	0.000e+00	0.000e+00	-70.781	-71.009	-0.228	(0)
S2-2	0.000e+00	0.000e+00	-71.797	-72.025	-0.228	(0)
S-2	0.000e+00	0.000e+00	-77.350	-77.543	-0.193	(0)
Cu(S4)2-3	0.000e+00	0.000e+00	-125.642	-125.921	-0.278	(0)
CuS4S5-3	0.000e+00	0.000e+00	-126.383	-126.651	-0.268	(0)
ZnS(HS)-	0.000e+00	0.000e+00	-128.176	-128.233	-0.057	(0)
Cd(HS)2	0.000e+00	0.000e+00	-129.444	-129.444	0.000	(0)
Pb(HS)2	0.000e+00	0.000e+00	-130.229	-130.229	0.000	(0)
Zn(HS)2	0.000e+00	0.000e+00	-130.288	-130.288	0.000	(0)
Fe(HS)2	0.000e+00	0.000e+00	-135.701	-135.701	0.000	(0)
Cu(HS)3-	0.000e+00	0.000e+00	-187.172	-187.229	-0.057	(0)
Zn(HS)3-	0.000e+00	0.000e+00	-195.258	-195.315	-0.057	(0)
Cd(HS)3-	0.000e+00	0.000e+00	-195.794	-195.851	-0.057	(0)
ZnS(HS)2-2	0.000e+00	0.000e+00	-197.002	-197.230	-0.228	(0)
Pb(HS)3-	0.000e+00	0.000e+00	-197.179	-197.236	-0.057	(0)
Fe(HS)3-	0.000e+00	0.000e+00	-201.915	-201.972	-0.057	(0)
Cd(HS)4-2	0.000e+00	0.000e+00	-261.734	-261.962	-0.228	(0)
Zn(HS)4-2	0.000e+00	0.000e+00	-264.854	-265.082	-0.228	(0)
S(6)	2.432e-03					
SO4-2	1.954e-03	1.240e-03	-2.709	-2.907	-0.198	(0)
CaSO4	3.451e-04	3.451e-04	-3.462	-3.462	0.000	(0)
MgSO4	1.115e-04	1.115e-04	-3.953	-3.953	0.000	(0)
NaSO4-	1.574e-05	1.411e-05	-4.803	-4.851	-0.048	(0)
KSO4-	4.707e-06	4.218e-06	-5.327	-5.375	-0.048	(0)
MnSO4	1.844e-07	1.844e-07	-6.734	-6.734	0.000	(0)
ZnSO4	8.716e-08	8.716e-08	-7.060	-7.060	0.000	(0)
CoSO4	6.870e-09	6.870e-09	-8.163	-8.163	0.000	(0)
NiSO4	4.995e-09	4.995e-09	-8.301	-8.301	0.000	(0)
FeSO4	2.796e-09	2.796e-09	-8.553	-8.553	0.000	(0)
CdSO4	2.644e-09	2.644e-09	-8.578	-8.578	0.000	(0)
CuSO4	1.768e-09	1.768e-09	-8.753	-8.753	0.000	(0)
Zn(SO4)2-2	1.592e-09	9.412e-10	-8.798	-9.026	-0.228	(0)
HSO4-	1.168e-09	1.044e-09	-8.932	-8.981	-0.049	(0)
PbSO4	7.933e-10	7.933e-10	-9.101	-9.101	0.000	(0)
Cd(SO4)2-2	7.480e-11	4.422e-11	-10.126	-10.354	-0.228	(0)
CrOHSO4	5.521e-11	5.521e-11	-10.258	-10.258	0.000	(0)
Pb(SO4)2-2	1.002e-11	5.926e-12	-10.999	-11.227	-0.228	(0)
Ni(SO4)2-2	3.469e-13	2.051e-13	-12.460	-12.688	-0.228	(0)
CrSO4+	2.423e-14	2.125e-14	-13.616	-13.673	-0.057	(0)
AlSO4+	8.246e-15	7.366e-15	-14.084	-14.133	-0.049	(0)
UO2SO4	1.820e-16	1.820e-16	-15.740	-15.740	0.000	(0)
Al(SO4)2-	1.095e-16	9.786e-17	-15.960	-16.009	-0.049	(0)
FeSO4+	2.707e-17	2.423e-17	-16.568	-16.616	-0.048	(0)
UO2(SO4)2-2	5.032e-18	2.975e-18	-17.298	-17.526	-0.228	(0)
Cr2(OH)2SO4+2	1.584e-18	9.365e-19	-17.800	-18.028	-0.228	(0)
Fe(SO4)2-	7.323e-19	6.421e-19	-18.135	-18.192	-0.057	(0)
VO2SO4-	4.631e-19	4.061e-19	-18.334	-18.391	-0.057	(0)
Cr2(OH)2(SO4)2	6.897e-20	6.897e-20	-19.161	-19.161	0.000	(0)
VOSO4	1.363e-20	1.363e-20	-19.866	-19.866	0.000	(0)
CrO3SO4-2	3.580e-27	2.117e-27	-26.446	-26.674	-0.228	(0)
VSO4+	4.811e-34	4.218e-34	-33.318	-33.375	-0.057	(0)
U(SO4)2	0.000e+00	0.000e+00	-40.989	-40.989	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-41.754	-41.982	-0.228	(0)
Se(-2)	6.467e-32					
HSe-	6.464e-32	5.668e-32	-31.190	-31.247	-0.057	(0)
MnSe	2.267e-35	2.267e-35	-34.644	-34.644	0.000	(0)
H2Se	3.790e-36	3.790e-36	-35.421	-35.421	0.000	(0)
Se-2	1.113e-38	6.580e-39	-37.954	-38.182	-0.228	(0)
Se(4)	2.655e-08					
HSeO3-	1.575e-08	1.381e-08	-7.803	-7.860	-0.057	(0)
SeO3-2	1.080e-08	6.384e-09	-7.967	-8.195	-0.228	(0)
H2SeO3	5.076e-14	5.076e-14	-13.294	-13.294	0.000	(0)
Cd(SeO3)2-2	5.169e-19	3.056e-19	-18.287	-18.515	-0.228	(0)
FeHSeO3+2	1.075e-22	6.357e-23	-21.968	-22.197	-0.228	(0)
Se(6)	6.979e-14					
SeO4-2	6.978e-14	4.427e-14	-13.156	-13.354	-0.198	(0)
MnSeO4	9.963e-18	9.963e-18	-17.002	-17.002	0.000	(0)
ZnSeO4	2.203e-18	2.203e-18	-17.657	-17.657	0.000	(0)
CoSeO4	6.162e-19	6.162e-19	-18.210	-18.210	0.000	(0)
NiSeO4	4.181e-19	4.181e-19	-18.379	-18.379	0.000	(0)
CdSeO4	7.499e-20	7.499e-20	-19.125	-19.125	0.000	(0)
HSeO4-	2.180e-20	1.911e-20	-19.662	-19.719	-0.057	(0)
Zn(SeO4)2-2	1.673e-31	9.888e-32	-30.777	-31.005	-0.228	(0)
U(3)	0.000e+00					
U+3	0.000e+00	0.000e+00	-57.268	-57.781	-0.514	(0)
U(4)	3.846e-19					
U(OH)5-	3.845e-19	3.372e-19	-18.415	-18.472	-0.057	(0)
U(OH)4	1.217e-22	1.217e-22	-21.915	-21.915	0.000	(0)
U(OH)3+	4.370e-27	3.832e-27	-26.359	-26.417	-0.057	(0)
U(OH)2+2	2.582e-32	1.527e-32	-31.588	-31.816	-0.228	(0)
UOH+3	2.021e-38	6.195e-39	-37.694	-38.208	-0.514	(0)
UF3+	9.582e-39	8.402e-39	-38.019	-38.076	-0.057	(0)
UF2+2	4.162e-39	2.461e-39	-38.381	-38.609	-0.228	(0)
UF+3	0.000e+00	0.000e+00	-40.529	-41.042	-0.514	(0)
UF4	0.000e+00	0.000e+00	-40.702	-40.702	0.000	(0)
U(SO4)2	0.000e+00	0.000e+00	-40.989	-40.989	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-41.754	-41.982	-0.228	(0)
UF5-	0.000e+00	0.000e+00	-43.714	-43.771	-0.057	(0)
U+4	0.000e+00	0.000e+00	-44.763	-45.676	-0.913	(0)
UF6-2	0.000e+00	0.000e+00	-45.729	-45.958	-0.228	(0)
UCl+3	0.000e+00	0.000e+00	-46.881	-47.395	-0.514	(0)
U6(OH)15+9	0.000e+00	0.000e+00	-165.616	-170.239	-4.623	(0)
U(5)	3.305e-17					
UO2+	3.305e-17	2.898e-17	-16.481	-16.538	-0.057	(0)
U(6)	1.127e-08					
UO2(CO3)3-4	8.702e-09	1.063e-09	-8.060	-8.973	-0.913	(0)
UO2(CO3)2-2	2.560e-09	1.513e-09	-8.592	-8.820	-0.228	(0)
UO2CO3	5.412e-12	5.412e-12	-11.267	-11.267	0.000	(0)
UO2OH+	1.628e-14	1.427e-14	-13.788	-13.846	-0.057	(0)
UO2F+	3.290e-16	2.885e-16	-15.483	-15.540	-0.057	(0)
UO2SO4	1.820e-16	1.820e-16	-15.740	-15.740	0.000	(0)
UO2+2	1.529e-16	9.700e-17	-15.816	-16.013	-0.198	(0)
UO2F2	1.793e-17	1.793e-17	-16.746	-16.746	0.000	(0)
UO2(SO4)2-2	5.032e-18	2.975e-18	-17.298	-17.526	-0.228	(0)
UO2F3-	1.106e-19	9.702e-20	-18.956	-19.013	-0.057	(0)
UO2Cl+	6.837e-20	5.995e-20	-19.165	-19.222	-0.057	(0)
(UO2)2(OH)2+2	5.718e-22	3.380e-22	-21.243	-21.471	-0.228	(0)
UO2F4-2	2.809e-23	1.660e-23	-22.551	-22.780	-0.228	(0)
(UO2)3(OH)5+	5.701e-24	4.999e-24	-23.244	-23.301	-0.057	(0)
V(2)	7.462e-40					
VOH+	7.462e-40	6.543e-40	-39.127	-39.184	-0.057	(0)
V+2	0.000e+00	0.000e+00	-40.534	-40.762	-0.228	(0)
V(3)	9.282e-13					
V(OH)3	9.282e-13	9.282e-13	-12.032	-12.032	0.000	(0)
V(OH)2+	5.892e-24	5.167e-24	-23.230	-23.287	-0.057	(0)
VOH+2	7.141e-28	4.222e-28	-27.146	-27.374	-0.228	(0)
V+3	2.352e-33	7.208e-34	-32.629	-33.142	-0.514	(0)
VSO4+	4.811e-34	4.218e-34	-33.318	-33.375	-0.057	(0)
V2(OH)3+3	0.000e+00	0.000e+00	-51.696	-52.209	-0.514	(0)
V2(OH)2+4	0.000e+00	0.000e+00	-53.036	-53.949	-0.913	(0)
V(4)	1.070e-17					
V(OH)3+	1.061e-17	9.304e-18	-16.974	-17.031	-0.057	(0)
VO+2	6.750e-20	3.991e-20	-19.171	-19.399	-0.228	(0)
VOSO4	1.363e-20	1.363e-20	-19.866	-19.866	0.000	(0)
VOF+	5.881e-21	5.157e-21	-20.231	-20.288	-0.057	(0)
VOCl+	4.866e-23	4.266e-23	-22.313	-22.370	-0.057	(0)
VOF2	4.166e-23	4.166e-23	-22.380	-22.380	0.000	(0)
VOF3-	3.632e-26	3.185e-26	-25.440	-25.497	-0.057	(0)
H2V2O4+2	7.341e-30	4.340e-30	-29.134	-29.363	-0.228	(0)
VOF4-2	4.685e-30	2.770e-30	-29.329	-29.558	-0.228	(0)
V(5)	1.513e-08					
H2VO4-	1.056e-08	9.261e-09	-7.976	-8.033	-0.057	(0)
HVO4-2	4.568e-09	2.701e-09	-8.340	-8.569	-0.228	(0)
H3VO4	7.978e-13	7.978e-13	-12.098	-12.098	0.000	(0)
H3V2O7-	5.442e-14	4.771e-14	-13.264	-13.321	-0.057	(0)
HV2O7-3	2.766e-14	8.477e-15	-13.558	-14.072	-0.514	(0)
VO4-3	5.127e-15	1.571e-15	-14.290	-14.804	-0.514	(0)
V2O7-4	2.168e-16	2.649e-17	-15.664	-16.577	-0.913	(0)
VO2+	1.537e-17	1.372e-17	-16.813	-16.863	-0.049	(0)
V3O9-3	2.716e-18	8.323e-19	-17.566	-18.080	-0.514	(0)
VO2F	5.184e-19	5.184e-19	-18.285	-18.285	0.000	(0)
VO2SO4-	4.631e-19	4.061e-19	-18.334	-18.391	-0.057	(0)
VO2F2-	4.624e-21	4.055e-21	-20.335	-20.392	-0.057	(0)
V4O12-4	2.631e-23	3.214e-24	-22.580	-23.493	-0.913	(0)
VO2F3-2	1.843e-24	1.090e-24	-23.734	-23.963	-0.228	(0)
VO2F4-3	3.770e-29	1.155e-29	-28.424	-28.937	-0.514	(0)
V10O28-6	0.000e+00	0.000e+00	-61.631	-63.686	-2.054	(0)
HV10O28-5	0.000e+00	0.000e+00	-62.137	-63.564	-1.427	(0)
H2V10O28-4	0.000e+00	0.000e+00	-65.508	-66.421	-0.913	(0)
Zn	9.350e-07					
Zn+2	5.065e-07	3.213e-07	-6.295	-6.493	-0.198	(0)
ZnCO3	2.591e-07	2.591e-07	-6.586	-6.586	0.000	(0)
ZnSO4	8.716e-08	8.716e-08	-7.060	-7.060	0.000	(0)
ZnOH+	4.283e-08	3.755e-08	-7.368	-7.425	-0.057	(0)
ZnHCO3+	2.984e-08	2.617e-08	-7.525	-7.582	-0.057	(0)
Zn(OH)2	6.956e-09	6.956e-09	-8.158	-8.158	0.000	(0)
Zn(SO4)2-2	1.592e-09	9.412e-10	-8.798	-9.026	-0.228	(0)
ZnOHCl	4.706e-10	4.706e-10	-9.327	-9.327	0.000	(0)
ZnCl+	3.449e-10	3.076e-10	-9.462	-9.512	-0.050	(0)
ZnF+	1.575e-10	1.381e-10	-9.803	-9.860	-0.057	(0)
Zn(OH)3-	4.647e-11	4.075e-11	-10.333	-10.390	-0.057	(0)
ZnCl2	1.858e-13	1.858e-13	-12.731	-12.731	0.000	(0)
Zn(OH)4-2	3.207e-15	1.896e-15	-14.494	-14.722	-0.228	(0)
ZnCl3-	6.307e-17	5.624e-17	-16.200	-16.250	-0.050	(0)
ZnSeO4	2.203e-18	2.203e-18	-17.657	-17.657	0.000	(0)
ZnCl4-2	1.671e-20	1.072e-20	-19.777	-19.970	-0.193	(0)
Zn(SeO4)2-2	1.673e-31	9.888e-32	-30.777	-31.005	-0.228	(0)
ZnS(HS)-	0.000e+00	0.000e+00	-128.176	-128.233	-0.057	(0)
Zn(HS)2	0.000e+00	0.000e+00	-130.288	-130.288	0.000	(0)
Zn(HS)3-	0.000e+00	0.000e+00	-195.258	-195.315	-0.057	(0)
ZnS(HS)2-2	0.000e+00	0.000e+00	-197.002	-197.230	-0.228	(0)
Zn(HS)4-2	0.000e+00	0.000e+00	-264.854	-265.082	-0.228	(0)

-------------------------------Saturation indices-------------------------------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.72	9.08	10.80	Al(OH)3
Al2(MoO4)3	-55.06	-52.69	2.37	Al2(MoO4)3
Al2O3	-1.50	18.16	19.65	Al2O3
Al4(OH)10SO4	-5.42	17.28	22.70	Al4(OH)10SO4
AlAsO4:2H2O	-9.68	-4.88	4.80	AlAsO4:2H2O
AlOHSO4	-6.73	-9.96	-3.23	AlOHSO4
Alunite	-4.69	-6.09	-1.40	KAl3(SO4)2(OH)6
Anglesite	-4.00	-11.79	-7.79	PbSO4
Anhydrite	-1.46	-5.82	-4.36	CaSO4
Anilite	-43.65	-75.53	-31.88	Cu0.25Cu1.5S
Antlerite	-4.05	4.73	8.79	Cu3(OH)4SO4
Aragonite	0.53	-7.77	-8.30	CaCO3
Arsenolite	-68.49	-71.25	-2.76	As4O6
Artinite	-4.94	4.66	9.60	MgCO3:Mg(OH)2:3H2O
As2O5	-34.63	-27.92	6.71	As2O5
Atacamite	-3.03	4.36	7.39	Cu2(OH)3Cl
Azurite	-1.29	-18.20	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-14.77	9.62	24.39	Ba(OH)2:8H2O
Ba2V2O7:2H2O	-14.22	1.65	15.87	Ba2V2O7:2H2O
Ba3(AsO4)2	9.86	0.95	-8.91	Ba3(AsO4)2
Ba3(VO4)2:4H2O	-21.67	11.27	32.94	Ba3(VO4)2:4H2O
BaCrO4	-13.47	-23.14	-9.67	BaCrO4
BaF2	-10.02	-15.84	-5.82	BaF2
BaMoO4	-7.03	-13.99	-6.96	BaMoO4
Barite	0.57	-9.41	-9.98	BaSO4
BaS	-82.93	-66.75	16.18	BaS
BaSeO3	-8.13	-6.30	1.83	BaSeO3
BaSeO4	-12.40	-19.86	-7.46	BaSeO4
Bianchite	-7.64	-9.40	-1.76	ZnSO4:6H2O
Birnessite	-10.64	7.45	18.09	MnO2
Bixbyite	-7.20	-7.85	-0.64	Mn2O3
BlaubleiI	-45.23	-69.39	-24.16	Cu0.9Cu0.2S
BlaubleiII	-44.95	-72.23	-27.28	Cu0.6Cu0.8S
Boehmite	0.50	9.08	8.58	AlOOH
Brochantite	-2.56	12.66	15.22	Cu4(OH)6SO4
Brucite	-4.02	12.82	16.84	Mg(OH)2
Bunsenite	-4.01	8.43	12.45	NiO
Ca(VO3)2	-10.04	-4.38	5.66	Ca(VO3)2
Ca2V2O7	-8.67	8.83	17.50	Ca2V2O7
Ca2V2O7:2H2O	-12.72	8.83	21.55	Ca2V2O7:2H2O
Ca3(AsO4)2:4H2O	-10.58	11.72	22.30	Ca3(AsO4)2:4H2O
Ca3(VO4)2	-16.91	22.05	38.96	Ca3(VO4)2
Ca3(VO4)2:4H2O	-17.81	22.05	39.86	Ca3(VO4)2:4H2O
CaCrO4	-17.28	-19.55	-2.27	CaCrO4
Calcite	0.71	-7.77	-8.48	CaCO3
CaMoO4	-2.45	-10.40	-7.95	CaMoO4
Carnotite	-4.17	-3.94	0.23	KUO2VO4
CaSeO3:2H2O	-5.52	-2.71	2.81	CaSeO3:2H2O
CaSeO4:2H2O	-13.25	-16.27	-3.02	CaSeO4:2H2O
Cd(BO2)2	-12.68	-2.84	9.84	Cd(BO2)2
Cd(OH)2	-5.56	8.09	13.64	Cd(OH)2
Cd(OH)2(am)	-5.64	8.09	13.73	Cd(OH)2
Cd3(OH)2(SO4)2	-20.52	-13.81	6.71	Cd3(OH)2(SO4)2
Cd3(OH)4SO4	-17.33	5.23	22.56	Cd3(OH)4SO4
Cd4(OH)6SO4	-15.08	13.32	28.40	Cd4(OH)6SO4
CdCl2	-14.22	-14.88	-0.66	CdCl2
CdCl2:1H2O	-13.19	-14.88	-1.69	CdCl2:1H2O
CdCl2:2.5H2O	-12.97	-14.88	-1.91	CdCl2:2.5H2O
CdF2	-16.16	-17.37	-1.21	CdF2
Cdmetal(alpha)	-28.18	-14.66	13.51	Cd
Cdmetal(gamma)	-28.28	-14.66	13.62	Cd
CdMoO4	-1.38	-15.53	-14.15	CdMoO4
CdOHCl	-6.93	-3.40	3.54	CdOHCl
CdSe	-11.02	-31.22	-20.20	CdSe
CdSeO4:2H2O	-19.55	-21.40	-1.85	CdSeO4:2H2O
CdSO4	-10.78	-10.95	-0.17	CdSO4
CdSO4:1H2O	-9.22	-10.95	-1.73	CdSO4:1H2O
CdSO4:2.67H2O	-9.07	-10.95	-1.87	CdSO4:2.67H2O
Cerussite	-0.61	-13.74	-13.13	PbCO3
CH4(g)	-70.93	-111.98	-41.05	CH4
Chalcanthite	-8.47	-11.11	-2.64	CuSO4:5H2O
Chalcocite	-42.97	-77.89	-34.92	Cu2S
Chalcopyrite	-101.46	-136.73	-35.27	CuFeS2
Claudetite	-68.18	-71.25	-3.06	As4O6
Clausthalite	-4.97	-32.07	-27.10	PbSe
Co(BO2)2	-29.43	-2.36	27.07	Co(BO2)2
Co(OH)2	-4.52	8.57	13.09	Co(OH)2
Co(OH)3	-10.14	-12.45	-2.31	Co(OH)3
CO2(g)	-2.84	-20.98	-18.15	CO2
Co3(AsO4)2	-15.24	-2.20	13.03	Co3(AsO4)2
Co3O4	-5.84	-16.33	-10.50	Co3O4
CoCl2	-22.66	-14.39	8.27	CoCl2

CoCl2:6H2O	-16.93	-14.39	2.54	CoCl2:6H2O
CoCO3	-2.43	-12.41	-9.98	CoCO3
CoF2	-15.29	-16.89	-1.60	CoF2
CoF3	-49.19	-50.65	-1.46	CoF3
CoFe2O4	24.97	21.44	-3.53	CoFe2O4
CoMoO4	-7.28	-15.04	-7.76	CoMoO4
CoO	-5.01	8.57	13.59	CoO
CoS(alpha)	-60.36	-67.80	-7.44	CoS
CoS(beta)	-56.73	-67.80	-11.07	CoS
CoSe	-14.54	-30.74	-16.20	CoSe
CoSeO3	-8.67	-7.35	1.32	CoSeO3
CoSeO4:6H2O	-19.38	-20.91	-1.53	CoSeO4:6H2O
CoSO4	-13.27	-10.46	2.80	CoSO4
CoSO4:6H2O	-7.99	-10.46	-2.47	CoSO4:6H2O
Cotunnite	-10.94	-15.72	-4.78	PbCl2
Covellite	-46.15	-68.45	-22.30	CuS
Cr(OH)2	-18.76	-7.94	10.82	Cr(OH)2
Cr(OH)3	-0.84	0.49	1.34	Cr(OH)3
Cr(OH)3(am)	1.24	0.49	-0.75	Cr(OH)3
Cr2O3	3.34	0.98	-2.36	Cr2O3
CrCl2	-45.00	-30.90	14.09	CrCl2
CrCl3	-49.07	-33.96	15.11	CrCl3
CrF3	-26.37	-37.70	-11.34	CrF3
Crmetal	-61.17	-30.69	30.48	Cr
CrO3	-29.55	-32.76	-3.21	CrO3
Cryolite	-17.30	-51.14	-33.84	Na3AlF6
Cu(OH)2	-0.75	7.92	8.67	Cu(OH)2
Cu2Se(alpha)	4.97	-40.83	-45.80	Cu2Se
Cu2SO4	-18.61	-20.56	-1.95	Cu2SO4
Cu3(AsO4)2:2H2O	-10.25	-4.15	6.10	Cu3(AsO4)2:2H2O
Cu3Se2	-8.73	-72.22	-63.49	Cu3Se2
CuCO3	-1.56	-13.06	-11.50	CuCO3
CuCrO4	-19.40	-24.84	-5.44	CuCrO4
CuF	-8.59	-13.49	-4.91	CuF
CuF2	-18.65	-17.54	1.12	CuF2
CuF2:2H2O	-12.99	-17.54	-4.55	CuF2:2H2O
Cumetal	-3.38	-12.14	-8.76	Cu
CuMoO4	-2.62	-15.69	-13.08	CuMoO4
CuOCuSO4	-13.49	-3.19	10.30	CuOCuSO4
Cupricferrite	14.81	20.79	5.99	CuFe2O4
Cuprite	-0.12	-1.52	-1.41	Cu2O
Cuprousferrite	14.59	5.67	-8.92	CuFeO2
CuSe	1.71	-31.39	-33.10	CuSe
CuSe2	-14.58	-47.95	-33.37	CuSe2
CuSeO3:2H2O	-8.51	-8.00	0.51	CuSeO3:2H2O
CuSeO4:5H2O	-19.12	-21.56	-2.44	CuSeO4:5H2O
CuSO4	-14.05	-11.11	2.94	CuSO4
Diaspore	2.21	9.08	6.87	AlOOH
Djurleite	-43.35	-77.27	-33.92	Cu0.066Cu1.868S
Dolomite(disordered)	0.61	-15.93	-16.54	CaMg(CO3)2
Dolomite(ordered)	1.16	-15.93	-17.09	CaMg(CO3)2
Epsomite	-4.09	-6.21	-2.13	MgSO4:7H2O
Fe(OH)2	-5.47	8.09	13.56	Fe(OH)2
Fe(OH)2.7Cl.3	6.03	2.99	-3.04	Fe(OH)2.7Cl.3
Fe(VO3)2	-5.78	-9.50	-3.72	Fe(VO3)2
Fe2(OH)4SeO3	-4.61	-3.05	1.55	Fe2(OH)4SeO3
Fe2(SeO3)3:2H2O	-14.28	-34.90	-20.63	Fe2(SeO3)3:2H2O
Fe2(SO4)3	-40.50	-44.24	-3.73	Fe2(SO4)3
Fe3(OH)8	0.74	20.96	20.22	Fe3(OH)8
FeAsO4:2H2O	-7.93	-7.53	0.40	FeAsO4:2H2O
FeCr2O4	1.87	9.07	7.20	FeCr2O4
FeMoO4	-5.43	-15.52	-10.09	FeMoO4
Ferrihydrite	3.24	6.44	3.19	Fe(OH)3
Ferroselite	-29.19	-47.78	-18.60	FeSe2
FeS(ppt)	-65.33	-68.28	-2.95	FeS
FeSe	-20.22	-31.22	-11.00	FeSe

Fluorite	-1.75	-12.25	-10.50	CaF2
Galena	-55.16	-69.13	-13.97	PbS
Gibbsite	0.79	9.08	8.29	Al(OH)3
Goethite	5.94	6.44	0.49	FeOOH
Goslarite	-7.39	-9.40	-2.01	ZnSO4:7H2O
Greenockite	-53.92	-68.28	-14.36	CdS
Greigite	-239.49	-284.53	-45.03	Fe3S4
Gummite	-7.56	0.12	7.67	UO3
Gypsum	-1.21	-5.82	-4.61	CaSO4:2H2O
H-Jarosite	-6.67	-18.77	-12.10	(H3O)Fe3(SO4)2(OH)6
H2MoO4	-10.74	-23.62	-12.88	H2MoO4
H2S(g)	-68.36	-76.37	-8.01	H2S
H2Se(g)	-34.35	-39.31	-4.96	H2Se
Halite	-7.70	-6.09	1.60	NaCl
Hausmannite	-8.13	52.90	61.03	Mn3O4
Hematite	14.29	12.87	-1.42	Fe2O3
Hercynite	3.36	26.25	22.89	FeAl2O4
Huntite	-2.28	-32.25	-29.97	CaMg3(CO3)4
Hydrocerussite	-1.46	-20.23	-18.77	Pb3(OH)2(CO3)2
Hydromagnesite	-11.05	-19.81	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-19.08	-24.25	-5.17	KAl(SO4)2:12H2O
K-Jarosite	0.78	-14.02	-14.80	KFe3(SO4)2(OH)6
K2Cr2O7	-38.79	-56.03	-17.24	K2Cr2O7
K2CrO4	-22.75	-23.27	-0.51	K2CrO4
K2MoO4	-17.38	-14.12	3.26	K2MoO4
K2SeO4	-19.26	-19.99	-0.73	K2SeO4
Langite	-4.83	12.66	17.49	Cu4(OH)6SO4:H2O
Larnakite	-4.11	-4.55	-0.43	PbO:PbSO4
Laurionite	-4.86	-4.24	0.62	PbOHCl
Lepidocrocite	5.06	6.44	1.37	FeOOH
Lime	-19.49	13.21	32.70	CaO
Litharge	-5.45	7.25	12.69	PbO
Mackinawite	-64.68	-68.28	-3.60	FeS
Maghemite	6.48	12.87	6.39	Fe2O3
Magnesioferrite	8.83	25.69	16.86	Fe2MgO4
Magnesite	-0.70	-8.16	-7.46	MgCO3
Magnetite	17.56	20.96	3.40	Fe3O4
Malachite	0.17	-5.14	-5.31	Cu2(OH)2CO3
Manganite	-3.91	21.43	25.34	MnOOH
Massicot	-5.65	7.25	12.89	PbO
Matlockite	-8.00	-16.97	-8.97	PbClF
Melanothallite	-21.30	-15.04	6.26	CuCl2
Melanterite	-8.74	-10.94	-2.21	FeSO4:7H2O
Mg(OH)2(active)	-5.97	12.82	18.79	Mg(OH)2
Mg(VO3)2	-16.05	-4.77	11.28	Mg(VO3)2
Mg2V2O7	-18.31	8.05	26.36	Mg2V2O7
MgCr2O4	-2.39	13.81	16.20	MgCr2O4
MgCrO4	-25.32	-19.94	5.38	MgCrO4
MgF2	-4.51	-12.64	-8.13	MgF2
MgMoO4	-8.94	-10.79	-1.85	MgMoO4
MgSeO3:6H2O	-6.16	-3.10	3.06	MgSeO3:6H2O
MgSeO4:6H2O	-15.46	-16.66	-1.20	MgSeO4:6H2O
Minium	-29.04	44.49	73.52	Pb3O4
Mirabilite	-7.14	-8.26	-1.11	Na2SO4:10H2O
Mn(VO3)2	-12.44	-7.54	4.90	Mn(VO3)2
Mn2(SO4)3	-59.24	-64.96	-5.71	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-10.27	2.23	12.50	Mn3(AsO4)2:8H2O
MnCl2:4H2O	-15.63	-12.92	2.72	MnCl2:4H2O
MnS(grn)	-66.49	-66.32	0.17	MnS
MnS(pnk)	-69.66	-66.32	3.34	MnS
MnSe	-32.76	-29.26	3.50	MnSe
MnSeO3	-7.00	-5.87	1.13	MnSeO3
MnSeO3:2H2O	-6.85	-5.87	0.98	MnSeO3:2H2O
MnSeO4:5H2O	-17.38	-19.43	-2.05	MnSeO4:5H2O
MnSO4	-11.57	-8.98	2.58	MnSO4
Monteponite	-7.01	8.09	15.10	CdO

MoO3	-15.62	-23.62	-8.00	MoO3
Morenosite	-8.46	-10.60	-2.14	NiSO4:7H2O
MoS2	-128.85	-199.11	-70.26	MoS2
Na-Jarosite	-2.18	-13.38	-11.20	NaFe3(SO4)2(OH)6
Na2Cr2O7	-44.85	-54.74	-9.90	Na2Cr2O7
Na2CrO4	-24.91	-21.98	2.93	Na2CrO4
Na2Mo2O7	-19.85	-36.45	-16.60	Na2Mo2O7
Na2MoO4	-14.32	-12.83	1.49	Na2MoO4
Na2MoO4:2H2O	-14.06	-12.83	1.22	Na2MoO4:2H2O
Na2SeO3:5H2O	-15.44	-5.14	10.30	Na2SeO3:5H2O
Na2SeO4	-19.98	-18.70	1.28	Na2SeO4
Na3VO4	-29.31	7.37	36.68	Na3VO4
Na4V2O7	-33.43	3.97	37.40	Na4V2O7
Nantokite	-5.51	-12.24	-6.73	CuCl
Natron	-8.89	-10.20	-1.31	Na2CO3:10H2O
NaVO3	-7.27	-3.41	3.86	NaVO3
Nesquehonite	-3.49	-8.16	-4.67	MgCO3:3H2O
Ni(OH)2	-4.36	8.43	12.79	Ni(OH)2
Ni3(AsO4)2:8H2O	-18.32	-2.62	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-17.30	14.70	32.00	Ni4(OH)6SO4
NiCO3	-5.68	-12.55	-6.87	NiCO3
NiMoO4	-4.04	-15.18	-11.14	NiMoO4
NiS(alpha)	-62.34	-67.94	-5.60	NiS
NiS(beta)	-56.84	-67.94	-11.10	NiS
NiS(gamma)	-55.14	-67.94	-12.80	NiS
NiSe	-13.18	-30.88	-17.70	NiSe
NiSeO3:2H2O	-10.30	-7.49	2.81	NiSeO3:2H2O
NiSeO4:6H2O	-19.53	-21.05	-1.52	NiSeO4:6H2O
Nsutite	-10.05	7.45	17.50	MnO2
O2(g)	-37.59	45.50	83.09	O2
Orpiment	-203.67	-264.74	-61.07	As2S3
Otavite	-0.89	-12.89	-12.00	CdCO3
Pb(BO2)2	-10.21	-3.69	6.52	Pb(BO2)2
Pb(OH)2	-0.90	7.25	8.15	Pb(OH)2
Pb10(OH)6O(CO3)6	-44.68	-53.44	-8.76	Pb10(OH)6O(CO3)6
Pb2(OH)3Cl	-5.79	3.01	8.79	Pb2(OH)3Cl
Pb2O(OH)2	-11.70	14.49	26.19	Pb2O(OH)2
Pb2O3	-23.80	37.24	61.04	Pb2O3
Pb2OCO3	-5.93	-6.49	-0.56	Pb2OCO3
Pb2V2O7	-1.20	-3.10	-1.90	Pb2V2O7
Pb3(AsO4)2	-11.99	-6.19	5.80	Pb3(AsO4)2
Pb3(VO4)2	-2.00	4.14	6.14	Pb3(VO4)2
Pb3O2CO3	-10.27	0.75	11.02	Pb3O2CO3
Pb3O2SO4	-7.99	2.70	10.69	Pb3O2SO4
Pb4(OH)6SO4	-11.15	9.95	21.10	Pb4(OH)6SO4
Pb4O3SO4	-11.93	9.95	21.88	Pb4O3SO4
PbCrO4	-12.92	-25.52	-12.60	PbCrO4
PbF2	-10.78	-18.22	-7.44	PbF2
Pbmetal	-19.75	-15.50	4.25	Pb
PbMoO4	-0.75	-16.37	-15.62	PbMoO4
PbO:0.3H2O	-5.73	7.25	12.98	PbO:0.33H2O
PbSeO4	-15.40	-22.24	-6.84	PbSeO4
Periclase	-8.76	12.82	21.58	MgO
Phosgenite	-9.65	-29.46	-19.81	PbCl2:PbCO3
Plattnerite	-19.61	29.99	49.60	PbO2
Portlandite	-9.59	13.21	22.80	Ca(OH)2
Pyrite	-103.39	-121.90	-18.51	FeS2
Pyrochroite	-5.14	10.05	15.19	Mn(OH)2
Pyrolusite	-8.58	32.80	41.38	MnO2
Realgar	-85.81	-105.56	-19.75	AsS
Retgersite	-8.56	-10.60	-2.04	NiSO4:6H2O
Rhodochrosite	-0.35	-10.93	-10.58	MnCO3
Rutherfordine	-6.37	-20.87	-14.50	UO2CO3
Schoepite	-5.88	0.12	5.99	UO2(OH)2:H2O
Semetal(am)	-9.45	-16.56	-7.11	Se
Semetal(hex)	-8.85	-16.56	-7.71	Se

SeO2	-16.05	-15.92	0.12	SeO2
SeO3	-50.53	-29.48	21.04	SeO3
Siderite	-2.65	-12.89	-10.24	FeCO3
Smithsonite	-1.35	-11.35	-10.00	ZnCO3
Sphalerite	-55.29	-66.74	-11.45	ZnS
Spinel	-5.87	30.98	36.85	MgAl2O4
Sulfur	-51.48	-53.62	-2.14	S
Tenorite	0.28	7.92	7.64	CuO
Thenardite	-8.58	-8.25	0.32	Na2SO4
Thermonatrite	-10.84	-10.20	0.64	Na2CO3:H2O
Tyuyamunite	-8.23	-4.15	4.08	Ca(UO2)2(VO4)2
U3O8	-15.84	5.25	21.08	U3O8
U4O9	-27.90	-30.92	-3.02	U4O9
UF4	-34.81	-64.34	-29.54	UF4
UF4:2.5H2O	-31.62	-64.34	-32.72	UF4:2.5H2O
UO2(am)	-14.35	-13.42	0.93	UO2
UO2(OH)2(beta)	-5.50	0.12	5.61	UO2(OH)2
UO2SeO4:4H2O	-27.12	-29.37	-2.25	UO2SeO4:4H2O
UO3	-7.58	0.12	7.70	UO3
Uraninite	-8.75	-13.42	-4.67	UO2
V(OH)3	-16.54	-8.95	7.59	V(OH)3
V2O5	-16.24	-17.60	-1.36	V2O5
V3O5	-34.39	-32.56	1.84	V3O5
V4O7	-43.01	-35.83	7.19	V4O7
V6O13	-37.43	-98.29	-60.86	V6O13
VCl2	-62.16	-43.29	18.87	VCl2
VCl3	-66.83	-43.40	23.43	VCl3
VF4	-69.13	-54.20	14.93	VF4
Vmetal	-87.10	-43.07	44.03	V
VO	-35.08	-20.32	14.76	VO
VO(OH)2	-8.42	-3.27	5.15	VO(OH)2
VO2Cl	-23.12	-20.28	2.84	VO2Cl
VOCl	-31.58	-20.43	11.15	VOCl
VOCl2	-39.00	-26.24	12.76	VOCl2
VOSO4	-25.92	-22.31	3.61	VOSO4
Witherite	-2.79	-11.36	-8.57	BaCO3
Wurtzite	-57.79	-66.74	-8.95	ZnS
Zincite	-1.70	9.64	11.33	ZnO
Zincosite	-13.33	-9.40	3.93	ZnSO4
Zn(BO2)2	-9.59	-1.30	8.29	Zn(BO2)2
Zn(OH)2	-2.56	9.64	12.20	Zn(OH)2
Zn(OH)2(am)	-2.84	9.64	12.47	Zn(OH)2
Zn(OH)2(beta)	-2.12	9.64	11.75	Zn(OH)2
Zn(OH)2(epsilon)	-1.90	9.64	11.53	Zn(OH)2
Zn(OH)2(gamma)	-2.10	9.64	11.73	Zn(OH)2
Zn2(OH)2SO4	-7.26	0.24	7.50	Zn2(OH)2SO4
Zn2(OH)3Cl	-7.40	7.79	15.19	Zn2(OH)3Cl
Zn3(AsO4)2:2.5H2O	-12.66	0.99	13.65	Zn3(AsO4)2:2.5H2O
Zn3O(SO4)2	-28.08	-9.16	18.91	Zn3O(SO4)2
Zn4(OH)6SO4	-8.89	19.51	28.40	Zn4(OH)6SO4
Zn5(OH)8Cl2	-13.29	25.21	38.50	Zn5(OH)8Cl2
ZnCl2	-20.38	-13.33	7.05	ZnCl2
ZnCO3:1H2O	-1.09	-11.35	-10.26	ZnCO3:1H2O
ZnF2	-15.29	-15.83	-0.53	ZnF2
Znmetal	-38.90	-13.11	25.79	Zn
ZnMoO4	-3.85	-13.98	-10.13	ZnMoO4
ZnO(active)	-1.55	9.64	11.19	ZnO
ZnS(am)	-57.68	-66.74	-9.05	ZnS
ZnSe	-15.27	-29.67	-14.40	ZnSe
ZnSeO4:6H2O	-18.33	-19.85	-1.52	ZnSeO4:6H2O
ZnSO4:1H2O	-8.76	-9.40	-0.64	ZnSO4:1H2O

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

```
End of simulation.
------------------

------------------------------------
Reading input data for simulation 2.
------------------------------------

------------------------------
End of Run after 0.236 Seconds.
------------------------------
```

```
# P75Scenario

SOLUTION 1 UG Water P75
    temp      25
    pH        8.112
    units     mg/L
    density   1
Al    0.0784
As    0.0029
Ba    0.1829
B     0.1305
Ca    108.3
Cl    56.4
Mg    54.6
Na    209.6
K     39.8
F     1.0230
S(6)  286.6
Cd    0.0089
Cr    0.0083
Co    0.0040
Cu    0.0817
Fe    0.2095
Pb    0.0552
Mn    0.1027
Mo    0.0124
Ni    0.0058
Se    0.0180
U     0.0083
V     0.0024
Zn    0.2240
Alkalinity 540.5 as HCO3
    -water    1 # kg

SOLUTION 2 PAF Material
    temp      25
    pH        7.5
    units     mg/L
    density   1
      Al    0.020
      As    0
      Ba    0.020
      B     0
      Ca    67.0
      Cl    0
      Mg    8.0
      Na    1.0
      K     13.0
      F     0.300
      S(6)  197.0
      Cd    0.000
      Cr    0
      Co    0.007
      Cu    0.028
      Fe    0
      Pb    0
      Mn    0.040
      Mo    0.003
      Ni    0.004
      Se    0
      U     0
      V     0
      Zn    0
      Alkalinity 22 as HCO3
    -water    1 # kg
```

```
SOLUTION 3 NAF Material
    temp      25
    pH        7.6
    units     mg/L
    density   1
      Al    0.140
      As    0.029
      Ba    0.020
      B     0
      Ca    122.0
      Cl    0
      Mg    18.0
      Na    1.0
      K     16.0
      F     0.300
      S(6)  331.0
      Cd    0.000
      Cr    0
      Co    0.002
      Cu    0.019
      Fe    0.070
      Pb    0
      Mn    0.130
      Mo    0.005
      Ni    0.001
      Se    0
      U     0.001
      V     0
      Zn    0
      Alkalinity 28 as HCO3
    -water    1 # kg


SOLUTION 4 Make-up Material
    temp      25
    pH        7.7
    units     mg/L
    density   1
      Al    0.020
      As    0
      Ba    0.020
      B     0
      Ca    67.0
      Cl    0
      Mg    8.0
      Na    1.0
      K     13.0
      F     0.300
      S(6)  197.0
      Cd    0.000
      Cr    0
      Co    0.007
      Cu    0.028
      Fe    0
      Pb    0
      Mn    0.040
      Mo    0.003
      Ni    0.004
      Se    0
      U     0
      V     0
      Zn    0
      Alkalinity 22 as HCO3
    -water    1 # kg

# Mix the three solutions together
```

```
MIX 1 Mix within UG Works
    1    0.278
    2    0.114
    3    0.418
    4    0.190

SAVE Solution 5

SELECTED_OUTPUT 2
    -file                D:\selected_output_3.txt
    -high_precision      true
    -reset               true
    -distance            false
    -time                false
    -temperature         false
    -ionic_strength      false
    -water               false
    -totals              pH Al As Ba B Ca Cl Mg
                         Na K  F  S(6) Cd Cr Co
                         Cu Fe Pb Mn Mo  Ni Se
                         U V Zn Alkalinity
END
```

```
   Input file: P:\J23011 - BCP Underground EA (Aeris)\2. Tech Work Area\2.08 Water Quality
Model\2.08.02 PAF Assessment\BPC_UG_PAF_Disposal_P75.pqi
  Output file: P:\J23011 - BCP Underground EA (Aeris)\2. Tech Work Area\2.08 Water Quality
Model\2.08.02 PAF Assessment\BPC_UG_PAF_Disposal_P75.pqo
Database file: c:\phreeqc\database\minteq.v4.dat

------------------
Reading data base.
------------------

      SOLUTION_MASTER_SPECIES
      SOLUTION_SPECIES
      SOLUTION_SPECIES
      PHASES
      PHASES
      SURFACE_MASTER_SPECIES
      SURFACE_SPECIES
      END
-----------------------------------
Reading input data for simulation 1.
-----------------------------------

      DATABASE c:\phreeqc\database\minteq.v4.dat
      SOLUTION 1 UG Water P75
          temp      25
          pH        8.112
          units     mg/L
          density   1
      Al    0.0784
      As    0.0029
      Ba    0.1829
      B     0.1305
      Ca    108.3
      Cl    56.4
      Mg    54.6
      Na    209.6
      K     39.8
      F     1.0230
      S(6)  286.6
      Cd    0.0089
      Cr    0.0083
      Co    0.0040
      Cu    0.0817
      Fe    0.2095
      Pb    0.0552
      Mn    0.1027
      Mo    0.0124
      Ni    0.0058
      Se    0.0180
      U     0.0083
      V     0.0024
      Zn    0.2240
      Alkalinity 540.5 as HCO3
          water    1 # kg
      SOLUTION 2 PAF Material
          temp      25
          pH        7.5
          units     mg/L
          density   1
            Al    0.020
            As    0
            Ba    0.020
            B     0
            Ca    67.0
            Cl    0
            Mg    8.0
            Na    1.0
            K     13.0
            F     0.300
            S(6)  197.0
            Cd    0.000
            Cr    0
            Co    0.007
            Cu    0.028
            Fe    0
            Pb    0
            Mn    0.040
            Mo    0.003
            Ni    0.004
            Se    0
            U     0
            V     0
            Zn    0
            Alkalinity 22 as HCO3
          water    1 # kg
      MIX 1 Mix within UG Works
          1    0.278
          2    0.114
          3    0.418
          4    0.190
      SAVE Solution 5
      SELECTED_OUTPUT 2
          file                 D:\selected_output_3.txt
          high_precision       true
          reset                true
          distance             false
          time                 false
          temperature          false
          ionic_strength       false
          water                false
          totals               pH Al As Ba B Ca Cl Mg
WARNING: Expected element name to begin with upper case letter.
                                Na K  F  S(6) Cd Cr Co
                                Cu Fe Pb Mn Mo  Ni Se
                                U V Zn Alkalinity
      END
--------------------------------------------
Beginning of initial solution calculations.
--------------------------------------------

Initial solution 1.     UG Water P75

-----------------------------Solution composition------------------------------

      Elements           Molality       Moles

      Al                 2.909e-06   2.909e-06
      Alkalinity         8.869e-03   8.869e-03
      As                 3.876e-08   3.876e-08
      B                  1.209e-05   1.209e-05
      Ba                 1.334e-06   1.334e-06
      Ca                 2.706e-03   2.706e-03
      Cd                 7.928e-08   7.928e-08
      Cl                 1.593e-03   1.593e-03
      Co                 6.796e-08   6.796e-08
      Cr                 1.598e-07   1.598e-07
      Cu                 1.287e-06   1.287e-06
      F                  5.392e-05   5.392e-05
      Fe                 3.756e-06   3.756e-06
      K                  1.019e-03   1.019e-03
      Mg                 2.249e-03   2.249e-03
      Mn                 1.872e-06   1.872e-06
      Mo                 1.294e-07   1.294e-07
      Na                 9.129e-03   9.129e-03
      Ni                 9.895e-08   9.895e-08
      Pb                 2.668e-07   2.668e-07
      S(6)               2.987e-03   2.987e-03
      Se                 2.283e-07   2.283e-07
      U                  3.492e-08   3.492e-08
      V                  4.718e-08   4.718e-08
      Zn                 3.430e-06   3.430e-06

----------------------------Description of solution----------------------------

                                       pH  =   8.112
                                       pe  =   4.000
                                 Activity of water  =   1.000
                       Ionic strength (mol/kgw)  =   2.285e-02
                            Mass of water (kg)  =   1.000e+00
                          Total carbon (mol/kg)  =   8.770e-03
                             Total CO2 (mol/kg)  =   8.770e-03
                               Temperature (°C)  =  25.00
                        Electrical balance (eq)  =   3.597e-03
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  10.92
                                    Iterations  =  10
                                       Total H  = 1.110224e+02
                                       Total O  = 5.554515e+01

----------------------------Distribution of species----------------------------

                                                  Log       Log       Log    mole V
   Species          Molality    Activity  Molality  Activity     Gamma    cm³/mol

   OH-            1.515e-06   1.303e-06    -5.820    -5.885    -0.066     (0)
   H+             8.943e-09   7.727e-09    -8.049    -8.112    -0.063     0.00
   H2O            5.551e+01   9.995e-01     1.744    -0.000     0.000    18.07
Al             2.909e-06
   Al(OH)4-       2.894e-06   2.503e-06    -5.539    -5.602    -0.063     (0)
   Al(OH)3        1.526e-08   1.526e-08    -7.816    -7.816     0.000     (0)
   Al(OH)2+       6.755e-10   5.872e-10    -9.170    -9.231    -0.061     (0)
   AlF2+          3.367e-12   2.927e-12   -11.473   -11.534    -0.061     (0)
   AlF3           1.514e-12   1.514e-12   -11.820   -11.820     0.000     (0)
   AlOH+2         9.936e-13   5.676e-13   -12.003   -12.246    -0.243     (0)
   AlF+2          3.133e-13   1.790e-13   -12.504   -12.747    -0.243     (0)
   AlF4-          3.604e-14   3.117e-14   -13.443   -13.506    -0.063     (0)
   AlSO4+         5.061e-15   4.378e-15   -14.296   -14.359    -0.063     (0)
   Al+3           1.624e-15   4.357e-16   -14.790   -15.361    -0.571     (0)
   Al(SO4)2-      7.019e-17   6.071e-17   -16.154   -16.217    -0.063     (0)
   AlMo6O21-3     0.000e+00   0.000e+00   -51.198   -51.891    -0.694     (0)
As(3)          8.817e-21
   H3AsO3         8.169e-21   8.169e-21   -20.088   -20.088     0.000     (0)
   H2AsO3-        6.475e-22   5.422e-22   -21.189   -21.266    -0.077     (0)
   HAsO3-2        1.302e-25   6.400e-26   -24.885   -25.194    -0.308     (0)
   H4AsO3+        3.735e-29   3.127e-29   -28.428   -28.505    -0.077     (0)
   AsO3-3         1.578e-30   3.193e-31   -29.802   -30.496    -0.694     (0)
As(5)          3.876e-08
   HAsO4-2        3.718e-08   1.828e-08    -7.430    -7.738    -0.308     (0)
   H2AsO4-        1.538e-09   1.288e-09    -8.813    -8.890    -0.077     (0)
   AsO4-3         3.696e-11   7.481e-12   -10.432   -11.126    -0.694     (0)
   H3AsO4         1.721e-15   1.730e-15   -14.764   -14.762     0.002     (0)
B              1.209e-05
   H3BO3          1.100e-05   1.106e-05    -4.958    -4.956     0.002     (0)
   H2BO3-         9.736e-07   8.314e-07    -6.012    -6.080    -0.069     (0)
   CaH2BO3+       6.560e-08   5.602e-08    -7.183    -7.252    -0.069     (0)
   MgH2BO3+       3.523e-08   3.008e-08    -7.453    -7.522    -0.069     (0)
   NaH2BO3        1.028e-08   1.028e-08    -7.988    -7.988     0.000     (0)
   BF(OH)3-       2.123e-10   1.813e-10    -9.673    -9.742    -0.069     (0)
   BaH2BO3+       2.118e-11   1.809e-11   -10.674   -10.743    -0.069     (0)
   H5(BO3)2-      9.166e-12   7.827e-12   -11.038   -11.106    -0.069     (0)
   H8(BO3)3-      1.014e-14   8.657e-15   -13.994   -14.063    -0.069     (0)
   BF2(OH)2-      7.208e-15   6.156e-15   -14.142   -14.211    -0.069     (0)
   BF3OH-         8.906e-22   7.605e-22   -21.050   -21.119    -0.069     (0)
```

BF4-	1.392e-27	1.188e-27	-26.856	-26.925	-0.069	(0)
Ba	1.334e-06					
Ba+2	1.263e-06	7.041e-07	-5.898	-6.152	-0.254	(0)
BaHCO3+	5.460e-08	4.762e-08	-7.263	-7.322	-0.059	(0)
BaCO3	1.552e-08	1.552e-08	-7.809	-7.809	0.000	(0)
BaH2BO3+	2.118e-11	1.809e-11	-10.674	-10.743	-0.069	(0)
BaOH+	4.615e-12	4.004e-12	-11.336	-11.398	-0.062	(0)
C(4)	8.770e-03					
HCO3-	8.146e-03	7.082e-03	-2.089	-2.150	-0.061	(0)
CaHCO3+	1.770e-04	1.544e-04	-3.752	-3.811	-0.059	(0)
H2CO3	1.231e-04	1.231e-04	-3.910	-3.910	0.000	(0)
MgHCO3+	8.769e-05	7.562e-05	-4.057	-4.121	-0.064	(0)
CaCO3	7.974e-05	7.974e-05	-4.098	-4.098	0.000	(0)
CO3-2	7.709e-05	4.297e-05	-4.113	-4.367	-0.254	(0)
MgCO3	3.729e-05	3.729e-05	-4.428	-4.428	0.000	(0)
NaHCO3	3.106e-05	3.106e-05	-4.508	-4.508	0.000	(0)
NaCO3-	7.179e-06	6.241e-06	-5.144	-5.205	-0.061	(0)
ZnCO3	1.690e-06	1.690e-06	-5.772	-5.772	0.000	(0)
CuCO3	1.014e-06	1.014e-06	-5.994	-5.994	0.000	(0)
Cu(CO3)2-2	2.385e-07	1.173e-07	-6.622	-6.931	-0.308	(0)
PbCO3	1.974e-07	1.974e-07	-6.705	-6.705	0.000	(0)
ZnHCO3+	1.828e-07	1.531e-07	-6.738	-6.815	-0.077	(0)
MnHCO3+	1.252e-07	1.086e-07	-6.902	-6.964	-0.062	(0)
BaHCO3+	5.460e-08	4.762e-08	-7.263	-7.322	-0.059	(0)
Pb(CO3)2-2	4.975e-08	2.446e-08	-7.303	-7.612	-0.308	(0)
NiCO3	3.357e-08	3.357e-08	-7.474	-7.474	0.000	(0)
UO2(CO3)3-4	3.309e-08	1.933e-09	-7.480	-8.714	-1.233	(0)
CdCO3	2.319e-08	2.319e-08	-7.635	-7.635	0.000	(0)
NiHCO3+	2.184e-08	1.828e-08	-7.661	-7.738	-0.077	(0)
BaCO3	1.552e-08	1.552e-08	-7.809	-7.809	0.000	(0)
CoCO3	1.328e-08	1.328e-08	-7.877	-7.877	0.000	(0)
CoHCO3+	1.203e-08	1.007e-08	-7.920	-7.997	-0.077	(0)
PbHCO3+	9.604e-09	8.042e-09	-8.018	-8.095	-0.077	(0)
CuHCO3+	2.139e-09	1.791e-09	-8.670	-8.747	-0.077	(0)
UO2(CO3)2-2	1.826e-09	8.976e-10	-8.739	-9.047	-0.308	(0)
Cd(CO3)2-2	1.502e-09	7.385e-10	-8.823	-9.132	-0.308	(0)
CdHCO3+	4.559e-10	3.817e-10	-9.341	-9.418	-0.077	(0)
FeHCO3+	3.526e-10	3.075e-10	-9.453	-9.512	-0.059	(0)
UO2CO3	1.047e-12	1.047e-12	-11.980	-11.980	0.000	(0)
Ca	2.706e-03					
Ca+2	2.101e-03	1.171e-03	-2.678	-2.931	-0.254	(0)
CaSO4	3.472e-04	3.472e-04	-3.459	-3.459	0.000	(0)
CaHCO3+	1.770e-04	1.544e-04	-3.752	-3.811	-0.059	(0)
CaCO3	7.974e-05	7.974e-05	-4.098	-4.098	0.000	(0)
CaF+	6.053e-07	5.250e-07	-6.218	-6.280	-0.062	(0)
CaH2BO3+	6.560e-08	5.602e-08	-7.183	-7.252	-0.069	(0)
CaOH+	3.489e-08	3.043e-08	-7.457	-7.517	-0.059	(0)
Cd	7.928e-08					
Cd+2	4.248e-08	2.368e-08	-7.372	-7.626	-0.254	(0)
CdCO3	2.319e-08	2.319e-08	-7.635	-7.635	0.000	(0)
CdSO4	7.183e-09	7.183e-09	-8.144	-8.144	0.000	(0)
CdCl+	3.716e-09	3.112e-09	-8.430	-8.507	-0.077	(0)
Cd(CO3)2-2	1.502e-09	7.385e-10	-8.823	-9.132	-0.308	(0)
CdHCO3+	4.559e-10	3.817e-10	-9.341	-9.418	-0.077	(0)
CdOH+	2.925e-10	2.450e-10	-9.534	-9.611	-0.077	(0)
Cd(SO4)2-2	2.551e-10	1.254e-10	-9.593	-9.902	-0.308	(0)
CdOHCl	1.663e-10	1.663e-10	-9.779	-9.779	0.000	(0)
CdF+	1.841e-11	1.541e-11	-10.735	-10.812	-0.077	(0)
CdCl2	1.785e-11	1.785e-11	-10.748	-10.748	0.000	(0)
Cd(OH)2	2.013e-12	2.013e-12	-11.696	-11.696	0.000	(0)
CdCl3-	1.852e-14	1.550e-14	-13.732	-13.810	-0.077	(0)
CdF2	1.263e-15	1.263e-15	-14.898	-14.898	0.000	(0)
Cd(OH)3-	1.913e-16	1.602e-16	-15.718	-15.795	-0.077	(0)
Cd2OH+3	1.436e-16	2.907e-17	-15.843	-16.537	-0.694	(0)
Cd(SeO3)2-2	1.092e-16	5.367e-17	-15.962	-16.270	-0.308	(0)
CdSeO4	4.784e-17	4.784e-17	-16.320	-16.320	0.000	(0)
Cd(OH)4-2	6.948e-23	3.416e-23	-22.158	-22.467	-0.308	(0)
Cl	1.593e-03					
Cl-	1.593e-03	1.376e-03	-2.798	-2.861	-0.063	(0)
ZnOHCl	4.030e-09	4.030e-09	-8.395	-8.395	0.000	(0)
CdCl+	3.716e-09	3.112e-09	-8.430	-8.507	-0.077	(0)
ZnCl+	2.741e-09	2.363e-09	-8.562	-8.626	-0.064	(0)
MnCl+	1.536e-09	1.332e-09	-8.814	-8.875	-0.062	(0)
CuCl	3.401e-10	3.401e-10	-9.468	-9.468	0.000	(0)
CdOHCl	1.663e-10	1.663e-10	-9.779	-9.779	0.000	(0)
CuCl2-	1.134e-10	9.781e-11	-9.945	-10.010	-0.064	(0)
CoCl+	1.040e-10	8.704e-11	-9.983	-10.060	-0.077	(0)
PbCl+	8.913e-11	7.463e-11	-10.050	-10.127	-0.077	(0)
NiCl+	8.807e-11	7.375e-11	-10.055	-10.132	-0.077	(0)
CdCl2	1.785e-11	1.785e-11	-10.748	-10.748	0.000	(0)
CuCl+	1.014e-11	8.743e-12	-10.994	-11.058	-0.064	(0)
ZnCl2	5.155e-12	5.155e-12	-11.288	-11.288	0.000	(0)
MnCl2	2.590e-12	2.590e-12	-11.587	-11.587	0.000	(0)
PbCl2	4.588e-13	4.588e-13	-12.338	-12.338	0.000	(0)
CuCl3-2	5.083e-14	2.878e-14	-13.294	-13.541	-0.247	(0)
CdCl3-	1.852e-14	1.550e-14	-13.732	-13.810	-0.077	(0)
ZnCl3-	6.536e-15	5.636e-15	-14.185	-14.249	-0.064	(0)
CuCl2	4.172e-15	4.172e-15	-14.380	-14.380	0.000	(0)
MnCl3-	1.132e-15	9.816e-16	-14.946	-15.008	-0.062	(0)
NiCl2	5.111e-16	5.111e-16	-15.292	-15.292	0.000	(0)
PbCl3-	3.002e-16	2.514e-16	-15.523	-15.600	-0.077	(0)
CrCl+2	7.266e-17	3.572e-17	-16.139	-16.447	-0.308	(0)
ZnCl4-2	6.850e-18	3.879e-18	-17.164	-17.411	-0.247	(0)
CrOHCl2	1.217e-18	1.217e-18	-17.915	-17.915	0.000	(0)
PbCl4-2	3.217e-19	1.581e-19	-18.493	-18.801	-0.308	(0)
FeCl+2	2.352e-19	1.332e-19	-18.629	-18.876	-0.247	(0)
CuCl3-	6.215e-20	5.359e-20	-19.207	-19.271	-0.064	(0)
UO2Cl+	1.632e-20	1.366e-20	-19.787	-19.864	-0.077	(0)
CrCl2+	5.571e-21	4.665e-21	-20.254	-20.331	-0.077	(0)
FeCl2+	9.438e-22	8.187e-22	-21.025	-21.087	-0.062	(0)
VOCl+	6.678e-23	5.592e-23	-22.175	-22.252	-0.077	(0)
CuCl4-2	6.529e-25	3.697e-25	-24.185	-24.432	-0.247	(0)
FeCl3	1.127e-25	1.127e-25	-24.948	-24.948	0.000	(0)
CrO3Cl-	3.575e-26	2.993e-26	-25.447	-25.524	-0.077	(0)
CoCl+2	4.146e-37	2.038e-37	-36.382	-36.691	-0.308	(0)
UCl+3	0.000e+00	0.000e+00	-48.912	-49.606	-0.694	(0)
Co(2)	6.796e-08					
Co+2	3.719e-08	1.828e-08	-7.430	-7.738	-0.308	(0)
CoCO3	1.328e-08	1.328e-08	-7.877	-7.877	0.000	(0)
CoHCO3+	1.203e-08	1.007e-08	-7.920	-7.997	-0.077	(0)
CoSO4	4.721e-09	4.721e-09	-8.326	-8.326	0.000	(0)
CoOH+	5.674e-10	4.751e-10	-9.246	-9.323	-0.077	(0)
CoCl+	1.040e-10	8.704e-11	-9.983	-10.060	-0.077	(0)
Co(OH)2	4.916e-11	4.916e-11	-10.308	-10.308	0.000	(0)
CoF+	2.836e-11	2.375e-11	-10.547	-10.624	-0.077	(0)
Co(OH)3-	1.526e-15	1.278e-15	-14.816	-14.894	-0.077	(0)
CoOOH-	3.830e-16	3.207e-16	-15.417	-15.494	-0.077	(0)
CoSeO4	9.943e-17	9.943e-17	-16.002	-16.002	0.000	(0)
Co2OH+3	2.151e-18	4.354e-19	-17.667	-18.361	-0.694	(0)
Co(OH)4-2	5.365e-22	2.638e-22	-21.270	-21.579	-0.308	(0)
Co4(OH)4+4	1.741e-28	1.017e-29	-27.759	-28.993	-1.233	(0)
Co(3)	9.799e-30					
CoOH+2	9.799e-30	4.817e-30	-29.009	-29.317	-0.308	(0)
Co+3	2.712e-36	7.278e-37	-35.567	-36.138	-0.571	(0)
CoCl+2	4.146e-37	2.038e-37	-36.382	-36.691	-0.308	(0)
Cr(2)	9.745e-25					
Cr+2	9.745e-25	4.791e-25	-24.011	-24.320	-0.308	(0)
Cr(3)	1.598e-07					
Cr(OH)2+	1.082e-07	9.058e-08	-6.966	-7.043	-0.077	(0)
Cr(OH)3	4.432e-08	4.432e-08	-7.353	-7.353	0.000	(0)
CrO2-	3.255e-09	2.725e-09	-8.487	-8.565	-0.077	(0)
Cr(OH)4-	2.745e-09	2.298e-09	-8.561	-8.639	-0.077	(0)
Cr(OH)+2	1.163e-09	5.715e-10	-8.935	-9.243	-0.308	(0)
CrOHSO4	1.755e-10	1.755e-10	-9.756	-9.756	0.000	(0)
CrF+2	2.656e-13	1.306e-13	-12.576	-12.884	-0.308	(0)
Cr+3	9.910e-14	2.006e-14	-13.004	-13.698	-0.694	(0)
CrSO4+	7.239e-14	6.061e-14	-13.140	-13.217	-0.077	(0)
CrCl+2	7.266e-17	3.572e-17	-16.139	-16.447	-0.308	(0)
Cr2(OH)2SO4+2	1.844e-17	9.068e-18	-16.734	-17.043	-0.308	(0)
CrOHCl2	1.217e-18	1.217e-18	-17.915	-17.915	0.000	(0)
Cr2(OH)2(SO4)2	6.971e-19	6.971e-19	-18.157	-18.157	0.000	(0)
CrCl2+	5.571e-21	4.665e-21	-20.254	-20.331	-0.077	(0)
Cr(6)	3.353e-14					
CrO4-2	3.210e-14	1.789e-14	-13.493	-13.747	-0.254	(0)
NaCrO4-	8.282e-16	6.935e-16	-15.082	-15.159	-0.077	(0)
HCrO4-	5.342e-16	4.473e-16	-15.272	-15.349	-0.077	(0)
KCrO4-	6.928e-17	5.801e-17	-16.159	-16.236	-0.077	(0)
H2CrO4	2.802e-24	2.802e-24	-23.553	-23.553	0.000	(0)
CrO3SO4-2	2.773e-24	1.363e-24	-23.557	-23.865	-0.308	(0)
CrO3Cl-	3.575e-26	2.993e-26	-25.447	-25.524	-0.077	(0)
Cr2O7-2	1.412e-29	6.942e-30	-28.850	-29.159	-0.308	(0)
Cu(1)	6.881e-10					
CuCl	3.401e-10	3.401e-10	-9.468	-9.468	0.000	(0)
Cu+	2.344e-10	1.963e-10	-9.630	-9.707	-0.077	(0)
CuCl2-	1.134e-10	9.781e-11	-9.945	-10.010	-0.064	(0)
CuCl3-2	5.083e-14	2.878e-14	-13.294	-13.541	-0.247	(0)
Cu(2)	1.287e-06					
CuCO3	1.014e-06	1.014e-06	-5.994	-5.994	0.000	(0)
Cu(CO3)2-2	2.385e-07	1.173e-07	-6.622	-6.931	-0.308	(0)
CuOH+	1.915e-08	1.651e-08	-7.718	-7.782	-0.064	(0)
Cu+2	7.192e-09	4.008e-09	-8.143	-8.397	-0.254	(0)
Cu(OH)2	4.291e-09	4.291e-09	-8.367	-8.367	0.000	(0)
CuHCO3+	2.139e-09	1.791e-09	-8.670	-8.747	-0.077	(0)
CuSO4	1.188e-09	1.188e-09	-8.925	-8.925	0.000	(0)
Cu2(OH)2+2	1.393e-11	6.847e-12	-10.856	-11.165	-0.308	(0)
Cu(OH)3-	1.369e-11	1.146e-11	-10.864	-10.941	-0.077	(0)
CuF+	1.241e-11	1.039e-11	-10.906	-10.983	-0.077	(0)
CuCl+	1.014e-11	8.743e-12	-10.994	-11.058	-0.064	(0)
CuCl2	4.172e-15	4.172e-15	-14.380	-14.380	0.000	(0)
Cu(OH)4-2	2.391e-16	1.175e-16	-15.621	-15.930	-0.308	(0)
CuCl3-	6.215e-20	5.359e-20	-19.207	-19.271	-0.064	(0)
CuCl4-2	6.529e-25	3.697e-25	-24.185	-24.432	-0.247	(0)
F	5.392e-05					
F-	4.755e-05	4.108e-05	-4.323	-4.386	-0.063	(0)
MgF+	5.561e-06	4.810e-06	-5.255	-5.318	-0.063	(0)
CaF+	6.053e-07	5.250e-07	-6.218	-6.280	-0.062	(0)
NaF	2.022e-07	2.022e-07	-6.694	-6.694	0.000	(0)
MnF+	1.449e-09	1.257e-09	-8.839	-8.901	-0.062	(0)
ZnF+	6.692e-10	5.603e-10	-9.174	-9.252	-0.077	(0)
HF	4.695e-10	4.695e-10	-9.328	-9.328	0.000	(0)
BF(OH)3-	2.123e-10	1.813e-10	-9.673	-9.742	-0.069	(0)
CoF+	2.836e-11	2.375e-11	-10.547	-10.624	-0.077	(0)
NiF+	2.581e-11	2.161e-11	-10.588	-10.665	-0.077	(0)
CdF+	1.841e-11	1.541e-11	-10.735	-10.812	-0.077	(0)
CuF+	1.241e-11	1.039e-11	-10.906	-10.983	-0.077	(0)
PbF+	5.284e-12	4.424e-12	-11.277	-11.354	-0.077	(0)
AlF2+	3.367e-12	2.927e-12	-11.473	-11.534	-0.061	(0)
AlF3	1.514e-12	1.514e-12	-11.820	-11.820	0.000	(0)
AlF+2	3.133e-13	1.790e-13	-12.504	-12.747	-0.243	(0)
CrF+2	2.656e-13	1.306e-13	-12.576	-12.884	-0.308	(0)
HF2-	8.530e-14	7.333e-14	-13.069	-13.135	-0.066	(0)
AlF4-	3.604e-14	3.117e-14	-13.443	-13.506	-0.063	(0)
BF2(OH)2-	7.208e-15	6.156e-15	-14.142	-14.211	-0.069	(0)
PbF2	3.577e-15	3.577e-15	-14.447	-14.447	0.000	(0)
CdF2	1.263e-15	1.263e-15	-14.898	-14.898	0.000	(0)
FeF+2	2.549e-16	1.443e-16	-15.594	-15.841	-0.247	(0)
FeF2+	1.829e-16	1.587e-16	-15.738	-15.800	-0.062	(0)
UO2F+	4.145e-17	3.471e-17	-16.382	-16.460	-0.077	(0)
FeF3	9.196e-18	9.196e-18	-17.036	-17.036	0.000	(0)
UO2F2	4.112e-18	4.112e-18	-17.386	-17.386	0.000	(0)
VO2F	2.184e-18	2.184e-18	-17.661	-17.661	0.000	(0)
H2F2	5.906e-19	5.906e-19	-18.229	-18.229	0.000	(0)
PbF3-	3.328e-19	2.787e-19	-18.478	-18.555	-0.077	(0)
UO2F3-	5.068e-20	4.244e-20	-19.295	-19.372	-0.077	(0)
VO2F2-	3.890e-20	3.258e-20	-19.410	-19.487	-0.077	(0)
VOF+	4.261e-21	3.568e-21	-20.370	-20.448	-0.077	(0)
BF3OH-	8.906e-22	7.605e-22	-21.050	-21.119	-0.069	(0)
VOF2	5.497e-23	5.497e-23	-22.260	-22.260	0.000	(0)
VO2F3-2	3.395e-23	1.669e-23	-22.469	-22.777	-0.308	(0)
UO2F4-2	2.817e-23	1.385e-23	-22.550	-22.859	-0.308	(0)
PbF4-2	1.115e-23	5.480e-24	-22.953	-23.261	-0.308	(0)
VOF3-	9.568e-26	8.012e-26	-25.019	-25.096	-0.077	(0)
VO2F4-3	1.667e-27	3.374e-28	-26.778	-27.472	-0.694	(0)
BF4-	1.392e-27	1.188e-27	-26.856	-26.925	-0.069	(0)
VOF4-2	2.702e-29	1.329e-29	-28.568	-28.877	-0.308	(0)
UF3+	1.184e-40	0.000e+00	-39.927	-40.004	-0.077	(0)
UF2+2	0.000e+00	0.000e+00	-40.509	-40.817	-0.308	(0)
UF4	0.000e+00	0.000e+00	-42.350	-42.350	0.000	(0)
UF+3	0.000e+00	0.000e+00	-42.837	-43.531	-0.694	(0)
UF5-	0.000e+00	0.000e+00	-45.062	-45.139	-0.077	(0)
UF6-2	0.000e+00	0.000e+00	-46.737	-47.045	-0.308	(0)
Fe(2)	8.671e-09					
Fe+2	7.016e-09	3.449e-09	-8.154	-8.462	-0.308	(0)
FeSO4	1.096e-09	1.096e-09	-8.960	-8.960	0.000	(0)
FeHCO3+	3.526e-10	3.075e-10	-9.453	-9.512	-0.059	(0)
FeOH+	2.062e-10	1.789e-10	-9.686	-9.747	-0.062	(0)
Fe(OH)2	1.851e-13	1.851e-13	-12.733	-12.733	0.000	(0)
Fe(OH)3-	8.787e-14	7.623e-14	-13.056	-13.118	-0.062	(0)
Fe(3)	3.748e-06					
Fe(OH)3	1.910e-06	1.910e-06	-5.719	-5.719	0.000	(0)
Fe(OH)2+	1.571e-06	1.366e-06	-5.804	-5.865	-0.061	(0)
Fe(OH)4-	2.665e-07	2.317e-07	-6.574	-6.635	-0.061	(0)
FeOH+2	4.759e-12	2.695e-12	-11.322	-11.569	-0.247	(0)
FeF+2	2.549e-16	1.443e-16	-15.594	-15.841	-0.247	(0)
FeF2+	1.829e-16	1.587e-16	-15.738	-15.800	-0.062	(0)
FeSO4+	5.364e-17	4.653e-17	-16.271	-16.332	-0.062	(0)
Fe+3	1.194e-17	3.204e-18	-16.923	-17.494	-0.571	(0)
FeF3	9.196e-18	9.196e-18	-17.036	-17.036	0.000	(0)
Fe(SO4)2-	1.538e-18	1.288e-18	-17.813	-17.890	-0.077	(0)
FeCl+2	2.352e-19	1.332e-19	-18.629	-18.876	-0.247	(0)
Fe2(OH)2+4	4.116e-21	2.404e-22	-20.386	-21.619	-1.233	(0)
FeHSeO3+2	1.753e-21	8.618e-22	-20.756	-21.065	-0.308	(0)
FeCl2+	9.438e-22	8.187e-22	-21.025	-21.087	-0.062	(0)
Fe3(OH)4+5	4.014e-25	4.746e-27	-24.396	-26.324	-1.927	(0)
FeCl3	1.127e-25	1.127e-25	-24.948	-24.948	0.000	(0)
H(0)	8.409e-28					
H2	4.205e-28	4.227e-28	-27.376	-27.374	0.002	(0)
K	1.019e-03					
K+	1.010e-03	8.727e-04	-2.996	-3.059	-0.063	(0)
KSO4-	9.198e-06	7.997e-06	-5.036	-5.097	-0.061	(0)
KCrO4-	6.928e-17	5.801e-17	-16.159	-16.236	-0.077	(0)
Mg	2.249e-03					
Mg+2	1.872e-03	1.044e-03	-2.728	-2.981	-0.254	(0)
MgSO4	2.458e-04	2.458e-04	-3.609	-3.609	0.000	(0)
MgHCO3+	8.769e-05	7.562e-05	-4.057	-4.121	-0.064	(0)
MgCO3	3.729e-05	3.729e-05	-4.428	-4.428	0.000	(0)
MgF+	5.561e-06	4.810e-06	-5.255	-5.318	-0.063	(0)
MgOH+	6.188e-07	5.411e-07	-6.208	-6.267	-0.058	(0)
MgH2BO3+	3.523e-08	3.008e-08	-7.453	-7.522	-0.069	(0)
Mn(2)	1.872e-06					
Mn+2	1.564e-06	7.688e-07	-5.806	-6.114	-0.308	(0)
MnSO4	1.769e-07	1.769e-07	-6.752	-6.752	0.000	(0)
MnHCO3+	1.252e-07	1.086e-07	-6.902	-6.964	-0.062	(0)
MnOH+	2.900e-09	2.515e-09	-8.538	-8.599	-0.062	(0)

MnCl+	1.536e-09	1.332e-09	-8.814	-8.875	-0.062	(0)
MnF+	1.449e-09	1.257e-09	-8.839	-8.901	-0.062	(0)
MnCl2	2.590e-12	2.590e-12	-11.587	-11.587	0.000	(0)
MnSeO4	2.245e-15	2.245e-15	-14.649	-14.649	0.000	(0)
MnCl3-	1.132e-15	9.816e-16	-14.946	-15.008	-0.062	(0)
Mn(OH)3-	3.041e-17	2.638e-17	-16.517	-16.579	-0.062	(0)
Mn(OH)4-2	1.959e-22	1.109e-22	-21.708	-21.955	-0.247	(0)
MnSe	6.443e-39	6.443e-39	-38.191	-38.191	0.000	(0)
Mn(3)	1.280e-27					
Mn+3	1.280e-27	3.434e-28	-26.893	-27.464	-0.571	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-43.394	-43.641	-0.247	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-48.946	-49.013	-0.067	(0)
Mo	1.294e-07					
MoO4-2	1.294e-07	7.212e-08	-6.888	-7.142	-0.254	(0)
HMoO4-	1.324e-11	1.109e-11	-10.878	-10.955	-0.077	(0)
H2MoO4	6.276e-16	6.276e-16	-15.202	-15.202	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-51.198	-51.891	-0.694	(0)
Mo7O24-6	0.000e+00	0.000e+00	-59.124	-61.899	-2.775	(0)
HMo7O24-5	0.000e+00	0.000e+00	-61.697	-63.624	-1.927	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-65.720	-66.954	-1.233	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-71.126	-71.820	-0.694	(0)
Na	9.129e-03					
Na+	9.028e-03	7.801e-03	-2.044	-2.108	-0.063	(0)
NaSO4-	6.237e-05	5.422e-05	-4.205	-4.266	-0.061	(0)
NaHCO3	3.106e-05	3.106e-05	-4.508	-4.508	0.000	(0)
NaCO3-	7.179e-06	6.241e-06	-5.144	-5.205	-0.061	(0)
NaF	2.022e-07	2.022e-07	-6.694	-6.694	0.000	(0)
NaH2BO3	1.028e-08	1.028e-08	-7.988	-7.988	0.000	(0)
NaCrO4-	8.282e-16	6.935e-16	-15.082	-15.159	-0.077	(0)
Ni	9.895e-08					
Ni+2	3.758e-08	2.094e-08	-7.425	-7.679	-0.254	(0)
NiCO3	3.357e-08	3.357e-08	-7.474	-7.474	0.000	(0)
NiHCO3+	2.184e-08	1.828e-08	-7.661	-7.738	-0.077	(0)
NiSO4	5.408e-09	5.408e-09	-8.267	-8.267	0.000	(0)
NiOH+	4.101e-10	3.434e-10	-9.387	-9.464	-0.077	(0)
NiCl+	8.807e-11	7.375e-11	-10.055	-10.132	-0.077	(0)
Ni(OH)2	3.553e-11	3.553e-11	-10.449	-10.449	0.000	(0)
NiF+	2.581e-11	2.161e-11	-10.588	-10.665	-0.077	(0)
Ni(SO4)2-2	4.715e-13	2.318e-13	-12.327	-12.635	-0.308	(0)
Ni(OH)3-	5.527e-14	4.628e-14	-13.257	-13.335	-0.077	(0)
NiCl2	5.111e-16	5.111e-16	-15.292	-15.292	0.000	(0)
NiSeO4	1.063e-16	1.063e-16	-15.973	-15.973	0.000	(0)
O(0)	5.640e-38					
O2	2.820e-38	2.835e-38	-37.550	-37.547	0.002	(0)
Pb	2.668e-07					
PbCO3	1.974e-07	1.974e-07	-6.705	-6.705	0.000	(0)
Pb(CO3)2-2	4.975e-08	2.446e-08	-7.303	-7.612	-0.308	(0)
PbHCO3+	9.604e-09	8.042e-09	-8.018	-8.095	-0.077	(0)
PbOH+	5.972e-09	5.000e-09	-8.224	-8.301	-0.077	(0)
Pb+2	2.742e-09	1.528e-09	-8.562	-8.816	-0.254	(0)
PbSO4	9.688e-10	9.688e-10	-9.014	-9.014	0.000	(0)
Pb(OH)2	2.060e-10	2.060e-10	-9.686	-9.686	0.000	(0)
PbCl+	8.913e-11	7.463e-11	-10.050	-10.127	-0.077	(0)
Pb(SO4)2-2	1.537e-11	7.556e-12	-10.813	-11.122	-0.308	(0)
PbF+	5.284e-12	4.424e-12	-11.277	-11.354	-0.077	(0)
PbCl2	4.588e-13	4.588e-13	-12.338	-12.338	0.000	(0)
Pb(OH)3-	3.204e-13	2.683e-13	-12.494	-12.571	-0.077	(0)
PbF2	3.577e-15	3.577e-15	-14.447	-14.447	0.000	(0)
Pb2OH+3	5.985e-16	1.211e-16	-15.223	-15.917	-0.694	(0)
PbCl3-	3.002e-16	2.514e-16	-15.523	-15.600	-0.077	(0)
Pb(OH)4-2	1.741e-16	8.559e-17	-15.759	-16.068	-0.308	(0)
Pb3(OH)4+2	2.631e-18	1.294e-18	-17.580	-17.888	-0.308	(0)
PbF3-	3.328e-19	2.787e-19	-18.478	-18.555	-0.077	(0)
PbCl4-2	3.217e-19	1.581e-19	-18.493	-18.801	-0.308	(0)
Pb4(OH)4+4	2.688e-22	1.571e-23	-21.570	-22.804	-1.233	(0)
PbF4-2	1.115e-23	5.480e-24	-22.953	-23.261	-0.308	(0)
S(6)	2.987e-03					
SO4-2	2.322e-03	1.294e-03	-2.634	-2.888	-0.254	(0)
CaSO4	3.472e-04	3.472e-04	-3.459	-3.459	0.000	(0)
MgSO4	2.458e-04	2.458e-04	-3.609	-3.609	0.000	(0)
NaSO4-	6.237e-05	5.422e-05	-4.205	-4.266	-0.061	(0)
KSO4-	9.198e-06	7.997e-06	-5.036	-5.097	-0.061	(0)
ZnSO4	1.936e-07	1.936e-07	-6.713	-6.713	0.000	(0)
MnSO4	1.769e-07	1.769e-07	-6.752	-6.752	0.000	(0)
CdSO4	7.183e-09	7.183e-09	-8.144	-8.144	0.000	(0)
NiSO4	5.408e-09	5.408e-09	-8.267	-8.267	0.000	(0)
CoSO4	4.721e-09	4.721e-09	-8.326	-8.326	0.000	(0)
Zn(SO4)2-2	4.439e-09	2.182e-09	-8.353	-8.661	-0.308	(0)
CuSO4	1.188e-09	1.188e-09	-8.925	-8.925	0.000	(0)
HSO4-	1.130e-09	9.773e-10	-8.947	-9.010	-0.063	(0)
FeSO4	1.096e-09	1.096e-09	-8.960	-8.960	0.000	(0)
PbSO4	9.688e-10	9.688e-10	-9.014	-9.014	0.000	(0)
Cd(SO4)2-2	2.551e-10	1.254e-10	-9.593	-9.902	-0.308	(0)
CrOHSO4	1.755e-10	1.755e-10	-9.756	-9.756	0.000	(0)
Pb(SO4)2-2	1.537e-11	7.556e-12	-10.813	-11.122	-0.308	(0)
Ni(SO4)2-2	4.715e-13	2.318e-13	-12.327	-12.635	-0.308	(0)
CrSO4+	7.239e-14	6.061e-14	-13.140	-13.217	-0.077	(0)
AlSO4+	5.061e-15	4.378e-15	-14.296	-14.359	-0.063	(0)
Al(SO4)2-	7.019e-17	6.071e-17	-16.154	-16.217	-0.063	(0)
FeSO4+	5.364e-17	4.653e-17	-16.271	-16.332	-0.062	(0)
Cr2(OH)2SO4+2	1.844e-17	9.068e-18	-16.734	-17.043	-0.308	(0)
UO2SO4	1.199e-17	1.199e-17	-16.921	-16.921	0.000	(0)
Fe(SO4)2-	1.538e-18	1.288e-18	-17.813	-17.890	-0.077	(0)
VO2SO4-	1.119e-18	9.368e-19	-17.951	-18.028	-0.077	(0)
Cr2(OH)2(SO4)2	6.971e-19	6.971e-19	-18.157	-18.157	0.000	(0)
UO2(SO4)2-2	4.162e-19	2.046e-19	-18.381	-18.689	-0.308	(0)
VOSO4	5.163e-21	5.163e-21	-20.287	-20.287	0.000	(0)
CrO3SO4-2	2.773e-24	1.363e-24	-23.557	-23.865	-0.308	(0)
VSO4+	3.134e-35	2.625e-35	-34.504	-34.581	-0.077	(0)
U(SO4)2	0.000e+00	0.000e+00	-43.721	-43.721	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-44.424	-44.733	-0.308	(0)
Se(-2)	1.877e-35					
HSe-	1.877e-35	1.572e-35	-34.727	-34.804	-0.077	(0)
MnSe	6.443e-39	6.443e-39	-38.191	-38.191	0.000	(0)
H2Se	9.426e-40	9.426e-40	-39.026	-39.026	0.000	(0)
Se-2	0.000e+00	0.000e+00	-41.383	-41.692	-0.308	(0)
Se(4)	2.282e-07					
HSeO3-	1.216e-07	1.018e-07	-6.915	-6.992	-0.077	(0)
SeO3-2	1.067e-07	5.245e-08	-6.972	-7.280	-0.308	(0)
H2SeO3	3.355e-13	3.355e-13	-12.474	-12.474	0.000	(0)
Cd(SeO3)2-2	1.092e-16	5.367e-17	-15.962	-16.270	-0.308	(0)
FeHSeO3+2	1.753e-21	8.618e-22	-20.756	-21.065	-0.308	(0)
Se(6)	1.948e-11					
SeO4-2	1.947e-11	1.085e-11	-10.711	-10.964	-0.254	(0)
MnSeO4	2.245e-15	2.245e-15	-14.649	-14.649	0.000	(0)
ZnSeO4	1.149e-15	1.149e-15	-14.940	-14.940	0.000	(0)
NiSeO4	1.063e-16	1.063e-16	-15.973	-15.973	0.000	(0)
CoSeO4	9.943e-17	9.943e-17	-16.002	-16.002	0.000	(0)
CdSeO4	4.784e-17	4.784e-17	-16.320	-16.320	0.000	(0)
HSeO4-	5.019e-18	4.202e-18	-17.299	-17.376	-0.077	(0)
Zn(SeO4)2-2	2.572e-26	1.264e-26	-25.590	-25.898	-0.308	(0)
U(3)	0.000e+00					
U+3	0.000e+00	0.000e+00	-60.547	-61.241	-0.694	(0)
U(4)	1.179e-21					
U(OH)5-	1.178e-21	9.868e-22	-20.929	-21.006	-0.077	(0)
U(OH)4	3.195e-25	3.195e-25	-24.496	-24.496	0.000	(0)
U(OH)3+	1.078e-29	9.029e-30	-28.967	-29.044	-0.077	(0)
U(OH)2+2	6.564e-35	3.227e-35	-34.183	-34.491	-0.308	(0)
UF3+	1.184e-40	0.000e+00	-39.927	-40.004	-0.077	(0)
UOH+3	0.000e+00	0.000e+00	-40.236	-40.930	-0.694	(0)
UF2+2	0.000e+00	0.000e+00	-40.509	-40.817	-0.308	(0)
UF4	0.000e+00	0.000e+00	-42.350	-42.350	0.000	(0)
UF+3	0.000e+00	0.000e+00	-42.837	-43.531	-0.694	(0)
U(SO4)2	0.000e+00	0.000e+00	-43.721	-43.721	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-44.424	-44.733	-0.308	(0)
UF5-	0.000e+00	0.000e+00	-45.062	-45.139	-0.077	(0)
UF6-2	0.000e+00	0.000e+00	-46.737	-47.045	-0.308	(0)
U+4	0.000e+00	0.000e+00	-47.211	-48.445	-1.233	(0)
UCl+3	0.000e+00	0.000e+00	-48.912	-49.606	-0.694	(0)
U6(OH)15+9	0.000e+00	0.000e+00	-179.902	-186.147	-6.244	(0)
U(5)	4.456e-19					
UO2+	4.456e-19	3.731e-19	-18.351	-18.428	-0.077	(0)
U(6)	3.492e-08					
UO2(CO3)3-4	3.309e-08	1.933e-09	-7.480	-8.714	-1.233	(0)
UO2(CO3)2-2	1.826e-09	8.976e-10	-8.739	-9.047	-0.308	(0)
UO2CO3	1.047e-12	1.047e-12	-11.980	-11.980	0.000	(0)
UO2OH+	1.199e-15	1.004e-15	-14.921	-14.998	-0.077	(0)
UO2F+	4.145e-17	3.471e-17	-16.382	-16.460	-0.077	(0)
UO2SO4	1.199e-17	1.199e-17	-16.921	-16.921	0.000	(0)
UO2+2	1.098e-17	6.121e-18	-16.959	-17.213	-0.254	(0)
UO2F2	4.112e-18	4.112e-18	-17.386	-17.386	0.000	(0)
UO2(SO4)2-2	4.162e-19	2.046e-19	-18.381	-18.689	-0.308	(0)
UO2F3-	5.068e-20	4.244e-20	-19.295	-19.372	-0.077	(0)
UO2Cl+	1.632e-20	1.366e-20	-19.787	-19.864	-0.077	(0)
UO2F4-2	2.817e-23	1.385e-23	-22.550	-22.859	-0.308	(0)
(UO2)2(OH)2+2	3.401e-24	1.672e-24	-23.468	-23.777	-0.308	(0)
(UO2)3(OH)5+	2.580e-27	2.160e-27	-26.588	-26.666	-0.077	(0)
V(2)	0.000e+00					
VOH+	0.000e+00	0.000e+00	-40.975	-41.052	-0.077	(0)
V+2	0.000e+00	0.000e+00	-42.369	-42.677	-0.308	(0)
V(3)	7.658e-14					
V(OH)3	7.658e-14	7.658e-14	-13.116	-13.116	0.000	(0)
V(OH)2+	4.568e-25	3.825e-25	-24.340	-24.417	-0.077	(0)
VOH+2	5.704e-29	2.804e-29	-28.244	-28.552	-0.308	(0)
V+3	2.123e-34	4.296e-35	-33.673	-34.367	-0.694	(0)
VSO4+	3.134e-35	2.625e-35	-34.504	-34.581	-0.077	(0)
V2(OH)3+3	0.000e+00	0.000e+00	-53.824	-54.518	-0.694	(0)
V2(OH)2+4	0.000e+00	0.000e+00	-55.071	-56.304	-1.233	(0)
V(4)	4.532e-18					
V(OH)3+	4.493e-18	3.762e-18	-17.347	-17.425	-0.077	(0)
VO+2	2.946e-20	1.448e-20	-19.531	-19.839	-0.308	(0)
VOSO4	5.163e-21	5.163e-21	-20.287	-20.287	0.000	(0)
VOF+	4.261e-21	3.568e-21	-20.370	-20.448	-0.077	(0)
VOCl+	6.678e-23	5.592e-23	-22.175	-22.252	-0.077	(0)
VOF2	5.497e-23	5.497e-23	-22.260	-22.260	0.000	(0)
VOF3-	9.568e-26	8.012e-26	-25.019	-25.096	-0.077	(0)
VOF4-2	2.702e-29	1.329e-29	-28.568	-28.877	-0.308	(0)
H2V2O4+2	1.444e-30	7.100e-31	-29.840	-30.149	-0.308	(0)
V(5)	4.718e-08					
H2VO4-	3.036e-08	2.542e-08	-7.518	-7.595	-0.077	(0)
HVO4-2	1.681e-08	8.265e-09	-7.774	-8.083	-0.308	(0)
H3VO4	1.964e-12	1.964e-12	-11.707	-11.707	0.000	(0)
H3V2O7-	3.853e-13	3.226e-13	-12.414	-12.491	-0.077	(0)
HV2O7-3	3.519e-13	7.123e-14	-12.454	-13.147	-0.694	(0)
VO4-3	2.649e-14	5.361e-15	-13.577	-14.271	-0.694	(0)
V2O7-4	4.247e-15	2.481e-16	-14.372	-15.605	-1.233	(0)
V3O9-3	8.513e-17	1.723e-17	-16.070	-16.764	-0.694	(0)
VO2+	3.508e-17	3.031e-17	-16.455	-16.518	-0.063	(0)
VO2F	2.184e-18	2.184e-18	-17.661	-17.661	0.000	(0)
VO2SO4-	1.119e-18	9.368e-19	-17.951	-18.028	-0.077	(0)
VO2F2-	3.890e-20	3.258e-20	-19.410	-19.487	-0.077	(0)
V4O12-4	3.127e-21	1.827e-22	-20.505	-21.738	-1.233	(0)
VO2F3-2	3.395e-23	1.669e-23	-22.469	-22.777	-0.308	(0)
VO2F4-3	1.667e-27	3.374e-28	-26.778	-27.472	-0.694	(0)
V10O28-6	0.000e+00	0.000e+00	-56.712	-59.488	-2.775	(0)
HV10O28-5	0.000e+00	0.000e+00	-57.486	-59.413	-1.927	(0)
H2V10O28-4	0.000e+00	0.000e+00	-61.084	-62.317	-1.233	(0)
Zn	3.430e-06					
ZnCO3	1.690e-06	1.690e-06	-5.772	-5.772	0.000	(0)
Zn+2	1.227e-06	6.836e-07	-5.911	-6.165	-0.254	(0)
ZnSO4	1.936e-07	1.936e-07	-6.713	-6.713	0.000	(0)
ZnHCO3+	1.828e-07	1.531e-07	-6.738	-6.815	-0.077	(0)
ZnOH+	1.063e-07	8.905e-08	-6.973	-7.050	-0.077	(0)
Zn(OH)2	1.838e-08	1.838e-08	-7.736	-7.736	0.000	(0)
Zn(SO4)2-2	4.439e-09	2.182e-09	-8.353	-8.661	-0.308	(0)
ZnOHCl	4.030e-09	4.030e-09	-8.395	-8.395	0.000	(0)
ZnCl+	2.741e-09	2.363e-09	-8.562	-8.626	-0.064	(0)
ZnF+	6.692e-10	5.603e-10	-9.174	-9.252	-0.077	(0)
Zn(OH)3-	1.433e-10	1.200e-10	-9.844	-9.921	-0.077	(0)
ZnCl2	5.155e-12	5.155e-12	-11.288	-11.288	0.000	(0)
Zn(OH)4-2	1.266e-14	6.223e-15	-13.898	-14.206	-0.308	(0)
ZnCl3-	6.536e-15	5.636e-15	-14.185	-14.249	-0.064	(0)
ZnSeO4	1.149e-15	1.149e-15	-14.940	-14.940	0.000	(0)
ZnCl4-2	6.850e-18	3.879e-18	-17.164	-17.411	-0.247	(0)
Zn(SeO4)2-2	2.572e-26	1.264e-26	-25.590	-25.898	-0.308	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.83	8.97	10.80	Al(OH)3
Al2(MoO4)3	-54.51	-52.15	2.37	Al2(MoO4)3
Al2O3	-1.70	17.95	19.65	Al2O3
Al4(OH)10SO4	-5.91	16.79	22.70	Al4(OH)10SO4
AlAsO4:2H2O	-10.59	-5.79	4.80	AlAsO4:2H2O
AlOHSO4	-6.91	-10.14	-3.23	AlOHSO4
Alunite	-4.85	-6.25	-1.40	KAl3(SO4)2(OH)6
Anglesite	-3.91	-11.70	-7.79	PbSO4
Anhydrite	-1.46	-5.82	-4.36	CaSO4
Antlerite	-4.42	4.37	8.79	Cu3(OH)4SO4
Aragonite	1.00	-7.30	-8.30	CaCO3
Arsenolite	-77.59	-80.35	-2.76	As4O6
Artinite	-3.71	5.89	9.60	MgCO3:Mg(OH)2:3H2O
As2O5	-36.23	-29.52	6.71	As2O5
Atacamite	-2.71	4.68	7.39	Cu2(OH)3Cl
Azurite	-0.80	-17.70	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-14.32	10.07	24.39	Ba(OH)2:8H2O
Ba2V2O7:2H2O	-12.54	3.33	15.87	Ba2V2O7:2H2O
Ba3(AsO4)2	9.60	0.69	-8.91	Ba3(AsO4)2
Ba3(VO4)2:4H2O	-19.54	13.40	32.94	Ba3(VO4)2:4H2O
BaCrO4	-10.23	-19.90	-9.67	BaCrO4
BaF2	-9.11	-14.93	-5.82	BaF2
BaMoO4	-6.33	-13.29	-6.96	BaMoO4
Barite	0.94	-9.04	-9.98	BaSO4
BaSeO3	-6.86	-5.03	1.83	BaSeO3
BaSeO4	-9.66	-17.12	-7.46	BaSeO4
Bianchite	-7.29	-9.05	-1.76	ZnSO4:6H2O
Birnessite	-9.11	8.98	18.09	MnO2
Bixbyite	-5.61	-6.26	-0.64	Mn2O3
Boehmite	0.40	8.97	8.58	AlOOH
Brochantite	-3.03	12.19	15.22	Cu4(OH)6SO4
Brucite	-3.60	13.24	16.84	Mg(OH)2
Bunsenite	-3.90	8.54	12.45	NiO
Ca(VO3)2	-9.18	-3.52	5.66	Ca(VO3)2
Ca2V2O7	-7.73	9.77	17.50	Ca2V2O7
Ca2V2O7:2H2O	-11.78	9.77	21.55	Ca2V2O7:2H2O
Ca3(AsO4)2:4H2O	-11.95	10.35	22.30	Ca3(AsO4)2:4H2O
Ca3(VO4)2	-15.90	23.06	38.96	Ca3(VO4)2
Ca3(VO4)2:4H2O	-16.80	23.06	39.86	Ca3(VO4)2:4H2O
CaCrO4	-14.41	-16.68	-2.27	CaCrO4
Calcite	1.18	-7.30	-8.48	CaCO3
CaMoO4	-2.12	-10.07	-7.95	CaMoO4

Carnotite	-4.57	-4.34	0.23	KUO2VO4
CaSeO3:2H2O	-4.63	-1.81	2.81	CaSeO3:2H2O
CaSeO4:2H2O	-10.88	-13.90	-3.02	CaSeO4:2H2O
Cd(BO2)2	-11.15	-1.31	9.84	Cd(BO2)2
Cd(OH)2	-5.05	8.60	13.64	Cd(OH)2
Cd(OH)2(am)	-5.13	8.60	13.73	Cd(OH)2
Cd3(OH)2(SO4)2	-19.14	-12.43	6.71	Cd3(OH)2(SO4)2
Cd3(OH)4SO4	-15.88	6.68	22.56	Cd3(OH)4SO4
Cd4(OH)6SO4	-13.12	15.28	28.40	Cd4(OH)6SO4
CdCl2	-12.69	-13.35	-0.66	CdCl2
CdCl2:1H2O	-11.66	-13.35	-1.69	CdCl2:1H2O
CdCl2:2.5H2O	-11.44	-13.35	-1.91	CdCl2:2.5H2O
CdF2	-15.19	-16.40	-1.21	CdF2
Cdmetal(alpha)	-29.14	-15.63	13.51	Cd
Cdmetal(gamma)	-29.24	-15.63	13.62	Cd
CdMoO4	-0.62	-14.77	-14.15	CdMoO4
CdOHCl	-5.91	-2.38	3.54	CdOHCl
CdSe	-14.12	-34.32	-20.20	CdSe
CdSeO4:2H2O	-16.74	-18.59	-1.85	CdSeO4:2H2O
CdSO4	-10.34	-10.51	-0.17	CdSO4
CdSO4:1H2O	-8.79	-10.51	-1.73	CdSO4:1H2O
CdSO4:2.67H2O	-8.64	-10.51	-1.87	CdSO4:2.67H2O
Cerussite	-0.05	-13.18	-13.13	PbCO3
CH4(g)	-76.44	-117.49	-41.05	CH4
Chalcanthite	-8.65	-11.29	-2.64	CuSO4:5H2O
Claudetite	-77.29	-80.35	-3.06	As4O6
Clausthalite	-8.41	-35.51	-27.10	PbSe
Co(BO2)2	-28.50	-1.43	27.07	Co(BO2)2
Co(OH)2	-4.61	8.49	13.09	Co(OH)2
Co(OH)3	-9.49	-11.80	-2.31	Co(OH)3
CO2(g)	-2.44	-20.59	-18.15	CO2
Co3(AsO4)2	-17.10	-4.07	13.03	Co3(AsO4)2
Co3O4	-4.62	-15.12	-10.50	Co3O4
CoCl2	-21.73	-13.46	8.27	CoCl2
CoCl2:6H2O	-16.00	-13.46	2.54	CoCl2:6H2O
CoCO3	-2.12	-12.10	-9.98	CoCO3
CoF2	-14.91	-16.51	-1.60	CoF2
CoF3	-47.84	-49.30	-1.46	CoF3
CoFe2O4	25.70	22.17	-3.53	CoFe2O4
CoMoO4	-7.12	-14.88	-7.76	CoMoO4
CoO	-5.10	8.49	13.59	CoO
CoSe	-18.23	-34.43	-16.20	CoSe
CoSeO3	-7.94	-6.62	1.32	CoSeO3
CoSeO4:6H2O	-17.17	-18.70	-1.53	CoSeO4:6H2O
CoSO4	-13.43	-10.63	2.80	CoSO4
CoSO4:6H2O	-8.15	-10.63	-2.47	CoSO4:6H2O
Cotunnite	-9.76	-14.54	-4.78	PbCl2
Cr(OH)2	-18.91	-8.10	10.82	Cr(OH)2
Cr(OH)3	-0.27	1.07	1.34	Cr(OH)3
Cr(OH)3(am)	1.82	1.07	-0.75	Cr(OH)3
Cr2O3	4.50	2.14	-2.36	Cr2O3
CrCl2	-44.13	-30.04	14.09	CrCl2
CrCl3	-46.96	-31.85	15.11	CrCl3
CrF3	-25.09	-36.43	-11.34	CrF3
Crmetal	-62.80	-32.32	30.48	Cr
CrO3	-26.76	-29.97	-3.21	CrO3
Cryolite	-14.16	-48.00	-33.84	Na3AlF6
Cu(OH)2	-0.85	7.83	8.67	Cu(OH)2
Cu2Se(alpha)	-0.31	-46.11	-45.80	Cu2Se
Cu2SO4	-20.35	-22.30	-1.95	Cu2SO4
Cu3(AsO4)2:2H2O	-12.14	-6.04	6.10	Cu3(AsO4)2:2H2O
Cu3Se2	-17.70	-81.19	-63.49	Cu3Se2
CuCO3	-1.26	-12.76	-11.50	CuCO3
CuCrO4	-16.70	-22.14	-5.44	CuCrO4
CuF	-9.19	-14.09	-4.91	CuF
CuF2	-18.28	-17.17	1.12	CuF2

CuF2:2H2O	-12.62	-17.17	-4.55	CuF2:2H2O
Cumetal	-4.95	-13.71	-8.76	Cu
CuMoO4	-2.46	-15.54	-13.08	CuMoO4
CuOCuSO4	-13.76	-3.46	10.30	CuOCuSO4
Cupricferrite	15.52	21.51	5.99	CuFe2O4
Cuprite	-1.78	-3.19	-1.41	Cu2O
Cuprousferrite	14.16	5.25	-8.92	CuFeO2
CuSe	-1.99	-35.09	-33.10	CuSe
CuSe2	-20.41	-53.78	-33.37	CuSe2
CuSeO3:2H2O	-7.79	-7.28	0.51	CuSeO3:2H2O
CuSeO4:5H2O	-16.92	-19.36	-2.44	CuSeO4:5H2O
CuSO4	-14.22	-11.29	2.94	CuSO4
Diaspore	2.10	8.97	6.87	AlOOH
Dolomite(disordered)	1.89	-14.65	-16.54	CaMg(CO3)2
Dolomite(ordered)	2.44	-14.65	-17.09	CaMg(CO3)2
Epsomite	-3.74	-5.87	-2.13	MgSO4:7H2O
Fe(OH)2	-5.80	7.76	13.56	Fe(OH)2
Fe(OH)2.7Cl.3	6.59	3.55	-3.04	Fe(OH)2.7Cl.3
Fe(VO3)2	-5.33	-9.05	-3.72	Fe(VO3)2
Fe2(OH)4SeO3	-2.98	-1.42	1.55	Fe2(OH)4SeO3
Fe2(SeO3)3:2H2O	-11.00	-31.63	-20.63	Fe2(SeO3)3:2H2O
Fe2(SO4)3	-39.92	-43.65	-3.73	Fe2(SO4)3
Fe3(OH)8	1.22	21.44	20.22	Fe3(OH)8
FeAsO4:2H2O	-8.32	-7.92	0.40	FeAsO4:2H2O
FeCr2O4	2.70	9.90	7.20	FeCr2O4
FeMoO4	-5.51	-15.60	-10.09	FeMoO4
Ferrihydrite	3.65	6.84	3.19	Fe(OH)3
Ferroselite	-35.25	-53.85	-18.60	FeSe2
FeSe	-24.15	-35.15	-11.00	FeSe
Fluorite	-1.20	-11.70	-10.50	CaF2
Gibbsite	0.68	8.97	8.29	Al(OH)3
Goethite	6.35	6.84	0.49	FeOOH
Goslarite	-7.04	-9.05	-2.01	ZnSO4:7H2O
Gummite	-8.66	-0.99	7.67	UO3
Gypsum	-1.21	-5.82	-4.61	CaSO4:2H2O
H-Jarosite	-5.60	-17.70	-12.10	(H3O)Fe3(SO4)2(OH)6
H2MoO4	-10.49	-23.37	-12.88	H2MoO4
H2Se(g)	-37.96	-42.92	-4.96	H2Se
Halite	-6.57	-4.97	1.60	NaCl
Hausmannite	-6.48	54.55	61.03	Mn3O4
Hematite	15.10	13.68	-1.42	Fe2O3
Hercynite	2.82	25.71	22.89	FeAl2O4
Huntite	0.62	-29.34	-29.97	CaMg3(CO3)4
Hydrocerussite	-0.19	-18.96	-18.77	Pb3(OH)2(CO3)2
Hydromagnesite	-7.39	-16.15	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-19.03	-24.20	-5.17	KAl(SO4)2:12H2O
K-Jarosite	2.15	-12.65	-14.80	KFe3(SO4)2(OH)6
K2Cr2O7	-32.59	-49.84	-17.24	K2Cr2O7
K2CrO4	-19.35	-19.87	-0.51	K2CrO4
K2MoO4	-16.52	-13.26	3.26	K2MoO4
K2SeO4	-16.35	-17.08	-0.73	K2SeO4
Langite	-5.29	12.19	17.49	Cu4(OH)6SO4:H2O
Larnakite	-3.86	-4.30	-0.43	PbO:PbSO4
Laurionite	-4.19	-3.57	0.62	PbOHCl
Lepidocrocite	5.47	6.84	1.37	FeOOH
Lime	-19.41	13.29	32.70	CaO
Litharge	-5.29	7.41	12.69	PbO
Maghemite	7.30	13.68	6.39	Fe2O3
Magnesioferrite	10.07	26.93	16.86	Fe2MgO4
Magnesite	0.11	-7.35	-7.46	MgCO3
Magnetite	18.04	21.44	3.40	Fe3O4
Malachite	0.37	-4.94	-5.31	Cu2(OH)2CO3
Manganite	-3.12	22.22	25.34	MnOOH
Massicot	-5.49	7.41	12.89	PbO
Matlockite	-7.09	-16.06	-8.97	PbClF
Melanothallite	-20.38	-14.12	6.26	CuCl2

Melanterite	-9.14	-11.35	-2.21	FeSO4:7H2O
Mg(OH)2(active)	-5.55	13.24	18.79	Mg(OH)2
Mg(VO3)2	-14.85	-3.57	11.28	Mg(VO3)2
Mg2V2O7	-16.69	9.67	26.36	Mg2V2O7
MgCr2O4	-0.82	15.38	16.20	MgCr2O4
MgCrO4	-22.11	-16.73	5.38	MgCrO4
MgF2	-3.62	-11.75	-8.13	MgF2
MgMoO4	-8.27	-10.12	-1.85	MgMoO4
MgSeO3:6H2O	-4.92	-1.86	3.06	MgSeO3:6H2O
MgSeO4:6H2O	-12.75	-13.95	-1.20	MgSeO4:6H2O
Minium	-27.07	46.45	73.52	Pb3O4
Mirabilite	-5.99	-7.11	-1.11	Na2SO4:10H2O
Mn(VO3)2	-11.60	-6.70	4.90	Mn(VO3)2
Mn2(SO4)3	-57.88	-63.59	-5.71	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-11.70	0.80	12.50	Mn3(AsO4)2:8H2O
MnCl2:4H2O	-14.55	-11.84	2.72	MnCl2:4H2O
MnSe	-36.31	-32.81	3.50	MnSe
MnSeO3	-6.12	-4.99	1.13	MnSeO3
MnSeO3:2H2O	-5.98	-4.99	0.98	MnSeO3:2H2O
MnSeO4:5H2O	-15.03	-17.08	-2.05	MnSeO4:5H2O
MnSO4	-11.59	-9.00	2.58	MnSO4
Monteponite	-6.51	8.60	15.10	CdO
MoO3	-15.37	-23.37	-8.00	MoO3
Morenosite	-8.42	-10.57	-2.14	NiSO4:7H2O
Na-Jarosite	-0.50	-11.70	-11.20	NaFe3(SO4)2(OH)6
Na2Cr2O7	-38.04	-47.93	-9.90	Na2Cr2O7
Na2CrO4	-20.89	-17.96	2.93	Na2CrO4
Na2Mo2O7	-18.13	-34.72	-16.60	Na2Mo2O7
Na2MoO4	-12.85	-11.36	1.49	Na2MoO4
Na2MoO4:2H2O	-12.58	-11.36	1.22	Na2MoO4:2H2O
Na2SeO3:5H2O	-13.40	-3.10	10.30	Na2SeO3:5H2O
Na2SeO4	-16.46	-15.18	1.28	Na2SeO4
Na3VO4	-27.08	9.61	36.68	Na3VO4
Na4V2O7	-30.20	7.20	37.40	Na4V2O7
Nantokite	-5.84	-12.57	-6.73	CuCl
Natron	-7.27	-8.58	-1.31	Na2CO3:10H2O
NaVO3	-6.26	-2.40	3.86	NaVO3
Nesquehonite	-2.68	-7.35	-4.67	MgCO3:3H2O
Ni(OH)2	-4.25	8.54	12.79	Ni(OH)2
Ni3(AsO4)2:8H2O	-19.59	-3.89	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-16.93	15.07	32.00	Ni4(OH)6SO4
NiCO3	-5.18	-12.05	-6.87	NiCO3
NiMoO4	-3.68	-14.82	-11.14	NiMoO4
NiSe	-16.67	-34.37	-17.70	NiSe
NiSeO3:2H2O	-9.37	-6.56	2.81	NiSeO3:2H2O
NiSeO4:6H2O	-17.12	-18.64	-1.52	NiSeO4:6H2O
Nsutite	-8.52	8.98	17.50	MnO2
O2(g)	-34.64	48.45	83.09	O2
Otavite	0.01	-11.99	-12.00	CdCO3
Pb(BO2)2	-9.02	-2.50	6.52	Pb(BO2)2
Pb(OH)2	-0.74	7.41	8.15	Pb(OH)2
Pb10(OH)6O(CO3)6	-40.70	-49.46	-8.76	Pb10(OH)6O(CO3)6
Pb2(OH)3Cl	-4.95	3.84	8.79	Pb2(OH)3Cl
Pb2O(OH)2	-11.37	14.82	26.19	Pb2O(OH)2
Pb2O3	-22.00	39.04	61.04	Pb2O3
Pb2OCO3	-5.22	-5.77	-0.56	Pb2OCO3
Pb2V2O7	-0.10	-2.00	-1.90	Pb2V2O7
Pb3(AsO4)2	-13.10	-7.30	5.80	Pb3(AsO4)2
Pb3(VO4)2	-0.73	5.41	6.14	Pb3(VO4)2
Pb3O2CO3	-9.39	1.63	11.02	Pb3O2CO3
Pb3O2SO4	-7.57	3.11	10.69	Pb3O2SO4
Pb4(OH)6SO4	-10.58	10.52	21.10	Pb4(OH)6SO4
Pb4O3SO4	-11.36	10.52	21.88	Pb4O3SO4
PbCrO4	-9.96	-22.56	-12.60	PbCrO4
PbF2	-10.15	-17.59	-7.44	PbF2
Pbmetal	-21.06	-16.82	4.25	Pb

PbMoO4	-0.34	-15.96	-15.62	PbMoO4
PbO:0.3H2O	-5.57	7.41	12.98	PbO:0.33H2O
PbSeO4	-12.94	-19.78	-6.84	PbSeO4
Periclase	-8.34	13.24	21.58	MgO
Phosgenite	-7.91	-27.72	-19.81	PbCl2:PbCO3
Plattnerite	-17.97	31.63	49.60	PbO2
Portlandite	-9.51	13.29	22.80	Ca(OH)2
Pyrochroite	-5.08	10.11	15.19	Mn(OH)2
Pyrolusite	-7.05	34.33	41.38	MnO2
Retgersite	-8.53	-10.57	-2.04	NiSO4:6H2O
Rhodochrosite	0.10	-10.48	-10.58	MnCO3
Rutherfordine	-7.08	-21.58	-14.50	UO2CO3
Schoepite	-6.98	-0.99	5.99	UO2(OH)2:H2O
Semetal(am)	-11.58	-18.69	-7.11	Se
Semetal(hex	-10.98	-18.69	-7.71	Se
SeO2	-15.23	-15.10	0.12	SeO2
SeO3	-48.23	-27.19	21.04	SeO3
Siderite	-2.59	-12.83	-10.24	FeCO3
Smithsonite	-0.53	-10.53	-10.00	ZnCO3
Spinel	-5.66	31.19	36.85	MgAl2O4
Tenorite	0.18	7.83	7.64	CuO
Thenardite	-7.43	-7.10	0.32	Na2SO4
Thermonatrite	-9.22	-8.58	0.64	Na2CO3:H2O
Tyuyamunite	-9.58	-5.50	4.08	Ca(UO2)2(VO4)2
U3O8	-20.63	0.46	21.08	U3O8
U4O9	-36.75	-39.76	-3.02	U4O9
UF4	-36.45	-65.99	-29.54	UF4
UF4:2.5H2O	-33.27	-65.99	-32.72	UF4:2.5H2O
UO2(am)	-16.93	-16.00	0.93	UO2
UO2(OH)2(beta)	-6.60	-0.99	5.61	UO2(OH)2
UO2SeO4:4H2O	-25.93	-28.18	-2.25	UO2SeO4:4H2O
UO3	-8.69	-0.99	7.70	UO3
Uraninite	-11.33	-16.00	-4.67	UO2
V(OH)3	-17.62	-10.03	7.59	V(OH)3
V2O5	-15.45	-16.81	-1.36	V2O5
V3O5	-36.91	-35.07	1.84	V3O5
V4O7	-45.87	-38.69	7.19	V4O7
V6O13	-38.03	-98.89	-60.86	V6O13
VCl2	-62.96	-44.09	18.87	VCl2
VCl3	-66.38	-42.95	23.43	VCl3
VF4	-68.54	-53.61	14.93	VF4
Vmetal	-90.39	-46.37	44.03	V
VO	-36.90	-22.14	14.76	VO
VO(OH)2	-8.77	-3.62	5.15	VO(OH)2
VO2Cl	-22.22	-19.38	2.84	VO2Cl
VOCl	-32.16	-21.00	11.15	VOCl
VOCl2	-38.32	-25.56	12.76	VOCl2
VOSO4	-26.34	-22.73	3.61	VOSO4
Witherite	-1.95	-10.52	-8.57	BaCO3
Zincite	-1.28	10.06	11.33	ZnO
Zincosite	-12.98	-9.05	3.93	ZnSO4
Zn(BO2)2	-8.14	0.15	8.29	Zn(BO2)2
Zn(OH)2	-2.14	10.06	12.20	Zn(OH)2
Zn(OH)2(am)	-2.42	10.06	12.47	Zn(OH)2
Zn(OH)2(beta)	-1.70	10.06	11.75	Zn(OH)2
Zn(OH)2(epsilon)	-1.48	10.06	11.53	Zn(OH)2
Zn(OH)2(gamma)	-1.68	10.06	11.73	Zn(OH)2
Zn2(OH)2SO4	-6.49	1.01	7.50	Zn2(OH)2SO4
Zn2(OH)3Cl	-6.05	9.14	15.19	Zn2(OH)3Cl
Zn3(AsO4)2:2.5H2O	-13.00	0.65	13.65	Zn3(AsO4)2:2.5H2O
Zn3O(SO4)2	-26.96	-8.05	18.91	Zn3O(SO4)2
Zn4(OH)6SO4	-7.28	21.12	28.40	Zn4(OH)6SO4
Zn5(OH)8Cl2	-10.15	28.35	38.50	Zn5(OH)8Cl2
ZnCl2	-18.94	-11.89	7.05	ZnCl2
ZnCO3:1H2O	-0.27	-10.53	-10.26	ZnCO3:1H2O
ZnF2	-14.40	-14.94	-0.53	ZnF2

```
  Znmetal         -39.95    -14.17   25.79  Zn
  ZnMoO4           -3.18    -13.31  -10.13  ZnMoO4
  ZnO(active)      -1.13     10.06   11.19  ZnO
  ZnSe            -18.46    -32.86  -14.40  ZnSe
  ZnSeO4:6H2O     -15.61    -17.13   -1.52  ZnSeO4:6H2O
  ZnSO4:1H2O       -8.42     -9.05   -0.64  ZnSO4:1H2O

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
  For ideal gases, phi = 1.

Initial solution 2.     PAF Material

-----------------------------Solution composition------------------------------

      Elements           Molality       Moles

      Al                7.415e-07   7.415e-07
      Alkalinity        3.607e-04   3.607e-04
      Ba                1.457e-07   1.457e-07
      Ca                1.672e-03   1.672e-03
      Co                1.188e-07   1.188e-07
      Cu                4.408e-07   4.408e-07
      F                 1.580e-05   1.580e-05
      K                 3.326e-04   3.326e-04
      Mg                3.293e-04   3.293e-04
      Mn                7.283e-07   7.283e-07
      Mo                3.128e-08   3.128e-08
      Na                4.351e-05   4.351e-05
      Ni                6.818e-08   6.818e-08
      S(6)              2.051e-03   2.051e-03

----------------------------Description of solution----------------------------

                                    pH  =   7.500
                                    pe  =   4.000
                          Activity of water  =   1.000
                  Ionic strength (mol/kgw)  =   7.200e-03
                      Mass of water (kg)  =   1.000e+00
                  Total carbon (mol/kg)  =   3.782e-04
                     Total CO2 (mol/kg)  =   3.782e-04
                       Temperature (°C)  =  25.00
                  Electrical balance (eq)  =  -9.478e-05
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -1.25
                             Iterations  =  13 (23 overall)
                                Total H  = 1.110141e+02
                                Total O  = 5.551618e+01

----------------------------Distribution of species----------------------------

                                                Log       Log       Log    mole V
   Species          Molality    Activity  Molality  Activity     Gamma    cm³/mol

   OH-             3.487e-07   3.184e-07    -6.458    -6.497    -0.039     (0)
   H+              3.458e-08   3.162e-08    -7.461    -7.500    -0.039      0.00
   H2O             5.551e+01   9.999e-01     1.744    -0.000     0.000     18.07
Al              7.415e-07
   Al(OH)4-        7.221e-07   6.609e-07    -6.141    -6.180    -0.038     (0)
   Al(OH)3         1.649e-08   1.649e-08    -7.783    -7.783     0.000     (0)
   Al(OH)2+        2.830e-09   2.595e-09    -8.548    -8.586    -0.038     (0)
   AlF2+           2.736e-11   2.509e-11   -10.563   -10.600    -0.038     (0)
   AlOH+2          1.451e-11   1.026e-11   -10.838   -10.989    -0.150     (0)
   AlF+2           6.374e-12   4.507e-12   -11.196   -11.346    -0.150     (0)
   AlF3            4.418e-12   4.418e-12   -11.355   -11.355     0.000     (0)
   AlSO4+          3.315e-13   3.034e-13   -12.480   -12.518    -0.038     (0)
   Al+3            7.201e-14   3.223e-14   -13.143   -13.492    -0.349     (0)
   AlF4-           3.383e-14   3.096e-14   -13.471   -13.509    -0.038     (0)
   Al(SO4)2-       4.307e-15   3.942e-15   -14.366   -14.404    -0.038     (0)
   AlMo6O21-3      0.000e+00   0.000e+00   -49.070   -49.460    -0.390     (0)
Ba              1.457e-07
   Ba+2            1.453e-07   1.017e-07    -6.838    -6.993    -0.155     (0)
   BaHCO3+         3.363e-10   3.088e-10    -9.473    -9.510    -0.037     (0)
   BaCO3           2.459e-11   2.459e-11   -10.609   -10.609     0.000     (0)
   BaOH+           1.542e-13   1.413e-13   -12.812   -12.850    -0.038     (0)
C(4)            3.782e-04
   HCO3-           3.469e-04   3.181e-04    -3.460    -3.497    -0.038     (0)
   H2CO3           2.262e-05   2.262e-05    -4.645    -4.645     0.000     (0)
   CaHCO3+         6.292e-06   5.777e-06    -5.201    -5.238    -0.037     (0)
   CaCO3           7.289e-07   7.289e-07    -6.137    -6.137     0.000     (0)
   MgHCO3+         7.079e-07   6.472e-07    -6.150    -6.189    -0.039     (0)
   CO3-2           6.741e-07   4.716e-07    -6.171    -6.326    -0.155     (0)
   CuCO3           2.133e-07   2.133e-07    -6.671    -6.671     0.000     (0)
   MgCO3           7.799e-08   7.799e-08    -7.108    -7.108     0.000     (0)
   NaHCO3          7.071e-09   7.071e-09    -8.151    -8.151     0.000     (0)
   MnHCO3+         2.944e-09   2.697e-09    -8.531    -8.569    -0.038     (0)
   CoHCO3+         1.830e-09   1.657e-09    -8.738    -8.781    -0.043     (0)
   CuHCO3+         1.703e-09   1.542e-09    -8.769    -8.812    -0.043     (0)
   NiHCO3+         1.700e-09   1.539e-09    -8.770    -8.813    -0.043     (0)
   NiCO3           6.904e-10   6.904e-10    -9.161    -9.161     0.000     (0)
   CoCO3           5.337e-10   5.337e-10    -9.273    -9.273     0.000     (0)
   Cu(CO3)2-2      4.033e-10   2.707e-10    -9.394    -9.567    -0.173     (0)
   NaCO3-          3.785e-10   3.471e-10    -9.422    -9.460    -0.038     (0)
   BaHCO3+         3.363e-10   3.088e-10    -9.473    -9.510    -0.037     (0)
   BaCO3           2.459e-11   2.459e-11   -10.609   -10.609     0.000     (0)
Ca              1.672e-03
   Ca+2            1.394e-03   9.753e-04    -2.856    -3.011    -0.155     (0)
   CaSO4           2.709e-04   2.709e-04    -3.567    -3.567     0.000     (0)
   CaHCO3+         6.292e-06   5.777e-06    -5.201    -5.238    -0.037     (0)
   CaCO3           7.289e-07   7.289e-07    -6.137    -6.137     0.000     (0)
   CaF+            1.625e-07   1.489e-07    -6.789    -6.827    -0.038     (0)
   CaOH+           6.748e-09   6.196e-09    -8.171    -8.208    -0.037     (0)
Co(2)           1.188e-07
   Co+2            9.974e-08   6.695e-08    -7.001    -7.174    -0.173     (0)
   CoSO4           1.620e-08   1.620e-08    -7.791    -7.791     0.000     (0)
   CoHCO3+         1.830e-09   1.657e-09    -8.738    -8.781    -0.043     (0)
   CoCO3           5.337e-10   5.337e-10    -9.273    -9.273     0.000     (0)
   CoOH+           4.699e-10   4.253e-10    -9.328    -9.371    -0.043     (0)
   CoF+            3.271e-11   2.961e-11   -10.485   -10.529    -0.043     (0)
   Co(OH)2         1.076e-11   1.076e-11   -10.968   -10.968     0.000     (0)
   Co(OH)3-        7.550e-17   6.834e-17   -16.122   -16.165    -0.043     (0)
   CoOOH-          1.894e-17   1.715e-17   -16.723   -16.766    -0.043     (0)
   Co2OH+3         3.499e-18   1.427e-18   -17.456   -17.846    -0.390     (0)
   Co(OH)4-2       5.137e-24   3.448e-24   -23.289   -23.462    -0.173     (0)
   Co4(OH)4+4      3.216e-29   6.530e-30   -28.493   -29.185    -0.692     (0)
Co(3)           6.424e-30
   CoOH+2          6.424e-30   4.312e-30   -29.192   -29.365    -0.173     (0)
   Co+3            5.955e-36   2.665e-36   -35.225   -35.574    -0.349     (0)
Cu(1)           4.157e-09
   Cu+             4.157e-09   3.762e-09    -8.381    -8.425    -0.043     (0)
Cu(2)           4.366e-07
   CuCO3           2.133e-07   2.133e-07    -6.671    -6.671     0.000     (0)
   Cu+2            1.098e-07   7.682e-08    -6.959    -7.115    -0.155     (0)
   CuOH+           8.460e-08   7.735e-08    -7.073    -7.112    -0.039     (0)
   CuSO4           2.134e-08   2.134e-08    -7.671    -7.671     0.000     (0)
   Cu(OH)2         4.914e-09   4.914e-09    -8.309    -8.309     0.000     (0)
   CuHCO3+         1.703e-09   1.542e-09    -8.769    -8.812    -0.043     (0)
   Cu(CO3)2-2      4.033e-10   2.707e-10    -9.394    -9.567    -0.173     (0)
   Cu2(OH)2+2      2.239e-10   1.503e-10    -9.650    -9.823    -0.173     (0)
   CuF+            7.488e-11   6.778e-11   -10.126   -10.169    -0.043     (0)
   Cu(OH)3-        3.545e-12   3.209e-12   -11.450   -11.494    -0.043     (0)
   Cu(OH)4-2       1.198e-17   8.042e-18   -16.922   -17.095    -0.173     (0)
F               1.580e-05
   F-              1.529e-05   1.398e-05    -4.816    -4.854    -0.039     (0)
   MgF+            3.409e-07   3.120e-07    -6.467    -6.506    -0.038     (0)
   CaF+            1.625e-07   1.489e-07    -6.789    -6.827    -0.038     (0)
   HF              6.541e-10   6.541e-10    -9.184    -9.184     0.000     (0)
   NaF             3.488e-10   3.488e-10    -9.457    -9.457     0.000     (0)
   MnF+            2.582e-10   2.366e-10    -9.588    -9.626    -0.038     (0)
   CuF+            7.488e-11   6.778e-11   -10.126   -10.169    -0.043     (0)
   CoF+            3.271e-11   2.961e-11   -10.485   -10.529    -0.043     (0)
   AlF2+           2.736e-11   2.509e-11   -10.563   -10.600    -0.038     (0)
   NiF+            1.523e-11   1.379e-11   -10.817   -10.861    -0.043     (0)
   AlF+2           6.374e-12   4.507e-12   -11.196   -11.346    -0.150     (0)
   AlF3            4.418e-12   4.418e-12   -11.355   -11.355     0.000     (0)
   HF2-            3.808e-14   3.478e-14   -13.419   -13.459    -0.039     (0)
   AlF4-           3.383e-14   3.096e-14   -13.471   -13.509    -0.038     (0)
   H2F2            1.146e-18   1.146e-18   -17.941   -17.941     0.000     (0)
H(0)            1.414e-26
   H2              7.068e-27   7.079e-27   -26.151   -26.150     0.001     (0)
K               3.326e-04
   K+              3.298e-04   3.016e-04    -3.482    -3.521    -0.039     (0)
   KSO4-           2.823e-06   2.589e-06    -5.549    -5.587    -0.038     (0)
Mg              3.293e-04
   Mg+2            2.842e-04   1.988e-04    -3.546    -3.702    -0.155     (0)
   MgSO4           4.387e-05   4.387e-05    -4.358    -4.358     0.000     (0)
   MgHCO3+         7.079e-07   6.472e-07    -6.150    -6.189    -0.039     (0)
   MgF+            3.409e-07   3.120e-07    -6.467    -6.506    -0.038     (0)
   MgCO3           7.799e-08   7.799e-08    -7.108    -7.108     0.000     (0)
   MgOH+           2.742e-08   2.520e-08    -7.562    -7.599    -0.037     (0)
Mn(2)           7.283e-07
   Mn+2            6.331e-07   4.250e-07    -6.199    -6.372    -0.173     (0)
   MnSO4           9.164e-08   9.164e-08    -7.038    -7.038     0.000     (0)
   MnHCO3+         2.944e-09   2.697e-09    -8.531    -8.569    -0.038     (0)
   MnOH+           3.710e-10   3.399e-10    -9.431    -9.469    -0.038     (0)
   MnF+            2.582e-10   2.366e-10    -9.588    -9.626    -0.038     (0)
   Mn(OH)3-        2.324e-19   2.129e-19   -18.634   -18.672    -0.038     (0)
   Mn(OH)4-2       3.106e-25   2.189e-25   -24.508   -24.660    -0.152     (0)
Mn(3)           4.241e-28
   Mn+3            4.241e-28   1.898e-28   -27.373   -27.722    -0.349     (0)
Mn(6)           0.000e+00
   MnO4-2          0.000e+00   0.000e+00   -48.642   -48.794    -0.152     (0)
Mn(7)           0.000e+00
   MnO4-           0.000e+00   0.000e+00   -54.126   -54.166    -0.040     (0)
Mo              3.128e-08
   MoO4-2          3.126e-08   2.187e-08    -7.505    -7.660    -0.155     (0)
   HMoO4-          1.520e-11   1.376e-11   -10.818   -10.861    -0.043     (0)
   H2MoO4          3.188e-15   3.188e-15   -14.497   -14.497     0.000     (0)
   AlMo6O21-3      0.000e+00   0.000e+00   -49.070   -49.460    -0.390     (0)
   Mo7O24-6        0.000e+00   0.000e+00   -59.073   -60.631    -1.558     (0)
   HMo7O24-5       0.000e+00   0.000e+00   -60.662   -61.744    -1.082     (0)
   H2Mo7O24-4      0.000e+00   0.000e+00   -63.769   -64.462    -0.692     (0)
   H3Mo7O24-3      0.000e+00   0.000e+00   -68.326   -68.716    -0.390     (0)
Na              4.351e-05
   Na+             4.322e-05   3.953e-05    -4.364    -4.403    -0.039     (0)
   NaSO4-          2.807e-07   2.574e-07    -6.552    -6.589    -0.038     (0)
   NaHCO3          7.071e-09   7.071e-09    -8.151    -8.151     0.000     (0)
   NaCO3-          3.785e-10   3.471e-10    -9.422    -9.460    -0.038     (0)
   NaF             3.488e-10   3.488e-10    -9.457    -9.457     0.000     (0)
Ni              6.818e-08
   Ni+2            5.610e-08   3.924e-08    -7.251    -7.406    -0.155     (0)
   NiSO4           9.495e-09   9.495e-09    -8.023    -8.023     0.000     (0)
   NiHCO3+         1.700e-09   1.539e-09    -8.770    -8.813    -0.043     (0)
   NiCO3           6.904e-10   6.904e-10    -9.161    -9.161     0.000     (0)
   NiOH+           1.738e-10   1.573e-10    -9.760    -9.803    -0.043     (0)
   NiF+            1.523e-11   1.379e-11   -10.817   -10.861    -0.043     (0)
   Ni(OH)2         3.978e-12   3.978e-12   -11.400   -11.400     0.000     (0)
   Ni(SO4)2-2      5.679e-13   3.812e-13   -12.246   -12.419    -0.173     (0)
   Ni(OH)3-        1.399e-15   1.267e-15   -14.854   -14.897    -0.043     (0)
O(0)            2.019e-40
   O2              1.010e-40   1.011e-40   -39.996   -39.995     0.001     (0)
S(6)            2.051e-03
   SO4-2           1.733e-03   1.213e-03    -2.761    -2.916    -0.155     (0)
   CaSO4           2.709e-04   2.709e-04    -3.567    -3.567     0.000     (0)
   MgSO4           4.387e-05   4.387e-05    -4.358    -4.358     0.000     (0)
   KSO4-           2.823e-06   2.589e-06    -5.549    -5.587    -0.038     (0)
   NaSO4-          2.807e-07   2.574e-07    -6.552    -6.589    -0.038     (0)
   MnSO4           9.164e-08   9.164e-08    -7.038    -7.038     0.000     (0)
   CuSO4           2.134e-08   2.134e-08    -7.671    -7.671     0.000     (0)
   CoSO4           1.620e-08   1.620e-08    -7.791    -7.791     0.000     (0)
   NiSO4           9.495e-09   9.495e-09    -8.023    -8.023     0.000     (0)
   HSO4-           4.094e-09   3.747e-09    -8.388    -8.426    -0.038     (0)
   Ni(SO4)2-2      5.679e-13   3.812e-13   -12.246   -12.419    -0.173     (0)
   AlSO4+          3.315e-13   3.034e-13   -12.480   -12.518    -0.038     (0)
   Al(SO4)2-       4.307e-15   3.942e-15   -14.366   -14.404    -0.038     (0)

---------------------------Saturation indices---------------------------

  Phase               SI** log IAP   log K(298 K,   1 atm)

  Al(OH)3(am)       -1.79     9.01   10.80  Al(OH)3
  Al2(MoO4)3       -52.33    -49.96    2.37  Al2(MoO4)3
  Al2O3             -1.64    18.02   19.65  Al2O3
  Al4(OH)10SO4      -4.58    18.12   22.70  Al4(OH)10SO4
  AlOHSO4           -5.68    -8.91   -3.23  AlOHSO4
  Alunite           -3.43    -4.83   -1.40  KAl3(SO4)2(OH)6
  Anhydrite         -1.57    -5.93   -4.36  CaSO4
  Antlerite         -3.05     5.74    8.79  Cu3(OH)4SO4
  Aragonite         -1.04    -9.34   -8.30  CaCO3
  Artinite          -8.33     1.27    9.60  MgCO3:Mg(OH)2:3H2O
  Azurite           -2.09   -19.00  -16.91  Cu3(OH)2(CO3)2
  Ba(OH)2:8H2O     -16.39     8.01   24.39  Ba(OH)2:8H2O
  BaF2             -10.88   -16.70   -5.82  BaF2
  BaMoO4            -7.69   -14.65   -6.96  BaMoO4
  Barite             0.07    -9.91   -9.98  BaSO4
  Birnessite       -11.81     6.28   18.09  MnO2
  Bixbyite          -9.80   -10.44   -0.64  Mn2O3
  Boehmite           0.43     9.01    8.58  AlOOH
  Brochantite       -1.60    13.63   15.22  Cu4(OH)6SO4
  Brucite           -5.55    11.30   16.84  Mg(OH)2
  Bunsenite         -4.85     7.59   12.45  NiO
  Calcite           -0.86    -9.34   -8.48  CaCO3
  CaMoO4            -2.72   -10.67   -7.95  CaMoO4
  CH4(g)           -72.28  -113.33  -41.05  CH4
  Chalcanthite      -7.39   -10.03   -2.64  CuSO4:5H2O
  Co(OH)2           -5.27     7.83   13.09  Co(OH)2
  Co(OH)3          -10.77   -13.07   -2.31  Co(OH)3
  CO2(g)            -3.18   -21.33  -18.15  CO2
  Co3O4             -7.83   -18.32  -10.50  Co3O4
  CoCO3             -3.52   -13.50   -9.98  CoCO3
  CoF2             -15.29   -16.88   -1.60  CoF2
  CoF3             -48.68   -50.14   -1.46  CoF3
  CoMoO4            -7.07   -14.83   -7.76  CoMoO4
  CoO               -5.76     7.83   13.59  CoO
  CoSO4            -12.89   -10.09    2.80  CoSO4
  CoSO4:6H2O        -7.62   -10.09   -2.47  CoSO4:6H2O
  Cryolite         -21.99   -55.83  -33.84  Na3AlF6
  Cu(OH)2           -0.79     7.89    8.67  Cu(OH)2
  Cu2SO4           -17.82   -19.77   -1.95  Cu2SO4
  CuCO3             -1.94   -13.44  -11.50  CuCO3
  CuF               -8.37   -13.28   -4.91  CuF
  CuF2             -17.94   -16.82    1.12  CuF2
  CuF2:2H2O        -12.27   -16.82   -4.55  CuF2:2H2O
  Cumetal           -3.67   -12.42   -8.76  Cu
  CuMoO4            -1.70   -14.77  -13.08  CuMoO4
  CuOCuSO4         -12.45    -2.15   10.30  CuOCuSO4
```

Cuprite	-0.44	-1.85	-1.41	Cu2O
CuSO4	-12.97	-10.03	2.94	CuSO4
Diaspore	2.14	9.01	6.87	AlOOH
Dolomite(disordered)	-2.83	-19.37	-16.54	CaMg(CO3)2
Dolomite(ordered)	-2.28	-19.37	-17.09	CaMg(CO3)2
Epsomite	-4.49	-6.62	-2.13	MgSO4:7H2O
Fluorite	-2.22	-12.72	-10.50	CaF2
Gibbsite	0.72	9.01	8.29	Al(OH)3
Gypsum	-1.32	-5.93	-4.61	CaSO4:2H2O
H2MoO4	-9.78	-22.66	-12.88	H2MoO4
Hausmannite	-12.15	48.88	61.03	Mn3O4
Huntite	-9.45	-39.42	-29.97	CaMg3(CO3)4
Hydromagnesite	-20.05	-28.81	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-17.68	-22.85	-5.17	KAl(SO4)2:12H2O
K2MoO4	-17.96	-14.70	3.26	K2MoO4
Langite	-3.86	13.63	17.49	Cu4(OH)6SO4:H2O
Lime	-20.71	11.99	32.70	CaO
Magnesite	-2.57	-10.03	-7.46	MgCO3
Malachite	-0.25	-5.56	-5.31	Cu2(OH)2CO3
Manganite	-5.21	20.13	25.34	MnOOH
Mg(OH)2(active)	-7.50	11.30	18.79	Mg(OH)2
MgF2	-5.28	-13.41	-8.13	MgF2
MgMoO4	-9.51	-11.36	-1.85	MgMoO4
Mirabilite	-10.61	-11.72	-1.11	Na2SO4:10H2O
Mn2(SO4)3	-58.48	-64.19	-5.71	Mn2(SO4)3
MnSO4	-11.87	-9.29	2.58	MnSO4
MoO3	-14.66	-22.66	-8.00	MoO3
Morenosite	-8.18	-10.32	-2.14	NiSO4:7H2O
Na2Mo2O7	-22.53	-39.13	-16.60	Na2Mo2O7
Na2MoO4	-17.96	-16.47	1.49	Na2MoO4
Na2MoO4:2H2O	-17.69	-16.47	1.22	Na2MoO4:2H2O
Natron	-13.82	-15.13	-1.31	Na2CO3:10H2O
Nesquehonite	-5.36	-10.03	-4.67	MgCO3:3H2O
Ni(OH)2	-5.20	7.59	12.79	Ni(OH)2
Ni4(OH)6SO4	-19.54	12.46	32.00	Ni4(OH)6SO4
NiCO3	-6.86	-13.73	-6.87	NiCO3
NiMoO4	-3.92	-15.07	-11.14	NiMoO4
Nsutite	-11.23	6.28	17.50	MnO2
O2(g)	-37.09	46.00	83.09	O2
Periclase	-10.29	11.30	21.58	MgO
Portlandite	-10.81	11.99	22.80	Ca(OH)2
Pyrochroite	-6.57	8.63	15.19	Mn(OH)2
Pyrolusite	-9.75	31.63	41.38	MnO2
Retgersite	-8.28	-10.32	-2.04	NiSO4:6H2O
Rhodochrosite	-2.12	-12.70	-10.58	MnCO3
Spinel	-7.53	29.31	36.85	MgAl2O4
Tenorite	0.24	7.89	7.64	CuO
Thenardite	-12.04	-11.72	0.32	Na2SO4
Thermonatrite	-15.77	-15.13	0.64	Na2CO3:H2O
Witherite	-4.75	-13.32	-8.57	BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Initial solution 3. NAF Material

----------Solution composition----------

Elements	Molality	Moles
Al	5.191e-06	5.191e-06
Alkalinity	4.591e-04	4.591e-04
As	3.873e-07	3.873e-07
Ba	1.457e-07	1.457e-07
Ca	3.046e-03	3.046e-03
Co	3.395e-08	3.395e-08
Cu	2.992e-07	2.992e-07
F	1.580e-05	1.580e-05
Fe	1.254e-06	1.254e-06
K	4.094e-04	4.094e-04
Mg	7.410e-04	7.410e-04
Mn	2.368e-06	2.368e-06
Mo	5.214e-08	5.214e-08
Na	4.352e-05	4.352e-05
Ni	1.705e-08	1.705e-08
S(6)	3.447e-03	3.447e-03
U	4.203e-09	4.203e-09

----------Description of solution----------

pH	= 7.600
pe	= 4.000
Activity of water	= 1.000
Ionic strength (mol/kgw)	= 1.193e-02
Mass of water (kg)	= 1.000e+00
Total carbon (mol/kg)	= 4.552e-04
Total CO2 (mol/kg)	= 4.552e-04
Temperature (°C)	= 25.00
Electrical balance (eq)	= 6.787e-04
Percent error, 100*(Cat-|An|)/(Cat+|An|)	= 5.48
Iterations	= 11 (34 overall)
Total H	= 1.110142e+02
Total O	= 5.552201e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
OH-	4.492e-07	4.008e-07	-6.348	-6.397	-0.049	(0)
H+	2.808e-08	2.512e-08	-7.552	-7.600	-0.048	0.00
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000	18.07
Al	**5.191e-06**					
Al(OH)4-	5.088e-06	4.556e-06	-5.293	-5.341	-0.048	(0)
Al(OH)3	9.030e-08	9.030e-08	-7.044	-7.044	0.000	(0)
Al(OH)2+	1.257e-08	1.129e-08	-7.901	-7.947	-0.047	(0)
AlF2+	6.958e-11	6.249e-11	-10.158	-10.204	-0.047	(0)
AlOH+2	5.451e-11	3.546e-11	-10.264	-10.450	-0.187	(0)
AlF+2	1.811e-11	1.178e-11	-10.742	-10.929	-0.187	(0)
AlF3	1.048e-11	1.048e-11	-10.980	-10.980	0.000	(0)
AlSO4+	1.328e-12	1.189e-12	-11.877	-11.925	-0.048	(0)
Al+3	2.412e-13	8.848e-14	-12.618	-13.053	-0.436	(0)
AlF4-	7.812e-14	6.995e-14	-13.107	-13.155	-0.048	(0)
Al(SO4)2-	2.463e-14	2.206e-14	-13.608	-13.656	-0.048	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-48.018	-48.520	-0.501	(0)
As(3)	**1.024e-17**					
H3AsO3	1.000e-17	1.000e-17	-17.000	-17.000	0.000	(0)
H2AsO3-	2.322e-19	2.043e-19	-18.634	-18.690	-0.056	(0)
HAsO3-2	1.239e-23	7.417e-24	-22.907	-23.130	-0.223	(0)
H4AsO3+	1.416e-25	1.245e-25	-24.849	-24.905	-0.056	(0)
AsO3-3	3.611e-29	1.138e-29	-28.442	-28.944	-0.501	(0)
As(5)	**3.873e-07**					
HAsO4-2	3.350e-07	2.005e-07	-6.475	-6.698	-0.223	(0)
H2AsO4-	5.222e-08	4.594e-08	-7.282	-7.338	-0.056	(0)
AsO4-3	8.009e-11	2.524e-11	-10.096	-10.598	-0.501	(0)
H3AsO4	2.000e-13	2.005e-13	-12.699	-12.698	0.001	(0)
Ba	**1.457e-07**					
Ba+2	1.453e-07	9.304e-08	-6.838	-7.031	-0.194	(0)
BaHCO3+	3.699e-10	3.328e-10	-9.432	-9.478	-0.046	(0)
BaCO3	3.336e-11	3.336e-11	-10.477	-10.477	0.000	(0)
BaOH+	1.815e-13	1.628e-13	-12.741	-12.788	-0.047	(0)
C(4)	**4.552e-04**					
HCO3-	4.171e-04	3.746e-04	-3.380	-3.426	-0.047	(0)
H2CO3	2.116e-05	2.116e-05	-4.674	-4.674	0.000	(0)
CaHCO3+	1.200e-05	1.080e-05	-4.921	-4.967	-0.046	(0)
CaCO3	1.715e-06	1.715e-06	-5.766	-5.766	0.000	(0)
MgHCO3+	1.687e-06	1.508e-06	-5.773	-5.822	-0.049	(0)
CO3-2	1.092e-06	6.991e-07	-5.962	-6.155	-0.194	(0)
MgCO3	2.288e-07	2.288e-07	-6.641	-6.641	0.000	(0)
CuCO3	1.600e-07	1.600e-07	-6.796	-6.796	0.000	(0)
MnHCO3+	9.921e-09	8.899e-09	-8.003	-8.051	-0.047	(0)
NaHCO3	8.124e-09	8.124e-09	-8.090	-8.090	0.000	(0)
UO2(CO3)2-2	3.482e-09	2.084e-09	-8.458	-8.681	-0.223	(0)
CuHCO3+	1.044e-09	9.187e-10	-8.981	-9.037	-0.056	(0)
UO2(CO3)3-4	5.687e-10	7.303e-11	-9.245	-10.136	-0.891	(0)
NaCO3-	5.590e-10	5.020e-10	-9.253	-9.299	-0.047	(0)
CoHCO3+	5.432e-10	4.778e-10	-9.265	-9.321	-0.056	(0)
Cu(CO3)2-2	5.030e-10	3.011e-10	-9.298	-9.521	-0.223	(0)
NiHCO3+	4.493e-10	3.952e-10	-9.347	-9.403	-0.056	(0)
BaHCO3+	3.699e-10	3.328e-10	-9.432	-9.478	-0.046	(0)
NiCO3	2.232e-10	2.232e-10	-9.651	-9.651	0.000	(0)
CoCO3	1.938e-10	1.938e-10	-9.713	-9.713	0.000	(0)
UO2CO3	1.494e-10	1.494e-10	-9.826	-9.826	0.000	(0)
FeHCO3+	1.083e-10	9.748e-11	-9.965	-10.011	-0.046	(0)
BaCO3	3.336e-11	3.336e-11	-10.477	-10.477	0.000	(0)
Ca	**3.046e-03**					
Ca+2	2.418e-03	1.548e-03	-2.617	-2.810	-0.194	(0)
CaSO4	6.140e-04	6.140e-04	-3.212	-3.212	0.000	(0)
CaHCO3+	1.200e-05	1.080e-05	-4.921	-4.967	-0.046	(0)
CaCO3	1.715e-06	1.715e-06	-5.766	-5.766	0.000	(0)
CaF+	2.509e-07	2.251e-07	-6.600	-6.648	-0.047	(0)
CaOH+	1.376e-08	1.238e-08	-7.861	-7.907	-0.046	(0)
Co(2)	**3.395e-08**					
Co+2	2.739e-08	1.640e-08	-7.562	-7.785	-0.223	(0)
CoSO4	5.664e-09	5.664e-09	-8.247	-8.247	0.000	(0)
CoHCO3+	5.432e-10	4.778e-10	-9.265	-9.321	-0.056	(0)
CoCO3	1.938e-10	1.938e-10	-9.713	-9.713	0.000	(0)
CoOH+	1.491e-10	1.311e-10	-9.827	-9.882	-0.056	(0)
CoF+	7.852e-12	6.907e-12	-11.105	-11.161	-0.056	(0)
Co(OH)2	4.175e-12	4.175e-12	-11.379	-11.379	0.000	(0)
Co(OH)3-	3.796e-17	3.339e-17	-16.421	-16.476	-0.056	(0)
CoOOH-	9.525e-18	8.379e-18	-17.021	-17.077	-0.056	(0)
Co2OH+3	3.419e-19	1.078e-19	-18.466	-18.968	-0.501	(0)
Co(OH)4-2	3.543e-24	2.121e-24	-23.451	-23.673	-0.223	(0)
Co4(OH)4+4	4.595e-31	5.900e-32	-30.338	-31.229	-0.891	(0)
Co(3)	**2.221e-30**					
CoOH+2	2.221e-30	1.330e-30	-29.653	-29.876	-0.223	(0)
Co+3	1.780e-36	6.528e-37	-35.750	-36.185	-0.436	(0)
Cu(1)	**2.164e-09**					
Cu+	2.164e-09	1.904e-09	-8.665	-8.720	-0.056	(0)
Cu(2)	**2.970e-07**					
CuCO3	1.600e-07	1.600e-07	-6.796	-6.796	0.000	(0)
Cu+2	6.070e-08	3.887e-08	-7.217	-7.410	-0.194	(0)
CuOH+	5.512e-08	4.927e-08	-7.259	-7.307	-0.049	(0)
CuSO4	1.542e-08	1.542e-08	-7.812	-7.812	0.000	(0)
Cu(OH)2	3.940e-09	3.940e-09	-8.404	-8.404	0.000	(0)
CuHCO3+	1.044e-09	9.187e-10	-8.981	-9.037	-0.056	(0)
Cu(CO3)2-2	5.030e-10	3.011e-10	-9.298	-9.521	-0.223	(0)
Cu2(OH)2+2	1.019e-10	6.097e-11	-9.992	-10.215	-0.223	(0)
CuF+	3.714e-11	3.267e-11	-10.430	-10.486	-0.056	(0)
Cu(OH)3-	3.683e-12	3.239e-12	-11.434	-11.490	-0.056	(0)
Cu(OH)4-2	1.707e-17	1.022e-17	-16.768	-16.991	-0.223	(0)
F	**1.580e-05**					
F-	1.489e-05	1.332e-05	-4.827	-4.876	-0.048	(0)
MgF+	6.566e-07	5.879e-07	-6.183	-6.231	-0.048	(0)
CaF+	2.509e-07	2.251e-07	-6.600	-6.648	-0.047	(0)
MnF+	7.039e-10	6.314e-10	-9.152	-9.200	-0.047	(0)
HF	4.949e-10	4.949e-10	-9.306	-9.306	0.000	(0)
NaF	3.241e-10	3.241e-10	-9.489	-9.489	0.000	(0)
AlF2+	6.958e-11	6.249e-11	-10.158	-10.204	-0.047	(0)
CuF+	3.714e-11	3.267e-11	-10.430	-10.486	-0.056	(0)
AlF+2	1.811e-11	1.178e-11	-10.742	-10.929	-0.187	(0)
AlF3	1.048e-11	1.048e-11	-10.980	-10.980	0.000	(0)
CoF+	7.852e-12	6.907e-12	-11.105	-11.161	-0.056	(0)
NiF+	3.255e-12	2.863e-12	-11.487	-11.543	-0.056	(0)
UO2F+	1.122e-13	9.871e-14	-12.950	-13.006	-0.056	(0)
AlF4-	7.812e-14	6.995e-14	-13.107	-13.155	-0.048	(0)
HF2-	2.808e-14	2.506e-14	-13.552	-13.601	-0.049	(0)
UO2F2	3.792e-15	3.792e-15	-14.421	-14.421	0.000	(0)
FeF+2	4.333e-16	2.804e-16	-15.363	-15.552	-0.189	(0)
FeF2+	1.114e-16	9.996e-17	-15.953	-16.000	-0.047	(0)
UO2F3-	1.442e-17	1.269e-17	-16.841	-16.897	-0.056	(0)
FeF3	1.879e-18	1.879e-18	-17.726	-17.726	0.000	(0)
H2F2	6.561e-19	6.561e-19	-18.183	-18.183	0.000	(0)
UO2F4-2	2.242e-21	1.342e-21	-20.649	-20.872	-0.223	(0)
UF3+	3.760e-36	3.307e-36	-35.425	-35.481	-0.056	(0)
UF2+2	2.617e-36	1.567e-36	-35.582	-35.805	-0.223	(0)
UF+3	2.964e-38	9.342e-39	-37.528	-38.030	-0.501	(0)
UF4	4.830e-39	4.830e-39	-38.316	-38.316	0.000	(0)
UF5-	0.000e+00	0.000e+00	-41.538	-41.594	-0.056	(0)
UF6-2	0.000e+00	0.000e+00	-43.766	-43.989	-0.223	(0)
Fe(2)	**4.379e-08**					
Fe+2	3.453e-08	2.067e-08	-7.462	-7.685	-0.223	(0)
FeSO4	8.785e-09	8.785e-09	-8.056	-8.056	0.000	(0)
FeOH+	3.677e-10	3.298e-10	-9.434	-9.482	-0.047	(0)
FeHCO3+	1.083e-10	9.748e-11	-9.965	-10.011	-0.046	(0)
Fe(OH)2	1.050e-13	1.050e-13	-12.979	-12.979	0.000	(0)
Fe(OH)3-	1.484e-14	1.331e-14	-13.829	-13.876	-0.047	(0)
Fe(3)	**1.210e-06**					
Fe(OH)2+	8.628e-07	7.749e-07	-6.064	-6.111	-0.047	(0)
Fe(OH)3	3.336e-07	3.336e-07	-6.477	-6.477	0.000	(0)
Fe(OH)4-	1.386e-08	1.245e-08	-7.858	-7.905	-0.047	(0)
FeOH+2	7.678e-12	4.969e-12	-11.115	-11.304	-0.189	(0)
FeF+2	4.333e-16	2.804e-16	-15.363	-15.552	-0.189	(0)
FeSO4+	4.159e-16	3.730e-16	-15.381	-15.428	-0.047	(0)
FeF2+	1.114e-16	9.996e-17	-15.953	-16.000	-0.047	(0)
Fe+3	5.236e-17	1.920e-17	-16.281	-16.717	-0.436	(0)
Fe(SO4)2-	1.570e-17	1.381e-17	-16.804	-16.860	-0.056	(0)
FeF3	1.879e-18	1.879e-18	-17.726	-17.726	0.000	(0)
Fe2(OH)2+4	6.368e-21	8.178e-22	-20.196	-21.087	-0.891	(0)
Fe3(OH)4+5	2.263e-25	9.160e-27	-24.645	-26.038	-1.393	(0)
H(0)	**8.909e-27**					
H2	4.455e-27	4.467e-27	-26.351	-26.350	0.001	(0)
K	**4.094e-04**					
K+	4.045e-04	3.618e-04	-3.393	-3.441	-0.048	(0)
KSO4-	4.938e-06	4.435e-06	-5.306	-5.353	-0.047	(0)
Mg	**7.410e-04**					
Mg+2	6.144e-04	3.934e-04	-3.212	-3.405	-0.194	(0)
MgSO4	1.239e-04	1.239e-04	-3.907	-3.907	0.000	(0)
MgHCO3+	1.687e-06	1.508e-06	-5.773	-5.822	-0.049	(0)
MgF+	6.566e-07	5.879e-07	-6.183	-6.231	-0.048	(0)
MgCO3	2.288e-07	2.288e-07	-6.641	-6.641	0.000	(0)
MgOH+	6.966e-08	6.278e-08	-7.157	-7.202	-0.045	(0)
Mn(2)	**2.368e-06**					
Mn+2	1.989e-06	1.191e-06	-5.701	-5.924	-0.223	(0)
MnSO4	3.666e-07	3.666e-07	-6.436	-6.436	0.000	(0)
MnHCO3+	9.921e-09	8.899e-09	-8.003	-8.051	-0.047	(0)
MnOH+	1.337e-09	1.199e-09	-8.874	-8.921	-0.047	(0)
MnF+	7.039e-10	6.314e-10	-9.152	-9.200	-0.047	(0)
Mn(OH)3-	1.327e-18	1.190e-18	-17.877	-17.924	-0.047	(0)
Mn(OH)4-2	2.380e-24	1.540e-24	-23.623	-23.812	-0.189	(0)
Mn(3)	**1.450e-27**					
Mn+3	1.450e-27	5.318e-28	-26.839	-27.274	-0.436	(0)
Mn(6)	**0.000e+00**					

MnO4-2	0.000e+00	0.000e+00	-47.357	-47.546	-0.189	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-52.868	-52.918	-0.050	(0)
Mo	5.214e-08					
MoO4-2	5.212e-08	3.338e-08	-7.283	-7.477	-0.194	(0)
HMoO4-	1.896e-11	1.668e-11	-10.722	-10.778	-0.056	(0)
H2MoO4	3.069e-15	3.069e-15	-14.513	-14.513	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-48.018	-48.520	-0.501	(0)
Mo7O24-6	0.000e+00	0.000e+00	-58.140	-60.146	-2.006	(0)
HMo7O24-5	0.000e+00	0.000e+00	-59.966	-61.359	-1.393	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-63.285	-64.177	-0.891	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-68.029	-68.531	-0.501	(0)
Na	4.352e-05					
Na+	4.311e-05	3.857e-05	-4.365	-4.414	-0.048	(0)
NaSO4-	3.992e-07	3.586e-07	-6.399	-6.445	-0.047	(0)
NaHCO3	8.124e-09	8.124e-09	-8.090	-8.090	0.000	(0)
NaCO3-	5.590e-10	5.020e-10	-9.253	-9.299	-0.047	(0)
NaF	3.241e-10	3.241e-10	-9.489	-9.489	0.000	(0)
Ni	1.705e-08					
Ni+2	1.336e-08	8.558e-09	-7.874	-8.068	-0.194	(0)
NiSO4	2.956e-09	2.956e-09	-8.529	-8.529	0.000	(0)
NiHCO3+	4.493e-10	3.952e-10	-9.347	-9.403	-0.056	(0)
NiCO3	2.232e-10	2.232e-10	-9.651	-9.651	0.000	(0)
NiOH+	4.909e-11	4.318e-11	-10.309	-10.365	-0.056	(0)
NiF+	3.255e-12	2.863e-12	-11.487	-11.543	-0.056	(0)
Ni(OH)2	1.375e-12	1.375e-12	-11.862	-11.862	0.000	(0)
Ni(SO4)2-2	2.831e-13	1.695e-13	-12.548	-12.771	-0.223	(0)
Ni(OH)3-	6.265e-16	5.511e-16	-15.203	-15.259	-0.056	(0)
O(0)	5.066e-40					
O2	2.533e-40	2.540e-40	-39.596	-39.595	0.001	(0)
S(6)	3.447e-03					
SO4-2	2.704e-03	1.731e-03	-2.568	-2.762	-0.194	(0)
CaSO4	6.140e-04	6.140e-04	-3.212	-3.212	0.000	(0)
MgSO4	1.239e-04	1.239e-04	-3.907	-3.907	0.000	(0)
KSO4-	4.938e-06	4.435e-06	-5.306	-5.353	-0.047	(0)
NaSO4-	3.992e-07	3.586e-07	-6.399	-6.445	-0.047	(0)
MnSO4	3.666e-07	3.666e-07	-6.436	-6.436	0.000	(0)
CuSO4	1.542e-08	1.542e-08	-7.812	-7.812	0.000	(0)
FeSO4	8.785e-09	8.785e-09	-8.056	-8.056	0.000	(0)
CoSO4	5.664e-09	5.664e-09	-8.247	-8.247	0.000	(0)
HSO4-	4.746e-09	4.250e-09	-8.324	-8.372	-0.048	(0)
NiSO4	2.956e-09	2.956e-09	-8.529	-8.529	0.000	(0)
AlSO4+	1.328e-12	1.189e-12	-11.877	-11.925	-0.048	(0)
Ni(SO4)2-2	2.831e-13	1.695e-13	-12.548	-12.771	-0.223	(0)
UO2SO4	1.407e-13	1.407e-13	-12.852	-12.852	0.000	(0)
Al(SO4)2-	2.463e-14	2.206e-14	-13.608	-13.656	-0.048	(0)
UO2(SO4)2-2	5.363e-15	3.210e-15	-14.271	-14.493	-0.223	(0)
FeSO4+	4.159e-16	3.730e-16	-15.381	-15.428	-0.047	(0)
Fe(SO4)2-	1.570e-17	1.381e-17	-16.804	-16.860	-0.056	(0)
U(SO4)2	3.332e-38	3.332e-38	-37.477	-37.477	0.000	(0)
USO4+2	4.047e-39	2.423e-39	-38.393	-38.616	-0.223	(0)
U(3)	0.000e+00					
U+3	0.000e+00	0.000e+00	-54.749	-55.250	-0.501	(0)
U(4)	3.033e-18					
U(OH)5-	3.030e-18	2.665e-18	-17.519	-17.574	-0.056	(0)
U(OH)4	2.804e-21	2.804e-21	-20.552	-20.552	0.000	(0)
U(OH)3+	2.928e-25	2.575e-25	-24.533	-24.589	-0.056	(0)
U(OH)2+2	4.997e-30	2.991e-30	-29.301	-29.524	-0.223	(0)
UOH+3	1.123e-35	3.539e-36	-34.950	-35.451	-0.501	(0)
UF3+	3.760e-36	3.307e-36	-35.425	-35.481	-0.056	(0)
UF2+2	2.617e-36	1.567e-36	-35.582	-35.805	-0.223	(0)
U(SO4)2	3.332e-38	3.332e-38	-37.477	-37.477	0.000	(0)
UF+3	2.964e-38	9.342e-39	-37.528	-38.030	-0.501	(0)
UF4	4.830e-39	4.830e-39	-38.316	-38.316	0.000	(0)
USO4+2	4.047e-39	2.423e-39	-38.393	-38.616	-0.223	(0)
UF5-	0.000e+00	0.000e+00	-41.538	-41.594	-0.056	(0)
U+4	0.000e+00	0.000e+00	-41.563	-42.454	-0.891	(0)
UF6-2	0.000e+00	0.000e+00	-43.766	-43.989	-0.223	(0)
U6(OH)15+9	0.000e+00	0.000e+00	-153.367	-157.880	-4.513	(0)
U(5)	3.720e-15					
UO2+	3.720e-15	3.272e-15	-14.429	-14.485	-0.056	(0)
U(6)	4.203e-09					
UO2(CO3)2-2	3.482e-09	2.084e-09	-8.458	-8.681	-0.223	(0)
UO2(CO3)3-4	5.687e-10	7.303e-11	-9.245	-10.136	-0.891	(0)
UO2CO3	1.494e-10	1.494e-10	-9.826	-9.826	0.000	(0)
UO2OH+	3.080e-12	2.709e-12	-11.511	-11.567	-0.056	(0)
UO2SO4	1.407e-13	1.407e-13	-12.852	-12.852	0.000	(0)
UO2F+	1.122e-13	9.871e-14	-12.950	-13.006	-0.056	(0)
UO2+2	8.384e-14	5.369e-14	-13.077	-13.270	-0.194	(0)
UO2(SO4)2-2	5.363e-15	3.210e-15	-14.271	-14.493	-0.223	(0)
UO2F2	3.792e-15	3.792e-15	-14.421	-14.421	0.000	(0)
(UO2)2(OH)2+2	2.034e-17	1.218e-17	-16.692	-16.914	-0.223	(0)
UO2F3-	1.442e-17	1.269e-17	-16.841	-16.897	-0.056	(0)
(UO2)3(OH)5+	4.571e-18	4.021e-18	-17.340	-17.396	-0.056	(0)
UO2F4-2	2.242e-21	1.342e-21	-20.649	-20.872	-0.223	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.05	9.75	10.80	Al(OH)3
Al2(MoO4)3	-50.90	-48.54	2.37	Al2(MoO4)3
Al2O3	-0.16	19.49	19.65	Al2O3
Al4(OH)10SO4	-1.67	21.03	22.70	Al4(OH)10SO4
AlAsO4:2H2O	-7.75	-2.95	4.80	AlAsO4:2H2O
AlOHSO4	-4.98	-8.21	-3.23	AlOHSO4
Alunite	-1.12	-2.52	-1.40	KAl3(SO4)2(OH)6
Anhydrite	-1.21	-5.57	-4.36	CaSO4
Antlerite	-3.38	5.41	8.79	Cu3(OH)4SO4
Aragonite	-0.67	-8.97	-8.30	CaCO3
Arsenolite	-65.24	-68.00	-2.76	As4O6
Artinite	-7.37	2.23	9.60	MgCO3:Mg(OH)2:3H2O
As2O5	-32.10	-25.40	6.71	As2O5
Azurite	-2.44	-19.34	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-16.23	8.17	24.39	Ba(OH)2:8H2O
Ba3(AsO4)2	8.02	-0.89	-8.91	Ba3(AsO4)2
BaF2	-10.96	-16.78	-5.82	BaF2
BaMoO4	-7.55	-14.51	-6.96	BaMoO4
Barite	0.19	-9.79	-9.98	BaSO4
Birnessite	-10.97	7.13	18.09	MnO2
Bixbyite	-8.30	-8.95	-0.64	Mn2O3
Boehmite	1.17	9.75	8.58	AlOOH
Brochantite	-2.03	13.20	15.22	Cu4(OH)6SO4
Brucite	-5.05	11.79	16.84	Mg(OH)2
Bunsenite	-5.31	7.13	12.45	NiO
Ca3(AsO4)2:4H2O	-10.53	11.77	22.30	Ca3(AsO4)2:4H2O
Calcite	-0.49	-8.97	-8.48	CaCO3
CaMoO4	-2.34	-10.29	-7.95	CaMoO4
CH4(g)	-73.11	-114.16	-41.05	CH4
Chalcanthite	-7.53	-10.17	-2.64	CuSO4:5H2O
Claudetite	-64.93	-68.00	-3.06	As4O6
Co(OH)2	-5.68	7.41	13.09	Co(OH)2
Co(OH)3	-11.08	-13.39	-2.31	Co(OH)3
CO2(g)	-3.21	-21.36	-18.15	CO2
Co3(AsO4)2	-16.19	-3.15	13.03	Co3(AsO4)2
Co3O4	-8.86	-19.36	-10.50	Co3O4
CoCO3	-3.96	-13.94	-9.98	CoCO3
CoF2	-15.94	-17.54	-1.60	CoF2
CoF3	-49.35	-50.81	-1.46	CoF3
CoFe2O4	23.11	19.58	-3.53	CoFe2O4
CoMoO4	-7.50	-15.26	-7.76	CoMoO4
CoO	-6.17	7.41	13.59	CoO
CoSO4	-13.35	-10.55	2.80	CoSO4
CoSO4:6H2O	-8.07	-10.55	-2.47	CoSO4:6H2O
Cryolite	-21.71	-55.55	-33.84	Na3AlF6
Cu(OH)2	-0.88	7.79	8.67	Cu(OH)2
Cu2SO4	-18.25	-20.20	-1.95	Cu2SO4
Cu3(AsO4)2:2H2O	-8.13	-2.03	6.10	Cu3(AsO4)2:2H2O
CuCO3	-2.07	-13.57	-11.50	CuCO3
CuF	-8.69	-13.60	-4.91	CuF
CuF2	-18.28	-17.16	1.12	CuF2
CuF2:2H2O	-12.61	-17.16	-4.55	CuF2:2H2O
Cumetal	-3.96	-12.72	-8.76	Cu
CuMoO4	-1.81	-14.89	-13.08	CuMoO4
CuOCuSO4	-12.69	-2.38	10.30	CuOCuSO4
Cupricferrite	13.97	19.96	5.99	CuFe2O4
Cuprite	-0.83	-2.24	-1.41	Cu2O
Cuprousferrite	13.88	4.96	-8.92	CuFeO2
CuSO4	-13.11	-10.17	2.94	CuSO4
Diaspore	2.87	9.75	6.87	AlOOH
Dolomite(disordered)	-1.99	-18.53	-16.54	CaMg(CO3)2
Dolomite(ordered)	-1.44	-18.53	-17.09	CaMg(CO3)2
Epsomite	-4.04	-6.17	-2.13	MgSO4:7H2O
Fe(OH)2	-6.05	7.52	13.56	Fe(OH)2
Fe2(SO4)3	-37.98	-41.72	-3.73	Fe2(SO4)3
Fe3(OH)8	-0.54	19.68	20.22	Fe3(OH)8
FeAsO4:2H2O	-7.01	-6.61	0.40	FeAsO4:2H2O
FeMoO4	-5.07	-15.16	-10.09	FeMoO4
Ferrihydrite	2.89	6.08	3.19	Fe(OH)3
Fluorite	-2.06	-12.56	-10.50	CaF2
Gibbsite	1.46	9.75	8.29	Al(OH)3
Goethite	5.59	6.08	0.49	FeOOH
Gummite	-5.74	1.93	7.67	UO3
Gypsum	-0.96	-5.57	-4.61	CaSO4:2H2O
H-Jarosite	-5.57	-17.67	-12.10	(H3O)Fe3(SO4)2(OH)6
H2MoO4	-9.80	-22.68	-12.88	H2MoO4
Hausmannite	-10.00	51.03	61.03	Mn3O4
Hematite	13.58	12.17	-1.42	Fe2O3
Hercynite	4.12	27.01	22.89	FeAl2O4
Huntite	-7.68	-37.65	-29.97	CaMg3(CO3)4
Hydromagnesite	-17.68	-26.45	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-16.85	-22.02	-5.17	KAl(SO4)2:12H2O
K-Jarosite	1.28	-13.52	-14.80	KFe3(SO4)2(OH)6
K2MoO4	-17.62	-14.36	3.26	K2MoO4
Langite	-4.29	13.20	17.49	Cu4(OH)6SO4:H2O
Lepidocrocite	4.71	6.08	1.37	FeOOH
Lime	-20.31	12.39	32.70	CaO
Maghemite	5.78	12.17	6.39	Fe2O3
Magnesioferrite	7.10	23.96	16.86	Fe2MgO4
Magnesite	-2.10	-9.56	-7.46	MgCO3
Magnetite	16.28	19.68	3.40	Fe3O4
Malachite	-0.47	-5.78	-5.31	Cu2(OH)2CO3
Manganite	-4.46	20.88	25.34	MnOOH
Melanterite	-8.24	-10.45	-2.21	FeSO4:7H2O
Mg(OH)2(active)	-7.00	11.79	18.79	Mg(OH)2
MgF2	-5.03	-13.16	-8.13	MgF2
MgMoO4	-9.03	-10.88	-1.85	MgMoO4
Mirabilite	-10.48	-11.59	-1.11	Na2SO4:10H2O
Mn2(SO4)3	-57.12	-62.83	-5.71	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-10.07	2.43	12.50	Mn3(AsO4)2:8H2O
MnSO4	-11.27	-8.69	2.58	MnSO4
MoO3	-14.68	-22.68	-8.00	MoO3
Morenosite	-8.68	-10.83	-2.14	NiSO4:7H2O
Na-Jarosite	-3.29	-14.49	-11.20	NaFe3(SO4)2(OH)6
Na2Mo2O7	-22.38	-38.98	-16.60	Na2Mo2O7
Na2MoO4	-17.79	-16.30	1.49	Na2MoO4
Na2MoO4:2H2O	-17.53	-16.30	1.22	Na2MoO4:2H2O
Natron	-13.67	-14.98	-1.31	Na2CO3:10H2O
Nesquehonite	-4.89	-9.56	-4.67	MgCO3:3H2O
Ni(OH)2	-5.66	7.13	12.79	Ni(OH)2
Ni3(AsO4)2:8H2O	-19.70	-4.00	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-21.43	10.57	32.00	Ni4(OH)6SO4
NiCO3	-7.35	-14.22	-6.87	NiCO3
NiMoO4	-4.40	-15.54	-11.14	NiMoO4
Nsutite	-10.38	7.13	17.50	MnO2
O2(g)	-36.69	46.40	83.09	O2
Periclase	-9.79	11.79	21.58	MgO
Portlandite	-10.41	12.39	22.80	Ca(OH)2
Pyrochroite	-5.92	9.28	15.19	Mn(OH)2
Pyrolusite	-8.90	32.48	41.38	MnO2
Retgersite	-8.79	-10.83	-2.04	NiSO4:6H2O
Rhodochrosite	-1.50	-12.08	-10.58	MnCO3
Rutherfordine	-4.93	-19.43	-14.50	UO2CO3
Schoepite	-4.06	1.93	5.99	UO2(OH)2:H2O
Siderite	-3.60	-13.84	-10.24	FeCO3
Spinel	-5.56	31.29	36.85	MgAl2O4
Tenorite	0.15	7.79	7.64	CuO
Thenardite	-11.91	-11.59	0.32	Na2SO4
Thermonatrite	-15.62	-14.98	0.64	Na2CO3:H2O
U3O8	-10.85	10.24	21.08	U3O8
U4O9	-22.00	-25.02	-3.02	U4O9
UF4	-32.42	-61.96	-29.54	UF4
UF4:2.5H2O	-29.24	-61.96	-32.72	UF4:2.5H2O
UO2(am)	-12.99	-12.05	0.93	UO2
UO2(OH)2(beta)	-3.68	1.93	5.61	UO2(OH)2
UO3	-5.77	1.93	7.70	UO3
Uraninite	-7.38	-12.05	-4.67	UO2
Witherite	-4.62	-13.19	-8.57	BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Initial solution 4. Make-up Material

----------Solution composition----------

Elements	Molality	Moles
Al	7.415e-07	7.415e-07
Alkalinity	3.607e-04	3.607e-04
Ba	1.457e-07	1.457e-07
Ca	1.672e-03	1.672e-03
Co	1.188e-07	1.188e-07
Cu	4.408e-07	4.408e-07
F	1.580e-05	1.580e-05
K	3.326e-04	3.326e-04
Mg	3.293e-04	3.293e-04
Mn	7.283e-07	7.283e-07
Mo	3.128e-08	3.128e-08
Na	4.351e-05	4.351e-05
Ni	6.818e-08	6.818e-08
S(6)	2.051e-03	2.051e-03

----------Description of solution----------

pH	=	7.700
pe	=	4.000
Activity of water	=	1.000
Ionic strength (mol/kgw)	=	7.199e-03
Mass of water (kg)	=	1.000e+00
Total carbon (mol/kg)	=	3.686e-04
Total CO2 (mol/kg)	=	3.686e-04
Temperature (°C)	=	25.00
Electrical balance (eq)	=	-9.478e-05

```
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  -1.25
                              Iterations  =  12 (6 overall)
                                 Total H  = 1.110140e+02
                                 Total O  = 5.551615e+01

----------------------------Distribution of species----------------------------

                                                 Log       Log       Log    mole V
   Species          Molality    Activity  Molality  Activity     Gamma    cm³/mol

   OH-            5.526e-07   5.046e-07    -6.258    -6.297    -0.039     (0)
   H+             2.182e-08   1.995e-08    -7.661    -7.700    -0.039      0.00
   H2O            5.551e+01   9.999e-01     1.744    -0.000     0.000     18.07
Al             7.415e-07
   Al(OH)4-       7.298e-07   6.680e-07    -6.137    -6.175    -0.038     (0)
   Al(OH)3        1.051e-08   1.051e-08    -7.978    -7.978     0.000     (0)
   Al(OH)2+       1.139e-09   1.044e-09    -8.944    -8.981    -0.038     (0)
   AlF2+          4.383e-12   4.020e-12   -11.358   -11.396    -0.038     (0)
   AlOH+2         3.684e-12   2.605e-12   -11.434   -11.584    -0.150     (0)
   AlF+2          1.021e-12   7.220e-13   -11.991   -12.141    -0.150     (0)
   AlF3           7.077e-13   7.077e-13   -12.150   -12.150     0.000     (0)
   AlSO4+         5.310e-14   4.860e-14   -13.275   -13.313    -0.038     (0)
   Al+3           1.153e-14   5.163e-15   -13.938   -14.287    -0.349     (0)
   AlF4-          5.420e-15   4.960e-15   -14.266   -14.304    -0.038     (0)
   Al(SO4)2-      6.899e-16   6.315e-16   -15.161   -15.200    -0.038     (0)
   AlMo6O21-3     0.000e+00   0.000e+00   -51.065   -51.455    -0.389     (0)
Ba             1.457e-07
   Ba+2           1.453e-07   1.017e-07    -6.838    -6.993    -0.155     (0)
   BaHCO3+        3.344e-10   3.070e-10    -9.476    -9.513    -0.037     (0)
   BaCO3          3.874e-11   3.874e-11   -10.412   -10.412     0.000     (0)
   BaOH+          2.444e-13   2.239e-13   -12.612   -12.650    -0.038     (0)
C(4)           3.686e-04
   HCO3-          3.449e-04   3.163e-04    -3.462    -3.500    -0.038     (0)
   H2CO3          1.419e-05   1.419e-05    -4.848    -4.848     0.000     (0)
   CaHCO3+        6.254e-06   5.742e-06    -5.204    -5.241    -0.037     (0)
   CaCO3          1.148e-06   1.148e-06    -5.940    -5.940     0.000     (0)
   CO3-2          1.062e-06   7.431e-07    -5.974    -6.129    -0.155     (0)
   MgHCO3+        7.037e-07   6.434e-07    -6.153    -6.192    -0.039     (0)
   CuCO3          2.384e-07   2.384e-07    -6.623    -6.623     0.000     (0)
   MgCO3          1.229e-07   1.229e-07    -6.911    -6.911     0.000     (0)
   NaHCO3         7.030e-09   7.030e-09    -8.153    -8.153     0.000     (0)
   MnHCO3+        2.926e-09   2.681e-09    -8.534    -8.572    -0.038     (0)
   CoHCO3+        1.811e-09   1.639e-09    -8.742    -8.785    -0.043     (0)
   NiHCO3+        1.678e-09   1.519e-09    -8.775    -8.818    -0.043     (0)
   CuHCO3+        1.201e-09   1.087e-09    -8.920    -8.964    -0.043     (0)
   NiCO3          1.080e-09   1.080e-09    -8.967    -8.967     0.000     (0)
   CoCO3          8.369e-10   8.369e-10    -9.077    -9.077     0.000     (0)
   Cu(CO3)2-2     7.104e-10   4.768e-10    -9.149    -9.322    -0.173     (0)
   NaCO3-         5.965e-10   5.470e-10    -9.224    -9.262    -0.038     (0)
   BaHCO3+        3.344e-10   3.070e-10    -9.476    -9.513    -0.037     (0)
   BaCO3          3.874e-11   3.874e-11   -10.412   -10.412     0.000     (0)
Ca             1.672e-03
   Ca+2           1.394e-03   9.751e-04    -2.856    -3.011    -0.155     (0)
   CaSO4          2.709e-04   2.709e-04    -3.567    -3.567     0.000     (0)
   CaHCO3+        6.254e-06   5.742e-06    -5.204    -5.241    -0.037     (0)
   CaCO3          1.148e-06   1.148e-06    -5.940    -5.940     0.000     (0)
   CaF+           1.624e-07   1.488e-07    -6.789    -6.827    -0.038     (0)
   CaOH+          1.069e-08   9.818e-09    -7.971    -8.008    -0.037     (0)
Co(2)          1.188e-07
   Co+2           9.925e-08   6.662e-08    -7.003    -7.176    -0.173     (0)
   CoSO4          1.612e-08   1.612e-08    -7.793    -7.793     0.000     (0)
   CoHCO3+        1.811e-09   1.639e-09    -8.742    -8.785    -0.043     (0)
   CoCO3          8.369e-10   8.369e-10    -9.077    -9.077     0.000     (0)
   CoOH+          7.411e-10   6.708e-10    -9.130    -9.173    -0.043     (0)
   CoF+           3.255e-11   2.946e-11   -10.487   -10.531    -0.043     (0)
   Co(OH)2        2.689e-11   2.689e-11   -10.570   -10.570     0.000     (0)
   Co(OH)3-       2.991e-16   2.707e-16   -15.524   -15.567    -0.043     (0)
   CoOOH-         7.505e-17   6.793e-17   -16.125   -16.168    -0.043     (0)
   Co2OH+3        5.491e-18   2.240e-18   -17.260   -17.650    -0.389     (0)
   Co(OH)4-2      3.225e-23   2.165e-23   -22.491   -22.665    -0.173     (0)
   Co4(OH)4+4     1.990e-28   4.040e-29   -27.701   -28.394    -0.692     (0)
Co(3)          1.013e-29
   CoOH+2         1.013e-29   6.801e-30   -28.994   -29.167    -0.173     (0)
   Co+3           5.925e-36   2.652e-36   -35.227   -35.576    -0.349     (0)
Cu(1)          2.948e-09
   Cu+            2.948e-09   2.668e-09    -8.530    -8.574    -0.043     (0)
Cu(2)          4.378e-07
   CuCO3          2.384e-07   2.384e-07    -6.623    -6.623     0.000     (0)
   CuOH+          9.510e-08   8.694e-08    -7.022    -7.061    -0.039     (0)
   Cu+2           7.788e-08   5.448e-08    -7.109    -7.264    -0.155     (0)
   CuSO4          1.514e-08   1.514e-08    -7.820    -7.820     0.000     (0)
   Cu(OH)2        8.754e-09   8.754e-09    -8.058    -8.058     0.000     (0)
   CuHCO3+        1.201e-09   1.087e-09    -8.920    -8.964    -0.043     (0)
   Cu(CO3)2-2     7.104e-10   4.768e-10    -9.149    -9.322    -0.173     (0)
   Cu2(OH)2+2     2.829e-10   1.899e-10    -9.548    -9.722    -0.173     (0)
   CuF+           5.311e-11   4.808e-11   -10.275   -10.318    -0.043     (0)
   Cu(OH)3-       1.001e-11   9.061e-12   -11.000   -11.043    -0.043     (0)
   Cu(OH)4-2      5.361e-17   3.599e-17   -16.271   -16.444    -0.173     (0)
F              1.580e-05
   F-             1.529e-05   1.398e-05    -4.816    -4.854    -0.039     (0)
   MgF+           3.408e-07   3.119e-07    -6.467    -6.506    -0.038     (0)
   CaF+           1.624e-07   1.488e-07    -6.789    -6.827    -0.038     (0)
   HF             4.127e-10   4.127e-10    -9.384    -9.384     0.000     (0)
   NaF            3.488e-10   3.488e-10    -9.457    -9.457     0.000     (0)
   MnF+           2.582e-10   2.365e-10    -9.588    -9.626    -0.038     (0)
   CuF+           5.311e-11   4.808e-11   -10.275   -10.318    -0.043     (0)
   CoF+           3.255e-11   2.946e-11   -10.487   -10.531    -0.043     (0)
   NiF+           1.512e-11   1.369e-11   -10.820   -10.864    -0.043     (0)
   AlF2+          4.383e-12   4.020e-12   -11.358   -11.396    -0.038     (0)
   AlF+2          1.021e-12   7.220e-13   -11.991   -12.141    -0.150     (0)
   AlF3           7.077e-13   7.077e-13   -12.150   -12.150     0.000     (0)
   HF2-           2.403e-14   2.194e-14   -13.619   -13.659    -0.039     (0)
   AlF4-          5.420e-15   4.960e-15   -14.266   -14.304    -0.038     (0)
   H2F2           4.564e-19   4.564e-19   -18.341   -18.341     0.000     (0)
H(0)           5.627e-27
   H2             2.814e-27   2.818e-27   -26.551   -26.550     0.001     (0)
K              3.326e-04
   K+             3.298e-04   3.016e-04    -3.482    -3.521    -0.039     (0)
   KSO4-          2.823e-06   2.589e-06    -5.549    -5.587    -0.038     (0)
Mg             3.293e-04
   Mg+2           2.842e-04   1.988e-04    -3.546    -3.702    -0.155     (0)
   MgSO4          4.387e-05   4.387e-05    -4.358    -4.358     0.000     (0)
   MgHCO3+        7.037e-07   6.434e-07    -6.153    -6.192    -0.039     (0)
   MgF+           3.408e-07   3.119e-07    -6.467    -6.506    -0.038     (0)
   MgCO3          1.229e-07   1.229e-07    -6.911    -6.911     0.000     (0)
   MgOH+          4.345e-08   3.994e-08    -7.362    -7.399    -0.037     (0)
Mn(2)          7.283e-07
   Mn+2           6.329e-07   4.249e-07    -6.199    -6.372    -0.173     (0)
   MnSO4          9.162e-08   9.162e-08    -7.038    -7.038     0.000     (0)
   MnHCO3+        2.926e-09   2.681e-09    -8.534    -8.572    -0.038     (0)
   MnOH+          5.878e-10   5.385e-10    -9.231    -9.269    -0.038     (0)
   MnF+           2.582e-10   2.365e-10    -9.588    -9.626    -0.038     (0)
   Mn(OH)3-       9.250e-19   8.475e-19   -18.034   -18.072    -0.038     (0)
   Mn(OH)4-2      1.959e-24   1.381e-24   -23.708   -23.860    -0.152     (0)
Mn(3)          4.240e-28
   Mn+3           4.240e-28   1.898e-28   -27.373   -27.722    -0.349     (0)
Mn(6)          0.000e+00
   MnO4-2         0.000e+00   0.000e+00   -47.042   -47.194    -0.152     (0)
Mn(7)          0.000e+00
   MnO4-          0.000e+00   0.000e+00   -52.526   -52.566    -0.040     (0)
Mo             3.128e-08
   MoO4-2         3.127e-08   2.188e-08    -7.505    -7.660    -0.155     (0)
   HMoO4-         9.595e-12   8.685e-12   -11.018   -11.061    -0.043     (0)
   H2MoO4         1.269e-15   1.269e-15   -14.896   -14.896     0.000     (0)
   AlMo6O21-3     0.000e+00   0.000e+00   -51.065   -51.455    -0.389     (0)
   Mo7O24-6       0.000e+00   0.000e+00   -60.672   -62.230    -1.558     (0)
   HMo7O24-5      0.000e+00   0.000e+00   -62.461   -63.543    -1.082     (0)
   H2Mo7O24-4     0.000e+00   0.000e+00   -65.769   -66.461    -0.692     (0)
   H3Mo7O24-3     0.000e+00   0.000e+00   -70.526   -70.915    -0.389     (0)
Na             4.351e-05
   Na+            4.322e-05   3.953e-05    -4.364    -4.403    -0.039     (0)
   NaSO4-         2.807e-07   2.574e-07    -6.552    -6.589    -0.038     (0)
   NaHCO3         7.030e-09   7.030e-09    -8.153    -8.153     0.000     (0)
   NaCO3-         5.965e-10   5.470e-10    -9.224    -9.262    -0.038     (0)
   NaF            3.488e-10   3.488e-10    -9.457    -9.457     0.000     (0)
Ni             6.818e-08
   Ni+2           5.569e-08   3.896e-08    -7.254    -7.409    -0.155     (0)
   NiSO4          9.427e-09   9.427e-09    -8.026    -8.026     0.000     (0)
   NiHCO3+        1.678e-09   1.519e-09    -8.775    -8.818    -0.043     (0)
   NiCO3          1.080e-09   1.080e-09    -8.967    -8.967     0.000     (0)
   NiOH+          2.734e-10   2.475e-10    -9.563    -9.606    -0.043     (0)
   NiF+           1.512e-11   1.369e-11   -10.820   -10.864    -0.043     (0)
   Ni(OH)2        9.921e-12   9.921e-12   -11.003   -11.003     0.000     (0)
   Ni(SO4)2-2     5.639e-13   3.785e-13   -12.249   -12.422    -0.173     (0)
   Ni(OH)3-       5.531e-15   5.006e-15   -14.257   -14.300    -0.043     (0)
O(0)           1.274e-39
   O2             6.370e-40   6.381e-40   -39.196   -39.195     0.001     (0)
S(6)           2.051e-03
   SO4-2          1.733e-03   1.213e-03    -2.761    -2.916    -0.155     (0)
   CaSO4          2.709e-04   2.709e-04    -3.567    -3.567     0.000     (0)
   MgSO4          4.387e-05   4.387e-05    -4.358    -4.358     0.000     (0)
   KSO4-          2.823e-06   2.589e-06    -5.549    -5.587    -0.038     (0)
   NaSO4-         2.807e-07   2.574e-07    -6.552    -6.589    -0.038     (0)
   MnSO4          9.162e-08   9.162e-08    -7.038    -7.038     0.000     (0)
   CoSO4          1.612e-08   1.612e-08    -7.793    -7.793     0.000     (0)
   CuSO4          1.514e-08   1.514e-08    -7.820    -7.820     0.000     (0)
   NiSO4          9.427e-09   9.427e-09    -8.026    -8.026     0.000     (0)
   HSO4-          2.583e-09   2.364e-09    -8.588    -8.626    -0.038     (0)
   Ni(SO4)2-2     5.639e-13   3.785e-13   -12.249   -12.422    -0.173     (0)
   AlSO4+         5.310e-14   4.860e-14   -13.275   -13.313    -0.038     (0)
   Al(SO4)2-      6.899e-16   6.315e-16   -15.161   -15.200    -0.038     (0)

-------------------------------Saturation indices-------------------------------

  Phase               SI** log IAP   log K(298 K,   1 atm)

  Al(OH)3(am)      -1.99      8.81   10.80  Al(OH)3
  Al2(MoO4)3      -53.92    -51.55    2.37  Al2(MoO4)3
  Al2O3            -2.03     17.63   19.65  Al2O3
  Al4(OH)10SO4     -5.77     16.93   22.70  Al4(OH)10SO4
  AlOHSO4          -6.27     -9.50   -3.23  AlOHSO4
  Alunite          -4.61     -6.01   -1.40  KAl3(SO4)2(OH)6
  Anhydrite        -1.57     -5.93   -4.36  CaSO4
  Antlerite        -2.70      6.09    8.79  Cu3(OH)4SO4
  Aragonite        -0.84     -9.14   -8.30  CaCO3
  Artinite         -7.73      1.87    9.60  MgCO3:Mg(OH)2:3H2O
  Azurite          -1.74    -18.65  -16.91  Cu3(OH)2(CO3)2
  Ba(OH)2:8H2O    -15.99      8.41   24.39  Ba(OH)2:8H2O
  BaF2            -10.88    -16.70   -5.82  BaF2
  BaMoO4           -7.69    -14.65   -6.96  BaMoO4
  Barite            0.07     -9.91   -9.98  BaSO4
  Birnessite      -11.01      7.08   18.09  MnO2
  Bixbyite         -8.60     -9.24   -0.64  Mn2O3
  Boehmite          0.23      8.81    8.58  AlOOH
  Brochantite      -0.99     14.23   15.22  Cu4(OH)6SO4
  Brucite          -5.15     11.70   16.84  Mg(OH)2
  Bunsenite        -4.45      7.99   12.45  NiO
  Calcite          -0.66     -9.14   -8.48  CaCO3
  CaMoO4           -2.72    -10.67   -7.95  CaMoO4
  CH4(g)          -74.08   -115.13  -41.05  CH4
  Chalcanthite     -7.54    -10.18   -2.64  CuSO4:5H2O
  Co(OH)2          -4.87      8.22    13.09  Co(OH)2
  Co(OH)3         -10.17    -12.48    -2.31  Co(OH)3
  CO2(g)           -3.38    -21.53   -18.15  CO2
  Co3O4            -6.23    -16.73   -10.50  Co3O4
  CoCO3            -3.33    -13.31    -9.98  CoCO3
  CoF2            -15.29    -16.89    -1.60  CoF2
  CoF3            -48.68    -50.14    -1.46  CoF3
  CoMoO4           -7.08    -14.84    -7.76  CoMoO4
  CoO              -5.36      8.22    13.59  CoO
  CoSO4           -12.90    -10.09     2.80  CoSO4
  CoSO4:6H2O       -7.62    -10.09    -2.47  CoSO4:6H2O
  Cryolite        -22.78    -56.62   -33.84  Na3AlF6
  Cu(OH)2          -0.54      8.14     8.67  Cu(OH)2
  Cu2SO4          -18.11    -20.06    -1.95  Cu2SO4
  CuCO3            -1.89    -13.39   -11.50  CuCO3
  CuF              -8.52    -13.43    -4.91  CuF
  CuF2            -18.09    -16.97     1.12  CuF2
  CuF2:2H2O       -12.42    -16.97    -4.55  CuF2:2H2O
  Cumetal          -3.82    -12.57    -8.76  Cu
  CuMoO4           -1.85    -14.92   -13.08  CuMoO4
  CuOCuSO4        -12.35     -2.04    10.30  CuOCuSO4
  Cuprite          -0.34     -1.75    -1.41  Cu2O
  CuSO4           -13.12    -10.18     2.94  CuSO4
  Diaspore          1.94      8.81     6.87  AlOOH
  Dolomite(disordered)  -2.43     -18.97  -16.54  CaMg(CO3)2
  Dolomite(ordered)  -1.88    -18.97  -17.09  CaMg(CO3)2
  Epsomite         -4.49     -6.62    -2.13  MgSO4:7H2O
  Fluorite         -2.22    -12.72   -10.50  CaF2
  Gibbsite          0.52      8.81     8.29  Al(OH)3
  Gypsum           -1.32     -5.93    -4.61  CaSO4:2H2O
  H2MoO4          -10.18    -23.06   -12.88  H2MoO4
  Hausmannite     -10.55     50.48    61.03  Mn3O4
  Huntite          -8.66    -38.63   -29.97  CaMg3(CO3)4
  Hydromagnesite  -18.86    -27.62    -8.77  Mg5(CO3)4(OH)2:4H2O
  K-Alum          -18.47    -23.64    -5.17  KAl(SO4)2:12H2O
  K2MoO4          -17.96    -14.70     3.26  K2MoO4
  Langite          -3.26     14.23    17.49  Cu4(OH)6SO4:H2O
  Lime            -20.31     12.39    32.70  CaO
  Magnesite        -2.37     -9.83    -7.46  MgCO3
  Malachite         0.05     -5.26    -5.31  Cu2(OH)2CO3
  Manganite        -4.61     20.73    25.34  MnOOH
  Mg(OH)2(active)  -7.10     11.70    18.79  Mg(OH)2
  MgF2             -5.28    -13.41    -8.13  MgF2
  MgMoO4           -9.51    -11.36    -1.85  MgMoO4
  Mirabilite      -10.61    -11.72    -1.11  Na2SO4:10H2O
  Mn2(SO4)3       -58.48    -64.19    -5.71  Mn2(SO4)3
  MnSO4           -11.87     -9.29     2.58  MnSO4
  MoO3            -15.06    -23.06    -8.00  MoO3
  Morenosite       -8.18    -10.33    -2.14  NiSO4:7H2O
  Na2Mo2O7        -22.93    -39.53   -16.60  Na2Mo2O7
  Na2MoO4         -17.96    -16.47     1.49  Na2MoO4
  Na2MoO4:2H2O    -17.69    -16.47     1.22  Na2MoO4:2H2O
  Natron          -13.62    -14.94    -1.31  Na2CO3:10H2O
  Nesquehonite     -5.16     -9.83    -4.67  MgCO3:3H2O
  Ni(OH)2          -4.80      7.99    12.79  Ni(OH)2
  Ni4(OH)6SO4     -18.35     13.65    32.00  Ni4(OH)6SO4
  NiCO3            -6.67    -13.54    -6.87  NiCO3
  NiMoO4           -3.93    -15.07   -11.14  NiMoO4
  Nsutite         -10.43      7.08    17.50  MnO2
  O2(g)           -36.29     46.80    83.09  O2
  Periclase        -9.89     11.70    21.58  MgO
  Portlandite     -10.42     12.39    22.80  Ca(OH)2
  Pyrochroite      -6.17      9.03    15.19  Mn(OH)2
```

Pyrolusite	-8.95	32.43	41.38	MnO2
Retgersite	-8.29	-10.33	-2.04	NiSO4:6H2O
Rhodochrosite	-1.92	-12.50	-10.58	MnCO3
Spinel	-7.52	29.32	36.85	MgAl2O4
Tenorite	0.49	8.14	7.64	CuO
Thenardite	-12.04	-11.72	0.32	Na2SO4
Thermonatrite	-15.57	-14.94	0.64	Na2CO3:H2O
Witherite	-4.55	-13.12	-8.57	BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Beginning of batch-reaction calculations.

Reaction step 1.

Using mix 1. Mix within UG Works

Mixture 1. Mix within UG Works

2.780e-01 Solution 1 UG Water P75
1.140e-01 Solution 2 PAF Material
4.180e-01 Solution 3 NAF Material
1.900e-01 Solution 4 Make-up Material

----------Solution composition----------

Elements	Molality	Moles
Al	3.204e-06	3.204e-06
As	1.727e-07	1.727e-07
B	3.360e-06	3.360e-06
Ba	4.759e-07	4.759e-07
C	2.741e-03	2.741e-03
Ca	2.534e-03	2.534e-03
Cd	2.204e-08	2.204e-08
Cl	4.428e-04	4.428e-04
Co	6.921e-08	6.921e-08
Cr	4.443e-08	4.443e-08
Cu	6.169e-07	6.169e-07
F	2.639e-05	2.639e-05
Fe	1.568e-06	1.568e-06
K	5.556e-04	5.556e-04
Mg	1.035e-03	1.035e-03
Mn	1.731e-06	1.731e-06
Mo	6.728e-08	6.728e-08
Na	2.569e-03	2.569e-03
Ni	5.536e-08	5.536e-08
Pb	7.416e-08	7.416e-08
S	2.895e-03	2.895e-03
Se	6.346e-08	6.346e-08
U	1.146e-08	1.146e-08
V	1.311e-08	1.311e-08
Zn	9.536e-07	9.536e-07

----------Description of solution----------

pH	=	8.074	Charge balance
pe	=	3.297	Adjusted to redox equilibrium
Activity of water	=	1.000	
Ionic strength (mol/kgw)	=	1.358e-02	
Mass of water (kg)	=	1.000e+00	
Total alkalinity (eq/kg)	=	2.767e-03	
Total CO2 (mol/kg)	=	2.741e-03	

Temperature (°C)	=	25.00				
Electrical balance (eq)	=	1.255e-03				
Percent error, 100*(Cat-|An|)/(Cat+|An|)	=	7.51				
Iterations	=	12				
Total H	=	1.110164e+02				
Total O	=	5.552667e+01				

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
OH-	1.347e-06	1.194e-06	-5.871	-5.923	-0.052	(0)
H+	9.488e-09	8.434e-09	-8.023	-8.074	-0.051	0.00
H2O	5.551e+01	9.998e-01	1.744	-0.000	0.000	18.07
Al	3.204e-06					
Al(OH)4-	3.185e-06	2.834e-06	-5.497	-5.548	-0.051	(0)
Al(OH)3	1.886e-08	1.886e-08	-7.725	-7.725	0.000	(0)
Al(OH)2+	8.868e-10	7.917e-10	-9.052	-9.101	-0.049	(0)
AlF2+	1.483e-12	1.324e-12	-11.829	-11.878	-0.049	(0)
AlOH+2	1.314e-12	8.350e-13	-11.881	-12.078	-0.197	(0)
AlF3	3.634e-13	3.634e-13	-12.440	-12.440	0.000	(0)
AlF+2	2.401e-13	1.525e-13	-12.620	-12.817	-0.197	(0)
AlSO4+	8.795e-15	7.826e-15	-14.056	-14.106	-0.051	(0)
AlF4-	4.463e-15	3.971e-15	-14.350	-14.401	-0.051	(0)
Al+3	2.019e-15	6.995e-16	-14.695	-15.155	-0.460	(0)
Al(SO4)2-	1.358e-16	1.209e-16	-15.867	-15.918	-0.051	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-52.332	-52.867	-0.535	(0)
As(3)	1.638e-18					
H3AsO3	1.531e-18	1.531e-18	-17.815	-17.815	0.000	(0)
H2AsO3-	1.068e-19	9.312e-20	-18.971	-19.031	-0.059	(0)
HAsO3-2	1.741e-23	1.007e-23	-22.759	-22.997	-0.238	(0)
H4AsO3+	7.338e-27	6.399e-27	-26.134	-26.194	-0.059	(0)
AsO3-3	1.578e-28	4.603e-29	-27.802	-28.337	-0.535	(0)
As(5)	1.727e-07					
HAsO4-2	1.642e-07	9.495e-08	-6.785	-7.023	-0.238	(0)
H2AsO4-	8.375e-09	7.303e-09	-8.077	-8.136	-0.059	(0)
AsO4-3	1.220e-10	3.560e-11	-9.914	-10.449	-0.535	(0)
H3AsO4	1.067e-14	1.070e-14	-13.972	-13.970	0.001	(0)
B	3.360e-06					
H3BO3	3.095e-06	3.105e-06	-5.509	-5.508	0.001	(0)
H2BO3-	2.422e-07	2.138e-07	-6.616	-6.670	-0.054	(0)
CaH2BO3+	1.766e-08	1.558e-08	-7.753	-7.807	-0.054	(0)
MgH2BO3+	4.566e-09	4.029e-09	-8.341	-8.395	-0.054	(0)
NaH2BO3	7.669e-10	7.669e-10	-9.115	-9.115	0.000	(0)
BF(OH)3-	3.061e-11	2.701e-11	-10.514	-10.568	-0.054	(0)
BaH2BO3+	2.182e-12	1.926e-12	-11.661	-11.715	-0.054	(0)
H5(BO3)2-	6.402e-13	5.650e-13	-12.194	-12.248	-0.054	(0)
BF2(OH)2-	6.018e-16	5.312e-16	-15.221	-15.275	-0.054	(0)
H8(BO3)3-	1.988e-16	1.754e-16	-15.702	-15.756	-0.054	(0)
BF3OH-	4.306e-23	3.801e-23	-22.366	-22.420	-0.054	(0)
BF4-	3.897e-29	3.440e-29	-28.409	-28.463	-0.054	(0)
Ba	4.759e-07					
Ba+2	4.669e-07	2.915e-07	-6.331	-6.535	-0.205	(0)
BaHCO3+	7.130e-09	6.379e-09	-8.147	-8.195	-0.048	(0)
BaCO3	1.904e-09	1.904e-09	-8.720	-8.720	0.000	(0)
BaH2BO3+	2.182e-12	1.926e-12	-11.661	-11.715	-0.054	(0)
BaOH+	1.704e-12	1.519e-12	-11.769	-11.819	-0.050	(0)
C(4)	2.741e-03					
HCO3-	2.567e-03	2.292e-03	-2.591	-2.640	-0.049	(0)
CaHCO3+	6.041e-05	5.405e-05	-4.219	-4.267	-0.048	(0)
H2CO3	4.347e-05	4.347e-05	-4.362	-4.362	0.000	(0)
CaCO3	2.557e-05	2.557e-05	-4.592	-4.592	0.000	(0)
CO3-2	2.041e-05	1.274e-05	-4.690	-4.895	-0.205	(0)
MgHCO3+	1.435e-05	1.275e-05	-4.843	-4.895	-0.052	(0)
MgCO3	5.759e-06	5.759e-06	-5.240	-5.240	0.000	(0)
NaHCO3	2.916e-06	2.916e-06	-5.535	-5.535	0.000	(0)
NaCO3-	6.013e-07	5.368e-07	-6.221	-6.270	-0.049	(0)
CuCO3	5.311e-07	5.311e-07	-6.275	-6.275	0.000	(0)
ZnCO3	2.408e-07	2.408e-07	-6.618	-6.618	0.000	(0)
PbCO3	5.847e-08	5.847e-08	-7.233	-7.233	0.000	(0)
MnHCO3+	4.350e-08	3.878e-08	-7.361	-7.411	-0.050	(0)
Cu(CO3)2-2	3.148e-08	1.821e-08	-7.502	-7.740	-0.238	(0)
ZnHCO3+	2.730e-08	2.380e-08	-7.564	-7.623	-0.059	(0)
NiCO3	9.711e-09	9.711e-09	-8.013	-8.013	0.000	(0)
UO2(CO3)3-4	8.792e-09	9.841e-10	-8.056	-9.007	-0.951	(0)
BaHCO3+	7.130e-09	6.379e-09	-8.147	-8.195	-0.048	(0)
NiHCO3+	6.620e-09	5.773e-09	-8.179	-8.239	-0.059	(0)
CoCO3	6.038e-09	6.038e-09	-8.219	-8.219	0.000	(0)
CoHCO3+	5.731e-09	4.998e-09	-8.242	-8.301	-0.059	(0)
Pb(CO3)2-2	3.714e-09	2.148e-09	-8.430	-8.668	-0.238	(0)
PbHCO3+	2.981e-09	2.600e-09	-8.526	-8.585	-0.059	(0)
CdCO3	2.772e-09	2.772e-09	-8.557	-8.557	0.000	(0)
UO2(CO3)2-2	2.665e-09	1.541e-09	-8.574	-8.812	-0.238	(0)
BaCO3	1.904e-09	1.904e-09	-8.720	-8.720	0.000	(0)
CuHCO3+	1.174e-09	1.024e-09	-8.930	-8.990	-0.059	(0)
FeHCO3+	2.957e-10	2.645e-10	-9.529	-9.578	-0.048	(0)
CdHCO3+	5.711e-11	4.981e-11	-10.243	-10.303	-0.059	(0)
Cd(CO3)2-2	4.525e-11	2.618e-11	-10.344	-10.582	-0.238	(0)
UO2CO3	6.065e-12	6.065e-12	-11.217	-11.217	0.000	(0)
Ca	2.534e-03					
Ca+2	2.029e-03	1.267e-03	-2.693	-2.897	-0.205	(0)
CaSO4	4.182e-04	4.182e-04	-3.379	-3.379	0.000	(0)
CaHCO3+	6.041e-05	5.405e-05	-4.219	-4.267	-0.048	(0)
CaCO3	2.557e-05	2.557e-05	-4.592	-4.592	0.000	(0)
CaF+	3.381e-07	3.014e-07	-6.471	-6.521	-0.050	(0)
CaOH+	3.372e-08	3.017e-08	-7.472	-7.520	-0.048	(0)
CaH2BO3+	1.766e-08	1.558e-08	-7.753	-7.807	-0.054	(0)
Cd	2.204e-08					
Cd+2	1.529e-08	9.547e-09	-7.816	-8.020	-0.205	(0)
CdSO4	3.225e-09	3.225e-09	-8.491	-8.491	0.000	(0)
CdCO3	2.772e-09	2.772e-09	-8.557	-8.557	0.000	(0)
CdCl+	4.115e-10	3.589e-10	-9.386	-9.445	-0.059	(0)
Cd(SO4)2-2	1.084e-10	6.271e-11	-9.965	-10.203	-0.238	(0)
CdOH+	1.038e-10	9.052e-11	-9.984	-10.043	-0.059	(0)
CdHCO3+	5.711e-11	4.981e-11	-10.243	-10.303	-0.059	(0)
Cd(CO3)2-2	4.525e-11	2.618e-11	-10.344	-10.582	-0.238	(0)
CdOHCl	1.757e-11	1.757e-11	-10.755	-10.755	0.000	(0)
CdF+	3.783e-12	3.299e-12	-11.422	-11.482	-0.059	(0)
Cd(OH)2	6.817e-13	6.817e-13	-12.166	-12.166	0.000	(0)
CdCl2	5.889e-13	5.889e-13	-12.230	-12.230	0.000	(0)
CdCl3-	1.677e-16	1.462e-16	-15.775	-15.835	-0.059	(0)
CdF2	1.435e-16	1.435e-16	-15.843	-15.843	0.000	(0)
Cd(OH)3-	5.701e-17	4.972e-17	-16.244	-16.303	-0.059	(0)
Cd2OH+3	1.484e-17	4.331e-18	-16.828	-17.363	-0.535	(0)
Cd(SeO3)2-2	3.168e-18	1.832e-18	-17.499	-17.737	-0.238	(0)
CdSeO4	1.853e-19	1.853e-19	-18.732	-18.732	0.000	(0)
Cd(OH)4-2	1.679e-23	9.714e-24	-22.775	-23.013	-0.238	(0)
CdHS+	0.000e+00	0.000e+00	-68.178	-68.237	-0.059	(0)
Cd(HS)2	0.000e+00	0.000e+00	-129.258	-129.258	0.000	(0)
Cd(HS)3-	0.000e+00	0.000e+00	-195.524	-195.583	-0.059	(0)
Cd(HS)4-2	0.000e+00	0.000e+00	-261.375	-261.612	-0.238	(0)
Cl	4.428e-04					
Cl-	4.428e-04	3.936e-04	-3.354	-3.405	-0.051	(0)
CuCl	8.666e-10	8.666e-10	-9.062	-9.062	0.000	(0)
ZnOHCl	5.075e-10	5.075e-10	-9.295	-9.295	0.000	(0)
MnCl+	4.715e-10	4.203e-10	-9.327	-9.376	-0.050	(0)
CdCl+	4.115e-10	3.589e-10	-9.386	-9.445	-0.059	(0)
ZnCl+	3.657e-10	3.248e-10	-9.437	-9.488	-0.052	(0)
CuCl2-	8.025e-11	7.127e-11	-10.096	-10.147	-0.052	(0)
CoCl+	4.378e-11	3.818e-11	-10.359	-10.418	-0.059	(0)
PbCl+	2.445e-11	2.133e-11	-10.612	-10.671	-0.059	(0)
NiCl+	2.360e-11	2.058e-11	-10.627	-10.687	-0.059	(0)
CdOHCl	1.757e-11	1.757e-11	-10.755	-10.755	0.000	(0)
CuCl+	4.974e-12	4.417e-12	-11.303	-11.355	-0.052	(0)
CdCl2	5.889e-13	5.889e-13	-12.230	-12.230	0.000	(0)
MnCl2	2.337e-13	2.337e-13	-12.631	-12.631	0.000	(0)
ZnCl2	2.026e-13	2.026e-13	-12.693	-12.693	0.000	(0)
PbCl2	3.750e-14	3.750e-14	-13.426	-13.426	0.000	(0)
CuCl3-2	9.496e-15	5.997e-15	-14.022	-14.222	-0.200	(0)
CuCl2	6.028e-16	6.028e-16	-15.220	-15.220	0.000	(0)
CdCl3-	1.677e-16	1.462e-16	-15.775	-15.835	-0.059	(0)
ZnCl3-	7.133e-17	6.335e-17	-16.147	-16.198	-0.052	(0)
NiCl2	4.079e-17	4.079e-17	-16.389	-16.389	0.000	(0)
MnCl3-	2.842e-17	2.533e-17	-16.546	-16.596	-0.050	(0)
PbCl3-	6.737e-18	5.876e-18	-17.172	-17.231	-0.059	(0)
CrCl+2	6.205e-18	3.589e-18	-17.207	-17.445	-0.238	(0)
UO2Cl+	8.754e-20	7.634e-20	-19.058	-19.117	-0.059	(0)
CrOHCl2	3.205e-20	3.205e-20	-19.494	-19.494	0.000	(0)
FeCl+2	3.179e-20	2.008e-20	-19.498	-19.697	-0.200	(0)
ZnCl4-2	1.974e-20	1.247e-20	-19.705	-19.904	-0.200	(0)
CuCl3-	2.494e-21	2.214e-21	-20.603	-20.655	-0.052	(0)
PbCl4-2	1.828e-21	1.057e-21	-20.738	-20.976	-0.238	(0)
CrCl2+	1.537e-22	1.341e-22	-21.813	-21.873	-0.059	(0)
VOCl+	4.072e-23	3.551e-23	-22.390	-22.450	-0.059	(0)
FeCl2+	3.960e-23	3.530e-23	-22.402	-22.452	-0.050	(0)
CuCl4-2	6.917e-27	4.369e-27	-26.160	-26.360	-0.200	(0)
FeCl3	1.389e-27	1.389e-27	-26.857	-26.857	0.000	(0)
CrO3Cl-	1.591e-29	1.388e-29	-28.798	-28.858	-0.059	(0)
CoCl+2	3.065e-38	1.773e-38	-37.514	-37.751	-0.238	(0)
UCl+3	0.000e+00	0.000e+00	-46.767	-47.302	-0.535	(0)
Co(2)	6.921e-08					
Co+2	4.848e-08	2.804e-08	-7.314	-7.552	-0.238	(0)
CoSO4	8.063e-09	8.063e-09	-8.093	-8.093	0.000	(0)
CoCO3	6.038e-09	6.038e-09	-8.219	-8.219	0.000	(0)
CoHCO3+	5.731e-09	4.998e-09	-8.242	-8.301	-0.059	(0)
CoOH+	7.658e-10	6.678e-10	-9.116	-9.175	-0.059	(0)
Co(OH)2	6.332e-11	6.332e-11	-10.198	-10.198	0.000	(0)
CoCl+	4.378e-11	3.818e-11	-10.359	-10.418	-0.059	(0)
CoF+	2.217e-11	1.933e-11	-10.654	-10.714	-0.059	(0)
Co(OH)3-	1.729e-15	1.508e-15	-14.762	-14.822	-0.059	(0)
CoOOH-	4.340e-16	3.785e-16	-15.363	-15.422	-0.059	(0)
Co2OH+3	3.217e-18	9.385e-19	-17.493	-18.028	-0.535	(0)
CoSeO4	1.465e-18	1.465e-18	-17.834	-17.834	0.000	(0)
Co(OH)4-2	4.933e-22	2.853e-22	-21.307	-21.545	-0.238	(0)
Co4(OH)4+4	3.546e-28	3.969e-29	-27.450	-28.401	-0.951	(0)
Co(3)	2.321e-30					
CoOH+2	2.321e-30	1.343e-30	-29.634	-29.872	-0.238	(0)
Co+3	6.390e-37	2.214e-37	-36.194	-36.655	-0.460	(0)
CoCl+2	3.065e-38	1.773e-38	-37.514	-37.751	-0.238	(0)
Cr(2)	1.468e-24					
Cr+2	1.468e-24	8.488e-25	-23.833	-24.071	-0.238	(0)
Cr(3)	4.443e-08					
Cr(OH)2+	3.064e-08	2.672e-08	-7.514	-7.573	-0.059	(0)
Cr(OH)3	1.198e-08	1.198e-08	-7.921	-7.921	0.000	(0)
CrO2-	7.739e-10	6.749e-10	-9.111	-9.171	-0.059	(0)
Cr(OH)4-	6.530e-10	5.694e-10	-9.185	-9.245	-0.059	(0)
Cr(OH)+2	3.181e-10	1.840e-10	-9.497	-9.735	-0.238	(0)
CrOHSO4	6.293e-11	6.293e-11	-10.201	-10.201	0.000	(0)
CrF+2	4.209e-14	2.435e-14	-13.376	-13.614	-0.238	(0)
CrSO4+	2.719e-14	2.371e-14	-13.566	-13.625	-0.059	(0)
Cr+3	2.415e-14	7.046e-15	-13.617	-14.152	-0.535	(0)
CrCl+2	6.205e-18	3.589e-18	-17.207	-17.445	-0.238	(0)
Cr2(OH)2SO4+2	1.809e-18	1.047e-18	-17.742	-17.980	-0.238	(0)
Cr2(OH)2(SO4)2	8.960e-20	8.960e-20	-19.048	-19.048	0.000	(0)
CrOHCl2	3.205e-20	3.205e-20	-19.494	-19.494	0.000	(0)
CrCl2+	1.537e-22	1.341e-22	-21.813	-21.873	-0.059	(0)
Cr(6)	4.013e-17					

CrO4-2	3.900e-17	2.435e-17	-16.409	-16.614	-0.205	(0)
HCrO4-	7.619e-19	6.645e-19	-18.118	-18.178	-0.059	(0)
NaCrO4-	3.140e-19	2.738e-19	-18.503	-18.563	-0.059	(0)
KCrO4-	5.071e-20	4.423e-20	-19.295	-19.354	-0.059	(0)
H2CrO4	4.543e-27	4.543e-27	-26.343	-26.343	0.000	(0)
CrO3SO4-2	4.254e-27	2.461e-27	-26.371	-26.609	-0.238	(0)
CrO3Cl-	1.591e-29	1.388e-29	-28.798	-28.858	-0.059	(0)
Cr2O7-2	2.647e-35	1.531e-35	-34.577	-34.815	-0.238	(0)
Cu(1)	2.952e-09					
Cu+	2.005e-09	1.749e-09	-8.698	-8.757	-0.059	(0)
CuCl	8.666e-10	8.666e-10	-9.062	-9.062	0.000	(0)
CuCl2-	8.025e-11	7.127e-11	-10.096	-10.147	-0.052	(0)
CuCl3-2	9.496e-15	5.997e-15	-14.022	-14.222	-0.200	(0)
Cu(S4)2-3	0.000e+00	0.000e+00	-125.385	-125.669	-0.284	(0)
CuS4S5-3	0.000e+00	0.000e+00	-126.126	-126.399	-0.273	(0)
Cu(2)	6.140e-07					
CuCO3	5.311e-07	5.311e-07	-6.275	-6.275	0.000	(0)
Cu(CO3)2-2	3.148e-08	1.821e-08	-7.502	-7.740	-0.238	(0)
CuOH+	3.009e-08	2.673e-08	-7.522	-7.573	-0.052	(0)
Cu+2	1.134e-08	7.080e-09	-7.945	-8.150	-0.205	(0)
Cu(OH)2	6.365e-09	6.365e-09	-8.196	-8.196	0.000	(0)
CuSO4	2.338e-09	2.338e-09	-8.631	-8.631	0.000	(0)
CuHCO3+	1.174e-09	1.024e-09	-8.930	-8.990	-0.059	(0)
Cu2(OH)2+2	3.102e-11	1.794e-11	-10.508	-10.746	-0.238	(0)
Cu(OH)3-	1.787e-11	1.558e-11	-10.748	-10.807	-0.059	(0)
CuF+	1.117e-11	9.740e-12	-10.952	-11.011	-0.059	(0)
CuCl+	4.974e-12	4.417e-12	-11.303	-11.355	-0.052	(0)
CuCl2	6.028e-16	6.028e-16	-15.220	-15.220	0.000	(0)
Cu(OH)4-2	2.531e-16	1.464e-16	-15.597	-15.834	-0.238	(0)
CuCl3-	2.494e-21	2.214e-21	-20.603	-20.655	-0.052	(0)
CuCl4-2	6.917e-27	4.369e-27	-26.160	-26.360	-0.200	(0)
Cu(HS)3-	0.000e+00	0.000e+00	-186.867	-186.926	-0.059	(0)
F	2.639e-05					
F-	2.453e-05	2.180e-05	-4.610	-4.661	-0.051	(0)
MgF+	1.494e-06	1.330e-06	-5.826	-5.876	-0.051	(0)
CaF+	3.381e-07	3.014e-07	-6.471	-6.521	-0.050	(0)
NaF	3.113e-08	3.113e-08	-7.507	-7.507	0.000	(0)
MnF+	8.258e-10	7.362e-10	-9.083	-9.133	-0.050	(0)
HF	2.720e-10	2.720e-10	-9.565	-9.565	0.000	(0)
ZnF+	1.639e-10	1.429e-10	-9.786	-9.845	-0.059	(0)
BF(OH)3-	3.061e-11	2.701e-11	-10.514	-10.568	-0.054	(0)
CoF+	2.217e-11	1.933e-11	-10.654	-10.714	-0.059	(0)
NiF+	1.283e-11	1.119e-11	-10.892	-10.951	-0.059	(0)
CuF+	1.117e-11	9.740e-12	-10.952	-11.011	-0.059	(0)
CdF+	3.783e-12	3.299e-12	-11.422	-11.482	-0.059	(0)
PbF+	2.690e-12	2.346e-12	-11.570	-11.630	-0.059	(0)
AlF2+	1.483e-12	1.324e-12	-11.829	-11.878	-0.049	(0)
AlF3	3.634e-13	3.634e-13	-12.440	-12.440	0.000	(0)
AlF+2	2.401e-13	1.525e-13	-12.620	-12.817	-0.197	(0)
CrF+2	4.209e-14	2.435e-14	-13.376	-13.614	-0.238	(0)
HF2-	2.544e-14	2.255e-14	-13.594	-13.647	-0.052	(0)
AlF4-	4.463e-15	3.971e-15	-14.350	-14.401	-0.051	(0)
PbF2	1.007e-15	1.007e-15	-14.997	-14.997	0.000	(0)
BF2(OH)2-	6.018e-16	5.312e-16	-15.221	-15.275	-0.054	(0)
UO2F+	4.127e-16	3.599e-16	-15.384	-15.444	-0.059	(0)
CdF2	1.435e-16	1.435e-16	-15.843	-15.843	0.000	(0)
FeF+2	6.393e-17	4.038e-17	-16.194	-16.394	-0.200	(0)
FeF2+	2.643e-17	2.356e-17	-16.578	-16.628	-0.050	(0)
UO2F2	2.263e-17	2.263e-17	-16.645	-16.645	0.000	(0)
FeF3	7.248e-19	7.248e-19	-18.140	-18.140	0.000	(0)
VO2F	4.285e-19	4.285e-19	-18.368	-18.368	0.000	(0)
H2F2	1.982e-19	1.982e-19	-18.703	-18.703	0.000	(0)
UO2F3-	1.421e-19	1.240e-19	-18.847	-18.907	-0.059	(0)
PbF3-	4.774e-20	4.163e-20	-19.321	-19.381	-0.059	(0)
VOF+	4.822e-21	4.205e-21	-20.317	-20.376	-0.059	(0)
VO2F2-	3.890e-21	3.392e-21	-20.410	-20.470	-0.059	(0)
BF3OH-	4.306e-23	3.801e-23	-22.366	-22.420	-0.054	(0)
UO2F4-2	3.712e-23	2.147e-23	-22.430	-22.668	-0.238	(0)
VOF2	3.438e-23	3.438e-23	-22.464	-22.464	0.000	(0)
VO2F3-2	1.595e-24	9.226e-25	-23.797	-24.035	-0.238	(0)
PbF4-2	7.512e-25	4.345e-25	-24.124	-24.362	-0.238	(0)
VOF3-	3.050e-26	2.660e-26	-25.516	-25.575	-0.059	(0)
BF4-	3.897e-29	3.440e-29	-28.409	-28.463	-0.054	(0)
VO2F4-3	3.393e-29	9.898e-30	-28.469	-29.004	-0.535	(0)
VOF4-2	4.047e-30	2.341e-30	-29.393	-29.631	-0.238	(0)
UF3+	1.198e-38	1.045e-38	-37.922	-37.981	-0.059	(0)
UF2+2	5.226e-39	3.023e-39	-38.282	-38.520	-0.238	(0)
UF+3	0.000e+00	0.000e+00	-40.423	-40.958	-0.535	(0)
UF4	0.000e+00	0.000e+00	-40.602	-40.602	0.000	(0)
UF5-	0.000e+00	0.000e+00	-43.607	-43.666	-0.059	(0)
UF6-2	0.000e+00	0.000e+00	-45.610	-45.847	-0.238	(0)
Fe(2)	1.988e-08					
Fe+2	1.585e-08	9.169e-09	-7.800	-8.038	-0.238	(0)
FeSO4	3.244e-09	3.244e-09	-8.489	-8.489	0.000	(0)
FeOH+	4.888e-10	4.357e-10	-9.311	-9.361	-0.050	(0)
FeHCO3+	2.957e-10	2.645e-10	-9.529	-9.578	-0.048	(0)
Fe(OH)2	4.131e-13	4.131e-13	-12.384	-12.384	0.000	(0)
Fe(OH)3-	1.749e-13	1.559e-13	-12.757	-12.807	-0.050	(0)
Fe(HS)2	0.000e+00	0.000e+00	-135.538	-135.538	0.000	(0)
Fe(HS)3-	0.000e+00	0.000e+00	-201.666	-201.726	-0.059	(0)
Fe(3)	1.549e-06					
Fe(OH)3	7.750e-07	7.750e-07	-6.111	-6.111	0.000	(0)
Fe(OH)2+	6.771e-07	6.045e-07	-6.169	-6.219	-0.049	(0)
Fe(OH)4-	9.648e-08	8.613e-08	-7.016	-7.065	-0.049	(0)
FeOH+2	2.061e-12	1.302e-12	-11.686	-11.885	-0.200	(0)
FeF+2	6.393e-17	4.038e-17	-16.194	-16.394	-0.200	(0)
FeSO4+	3.064e-17	2.731e-17	-16.514	-16.564	-0.050	(0)
FeF2+	2.643e-17	2.356e-17	-16.578	-16.628	-0.050	(0)
Fe+3	4.876e-18	1.689e-18	-17.312	-17.772	-0.460	(0)
Fe(SO4)2-	9.650e-19	8.416e-19	-18.015	-18.075	-0.059	(0)
FeF3	7.248e-19	7.248e-19	-18.140	-18.140	0.000	(0)
FeCl+2	3.179e-20	2.008e-20	-19.498	-19.697	-0.200	(0)
Fe2(OH)2+4	5.013e-22	5.611e-23	-21.300	-22.251	-0.951	(0)
FeHSeO3+2	2.495e-22	1.443e-22	-21.603	-21.841	-0.238	(0)
FeCl2+	3.960e-23	3.530e-23	-22.402	-22.452	-0.050	(0)
Fe3(OH)4+5	1.501e-26	4.903e-28	-25.824	-27.310	-1.486	(0)
FeCl3	1.389e-27	1.389e-27	-26.857	-26.857	0.000	(0)
H(0)	2.553e-26					
H2	1.277e-26	1.281e-26	-25.894	-25.893	0.001	(0)
K	5.556e-04					
K+	5.500e-04	4.889e-04	-3.260	-3.311	-0.051	(0)
KSO4-	5.587e-06	4.988e-06	-5.253	-5.302	-0.049	(0)
KCrO4-	5.071e-20	4.423e-20	-19.295	-19.354	-0.059	(0)
Mg	1.035e-03					
Mg+2	8.707e-04	5.435e-04	-3.060	-3.265	-0.205	(0)
MgSO4	1.426e-04	1.426e-04	-3.846	-3.846	0.000	(0)
MgHCO3+	1.435e-05	1.275e-05	-4.843	-4.895	-0.052	(0)
MgCO3	5.759e-06	5.759e-06	-5.240	-5.240	0.000	(0)
MgF+	1.494e-06	1.330e-06	-5.826	-5.876	-0.051	(0)
MgOH+	2.882e-07	2.583e-07	-6.540	-6.588	-0.048	(0)
MgH2BO3+	4.566e-09	4.029e-09	-8.341	-8.395	-0.054	(0)
Mn(2)	1.731e-06					
Mn+2	1.466e-06	8.482e-07	-5.834	-6.072	-0.238	(0)
MnSO4	2.174e-07	2.174e-07	-6.663	-6.663	0.000	(0)
MnHCO3+	4.350e-08	3.878e-08	-7.361	-7.411	-0.050	(0)
MnOH+	2.853e-09	2.543e-09	-8.545	-8.595	-0.050	(0)
MnF+	8.258e-10	7.362e-10	-9.083	-9.133	-0.050	(0)
MnCl+	4.715e-10	4.203e-10	-9.327	-9.376	-0.050	(0)
MnCl2	2.337e-13	2.337e-13	-12.631	-12.631	0.000	(0)
MnCl3-	2.842e-17	2.533e-17	-16.546	-16.596	-0.050	(0)
Mn(OH)3-	2.512e-17	2.239e-17	-16.600	-16.650	-0.050	(0)
MnSeO4	2.380e-17	2.380e-17	-16.623	-16.623	0.000	(0)
Mn(OH)4-2	1.366e-22	8.630e-23	-21.864	-22.064	-0.200	(0)
MnSe	5.750e-35	5.750e-35	-34.240	-34.240	0.000	(0)
Mn(3)	2.169e-28					
Mn+3	2.169e-28	7.512e-29	-27.664	-28.124	-0.460	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-46.513	-46.713	-0.200	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-52.734	-52.788	-0.053	(0)
Mo	6.728e-08					
MoO4-2	6.727e-08	4.200e-08	-7.172	-7.377	-0.205	(0)
HMoO4-	8.081e-12	7.048e-12	-11.093	-11.152	-0.059	(0)
H2MoO4	4.354e-16	4.354e-16	-15.361	-15.361	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-52.332	-52.867	-0.535	(0)
Mo7O24-6	0.000e+00	0.000e+00	-61.099	-63.239	-2.140	(0)
HMo7O24-5	0.000e+00	0.000e+00	-63.440	-64.926	-1.486	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-67.267	-68.218	-0.951	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-72.511	-73.046	-0.535	(0)
Na	2.569e-03					
Na+	2.546e-03	2.263e-03	-2.594	-2.645	-0.051	(0)
NaSO4-	1.962e-05	1.752e-05	-4.707	-4.757	-0.049	(0)
NaHCO3	2.916e-06	2.916e-06	-5.535	-5.535	0.000	(0)
NaCO3-	6.013e-07	5.368e-07	-6.221	-6.270	-0.049	(0)
NaF	3.113e-08	3.113e-08	-7.507	-7.507	0.000	(0)
NaH2BO3	7.669e-10	7.669e-10	-9.115	-9.115	0.000	(0)
NaCrO4-	3.140e-19	2.738e-19	-18.503	-18.563	-0.059	(0)
Ni	5.536e-08					
Ni+2	3.273e-08	2.043e-08	-7.485	-7.690	-0.205	(0)
NiCO3	9.711e-09	9.711e-09	-8.013	-8.013	0.000	(0)
NiHCO3+	6.620e-09	5.773e-09	-8.179	-8.239	-0.059	(0)
NiSO4	5.876e-09	5.876e-09	-8.231	-8.231	0.000	(0)
NiOH+	3.521e-10	3.071e-10	-9.453	-9.513	-0.059	(0)
Ni(OH)2	2.912e-11	2.912e-11	-10.536	-10.536	0.000	(0)
NiCl+	2.360e-11	2.058e-11	-10.627	-10.687	-0.059	(0)
NiF+	1.283e-11	1.119e-11	-10.892	-10.951	-0.059	(0)
Ni(SO4)2-2	4.848e-13	2.804e-13	-12.314	-12.552	-0.238	(0)
Ni(OH)3-	3.985e-14	3.475e-14	-13.400	-13.459	-0.059	(0)
NiCl2	4.079e-17	4.079e-17	-16.389	-16.389	0.000	(0)
NiSeO4	9.963e-19	9.963e-19	-18.002	-18.002	0.000	(0)
O(0)	0.000e+00					
O2	0.000e+00	0.000e+00	-40.512	-40.510	0.001	(0)
Pb	7.416e-08					
PbCO3	5.847e-08	5.847e-08	-7.233	-7.233	0.000	(0)
PbOH+	5.250e-09	4.578e-09	-8.280	-8.339	-0.059	(0)
Pb(CO3)2-2	3.714e-09	2.148e-09	-8.430	-8.668	-0.238	(0)
PbHCO3+	2.981e-09	2.600e-09	-8.526	-8.585	-0.059	(0)
Pb+2	2.446e-09	1.527e-09	-8.612	-8.816	-0.205	(0)
PbSO4	1.078e-09	1.078e-09	-8.967	-8.967	0.000	(0)
Pb(OH)2	1.728e-10	1.728e-10	-9.762	-9.762	0.000	(0)
PbCl+	2.445e-11	2.133e-11	-10.612	-10.671	-0.059	(0)
Pb(SO4)2-2	1.618e-11	9.361e-12	-10.791	-11.029	-0.238	(0)
PbF+	2.690e-12	2.346e-12	-11.570	-11.630	-0.059	(0)
Pb(OH)3-	2.365e-13	2.063e-13	-12.626	-12.686	-0.059	(0)
PbCl2	3.750e-14	3.750e-14	-13.426	-13.426	0.000	(0)
PbF2	1.007e-15	1.007e-15	-14.997	-14.997	0.000	(0)
Pb2OH+3	3.798e-16	1.108e-16	-15.420	-15.955	-0.535	(0)
Pb(OH)4-2	1.043e-16	6.031e-17	-15.982	-16.220	-0.238	(0)
PbCl3-	6.737e-18	5.876e-18	-17.172	-17.231	-0.059	(0)
Pb3(OH)4+2	1.573e-18	9.100e-19	-17.803	-18.041	-0.238	(0)
PbF3-	4.774e-20	4.163e-20	-19.321	-19.381	-0.059	(0)
PbCl4-2	1.828e-21	1.057e-21	-20.738	-20.976	-0.238	(0)
Pb4(OH)4+4	9.861e-23	1.104e-23	-22.006	-22.957	-0.951	(0)
PbF4-2	7.512e-25	4.345e-25	-24.124	-24.362	-0.238	(0)
Pb(HS)2	0.000e+00	0.000e+00	-129.996	-129.996	0.000	(0)
Pb(HS)3-	0.000e+00	0.000e+00	-196.862	-196.921	-0.059	(0)
S(-2)	0.000e+00					
HS-	0.000e+00	0.000e+00	-68.166	-68.225	-0.059	(0)
CdHS+	0.000e+00	0.000e+00	-68.178	-68.237	-0.059	(0)
S5-2	0.000e+00	0.000e+00	-69.278	-69.516	-0.238	(0)
H2S	0.000e+00	0.000e+00	-69.279	-69.279	0.000	(0)
S6-2	0.000e+00	0.000e+00	-69.794	-70.032	-0.238	(0)
S4-2	0.000e+00	0.000e+00	-69.874	-70.112	-0.238	(0)
S3-2	0.000e+00	0.000e+00	-70.680	-70.918	-0.238	(0)
S2-2	0.000e+00	0.000e+00	-71.696	-71.934	-0.238	(0)
S-2	0.000e+00	0.000e+00	-77.252	-77.451	-0.200	(0)
Cu(S4)2-3	0.000e+00	0.000e+00	-125.385	-125.669	-0.284	(0)
CuS4S5-3	0.000e+00	0.000e+00	-126.126	-126.399	-0.273	(0)
ZnS(HS)-	0.000e+00	0.000e+00	-127.990	-128.050	-0.059	(0)
Cd(HS)2	0.000e+00	0.000e+00	-129.258	-129.258	0.000	(0)
Pb(HS)2	0.000e+00	0.000e+00	-129.996	-129.996	0.000	(0)
Zn(HS)2	0.000e+00	0.000e+00	-130.114	-130.114	0.000	(0)
Fe(HS)2	0.000e+00	0.000e+00	-135.538	-135.538	0.000	(0)
Cu(HS)3-	0.000e+00	0.000e+00	-186.867	-186.926	-0.059	(0)
Zn(HS)3-	0.000e+00	0.000e+00	-194.999	-195.059	-0.059	(0)
Cd(HS)3-	0.000e+00	0.000e+00	-195.524	-195.583	-0.059	(0)
ZnS(HS)2-2	0.000e+00	0.000e+00	-196.727	-196.965	-0.238	(0)
Pb(HS)3-	0.000e+00	0.000e+00	-196.862	-196.921	-0.059	(0)
Fe(HS)3-	0.000e+00	0.000e+00	-201.666	-201.726	-0.059	(0)
Cd(HS)4-2	0.000e+00	0.000e+00	-261.375	-261.612	-0.238	(0)
Zn(HS)4-2	0.000e+00	0.000e+00	-264.506	-264.744	-0.238	(0)
S(6)	2.895e-03					
SO4-2	2.309e-03	1.441e-03	-2.637	-2.841	-0.205	(0)
CaSO4	4.182e-04	4.182e-04	-3.379	-3.379	0.000	(0)
MgSO4	1.426e-04	1.426e-04	-3.846	-3.846	0.000	(0)
NaSO4-	1.962e-05	1.752e-05	-4.707	-4.757	-0.049	(0)
KSO4-	5.587e-06	4.988e-06	-5.253	-5.302	-0.049	(0)
MnSO4	2.174e-07	2.174e-07	-6.663	-6.663	0.000	(0)
ZnSO4	1.036e-07	1.036e-07	-6.985	-6.985	0.000	(0)
CoSO4	8.063e-09	8.063e-09	-8.093	-8.093	0.000	(0)
NiSO4	5.876e-09	5.876e-09	-8.231	-8.231	0.000	(0)
FeSO4	3.244e-09	3.244e-09	-8.489	-8.489	0.000	(0)
CdSO4	3.225e-09	3.225e-09	-8.491	-8.491	0.000	(0)
CuSO4	2.338e-09	2.338e-09	-8.631	-8.631	0.000	(0)
Zn(SO4)2-2	2.248e-09	1.300e-09	-8.648	-8.886	-0.238	(0)
HSO4-	1.335e-09	1.188e-09	-8.875	-8.925	-0.051	(0)
PbSO4	1.078e-09	1.078e-09	-8.967	-8.967	0.000	(0)
Cd(SO4)2-2	1.084e-10	6.271e-11	-9.965	-10.203	-0.238	(0)
CrOHSO4	6.293e-11	6.293e-11	-10.201	-10.201	0.000	(0)
Pb(SO4)2-2	1.618e-11	9.361e-12	-10.791	-11.029	-0.238	(0)
Ni(SO4)2-2	4.848e-13	2.804e-13	-12.314	-12.552	-0.238	(0)
CrSO4+	2.719e-14	2.371e-14	-13.566	-13.625	-0.059	(0)
AlSO4+	8.795e-15	7.826e-15	-14.056	-14.106	-0.051	(0)
UO2SO4	2.609e-16	2.609e-16	-15.584	-15.584	0.000	(0)
Al(SO4)2-	1.358e-16	1.209e-16	-15.867	-15.918	-0.051	(0)
FeSO4+	3.064e-17	2.731e-17	-16.514	-16.564	-0.050	(0)
UO2(SO4)2-2	8.569e-18	4.956e-18	-17.067	-17.305	-0.238	(0)
Cr2(OH)2SO4+2	1.809e-18	1.047e-18	-17.742	-17.980	-0.238	(0)
Fe(SO4)2-	9.650e-19	8.416e-19	-18.015	-18.075	-0.059	(0)
VO2SO4-	4.422e-19	3.856e-19	-18.354	-18.414	-0.059	(0)
Cr2(OH)2(SO4)2	8.960e-20	8.960e-20	-19.048	-19.048	0.000	(0)
VOSO4	1.276e-20	1.276e-20	-19.894	-19.894	0.000	(0)
CrO3SO4-2	4.254e-27	2.461e-27	-26.371	-26.609	-0.238	(0)
VSO4+	4.470e-34	3.898e-34	-33.350	-33.409	-0.059	(0)
U(SO4)2	0.000e+00	0.000e+00	-40.779	-40.779	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-41.600	-41.838	-0.238	(0)
Se(-2)	1.592e-31					
HSe-	1.591e-31	1.387e-31	-30.798	-30.858	-0.059	(0)
MnSe	5.750e-35	5.750e-35	-34.240	-34.240	0.000	(0)
H2Se	9.083e-36	9.083e-36	-35.042	-35.042	0.000	(0)
Se-2	2.844e-38	1.645e-38	-37.546	-37.784	-0.238	(0)
Se(4)	6.346e-08					
HSeO3-	3.707e-08	3.233e-08	-7.431	-7.490	-0.059	(0)
SeO3-2	2.638e-08	1.526e-08	-7.579	-7.816	-0.238	(0)

H2SeO3	1.163e-13	1.163e-13	-12.934	-12.934	0.000	(0)
Cd(SeO3)2-2	3.168e-18	1.832e-18	-17.499	-17.737	-0.238	(0)
FeHSeO3+2	2.495e-22	1.443e-22	-21.603	-21.841	-0.238	(0)
Se(6)	1.670e-13					
SeO4-2	1.670e-13	1.042e-13	-12.777	-12.982	-0.205	(0)
MnSeO4	2.380e-17	2.380e-17	-16.623	-16.623	0.000	(0)
ZnSeO4	5.303e-18	5.303e-18	-17.275	-17.275	0.000	(0)
CoSeO4	1.465e-18	1.465e-18	-17.834	-17.834	0.000	(0)
NiSeO4	9.963e-19	9.963e-19	-18.002	-18.002	0.000	(0)
CdSeO4	1.853e-19	1.853e-19	-18.732	-18.732	0.000	(0)
HSeO4-	5.053e-20	4.406e-20	-19.296	-19.356	-0.059	(0)
Zn(SeO4)2-2	9.691e-31	5.605e-31	-30.014	-30.251	-0.238	(0)
U(3)	0.000e+00					
U+3	0.000e+00	0.000e+00	-57.155	-57.690	-0.535	(0)
U(4)	5.157e-19					
U(OH)5-	5.155e-19	4.496e-19	-18.288	-18.347	-0.059	(0)
U(OH)4	1.588e-22	1.588e-22	-21.799	-21.799	0.000	(0)
U(OH)3+	5.616e-27	4.898e-27	-26.251	-26.310	-0.059	(0)
U(OH)2+2	3.303e-32	1.910e-32	-31.481	-31.719	-0.238	(0)
UOH+3	2.602e-38	7.590e-39	-37.585	-38.120	-0.535	(0)
UF3+	1.198e-38	1.045e-38	-37.922	-37.981	-0.059	(0)
UF2+2	5.226e-39	3.023e-39	-38.282	-38.520	-0.238	(0)
UF+3	0.000e+00	0.000e+00	-40.423	-40.958	-0.535	(0)
UF4	0.000e+00	0.000e+00	-40.602	-40.602	0.000	(0)
U(SO4)2	0.000e+00	0.000e+00	-40.779	-40.779	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-41.600	-41.838	-0.238	(0)
UF5-	0.000e+00	0.000e+00	-43.607	-43.666	-0.059	(0)
U+4	0.000e+00	0.000e+00	-44.646	-45.597	-0.951	(0)
UF6-2	0.000e+00	0.000e+00	-45.610	-45.847	-0.238	(0)
UCl+3	0.000e+00	0.000e+00	-46.767	-47.302	-0.535	(0)
U6(OH)15+9	0.000e+00	0.000e+00	-164.812	-169.627	-4.815	(0)
U(5)	4.215e-17					
UO2+	4.215e-17	3.676e-17	-16.375	-16.435	-0.059	(0)
U(6)	1.146e-08					
UO2(CO3)3-4	8.792e-09	9.841e-10	-8.056	-9.007	-0.951	(0)
UO2(CO3)2-2	2.665e-09	1.541e-09	-8.574	-8.812	-0.238	(0)
UO2CO3	6.065e-12	6.065e-12	-11.217	-11.217	0.000	(0)
UO2OH+	2.061e-14	1.797e-14	-13.686	-13.745	-0.059	(0)
UO2F+	4.127e-16	3.599e-16	-15.384	-15.444	-0.059	(0)
UO2SO4	2.609e-16	2.609e-16	-15.584	-15.584	0.000	(0)
UO2+2	1.916e-16	1.196e-16	-15.718	-15.922	-0.205	(0)
UO2F2	2.263e-17	2.263e-17	-16.645	-16.645	0.000	(0)
UO2(SO4)2-2	8.569e-18	4.956e-18	-17.067	-17.305	-0.238	(0)
UO2F3-	1.421e-19	1.240e-19	-18.847	-18.907	-0.059	(0)
UO2Cl+	8.754e-20	7.634e-20	-19.058	-19.117	-0.059	(0)
(UO2)2(OH)2+2	9.266e-22	5.360e-22	-21.033	-21.271	-0.238	(0)
UO2F4-2	3.712e-23	2.147e-23	-22.430	-22.668	-0.238	(0)
(UO2)3(OH)5+	1.194e-23	1.041e-23	-22.923	-22.983	-0.059	(0)
V(2)	6.268e-40					
VOH+	6.268e-40	5.466e-40	-39.203	-39.262	-0.059	(0)
V+2	0.000e+00	0.000e+00	-40.611	-40.849	-0.238	(0)
V(3)	7.861e-13					
V(OH)3	7.861e-13	7.861e-13	-12.105	-12.105	0.000	(0)
V(OH)2+	4.913e-24	4.284e-24	-23.309	-23.368	-0.059	(0)
VOH+2	5.926e-28	3.428e-28	-27.227	-27.465	-0.238	(0)
V+3	1.964e-33	5.729e-34	-32.707	-33.242	-0.535	(0)
VSO4+	4.470e-34	3.898e-34	-33.350	-33.409	-0.059	(0)
V2(OH)3+3	0.000e+00	0.000e+00	-51.846	-52.381	-0.535	(0)
V2(OH)2+4	0.000e+00	0.000e+00	-53.179	-54.130	-0.951	(0)
V(4)	8.853e-18					
V(OH)3+	8.780e-18	7.657e-18	-17.057	-17.116	-0.059	(0)
VO+2	5.559e-20	3.216e-20	-19.255	-19.493	-0.238	(0)
VOSO4	1.276e-20	1.276e-20	-19.894	-19.894	0.000	(0)
VOF+	4.822e-21	4.205e-21	-20.317	-20.376	-0.059	(0)
VOCl+	4.072e-23	3.551e-23	-22.390	-22.450	-0.059	(0)
VOF2	3.438e-23	3.438e-23	-22.464	-22.464	0.000	(0)
VOF3-	3.050e-26	2.660e-26	-25.516	-25.575	-0.059	(0)
H2V2O4+2	5.082e-30	2.940e-30	-29.294	-29.532	-0.238	(0)
VOF4-2	4.047e-30	2.341e-30	-29.393	-29.631	-0.238	(0)
V(5)	1.311e-08					
H2VO4-	9.050e-09	7.892e-09	-8.043	-8.103	-0.059	(0)
HVO4-2	4.064e-09	2.350e-09	-8.391	-8.629	-0.238	(0)
H3VO4	6.656e-13	6.656e-13	-12.177	-12.177	0.000	(0)
H3V2O7-	3.890e-14	3.392e-14	-13.410	-13.470	-0.059	(0)
HV2O7-3	2.155e-14	6.287e-15	-13.667	-14.202	-0.535	(0)
VO4-3	4.787e-15	1.397e-15	-14.320	-14.855	-0.535	(0)
V2O7-4	1.793e-16	2.006e-17	-15.747	-16.698	-0.951	(0)
VO2+	1.261e-17	1.121e-17	-16.899	-16.951	-0.051	(0)
V3O9-3	1.765e-18	5.150e-19	-17.753	-18.288	-0.535	(0)
VO2SO4-	4.422e-19	3.856e-19	-18.354	-18.414	-0.059	(0)
VO2F	4.285e-19	4.285e-19	-18.368	-18.368	0.000	(0)
VO2F2-	3.890e-21	3.392e-21	-20.410	-20.470	-0.059	(0)
V4O12-4	1.514e-23	1.695e-24	-22.820	-23.771	-0.951	(0)
VO2F3-2	1.595e-24	9.226e-25	-23.797	-24.035	-0.238	(0)
VO2F4-3	3.393e-29	9.898e-30	-28.469	-29.004	-0.535	(0)
V10O28-6	0.000e+00	0.000e+00	-62.277	-64.417	-2.140	(0)
HV10O28-5	0.000e+00	0.000e+00	-62.819	-64.305	-1.486	(0)
H2V10O28-4	0.000e+00	0.000e+00	-66.220	-67.171	-0.951	(0)
Zn	9.536e-07					
Zn+2	5.262e-07	3.285e-07	-6.279	-6.483	-0.205	(0)
ZnCO3	2.408e-07	2.408e-07	-6.618	-6.618	0.000	(0)
ZnSO4	1.036e-07	1.036e-07	-6.985	-6.985	0.000	(0)
ZnOH+	4.496e-08	3.921e-08	-7.347	-7.407	-0.059	(0)
ZnHCO3+	2.730e-08	2.380e-08	-7.564	-7.623	-0.059	(0)
Zn(OH)2	7.418e-09	7.418e-09	-8.130	-8.130	0.000	(0)
Zn(SO4)2-2	2.248e-09	1.300e-09	-8.648	-8.886	-0.238	(0)
ZnOHCl	5.075e-10	5.075e-10	-9.295	-9.295	0.000	(0)
ZnCl+	3.657e-10	3.248e-10	-9.437	-9.488	-0.052	(0)
ZnF+	1.639e-10	1.429e-10	-9.786	-9.845	-0.059	(0)
Zn(OH)3-	5.089e-11	4.438e-11	-10.293	-10.353	-0.059	(0)
ZnCl2	2.026e-13	2.026e-13	-12.693	-12.693	0.000	(0)
Zn(OH)4-2	3.646e-15	2.109e-15	-14.438	-14.676	-0.238	(0)
ZnCl3-	7.133e-17	6.335e-17	-16.147	-16.198	-0.052	(0)
ZnSeO4	5.303e-18	5.303e-18	-17.275	-17.275	0.000	(0)
ZnCl4-2	1.974e-20	1.247e-20	-19.705	-19.904	-0.200	(0)
Zn(SeO4)2-2	9.691e-31	5.605e-31	-30.014	-30.251	-0.238	(0)
ZnS(HS)-	0.000e+00	0.000e+00	-127.990	-128.050	-0.059	(0)
Zn(HS)2	0.000e+00	0.000e+00	-130.114	-130.114	0.000	(0)
Zn(HS)3-	0.000e+00	0.000e+00	-194.999	-195.059	-0.059	(0)
ZnS(HS)2-2	0.000e+00	0.000e+00	-196.727	-196.965	-0.238	(0)
Zn(HS)4-2	0.000e+00	0.000e+00	-264.506	-264.744	-0.238	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.73	9.07	10.80	Al(OH)3
Al2(MoO4)3	-54.81	-52.44	2.37	Al2(MoO4)3
Al2O3	-1.52	18.13	19.65	Al2O3
Al4(OH)10SO4	-5.42	17.28	22.70	Al4(OH)10SO4
AlAsO4:2H2O	-9.70	-4.90	4.80	AlAsO4:2H2O
AlOHSO4	-6.69	-9.92	-3.23	AlOHSO4
Alunite	-4.62	-6.02	-1.40	KAl3(SO4)2(OH)6
Anglesite	-3.87	-11.66	-7.79	PbSO4
Anhydrite	-1.38	-5.74	-4.36	CaSO4
Anilite	-43.45	-75.32	-31.88	Cu0.25Cu1.5S
Antlerite	-3.78	5.00	8.79	Cu3(OH)4SO4
Aragonite	0.51	-7.79	-8.30	CaCO3
Arsenolite	-68.50	-71.26	-2.76	As4O6
Artinite	-4.88	4.72	9.60	MgCO3:Mg(OH)2:3H2O
As2O5	-34.65	-27.94	6.71	As2O5
Atacamite	-2.87	4.52	7.39	Cu2(OH)3Cl
Azurite	-1.19	-18.09	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-14.78	9.61	24.39	Ba(OH)2:8H2O
Ba2V2O7:2H2O	-14.40	1.47	15.87	Ba2V2O7:2H2O
Ba3(AsO4)2	9.81	0.90	-8.91	Ba3(AsO4)2
Ba3(VO4)2:4H2O	-21.86	11.08	32.94	Ba3(VO4)2:4H2O
BaCrO4	-13.48	-23.15	-9.67	BaCrO4
BaF2	-10.04	-15.86	-5.82	BaF2
BaMoO4	-6.95	-13.91	-6.96	BaMoO4
Barite	0.60	-9.38	-9.98	BaSO4
BaS	-82.87	-66.69	16.18	BaS
BaSeO3	-7.78	-5.95	1.83	BaSeO3
BaSeO4	-12.06	-19.52	-7.46	BaSeO4
Bianchite	-7.56	-9.33	-1.76	ZnSO4:6H2O
Birnessite	-10.62	7.47	18.09	MnO2
Bixbyite	-7.16	-7.80	-0.64	Mn2O3
BlaubleiI	-45.08	-69.24	-24.16	Cu0.9Cu0.2S
BlaubleiII	-44.77	-72.05	-27.28	Cu0.6Cu0.8S
Boehmite	0.49	9.07	8.58	AlOOH
Brochantite	-2.22	13.00	15.22	Cu4(OH)6SO4
Brucite	-3.96	12.88	16.84	Mg(OH)2
Bunsenite	-3.99	8.46	12.45	NiO
Ca(VO3)2	-10.16	-4.50	5.66	Ca(VO3)2
Ca2V2O7	-8.75	8.75	17.50	Ca2V2O7
Ca2V2O7:2H2O	-12.80	8.75	21.55	Ca2V2O7:2H2O
Ca3(AsO4)2:4H2O	-10.49	11.81	22.30	Ca3(AsO4)2:4H2O
Ca3(VO4)2	-16.96	22.00	38.96	Ca3(VO4)2
Ca3(VO4)2:4H2O	-17.86	22.00	39.86	Ca3(VO4)2:4H2O
CaCrO4	-17.25	-19.51	-2.27	CaCrO4
Calcite	0.69	-7.79	-8.48	CaCO3
CaMoO4	-2.32	-10.27	-7.95	CaMoO4
Carnotite	-4.12	-3.89	0.23	KUO2VO4
CaSeO3:2H2O	-5.13	-2.31	2.81	CaSeO3:2H2O
CaSeO4:2H2O	-12.86	-15.88	-3.02	CaSeO4:2H2O
Cd(BO2)2	-12.73	-2.89	9.84	Cd(BO2)2
Cd(OH)2	-5.52	8.13	13.64	Cd(OH)2
Cd(OH)2(am)	-5.60	8.13	13.73	Cd(OH)2
Cd3(OH)2(SO4)2	-20.31	-13.60	6.71	Cd3(OH)2(SO4)2
Cd3(OH)4SO4	-17.17	5.39	22.56	Cd3(OH)4SO4
Cd4(OH)6SO4	-14.88	13.52	28.40	Cd4(OH)6SO4
CdCl2	-14.17	-14.83	-0.66	CdCl2
CdCl2:1H2O	-13.14	-14.83	-1.69	CdCl2:1H2O
CdCl2:2.5H2O	-12.92	-14.83	-1.91	CdCl2:2.5H2O
CdF2	-16.13	-17.34	-1.21	CdF2
Cdmetal(alpha)	-28.13	-14.61	13.51	Cd
Cdmetal(gamma)	-28.23	-14.61	13.62	Cd
CdMoO4	-1.25	-15.40	-14.15	CdMoO4
CdOHCl	-6.89	-3.35	3.54	CdOHCl
CdSe	-10.60	-30.80	-20.20	CdSe
CdSeO4:2H2O	-19.15	-21.00	-1.85	CdSeO4:2H2O
CdSO4	-10.69	-10.86	-0.17	CdSO4
CdSO4:1H2O	-9.14	-10.86	-1.73	CdSO4:1H2O
CdSO4:2.67H2O	-8.99	-10.86	-1.87	CdSO4:2.67H2O
Cerussite	-0.58	-13.71	-13.13	PbCO3
CH4(g)	-70.97	-112.01	-41.05	CH4
Chalcanthite	-8.35	-10.99	-2.64	CuSO4:5H2O
Chalcocite	-42.75	-77.67	-34.92	Cu2S
Chalcopyrite	-101.22	-136.49	-35.27	CuFeS2
Claudetite	-68.19	-71.26	-3.06	As4O6
Clausthalite	-4.50	-31.60	-27.10	PbSe
Co(BO2)2	-29.49	-2.42	27.07	Co(BO2)2
Co(OH)2	-4.50	8.60	13.09	Co(OH)2
Co(OH)3	-10.12	-12.43	-2.31	Co(OH)3
CO2(g)	-2.90	-21.04	-18.15	CO2
Co3(AsO4)2	-15.19	-2.15	13.03	Co3(AsO4)2
Co3O4	-5.78	-16.27	-10.50	Co3O4
CoCl2	-22.63	-14.36	8.27	CoCl2
CoCl2:6H2O	-16.90	-14.36	2.54	CoCl2:6H2O
CoCO3	-2.47	-12.45	-9.98	CoCO3
CoF2	-15.28	-16.88	-1.60	CoF2
CoF3	-49.18	-50.64	-1.46	CoF3
CoFe2O4	25.02	21.49	-3.53	CoFe2O4
CoMoO4	-7.17	-14.93	-7.76	CoMoO4
CoO	-4.99	8.60	13.59	CoO
CoS(alpha)	-60.26	-67.70	-7.44	CoS
CoS(beta)	-56.63	-67.70	-11.07	CoS
CoSe	-14.14	-30.34	-16.20	CoSe
CoSeO3	-8.29	-6.97	1.32	CoSeO3
CoSeO4:6H2O	-19.00	-20.53	-1.53	CoSeO4:6H2O
CoSO4	-13.20	-10.39	2.80	CoSO4
CoSO4:6H2O	-7.92	-10.39	-2.47	CoSO4:6H2O
Cotunnite	-10.85	-15.63	-4.78	PbCl2
Covellite	-46.00	-68.30	-22.30	CuS
Cr(OH)2	-18.74	-7.92	10.82	Cr(OH)2
Cr(OH)3	-0.83	0.50	1.34	Cr(OH)3
Cr(OH)3(am)	1.25	0.50	-0.75	Cr(OH)3
Cr2O3	3.36	1.00	-2.36	Cr2O3
CrCl2	-44.97	-30.88	14.09	CrCl2
CrCl3	-49.05	-33.94	15.11	CrCl3
CrF3	-26.37	-37.71	-11.34	CrF3
Crmetal	-61.15	-30.67	30.48	Cr
CrO3	-29.55	-32.76	-3.21	CrO3
Cryolite	-17.22	-51.06	-33.84	Na3AlF6
Cu(OH)2	-0.68	8.00	8.67	Cu(OH)2
Cu2Se(alpha)	5.50	-40.30	-45.80	Cu2Se
Cu2SO4	-18.41	-20.36	-1.95	Cu2SO4
Cu3(AsO4)2:2H2O	-10.05	-3.95	6.10	Cu3(AsO4)2:2H2O
Cu3Se2	-7.74	-71.23	-63.49	Cu3Se2
CuCO3	-1.54	-13.04	-11.50	CuCO3
CuCrO4	-19.32	-24.76	-5.44	CuCrO4
CuF	-8.51	-13.42	-4.91	CuF
CuF2	-18.59	-17.47	1.12	CuF2
CuF2:2H2O	-12.92	-17.47	-4.55	CuF2:2H2O
Cumetal	-3.30	-12.05	-8.76	Cu
CuMoO4	-2.45	-15.53	-13.08	CuMoO4
CuOCuSO4	-13.30	-2.99	10.30	CuOCuSO4
Cupricferrite	14.91	20.90	5.99	CuFe2O4
Cuprite	0.04	-1.37	-1.41	Cu2O
Cuprousferrite	14.68	5.77	-8.92	CuFeO2
CuSe	2.17	-30.93	-33.10	CuSe
CuSe2	-13.76	-47.12	-33.37	CuSe2
CuSeO3:2H2O	-8.08	-7.57	0.51	CuSeO3:2H2O
CuSeO4:5H2O	-18.69	-21.13	-2.44	CuSeO4:5H2O
CuSO4	-13.93	-10.99	2.94	CuSO4
Diaspore	2.19	9.07	6.87	AlOOH
Djurleite	-43.13	-77.05	-33.92	Cu0.066Cu1.868S
Dolomite(disordered)	0.59	-15.95	-16.54	CaMg(CO3)2
Dolomite(ordered)	1.14	-15.95	-17.09	CaMg(CO3)2
Epsomite	-3.98	-6.11	-2.13	MgSO4:7H2O
Fe(OH)2	-5.45	8.11	13.56	Fe(OH)2
Fe(OH)2.7Cl.3	6.05	3.01	-3.04	Fe(OH)2.7Cl.3
Fe(VO3)2	-5.92	-9.64	-3.72	Fe(VO3)2
Fe2(OH)4SeO3	-4.22	-2.67	1.55	Fe2(OH)4SeO3
Fe2(SeO3)3:2H2O	-13.17	-33.79	-20.63	Fe2(SeO3)3:2H2O
Fe2(SO4)3	-40.33	-44.07	-3.73	Fe2(SO4)3
Fe3(OH)8	0.79	21.01	20.22	Fe3(OH)8
FeAsO4:2H2O	-7.92	-7.52	0.40	FeAsO4:2H2O
FeCr2O4	1.91	9.11	7.20	FeCr2O4
FeMoO4	-5.32	-15.41	-10.09	FeMoO4
Ferrihydrite	3.26	6.45	3.19	Fe(OH)3
Ferroselite	-28.41	-47.01	-18.60	FeSe2
FeS(ppt)	-65.24	-68.19	-2.95	FeS
FeSe	-19.82	-30.82	-11.00	FeSe

Fluorite	-1.72	-12.22	-10.50	CaF2
Galena	-55.00	-68.97	-13.97	PbS
Gibbsite	0.78	9.07	8.29	Al(OH)3
Goethite	5.96	6.45	0.49	FeOOH
Goslarite	-7.31	-9.33	-2.01	ZnSO4:7H2O
Greenockite	-53.81	-68.17	-14.36	CdS
Greigite	-239.15	-284.19	-45.03	Fe3S4
Gummite	-7.45	0.23	7.67	UO3
Gypsum	-1.13	-5.74	-4.61	CaSO4:2H2O
H-Jarosite	-6.53	-18.63	-12.10	(H3O)Fe3(SO4)2(OH)6
H2MoO4	-10.65	-23.52	-12.88	H2MoO4
H2S(g)	-68.29	-76.30	-8.01	H2S
H2Se(g)	-33.97	-38.93	-4.96	H2Se
Halite	-7.65	-6.05	1.60	NaCl
Hausmannite	-8.06	52.97	61.03	Mn3O4
Hematite	14.32	12.90	-1.42	Fe2O3
Hercynite	3.35	26.24	22.89	FeAl2O4
Huntite	-2.30	-32.27	-29.97	CaMg3(CO3)4
Hydrocerussite	-1.32	-20.09	-18.77	Pb3(OH)2(CO3)2
Hydromagnesite	-10.99	-19.76	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-18.98	-24.15	-5.17	KAl(SO4)2:12H2O
K-Jarosite	0.93	-13.87	-14.80	KFe3(SO4)2(OH)6
K2Cr2O7	-38.75	-56.00	-17.24	K2Cr2O7
K2CrO4	-22.72	-23.24	-0.51	K2CrO4
K2MoO4	-17.26	-14.00	3.26	K2MoO4
K2SeO4	-18.87	-19.60	-0.73	K2SeO4
Langite	-4.49	13.00	17.49	Cu4(OH)6SO4:H2O
Larnakite	-3.89	-4.33	-0.43	PbO:PbSO4
Laurionite	-4.77	-4.15	0.62	PbOHCl
Lepidocrocite	5.08	6.45	1.37	FeOOH
Lime	-19.45	13.25	32.70	CaO
Litharge	-5.36	7.33	12.69	PbO
Mackinawite	-64.59	-68.19	-3.60	FeS
Maghemite	6.51	12.90	6.39	Fe2O3
Magnesioferrite	8.92	25.78	16.86	Fe2MgO4
Magnesite	-0.70	-8.16	-7.46	MgCO3
Magnetite	17.61	21.01	3.40	Fe3O4
Malachite	0.26	-5.05	-5.31	Cu2(OH)2CO3
Manganite	-3.89	21.45	25.34	MnOOH
Massicot	-5.56	7.33	12.89	PbO
Matlockite	-7.91	-16.88	-8.97	PbClF
Melanothallite	-21.22	-14.96	6.26	CuCl2
Melanterite	-8.67	-10.88	-2.21	FeSO4:7H2O
Mg(OH)2(active)	-5.91	12.88	18.79	Mg(OH)2
Mg(VO3)2	-16.15	-4.87	11.28	Mg(VO3)2
Mg2V2O7	-18.35	8.01	26.36	Mg2V2O7
MgCr2O4	-2.32	13.88	16.20	MgCr2O4
MgCrO4	-25.26	-19.88	5.38	MgCrO4
MgF2	-4.46	-12.59	-8.13	MgF2
MgMoO4	-8.79	-10.64	-1.85	MgMoO4
MgSeO3:6H2O	-5.74	-2.68	3.06	MgSeO3:6H2O
MgSeO4:6H2O	-15.05	-16.25	-1.20	MgSeO4:6H2O
Minium	-28.78	44.74	73.52	Pb3O4
Mirabilite	-7.02	-8.13	-1.11	Na2SO4:10H2O
Mn(VO3)2	-12.58	-7.68	4.90	Mn(VO3)2
Mn2(SO4)3	-59.06	-64.77	-5.71	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-10.21	2.29	12.50	Mn3(AsO4)2:8H2O
MnCl2:4H2O	-15.60	-12.88	2.72	MnCl2:4H2O
MnS(grn)	-66.39	-66.22	0.17	MnS
MnS(pnk)	-69.56	-66.22	3.34	MnS
MnSe	-32.36	-28.86	3.50	MnSe
MnSeO3	-6.62	-5.49	1.13	MnSeO3
MnSeO3:2H2O	-6.47	-5.49	0.98	MnSeO3:2H2O
MnSeO4:5H2O	-17.00	-19.05	-2.05	MnSeO4:5H2O
MnSO4	-11.50	-8.91	2.58	MnSO4
Monteponite	-6.98	8.13	15.10	CdO
MoO3	-15.52	-23.52	-8.00	MoO3
Morenosite	-8.39	-10.53	-2.14	NiSO4:7H2O
MoS2	-128.61	-198.87	-70.26	MoS2
Na-Jarosite	-2.00	-13.20	-11.20	NaFe3(SO4)2(OH)6
Na2Cr2O7	-44.77	-54.67	-9.90	Na2Cr2O7
Na2CrO4	-24.83	-21.90	2.93	Na2CrO4
Na2Mo2O7	-19.60	-36.19	-16.60	Na2Mo2O7
Na2MoO4	-14.16	-12.67	1.49	Na2MoO4
Na2MoO4:2H2O	-13.89	-12.67	1.22	Na2MoO4:2H2O
Na2SeO3:5H2O	-15.01	-4.71	10.30	Na2SeO3:5H2O
Na2SeO4	-19.55	-18.27	1.28	Na2SeO4
Na3VO4	-29.27	7.41	36.68	Na3VO4
Na4V2O7	-33.44	3.96	37.40	Na4V2O7
Nantokite	-5.43	-12.16	-6.73	CuCl
Natron	-8.88	-10.19	-1.31	Na2CO3:10H2O
NaVO3	-7.31	-3.45	3.86	NaVO3
Nesquehonite	-3.49	-8.16	-4.67	MgCO3:3H2O
Ni(OH)2	-4.34	8.46	12.79	Ni(OH)2
Ni3(AsO4)2:8H2O	-18.27	-2.57	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-17.16	14.84	32.00	Ni4(OH)6SO4
NiCO3	-5.71	-12.58	-6.87	NiCO3
NiMoO4	-3.92	-15.07	-11.14	NiMoO4
NiS(alpha)	-62.24	-67.84	-5.60	NiS
NiS(beta)	-56.74	-67.84	-11.10	NiS
NiS(gamma)	-55.04	-67.84	-12.80	NiS
NiSe	-12.77	-30.47	-17.70	NiSe
NiSeO3:2H2O	-9.92	-7.11	2.81	NiSeO3:2H2O
NiSeO4:6H2O	-19.15	-20.67	-1.52	NiSeO4:6H2O
Nsutite	-10.04	7.47	17.50	MnO2
O2(g)	-37.60	45.48	83.09	O2
Orpiment	-203.46	-264.53	-61.07	As2S3
Otavite	-0.92	-12.92	-12.00	CdCO3
Pb(BO2)2	-10.20	-3.68	6.52	Pb(BO2)2
Pb(OH)2	-0.82	7.33	8.15	Pb(OH)2
Pb10(OH)6O(CO3)6	-44.18	-52.94	-8.76	Pb10(OH)6O(CO3)6
Pb2(OH)3Cl	-5.61	3.18	8.79	Pb2(OH)3Cl
Pb2O(OH)2	-11.52	14.66	26.19	Pb2O(OH)2
Pb2O3	-23.63	37.41	61.04	Pb2O3
Pb2OCO3	-5.82	-6.38	-0.56	Pb2OCO3
Pb2V2O7	-1.19	-3.09	-1.90	Pb2V2O7
Pb3(AsO4)2	-11.75	-5.95	5.80	Pb3(AsO4)2
Pb3(VO4)2	-1.90	4.24	6.14	Pb3(VO4)2
Pb3O2CO3	-10.07	0.95	11.02	Pb3O2CO3
Pb3O2SO4	-7.68	3.01	10.69	Pb3O2SO4
Pb4(OH)6SO4	-10.76	10.34	21.10	Pb4(OH)6SO4
Pb4O3SO4	-11.54	10.34	21.88	Pb4O3SO4
PbCrO4	-12.83	-25.43	-12.60	PbCrO4
PbF2	-10.70	-18.14	-7.44	PbF2
Pbmetal	-19.66	-15.41	4.25	Pb
PbMoO4	-0.57	-16.19	-15.62	PbMoO4
PbO:0.3H2O	-5.65	7.33	12.98	PbO:0.33H2O
PbSeO4	-14.96	-21.80	-6.84	PbSeO4
Periclase	-8.70	12.88	21.58	MgO
Phosgenite	-9.53	-29.34	-19.81	PbCl2:PbCO3
Plattnerite	-19.53	30.07	49.60	PbO2
Portlandite	-9.55	13.25	22.80	Ca(OH)2
Pyrite	-103.24	-121.75	-18.51	FeS2
Pyrochroite	-5.12	10.08	15.19	Mn(OH)2
Pyrolusite	-8.56	32.82	41.38	MnO2
Realgar	-85.74	-105.48	-19.75	AsS
Retgersite	-8.49	-10.53	-2.04	NiSO4:6H2O
Rhodochrosite	-0.39	-10.97	-10.58	MnCO3
Rutherfordine	-6.32	-20.82	-14.50	UO2CO3
Schoepite	-5.77	0.23	5.99	UO2(OH)2:H2O
Semetal(am)	-9.08	-16.19	-7.11	Se
Semetal(hex	-8.48	-16.19	-7.71	Se
SeO2	-15.69	-15.56	0.12	SeO2
SeO3	-50.17	-29.13	21.04	SeO3
Siderite	-2.69	-12.93	-10.24	FeCO3
Smithsonite	-1.38	-11.38	-10.00	ZnCO3
Sphalerite	-55.18	-66.63	-11.45	ZnS
Spinel	-5.83	31.02	36.85	MgAl2O4
Sulfur	-51.41	-53.56	-2.14	S
Tenorite	0.35	8.00	7.64	CuO
Thenardite	-8.45	-8.13	0.32	Na2SO4
Thermonatrite	-10.82	-10.19	0.64	Na2CO3:H2O
Tyuyamunite	-8.13	-4.05	4.08	Ca(UO2)2(VO4)2
U3O8	-15.50	5.58	21.08	U3O8
U4O9	-27.44	-30.46	-3.02	U4O9
UF4	-34.71	-64.24	-29.54	UF4
UF4:2.5H2O	-31.52	-64.24	-32.72	UF4:2.5H2O
UO2(am)	-14.23	-13.30	0.93	UO2
UO2(OH)2(beta)	-5.39	0.23	5.61	UO2(OH)2
UO2SeO4:4H2O	-26.65	-28.90	-2.25	UO2SeO4:4H2O
UO3	-7.47	0.23	7.70	UO3
Uraninite	-8.63	-13.30	-4.67	UO2
V(OH)3	-16.61	-9.02	7.59	V(OH)3
V2O5	-16.39	-17.75	-1.36	V2O5
V3O5	-34.61	-32.78	1.84	V3O5
V4O7	-43.31	-36.12	7.19	V4O7
V6O13	-37.88	-98.74	-60.86	V6O13
VCl2	-62.22	-43.35	18.87	VCl2
VCl3	-66.89	-43.46	23.43	VCl3
VF4	-69.22	-54.29	14.93	VF4
Vmetal	-87.16	-43.13	44.03	V
VO	-35.15	-20.39	14.76	VO
VO(OH)2	-8.50	-3.34	5.15	VO(OH)2
VO2Cl	-23.20	-20.36	2.84	VO2Cl
VOCl	-31.65	-20.50	11.15	VOCl
VOCl2	-39.06	-26.30	12.76	VOCl2
VOSO4	-25.94	-22.33	3.61	VOSO4
Witherite	-2.86	-11.43	-8.57	BaCO3
Wurtzite	-57.68	-66.63	-8.95	ZnS
Zincite	-1.67	9.66	11.33	ZnO
Zincosite	-13.25	-9.32	3.93	ZnSO4
Zn(BO2)2	-9.64	-1.35	8.29	Zn(BO2)2
Zn(OH)2	-2.54	9.66	12.20	Zn(OH)2
Zn(OH)2(am)	-2.81	9.66	12.47	Zn(OH)2
Zn(OH)2(beta)	-2.09	9.66	11.75	Zn(OH)2
Zn(OH)2(epsilon)	-1.87	9.66	11.53	Zn(OH)2
Zn(OH)2(gamma)	-2.07	9.66	11.73	Zn(OH)2
Zn2(OH)2SO4	-7.16	0.34	7.50	Zn2(OH)2SO4
Zn2(OH)3Cl	-7.34	7.85	15.19	Zn2(OH)3Cl
Zn3(AsO4)2:2.5H2O	-12.60	1.05	13.65	Zn3(AsO4)2:2.5H2O
Zn3O(SO4)2	-27.90	-8.99	18.91	Zn3O(SO4)2
Zn4(OH)6SO4	-8.73	19.67	28.40	Zn4(OH)6SO4
Zn5(OH)8Cl2	-13.14	25.36	38.50	Zn5(OH)8Cl2
ZnCl2	-20.34	-13.29	7.05	ZnCl2
ZnCO3:1H2O	-1.12	-11.38	-10.26	ZnCO3:1H2O
ZnF2	-15.27	-15.81	-0.53	ZnF2
Znmetal	-38.87	-13.08	25.79	Zn
ZnMoO4	-3.73	-13.86	-10.13	ZnMoO4
ZnO(active)	-1.52	9.66	11.19	ZnO
ZnS(am)	-57.58	-66.63	-9.05	ZnS
ZnSe	-14.87	-29.27	-14.40	ZnSe
ZnSeO4:6H2O	-17.95	-19.47	-1.52	ZnSeO4:6H2O
ZnSO4:1H2O	-8.69	-9.32	-0.64	ZnSO4:1H2O

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

End of simulation.

Reading input data for simulation 2.

End of Run after 0.273 Seconds.

```
# P100 Scenario

SOLUTION 1 UG Water P100
    temp      25
    pH        8.112
    units     mg/L
    density   1
Al    0.0806
As    0.0026
Ba    0.1761
B     0.1387
Ca    116.6
Cl    50.3
Mg    59.1
Na    224.5
K     35.4
F     1.0796
S(6)  319.6
Cd    0.0063
Cr    0.0071
Co    0.0036
Cu    0.0628
Fe    0.1666
Pb    0.0389
Mn    0.0740
Mo    0.0139
Ni    0.0054
Se    0.0205
U     0.0088
V     0.0026
Zn    0.1776
Alkalinity 558.0 as HCO3
    -water    1 # kg

SOLUTION 2 PAF Material
    temp      25
    pH        7.5
    units     mg/L
    density   1
      Al    0.020
      As    0
      Ba    0.020
      B     0
      Ca    67.0
      Cl    0
      Mg    8.0
      Na    1.0
      K     13.0
      F     0.300
      S(6)  197.0
      Cd    0.000
      Cr    0
      Co    0.007
      Cu    0.028
      Fe    0
      Pb    0
      Mn    0.040
      Mo    0.003
      Ni    0.004
      Se    0
      U     0
      V     0
      Zn    0
      Alkalinity 22 as HCO3
    -water    1 # kg
```

```
SOLUTION 3 NAF Material
    temp      25
    pH        7.6
    units     mg/L
    density   1
      Al    0.140
      As    0.029
      Ba    0.020
      B     0
      Ca    122.0
      Cl    0
      Mg    18.0
      Na    1.0
      K     16.0
      F     0.300
      S(6)  331.0
      Cd    0.000
      Cr    0
      Co    0.002
      Cu    0.019
      Fe    0.070
      Pb    0
      Mn    0.130
      Mo    0.005
      Ni    0.001
      Se    0
      U     0.001
      V     0
      Zn    0
      Alkalinity 28 as HCO3
    -water    1 # kg


SOLUTION 4 Make-up Material
    temp      25
    pH        7.7
    units     mg/L
    density   1
      Al    0.020
      As    0
      Ba    0.020
      B     0
      Ca    67.0
      Cl    0
      Mg    8.0
      Na    1.0
      K     13.0
      F     0.300
      S(6)  197.0
      Cd    0.000
      Cr    0
      Co    0.007
      Cu    0.028
      Fe    0
      Pb    0
      Mn    0.040
      Mo    0.003
      Ni    0.004
      Se    0
      U     0
      V     0
      Zn    0
      Alkalinity 22 as HCO3
    -water    1 # kg

# Mix the three solutions together
```

```
MIX 1 Mix within UG Works
    1    0.235
    2    0.122
    3    0.442
    4    0.201

SAVE Solution 5

SELECTED_OUTPUT 2
    -file                 D:\selected_output_3.txt
    -high_precision       true
    -reset                true
    -distance             false
    -time                 false
    -temperature          false
    -ionic_strength       false
    -water                false
    -totals               pH Al As Ba B Ca Cl Mg
                          Na K  F  S(6) Cd Cr Co
                          Cu Fe Pb Mn Mo  Ni Se
                          U V Zn Alkalinity
END
```

```
   Input file: P:\J23011 - BCP Underground EA (Aeris)\2. Tech Work Area\2.08 Water Quality
Model\2.08.02 PAF Assessment\BPC_UG_PAF_Disposal_P100.pqi
  Output file: P:\J23011 - BCP Underground EA (Aeris)\2. Tech Work Area\2.08 Water Quality
Model\2.08.02 PAF Assessment\BPC_UG_PAF_Disposal_P100.pqo
Database file: c:\phreeqc\database\minteq.v4.dat

------------------
Reading data base.
------------------

      SOLUTION_MASTER_SPECIES
      SOLUTION_SPECIES
      SOLUTION_SPECIES
      PHASES
      PHASES
      SURFACE_MASTER_SPECIES
      SURFACE_SPECIES
      END
-----------------------------------
Reading input data for simulation 1.
-----------------------------------

      DATABASE c:\phreeqc\database\minteq.v4.dat
      SOLUTION 1 UG Water P100
          temp      25
          pH        8.112
          units     mg/L
          density   1
      Al    0.0806
      As    0.0026
      Ba    0.1761
      B     0.1387
      Ca    116.6
      Cl    50.3
      Mg    59.1
      Na    224.5
      K     35.4
      F     1.0796
      S(6)  319.6
      Cd    0.0063
      Cr    0.0071
      Co    0.0036
      Cu    0.0628
      Fe    0.1666
      Pb    0.0389
      Mn    0.0740
      Mo    0.0139
      Ni    0.0054
      Se    0.0205
      U     0.0088
      V     0.0026
      Zn    0.1776
      Alkalinity 558.0 as HCO3
          water    1 # kg
      SOLUTION 2 PAF Material
          temp      25
          pH        7.5
          units     mg/L
          density   1
            Al    0.020
            As    0
            Ba    0.020
            B     0
            Ca    67.0
            Cl    0
            Mg    8.0
```

```
            Na    1.0
            K     13.0
            F     0.300
            S(6)  197.0
            Cd    0.000
            Cr    0
            Co    0.007
            Cu    0.028
            Fe    0
            Pb    0
            Mn    0.040
            Mo    0.003
            Ni    0.004
            Se    0
            U     0
            V     0
            Zn    0
            Alkalinity 22 as HCO3
        water    1 # kg
    SOLUTION 3 NAF Material
        temp      25
        pH        7.6
        units     mg/L
        density   1
            Al    0.140
            As    0.029
            Ba    0.020
            B     0
            Ca    122.0
            Cl    0
            Mg    18.0
            Na    1.0
            K     16.0
            F     0.300
            S(6)  331.0
            Cd    0.000
            Cr    0
            Co    0.002
            Cu    0.019
            Fe    0.070
            Pb    0
            Mn    0.130
            Mo    0.005
            Ni    0.001
            Se    0
            U     0.001
            V     0
            Zn    0
            Alkalinity 28 as HCO3
        water    1 # kg
    SOLUTION 4 Make-up Material
        temp      25
        pH        7.7
        units     mg/L
        density   1
            Al    0.020
            As    0
            Ba    0.020
            B     0
            Ca    67.0
            Cl    0
            Mg    8.0
            Na    1.0
            K     13.0
            F     0.300
            S(6)  197.0
```

```
            Cd    0.000
            Cr    0
            Co    0.007
            Cu    0.028
            Fe    0
            Pb    0
            Mn    0.040
            Mo    0.003
            Ni    0.004
            Se    0
            U     0
            V     0
            Zn    0
            Alkalinity 22 as HCO3
        water    1 # kg
    MIX 1 Mix within UG Works
        1    0.235
        2    0.122
        3    0.442
        4    0.201
    SAVE Solution 5
    SELECTED_OUTPUT 2
        file                 D:\selected_output_3.txt
        high_precision       true
        reset                true
        distance             false
        time                 false
        temperature          false
        ionic_strength       false
        water                false
        totals               pH Al As Ba B Ca Cl Mg
WARNING: Expected element name to begin with upper case letter.
                              Na K  F  S(6) Cd Cr Co
                              Cu Fe Pb Mn Mo  Ni Se
                              U V Zn Alkalinity
    END
-------------------------------------------
Beginning of initial solution calculations.
-------------------------------------------

Initial solution 1.     UG Water P100

------------------------------Solution composition------------------------------

      Elements           Molality       Moles

      Al                 2.991e-06   2.991e-06
      Alkalinity         9.157e-03   9.157e-03
      As                 3.475e-08   3.475e-08
      B                  1.285e-05   1.285e-05
      Ba                 1.284e-06   1.284e-06
      Ca                 2.913e-03   2.913e-03
      Cd                 5.612e-08   5.612e-08
      Cl                 1.421e-03   1.421e-03
      Co                 6.117e-08   6.117e-08
      Cr                 1.367e-07   1.367e-07
      Cu                 9.896e-07   9.896e-07
      F                  5.690e-05   5.690e-05
      Fe                 2.987e-06   2.987e-06
      K                  9.066e-04   9.066e-04
      Mg                 2.435e-03   2.435e-03
      Mn                 1.349e-06   1.349e-06
      Mo                 1.451e-07   1.451e-07
      Na                 9.779e-03   9.779e-03
      Ni                 9.213e-08   9.213e-08
      Pb                 1.880e-07   1.880e-07
```

```
      S(6)               3.331e-03   3.331e-03
      Se                 2.600e-07   2.600e-07
      U                  3.702e-08   3.702e-08
      V                  5.111e-08   5.111e-08
      Zn                 2.720e-06   2.720e-06

----------------------------Description of solution----------------------------

                                    pH  =   8.112
                                    pe  =   4.000
                       Activity of water  =   1.000
                  Ionic strength (mol/kgw)  =   2.420e-02
                       Mass of water (kg)  =   1.000e+00
                  Total carbon (mol/kg)    =   9.048e-03
                     Total CO2 (mol/kg)    =   9.048e-03
                       Temperature (°C)    =  25.00
                  Electrical balance (eq)  =   4.109e-03
 Percent error, 100*(Cat-|An|)/(Cat+|An|)  =  11.87
                                Iterations  =  11
                                   Total H  = 1.110227e+02
                                   Total O  = 5.554737e+01

----------------------------Distribution of species----------------------------

                                          Log       Log       Log    mole V
   Species          Molality    Activity  Molality  Activity     Gamma    cm³/mol

   OH-            1.521e-06   1.303e-06    -5.818    -5.885    -0.067     (0)
   H+             8.973e-09   7.727e-09    -8.047    -8.112    -0.065     0.00
   H2O            5.551e+01   9.995e-01     1.744    -0.000     0.000    18.07
Al             2.991e-06
   Al(OH)4-       2.975e-06   2.564e-06    -5.527    -5.591    -0.065     (0)
   Al(OH)3        1.564e-08   1.564e-08    -7.806    -7.806     0.000     (0)
   Al(OH)2+       6.944e-10   6.017e-10    -9.158    -9.221    -0.062     (0)
   AlF2+          3.778e-12   3.274e-12   -11.423   -11.485    -0.062     (0)
   AlF3           1.769e-12   1.769e-12   -11.752   -11.752     0.000     (0)
   AlOH+2         1.031e-12   5.816e-13   -11.987   -12.235    -0.249     (0)
   AlF+2          3.398e-13   1.916e-13   -12.469   -12.718    -0.249     (0)
   AlF4-          4.414e-14   3.805e-14   -13.355   -13.420    -0.065     (0)
   AlSO4+         5.677e-15   4.893e-15   -14.246   -14.310    -0.065     (0)
   Al+3           1.716e-15   4.465e-16   -14.766   -15.350    -0.585     (0)
   Al(SO4)2-      8.587e-17   7.402e-17   -16.066   -16.131    -0.065     (0)
   AlMo6O21-3     0.000e+00   0.000e+00   -50.905   -51.619    -0.714     (0)
As(3)          7.751e-21
   H3AsO3         7.179e-21   7.179e-21   -20.144   -20.144     0.000     (0)
   H2AsO3-        5.720e-22   4.765e-22   -21.243   -21.322    -0.079     (0)
   HAsO3-2        1.168e-25   5.624e-26   -24.933   -25.250    -0.317     (0)
   H4AsO3+        3.299e-29   2.748e-29   -28.482   -28.561    -0.079     (0)
   AsO3-3         1.452e-30   2.806e-31   -29.838   -30.552    -0.714     (0)
As(5)          3.475e-08
   HAsO4-2        3.336e-08   1.606e-08    -7.477    -7.794    -0.317     (0)
   H2AsO4-        1.359e-09   1.132e-09    -8.867    -8.946    -0.079     (0)
   AsO4-3         3.403e-11   6.574e-12   -10.468   -11.182    -0.714     (0)
   H3AsO4         1.512e-15   1.520e-15   -14.821   -14.818     0.002     (0)
B              1.285e-05
   H3BO3          1.168e-05   1.175e-05    -4.932    -4.930     0.002     (0)
   H2BO3-         1.038e-06   8.832e-07    -5.984    -6.054    -0.070     (0)
   CaH2BO3+       7.350e-08   6.251e-08    -7.134    -7.204    -0.070     (0)
   MgH2BO3+       3.976e-08   3.381e-08    -7.401    -7.471    -0.070     (0)
   NaH2BO3        1.165e-08   1.165e-08    -7.934    -7.934     0.000     (0)
   BF(OH)3-       2.366e-10   2.012e-10    -9.626    -9.696    -0.070     (0)
   BaH2BO3+       2.145e-11   1.824e-11   -10.669   -10.739    -0.070     (0)
   H5(BO3)2-      1.039e-11   8.832e-12   -10.984   -11.054    -0.070     (0)
   H8(BO3)3-      1.220e-14   1.038e-14   -13.914   -13.984    -0.070     (0)
   BF2(OH)2-      8.392e-15   7.137e-15   -14.076   -14.146    -0.070     (0)
   BF3OH-         1.083e-21   9.212e-22   -20.965   -21.036    -0.070     (0)
```

```
   BF4-           1.768e-27   1.504e-27   -26.752   -26.823    -0.070     (0)
Ba             1.284e-06
   Ba+2           1.216e-06   6.683e-07    -5.915    -6.175    -0.260     (0)
   BaHCO3+        5.333e-08   4.637e-08    -7.273    -7.334    -0.061     (0)
   BaCO3          1.511e-08   1.511e-08    -7.821    -7.821     0.000     (0)
   BaH2BO3+       2.145e-11   1.824e-11   -10.669   -10.739    -0.070     (0)
   BaOH+          4.395e-12   3.800e-12   -11.357   -11.420    -0.063     (0)
C(4)           9.048e-03
   HCO3-          8.384e-03   7.265e-03    -2.077    -2.139    -0.062     (0)
   CaHCO3+        1.914e-04   1.664e-04    -3.718    -3.779    -0.061     (0)
   H2CO3          1.263e-04   1.263e-04    -3.899    -3.899     0.000     (0)
   MgHCO3+        9.553e-05   8.209e-05    -4.020    -4.086    -0.066     (0)
   CaCO3          8.593e-05   8.593e-05    -4.066    -4.066     0.000     (0)
   CO3-2          8.018e-05   4.408e-05    -4.096    -4.356    -0.260     (0)
   MgCO3          4.048e-05   4.048e-05    -4.393    -4.393     0.000     (0)
   NaHCO3         3.400e-05   3.400e-05    -4.469    -4.469     0.000     (0)
   NaCO3-         7.882e-06   6.830e-06    -5.103    -5.166    -0.062     (0)
   ZnCO3          1.342e-06   1.342e-06    -5.872    -5.872     0.000     (0)
   CuCO3          7.731e-07   7.731e-07    -6.112    -6.112     0.000     (0)
   Cu(CO3)2-2     1.905e-07   9.173e-08    -6.720    -7.037    -0.317     (0)
   ZnHCO3+        1.459e-07   1.215e-07    -6.836    -6.915    -0.079     (0)
   PbCO3          1.379e-07   1.379e-07    -6.860    -6.860     0.000     (0)
   MnHCO3+        9.035e-08   7.812e-08    -7.044    -7.107    -0.063     (0)
   BaHCO3+        5.333e-08   4.637e-08    -7.273    -7.334    -0.061     (0)
   Pb(CO3)2-2     3.641e-08   1.753e-08    -7.439    -7.756    -0.317     (0)
   UO2(CO3)3-4    3.524e-08   1.895e-09    -7.453    -8.722    -1.269     (0)
   NiCO3          3.126e-08   3.126e-08    -7.505    -7.505     0.000     (0)
   NiHCO3+        2.044e-08   1.703e-08    -7.690    -7.769    -0.079     (0)
   CdCO3          1.651e-08   1.651e-08    -7.782    -7.782     0.000     (0)
   BaCO3          1.511e-08   1.511e-08    -7.821    -7.821     0.000     (0)
   CoCO3          1.192e-08   1.192e-08    -7.924    -7.924     0.000     (0)
   CoHCO3+        1.086e-08   9.044e-09    -7.964    -8.044    -0.079     (0)
   PbHCO3+        6.745e-09   5.619e-09    -8.171    -8.250    -0.079     (0)
   UO2(CO3)2-2    1.781e-09   8.577e-10    -8.749    -9.067    -0.317     (0)
   CuHCO3+        1.639e-09   1.365e-09    -8.785    -8.865    -0.079     (0)
   Cd(CO3)2-2     1.120e-09   5.394e-10    -8.951    -9.268    -0.317     (0)
   CdHCO3+        3.262e-10   2.717e-10    -9.487    -9.566    -0.079     (0)
   FeHCO3+        2.881e-10   2.505e-10    -9.540    -9.601    -0.061     (0)
   UO2CO3         9.751e-13   9.751e-13   -12.011   -12.011     0.000     (0)
Ca             2.913e-03
   Ca+2           2.237e-03   1.230e-03    -2.650    -2.910    -0.260     (0)
   CaSO4          3.978e-04   3.978e-04    -3.400    -3.400     0.000     (0)
   CaHCO3+        1.914e-04   1.664e-04    -3.718    -3.779    -0.061     (0)
   CaCO3          8.593e-05   8.593e-05    -4.066    -4.066     0.000     (0)
   CaF+           6.664e-07   5.762e-07    -6.176    -6.239    -0.063     (0)
   CaH2BO3+       7.350e-08   6.251e-08    -7.134    -7.204    -0.070     (0)
   CaOH+          3.676e-08   3.197e-08    -7.435    -7.495    -0.061     (0)
Cd             5.612e-08
   Cd+2           2.988e-08   1.643e-08    -7.525    -7.784    -0.260     (0)
   CdCO3          1.651e-08   1.651e-08    -7.782    -7.782     0.000     (0)
   CdSO4          5.437e-09   5.437e-09    -8.265    -8.265     0.000     (0)
   CdCl+          2.304e-09   1.919e-09    -8.638    -8.717    -0.079     (0)
   Cd(CO3)2-2     1.120e-09   5.394e-10    -8.951    -9.268    -0.317     (0)
   CdHCO3+        3.262e-10   2.717e-10    -9.487    -9.566    -0.079     (0)
   Cd(SO4)2-2     2.150e-10   1.035e-10    -9.668    -9.985    -0.317     (0)
   CdOH+          2.040e-10   1.700e-10    -9.690    -9.770    -0.079     (0)
   CdOHCl         1.025e-10   1.025e-10    -9.989    -9.989     0.000     (0)
   CdF+           1.341e-11   1.117e-11   -10.872   -10.952    -0.079     (0)
   CdCl2          9.788e-12   9.788e-12   -11.009   -11.009     0.000     (0)
   Cd(OH)2        1.397e-12   1.397e-12   -11.855   -11.855     0.000     (0)
   CdCl3-         9.069e-15   7.555e-15   -14.042   -14.122    -0.079     (0)
   CdF2           9.569e-16   9.569e-16   -15.019   -15.019     0.000     (0)
   Cd(OH)3-       1.334e-16   1.112e-16   -15.875   -15.954    -0.079     (0)
   Cd(SeO3)2-2    9.785e-17   4.712e-17   -16.009   -16.327    -0.317     (0)
   Cd2OH+3        7.245e-17   1.399e-17   -16.140   -16.854    -0.714     (0)
   CdSeO4         3.734e-17   3.734e-17   -16.428   -16.428     0.000     (0)
```

Cd(OH)4-2	4.922e-23	2.370e-23	-22.308	-22.625	-0.317	(0)
Cl	1.421e-03					
Cl-	1.421e-03	1.223e-03	-2.847	-2.912	-0.065	(0)
ZnOHCl	2.772e-09	2.772e-09	-8.557	-8.557	0.000	(0)
CdCl+	2.304e-09	1.919e-09	-8.638	-8.717	-0.079	(0)
ZnCl+	1.892e-09	1.626e-09	-8.723	-8.789	-0.066	(0)
MnCl+	9.600e-10	8.300e-10	-9.018	-9.081	-0.063	(0)
CuCl	2.247e-10	2.247e-10	-9.648	-9.648	0.000	(0)
CdOHCl	1.025e-10	1.025e-10	-9.989	-9.989	0.000	(0)
CoCl+	8.130e-11	6.772e-11	-10.090	-10.169	-0.079	(0)
NiCl+	7.143e-11	5.950e-11	-10.146	-10.225	-0.079	(0)
CuCl2-	6.683e-11	5.743e-11	-10.175	-10.241	-0.066	(0)
PbCl+	5.424e-11	4.518e-11	-10.266	-10.345	-0.079	(0)
CdCl2	9.788e-12	9.788e-12	-11.009	-11.009	0.000	(0)
CuCl+	6.721e-12	5.775e-12	-11.173	-11.238	-0.066	(0)
ZnCl2	3.152e-12	3.152e-12	-11.501	-11.501	0.000	(0)
MnCl2	1.434e-12	1.434e-12	-11.843	-11.843	0.000	(0)
PbCl2	2.469e-13	2.469e-13	-12.608	-12.608	0.000	(0)
CuCl3-2	2.688e-14	1.502e-14	-13.571	-13.823	-0.253	(0)
CdCl3-	9.069e-15	7.555e-15	-14.042	-14.122	-0.079	(0)
ZnCl3-	3.564e-15	3.063e-15	-14.448	-14.514	-0.066	(0)
CuCl2	2.450e-15	2.450e-15	-14.611	-14.611	0.000	(0)
MnCl3-	5.589e-16	4.832e-16	-15.253	-15.316	-0.063	(0)
NiCl2	3.665e-16	3.665e-16	-15.436	-15.436	0.000	(0)
PbCl3-	1.443e-16	1.202e-16	-15.841	-15.920	-0.079	(0)
CrCl+2	5.619e-17	2.706e-17	-16.250	-16.568	-0.317	(0)
ZnCl4-2	3.353e-18	1.873e-18	-17.475	-17.727	-0.253	(0)
CrOHCl2	8.195e-19	8.195e-19	-18.086	-18.086	0.000	(0)
FeCl+2	1.682e-19	9.399e-20	-18.774	-19.027	-0.253	(0)
PbCl4-2	1.396e-19	6.723e-20	-18.855	-19.172	-0.317	(0)
CuCl3-	3.255e-20	2.797e-20	-19.487	-19.553	-0.066	(0)
UO2Cl+	1.323e-20	1.102e-20	-19.878	-19.958	-0.079	(0)
CrCl2+	3.770e-21	3.141e-21	-20.424	-20.503	-0.079	(0)
FeCl2+	5.941e-22	5.136e-22	-21.226	-21.289	-0.063	(0)
VOCl+	6.395e-23	5.328e-23	-22.194	-22.273	-0.079	(0)
CuCl4-2	3.069e-25	1.715e-25	-24.513	-24.766	-0.253	(0)
FeCl3	6.283e-26	6.283e-26	-25.202	-25.202	0.000	(0)
CrO3Cl-	2.721e-26	2.267e-26	-25.565	-25.645	-0.079	(0)
CoCl+2	3.293e-37	1.586e-37	-36.482	-36.800	-0.317	(0)
UCl+3	0.000e+00	0.000e+00	-48.985	-49.699	-0.714	(0)
Co(2)	6.117e-08					
Co+2	3.323e-08	1.600e-08	-7.478	-7.796	-0.317	(0)
CoCO3	1.192e-08	1.192e-08	-7.924	-7.924	0.000	(0)
CoHCO3+	1.086e-08	9.044e-09	-7.964	-8.044	-0.079	(0)
CoSO4	4.508e-09	4.508e-09	-8.346	-8.346	0.000	(0)
CoOH+	4.993e-10	4.159e-10	-9.302	-9.381	-0.079	(0)
CoCl+	8.130e-11	6.772e-11	-10.090	-10.169	-0.079	(0)
Co(OH)2	4.303e-11	4.303e-11	-10.366	-10.366	0.000	(0)
CoF+	2.607e-11	2.172e-11	-10.584	-10.663	-0.079	(0)
Co(OH)3-	1.342e-15	1.118e-15	-14.872	-14.951	-0.079	(0)
CoOOH-	3.370e-16	2.807e-16	-15.472	-15.552	-0.079	(0)
CoSeO4	9.790e-17	9.790e-17	-16.009	-16.009	0.000	(0)
Co2OH+3	1.727e-18	3.336e-19	-17.763	-18.477	-0.714	(0)
Co(OH)4-2	4.794e-22	2.309e-22	-21.319	-21.637	-0.317	(0)
Co4(OH)4+4	1.110e-28	5.969e-30	-27.955	-29.224	-1.269	(0)
Co(3)	8.757e-30					
CoOH+2	8.757e-30	4.217e-30	-29.058	-29.375	-0.317	(0)
Co+3	2.448e-36	6.371e-37	-35.611	-36.196	-0.585	(0)
CoCl+2	3.293e-37	1.586e-37	-36.482	-36.800	-0.317	(0)
Cr(2)	8.478e-25					
Cr+2	8.478e-25	4.083e-25	-24.072	-24.389	-0.317	(0)
Cr(3)	1.367e-07					
Cr(OH)2+	9.265e-08	7.718e-08	-7.033	-7.112	-0.079	(0)
Cr(OH)3	3.777e-08	3.777e-08	-7.423	-7.423	0.000	(0)
CrO2-	2.788e-09	2.322e-09	-8.555	-8.634	-0.079	(0)
Cr(OH)4-	2.351e-09	1.958e-09	-8.629	-8.708	-0.079	(0)
Cr(OH)+2	1.011e-09	4.870e-10	-8.995	-9.312	-0.317	(0)
CrOHSO4	1.632e-10	1.632e-10	-9.787	-9.787	0.000	(0)
CrF+2	2.414e-13	1.162e-13	-12.617	-12.935	-0.317	(0)
Cr+3	8.847e-14	1.709e-14	-13.053	-13.767	-0.714	(0)
CrSO4+	6.763e-14	5.634e-14	-13.170	-13.249	-0.079	(0)
CrCl+2	5.619e-17	2.706e-17	-16.250	-16.568	-0.317	(0)
Cr2(OH)2SO4+2	1.491e-17	7.182e-18	-16.826	-17.144	-0.317	(0)
CrOHCl2	8.195e-19	8.195e-19	-18.086	-18.086	0.000	(0)
Cr2(OH)2(SO4)2	6.023e-19	6.023e-19	-18.220	-18.220	0.000	(0)
CrCl2+	3.770e-21	3.141e-21	-20.424	-20.503	-0.079	(0)
Cr(6)	2.900e-14					
CrO4-2	2.773e-14	1.524e-14	-13.557	-13.817	-0.260	(0)
NaCrO4-	7.567e-16	6.304e-16	-15.121	-15.200	-0.079	(0)
HCrO4-	4.576e-16	3.812e-16	-15.340	-15.419	-0.079	(0)
KCrO4-	5.256e-17	4.378e-17	-16.279	-16.359	-0.079	(0)
CrO3SO4-2	2.631e-24	1.267e-24	-23.580	-23.897	-0.317	(0)
H2CrO4	2.387e-24	2.387e-24	-23.622	-23.622	0.000	(0)
CrO3Cl-	2.721e-26	2.267e-26	-25.565	-25.645	-0.079	(0)
Cr2O7-2	1.047e-29	5.040e-30	-28.980	-29.298	-0.317	(0)
Cu(1)	4.667e-10					
CuCl	2.247e-10	2.247e-10	-9.648	-9.648	0.000	(0)
Cu+	1.751e-10	1.459e-10	-9.757	-9.836	-0.079	(0)
CuCl2-	6.683e-11	5.743e-11	-10.175	-10.241	-0.066	(0)
CuCl3-2	2.688e-14	1.502e-14	-13.571	-13.823	-0.253	(0)
Cu(2)	9.891e-07					
CuCO3	7.731e-07	7.731e-07	-6.112	-6.112	0.000	(0)
Cu(CO3)2-2	1.905e-07	9.173e-08	-6.720	-7.037	-0.317	(0)
CuOH+	1.428e-08	1.227e-08	-7.845	-7.911	-0.066	(0)
Cu+2	5.418e-09	2.979e-09	-8.266	-8.526	-0.260	(0)
Cu(OH)2	3.188e-09	3.188e-09	-8.496	-8.496	0.000	(0)
CuHCO3+	1.639e-09	1.365e-09	-8.785	-8.865	-0.079	(0)
CuSO4	9.633e-10	9.633e-10	-9.016	-9.016	0.000	(0)
Cu(OH)3-	1.023e-11	8.519e-12	-10.990	-11.070	-0.079	(0)
CuF+	9.682e-12	8.066e-12	-11.014	-11.093	-0.079	(0)
Cu2(OH)2+2	7.851e-12	3.781e-12	-11.105	-11.422	-0.317	(0)
CuCl+	6.721e-12	5.775e-12	-11.173	-11.238	-0.066	(0)
CuCl2	2.450e-15	2.450e-15	-14.611	-14.611	0.000	(0)
Cu(OH)4-2	1.814e-16	8.733e-17	-15.741	-16.059	-0.317	(0)
CuCl3-	3.255e-20	2.797e-20	-19.487	-19.553	-0.066	(0)
CuCl4-2	3.069e-25	1.715e-25	-24.513	-24.766	-0.253	(0)
F	5.690e-05					
F-	4.984e-05	4.292e-05	-4.302	-4.367	-0.065	(0)
MgF+	6.168e-06	5.317e-06	-5.210	-5.274	-0.065	(0)
CaF+	6.664e-07	5.762e-07	-6.176	-6.239	-0.063	(0)
NaF	2.253e-07	2.253e-07	-6.647	-6.647	0.000	(0)
MnF+	1.065e-09	9.207e-10	-8.973	-9.036	-0.063	(0)
ZnF+	5.438e-10	4.530e-10	-9.265	-9.344	-0.079	(0)
HF	4.905e-10	4.905e-10	-9.309	-9.309	0.000	(0)
BF(OH)3-	2.366e-10	2.012e-10	-9.626	-9.696	-0.070	(0)
CoF+	2.607e-11	2.172e-11	-10.584	-10.663	-0.079	(0)
NiF+	2.460e-11	2.049e-11	-10.609	-10.688	-0.079	(0)
CdF+	1.341e-11	1.117e-11	-10.872	-10.952	-0.079	(0)
CuF+	9.682e-12	8.066e-12	-11.014	-11.093	-0.079	(0)
PbF+	3.779e-12	3.148e-12	-11.423	-11.502	-0.079	(0)
AlF2+	3.778e-12	3.274e-12	-11.423	-11.485	-0.062	(0)
AlF3	1.769e-12	1.769e-12	-11.752	-11.752	0.000	(0)
AlF+2	3.398e-13	1.916e-13	-12.469	-12.718	-0.249	(0)
CrF+2	2.414e-13	1.162e-13	-12.617	-12.935	-0.317	(0)
HF2-	9.345e-14	8.003e-14	-13.029	-13.097	-0.067	(0)
AlF4-	4.414e-14	3.805e-14	-13.355	-13.420	-0.065	(0)
BF2(OH)2-	8.392e-15	7.137e-15	-14.076	-14.146	-0.070	(0)
PbF2	2.659e-15	2.659e-15	-14.575	-14.575	0.000	(0)
CdF2	9.569e-16	9.569e-16	-15.019	-15.019	0.000	(0)
FeF+2	2.143e-16	1.197e-16	-15.669	-15.922	-0.253	(0)
FeF2+	1.590e-16	1.375e-16	-15.798	-15.862	-0.063	(0)
UO2F+	3.952e-17	3.292e-17	-16.403	-16.483	-0.079	(0)
FeF3	8.326e-18	8.326e-18	-17.080	-17.080	0.000	(0)
UO2F2	4.075e-18	4.075e-18	-17.390	-17.390	0.000	(0)
VO2F	2.446e-18	2.446e-18	-17.612	-17.612	0.000	(0)
H2F2	6.446e-19	6.446e-19	-18.191	-18.191	0.000	(0)
PbF3-	2.598e-19	2.164e-19	-18.585	-18.665	-0.079	(0)
UO2F3-	5.273e-20	4.393e-20	-19.278	-19.357	-0.079	(0)
VO2F2-	4.575e-20	3.811e-20	-19.340	-19.419	-0.079	(0)
VOF+	4.797e-21	3.996e-21	-20.319	-20.398	-0.079	(0)
BF3OH-	1.083e-21	9.212e-22	-20.965	-21.036	-0.070	(0)
VOF2	6.431e-23	6.431e-23	-22.192	-22.192	0.000	(0)
VO2F3-2	4.237e-23	2.040e-23	-22.373	-22.690	-0.317	(0)
UO2F4-2	3.110e-23	1.497e-23	-22.507	-22.825	-0.317	(0)
PbF4-2	9.232e-24	4.446e-24	-23.035	-23.352	-0.317	(0)
VOF3-	1.175e-25	9.792e-26	-24.930	-25.009	-0.079	(0)
VO2F4-3	2.230e-27	4.308e-28	-26.652	-27.366	-0.714	(0)
BF4-	1.768e-27	1.504e-27	-26.752	-26.823	-0.070	(0)
VOF4-2	3.523e-29	1.696e-29	-28.453	-28.770	-0.317	(0)
UF3+	1.232e-40	1.026e-40	-39.910	-39.989	-0.079	(0)
UF2+2	0.000e+00	0.000e+00	-40.504	-40.821	-0.317	(0)
UF4	0.000e+00	0.000e+00	-42.316	-42.316	0.000	(0)
UF+3	0.000e+00	0.000e+00	-42.840	-43.554	-0.714	(0)
UF5-	0.000e+00	0.000e+00	-45.006	-45.086	-0.079	(0)
UF6-2	0.000e+00	0.000e+00	-46.656	-46.973	-0.317	(0)
Fe(2)	7.089e-09					
Fe+2	5.687e-09	2.739e-09	-8.245	-8.562	-0.317	(0)
FeSO4	9.491e-10	9.491e-10	-9.023	-9.023	0.000	(0)
FeHCO3+	2.881e-10	2.505e-10	-9.540	-9.601	-0.061	(0)
FeOH+	1.643e-10	1.420e-10	-9.784	-9.848	-0.063	(0)
Fe(OH)2	1.469e-13	1.469e-13	-12.833	-12.833	0.000	(0)
Fe(OH)3-	7.000e-14	6.052e-14	-13.155	-13.218	-0.063	(0)
Fe(3)	2.980e-06					
Fe(OH)3	1.517e-06	1.517e-06	-5.819	-5.819	0.000	(0)
Fe(OH)2+	1.251e-06	1.084e-06	-5.903	-5.965	-0.062	(0)
Fe(OH)4-	2.123e-07	1.839e-07	-6.673	-6.735	-0.062	(0)
FeOH+2	3.829e-12	2.140e-12	-11.417	-11.670	-0.253	(0)
FeF+2	2.143e-16	1.197e-16	-15.669	-15.922	-0.253	(0)
FeF2+	1.590e-16	1.375e-16	-15.798	-15.862	-0.063	(0)
FeSO4+	4.661e-17	4.030e-17	-16.332	-16.395	-0.063	(0)
Fe+3	9.776e-18	2.544e-18	-17.010	-17.594	-0.585	(0)
FeF3	8.326e-18	8.326e-18	-17.080	-17.080	0.000	(0)
Fe(SO4)2-	1.460e-18	1.216e-18	-17.836	-17.915	-0.079	(0)
FeCl+2	1.682e-19	9.399e-20	-18.774	-19.027	-0.253	(0)
Fe2(OH)2+4	2.819e-21	1.516e-22	-20.550	-21.819	-1.269	(0)
FeHSeO3+2	1.598e-21	7.697e-22	-20.796	-21.114	-0.317	(0)
FeCl2+	5.941e-22	5.136e-22	-21.226	-21.289	-0.063	(0)
Fe3(OH)4+5	2.287e-25	2.376e-27	-24.641	-26.624	-1.984	(0)
FeCl3	6.283e-26	6.283e-26	-25.202	-25.202	0.000	(0)
H(0)	8.406e-28					
H2	4.203e-28	4.227e-28	-27.376	-27.374	0.002	(0)
K	9.066e-04					
K+	8.977e-04	7.730e-04	-3.047	-3.112	-0.065	(0)
KSO4-	8.915e-06	7.726e-06	-5.050	-5.112	-0.062	(0)
KCrO4-	5.256e-17	4.378e-17	-16.279	-16.359	-0.079	(0)
Mg	2.435e-03					
Mg+2	2.008e-03	1.104e-03	-2.697	-2.957	-0.260	(0)
MgSO4	2.836e-04	2.836e-04	-3.547	-3.547	0.000	(0)
MgHCO3+	9.553e-05	8.209e-05	-4.020	-4.086	-0.066	(0)
MgCO3	4.048e-05	4.048e-05	-4.393	-4.393	0.000	(0)
MgF+	6.168e-06	5.317e-06	-5.210	-5.274	-0.065	(0)
MgOH+	6.567e-07	5.725e-07	-6.183	-6.242	-0.060	(0)
MgH2BO3+	3.976e-08	3.381e-08	-7.401	-7.471	-0.070	(0)
Mn(2)	1.349e-06					
Mn+2	1.119e-06	5.389e-07	-5.951	-6.268	-0.317	(0)
MnSO4	1.353e-07	1.353e-07	-6.869	-6.869	0.000	(0)
MnHCO3+	9.035e-08	7.812e-08	-7.044	-7.107	-0.063	(0)
MnOH+	2.039e-09	1.763e-09	-8.691	-8.754	-0.063	(0)
MnF+	1.065e-09	9.207e-10	-8.973	-9.036	-0.063	(0)
MnCl+	9.600e-10	8.300e-10	-9.018	-9.081	-0.063	(0)
MnCl2	1.434e-12	1.434e-12	-11.843	-11.843	0.000	(0)
MnSeO4	1.771e-15	1.771e-15	-14.752	-14.752	0.000	(0)
MnCl3-	5.589e-16	4.832e-16	-15.253	-15.316	-0.063	(0)
Mn(OH)3-	2.138e-17	1.849e-17	-16.670	-16.733	-0.063	(0)
Mn(OH)4-2	1.391e-22	7.774e-23	-21.857	-22.109	-0.253	(0)
MnSe	5.081e-39	5.081e-39	-38.294	-38.294	0.000	(0)
Mn(3)	9.250e-28					
Mn+3	9.250e-28	2.407e-28	-27.034	-27.618	-0.585	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-43.543	-43.795	-0.253	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-49.099	-49.167	-0.069	(0)
Mo	1.451e-07					
MoO4-2	1.451e-07	7.975e-08	-6.838	-7.098	-0.260	(0)
HMoO4-	1.472e-11	1.226e-11	-10.832	-10.911	-0.079	(0)
H2MoO4	6.940e-16	6.940e-16	-15.159	-15.159	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-50.905	-51.619	-0.714	(0)
Mo7O24-6	0.000e+00	0.000e+00	-58.737	-61.593	-2.856	(0)
HMo7O24-5	0.000e+00	0.000e+00	-61.335	-63.318	-1.984	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-65.379	-66.648	-1.269	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-70.800	-71.514	-0.714	(0)
Na	9.779e-03					
Na+	9.664e-03	8.321e-03	-2.015	-2.080	-0.065	(0)
NaSO4-	7.280e-05	6.309e-05	-4.138	-4.200	-0.062	(0)
NaHCO3	3.400e-05	3.400e-05	-4.469	-4.469	0.000	(0)
NaCO3-	7.882e-06	6.830e-06	-5.103	-5.166	-0.062	(0)
NaF	2.253e-07	2.253e-07	-6.647	-6.647	0.000	(0)
NaH2BO3	1.165e-08	1.165e-08	-7.934	-7.934	0.000	(0)
NaCrO4-	7.567e-16	6.304e-16	-15.121	-15.200	-0.079	(0)
Ni	9.213e-08					
Ni+2	3.458e-08	1.901e-08	-7.461	-7.721	-0.260	(0)
NiCO3	3.126e-08	3.126e-08	-7.505	-7.505	0.000	(0)
NiHCO3+	2.044e-08	1.703e-08	-7.690	-7.769	-0.079	(0)
NiSO4	5.354e-09	5.354e-09	-8.271	-8.271	0.000	(0)
NiOH+	3.742e-10	3.117e-10	-9.427	-9.506	-0.079	(0)
NiCl+	7.143e-11	5.950e-11	-10.146	-10.225	-0.079	(0)
Ni(OH)2	3.225e-11	3.225e-11	-10.491	-10.491	0.000	(0)
NiF+	2.460e-11	2.049e-11	-10.609	-10.688	-0.079	(0)
Ni(SO4)2-2	5.198e-13	2.503e-13	-12.284	-12.602	-0.317	(0)
Ni(OH)3-	5.043e-14	4.201e-14	-13.297	-13.377	-0.079	(0)
NiCl2	3.665e-16	3.665e-16	-15.436	-15.436	0.000	(0)
NiSeO4	1.085e-16	1.085e-16	-15.964	-15.964	0.000	(0)
O(0)	5.638e-38					
O2	2.819e-38	2.835e-38	-37.550	-37.547	0.002	(0)
Pb	1.880e-07					
PbCO3	1.379e-07	1.379e-07	-6.860	-6.860	0.000	(0)
Pb(CO3)2-2	3.641e-08	1.753e-08	-7.439	-7.756	-0.317	(0)
PbHCO3+	6.745e-09	5.619e-09	-8.171	-8.250	-0.079	(0)
PbOH+	4.088e-09	3.406e-09	-8.388	-8.468	-0.079	(0)
Pb+2	1.893e-09	1.041e-09	-8.723	-8.983	-0.260	(0)
PbSO4	7.197e-10	7.197e-10	-9.143	-9.143	0.000	(0)
Pb(OH)2	1.403e-10	1.403e-10	-9.853	-9.853	0.000	(0)
PbCl+	5.424e-11	4.518e-11	-10.266	-10.345	-0.079	(0)
Pb(SO4)2-2	1.271e-11	6.122e-12	-10.896	-11.213	-0.317	(0)
PbF+	3.779e-12	3.148e-12	-11.423	-11.502	-0.079	(0)
PbCl2	2.469e-13	2.469e-13	-12.608	-12.608	0.000	(0)
Pb(OH)3-	2.193e-13	1.827e-13	-12.659	-12.738	-0.079	(0)
PbF2	2.659e-15	2.659e-15	-14.575	-14.575	0.000	(0)
Pb2OH+3	2.908e-16	5.618e-17	-15.536	-16.250	-0.714	(0)
PbCl3-	1.443e-16	1.202e-16	-15.841	-15.920	-0.079	(0)
Pb(OH)4-2	1.210e-16	5.828e-17	-15.917	-16.234	-0.317	(0)
Pb3(OH)4+2	8.486e-19	4.087e-19	-18.071	-18.389	-0.317	(0)
PbF3-	2.598e-19	2.164e-19	-18.585	-18.665	-0.079	(0)
PbCl4-2	1.396e-19	6.723e-20	-18.855	-19.172	-0.317	(0)

Pb4(OH)4+4	6.284e-23	3.379e-24	-22.202	-23.471	-1.269	(0)
PbF4-2	9.232e-24	4.446e-24	-23.035	-23.352	-0.317	(0)
S(6)	3.331e-03					
SO4-2	2.568e-03	1.412e-03	-2.590	-2.850	-0.260	(0)
CaSO4	3.978e-04	3.978e-04	-3.400	-3.400	0.000	(0)
MgSO4	2.836e-04	2.836e-04	-3.547	-3.547	0.000	(0)
NaSO4-	7.280e-05	6.309e-05	-4.138	-4.200	-0.062	(0)
KSO4-	8.915e-06	7.726e-06	-5.050	-5.112	-0.062	(0)
ZnSO4	1.634e-07	1.634e-07	-6.787	-6.787	0.000	(0)
MnSO4	1.353e-07	1.353e-07	-6.869	-6.869	0.000	(0)
CdSO4	5.437e-09	5.437e-09	-8.265	-8.265	0.000	(0)
NiSO4	5.354e-09	5.354e-09	-8.271	-8.271	0.000	(0)
CoSO4	4.508e-09	4.508e-09	-8.346	-8.346	0.000	(0)
Zn(SO4)2-2	4.172e-09	2.009e-09	-8.380	-8.697	-0.317	(0)
HSO4-	1.237e-09	1.066e-09	-8.908	-8.972	-0.065	(0)
CuSO4	9.633e-10	9.633e-10	-9.016	-9.016	0.000	(0)
FeSO4	9.491e-10	9.491e-10	-9.023	-9.023	0.000	(0)
PbSO4	7.197e-10	7.197e-10	-9.143	-9.143	0.000	(0)
Cd(SO4)2-2	2.150e-10	1.035e-10	-9.668	-9.985	-0.317	(0)
CrOHSO4	1.632e-10	1.632e-10	-9.787	-9.787	0.000	(0)
Pb(SO4)2-2	1.271e-11	6.122e-12	-10.896	-11.213	-0.317	(0)
Ni(SO4)2-2	5.198e-13	2.503e-13	-12.284	-12.602	-0.317	(0)
CrSO4+	6.763e-14	5.634e-14	-13.170	-13.249	-0.079	(0)
AlSO4+	5.677e-15	4.893e-15	-14.246	-14.310	-0.065	(0)
Al(SO4)2-	8.587e-17	7.402e-17	-16.066	-16.131	-0.065	(0)
FeSO4+	4.661e-17	4.030e-17	-16.332	-16.395	-0.063	(0)
Cr2(OH)2SO4+2	1.491e-17	7.182e-18	-16.826	-17.144	-0.317	(0)
UO2SO4	1.187e-17	1.187e-17	-16.925	-16.925	0.000	(0)
Fe(SO4)2-	1.460e-18	1.216e-18	-17.836	-17.915	-0.079	(0)
VO2SO4-	1.315e-18	1.095e-18	-17.881	-17.960	-0.079	(0)
Cr2(OH)2(SO4)2	6.023e-19	6.023e-19	-18.220	-18.220	0.000	(0)
UO2(SO4)2-2	4.589e-19	2.210e-19	-18.338	-18.656	-0.317	(0)
VOSO4	6.036e-21	6.036e-21	-20.219	-20.219	0.000	(0)
CrO3SO4-2	2.631e-24	1.267e-24	-23.580	-23.897	-0.317	(0)
VSO4+	3.684e-35	3.069e-35	-34.434	-34.513	-0.079	(0)
U(SO4)2	0.000e+00	0.000e+00	-43.687	-43.687	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-44.420	-44.737	-0.317	(0)
Se(-2)	2.123e-35					
HSe-	2.122e-35	1.768e-35	-34.673	-34.753	-0.079	(0)
MnSe	5.081e-39	5.081e-39	-38.294	-38.294	0.000	(0)
H2Se	1.060e-39	1.060e-39	-38.975	-38.975	0.000	(0)
Se-2	0.000e+00	0.000e+00	-41.323	-41.641	-0.317	(0)
Se(4)	2.600e-07					
HSeO3-	1.374e-07	1.145e-07	-6.862	-6.941	-0.079	(0)
SeO3-2	1.225e-07	5.899e-08	-6.912	-7.229	-0.317	(0)
H2SeO3	3.774e-13	3.774e-13	-12.423	-12.423	0.000	(0)
Cd(SeO3)2-2	9.785e-17	4.712e-17	-16.009	-16.327	-0.317	(0)
FeHSeO3+2	1.598e-21	7.697e-22	-20.796	-21.114	-0.317	(0)
Se(6)	2.221e-11					
SeO4-2	2.220e-11	1.221e-11	-10.654	-10.913	-0.260	(0)
MnSeO4	1.771e-15	1.771e-15	-14.752	-14.752	0.000	(0)
ZnSeO4	1.000e-15	1.000e-15	-15.000	-15.000	0.000	(0)
NiSeO4	1.085e-16	1.085e-16	-15.964	-15.964	0.000	(0)
CoSeO4	9.790e-17	9.790e-17	-16.009	-16.009	0.000	(0)
CdSeO4	3.734e-17	3.734e-17	-16.428	-16.428	0.000	(0)
HSeO4-	5.675e-18	4.727e-18	-17.246	-17.325	-0.079	(0)
Zn(SeO4)2-2	2.570e-26	1.238e-26	-25.590	-25.907	-0.317	(0)
U(3)	0.000e+00					
U+3	0.000e+00	0.000e+00	-60.569	-61.283	-0.714	(0)
U(4)	1.076e-21					
U(OH)5-	1.075e-21	8.958e-22	-20.968	-21.048	-0.079	(0)
U(OH)4	2.900e-25	2.900e-25	-24.538	-24.538	0.000	(0)
U(OH)3+	9.839e-30	8.196e-30	-29.007	-29.086	-0.079	(0)
U(OH)2+2	6.084e-35	2.930e-35	-34.216	-34.533	-0.317	(0)
UF3+	1.232e-40	1.026e-40	-39.910	-39.989	-0.079	(0)
UOH+3	0.000e+00	0.000e+00	-40.258	-40.972	-0.714	(0)
UF2+2	0.000e+00	0.000e+00	-40.504	-40.821	-0.317	(0)
UF4	0.000e+00	0.000e+00	-42.316	-42.316	0.000	(0)
UF+3	0.000e+00	0.000e+00	-42.840	-43.554	-0.714	(0)
U(SO4)2	0.000e+00	0.000e+00	-43.687	-43.687	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-44.420	-44.737	-0.317	(0)
UF5-	0.000e+00	0.000e+00	-45.006	-45.086	-0.079	(0)
UF6-2	0.000e+00	0.000e+00	-46.656	-46.973	-0.317	(0)
U+4	0.000e+00	0.000e+00	-47.217	-48.487	-1.269	(0)
UCl+3	0.000e+00	0.000e+00	-48.985	-49.699	-0.714	(0)
U6(OH)15+9	0.000e+00	0.000e+00	-179.972	-186.399	-6.427	(0)
U(5)	4.066e-19					
UO2+	4.066e-19	3.387e-19	-18.391	-18.470	-0.079	(0)
U(6)	3.702e-08					
UO2(CO3)3-4	3.524e-08	1.895e-09	-7.453	-8.722	-1.269	(0)
UO2(CO3)2-2	1.781e-09	8.577e-10	-8.749	-9.067	-0.317	(0)
UO2CO3	9.751e-13	9.751e-13	-12.011	-12.011	0.000	(0)
UO2OH+	1.094e-15	9.112e-16	-14.961	-15.040	-0.079	(0)
UO2F+	3.952e-17	3.292e-17	-16.403	-16.483	-0.079	(0)
UO2SO4	1.187e-17	1.187e-17	-16.925	-16.925	0.000	(0)
UO2+2	1.011e-17	5.557e-18	-16.995	-17.255	-0.260	(0)
UO2F2	4.075e-18	4.075e-18	-17.390	-17.390	0.000	(0)
UO2(SO4)2-2	4.589e-19	2.210e-19	-18.338	-18.656	-0.317	(0)
UO2F3-	5.273e-20	4.393e-20	-19.278	-19.357	-0.079	(0)
UO2Cl+	1.323e-20	1.102e-20	-19.878	-19.958	-0.079	(0)
UO2F4-2	3.110e-23	1.497e-23	-22.507	-22.825	-0.317	(0)
(UO2)2(OH)2+2	2.861e-24	1.378e-24	-23.543	-23.861	-0.317	(0)
(UO2)3(OH)5+	1.940e-27	1.616e-27	-26.712	-26.792	-0.079	(0)
V(2)	0.000e+00					
VOH+	0.000e+00	0.000e+00	-40.943	-41.022	-0.079	(0)
V+2	0.000e+00	0.000e+00	-42.329	-42.647	-0.317	(0)
V(3)	8.208e-14					
V(OH)3	8.208e-14	8.208e-14	-13.086	-13.086	0.000	(0)
V(OH)2+	4.922e-25	4.100e-25	-24.308	-24.387	-0.079	(0)
VOH+2	6.242e-29	3.006e-29	-28.205	-28.522	-0.317	(0)
V+3	2.384e-34	4.605e-35	-33.623	-34.337	-0.714	(0)
VSO4+	3.684e-35	3.069e-35	-34.434	-34.513	-0.079	(0)
V2(OH)3+3	0.000e+00	0.000e+00	-53.743	-54.457	-0.714	(0)
V2(OH)2+4	0.000e+00	0.000e+00	-54.975	-56.244	-1.269	(0)
V(4)	4.884e-18					
V(OH)3+	4.841e-18	4.032e-18	-17.315	-17.394	-0.079	(0)
VO+2	3.224e-20	1.552e-20	-19.492	-19.809	-0.317	(0)
VOSO4	6.036e-21	6.036e-21	-20.219	-20.219	0.000	(0)
VOF+	4.797e-21	3.996e-21	-20.319	-20.398	-0.079	(0)
VOF2	6.431e-23	6.431e-23	-22.192	-22.192	0.000	(0)
VOCl+	6.395e-23	5.328e-23	-22.194	-22.273	-0.079	(0)
VOF3-	1.175e-25	9.792e-26	-24.930	-25.009	-0.079	(0)
VOF4-2	3.523e-29	1.696e-29	-28.453	-28.770	-0.317	(0)
H2V2O4+2	1.694e-30	8.157e-31	-29.771	-30.088	-0.317	(0)
V(5)	5.111e-08					
H2VO4-	3.271e-08	2.725e-08	-7.485	-7.565	-0.079	(0)
HVO4-2	1.840e-08	8.858e-09	-7.735	-8.053	-0.317	(0)
H3VO4	2.105e-12	2.105e-12	-11.677	-11.677	0.000	(0)
H3V2O7-	4.449e-13	3.706e-13	-12.352	-12.431	-0.079	(0)
HV2O7-3	4.236e-13	8.183e-14	-12.373	-13.087	-0.714	(0)
VO4-3	2.975e-14	5.746e-15	-13.527	-14.241	-0.714	(0)
V2O7-4	5.301e-15	2.850e-16	-14.276	-15.545	-1.269	(0)
V3O9-3	1.098e-16	2.122e-17	-15.959	-16.673	-0.714	(0)
VO2+	3.773e-17	3.249e-17	-16.423	-16.488	-0.065	(0)
VO2F	2.446e-18	2.446e-18	-17.612	-17.612	0.000	(0)
VO2SO4-	1.315e-18	1.095e-18	-17.881	-17.960	-0.079	(0)
VO2F2-	4.575e-20	3.811e-20	-19.340	-19.419	-0.079	(0)
V4O12-4	4.484e-21	2.411e-22	-20.348	-21.618	-1.269	(0)
VO2F3-2	4.237e-23	2.040e-23	-22.373	-22.690	-0.317	(0)
VO2F4-3	2.230e-27	4.308e-28	-26.652	-27.366	-0.714	(0)
V10O28-6	0.000e+00	0.000e+00	-56.330	-59.186	-2.856	(0)
HV10O28-5	0.000e+00	0.000e+00	-57.128	-59.112	-1.984	(0)
H2V10O28-4	0.000e+00	0.000e+00	-60.747	-62.016	-1.269	(0)
Zn	2.720e-06					
ZnCO3	1.342e-06	1.342e-06	-5.872	-5.872	0.000	(0)
Zn+2	9.622e-07	5.290e-07	-6.017	-6.277	-0.260	(0)
ZnSO4	1.634e-07	1.634e-07	-6.787	-6.787	0.000	(0)
ZnHCO3+	1.459e-07	1.215e-07	-6.836	-6.915	-0.079	(0)
ZnOH+	8.271e-08	6.890e-08	-7.082	-7.162	-0.079	(0)
Zn(OH)2	1.422e-08	1.422e-08	-7.847	-7.847	0.000	(0)
Zn(SO4)2-2	4.172e-09	2.009e-09	-8.380	-8.697	-0.317	(0)
ZnOHCl	2.772e-09	2.772e-09	-8.557	-8.557	0.000	(0)
ZnCl+	1.892e-09	1.626e-09	-8.723	-8.789	-0.066	(0)
ZnF+	5.438e-10	4.530e-10	-9.265	-9.344	-0.079	(0)
Zn(OH)3-	1.115e-10	9.286e-11	-9.953	-10.032	-0.079	(0)
ZnCl2	3.152e-12	3.152e-12	-11.501	-11.501	0.000	(0)
Zn(OH)4-2	9.999e-15	4.815e-15	-14.000	-14.317	-0.317	(0)
ZnCl3-	3.564e-15	3.063e-15	-14.448	-14.514	-0.066	(0)
ZnSeO4	1.000e-15	1.000e-15	-15.000	-15.000	0.000	(0)
ZnCl4-2	3.353e-18	1.873e-18	-17.475	-17.727	-0.253	(0)
Zn(SeO4)2-2	2.570e-26	1.238e-26	-25.590	-25.907	-0.317	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.81	8.99	10.80	Al(OH)3
Al2(MoO4)3	-54.36	-52.00	2.37	Al2(MoO4)3
Al2O3	-1.68	17.97	19.65	Al2O3
Al4(OH)10SO4	-5.83	16.87	22.70	Al4(OH)10SO4
AlAsO4:2H2O	-10.63	-5.83	4.80	AlAsO4:2H2O
AlOHSO4	-6.86	-10.09	-3.23	AlOHSO4
Alunite	-4.79	-6.19	-1.40	KAl3(SO4)2(OH)6
Anglesite	-4.04	-11.83	-7.79	PbSO4
Anhydrite	-1.40	-5.76	-4.36	CaSO4
Antlerite	-4.77	4.02	8.79	Cu3(OH)4SO4
Aragonite	1.03	-7.27	-8.30	CaCO3
Arsenolite	-77.81	-80.57	-2.76	As4O6
Artinite	-3.65	5.95	9.60	MgCO3:Mg(OH)2:3H2O
As2O5	-36.34	-29.64	6.71	As2O5
Atacamite	-3.02	4.37	7.39	Cu2(OH)3Cl
Azurite	-1.16	-18.07	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-14.35	10.05	24.39	Ba(OH)2:8H2O
Ba2V2O7:2H2O	-12.53	3.34	15.87	Ba2V2O7:2H2O
Ba3(AsO4)2	9.42	0.51	-8.91	Ba3(AsO4)2
Ba3(VO4)2:4H2O	-19.55	13.39	32.94	Ba3(VO4)2:4H2O
BaCrO4	-10.32	-19.99	-9.67	BaCrO4
BaF2	-9.09	-14.91	-5.82	BaF2
BaMoO4	-6.31	-13.27	-6.96	BaMoO4
Barite	0.95	-9.03	-9.98	BaSO4
BaSeO3	-6.83	-5.00	1.83	BaSeO3
BaSeO4	-9.63	-17.09	-7.46	BaSeO4
Bianchite	-7.36	-9.13	-1.76	ZnSO4:6H2O
Birnessite	-9.26	8.83	18.09	MnO2
Bixbyite	-5.92	-6.57	-0.64	Mn2O3
Boehmite	0.41	8.99	8.58	AlOOH
Brochantite	-3.51	11.72	15.22	Cu4(OH)6SO4
Brucite	-3.58	13.27	16.84	Mg(OH)2
Bunsenite	-3.94	8.50	12.45	NiO
Ca(VO3)2	-9.10	-3.44	5.66	Ca(VO3)2
Ca2V2O7	-7.63	9.87	17.50	Ca2V2O7
Ca2V2O7:2H2O	-11.68	9.87	21.55	Ca2V2O7:2H2O
Ca3(AsO4)2:4H2O	-12.00	10.30	22.30	Ca3(AsO4)2:4H2O
Ca3(VO4)2	-15.77	23.19	38.96	Ca3(VO4)2
Ca3(VO4)2:4H2O	-16.67	23.19	39.86	Ca3(VO4)2:4H2O
CaCrO4	-14.46	-16.73	-2.27	CaCrO4
Calcite	1.21	-7.27	-8.48	CaCO3
CaMoO4	-2.06	-10.01	-7.95	CaMoO4
Carnotite	-4.64	-4.41	0.23	KUO2VO4
CaSeO3:2H2O	-4.55	-1.74	2.81	CaSeO3:2H2O
CaSeO4:2H2O	-10.80	-13.82	-3.02	CaSeO4:2H2O
Cd(BO2)2	-11.26	-1.42	9.84	Cd(BO2)2
Cd(OH)2	-5.20	8.44	13.64	Cd(OH)2
Cd(OH)2(am)	-5.29	8.44	13.73	Cd(OH)2
Cd3(OH)2(SO4)2	-19.54	-12.83	6.71	Cd3(OH)2(SO4)2
Cd3(OH)4SO4	-16.32	6.24	22.56	Cd3(OH)4SO4
Cd4(OH)6SO4	-13.72	14.68	28.40	Cd4(OH)6SO4
CdCl2	-12.95	-13.61	-0.66	CdCl2
CdCl2:1H2O	-11.92	-13.61	-1.69	CdCl2:1H2O
CdCl2:2.5H2O	-11.70	-13.61	-1.91	CdCl2:2.5H2O
CdF2	-15.31	-16.52	-1.21	CdF2
Cdmetal(alpha)	-29.30	-15.78	13.51	Cd
Cdmetal(gamma)	-29.40	-15.78	13.62	Cd
CdMoO4	-0.73	-14.88	-14.15	CdMoO4
CdOHCl	-6.12	-2.59	3.54	CdOHCl
CdSe	-14.22	-34.42	-20.20	CdSe
CdSeO4:2H2O	-16.85	-18.70	-1.85	CdSeO4:2H2O
CdSO4	-10.46	-10.63	-0.17	CdSO4
CdSO4:1H2O	-8.91	-10.63	-1.73	CdSO4:1H2O
CdSO4:2.67H2O	-8.76	-10.64	-1.87	CdSO4:2.67H2O
Cerussite	-0.21	-13.34	-13.13	PbCO3
CH4(g)	-76.43	-117.48	-41.05	CH4
Chalcanthite	-8.74	-11.38	-2.64	CuSO4:5H2O
Claudetite	-77.51	-80.57	-3.06	As4O6
Clausthalite	-8.52	-35.62	-27.10	PbSe
Co(BO2)2	-28.50	-1.43	27.07	Co(BO2)2
Co(OH)2	-4.67	8.43	13.09	Co(OH)2
Co(OH)3	-9.55	-11.86	-2.31	Co(OH)3
CO2(g)	-2.43	-20.58	-18.15	CO2
Co3(AsO4)2	-17.39	-4.35	13.03	Co3(AsO4)2
Co3O4	-4.80	-15.29	-10.50	Co3O4
CoCl2	-21.89	-13.62	8.27	CoCl2
CoCl2:6H2O	-16.16	-13.62	2.54	CoCl2:6H2O
CoCO3	-2.17	-12.15	-9.98	CoCO3
CoF2	-14.93	-16.53	-1.60	CoF2
CoF3	-47.84	-49.30	-1.46	CoF3
CoFe2O4	25.44	21.91	-3.53	CoFe2O4
CoMoO4	-7.13	-14.89	-7.76	CoMoO4
CoO	-5.16	8.43	13.59	CoO
CoSe	-18.24	-34.44	-16.20	CoSe
CoSeO3	-7.95	-6.63	1.32	CoSeO3
CoSeO4:6H2O	-17.18	-18.71	-1.53	CoSeO4:6H2O
CoSO4	-13.45	-10.65	2.80	CoSO4
CoSO4:6H2O	-8.17	-10.65	-2.47	CoSO4:6H2O
Cotunnite	-10.03	-14.81	-4.78	PbCl2
Cr(OH)2	-18.98	-8.17	10.82	Cr(OH)2
Cr(OH)3	-0.34	1.00	1.34	Cr(OH)3
Cr(OH)3(am)	1.75	1.00	-0.75	Cr(OH)3
Cr2O3	4.36	2.00	-2.36	Cr2O3
CrCl2	-44.31	-30.21	14.09	CrCl2
CrCl3	-47.19	-32.07	15.11	CrCl3
CrF3	-25.10	-36.44	-11.34	CrF3
Crmetal	-62.87	-32.39	30.48	Cr
CrO3	-26.83	-30.04	-3.21	CrO3
Cryolite	-13.95	-47.79	-33.84	Na3AlF6
Cu(OH)2	-0.98	7.70	8.67	Cu(OH)2
Cu2Se(alpha)	-0.51	-46.31	-45.80	Cu2Se
Cu2SO4	-20.57	-22.52	-1.95	Cu2SO4
Cu3(AsO4)2:2H2O	-12.64	-6.54	6.10	Cu3(AsO4)2:2H2O
Cu3Se2	-17.99	-81.48	-63.49	Cu3Se2
CuCO3	-1.38	-12.88	-11.50	CuCO3
CuCrO4	-16.90	-22.34	-5.44	CuCrO4
CuF	-9.30	-14.20	-4.91	CuF
CuF2	-18.38	-17.26	1.12	CuF2

CuF2:2H2O	-12.71	-17.26	-4.55	CuF2:2H2O
Cumetal	-5.08	-13.84	-8.76	Cu
CuMoO4	-2.55	-15.62	-13.08	CuMoO4
CuOCuSO4	-13.98	-3.68	10.30	CuOCuSO4
Cupricferrite	15.19	21.18	5.99	CuFe2O4
Cuprite	-2.04	-3.45	-1.41	Cu2O
Cuprousferrite	13.93	5.02	-8.92	CuFeO2
CuSe	-2.07	-35.17	-33.10	CuSe
CuSe2	-20.44	-53.81	-33.37	CuSe2
CuSeO3:2H2O	-7.87	-7.36	0.51	CuSeO3:2H2O
CuSeO4:5H2O	-17.00	-19.44	-2.44	CuSeO4:5H2O
CuSO4	-14.32	-11.38	2.94	CuSO4
Diaspore	2.11	8.99	6.87	AlOOH
Dolomite(disordered)	1.96	-14.58	-16.54	CaMg(CO3)2
Dolomite(ordered)	2.51	-14.58	-17.09	CaMg(CO3)2
Epsomite	-3.68	-5.81	-2.13	MgSO4:7H2O
Fe(OH)2	-5.90	7.66	13.56	Fe(OH)2
Fe(OH)2.7Cl.3	6.47	3.43	-3.04	Fe(OH)2.7Cl.3
Fe(VO3)2	-5.37	-9.09	-3.72	Fe(VO3)2
Fe2(OH)4SeO3	-3.12	-1.57	1.55	Fe2(OH)4SeO3
Fe2(SeO3)3:2H2O	-11.05	-31.68	-20.63	Fe2(SeO3)3:2H2O
Fe2(SO4)3	-40.01	-43.74	-3.73	Fe2(SO4)3
Fe3(OH)8	0.92	21.14	20.22	Fe3(OH)8
FeAsO4:2H2O	-8.48	-8.08	0.40	FeAsO4:2H2O
FeCr2O4	2.46	9.66	7.20	FeCr2O4
FeMoO4	-5.57	-15.66	-10.09	FeMoO4
Ferrihydrite	3.55	6.74	3.19	Fe(OH)3
Ferroselite	-35.25	-53.84	-18.60	FeSe2
FeSe	-24.20	-35.20	-11.00	FeSe
Fluorite	-1.14	-11.64	-10.50	CaF2
Gibbsite	0.69	8.99	8.29	Al(OH)3
Goethite	6.25	6.74	0.49	FeOOH
Goslarite	-7.12	-9.13	-2.01	ZnSO4:7H2O
Gummite	-8.70	-1.03	7.67	UO3
Gypsum	-1.15	-5.76	-4.61	CaSO4:2H2O
H-Jarosite	-5.83	-17.93	-12.10	(H3O)Fe3(SO4)2(OH)6
H2MoO4	-10.45	-23.32	-12.88	H2MoO4
H2Se(g)	-37.90	-42.86	-4.96	H2Se
Halite	-6.59	-4.99	1.60	NaCl
Hausmannite	-6.94	54.09	61.03	Mn3O4
Hematite	14.90	13.48	-1.42	Fe2O3
Hercynite	2.74	25.63	22.89	FeAl2O4
Huntite	0.76	-29.20	-29.97	CaMg3(CO3)4
Hydrocerussite	-0.67	-19.44	-18.77	Pb3(OH)2(CO3)2
Hydromagnesite	-7.22	-15.99	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-19.00	-24.17	-5.17	KAl(SO4)2:12H2O
K-Jarosite	1.88	-12.92	-14.80	KFe3(SO4)2(OH)6
K2Cr2O7	-32.84	-50.08	-17.24	K2Cr2O7
K2CrO4	-19.53	-20.04	-0.51	K2CrO4
K2MoO4	-16.58	-13.32	3.26	K2MoO4
K2SeO4	-16.41	-17.14	-0.73	K2SeO4
Langite	-5.77	11.72	17.49	Cu4(OH)6SO4:H2O
Larnakite	-4.16	-4.59	-0.43	PbO:PbSO4
Laurionite	-4.41	-3.78	0.62	PbOHCl
Lepidocrocite	5.37	6.74	1.37	FeOOH
Lime	-19.39	13.31	32.70	CaO
Litharge	-5.45	7.24	12.69	PbO
Maghemite	7.10	13.48	6.39	Fe2O3
Magnesioferrite	9.89	26.75	16.86	Fe2MgO4
Magnesite	0.15	-7.31	-7.46	MgCO3
Magnetite	17.74	21.14	3.40	Fe3O4
Malachite	0.12	-5.18	-5.31	Cu2(OH)2CO3
Manganite	-3.27	22.07	25.34	MnOOH
Massicot	-5.65	7.24	12.89	PbO
Matlockite	-7.29	-16.26	-8.97	PbClF
Melanothallite	-20.61	-14.35	6.26	CuCl2
Melanterite	-9.21	-11.41	-2.21	FeSO4:7H2O
Mg(OH)2(active)	-5.53	13.27	18.79	Mg(OH)2
Mg(VO3)2	-14.77	-3.49	11.28	Mg(VO3)2
Mg2V2O7	-16.58	9.78	26.36	Mg2V2O7
MgCr2O4	-0.93	15.27	16.20	MgCr2O4
MgCrO4	-22.15	-16.77	5.38	MgCrO4
MgF2	-3.56	-11.69	-8.13	MgF2
MgMoO4	-8.21	-10.06	-1.85	MgMoO4
MgSeO3:6H2O	-4.84	-1.79	3.06	MgSeO3:6H2O
MgSeO4:6H2O	-12.67	-13.87	-1.20	MgSeO4:6H2O
Minium	-27.57	45.95	73.52	Pb3O4
Mirabilite	-5.90	-7.01	-1.11	Na2SO4:10H2O
Mn(VO3)2	-11.70	-6.80	4.90	Mn(VO3)2
Mn2(SO4)3	-58.08	-63.79	-5.71	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-12.27	0.23	12.50	Mn3(AsO4)2:8H2O
MnCl2:4H2O	-14.81	-12.09	2.72	MnCl2:4H2O
MnSe	-36.41	-32.91	3.50	MnSe
MnSeO3	-6.23	-5.10	1.13	MnSeO3
MnSeO3:2H2O	-6.08	-5.10	0.98	MnSeO3:2H2O
MnSeO4:5H2O	-15.13	-17.18	-2.05	MnSeO4:5H2O
MnSO4	-11.70	-9.12	2.58	MnSO4
Monteponite	-6.66	8.44	15.10	CdO
MoO3	-15.32	-23.32	-8.00	MoO3
Morenosite	-8.43	-10.57	-2.14	NiSO4:7H2O
Na-Jarosite	-0.69	-11.89	-11.20	NaFe3(SO4)2(OH)6
Na2Cr2O7	-38.12	-48.02	-9.90	Na2Cr2O7
Na2CrO4	-20.91	-17.98	2.93	Na2CrO4
Na2Mo2O7	-17.98	-34.58	-16.60	Na2Mo2O7
Na2MoO4	-12.75	-11.26	1.49	Na2MoO4
Na2MoO4:2H2O	-12.48	-11.26	1.22	Na2MoO4:2H2O
Na2SeO3:5H2O	-13.29	-2.99	10.30	Na2SeO3:5H2O
Na2SeO4	-16.35	-15.07	1.28	Na2SeO4
Na3VO4	-26.96	9.72	36.68	Na3VO4
Na4V2O7	-30.02	7.38	37.40	Na4V2O7
Nantokite	-6.02	-12.75	-6.73	CuCl
Natron	-7.21	-8.52	-1.31	Na2CO3:10H2O
NaVO3	-6.20	-2.34	3.86	NaVO3
Nesquehonite	-2.64	-7.31	-4.67	MgCO3:3H2O
Ni(OH)2	-4.29	8.50	12.79	Ni(OH)2
Ni3(AsO4)2:8H2O	-19.83	-4.13	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-17.06	14.94	32.00	Ni4(OH)6SO4
NiCO3	-5.21	-12.08	-6.87	NiCO3
NiMoO4	-3.68	-14.82	-11.14	NiMoO4
NiSe	-16.66	-34.36	-17.70	NiSe
NiSeO3:2H2O	-9.37	-6.55	2.81	NiSeO3:2H2O
NiSeO4:6H2O	-17.12	-18.64	-1.52	NiSeO4:6H2O
Nsutite	-8.67	8.83	17.50	MnO2
O2(g)	-34.64	48.45	83.09	O2
Otavite	-0.14	-12.14	-12.00	CdCO3
Pb(BO2)2	-9.14	-2.62	6.52	Pb(BO2)2
Pb(OH)2	-0.91	7.24	8.15	Pb(OH)2
Pb10(OH)6O(CO3)6	-42.31	-51.07	-8.76	Pb10(OH)6O(CO3)6
Pb2(OH)3Cl	-5.34	3.46	8.79	Pb2(OH)3Cl
Pb2O(OH)2	-11.71	14.48	26.19	Pb2O(OH)2
Pb2O3	-22.33	38.71	61.04	Pb2O3
Pb2OCO3	-5.54	-6.10	-0.56	Pb2OCO3
Pb2V2O7	-0.37	-2.27	-1.90	Pb2V2O7
Pb3(AsO4)2	-13.71	-7.91	5.80	Pb3(AsO4)2
Pb3(VO4)2	-1.17	4.97	6.14	Pb3(VO4)2
Pb3O2CO3	-9.88	1.14	11.02	Pb3O2CO3
Pb3O2SO4	-8.04	2.65	10.69	Pb3O2SO4
Pb4(OH)6SO4	-11.21	9.89	21.10	Pb4(OH)6SO4
Pb4O3SO4	-11.99	9.89	21.88	Pb4O3SO4
PbCrO4	-10.20	-22.80	-12.60	PbCrO4
PbF2	-10.28	-17.72	-7.44	PbF2
Pbmetal	-21.23	-16.98	4.25	Pb
PbMoO4	-0.46	-16.08	-15.62	PbMoO4
PbO:0.3H2O	-5.74	7.24	12.98	PbO:0.33H2O
PbSeO4	-13.06	-19.90	-6.84	PbSeO4
Periclase	-8.32	13.27	21.58	MgO
Phosgenite	-8.34	-28.15	-19.81	PbCl2:PbCO3
Plattnerite	-18.14	31.46	49.60	PbO2
Portlandite	-9.49	13.31	22.80	Ca(OH)2
Pyrochroite	-5.24	9.96	15.19	Mn(OH)2
Pyrolusite	-7.20	34.18	41.38	MnO2
Retgersite	-8.53	-10.57	-2.04	NiSO4:6H2O
Rhodochrosite	-0.04	-10.62	-10.58	MnCO3
Rutherfordine	-7.11	-21.61	-14.50	UO2CO3
Schoepite	-7.03	-1.03	5.99	UO2(OH)2:H2O
Semetal(am)	-11.53	-18.64	-7.11	Se
Semetal(hex)	-10.93	-18.64	-7.71	Se
SeO2	-15.18	-15.05	0.12	SeO2
SeO3	-48.18	-27.14	21.04	SeO3
Siderite	-2.68	-12.92	-10.24	FeCO3
Smithsonite	-0.63	-10.63	-10.00	ZnCO3
Spinel	-5.61	31.24	36.85	MgAl2O4
Tenorite	0.05	7.70	7.64	CuO
Thenardite	-7.33	-7.01	0.32	Na2SO4
Thermonatrite	-9.15	-8.52	0.64	Na2CO3:H2O
Tyuyamunite	-9.58	-5.50	4.08	Ca(UO2)2(VO4)2
U3O8	-20.75	0.33	21.08	U3O8
U4O9	-36.91	-39.93	-3.02	U4O9
UF4	-36.42	-65.96	-29.54	UF4
UF4:2.5H2O	-33.24	-65.96	-32.72	UF4:2.5H2O
UO2(am)	-16.97	-16.04	0.93	UO2
UO2(OH)2(beta)	-6.64	-1.03	5.61	UO2(OH)2
UO2SeO4:4H2O	-25.92	-28.17	-2.25	UO2SeO4:4H2O
UO3	-8.73	-1.03	7.70	UO3
Uraninite	-11.37	-16.04	-4.67	UO2
V(OH)3	-17.59	-10.00	7.59	V(OH)3
V2O5	-15.39	-16.75	-1.36	V2O5
V3O5	-36.82	-34.98	1.84	V3O5
V4O7	-45.75	-38.56	7.19	V4O7
V6O13	-37.85	-98.71	-60.86	V6O13
VCl2	-63.04	-44.16	18.87	VCl2
VCl3	-66.51	-43.07	23.43	VCl3
VF4	-68.43	-53.50	14.93	VF4
Vmetal	-90.36	-46.34	44.03	V
VO	-36.87	-22.11	14.76	VO
VO(OH)2	-8.74	-3.59	5.15	VO(OH)2
VO2Cl	-22.24	-19.40	2.84	VO2Cl
VOCl	-32.18	-21.03	11.15	VOCl
VOCl2	-38.39	-25.63	12.76	VOCl2
VOSO4	-26.27	-22.66	3.61	VOSO4
Witherite	-1.96	-10.53	-8.57	BaCO3
Zincite	-1.39	9.95	11.33	ZnO
Zincosite	-13.06	-9.13	3.93	ZnSO4
Zn(BO2)2	-8.20	0.09	8.29	Zn(BO2)2
Zn(OH)2	-2.25	9.95	12.20	Zn(OH)2
Zn(OH)2(am)	-2.53	9.95	12.47	Zn(OH)2
Zn(OH)2(beta)	-1.81	9.95	11.75	Zn(OH)2
Zn(OH)2(epsilon)	-1.59	9.95	11.53	Zn(OH)2
Zn(OH)2(gamma)	-1.79	9.95	11.73	Zn(OH)2
Zn2(OH)2SO4	-6.68	0.82	7.50	Zn2(OH)2SO4
Zn2(OH)3Cl	-6.32	8.87	15.19	Zn2(OH)3Cl
Zn3(AsO4)2:2.5H2O	-13.44	0.21	13.65	Zn3(AsO4)2:2.5H2O
Zn3O(SO4)2	-27.22	-8.31	18.91	Zn3O(SO4)2
Zn4(OH)6SO4	-7.69	20.71	28.40	Zn4(OH)6SO4
Zn5(OH)8Cl2	-10.81	27.69	38.50	Zn5(OH)8Cl2
ZnCl2	-19.15	-12.10	7.05	ZnCl2
ZnCO3:1H2O	-0.37	-10.63	-10.26	ZnCO3:1H2O
ZnF2	-14.48	-15.01	-0.53	ZnF2
Znmetal	-40.07	-14.28	25.79	Zn
ZnMoO4	-3.25	-13.37	-10.13	ZnMoO4
ZnO(active)	-1.24	9.95	11.19	ZnO
ZnSe	-18.52	-32.92	-14.40	ZnSe
ZnSeO4:6H2O	-15.67	-17.19	-1.52	ZnSeO4:6H2O
ZnSO4:1H2O	-8.49	-9.13	-0.64	ZnSO4:1H2O

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Initial solution 2. PAF Material

----------Solution composition----------

Elements	Molality	Moles
Al	7.415e-07	7.415e-07
Alkalinity	3.607e-04	3.607e-04
Ba	1.457e-07	1.457e-07
Ca	1.672e-03	1.672e-03
Co	1.188e-07	1.188e-07
Cu	4.408e-07	4.408e-07
F	1.580e-05	1.580e-05
K	3.326e-04	3.326e-04
Mg	3.293e-04	3.293e-04
Mn	7.283e-07	7.283e-07
Mo	3.128e-08	3.128e-08
Na	4.351e-05	4.351e-05
Ni	6.818e-08	6.818e-08
S(6)	2.051e-03	2.051e-03

----------Description of solution----------

pH	= 7.500
pe	= 4.000
Activity of water	= 1.000
Ionic strength (mol/kgw)	= 7.200e-03
Mass of water (kg)	= 1.000e+00
Total carbon (mol/kg)	= 3.782e-04
Total CO2 (mol/kg)	= 3.782e-04
Temperature (°C)	= 25.00
Electrical balance (eq)	= -9.478e-05
Percent error, 100*(Cat-|An|)/(Cat+|An|)	= -1.25
Iterations	= 13 (24 overall)
Total H	= 1.110141e+02
Total O	= 5.551618e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
OH-	3.487e-07	3.184e-07	-6.458	-6.497	-0.039	(0)
H+	3.458e-08	3.162e-08	-7.461	-7.500	-0.039	0.00
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000	18.07
Al 7.415e-07						
Al(OH)4-	7.221e-07	6.609e-07	-6.141	-6.180	-0.038	(0)
Al(OH)3	1.649e-08	1.649e-08	-7.783	-7.783	0.000	(0)
Al(OH)2+	2.830e-09	2.595e-09	-8.548	-8.586	-0.038	(0)
AlF2+	2.736e-11	2.509e-11	-10.563	-10.600	-0.038	(0)
AlOH+2	1.451e-11	1.026e-11	-10.838	-10.989	-0.150	(0)
AlF+2	6.374e-12	4.507e-12	-11.196	-11.346	-0.150	(0)
AlF3	4.418e-12	4.418e-12	-11.355	-11.355	0.000	(0)
AlSO4+	3.315e-13	3.034e-13	-12.480	-12.518	-0.038	(0)
Al+3	7.201e-14	3.223e-14	-13.143	-13.492	-0.349	(0)
AlF4-	3.383e-14	3.096e-14	-13.471	-13.509	-0.038	(0)

Al(SO4)2-	4.307e-15	3.942e-15	-14.366	-14.404	-0.038	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-49.070	-49.460	-0.390	(0)
Ba	1.457e-07					
Ba+2	1.453e-07	1.017e-07	-6.838	-6.993	-0.155	(0)
BaHCO3+	3.363e-10	3.088e-10	-9.473	-9.510	-0.037	(0)
BaCO3	2.459e-11	2.459e-11	-10.609	-10.609	0.000	(0)
BaOH+	1.542e-13	1.413e-13	-12.812	-12.850	-0.038	(0)
C(4)	3.782e-04					
HCO3-	3.469e-04	3.181e-04	-3.460	-3.497	-0.038	(0)
H2CO3	2.262e-05	2.262e-05	-4.645	-4.645	0.000	(0)
CaHCO3+	6.292e-06	5.777e-06	-5.201	-5.238	-0.037	(0)
CaCO3	7.289e-07	7.289e-07	-6.137	-6.137	0.000	(0)
MgHCO3+	7.079e-07	6.472e-07	-6.150	-6.189	-0.039	(0)
CO3-2	6.741e-07	4.716e-07	-6.171	-6.326	-0.155	(0)
CuCO3	2.133e-07	2.133e-07	-6.671	-6.671	0.000	(0)
MgCO3	7.799e-08	7.799e-08	-7.108	-7.108	0.000	(0)
NaHCO3	7.071e-09	7.071e-09	-8.151	-8.151	0.000	(0)
MnHCO3+	2.944e-09	2.697e-09	-8.531	-8.569	-0.038	(0)
CoHCO3+	1.830e-09	1.657e-09	-8.738	-8.781	-0.043	(0)
CuHCO3+	1.703e-09	1.542e-09	-8.769	-8.812	-0.043	(0)
NiHCO3+	1.700e-09	1.539e-09	-8.770	-8.813	-0.043	(0)
NiCO3	6.904e-10	6.904e-10	-9.161	-9.161	0.000	(0)
CoCO3	5.337e-10	5.337e-10	-9.273	-9.273	0.000	(0)
Cu(CO3)2-2	4.033e-10	2.707e-10	-9.394	-9.567	-0.173	(0)
NaCO3-	3.785e-10	3.471e-10	-9.422	-9.460	-0.038	(0)
BaHCO3+	3.363e-10	3.088e-10	-9.473	-9.510	-0.037	(0)
BaCO3	2.459e-11	2.459e-11	-10.609	-10.609	0.000	(0)
Ca	1.672e-03					
Ca+2	1.394e-03	9.753e-04	-2.856	-3.011	-0.155	(0)
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)
CaHCO3+	6.292e-06	5.777e-06	-5.201	-5.238	-0.037	(0)
CaCO3	7.289e-07	7.289e-07	-6.137	-6.137	0.000	(0)
CaF+	1.625e-07	1.489e-07	-6.789	-6.827	-0.038	(0)
CaOH+	6.748e-09	6.196e-09	-8.171	-8.208	-0.037	(0)
Co(2)	1.188e-07					
Co+2	9.974e-08	6.695e-08	-7.001	-7.174	-0.173	(0)
CoSO4	1.620e-08	1.620e-08	-7.791	-7.791	0.000	(0)
CoHCO3+	1.830e-09	1.657e-09	-8.738	-8.781	-0.043	(0)
CoCO3	5.337e-10	5.337e-10	-9.273	-9.273	0.000	(0)
CoOH+	4.699e-10	4.253e-10	-9.328	-9.371	-0.043	(0)
CoF+	3.271e-11	2.961e-11	-10.485	-10.529	-0.043	(0)
Co(OH)2	1.076e-11	1.076e-11	-10.968	-10.968	0.000	(0)
Co(OH)3-	7.550e-17	6.834e-17	-16.122	-16.165	-0.043	(0)
CoOOH-	1.894e-17	1.715e-17	-16.723	-16.766	-0.043	(0)
Co2OH+3	3.499e-18	1.427e-18	-17.456	-17.846	-0.390	(0)
Co(OH)4-2	5.137e-24	3.448e-24	-23.289	-23.462	-0.173	(0)
Co4(OH)4+4	3.216e-29	6.530e-30	-28.493	-29.185	-0.692	(0)
Co(3)	6.424e-30					
CoOH+2	6.424e-30	4.312e-30	-29.192	-29.365	-0.173	(0)
Co+3	5.955e-36	2.665e-36	-35.225	-35.574	-0.349	(0)
Cu(1)	4.157e-09					
Cu+	4.157e-09	3.762e-09	-8.381	-8.425	-0.043	(0)
Cu(2)	4.366e-07					
CuCO3	2.133e-07	2.133e-07	-6.671	-6.671	0.000	(0)
Cu+2	1.098e-07	7.682e-08	-6.959	-7.115	-0.155	(0)
CuOH+	8.460e-08	7.735e-08	-7.073	-7.112	-0.039	(0)
CuSO4	2.134e-08	2.134e-08	-7.671	-7.671	0.000	(0)
Cu(OH)2	4.914e-09	4.914e-09	-8.309	-8.309	0.000	(0)
CuHCO3+	1.703e-09	1.542e-09	-8.769	-8.812	-0.043	(0)
Cu(CO3)2-2	4.033e-10	2.707e-10	-9.394	-9.567	-0.173	(0)
Cu2(OH)2+2	2.239e-10	1.503e-10	-9.650	-9.823	-0.173	(0)
CuF+	7.488e-11	6.778e-11	-10.126	-10.169	-0.043	(0)
Cu(OH)3-	3.545e-12	3.209e-12	-11.450	-11.494	-0.043	(0)
Cu(OH)4-2	1.198e-17	8.042e-18	-16.922	-17.095	-0.173	(0)
F	1.580e-05					
F-	1.529e-05	1.398e-05	-4.816	-4.854	-0.039	(0)

MgF+	3.409e-07	3.120e-07	-6.467	-6.506	-0.038	(0)
CaF+	1.625e-07	1.489e-07	-6.789	-6.827	-0.038	(0)
HF	6.541e-10	6.541e-10	-9.184	-9.184	0.000	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
MnF+	2.582e-10	2.366e-10	-9.588	-9.626	-0.038	(0)
CuF+	7.488e-11	6.778e-11	-10.126	-10.169	-0.043	(0)
CoF+	3.271e-11	2.961e-11	-10.485	-10.529	-0.043	(0)
AlF2+	2.736e-11	2.509e-11	-10.563	-10.600	-0.038	(0)
NiF+	1.523e-11	1.379e-11	-10.817	-10.861	-0.043	(0)
AlF+2	6.374e-12	4.507e-12	-11.196	-11.346	-0.150	(0)
AlF3	4.418e-12	4.418e-12	-11.355	-11.355	0.000	(0)
HF2-	3.808e-14	3.478e-14	-13.419	-13.459	-0.039	(0)
AlF4-	3.383e-14	3.096e-14	-13.471	-13.509	-0.038	(0)
H2F2	1.146e-18	1.146e-18	-17.941	-17.941	0.000	(0)
H(0)	1.414e-26					
H2	7.068e-27	7.079e-27	-26.151	-26.150	0.001	(0)
K	3.326e-04					
K+	3.298e-04	3.016e-04	-3.482	-3.521	-0.039	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
Mg	3.293e-04					
Mg+2	2.842e-04	1.988e-04	-3.546	-3.702	-0.155	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
MgHCO3+	7.079e-07	6.472e-07	-6.150	-6.189	-0.039	(0)
MgF+	3.409e-07	3.120e-07	-6.467	-6.506	-0.038	(0)
MgCO3	7.799e-08	7.799e-08	-7.108	-7.108	0.000	(0)
MgOH+	2.742e-08	2.520e-08	-7.562	-7.599	-0.037	(0)
Mn(2)	7.283e-07					
Mn+2	6.331e-07	4.250e-07	-6.199	-6.372	-0.173	(0)
MnSO4	9.164e-08	9.164e-08	-7.038	-7.038	0.000	(0)
MnHCO3+	2.944e-09	2.697e-09	-8.531	-8.569	-0.038	(0)
MnOH+	3.710e-10	3.399e-10	-9.431	-9.469	-0.038	(0)
MnF+	2.582e-10	2.366e-10	-9.588	-9.626	-0.038	(0)
Mn(OH)3-	2.324e-19	2.129e-19	-18.634	-18.672	-0.038	(0)
Mn(OH)4-2	3.106e-25	2.189e-25	-24.508	-24.660	-0.152	(0)
Mn(3)	4.241e-28					
Mn+3	4.241e-28	1.898e-28	-27.373	-27.722	-0.349	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-48.642	-48.794	-0.152	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-54.126	-54.166	-0.040	(0)
Mo	3.128e-08					
MoO4-2	3.126e-08	2.187e-08	-7.505	-7.660	-0.155	(0)
HMoO4-	1.520e-11	1.376e-11	-10.818	-10.861	-0.043	(0)
H2MoO4	3.188e-15	3.188e-15	-14.497	-14.497	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-49.070	-49.460	-0.390	(0)
Mo7O24-6	0.000e+00	0.000e+00	-59.073	-60.631	-1.558	(0)
HMo7O24-5	0.000e+00	0.000e+00	-60.662	-61.744	-1.082	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-63.769	-64.462	-0.692	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-68.326	-68.716	-0.390	(0)
Na	4.351e-05					
Na+	4.322e-05	3.953e-05	-4.364	-4.403	-0.039	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
NaHCO3	7.071e-09	7.071e-09	-8.151	-8.151	0.000	(0)
NaCO3-	3.785e-10	3.471e-10	-9.422	-9.460	-0.038	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
Ni	6.818e-08					
Ni+2	5.610e-08	3.924e-08	-7.251	-7.406	-0.155	(0)
NiSO4	9.495e-09	9.495e-09	-8.023	-8.023	0.000	(0)
NiHCO3+	1.700e-09	1.539e-09	-8.770	-8.813	-0.043	(0)
NiCO3	6.904e-10	6.904e-10	-9.161	-9.161	0.000	(0)
NiOH+	1.738e-10	1.573e-10	-9.760	-9.803	-0.043	(0)
NiF+	1.523e-11	1.379e-11	-10.817	-10.861	-0.043	(0)
Ni(OH)2	3.978e-12	3.978e-12	-11.400	-11.400	0.000	(0)
Ni(SO4)2-2	5.679e-13	3.812e-13	-12.246	-12.419	-0.173	(0)
Ni(OH)3-	1.399e-15	1.267e-15	-14.854	-14.897	-0.043	(0)
O(0)	2.019e-40					

O2	1.010e-40	1.011e-40	-39.996	-39.995	0.001	(0)
S(6)	2.051e-03					
SO4-2	1.733e-03	1.213e-03	-2.761	-2.916	-0.155	(0)
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
MnSO4	9.164e-08	9.164e-08	-7.038	-7.038	0.000	(0)
CuSO4	2.134e-08	2.134e-08	-7.671	-7.671	0.000	(0)
CoSO4	1.620e-08	1.620e-08	-7.791	-7.791	0.000	(0)
NiSO4	9.495e-09	9.495e-09	-8.023	-8.023	0.000	(0)
HSO4-	4.094e-09	3.747e-09	-8.388	-8.426	-0.038	(0)
Ni(SO4)2-2	5.679e-13	3.812e-13	-12.246	-12.419	-0.173	(0)
AlSO4+	3.315e-13	3.034e-13	-12.480	-12.518	-0.038	(0)
Al(SO4)2-	4.307e-15	3.942e-15	-14.366	-14.404	-0.038	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.79	9.01	10.80	Al(OH)3
Al2(MoO4)3	-52.33	-49.96	2.37	Al2(MoO4)3
Al2O3	-1.64	18.02	19.65	Al2O3
Al4(OH)10SO4	-4.58	18.12	22.70	Al4(OH)10SO4
AlOHSO4	-5.68	-8.91	-3.23	AlOHSO4
Alunite	-3.43	-4.83	-1.40	KAl3(SO4)2(OH)6
Anhydrite	-1.57	-5.93	-4.36	CaSO4
Antlerite	-3.05	5.74	8.79	Cu3(OH)4SO4
Aragonite	-1.04	-9.34	-8.30	CaCO3
Artinite	-8.33	1.27	9.60	MgCO3:Mg(OH)2:3H2O
Azurite	-2.09	-19.00	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-16.39	8.01	24.39	Ba(OH)2:8H2O
BaF2	-10.88	-16.70	-5.82	BaF2
BaMoO4	-7.69	-14.65	-6.96	BaMoO4
Barite	0.07	-9.91	-9.98	BaSO4
Birnessite	-11.81	6.28	18.09	MnO2
Bixbyite	-9.80	-10.44	-0.64	Mn2O3
Boehmite	0.43	9.01	8.58	AlOOH
Brochantite	-1.60	13.63	15.22	Cu4(OH)6SO4
Brucite	-5.55	11.30	16.84	Mg(OH)2
Bunsenite	-4.85	7.59	12.45	NiO
Calcite	-0.86	-9.34	-8.48	CaCO3
CaMoO4	-2.72	-10.67	-7.95	CaMoO4
CH4(g)	-72.28	-113.33	-41.05	CH4
Chalcanthite	-7.39	-10.03	-2.64	CuSO4:5H2O
Co(OH)2	-5.27	7.83	13.09	Co(OH)2
Co(OH)3	-10.77	-13.07	-2.31	Co(OH)3
CO2(g)	-3.18	-21.33	-18.15	CO2
Co3O4	-7.83	-18.32	-10.50	Co3O4
CoCO3	-3.52	-13.50	-9.98	CoCO3
CoF2	-15.29	-16.88	-1.60	CoF2
CoF3	-48.68	-50.14	-1.46	CoF3
CoMoO4	-7.07	-14.83	-7.76	CoMoO4
CoO	-5.76	7.83	13.59	CoO
CoSO4	-12.89	-10.09	2.80	CoSO4
CoSO4:6H2O	-7.62	-10.09	-2.47	CoSO4:6H2O
Cryolite	-21.99	-55.83	-33.84	Na3AlF6
Cu(OH)2	-0.79	7.89	8.67	Cu(OH)2
Cu2SO4	-17.82	-19.77	-1.95	Cu2SO4
CuCO3	-1.94	-13.44	-11.50	CuCO3
CuF	-8.37	-13.28	-4.91	CuF
CuF2	-17.94	-16.82	1.12	CuF2
CuF2:2H2O	-12.27	-16.82	-4.55	CuF2:2H2O
Cumetal	-3.67	-12.42	-8.76	Cu
CuMoO4	-1.70	-14.77	-13.08	CuMoO4
CuOCuSO4	-12.45	-2.15	10.30	CuOCuSO4
Cuprite	-0.44	-1.85	-1.41	Cu2O
CuSO4	-12.97	-10.03	2.94	CuSO4
Diaspore	2.14	9.01	6.87	AlOOH
Dolomite(disordered)	-2.83	-19.37	-16.54	CaMg(CO3)2
Dolomite(ordered)	-2.28	-19.37	-17.09	CaMg(CO3)2
Epsomite	-4.49	-6.62	-2.13	MgSO4:7H2O
Fluorite	-2.22	-12.72	-10.50	CaF2
Gibbsite	0.72	9.01	8.29	Al(OH)3
Gypsum	-1.32	-5.93	-4.61	CaSO4:2H2O
H2MoO4	-9.78	-22.66	-12.88	H2MoO4
Hausmannite	-12.15	48.88	61.03	Mn3O4
Huntite	-9.45	-39.42	-29.97	CaMg3(CO3)4
Hydromagnesite	-20.05	-28.81	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-17.68	-22.85	-5.17	KAl(SO4)2:12H2O
K2MoO4	-17.96	-14.70	3.26	K2MoO4
Langite	-3.86	13.63	17.49	Cu4(OH)6SO4:H2O
Lime	-20.71	11.99	32.70	CaO
Magnesite	-2.57	-10.03	-7.46	MgCO3
Malachite	-0.25	-5.56	-5.31	Cu2(OH)2CO3
Manganite	-5.21	20.13	25.34	MnOOH
Mg(OH)2(active)	-7.50	11.30	18.79	Mg(OH)2
MgF2	-5.28	-13.41	-8.13	MgF2
MgMoO4	-9.51	-11.36	-1.85	MgMoO4
Mirabilite	-10.61	-11.72	-1.11	Na2SO4:10H2O
Mn2(SO4)3	-58.48	-64.19	-5.71	Mn2(SO4)3
MnSO4	-11.87	-9.29	2.58	MnSO4
MoO3	-14.66	-22.66	-8.00	MoO3
Morenosite	-8.18	-10.32	-2.14	NiSO4:7H2O
Na2Mo2O7	-22.53	-39.13	-16.60	Na2Mo2O7
Na2MoO4	-17.96	-16.47	1.49	Na2MoO4
Na2MoO4:2H2O	-17.69	-16.47	1.22	Na2MoO4:2H2O
Natron	-13.82	-15.13	-1.31	Na2CO3:10H2O
Nesquehonite	-5.36	-10.03	-4.67	MgCO3:3H2O
Ni(OH)2	-5.20	7.59	12.79	Ni(OH)2
Ni4(OH)6SO4	-19.54	12.46	32.00	Ni4(OH)6SO4
NiCO3	-6.86	-13.73	-6.87	NiCO3
NiMoO4	-3.92	-15.07	-11.14	NiMoO4
Nsutite	-11.23	6.28	17.50	MnO2
O2(g)	-37.09	46.00	83.09	O2
Periclase	-10.29	11.30	21.58	MgO
Portlandite	-10.81	11.99	22.80	Ca(OH)2
Pyrochroite	-6.57	8.63	15.19	Mn(OH)2
Pyrolusite	-9.75	31.63	41.38	MnO2
Retgersite	-8.28	-10.32	-2.04	NiSO4:6H2O
Rhodochrosite	-2.12	-12.70	-10.58	MnCO3
Spinel	-7.53	29.31	36.85	MgAl2O4
Tenorite	0.24	7.89	7.64	CuO
Thenardite	-12.04	-11.72	0.32	Na2SO4
Thermonatrite	-15.77	-15.13	0.64	Na2CO3:H2O
Witherite	-4.75	-13.32	-8.57	BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Initial solution 3. NAF Material

----------Solution composition----------

Elements	Molality	Moles
Al	5.191e-06	5.191e-06
Alkalinity	4.591e-04	4.591e-04
As	3.873e-07	3.873e-07
Ba	1.457e-07	1.457e-07
Ca	3.046e-03	3.046e-03
Co	3.395e-08	3.395e-08

Cu	2.992e-07	2.992e-07
F	1.580e-05	1.580e-05
Fe	1.254e-06	1.254e-06
K	4.094e-04	4.094e-04
Mg	7.410e-04	7.410e-04
Mn	2.368e-06	2.368e-06
Mo	5.214e-08	5.214e-08
Na	4.352e-05	4.352e-05
Ni	1.705e-08	1.705e-08
S(6)	3.447e-03	3.447e-03
U	4.203e-09	4.203e-09

----------Description of solution----------

pH	=	7.600
pe	=	4.000
Activity of water	=	1.000
Ionic strength (mol/kgw)	=	1.193e-02
Mass of water (kg)	=	1.000e+00
Total carbon (mol/kg)	=	4.552e-04
Total CO2 (mol/kg)	=	4.552e-04
Temperature (°C)	=	25.00
Electrical balance (eq)	=	6.787e-04
Percent error, 100*(Cat-|An|)/(Cat+|An|)	=	5.48
Iterations	=	11 (35 overall)
Total H	=	1.110142e+02
Total O	=	5.552201e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
OH-	4.492e-07	4.008e-07	-6.348	-6.397	-0.049	(0)
H+	2.808e-08	2.512e-08	-7.552	-7.600	-0.048	0.00
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000	18.07
Al	5.191e-06					
Al(OH)4-	5.088e-06	4.556e-06	-5.293	-5.341	-0.048	(0)
Al(OH)3	9.030e-08	9.030e-08	-7.044	-7.044	0.000	(0)
Al(OH)2+	1.257e-08	1.129e-08	-7.901	-7.947	-0.047	(0)
AlF2+	6.958e-11	6.249e-11	-10.158	-10.204	-0.047	(0)
AlOH+2	5.451e-11	3.546e-11	-10.264	-10.450	-0.187	(0)
AlF+2	1.811e-11	1.178e-11	-10.742	-10.929	-0.187	(0)
AlF3	1.048e-11	1.048e-11	-10.980	-10.980	0.000	(0)
AlSO4+	1.328e-12	1.189e-12	-11.877	-11.925	-0.048	(0)
Al+3	2.412e-13	8.848e-14	-12.618	-13.053	-0.436	(0)
AlF4-	7.812e-14	6.995e-14	-13.107	-13.155	-0.048	(0)
Al(SO4)2-	2.463e-14	2.206e-14	-13.608	-13.656	-0.048	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-48.018	-48.520	-0.501	(0)
As(3)	1.024e-17					
H3AsO3	1.000e-17	1.000e-17	-17.000	-17.000	0.000	(0)
H2AsO3-	2.322e-19	2.043e-19	-18.634	-18.690	-0.056	(0)
HAsO3-2	1.239e-23	7.417e-24	-22.907	-23.130	-0.223	(0)
H4AsO3+	1.416e-25	1.245e-25	-24.849	-24.905	-0.056	(0)
AsO3-3	3.611e-29	1.138e-29	-28.442	-28.944	-0.501	(0)
As(5)	3.873e-07					
HAsO4-2	3.350e-07	2.005e-07	-6.475	-6.698	-0.223	(0)
H2AsO4-	5.222e-08	4.594e-08	-7.282	-7.338	-0.056	(0)
AsO4-3	8.009e-11	2.524e-11	-10.096	-10.598	-0.501	(0)
H3AsO4	2.000e-13	2.005e-13	-12.699	-12.698	0.001	(0)
Ba	1.457e-07					
Ba+2	1.453e-07	9.304e-08	-6.838	-7.031	-0.194	(0)
BaHCO3+	3.699e-10	3.328e-10	-9.432	-9.478	-0.046	(0)
BaCO3	3.336e-11	3.336e-11	-10.477	-10.477	0.000	(0)
BaOH+	1.815e-13	1.628e-13	-12.741	-12.788	-0.047	(0)
C(4)	4.552e-04					
HCO3-	4.171e-04	3.746e-04	-3.380	-3.426	-0.047	(0)
H2CO3	2.116e-05	2.116e-05	-4.674	-4.674	0.000	(0)
CaHCO3+	1.200e-05	1.080e-05	-4.921	-4.967	-0.046	(0)
CaCO3	1.715e-06	1.715e-06	-5.766	-5.766	0.000	(0)
MgHCO3+	1.687e-06	1.508e-06	-5.773	-5.822	-0.049	(0)
CO3-2	1.092e-06	6.991e-07	-5.962	-6.155	-0.194	(0)
MgCO3	2.288e-07	2.288e-07	-6.641	-6.641	0.000	(0)
CuCO3	1.600e-07	1.600e-07	-6.796	-6.796	0.000	(0)
MnHCO3+	9.921e-09	8.899e-09	-8.003	-8.051	-0.047	(0)
NaHCO3	8.124e-09	8.124e-09	-8.090	-8.090	0.000	(0)
UO2(CO3)2-2	3.482e-09	2.084e-09	-8.458	-8.681	-0.223	(0)
CuHCO3+	1.044e-09	9.187e-10	-8.981	-9.037	-0.056	(0)
UO2(CO3)3-4	5.687e-10	7.303e-11	-9.245	-10.136	-0.891	(0)
NaCO3-	5.590e-10	5.020e-10	-9.253	-9.299	-0.047	(0)
CoHCO3+	5.432e-10	4.778e-10	-9.265	-9.321	-0.056	(0)
Cu(CO3)2-2	5.030e-10	3.011e-10	-9.298	-9.521	-0.223	(0)
NiHCO3+	4.493e-10	3.952e-10	-9.347	-9.403	-0.056	(0)
BaHCO3+	3.699e-10	3.328e-10	-9.432	-9.478	-0.046	(0)
NiCO3	2.232e-10	2.232e-10	-9.651	-9.651	0.000	(0)
CoCO3	1.938e-10	1.938e-10	-9.713	-9.713	0.000	(0)
UO2CO3	1.494e-10	1.494e-10	-9.826	-9.826	0.000	(0)
FeHCO3+	1.083e-10	9.748e-11	-9.965	-10.011	-0.046	(0)
BaCO3	3.336e-11	3.336e-11	-10.477	-10.477	0.000	(0)
Ca	3.046e-03					
Ca+2	2.418e-03	1.548e-03	-2.617	-2.810	-0.194	(0)
CaSO4	6.140e-04	6.140e-04	-3.212	-3.212	0.000	(0)
CaHCO3+	1.200e-05	1.080e-05	-4.921	-4.967	-0.046	(0)
CaCO3	1.715e-06	1.715e-06	-5.766	-5.766	0.000	(0)
CaF+	2.509e-07	2.251e-07	-6.600	-6.648	-0.047	(0)
CaOH+	1.376e-08	1.238e-08	-7.861	-7.907	-0.046	(0)
Co(2)	3.395e-08					
Co+2	2.739e-08	1.640e-08	-7.562	-7.785	-0.223	(0)
CoSO4	5.664e-09	5.664e-09	-8.247	-8.247	0.000	(0)
CoHCO3+	5.432e-10	4.778e-10	-9.265	-9.321	-0.056	(0)
CoCO3	1.938e-10	1.938e-10	-9.713	-9.713	0.000	(0)
CoOH+	1.491e-10	1.311e-10	-9.827	-9.882	-0.056	(0)
CoF+	7.852e-12	6.907e-12	-11.105	-11.161	-0.056	(0)
Co(OH)2	4.175e-12	4.175e-12	-11.379	-11.379	0.000	(0)
Co(OH)3-	3.796e-17	3.339e-17	-16.421	-16.476	-0.056	(0)
CoOOH-	9.525e-18	8.379e-18	-17.021	-17.077	-0.056	(0)
Co2OH+3	3.419e-19	1.078e-19	-18.466	-18.968	-0.501	(0)
Co(OH)4-2	3.543e-24	2.121e-24	-23.451	-23.673	-0.223	(0)
Co4(OH)4+4	4.595e-31	5.900e-32	-30.338	-31.229	-0.891	(0)
Co(3)	2.221e-30					
CoOH+2	2.221e-30	1.330e-30	-29.653	-29.876	-0.223	(0)
Co+3	1.780e-36	6.528e-37	-35.750	-36.185	-0.436	(0)
Cu(1)	2.164e-09					
Cu+	2.164e-09	1.904e-09	-8.665	-8.720	-0.056	(0)
Cu(2)	2.970e-07					
CuCO3	1.600e-07	1.600e-07	-6.796	-6.796	0.000	(0)
Cu+2	6.070e-08	3.887e-08	-7.217	-7.410	-0.194	(0)
CuOH+	5.512e-08	4.927e-08	-7.259	-7.307	-0.049	(0)
CuSO4	1.542e-08	1.542e-08	-7.812	-7.812	0.000	(0)
Cu(OH)2	3.940e-09	3.940e-09	-8.404	-8.404	0.000	(0)
CuHCO3+	1.044e-09	9.187e-10	-8.981	-9.037	-0.056	(0)
Cu(CO3)2-2	5.030e-10	3.011e-10	-9.298	-9.521	-0.223	(0)
Cu2(OH)2+2	1.019e-10	6.097e-11	-9.992	-10.215	-0.223	(0)
CuF+	3.714e-11	3.267e-11	-10.430	-10.486	-0.056	(0)
Cu(OH)3-	3.683e-12	3.239e-12	-11.434	-11.490	-0.056	(0)
Cu(OH)4-2	1.707e-17	1.022e-17	-16.768	-16.991	-0.223	(0)
F	1.580e-05					
F-	1.489e-05	1.332e-05	-4.827	-4.876	-0.048	(0)
MgF+	6.566e-07	5.879e-07	-6.183	-6.231	-0.048	(0)
CaF+	2.509e-07	2.251e-07	-6.600	-6.648	-0.047	(0)
MnF+	7.039e-10	6.314e-10	-9.152	-9.200	-0.047	(0)
HF	4.949e-10	4.949e-10	-9.306	-9.306	0.000	(0)
NaF	3.241e-10	3.241e-10	-9.489	-9.489	0.000	(0)
AlF2+	6.958e-11	6.249e-11	-10.158	-10.204	-0.047	(0)
CuF+	3.714e-11	3.267e-11	-10.430	-10.486	-0.056	(0)
AlF+2	1.811e-11	1.178e-11	-10.742	-10.929	-0.187	(0)
AlF3	1.048e-11	1.048e-11	-10.980	-10.980	0.000	(0)
CoF+	7.852e-12	6.907e-12	-11.105	-11.161	-0.056	(0)
NiF+	3.255e-12	2.863e-12	-11.487	-11.543	-0.056	(0)
UO2F+	1.122e-13	9.871e-14	-12.950	-13.006	-0.056	(0)
AlF4-	7.812e-14	6.995e-14	-13.107	-13.155	-0.048	(0)
HF2-	2.808e-14	2.506e-14	-13.552	-13.601	-0.049	(0)
UO2F2	3.792e-15	3.792e-15	-14.421	-14.421	0.000	(0)
FeF+2	4.333e-16	2.804e-16	-15.363	-15.552	-0.189	(0)
FeF2+	1.114e-16	9.996e-17	-15.953	-16.000	-0.047	(0)
UO2F3-	1.442e-17	1.269e-17	-16.841	-16.897	-0.056	(0)
FeF3	1.879e-18	1.879e-18	-17.726	-17.726	0.000	(0)
H2F2	6.561e-19	6.561e-19	-18.183	-18.183	0.000	(0)
UO2F4-2	2.242e-21	1.342e-21	-20.649	-20.872	-0.223	(0)
UF3+	3.760e-36	3.307e-36	-35.425	-35.481	-0.056	(0)
UF2+2	2.617e-36	1.567e-36	-35.582	-35.805	-0.223	(0)
UF+3	2.964e-38	9.342e-39	-37.528	-38.030	-0.501	(0)
UF4	4.830e-39	4.830e-39	-38.316	-38.316	0.000	(0)
UF5-	0.000e+00	0.000e+00	-41.538	-41.594	-0.056	(0)
UF6-2	0.000e+00	0.000e+00	-43.766	-43.989	-0.223	(0)
Fe(2)	4.379e-08					
Fe+2	3.453e-08	2.067e-08	-7.462	-7.685	-0.223	(0)
FeSO4	8.785e-09	8.785e-09	-8.056	-8.056	0.000	(0)
FeOH+	3.677e-10	3.298e-10	-9.434	-9.482	-0.047	(0)
FeHCO3+	1.083e-10	9.748e-11	-9.965	-10.011	-0.046	(0)
Fe(OH)2	1.050e-13	1.050e-13	-12.979	-12.979	0.000	(0)
Fe(OH)3-	1.484e-14	1.331e-14	-13.829	-13.876	-0.047	(0)
Fe(3)	1.210e-06					
Fe(OH)2+	8.628e-07	7.749e-07	-6.064	-6.111	-0.047	(0)
Fe(OH)3	3.336e-07	3.336e-07	-6.477	-6.477	0.000	(0)
Fe(OH)4-	1.386e-08	1.245e-08	-7.858	-7.905	-0.047	(0)
FeOH+2	7.678e-12	4.969e-12	-11.115	-11.304	-0.189	(0)
FeF+2	4.333e-16	2.804e-16	-15.363	-15.552	-0.189	(0)
FeSO4+	4.159e-16	3.730e-16	-15.381	-15.428	-0.047	(0)
FeF2+	1.114e-16	9.996e-17	-15.953	-16.000	-0.047	(0)
Fe+3	5.236e-17	1.920e-17	-16.281	-16.717	-0.436	(0)
Fe(SO4)2-	1.570e-17	1.381e-17	-16.804	-16.860	-0.056	(0)
FeF3	1.879e-18	1.879e-18	-17.726	-17.726	0.000	(0)
Fe2(OH)2+4	6.368e-21	8.178e-22	-20.196	-21.087	-0.891	(0)
Fe3(OH)4+5	2.263e-25	9.160e-27	-24.645	-26.038	-1.393	(0)
H(0)	8.909e-27					
H2	4.455e-27	4.467e-27	-26.351	-26.350	0.001	(0)
K	4.094e-04					
K+	4.045e-04	3.618e-04	-3.393	-3.441	-0.048	(0)
KSO4-	4.938e-06	4.435e-06	-5.306	-5.353	-0.047	(0)
Mg	7.410e-04					
Mg+2	6.144e-04	3.934e-04	-3.212	-3.405	-0.194	(0)
MgSO4	1.239e-04	1.239e-04	-3.907	-3.907	0.000	(0)
MgHCO3+	1.687e-06	1.508e-06	-5.773	-5.822	-0.049	(0)
MgF+	6.566e-07	5.879e-07	-6.183	-6.231	-0.048	(0)
MgCO3	2.288e-07	2.288e-07	-6.641	-6.641	0.000	(0)
MgOH+	6.966e-08	6.278e-08	-7.157	-7.202	-0.045	(0)
Mn(2)	2.368e-06					
Mn+2	1.989e-06	1.191e-06	-5.701	-5.924	-0.223	(0)
MnSO4	3.666e-07	3.666e-07	-6.436	-6.436	0.000	(0)
MnHCO3+	9.921e-09	8.899e-09	-8.003	-8.051	-0.047	(0)
MnOH+	1.337e-09	1.199e-09	-8.874	-8.921	-0.047	(0)
MnF+	7.039e-10	6.314e-10	-9.152	-9.200	-0.047	(0)
Mn(OH)3-	1.327e-18	1.190e-18	-17.877	-17.924	-0.047	(0)
Mn(OH)4-2	2.380e-24	1.540e-24	-23.623	-23.812	-0.189	(0)
Mn(3)	1.450e-27					
Mn+3	1.450e-27	5.318e-28	-26.839	-27.274	-0.436	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-47.357	-47.546	-0.189	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-52.868	-52.918	-0.050	(0)
Mo	5.214e-08					
MoO4-2	5.212e-08	3.338e-08	-7.283	-7.477	-0.194	(0)
HMoO4-	1.896e-11	1.668e-11	-10.722	-10.778	-0.056	(0)
H2MoO4	3.069e-15	3.069e-15	-14.513	-14.513	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-48.018	-48.520	-0.501	(0)
Mo7O24-6	0.000e+00	0.000e+00	-58.140	-60.146	-2.006	(0)
HMo7O24-5	0.000e+00	0.000e+00	-59.966	-61.359	-1.393	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-63.285	-64.177	-0.891	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-68.029	-68.531	-0.501	(0)
Na	4.352e-05					
Na+	4.311e-05	3.857e-05	-4.365	-4.414	-0.048	(0)
NaSO4-	3.992e-07	3.586e-07	-6.399	-6.445	-0.047	(0)
NaHCO3	8.124e-09	8.124e-09	-8.090	-8.090	0.000	(0)
NaCO3-	5.590e-10	5.020e-10	-9.253	-9.299	-0.047	(0)
NaF	3.241e-10	3.241e-10	-9.489	-9.489	0.000	(0)
Ni	1.705e-08					
Ni+2	1.336e-08	8.558e-09	-7.874	-8.068	-0.194	(0)
NiSO4	2.956e-09	2.956e-09	-8.529	-8.529	0.000	(0)
NiHCO3+	4.493e-10	3.952e-10	-9.347	-9.403	-0.056	(0)
NiCO3	2.232e-10	2.232e-10	-9.651	-9.651	0.000	(0)
NiOH+	4.909e-11	4.318e-11	-10.309	-10.365	-0.056	(0)
NiF+	3.255e-12	2.863e-12	-11.487	-11.543	-0.056	(0)
Ni(OH)2	1.375e-12	1.375e-12	-11.862	-11.862	0.000	(0)
Ni(SO4)2-2	2.831e-13	1.695e-13	-12.548	-12.771	-0.223	(0)
Ni(OH)3-	6.265e-16	5.511e-16	-15.203	-15.259	-0.056	(0)
O(0)	5.066e-40					
O2	2.533e-40	2.540e-40	-39.596	-39.595	0.001	(0)
S(6)	3.447e-03					
SO4-2	2.704e-03	1.731e-03	-2.568	-2.762	-0.194	(0)
CaSO4	6.140e-04	6.140e-04	-3.212	-3.212	0.000	(0)
MgSO4	1.239e-04	1.239e-04	-3.907	-3.907	0.000	(0)
KSO4-	4.938e-06	4.435e-06	-5.306	-5.353	-0.047	(0)
NaSO4-	3.992e-07	3.586e-07	-6.399	-6.445	-0.047	(0)
MnSO4	3.666e-07	3.666e-07	-6.436	-6.436	0.000	(0)
CuSO4	1.542e-08	1.542e-08	-7.812	-7.812	0.000	(0)
FeSO4	8.785e-09	8.785e-09	-8.056	-8.056	0.000	(0)
CoSO4	5.664e-09	5.664e-09	-8.247	-8.247	0.000	(0)
HSO4-	4.746e-09	4.250e-09	-8.324	-8.372	-0.048	(0)
NiSO4	2.956e-09	2.956e-09	-8.529	-8.529	0.000	(0)
AlSO4+	1.328e-12	1.189e-12	-11.877	-11.925	-0.048	(0)
Ni(SO4)2-2	2.831e-13	1.695e-13	-12.548	-12.771	-0.223	(0)
UO2SO4	1.407e-13	1.407e-13	-12.852	-12.852	0.000	(0)
Al(SO4)2-	2.463e-14	2.206e-14	-13.608	-13.656	-0.048	(0)
UO2(SO4)2-2	5.363e-15	3.210e-15	-14.271	-14.493	-0.223	(0)
FeSO4+	4.159e-16	3.730e-16	-15.381	-15.428	-0.047	(0)
Fe(SO4)2-	1.570e-17	1.381e-17	-16.804	-16.860	-0.056	(0)
U(SO4)2	3.332e-38	3.332e-38	-37.477	-37.477	0.000	(0)
USO4+2	4.047e-39	2.423e-39	-38.393	-38.616	-0.223	(0)
U(3)	0.000e+00					
U+3	0.000e+00	0.000e+00	-54.749	-55.250	-0.501	(0)
U(4)	3.033e-18					
U(OH)5-	3.030e-18	2.665e-18	-17.519	-17.574	-0.056	(0)
U(OH)4	2.804e-21	2.804e-21	-20.552	-20.552	0.000	(0)
U(OH)3+	2.928e-25	2.575e-25	-24.533	-24.589	-0.056	(0)
U(OH)2+2	4.997e-30	2.991e-30	-29.301	-29.524	-0.223	(0)
UOH+3	1.123e-35	3.539e-36	-34.950	-35.451	-0.501	(0)
UF3+	3.760e-36	3.307e-36	-35.425	-35.481	-0.056	(0)
UF2+2	2.617e-36	1.567e-36	-35.582	-35.805	-0.223	(0)
U(SO4)2	3.332e-38	3.332e-38	-37.477	-37.477	0.000	(0)
UF+3	2.964e-38	9.342e-39	-37.528	-38.030	-0.501	(0)
UF4	4.830e-39	4.830e-39	-38.316	-38.316	0.000	(0)
USO4+2	4.047e-39	2.423e-39	-38.393	-38.616	-0.223	(0)
UF5-	0.000e+00	0.000e+00	-41.538	-41.594	-0.056	(0)

U+4	0.000e+00	0.000e+00	-41.563	-42.454	-0.891	(0)
UF6-2	0.000e+00	0.000e+00	-43.766	-43.989	-0.223	(0)
U6(OH)15+9	0.000e+00	0.000e+00	-153.367	-157.880	-4.513	(0)
U(5)	3.720e-15					
UO2+	3.720e-15	3.272e-15	-14.429	-14.485	-0.056	(0)
U(6)	4.203e-09					
UO2(CO3)2-2	3.482e-09	2.084e-09	-8.458	-8.681	-0.223	(0)
UO2(CO3)3-4	5.687e-10	7.303e-11	-9.245	-10.136	-0.891	(0)
UO2CO3	1.494e-10	1.494e-10	-9.826	-9.826	0.000	(0)
UO2OH+	3.080e-12	2.709e-12	-11.511	-11.567	-0.056	(0)
UO2SO4	1.407e-13	1.407e-13	-12.852	-12.852	0.000	(0)
UO2F+	1.122e-13	9.871e-14	-12.950	-13.006	-0.056	(0)
UO2+2	8.384e-14	5.369e-14	-13.077	-13.270	-0.194	(0)
UO2(SO4)2-2	5.363e-15	3.210e-15	-14.271	-14.493	-0.223	(0)
UO2F2	3.792e-15	3.792e-15	-14.421	-14.421	0.000	(0)
(UO2)2(OH)2+2	2.034e-17	1.218e-17	-16.692	-16.914	-0.223	(0)
UO2F3-	1.442e-17	1.269e-17	-16.841	-16.897	-0.056	(0)
(UO2)3(OH)5+	4.571e-18	4.021e-18	-17.340	-17.396	-0.056	(0)
UO2F4-2	2.242e-21	1.342e-21	-20.649	-20.872	-0.223	(0)

----------Saturation indices----------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.05	9.75	10.80	Al(OH)3
Al2(MoO4)3	-50.90	-48.54	2.37	Al2(MoO4)3
Al2O3	-0.16	19.49	19.65	Al2O3
Al4(OH)10SO4	-1.67	21.03	22.70	Al4(OH)10SO4
AlAsO4:2H2O	-7.75	-2.95	4.80	AlAsO4:2H2O
AlOHSO4	-4.98	-8.21	-3.23	AlOHSO4
Alunite	-1.12	-2.52	-1.40	KAl3(SO4)2(OH)6
Anhydrite	-1.21	-5.57	-4.36	CaSO4
Antlerite	-3.38	5.41	8.79	Cu3(OH)4SO4
Aragonite	-0.67	-8.97	-8.30	CaCO3
Arsenolite	-65.24	-68.00	-2.76	As4O6
Artinite	-7.37	2.23	9.60	MgCO3:Mg(OH)2:3H2O
As2O5	-32.10	-25.40	6.71	As2O5
Azurite	-2.44	-19.34	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-16.23	8.17	24.39	Ba(OH)2:8H2O
Ba3(AsO4)2	8.02	-0.89	-8.91	Ba3(AsO4)2
BaF2	-10.96	-16.78	-5.82	BaF2
BaMoO4	-7.55	-14.51	-6.96	BaMoO4
Barite	0.19	-9.79	-9.98	BaSO4
Birnessite	-10.97	7.13	18.09	MnO2
Bixbyite	-8.30	-8.95	-0.64	Mn2O3
Boehmite	1.17	9.75	8.58	AlOOH
Brochantite	-2.03	13.20	15.22	Cu4(OH)6SO4
Brucite	-5.05	11.79	16.84	Mg(OH)2
Bunsenite	-5.31	7.13	12.45	NiO
Ca3(AsO4)2:4H2O	-10.53	11.77	22.30	Ca3(AsO4)2:4H2O
Calcite	-0.49	-8.97	-8.48	CaCO3
CaMoO4	-2.34	-10.29	-7.95	CaMoO4
CH4(g)	-73.11	-114.16	-41.05	CH4
Chalcanthite	-7.53	-10.17	-2.64	CuSO4:5H2O
Claudetite	-64.93	-68.00	-3.06	As4O6
Co(OH)2	-5.68	7.41	13.09	Co(OH)2
Co(OH)3	-11.08	-13.39	-2.31	Co(OH)3
CO2(g)	-3.21	-21.36	-18.15	CO2
Co3(AsO4)2	-16.19	-3.15	13.03	Co3(AsO4)2
Co3O4	-8.86	-19.36	-10.50	Co3O4
CoCO3	-3.96	-13.94	-9.98	CoCO3
CoF2	-15.94	-17.54	-1.60	CoF2
CoF3	-49.35	-50.81	-1.46	CoF3
CoFe2O4	23.11	19.58	-3.53	CoFe2O4
CoMoO4	-7.50	-15.26	-7.76	CoMoO4
CoO	-6.17	7.41	13.59	CoO
CoSO4	-13.35	-10.55	2.80	CoSO4
CoSO4:6H2O	-8.07	-10.55	-2.47	CoSO4:6H2O
Cryolite	-21.71	-55.55	-33.84	Na3AlF6
Cu(OH)2	-0.88	7.79	8.67	Cu(OH)2
Cu2SO4	-18.25	-20.20	-1.95	Cu2SO4
Cu3(AsO4)2:2H2O	-8.13	-2.03	6.10	Cu3(AsO4)2:2H2O
CuCO3	-2.07	-13.57	-11.50	CuCO3
CuF	-8.69	-13.60	-4.91	CuF
CuF2	-18.28	-17.16	1.12	CuF2
CuF2:2H2O	-12.61	-17.16	-4.55	CuF2:2H2O
Cumetal	-3.96	-12.72	-8.76	Cu
CuMoO4	-1.81	-14.89	-13.08	CuMoO4
CuOCuSO4	-12.69	-2.38	10.30	CuOCuSO4
Cupricferrite	13.97	19.96	5.99	CuFe2O4
Cuprite	-0.83	-2.24	-1.41	Cu2O
Cuprousferrite	13.88	4.96	-8.92	CuFeO2
CuSO4	-13.11	-10.17	2.94	CuSO4
Diaspore	2.87	9.75	6.87	AlOOH
Dolomite(disordered)	-1.99	-18.53	-16.54	CaMg(CO3)2
Dolomite(ordered)	-1.44	-18.53	-17.09	CaMg(CO3)2
Epsomite	-4.04	-6.17	-2.13	MgSO4:7H2O
Fe(OH)2	-6.05	7.52	13.56	Fe(OH)2
Fe2(SO4)3	-37.98	-41.72	-3.73	Fe2(SO4)3
Fe3(OH)8	-0.54	19.68	20.22	Fe3(OH)8
FeAsO4:2H2O	-7.01	-6.61	0.40	FeAsO4:2H2O
FeMoO4	-5.07	-15.16	-10.09	FeMoO4
Ferrihydrite	2.89	6.08	3.19	Fe(OH)3
Fluorite	-2.06	-12.56	-10.50	CaF2
Gibbsite	1.46	9.75	8.29	Al(OH)3
Goethite	5.59	6.08	0.49	FeOOH
Gummite	-5.74	1.93	7.67	UO3
Gypsum	-0.96	-5.57	-4.61	CaSO4:2H2O
H-Jarosite	-5.57	-17.67	-12.10	(H3O)Fe3(SO4)2(OH)6
H2MoO4	-9.80	-22.68	-12.88	H2MoO4
Hausmannite	-10.00	51.03	61.03	Mn3O4
Hematite	13.58	12.17	-1.42	Fe2O3
Hercynite	4.12	27.01	22.89	FeAl2O4
Huntite	-7.68	-37.65	-29.97	CaMg3(CO3)4
Hydromagnesite	-17.68	-26.45	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-16.85	-22.02	-5.17	KAl(SO4)2:12H2O
K-Jarosite	1.28	-13.52	-14.80	KFe3(SO4)2(OH)6
K2MoO4	-17.62	-14.36	3.26	K2MoO4
Langite	-4.29	13.20	17.49	Cu4(OH)6SO4:H2O
Lepidocrocite	4.71	6.08	1.37	FeOOH
Lime	-20.31	12.39	32.70	CaO
Maghemite	5.78	12.17	6.39	Fe2O3
Magnesioferrite	7.10	23.96	16.86	Fe2MgO4
Magnesite	-2.10	-9.56	-7.46	MgCO3
Magnetite	16.28	19.68	3.40	Fe3O4
Malachite	-0.47	-5.78	-5.31	Cu2(OH)2CO3
Manganite	-4.46	20.88	25.34	MnOOH
Melanterite	-8.24	-10.45	-2.21	FeSO4:7H2O
Mg(OH)2(active)	-7.00	11.79	18.79	Mg(OH)2
MgF2	-5.03	-13.16	-8.13	MgF2
MgMoO4	-9.03	-10.88	-1.85	MgMoO4
Mirabilite	-10.48	-11.59	-1.11	Na2SO4:10H2O
Mn2(SO4)3	-57.12	-62.83	-5.71	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-10.07	2.43	12.50	Mn3(AsO4)2:8H2O
MnSO4	-11.27	-8.69	2.58	MnSO4
MoO3	-14.68	-22.68	-8.00	MoO3
Morenosite	-8.68	-10.83	-2.14	NiSO4:7H2O
Na-Jarosite	-3.29	-14.49	-11.20	NaFe3(SO4)2(OH)6
Na2Mo2O7	-22.38	-38.98	-16.60	Na2Mo2O7
Na2MoO4	-17.79	-16.30	1.49	Na2MoO4
Na2MoO4:2H2O	-17.53	-16.30	1.22	Na2MoO4:2H2O
Natron	-13.67	-14.98	-1.31	Na2CO3:10H2O
Nesquehonite	-4.89	-9.56	-4.67	MgCO3:3H2O
Ni(OH)2	-5.66	7.13	12.79	Ni(OH)2
Ni3(AsO4)2:8H2O	-19.70	-4.00	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-21.43	10.57	32.00	Ni4(OH)6SO4
NiCO3	-7.35	-14.22	-6.87	NiCO3
NiMoO4	-4.40	-15.54	-11.14	NiMoO4
Nsutite	-10.38	7.13	17.50	MnO2
O2(g)	-36.69	46.40	83.09	O2
Periclase	-9.79	11.79	21.58	MgO
Portlandite	-10.41	12.39	22.80	Ca(OH)2
Pyrochroite	-5.92	9.28	15.19	Mn(OH)2
Pyrolusite	-8.90	32.48	41.38	MnO2
Retgersite	-8.79	-10.83	-2.04	NiSO4:6H2O
Rhodochrosite	-1.50	-12.08	-10.58	MnCO3
Rutherfordine	-4.93	-19.43	-14.50	UO2CO3
Schoepite	-4.06	1.93	5.99	UO2(OH)2:H2O
Siderite	-3.60	-13.84	-10.24	FeCO3
Spinel	-5.56	31.29	36.85	MgAl2O4
Tenorite	0.15	7.79	7.64	CuO
Thenardite	-11.91	-11.59	0.32	Na2SO4
Thermonatrite	-15.62	-14.98	0.64	Na2CO3:H2O
U3O8	-10.85	10.24	21.08	U3O8
U4O9	-22.00	-25.02	-3.02	U4O9
UF4	-32.42	-61.96	-29.54	UF4
UF4:2.5H2O	-29.24	-61.96	-32.72	UF4:2.5H2O
UO2(am)	-12.99	-12.05	0.93	UO2
UO2(OH)2(beta)	-3.68	1.93	5.61	UO2(OH)2
UO3	-5.77	1.93	7.70	UO3
Uraninite	-7.38	-12.05	-4.67	UO2
Witherite	-4.62	-13.19	-8.57	BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Initial solution 4. Make-up Material

----------Solution composition----------

Elements	Molality	Moles
Al	7.415e-07	7.415e-07
Alkalinity	3.607e-04	3.607e-04
Ba	1.457e-07	1.457e-07
Ca	1.672e-03	1.672e-03
Co	1.188e-07	1.188e-07
Cu	4.408e-07	4.408e-07
F	1.580e-05	1.580e-05
K	3.326e-04	3.326e-04
Mg	3.293e-04	3.293e-04
Mn	7.283e-07	7.283e-07
Mo	3.128e-08	3.128e-08
Na	4.351e-05	4.351e-05
Ni	6.818e-08	6.818e-08
S(6)	2.051e-03	2.051e-03

----------Description of solution----------

pH	=	7.700
pe	=	4.000
Activity of water	=	1.000
Ionic strength (mol/kgw)	=	7.199e-03
Mass of water (kg)	=	1.000e+00
Total carbon (mol/kg)	=	3.686e-04
Total CO2 (mol/kg)	=	3.686e-04
Temperature (°C)	=	25.00
Electrical balance (eq)	=	-9.478e-05

Percent error, 100*(Cat-|An|)/(Cat+|An|) = -1.25
Iterations = 12 (47 overall)
Total H = 1.110140e+02
Total O = 5.551615e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol
OH-	5.526e-07	5.046e-07	-6.258	-6.297	-0.039	(0)
H+	2.182e-08	1.995e-08	-7.661	-7.700	-0.039	0.00
H2O	5.551e+01	9.999e-01	1.744	-0.000	0.000	18.07
Al	7.415e-07					
Al(OH)4-	7.298e-07	6.680e-07	-6.137	-6.175	-0.038	(0)
Al(OH)3	1.051e-08	1.051e-08	-7.978	-7.978	0.000	(0)
Al(OH)2+	1.139e-09	1.044e-09	-8.944	-8.981	-0.038	(0)
AlF2+	4.383e-12	4.020e-12	-11.358	-11.396	-0.038	(0)
AlOH+2	3.684e-12	2.605e-12	-11.434	-11.584	-0.150	(0)
AlF+2	1.021e-12	7.220e-13	-11.991	-12.141	-0.150	(0)
AlF3	7.077e-13	7.077e-13	-12.150	-12.150	0.000	(0)
AlSO4+	5.310e-14	4.860e-14	-13.275	-13.313	-0.038	(0)
Al+3	1.153e-14	5.163e-15	-13.938	-14.287	-0.349	(0)
AlF4-	5.420e-15	4.960e-15	-14.266	-14.304	-0.038	(0)
Al(SO4)2-	6.899e-16	6.315e-16	-15.161	-15.200	-0.038	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-51.065	-51.455	-0.389	(0)
Ba	1.457e-07					
Ba+2	1.453e-07	1.017e-07	-6.838	-6.993	-0.155	(0)
BaHCO3+	3.344e-10	3.070e-10	-9.476	-9.513	-0.037	(0)
BaCO3	3.874e-11	3.874e-11	-10.412	-10.412	0.000	(0)
BaOH+	2.444e-13	2.239e-13	-12.612	-12.650	-0.038	(0)
C(4)	3.686e-04					
HCO3-	3.449e-04	3.163e-04	-3.462	-3.500	-0.038	(0)
H2CO3	1.419e-05	1.419e-05	-4.848	-4.848	0.000	(0)
CaHCO3+	6.254e-06	5.742e-06	-5.204	-5.241	-0.037	(0)
CaCO3	1.148e-06	1.148e-06	-5.940	-5.940	0.000	(0)
CO3-2	1.062e-06	7.431e-07	-5.974	-6.129	-0.155	(0)
MgHCO3+	7.037e-07	6.434e-07	-6.153	-6.192	-0.039	(0)
CuCO3	2.384e-07	2.384e-07	-6.623	-6.623	0.000	(0)
MgCO3	1.229e-07	1.229e-07	-6.911	-6.911	0.000	(0)
NaHCO3	7.030e-09	7.030e-09	-8.153	-8.153	0.000	(0)
MnHCO3+	2.926e-09	2.681e-09	-8.534	-8.572	-0.038	(0)
CoHCO3+	1.811e-09	1.639e-09	-8.742	-8.785	-0.043	(0)
NiHCO3+	1.678e-09	1.519e-09	-8.775	-8.818	-0.043	(0)
CuHCO3+	1.201e-09	1.087e-09	-8.920	-8.964	-0.043	(0)
NiCO3	1.080e-09	1.080e-09	-8.967	-8.967	0.000	(0)
CoCO3	8.369e-10	8.369e-10	-9.077	-9.077	0.000	(0)
Cu(CO3)2-2	7.104e-10	4.768e-10	-9.149	-9.322	-0.173	(0)
NaCO3-	5.965e-10	5.470e-10	-9.224	-9.262	-0.038	(0)
BaHCO3+	3.344e-10	3.070e-10	-9.476	-9.513	-0.037	(0)
BaCO3	3.874e-11	3.874e-11	-10.412	-10.412	0.000	(0)
Ca	1.672e-03					
Ca+2	1.394e-03	9.751e-04	-2.856	-3.011	-0.155	(0)
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)
CaHCO3+	6.254e-06	5.742e-06	-5.204	-5.241	-0.037	(0)
CaCO3	1.148e-06	1.148e-06	-5.940	-5.940	0.000	(0)
CaF+	1.624e-07	1.488e-07	-6.789	-6.827	-0.038	(0)
CaOH+	1.069e-08	9.818e-09	-7.971	-8.008	-0.037	(0)
Co(2)	1.188e-07					
Co+2	9.925e-08	6.662e-08	-7.003	-7.176	-0.173	(0)
CoSO4	1.612e-08	1.612e-08	-7.793	-7.793	0.000	(0)
CoHCO3+	1.811e-09	1.639e-09	-8.742	-8.785	-0.043	(0)
CoCO3	8.369e-10	8.369e-10	-9.077	-9.077	0.000	(0)
CoOH+	7.411e-10	6.708e-10	-9.130	-9.173	-0.043	(0)
CoF+	3.255e-11	2.946e-11	-10.487	-10.531	-0.043	(0)
Co(OH)2	2.689e-11	2.689e-11	-10.570	-10.570	0.000	(0)

Co(OH)3-	2.991e-16	2.707e-16	-15.524	-15.567	-0.043	(0)
CoOOH-	7.505e-17	6.793e-17	-16.125	-16.168	-0.043	(0)
Co2OH+3	5.491e-18	2.240e-18	-17.260	-17.650	-0.389	(0)
Co(OH)4-2	3.225e-23	2.165e-23	-22.491	-22.665	-0.173	(0)
Co4(OH)4+4	1.990e-28	4.040e-29	-27.701	-28.394	-0.692	(0)
Co(3)	1.013e-29					
CoOH+2	1.013e-29	6.801e-30	-28.994	-29.167	-0.173	(0)
Co+3	5.925e-36	2.652e-36	-35.227	-35.576	-0.349	(0)
Cu(1)	2.948e-09					
Cu+	2.948e-09	2.668e-09	-8.530	-8.574	-0.043	(0)
Cu(2)	4.378e-07					
CuCO3	2.384e-07	2.384e-07	-6.623	-6.623	0.000	(0)
CuOH+	9.510e-08	8.694e-08	-7.022	-7.061	-0.039	(0)
Cu+2	7.788e-08	5.448e-08	-7.109	-7.264	-0.155	(0)
CuSO4	1.514e-08	1.514e-08	-7.820	-7.820	0.000	(0)
Cu(OH)2	8.754e-09	8.754e-09	-8.058	-8.058	0.000	(0)
CuHCO3+	1.201e-09	1.087e-09	-8.920	-8.964	-0.043	(0)
Cu(CO3)2-2	7.104e-10	4.768e-10	-9.149	-9.322	-0.173	(0)
Cu2(OH)2+2	2.829e-10	1.899e-10	-9.548	-9.722	-0.173	(0)
CuF+	5.311e-11	4.808e-11	-10.275	-10.318	-0.043	(0)
Cu(OH)3-	1.001e-11	9.061e-12	-11.000	-11.043	-0.043	(0)
Cu(OH)4-2	5.361e-17	3.599e-17	-16.271	-16.444	-0.173	(0)
F	1.580e-05					
F-	1.529e-05	1.398e-05	-4.816	-4.854	-0.039	(0)
MgF+	3.408e-07	3.119e-07	-6.467	-6.506	-0.038	(0)
CaF+	1.624e-07	1.488e-07	-6.789	-6.827	-0.038	(0)
HF	4.127e-10	4.127e-10	-9.384	-9.384	0.000	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
MnF+	2.582e-10	2.365e-10	-9.588	-9.626	-0.038	(0)
CuF+	5.311e-11	4.808e-11	-10.275	-10.318	-0.043	(0)
CoF+	3.255e-11	2.946e-11	-10.487	-10.531	-0.043	(0)
NiF+	1.512e-11	1.369e-11	-10.820	-10.864	-0.043	(0)
AlF2+	4.383e-12	4.020e-12	-11.358	-11.396	-0.038	(0)
AlF+2	1.021e-12	7.220e-13	-11.991	-12.141	-0.150	(0)
AlF3	7.077e-13	7.077e-13	-12.150	-12.150	0.000	(0)
HF2-	2.403e-14	2.194e-14	-13.619	-13.659	-0.039	(0)
AlF4-	5.420e-15	4.960e-15	-14.266	-14.304	-0.038	(0)
H2F2	4.564e-19	4.564e-19	-18.341	-18.341	0.000	(0)
H(0)	5.627e-27					
H2	2.814e-27	2.818e-27	-26.551	-26.550	0.001	(0)
K	3.326e-04					
K+	3.298e-04	3.016e-04	-3.482	-3.521	-0.039	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
Mg	3.293e-04					
Mg+2	2.842e-04	1.988e-04	-3.546	-3.702	-0.155	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
MgHCO3+	7.037e-07	6.434e-07	-6.153	-6.192	-0.039	(0)
MgF+	3.408e-07	3.119e-07	-6.467	-6.506	-0.038	(0)
MgCO3	1.229e-07	1.229e-07	-6.911	-6.911	0.000	(0)
MgOH+	4.345e-08	3.994e-08	-7.362	-7.399	-0.037	(0)
Mn(2)	7.283e-07					
Mn+2	6.329e-07	4.249e-07	-6.199	-6.372	-0.173	(0)
MnSO4	9.162e-08	9.162e-08	-7.038	-7.038	0.000	(0)
MnHCO3+	2.926e-09	2.681e-09	-8.534	-8.572	-0.038	(0)
MnOH+	5.878e-10	5.385e-10	-9.231	-9.269	-0.038	(0)
MnF+	2.582e-10	2.365e-10	-9.588	-9.626	-0.038	(0)
Mn(OH)3-	9.250e-19	8.475e-19	-18.034	-18.072	-0.038	(0)
Mn(OH)4-2	1.959e-24	1.381e-24	-23.708	-23.860	-0.152	(0)
Mn(3)	4.240e-28					
Mn+3	4.240e-28	1.898e-28	-27.373	-27.722	-0.349	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-47.042	-47.194	-0.152	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-52.526	-52.566	-0.040	(0)
Mo	3.128e-08					
MoO4-2	3.127e-08	2.188e-08	-7.505	-7.660	-0.155	(0)
HMoO4-	9.595e-12	8.685e-12	-11.018	-11.061	-0.043	(0)
H2MoO4	1.269e-15	1.269e-15	-14.896	-14.896	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-51.065	-51.455	-0.389	(0)
Mo7O24-6	0.000e+00	0.000e+00	-60.672	-62.230	-1.558	(0)
HMo7O24-5	0.000e+00	0.000e+00	-62.461	-63.543	-1.082	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-65.769	-66.461	-0.692	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-70.526	-70.915	-0.389	(0)
Na	4.351e-05					
Na+	4.322e-05	3.953e-05	-4.364	-4.403	-0.039	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
NaHCO3	7.030e-09	7.030e-09	-8.153	-8.153	0.000	(0)
NaCO3-	5.965e-10	5.470e-10	-9.224	-9.262	-0.038	(0)
NaF	3.488e-10	3.488e-10	-9.457	-9.457	0.000	(0)
Ni	6.818e-08					
Ni+2	5.569e-08	3.896e-08	-7.254	-7.409	-0.155	(0)
NiSO4	9.427e-09	9.427e-09	-8.026	-8.026	0.000	(0)
NiHCO3+	1.678e-09	1.519e-09	-8.775	-8.818	-0.043	(0)
NiCO3	1.080e-09	1.080e-09	-8.967	-8.967	0.000	(0)
NiOH+	2.734e-10	2.475e-10	-9.563	-9.606	-0.043	(0)
NiF+	1.512e-11	1.369e-11	-10.820	-10.864	-0.043	(0)
Ni(OH)2	9.921e-12	9.921e-12	-11.003	-11.003	0.000	(0)
Ni(SO4)2-2	5.639e-13	3.785e-13	-12.249	-12.422	-0.173	(0)
Ni(OH)3-	5.531e-15	5.006e-15	-14.257	-14.300	-0.043	(0)
O(0)	1.274e-39					
O2	6.370e-40	6.381e-40	-39.196	-39.195	0.001	(0)
S(6)	2.051e-03					
SO4-2	1.733e-03	1.213e-03	-2.761	-2.916	-0.155	(0)
CaSO4	2.709e-04	2.709e-04	-3.567	-3.567	0.000	(0)
MgSO4	4.387e-05	4.387e-05	-4.358	-4.358	0.000	(0)
KSO4-	2.823e-06	2.589e-06	-5.549	-5.587	-0.038	(0)
NaSO4-	2.807e-07	2.574e-07	-6.552	-6.589	-0.038	(0)
MnSO4	9.162e-08	9.162e-08	-7.038	-7.038	0.000	(0)
CoSO4	1.612e-08	1.612e-08	-7.793	-7.793	0.000	(0)
CuSO4	1.514e-08	1.514e-08	-7.820	-7.820	0.000	(0)
NiSO4	9.427e-09	9.427e-09	-8.026	-8.026	0.000	(0)
HSO4-	2.583e-09	2.364e-09	-8.588	-8.626	-0.038	(0)
Ni(SO4)2-2	5.639e-13	3.785e-13	-12.249	-12.422	-0.173	(0)
AlSO4+	5.310e-14	4.860e-14	-13.275	-13.313	-0.038	(0)
Al(SO4)2-	6.899e-16	6.315e-16	-15.161	-15.200	-0.038	(0)

-------------------------------Saturation indices--------------------------------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.99	8.81	10.80	Al(OH)3
Al2(MoO4)3	-53.92	-51.55	2.37	Al2(MoO4)3
Al2O3	-2.03	17.63	19.65	Al2O3
Al4(OH)10SO4	-5.77	16.93	22.70	Al4(OH)10SO4
AlOHSO4	-6.27	-9.50	-3.23	AlOHSO4
Alunite	-4.61	-6.01	-1.40	KAl3(SO4)2(OH)6
Anhydrite	-1.57	-5.93	-4.36	CaSO4
Antlerite	-2.70	6.09	8.79	Cu3(OH)4SO4
Aragonite	-0.84	-9.14	-8.30	CaCO3
Artinite	-7.73	1.87	9.60	MgCO3:Mg(OH)2:3H2O
Azurite	-1.74	-18.65	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-15.99	8.41	24.39	Ba(OH)2:8H2O
BaF2	-10.88	-16.70	-5.82	BaF2
BaMoO4	-7.69	-14.65	-6.96	BaMoO4
Barite	0.07	-9.91	-9.98	BaSO4
Birnessite	-11.01	7.08	18.09	MnO2
Bixbyite	-8.60	-9.24	-0.64	Mn2O3
Boehmite	0.23	8.81	8.58	AlOOH
Brochantite	-0.99	14.23	15.22	Cu4(OH)6SO4
Brucite	-5.15	11.70	16.84	Mg(OH)2
Bunsenite	-4.45	7.99	12.45	NiO
Calcite	-0.66	-9.14	-8.48	CaCO3
CaMoO4	-2.72	-10.67	-7.95	CaMoO4
CH4(g)	-74.08	-115.13	-41.05	CH4
Chalcanthite	-7.54	-10.18	-2.64	CuSO4:5H2O
Co(OH)2	-4.87	8.22	13.09	Co(OH)2
Co(OH)3	-10.17	-12.48	-2.31	Co(OH)3
CO2(g)	-3.38	-21.53	-18.15	CO2
Co3O4	-6.23	-16.73	-10.50	Co3O4
CoCO3	-3.33	-13.31	-9.98	CoCO3
CoF2	-15.29	-16.89	-1.60	CoF2
CoF3	-48.68	-50.14	-1.46	CoF3
CoMoO4	-7.08	-14.84	-7.76	CoMoO4
CoO	-5.36	8.22	13.59	CoO
CoSO4	-12.90	-10.09	2.80	CoSO4
CoSO4:6H2O	-7.62	-10.09	-2.47	CoSO4:6H2O
Cryolite	-22.78	-56.62	-33.84	Na3AlF6
Cu(OH)2	-0.54	8.14	8.67	Cu(OH)2
Cu2SO4	-18.11	-20.06	-1.95	Cu2SO4
CuCO3	-1.89	-13.39	-11.50	CuCO3
CuF	-8.52	-13.43	-4.91	CuF
CuF2	-18.09	-16.97	1.12	CuF2
CuF2:2H2O	-12.42	-16.97	-4.55	CuF2:2H2O
Cumetal	-3.82	-12.57	-8.76	Cu
CuMoO4	-1.85	-14.92	-13.08	CuMoO4
CuOCuSO4	-12.35	-2.04	10.30	CuOCuSO4
Cuprite	-0.34	-1.75	-1.41	Cu2O
CuSO4	-13.12	-10.18	2.94	CuSO4
Diaspore	1.94	8.81	6.87	AlOOH
Dolomite(disordered)	-2.43	-18.97	-16.54	CaMg(CO3)2
Dolomite(ordered)	-1.88	-18.97	-17.09	CaMg(CO3)2
Epsomite	-4.49	-6.62	-2.13	MgSO4:7H2O
Fluorite	-2.22	-12.72	-10.50	CaF2
Gibbsite	0.52	8.81	8.29	Al(OH)3
Gypsum	-1.32	-5.93	-4.61	CaSO4:2H2O
H2MoO4	-10.18	-23.06	-12.88	H2MoO4
Hausmannite	-10.55	50.48	61.03	Mn3O4
Huntite	-8.66	-38.63	-29.97	CaMg3(CO3)4
Hydromagnesite	-18.86	-27.62	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-18.47	-23.64	-5.17	KAl(SO4)2:12H2O
K2MoO4	-17.96	-14.70	3.26	K2MoO4
Langite	-3.26	14.23	17.49	Cu4(OH)6SO4:H2O
Lime	-20.31	12.39	32.70	CaO
Magnesite	-2.37	-9.83	-7.46	MgCO3
Malachite	0.05	-5.26	-5.31	Cu2(OH)2CO3
Manganite	-4.61	20.73	25.34	MnOOH
Mg(OH)2(active)	-7.10	11.70	18.79	Mg(OH)2
MgF2	-5.28	-13.41	-8.13	MgF2
MgMoO4	-9.51	-11.36	-1.85	MgMoO4
Mirabilite	-10.61	-11.72	-1.11	Na2SO4:10H2O
Mn2(SO4)3	-58.48	-64.19	-5.71	Mn2(SO4)3
MnSO4	-11.87	-9.29	2.58	MnSO4
MoO3	-15.06	-23.06	-8.00	MoO3
Morenosite	-8.18	-10.33	-2.14	NiSO4:7H2O
Na2Mo2O7	-22.93	-39.53	-16.60	Na2Mo2O7
Na2MoO4	-17.96	-16.47	1.49	Na2MoO4
Na2MoO4:2H2O	-17.69	-16.47	1.22	Na2MoO4:2H2O
Natron	-13.62	-14.94	-1.31	Na2CO3:10H2O
Nesquehonite	-5.16	-9.83	-4.67	MgCO3:3H2O
Ni(OH)2	-4.80	7.99	12.79	Ni(OH)2
Ni4(OH)6SO4	-18.35	13.65	32.00	Ni4(OH)6SO4
NiCO3	-6.67	-13.54	-6.87	NiCO3
NiMoO4	-3.93	-15.07	-11.14	NiMoO4
Nsutite	-10.43	7.08	17.50	MnO2
O2(g)	-36.29	46.80	83.09	O2
Periclase	-9.89	11.70	21.58	MgO
Portlandite	-10.42	12.39	22.80	Ca(OH)2
Pyrochroite	-6.17	9.03	15.19	Mn(OH)2
Pyrolusite	-8.95	32.43	41.38	MnO2
Retgersite	-8.29	-10.33	-2.04	NiSO4:6H2O
Rhodochrosite	-1.92	-12.50	-10.58	MnCO3
Spinel	-7.52	29.32	36.85	MgAl2O4
Tenorite	0.49	8.14	7.64	CuO
Thenardite	-12.04	-11.72	0.32	Na2SO4
Thermonatrite	-15.57	-14.94	0.64	Na2CO3:H2O
Witherite	-4.55	-13.12	-8.57	BaCO3

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

Beginning of batch-reaction calculations.

Reaction step 1.

Using mix 1. Mix within UG Works

Mixture 1. Mix within UG Works

2.350e-01	Solution 1 UG Water P100
1.220e-01	Solution 2 PAF Material
4.420e-01	Solution 3 NAF Material
2.010e-01	Solution 4 Make-up Material

-----------------------------Solution composition-----------------------------

Elements	Molality	Moles
Al	3.237e-06	3.237e-06
As	1.793e-07	1.793e-07
B	3.019e-06	3.019e-06
Ba	4.132e-07	4.132e-07
C	2.448e-03	2.448e-03
Ca	2.571e-03	2.571e-03
Cd	1.319e-08	1.319e-08
Cl	3.339e-04	3.339e-04
Co	6.776e-08	6.776e-08
Cr	3.213e-08	3.213e-08
Cu	5.071e-07	5.071e-07
F	2.546e-05	2.546e-05
Fe	1.256e-06	1.256e-06
K	5.015e-04	5.015e-04
Mg	1.006e-03	1.006e-03
Mn	1.599e-06	1.599e-06
Mo	6.724e-08	6.724e-08
Na	2.331e-03	2.331e-03
Ni	5.121e-08	5.121e-08
Pb	4.418e-08	4.418e-08
S	2.969e-03	2.969e-03
Se	6.110e-08	6.110e-08
U	1.056e-08	1.056e-08
V	1.201e-08	1.201e-08
Zn	6.391e-07	6.391e-07

----------------------------Description of solution----------------------------

pH	=	8.069	Charge balance
pe	=	3.208	Adjusted to redox equilibrium
Activity of water	=	1.000	
Ionic strength (mol/kgw)	=	1.335e-02	
Mass of water (kg)	=	1.000e+00	
Total alkalinity (eq/kg)	=	2.471e-03	
Total CO2 (mol/kg)	=	2.448e-03	

Temperature (°C) = 25.00
Electrical balance (eq) = 1.235e-03
Percent error, 100*(Cat-|An|)/(Cat+|An|) = 7.66
Iterations = 9
Total H = 1.110161e+02
Total O = 5.552608e+01

----------Distribution of species----------

Species	Molality	Activity	Log Molality	Log Activity	Log Gamma	mole V cm³/mol	
OH-	1.329e-06	1.179e-06	-5.876	-5.928	-0.052	(0)	
H+	9.598e-09	8.539e-09	-8.018	-8.069	-0.051	0.00	
H2O	5.551e+01	9.998e-01	1.744	-0.000	0.000	18.07	
Al	3.237e-06						
Al(OH)4-	3.217e-06	2.865e-06	-5.493	-5.543	-0.050	(0)	
Al(OH)3	1.930e-08	1.930e-08	-7.714	-7.714	0.000	(0)	
Al(OH)2+	9.183e-10	8.205e-10	-9.037	-9.086	-0.049	(0)	
AlF2+	1.471e-12	1.314e-12	-11.832	-11.881	-0.049	(0)	
AlOH+2	1.375e-12	8.762e-13	-11.862	-12.057	-0.196	(0)	
AlF3	3.488e-13	3.488e-13	-12.457	-12.457	0.000	(0)	
AlF+2	2.458e-13	1.566e-13	-12.609	-12.805	-0.196	(0)	
AlSO4+	9.599e-15	8.549e-15	-14.018	-14.068	-0.050	(0)	
AlF4-	4.137e-15	3.685e-15	-14.383	-14.434	-0.050	(0)	
Al+3	2.129e-15	7.432e-16	-14.672	-15.129	-0.457	(0)	
Al(SO4)2-	1.524e-16	1.357e-16	-15.817	-15.867	-0.050	(0)	
AlMo6O21-3	0.000e+00	0.000e+00	-52.270	-52.801	-0.530	(0)	
As(3)	2.700e-18						
H3AsO3	2.526e-18	2.526e-18	-17.598	-17.598	0.000	(0)	
H2AsO3-	1.738e-19	1.517e-19	-18.760	-18.819	-0.059	(0)	
HAsO3-2	2.788e-23	1.620e-23	-22.555	-22.790	-0.236	(0)	
H4AsO3+	1.224e-26	1.069e-26	-25.912	-25.971	-0.059	(0)	
AsO3-3	2.481e-28	7.315e-29	-27.605	-28.136	-0.530	(0)	
As(5)	1.793e-07						
HAsO4-2	1.704e-07	9.902e-08	-6.769	-7.004	-0.236	(0)	
H2AsO4-	8.832e-09	7.711e-09	-8.054	-8.113	-0.059	(0)	
AsO4-3	1.244e-10	3.667e-11	-9.905	-10.436	-0.530	(0)	
H3AsO4	1.141e-14	1.144e-14	-13.943	-13.941	0.001	(0)	
B	3.019e-06						
H3BO3	2.784e-06	2.792e-06	-5.555	-5.554	0.001	(0)	
H2BO3-	2.150e-07	1.899e-07	-6.668	-6.721	-0.054	(0)	
CaH2BO3+	1.593e-08	1.407e-08	-7.798	-7.852	-0.054	(0)	
MgH2BO3+	3.943e-09	3.483e-09	-8.404	-8.458	-0.054	(0)	
NaH2BO3	6.186e-10	6.186e-10	-9.209	-9.209	0.000	(0)	
BF(OH)3-	2.658e-11	2.349e-11	-10.575	-10.629	-0.054	(0)	
BaH2BO3+	1.690e-12	1.493e-12	-11.772	-11.826	-0.054	(0)	
H5(BO3)2-	5.109e-13	4.514e-13	-12.292	-12.345	-0.054	(0)	
BF2(OH)2-	5.116e-16	4.520e-16	-15.291	-15.345	-0.054	(0)	
H8(BO3)3-	1.427e-16	1.260e-16	-15.846	-15.899	-0.054	(0)	
BF3OH-	3.583e-23	3.166e-23	-22.446	-22.500	-0.054	(0)	
BF4-	3.174e-29	2.804e-29	-28.498	-28.552	-0.054	(0)	
Ba	4.132e-07						
Ba+2	4.062e-07	2.544e-07	-6.391	-6.594	-0.203	(0)	
BaHCO3+	5.557e-09	4.976e-09	-8.255	-8.303	-0.048	(0)	
BaCO3	1.467e-09	1.467e-09	-8.834	-8.834	0.000	(0)	
BaH2BO3+	1.690e-12	1.493e-12	-11.772	-11.826	-0.054	(0)	
BaOH+	1.468e-12	1.309e-12	-11.833	-11.883	-0.050	(0)	
C(4)	2.448e-03						
HCO3-	2.292e-03	2.048e-03	-2.640	-2.689	-0.049	(0)	
CaHCO3+	5.484e-05	4.910e-05	-4.261	-4.309	-0.048	(0)	
H2CO3	3.932e-05	3.932e-05	-4.405	-4.405	0.000	(0)	
CaCO3	2.294e-05	2.294e-05	-4.639	-4.639	0.000	(0)	
CO3-2	1.795e-05	1.124e-05	-4.746	-4.949	-0.203	(0)	
MgHCO3+	1.247e-05	1.108e-05	-4.904	-4.955	-0.051	(0)	
MgCO3	4.946e-06	4.946e-06	-5.306	-5.306	0.000	(0)	
NaHCO3	2.366e-06	2.366e-06	-5.626	-5.626	0.000	(0)	
NaCO3-	4.815e-07	4.302e-07	-6.317	-6.366	-0.049	(0)	
CuCO3	4.344e-07	4.344e-07	-6.362	-6.362	0.000	(0)	
ZnCO3	1.472e-07	1.472e-07	-6.832	-6.832	0.000	(0)	
MnHCO3+	3.598e-08	3.210e-08	-7.444	-7.493	-0.050	(0)	
PbCO3	3.450e-08	3.450e-08	-7.462	-7.462	0.000	(0)	
Cu(CO3)2-2	2.262e-08	1.314e-08	-7.646	-7.881	-0.236	(0)	
ZnHCO3+	1.688e-08	1.474e-08	-7.773	-7.832	-0.059	(0)	
NiCO3	8.196e-09	8.196e-09	-8.086	-8.086	0.000	(0)	
UO2(CO3)3-4	7.825e-09	8.925e-10	-8.107	-9.049	-0.943	(0)	
NiHCO3+	5.650e-09	4.933e-09	-8.248	-8.307	-0.059	(0)	
BaHCO3+	5.557e-09	4.976e-09	-8.255	-8.303	-0.048	(0)	
CoCO3	5.321e-09	5.321e-09	-8.274	-8.274	0.000	(0)	
CoHCO3+	5.108e-09	4.460e-09	-8.292	-8.351	-0.059	(0)	
UO2(CO3)2-2	2.726e-09	1.584e-09	-8.565	-8.800	-0.236	(0)	
Pb(CO3)2-2	1.925e-09	1.119e-09	-8.716	-8.951	-0.236	(0)	
PbHCO3+	1.779e-09	1.553e-09	-8.750	-8.809	-0.059	(0)	
CdCO3	1.491e-09	1.491e-09	-8.826	-8.826	0.000	(0)	
BaCO3	1.467e-09	1.467e-09	-8.834	-8.834	0.000	(0)	
CuHCO3+	9.711e-10	8.479e-10	-9.013	-9.072	-0.059	(0)	
FeHCO3+	2.672e-10	2.392e-10	-9.573	-9.621	-0.048	(0)	
CdHCO3+	3.108e-11	2.713e-11	-10.508	-10.567	-0.059	(0)	
Cd(CO3)2-2	2.139e-11	1.243e-11	-10.670	-10.906	-0.236	(0)	
UO2CO3	7.062e-12	7.062e-12	-11.151	-11.151	0.000	(0)	
Ca	2.571e-03						
Ca+2	2.056e-03	1.288e-03	-2.687	-2.890	-0.203	(0)	
CaSO4	4.371e-04	4.371e-04	-3.359	-3.359	0.000	(0)	
CaHCO3+	5.484e-05	4.910e-05	-4.261	-4.309	-0.048	(0)	
CaCO3	2.294e-05	2.294e-05	-4.639	-4.639	0.000	(0)	
CaF+	3.320e-07	2.962e-07	-6.479	-6.528	-0.050	(0)	
CaOH+	3.383e-08	3.029e-08	-7.471	-7.519	-0.048	(0)	
CaH2BO3+	1.593e-08	1.407e-08	-7.798	-7.852	-0.054	(0)	
Cd	1.319e-08						
Cd+2	9.291e-09	5.820e-09	-8.032	-8.235	-0.203	(0)	
CdSO4	2.022e-09	2.022e-09	-8.694	-8.694	0.000	(0)	
CdCO3	1.491e-09	1.491e-09	-8.826	-8.826	0.000	(0)	
CdCl+	1.891e-10	1.651e-10	-9.723	-9.782	-0.059	(0)	
Cd(SO4)2-2	6.955e-11	4.042e-11	-10.158	-10.393	-0.236	(0)	
CdOH+	6.243e-11	5.450e-11	-10.205	-10.264	-0.059	(0)	
CdHCO3+	3.108e-11	2.713e-11	-10.508	-10.567	-0.059	(0)	
Cd(CO3)2-2	2.139e-11	1.243e-11	-10.670	-10.906	-0.236	(0)	
CdOHCl	7.984e-12	7.984e-12	-11.098	-11.098	0.000	(0)	
CdF+	2.227e-12	1.944e-12	-11.652	-11.711	-0.059	(0)	
Cd(OH)2	4.054e-13	4.054e-13	-12.392	-12.392	0.000	(0)	
CdCl2	2.044e-13	2.044e-13	-12.689	-12.689	0.000	(0)	
CdF2	8.177e-17	8.177e-17	-16.087	-16.087	0.000	(0)	
CdCl3-	4.388e-17	3.831e-17	-16.358	-16.417	-0.059	(0)	
Cd(OH)3-	3.345e-17	2.920e-17	-16.476	-16.535	-0.059	(0)	
Cd2OH+3	5.392e-18	1.590e-18	-17.268	-17.799	-0.530	(0)	
Cd(SeO3)2-2	1.765e-18	1.026e-18	-17.753	-17.989	-0.236	(0)	
CdSeO4	7.016e-20	7.016e-20	-19.154	-19.154	0.000	(0)	
Cd(OH)4-2	9.697e-24	5.636e-24	-23.013	-23.249	-0.236	(0)	
CdHS+	0.000e+00	0.000e+00	-67.622	-67.681	-0.059	(0)	
Cd(HS)2	0.000e+00	0.000e+00	-127.931	-127.931	0.000	(0)	
Cd(HS)3-	0.000e+00	0.000e+00	-193.426	-193.485	-0.059	(0)	
Cd(HS)4-2	0.000e+00	0.000e+00	-258.508	-258.743	-0.236	(0)	
Cl	3.339e-04						
Cl-	3.339e-04	2.970e-04	-3.476	-3.527	-0.051	(0)	
CuCl	7.437e-10	7.437e-10	-9.129	-9.129	0.000	(0)	
MnCl+	3.293e-10	2.938e-10	-9.482	-9.532	-0.050	(0)	
ZnOHCl	2.621e-10	2.621e-10	-9.582	-9.582	0.000	(0)	
ZnCl+	1.910e-10	1.698e-10	-9.719	-9.770	-0.051	(0)	
CdCl+	1.891e-10	1.651e-10	-9.723	-9.782	-0.059	(0)	
CuCl2-	5.192e-11	4.615e-11	-10.285	-10.336	-0.051	(0)	
CoCl+	3.295e-11	2.877e-11	-10.482	-10.541	-0.059	(0)	
NiCl+	1.701e-11	1.485e-11	-10.769	-10.828	-0.059	(0)	
PbCl+	1.232e-11	1.076e-11	-10.909	-10.968	-0.059	(0)	
CdOHCl	7.984e-12	7.984e-12	-11.098	-11.098	0.000	(0)	
CuCl+	3.476e-12	3.089e-12	-11.459	-11.510	-0.051	(0)	
CdCl2	2.044e-13	2.044e-13	-12.689	-12.689	0.000	(0)	
MnCl2	1.233e-13	1.233e-13	-12.909	-12.909	0.000	(0)	
ZnCl2	7.993e-14	7.993e-14	-13.097	-13.097	0.000	(0)	
PbCl2	1.428e-14	1.428e-14	-13.845	-13.845	0.000	(0)	
CuCl3-2	4.625e-15	2.931e-15	-14.335	-14.533	-0.198	(0)	
CuCl2	3.182e-16	3.182e-16	-15.497	-15.497	0.000	(0)	
CdCl3-	4.388e-17	3.831e-17	-16.358	-16.417	-0.059	(0)	
NiCl2	2.221e-17	2.221e-17	-16.653	-16.653	0.000	(0)	
ZnCl3-	2.122e-17	1.886e-17	-16.673	-16.725	-0.051	(0)	
MnCl3-	1.130e-17	1.008e-17	-16.947	-16.996	-0.050	(0)	
CrCl+2	3.472e-18	2.018e-18	-17.459	-17.695	-0.236	(0)	
PbCl3-	1.933e-18	1.688e-18	-17.714	-17.773	-0.059	(0)	
UO2Cl+	8.706e-20	7.601e-20	-19.060	-19.119	-0.059	(0)	
FeCl+2	1.972e-20	1.250e-20	-19.705	-19.903	-0.198	(0)	
CrOHCl2	1.343e-20	1.343e-20	-19.872	-19.872	0.000	(0)	
ZnCl4-2	4.420e-21	2.801e-21	-20.355	-20.553	-0.198	(0)	
CuCl3-	9.922e-22	8.820e-22	-21.003	-21.055	-0.051	(0)	
PbCl4-2	3.944e-22	2.292e-22	-21.404	-21.640	-0.236	(0)	
CrCl2+	6.512e-23	5.686e-23	-22.186	-22.245	-0.059	(0)	
VOCl+	3.646e-23	3.183e-23	-22.438	-22.497	-0.059	(0)	
FeCl2+	1.859e-23	1.658e-23	-22.731	-22.780	-0.050	(0)	
CuCl4-2	2.072e-27	1.313e-27	-26.684	-26.882	-0.198	(0)	
FeCl3	4.926e-28	4.926e-28	-27.308	-27.308	0.000	(0)	
CrO3Cl-	4.490e-30	3.921e-30	-29.348	-29.407	-0.059	(0)	
CoCl+2	1.874e-38	1.089e-38	-37.727	-37.963	-0.236	(0)	
UCl+3	0.000e+00	0.000e+00	-46.574	-47.104	-0.530	(0)	
Co(2)	6.776e-08						
Co+2	4.818e-08	2.800e-08	-7.317	-7.553	-0.236	(0)	
CoSO4	8.279e-09	8.279e-09	-8.082	-8.082	0.000	(0)	
CoCO3	5.321e-09	5.321e-09	-8.274	-8.274	0.000	(0)	
CoHCO3+	5.108e-09	4.460e-09	-8.292	-8.351	-0.059	(0)	
CoOH+	7.544e-10	6.587e-10	-9.122	-9.181	-0.059	(0)	
Co(OH)2	6.168e-11	6.168e-11	-10.210	-10.210	0.000	(0)	
CoCl+	3.295e-11	2.877e-11	-10.482	-10.541	-0.059	(0)	
CoF+	2.138e-11	1.866e-11	-10.670	-10.729	-0.059	(0)	
Co(OH)3-	1.662e-15	1.451e-15	-14.779	-14.838	-0.059	(0)	
CoOOH-	4.170e-16	3.641e-16	-15.380	-15.439	-0.059	(0)	
Co2OH+3	3.135e-18	9.243e-19	-17.504	-18.034	-0.530	(0)	
CoSeO4	9.085e-19	9.085e-19	-18.042	-18.042	0.000	(0)	
Co(OH)4-2	4.665e-22	2.711e-22	-21.331	-21.567	-0.236	(0)	
Co4(OH)4+4	3.292e-28	3.756e-29	-27.482	-28.425	-0.943	(0)	
Co(3)	1.857e-30						
CoOH+2	1.857e-30	1.079e-30	-29.731	-29.967	-0.236	(0)	
Co+3	5.161e-37	1.802e-37	-36.287	-36.744	-0.457	(0)	
CoCl+2	1.874e-38	1.089e-38	-37.727	-37.963	-0.236	(0)	
Cr(2)	1.335e-24						
Cr+2	1.335e-24	7.758e-25	-23.875	-24.110	-0.236	(0)	
Cr(3)	3.213e-08						
Cr(OH)2+	2.224e-08	1.942e-08	-7.653	-7.712	-0.059	(0)	
Cr(OH)3	8.601e-09	8.601e-09	-8.065	-8.065	0.000	(0)	
CrO2-	5.479e-10	4.784e-10	-9.261	-9.320	-0.059	(0)	
Cr(OH)4-	4.623e-10	4.037e-10	-9.335	-9.394	-0.059	(0)	
Cr(OH)+2	2.329e-10	1.354e-10	-9.633	-9.868	-0.236	(0)	
CrOHSO4	4.760e-11	4.760e-11	-10.322	-10.322	0.000	(0)	
CrF+2	3.017e-14	1.753e-14	-13.520	-13.756	-0.236	(0)	
CrSO4+	2.080e-14	1.816e-14	-13.682	-13.741	-0.059	(0)	
Cr+3	1.780e-14	5.248e-15	-13.750	-14.280	-0.530	(0)	
CrCl+2	3.472e-18	2.018e-18	-17.459	-17.695	-0.236	(0)	
Cr2(OH)2SO4+2	1.002e-18	5.825e-19	-17.999	-18.235	-0.236	(0)	
Cr2(OH)2(SO4)2	5.127e-20	5.127e-20	-19.290	-19.290	0.000	(0)	
CrOHCl2	1.343e-20	1.343e-20	-19.872	-19.872	0.000	(0)	
CrCl2+	6.512e-23	5.686e-23	-22.186	-22.245	-0.059	(0)	
Cr(6)	1.460e-17						
CrO4-2	1.420e-17	8.893e-18	-16.848	-17.051	-0.203	(0)	
HCrO4-	2.814e-19	2.457e-19	-18.551	-18.610	-0.059	(0)	
NaCrO4-	1.040e-19	9.082e-20	-18.983	-19.042	-0.059	(0)	
KCrO4-	1.671e-20	1.459e-20	-19.777	-19.836	-0.059	(0)	
H2CrO4	1.701e-27	1.701e-27	-26.769	-26.769	0.000	(0)	
CrO3SO4-2	1.630e-27	9.473e-28	-26.788	-27.024	-0.236	(0)	
CrO3Cl-	4.490e-30	3.921e-30	-29.348	-29.407	-0.059	(0)	
Cr2O7-2	3.604e-36	2.094e-36	-35.443	-35.679	-0.236	(0)	
Cu(1)	3.073e-09						
Cu+	2.278e-09	1.989e-09	-8.642	-8.701	-0.059	(0)	
CuCl	7.437e-10	7.437e-10	-9.129	-9.129	0.000	(0)	
CuCl2-	5.192e-11	4.615e-11	-10.285	-10.336	-0.051	(0)	
CuCl3-2	4.625e-15	2.931e-15	-14.335	-14.533	-0.198	(0)	
Cu(S4)2-3	0.000e+00	0.000e+00	-123.799	-124.082	-0.283	(0)	
CuS4S5-3	0.000e+00	0.000e+00	-124.540	-124.812	-0.272	(0)	
Cu(2)	5.041e-07						
CuCO3	4.344e-07	4.344e-07	-6.362	-6.362	0.000	(0)	
CuOH+	2.753e-08	2.447e-08	-7.560	-7.611	-0.051	(0)	
Cu(CO3)2-2	2.262e-08	1.314e-08	-7.646	-7.881	-0.236	(0)	
Cu+2	1.048e-08	6.563e-09	-7.980	-8.183	-0.203	(0)	
Cu(OH)2	5.755e-09	5.755e-09	-8.240	-8.240	0.000	(0)	
CuSO4	2.228e-09	2.228e-09	-8.652	-8.652	0.000	(0)	
CuHCO3+	9.711e-10	8.479e-10	-9.013	-9.072	-0.059	(0)	
Cu2(OH)2+2	2.587e-11	1.504e-11	-10.587	-10.823	-0.236	(0)	
Cu(OH)3-	1.594e-11	1.392e-11	-10.797	-10.856	-0.059	(0)	
CuF+	9.996e-12	8.728e-12	-11.000	-11.059	-0.059	(0)	
CuCl+	3.476e-12	3.089e-12	-11.459	-11.510	-0.051	(0)	
CuCl2	3.182e-16	3.182e-16	-15.497	-15.497	0.000	(0)	
Cu(OH)4-2	2.222e-16	1.291e-16	-15.653	-15.889	-0.236	(0)	
CuCl3-	9.922e-22	8.820e-22	-21.003	-21.055	-0.051	(0)	
CuCl4-2	2.072e-27	1.313e-27	-26.684	-26.882	-0.198	(0)	
Cu(HS)3-	0.000e+00	0.000e+00	-184.587	-184.646	-0.059	(0)	
F	2.546e-05						
F-	2.369e-05	2.108e-05	-4.625	-4.676	-0.051	(0)	
MgF+	1.405e-06	1.251e-06	-5.852	-5.903	-0.050	(0)	
CaF+	3.320e-07	2.962e-07	-6.479	-6.528	-0.050	(0)	
NaF	2.733e-08	2.733e-08	-7.563	-7.563	0.000	(0)	
MnF+	7.389e-10	6.593e-10	-9.131	-9.181	-0.050	(0)	
HF	2.662e-10	2.662e-10	-9.575	-9.575	0.000	(0)	
ZnF+	1.096e-10	9.571e-11	-9.960	-10.019	-0.059	(0)	
BF(OH)3-	2.658e-11	2.349e-11	-10.575	-10.629	-0.054	(0)	
CoF+	2.138e-11	1.866e-11	-10.670	-10.729	-0.059	(0)	
NiF+	1.185e-11	1.035e-11	-10.926	-10.985	-0.059	(0)	
CuF+	9.996e-12	8.728e-12	-11.000	-11.059	-0.059	(0)	
CdF+	2.227e-12	1.944e-12	-11.652	-11.711	-0.059	(0)	
PbF+	1.737e-12	1.517e-12	-11.760	-11.819	-0.059	(0)	
AlF2+	1.471e-12	1.314e-12	-11.832	-11.881	-0.049	(0)	
AlF3	3.488e-13	3.488e-13	-12.457	-12.457	0.000	(0)	
AlF+2	2.458e-13	1.566e-13	-12.609	-12.805	-0.196	(0)	
CrF+2	3.017e-14	1.753e-14	-13.520	-13.756	-0.236	(0)	
HF2-	2.405e-14	2.133e-14	-13.619	-13.671	-0.052	(0)	
AlF4-	4.137e-15	3.685e-15	-14.383	-14.434	-0.050	(0)	
PbF2	6.290e-16	6.290e-16	-15.201	-15.201	0.000	(0)	
UO2F+	5.258e-16	4.591e-16	-15.279	-15.338	-0.059	(0)	
BF2(OH)2-	5.116e-16	4.520e-16	-15.291	-15.345	-0.054	(0)	
CdF2	8.177e-17	8.177e-17	-16.087	-16.087	0.000	(0)	
FeF+2	5.082e-17	3.220e-17	-16.294	-16.492	-0.198	(0)	
UO2F2	2.791e-17	2.791e-17	-16.554	-16.554	0.000	(0)	
FeF2+	2.036e-17	1.817e-17	-16.691	-16.741	-0.050	(0)	
FeF3	5.402e-19	5.402e-19	-18.267	-18.267	0.000	(0)	
VO2F	3.913e-19	3.913e-19	-18.408	-18.408	0.000	(0)	
H2F2	1.899e-19	1.899e-19	-18.722	-18.722	0.000	(0)	
UO2F3-	1.692e-19	1.478e-19	-18.771	-18.830	-0.059	(0)	
PbF3-	2.880e-20	2.515e-20	-19.541	-19.600	-0.059	(0)	
VOF+	5.531e-21	4.829e-21	-20.257	-20.316	-0.059	(0)	
VO2F2-	3.429e-21	2.994e-21	-20.465	-20.524	-0.059	(0)	

UO2F4-2	4.257e-23	2.474e-23	-22.371	-22.607	-0.236	(0)
VOF2	3.817e-23	3.817e-23	-22.418	-22.418	0.000	(0)
BF3OH-	3.583e-23	3.166e-23	-22.446	-22.500	-0.054	(0)
VO2F3-2	1.355e-24	7.872e-25	-23.868	-24.104	-0.236	(0)
PbF4-2	4.366e-25	2.537e-25	-24.360	-24.596	-0.236	(0)
VOF3-	3.269e-26	2.854e-26	-25.486	-25.544	-0.059	(0)
BF4-	3.174e-29	2.804e-29	-28.498	-28.552	-0.054	(0)
VO2F4-3	2.769e-29	8.165e-30	-28.558	-29.088	-0.530	(0)
VOF4-2	4.179e-30	2.429e-30	-29.379	-29.615	-0.236	(0)
UF3+	2.256e-38	1.970e-38	-37.647	-37.706	-0.059	(0)
UF2+2	1.015e-38	5.897e-39	-37.994	-38.229	-0.236	(0)
UF+3	0.000e+00	0.000e+00	-40.123	-40.653	-0.530	(0)
UF4	0.000e+00	0.000e+00	-40.342	-40.342	0.000	(0)
UF5-	0.000e+00	0.000e+00	-43.361	-43.420	-0.059	(0)
UF6-2	0.000e+00	0.000e+00	-45.380	-45.616	-0.236	(0)
Fe(2)	2.010e-08					
Fe+2	1.597e-08	9.281e-09	-7.797	-8.032	-0.236	(0)
FeSO4	3.376e-09	3.376e-09	-8.472	-8.472	0.000	(0)
FeOH+	4.882e-10	4.356e-10	-9.311	-9.361	-0.050	(0)
FeHCO3+	2.672e-10	2.392e-10	-9.573	-9.621	-0.048	(0)
Fe(OH)2	4.079e-13	4.079e-13	-12.389	-12.389	0.000	(0)
Fe(OH)3-	1.705e-13	1.521e-13	-12.768	-12.818	-0.050	(0)
Fe(HS)2	0.000e+00	0.000e+00	-133.991	-133.991	0.000	(0)
Fe(HS)3-	0.000e+00	0.000e+00	-199.349	-199.408	-0.059	(0)
Fe(3)	1.236e-06					
Fe(OH)3	6.160e-07	6.160e-07	-6.210	-6.210	0.000	(0)
Fe(OH)2+	5.445e-07	4.865e-07	-6.264	-6.313	-0.049	(0)
Fe(OH)4-	7.568e-08	6.762e-08	-7.121	-7.170	-0.049	(0)
FeOH+2	1.674e-12	1.061e-12	-11.776	-11.974	-0.198	(0)
FeF+2	5.082e-17	3.220e-17	-16.294	-16.492	-0.198	(0)
FeSO4+	2.597e-17	2.317e-17	-16.586	-16.635	-0.050	(0)
FeF2+	2.036e-17	1.817e-17	-16.691	-16.741	-0.050	(0)
Fe+3	3.991e-18	1.393e-18	-17.399	-17.856	-0.457	(0)
Fe(SO4)2-	8.407e-19	7.340e-19	-18.075	-18.134	-0.059	(0)
FeF3	5.402e-19	5.402e-19	-18.267	-18.267	0.000	(0)
FeCl+2	1.972e-20	1.250e-20	-19.705	-19.903	-0.198	(0)
Fe2(OH)2+4	3.266e-22	3.725e-23	-21.486	-22.429	-0.943	(0)
FeHSeO3+2	1.988e-22	1.155e-22	-21.702	-21.937	-0.236	(0)
FeCl2+	1.859e-23	1.658e-23	-22.731	-22.780	-0.050	(0)
Fe3(OH)4+5	7.789e-27	2.620e-28	-26.109	-27.582	-1.473	(0)
FeCl3	4.926e-28	4.926e-28	-27.308	-27.308	0.000	(0)
H(0)	3.940e-26					
H2	1.970e-26	1.976e-26	-25.705	-25.704	0.001	(0)
K	5.015e-04					
K+	4.963e-04	4.415e-04	-3.304	-3.355	-0.051	(0)
KSO4-	5.184e-06	4.632e-06	-5.285	-5.334	-0.049	(0)
KCrO4-	1.671e-20	1.459e-20	-19.777	-19.836	-0.059	(0)
Mg	1.006e-03					
Mg+2	8.443e-04	5.289e-04	-3.073	-3.277	-0.203	(0)
MgSO4	1.426e-04	1.426e-04	-3.846	-3.846	0.000	(0)
MgHCO3+	1.247e-05	1.108e-05	-4.904	-4.955	-0.051	(0)
MgCO3	4.946e-06	4.946e-06	-5.306	-5.306	0.000	(0)
MgF+	1.405e-06	1.251e-06	-5.852	-5.903	-0.050	(0)
MgOH+	2.768e-07	2.482e-07	-6.558	-6.605	-0.047	(0)
MgH2BO3+	3.943e-09	3.483e-09	-8.404	-8.458	-0.054	(0)
Mn(2)	1.599e-06					
Mn+2	1.352e-06	7.857e-07	-5.869	-6.105	-0.236	(0)
MnSO4	2.070e-07	2.070e-07	-6.684	-6.684	0.000	(0)
MnHCO3+	3.598e-08	3.210e-08	-7.444	-7.493	-0.050	(0)
MnOH+	2.608e-09	2.327e-09	-8.584	-8.633	-0.050	(0)
MnF+	7.389e-10	6.593e-10	-9.131	-9.181	-0.050	(0)
MnCl+	3.293e-10	2.938e-10	-9.482	-9.532	-0.050	(0)
MnCl2	1.233e-13	1.233e-13	-12.909	-12.909	0.000	(0)
Mn(OH)3-	2.240e-17	1.999e-17	-16.650	-16.699	-0.050	(0)
MnSeO4	1.369e-17	1.369e-17	-16.864	-16.864	0.000	(0)
MnCl3-	1.130e-17	1.008e-17	-16.947	-16.996	-0.050	(0)
Mn(OH)4-2	1.201e-22	7.608e-23	-21.921	-22.119	-0.198	(0)
MnSe	1.876e-34	1.876e-34	-33.727	-33.727	0.000	(0)
Mn(3)	1.625e-28					
Mn+3	1.625e-28	5.672e-29	-27.789	-28.246	-0.457	(0)
Mn(6)	0.000e+00					
MnO4-2	0.000e+00	0.000e+00	-46.946	-47.144	-0.198	(0)
Mn(7)	0.000e+00					
MnO4-	0.000e+00	0.000e+00	-53.255	-53.308	-0.053	(0)
Mo	6.724e-08					
MoO4-2	6.724e-08	4.212e-08	-7.172	-7.376	-0.203	(0)
HMoO4-	8.196e-12	7.156e-12	-11.086	-11.145	-0.059	(0)
H2MoO4	4.476e-16	4.476e-16	-15.349	-15.349	0.000	(0)
AlMo6O21-3	0.000e+00	0.000e+00	-52.270	-52.801	-0.530	(0)
Mo7O24-6	0.000e+00	0.000e+00	-61.066	-63.187	-2.121	(0)
HMo7O24-5	0.000e+00	0.000e+00	-63.396	-64.869	-1.473	(0)
H2Mo7O24-4	0.000e+00	0.000e+00	-67.212	-68.155	-0.943	(0)
H3Mo7O24-3	0.000e+00	0.000e+00	-72.447	-72.978	-0.530	(0)
Na	2.331e-03					
Na+	2.310e-03	2.055e-03	-2.636	-2.687	-0.051	(0)
NaSO4-	1.830e-05	1.636e-05	-4.737	-4.786	-0.049	(0)
NaHCO3	2.366e-06	2.366e-06	-5.626	-5.626	0.000	(0)
NaCO3-	4.815e-07	4.302e-07	-6.317	-6.366	-0.049	(0)
NaF	2.733e-08	2.733e-08	-7.563	-7.563	0.000	(0)
NaH2BO3	6.186e-10	6.186e-10	-9.209	-9.209	0.000	(0)
NaCrO4-	1.040e-19	9.082e-20	-18.983	-19.042	-0.059	(0)
Ni	5.121e-08					
Ni+2	3.120e-08	1.954e-08	-7.506	-7.709	-0.203	(0)
NiCO3	8.196e-09	8.196e-09	-8.086	-8.086	0.000	(0)
NiSO4	5.778e-09	5.778e-09	-8.238	-8.238	0.000	(0)
NiHCO3+	5.650e-09	4.933e-09	-8.248	-8.307	-0.059	(0)
NiOH+	3.322e-10	2.900e-10	-9.479	-9.538	-0.059	(0)
Ni(OH)2	2.716e-11	2.716e-11	-10.566	-10.566	0.000	(0)
NiCl+	1.701e-11	1.485e-11	-10.769	-10.828	-0.059	(0)
NiF+	1.185e-11	1.035e-11	-10.926	-10.985	-0.059	(0)
Ni(SO4)2-2	4.879e-13	2.835e-13	-12.312	-12.547	-0.236	(0)
Ni(OH)3-	3.668e-14	3.202e-14	-13.436	-13.495	-0.059	(0)
NiCl2	2.221e-17	2.221e-17	-16.653	-16.653	0.000	(0)
NiSeO4	5.917e-19	5.917e-19	-18.228	-18.228	0.000	(0)
O(0)	0.000e+00					
O2	0.000e+00	0.000e+00	-40.888	-40.887	0.001	(0)
Pb	4.418e-08					
PbCO3	3.450e-08	3.450e-08	-7.462	-7.462	0.000	(0)
PbOH+	3.463e-09	3.024e-09	-8.461	-8.519	-0.059	(0)
Pb(CO3)2-2	1.925e-09	1.119e-09	-8.716	-8.951	-0.236	(0)
PbHCO3+	1.779e-09	1.553e-09	-8.750	-8.809	-0.059	(0)
Pb+2	1.630e-09	1.021e-09	-8.788	-8.991	-0.203	(0)
PbSO4	7.410e-10	7.410e-10	-9.130	-9.130	0.000	(0)
Pb(OH)2	1.127e-10	1.127e-10	-9.948	-9.948	0.000	(0)
PbCl+	1.232e-11	1.076e-11	-10.909	-10.968	-0.059	(0)
Pb(SO4)2-2	1.139e-11	6.617e-12	-10.944	-11.179	-0.236	(0)
PbF+	1.737e-12	1.517e-12	-11.760	-11.819	-0.059	(0)
Pb(OH)3-	1.522e-13	1.329e-13	-12.818	-12.876	-0.059	(0)
PbCl2	1.428e-14	1.428e-14	-13.845	-13.845	0.000	(0)
PbF2	6.290e-16	6.290e-16	-15.201	-15.201	0.000	(0)
Pb2OH+3	1.659e-16	4.893e-17	-15.780	-16.310	-0.530	(0)
Pb(OH)4-2	6.603e-17	3.837e-17	-16.180	-16.416	-0.236	(0)
PbCl3-	1.933e-18	1.688e-18	-17.714	-17.773	-0.059	(0)
Pb3(OH)4+2	4.454e-19	2.589e-19	-18.351	-18.587	-0.236	(0)
PbF3-	2.880e-20	2.515e-20	-19.541	-19.600	-0.059	(0)
PbCl4-2	3.944e-22	2.292e-22	-21.404	-21.640	-0.236	(0)
Pb4(OH)4+4	1.841e-23	2.099e-24	-22.735	-23.678	-0.943	(0)
PbF4-2	4.366e-25	2.537e-25	-24.360	-24.596	-0.236	(0)
Pb(HS)2	0.000e+00	0.000e+00	-128.629	-128.629	0.000	(0)
Pb(HS)3-	0.000e+00	0.000e+00	-194.724	-194.783	-0.059	(0)
S(-2)	0.000e+00					
HS-	0.000e+00	0.000e+00	-67.395	-67.454	-0.059	(0)
CdHS+	0.000e+00	0.000e+00	-67.622	-67.681	-0.059	(0)
H2S	0.000e+00	0.000e+00	-68.503	-68.503	0.000	(0)
S5-2	0.000e+00	0.000e+00	-68.515	-68.751	-0.236	(0)
S6-2	0.000e+00	0.000e+00	-69.031	-69.266	-0.236	(0)
S4-2	0.000e+00	0.000e+00	-69.111	-69.346	-0.236	(0)
S3-2	0.000e+00	0.000e+00	-69.916	-70.152	-0.236	(0)
S2-2	0.000e+00	0.000e+00	-70.933	-71.168	-0.236	(0)
S-2	0.000e+00	0.000e+00	-76.487	-76.685	-0.198	(0)
Cu(S4)2-3	0.000e+00	0.000e+00	-123.799	-124.082	-0.283	(0)
CuS4S5-3	0.000e+00	0.000e+00	-124.540	-124.812	-0.272	(0)
ZnS(HS)-	0.000e+00	0.000e+00	-126.613	-126.672	-0.059	(0)
Cd(HS)2	0.000e+00	0.000e+00	-127.931	-127.931	0.000	(0)
Pb(HS)2	0.000e+00	0.000e+00	-128.629	-128.629	0.000	(0)
Zn(HS)2	0.000e+00	0.000e+00	-128.731	-128.731	0.000	(0)
Fe(HS)2	0.000e+00	0.000e+00	-133.991	-133.991	0.000	(0)
Cu(HS)3-	0.000e+00	0.000e+00	-184.587	-184.646	-0.059	(0)
Zn(HS)3-	0.000e+00	0.000e+00	-192.846	-192.905	-0.059	(0)
Cd(HS)3-	0.000e+00	0.000e+00	-193.426	-193.485	-0.059	(0)
ZnS(HS)2-2	0.000e+00	0.000e+00	-194.581	-194.816	-0.236	(0)
Pb(HS)3-	0.000e+00	0.000e+00	-194.724	-194.783	-0.059	(0)
Fe(HS)3-	0.000e+00	0.000e+00	-199.349	-199.408	-0.059	(0)
Cd(HS)4-2	0.000e+00	0.000e+00	-258.508	-258.743	-0.236	(0)
Zn(HS)4-2	0.000e+00	0.000e+00	-261.583	-261.819	-0.236	(0)
S(6)	2.969e-03					
SO4-2	2.366e-03	1.482e-03	-2.626	-2.829	-0.203	(0)
CaSO4	4.371e-04	4.371e-04	-3.359	-3.359	0.000	(0)
MgSO4	1.426e-04	1.426e-04	-3.846	-3.846	0.000	(0)
NaSO4-	1.830e-05	1.636e-05	-4.737	-4.786	-0.049	(0)
KSO4-	5.184e-06	4.632e-06	-5.285	-5.334	-0.049	(0)
MnSO4	2.070e-07	2.070e-07	-6.684	-6.684	0.000	(0)
ZnSO4	7.378e-08	7.378e-08	-7.132	-7.132	0.000	(0)
CoSO4	8.279e-09	8.279e-09	-8.082	-8.082	0.000	(0)
NiSO4	5.778e-09	5.778e-09	-8.238	-8.238	0.000	(0)
FeSO4	3.376e-09	3.376e-09	-8.472	-8.472	0.000	(0)
CuSO4	2.228e-09	2.228e-09	-8.652	-8.652	0.000	(0)
CdSO4	2.022e-09	2.022e-09	-8.694	-8.694	0.000	(0)
Zn(SO4)2-2	1.639e-09	9.522e-10	-8.786	-9.021	-0.236	(0)
HSO4-	1.389e-09	1.237e-09	-8.857	-8.908	-0.050	(0)
PbSO4	7.410e-10	7.410e-10	-9.130	-9.130	0.000	(0)
Cd(SO4)2-2	6.955e-11	4.042e-11	-10.158	-10.393	-0.236	(0)
CrOHSO4	4.760e-11	4.760e-11	-10.322	-10.322	0.000	(0)
Pb(SO4)2-2	1.139e-11	6.617e-12	-10.944	-11.179	-0.236	(0)
Ni(SO4)2-2	4.879e-13	2.835e-13	-12.312	-12.547	-0.236	(0)
CrSO4+	2.080e-14	1.816e-14	-13.682	-13.741	-0.059	(0)
AlSO4+	9.599e-15	8.549e-15	-14.018	-14.068	-0.050	(0)
UO2SO4	3.539e-16	3.539e-16	-15.451	-15.451	0.000	(0)
Al(SO4)2-	1.524e-16	1.357e-16	-15.817	-15.867	-0.050	(0)
FeSO4+	2.597e-17	2.317e-17	-16.586	-16.635	-0.050	(0)
UO2(SO4)2-2	1.190e-17	6.914e-18	-16.925	-17.160	-0.236	(0)
Cr2(OH)2SO4+2	1.002e-18	5.825e-19	-17.999	-18.235	-0.236	(0)
Fe(SO4)2-	8.407e-19	7.340e-19	-18.075	-18.134	-0.059	(0)
VO2SO4-	4.289e-19	3.745e-19	-18.368	-18.427	-0.059	(0)
Cr2(OH)2(SO4)2	5.127e-20	5.127e-20	-19.290	-19.290	0.000	(0)
VOSO4	1.559e-20	1.559e-20	-19.807	-19.807	0.000	(0)
CrO3SO4-2	1.630e-27	9.473e-28	-26.788	-27.024	-0.236	(0)
VSO4+	6.858e-34	5.988e-34	-33.164	-33.223	-0.059	(0)
U(SO4)2	0.000e+00	0.000e+00	-40.435	-40.435	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-41.271	-41.506	-0.236	(0)
Se(-2)	5.668e-31					
HSe-	5.665e-31	4.947e-31	-30.247	-30.306	-0.059	(0)
MnSe	1.876e-34	1.876e-34	-33.727	-33.727	0.000	(0)
H2Se	3.279e-35	3.279e-35	-34.484	-34.484	0.000	(0)
Se-2	9.968e-38	5.793e-38	-37.001	-37.237	-0.236	(0)
Se(4)	6.110e-08					
HSeO3-	3.593e-08	3.137e-08	-7.445	-7.503	-0.059	(0)
SeO3-2	2.517e-08	1.463e-08	-7.599	-7.835	-0.236	(0)
H2SeO3	1.143e-13	1.143e-13	-12.942	-12.942	0.000	(0)
Cd(SeO3)2-2	1.765e-18	1.026e-18	-17.753	-17.989	-0.236	(0)
FeHSeO3+2	1.988e-22	1.155e-22	-21.702	-21.937	-0.236	(0)
Se(6)	1.034e-13					
SeO4-2	1.033e-13	6.474e-14	-12.986	-13.189	-0.203	(0)
MnSeO4	1.369e-17	1.369e-17	-16.864	-16.864	0.000	(0)
ZnSeO4	2.282e-18	2.282e-18	-17.642	-17.642	0.000	(0)
CoSeO4	9.085e-19	9.085e-19	-18.042	-18.042	0.000	(0)
NiSeO4	5.917e-19	5.917e-19	-18.228	-18.228	0.000	(0)
CdSeO4	7.016e-20	7.016e-20	-19.154	-19.154	0.000	(0)
HSeO4-	3.173e-20	2.771e-20	-19.498	-19.557	-0.059	(0)
Zn(SeO4)2-2	2.577e-31	1.498e-31	-30.589	-30.825	-0.236	(0)
U(3)	0.000e+00					
U+3	0.000e+00	0.000e+00	-56.751	-57.282	-0.530	(0)
U(4)	1.010e-18					
U(OH)5-	1.010e-18	8.820e-19	-17.996	-18.055	-0.059	(0)
U(OH)4	3.155e-22	3.155e-22	-21.501	-21.501	0.000	(0)
U(OH)3+	1.128e-26	9.850e-27	-25.948	-26.007	-0.059	(0)
U(OH)2+2	6.694e-32	3.890e-32	-31.174	-31.410	-0.236	(0)
UOH+3	5.306e-38	1.565e-38	-37.275	-37.806	-0.530	(0)
UF3+	2.256e-38	1.970e-38	-37.647	-37.706	-0.059	(0)
UF2+2	1.015e-38	5.897e-39	-37.994	-38.229	-0.236	(0)
UF+3	0.000e+00	0.000e+00	-40.123	-40.653	-0.530	(0)
UF4	0.000e+00	0.000e+00	-40.342	-40.342	0.000	(0)
U(SO4)2	0.000e+00	0.000e+00	-40.435	-40.435	0.000	(0)
USO4+2	0.000e+00	0.000e+00	-41.271	-41.506	-0.236	(0)
UF5-	0.000e+00	0.000e+00	-43.361	-43.420	-0.059	(0)
U+4	0.000e+00	0.000e+00	-44.334	-45.277	-0.943	(0)
UF6-2	0.000e+00	0.000e+00	-45.380	-45.616	-0.236	(0)
UCl+3	0.000e+00	0.000e+00	-46.574	-47.104	-0.530	(0)
U6(OH)15+9	0.000e+00	0.000e+00	-163.017	-167.790	-4.773	(0)
U(5)	6.816e-17					
UO2+	6.816e-17	5.951e-17	-16.166	-16.225	-0.059	(0)
U(6)	1.056e-08					
UO2(CO3)3-4	7.825e-09	8.925e-10	-8.107	-9.049	-0.943	(0)
UO2(CO3)2-2	2.726e-09	1.584e-09	-8.565	-8.800	-0.236	(0)
UO2CO3	7.062e-12	7.062e-12	-11.151	-11.151	0.000	(0)
UO2OH+	2.682e-14	2.342e-14	-13.571	-13.630	-0.059	(0)
UO2F+	5.258e-16	4.591e-16	-15.279	-15.338	-0.059	(0)
UO2SO4	3.539e-16	3.539e-16	-15.451	-15.451	0.000	(0)
UO2+2	2.519e-16	1.578e-16	-15.599	-15.802	-0.203	(0)
UO2F2	2.791e-17	2.791e-17	-16.554	-16.554	0.000	(0)
UO2(SO4)2-2	1.190e-17	6.914e-18	-16.925	-17.160	-0.236	(0)
UO2F3-	1.692e-19	1.478e-19	-18.771	-18.830	-0.059	(0)
UO2Cl+	8.706e-20	7.601e-20	-19.060	-19.119	-0.059	(0)
(UO2)2(OH)2+2	1.566e-21	9.104e-22	-20.805	-21.041	-0.236	(0)
UO2F4-2	4.257e-23	2.474e-23	-22.371	-22.607	-0.236	(0)
(UO2)3(OH)5+	2.575e-23	2.248e-23	-22.589	-22.648	-0.059	(0)
V(2)	1.133e-39					
VOH+	1.133e-39	9.896e-40	-38.946	-39.005	-0.059	(0)
V+2	0.000e+00	0.000e+00	-40.350	-40.586	-0.236	(0)
V(3)	1.132e-12					
V(OH)3	1.132e-12	1.132e-12	-11.946	-11.946	0.000	(0)
V(OH)2+	7.152e-24	6.244e-24	-23.146	-23.205	-0.059	(0)
VOH+2	8.703e-28	5.058e-28	-27.060	-27.296	-0.236	(0)
V+3	2.903e-33	8.560e-34	-32.537	-33.068	-0.530	(0)
VSO4+	6.858e-34	5.988e-34	-33.164	-33.223	-0.059	(0)
V2(OH)3+3	0.000e+00	0.000e+00	-51.518	-52.049	-0.530	(0)
V2(OH)2+4	0.000e+00	0.000e+00	-52.849	-53.792	-0.943	(0)
V(4)	1.038e-17					
V(OH)3+	1.029e-17	8.984e-18	-16.988	-17.047	-0.059	(0)
VO+2	6.573e-20	3.820e-20	-19.182	-19.418	-0.236	(0)
VOSO4	1.559e-20	1.559e-20	-19.807	-19.807	0.000	(0)
VOF+	5.531e-21	4.829e-21	-20.257	-20.316	-0.059	(0)
VOF2	3.817e-23	3.817e-23	-22.418	-22.418	0.000	(0)
VOCl+	3.646e-23	3.183e-23	-22.438	-22.497	-0.059	(0)

VOF3-	3.269e-26	2.854e-26	-25.486	-25.544	-0.059 (0)
H2V2O4+2	6.963e-30	4.047e-30	-29.157	-29.393	-0.236 (0)
VOF4-2	4.179e-30	2.429e-30	-29.379	-29.615	-0.236 (0)
V(5)	1.201e-08				
H2VO4-	8.328e-09	7.272e-09	-8.079	-8.138	-0.059 (0)
HVO4-2	3.681e-09	2.139e-09	-8.434	-8.670	-0.236 (0)
H3VO4	6.209e-13	6.209e-13	-12.207	-12.207	0.000 (0)
H3V2O7-	3.340e-14	2.916e-14	-13.476	-13.535	-0.059 (0)
HV2O7-3	1.788e-14	5.271e-15	-13.748	-14.278	-0.530 (0)
VO4-3	4.258e-15	1.255e-15	-14.371	-14.901	-0.530 (0)
V2O7-4	1.457e-16	1.662e-17	-15.837	-16.779	-0.943 (0)
VO2+	1.190e-17	1.058e-17	-16.925	-16.975	-0.051 (0)
V3O9-3	1.366e-18	4.029e-19	-17.864	-18.395	-0.530 (0)
VO2SO4-	4.289e-19	3.745e-19	-18.368	-18.427	-0.059 (0)
VO2F	3.913e-19	3.913e-19	-18.408	-18.408	0.000 (0)
VO2F2-	3.429e-21	2.994e-21	-20.465	-20.524	-0.059 (0)
V4O12-4	1.071e-23	1.221e-24	-22.970	-23.913	-0.943 (0)
VO2F3-2	1.355e-24	7.872e-25	-23.868	-24.104	-0.236 (0)
VO2F4-3	2.769e-29	8.165e-30	-28.558	-29.088	-0.530 (0)
V10O28-6	0.000e+00	0.000e+00	-62.630	-64.751	-2.121 (0)
HV10O28-5	0.000e+00	0.000e+00	-63.160	-64.633	-1.473 (0)
H2V10O28-4	0.000e+00	0.000e+00	-66.551	-67.494	-0.943 (0)
Zn	6.391e-07				
Zn+2	3.633e-07	2.276e-07	-6.440	-6.643	-0.203 (0)
ZnCO3	1.472e-07	1.472e-07	-6.832	-6.832	0.000 (0)
ZnSO4	7.378e-08	7.378e-08	-7.132	-7.132	0.000 (0)
ZnOH+	3.073e-08	2.683e-08	-7.512	-7.571	-0.059 (0)
ZnHCO3+	1.688e-08	1.474e-08	-7.773	-7.832	-0.059 (0)
Zn(OH)2	5.013e-09	5.013e-09	-8.300	-8.300	0.000 (0)
Zn(SO4)2-2	1.639e-09	9.522e-10	-8.786	-9.021	-0.236 (0)
ZnOHCl	2.621e-10	2.621e-10	-9.582	-9.582	0.000 (0)
ZnCl+	1.910e-10	1.698e-10	-9.719	-9.770	-0.051 (0)
ZnF+	1.096e-10	9.571e-11	-9.960	-10.019	-0.059 (0)
Zn(OH)3-	3.393e-11	2.962e-11	-10.469	-10.528	-0.059 (0)
ZnCl2	7.993e-14	7.993e-14	-13.097	-13.097	0.000 (0)
Zn(OH)4-2	2.392e-15	1.390e-15	-14.621	-14.857	-0.236 (0)
ZnCl3-	2.122e-17	1.886e-17	-16.673	-16.725	-0.051 (0)
ZnSeO4	2.282e-18	2.282e-18	-17.642	-17.642	0.000 (0)
ZnCl4-2	4.420e-21	2.801e-21	-20.355	-20.553	-0.198 (0)
Zn(SeO4)2-2	2.577e-31	1.498e-31	-30.589	-30.825	-0.236 (0)
ZnS(HS)-	0.000e+00	0.000e+00	-126.613	-126.672	-0.059 (0)
Zn(HS)2	0.000e+00	0.000e+00	-128.731	-128.731	0.000 (0)
Zn(HS)3-	0.000e+00	0.000e+00	-192.846	-192.905	-0.059 (0)
ZnS(HS)2-2	0.000e+00	0.000e+00	-194.581	-194.816	-0.236 (0)
Zn(HS)4-2	0.000e+00	0.000e+00	-261.583	-261.819	-0.236 (0)

-------------------------------Saturation indices-------------------------------

Phase	SI**	log IAP	log K(298 K, 1 atm)	
Al(OH)3(am)	-1.72	9.08	10.80	Al(OH)3
Al2(MoO4)3	-54.75	-52.38	2.37	Al2(MoO4)3
Al2O3	-1.50	18.15	19.65	Al2O3
Al4(OH)10SO4	-5.36	17.34	22.70	Al4(OH)10SO4
AlAsO4:2H2O	-9.66	-4.86	4.80	AlAsO4:2H2O
AlOHSO4	-6.66	-9.89	-3.23	AlOHSO4
Alunite	-4.59	-5.99	-1.40	KAl3(SO4)2(OH)6
Anglesite	-4.03	-11.82	-7.79	PbSO4
Anhydrite	-1.36	-5.72	-4.36	CaSO4
Anilite	-42.61	-74.48	-31.88	Cu0.25Cu1.5S
Antlerite	-3.89	4.90	8.79	Cu3(OH)4SO4
Aragonite	0.46	-7.84	-8.30	CaCO3
Arsenolite	-67.63	-70.39	-2.76	As4O6
Artinite	-4.97	4.63	9.60	MgCO3:Mg(OH)2:3H2O
As2O5	-34.59	-27.88	6.71	As2O5
Atacamite	-3.08	4.31	7.39	Cu2(OH)3Cl
Azurite	-1.40	-18.31	-16.91	Cu3(OH)2(CO3)2
Ba(OH)2:8H2O	-14.85	9.54	24.39	Ba(OH)2:8H2O
Ba2V2O7:2H2O	-14.60	1.27	15.87	Ba2V2O7:2H2O
Ba3(AsO4)2	9.66	0.75	-8.91	Ba3(AsO4)2
Ba3(VO4)2:4H2O	-22.13	10.81	32.94	Ba3(VO4)2:4H2O
BaCrO4	-13.98	-23.65	-9.67	BaCrO4
BaF2	-10.13	-15.95	-5.82	BaF2
BaMoO4	-7.01	-13.97	-6.96	BaMoO4
Barite	0.56	-9.42	-9.98	BaSO4
BaS	-82.16	-65.98	16.18	BaS
BaSeO3	-7.86	-6.03	1.83	BaSeO3
BaSeO4	-12.32	-19.78	-7.46	BaSeO4
Bianchite	-7.71	-9.47	-1.76	ZnSO4:6H2O
Birnessite	-10.85	7.24	18.09	MnO2
Bixbyite	-7.44	-8.08	-0.64	Mn2O3
BlaubleiI	-44.33	-68.49	-24.16	Cu0.9Cu0.2S
BlaubleiII	-43.98	-71.26	-27.28	Cu0.6Cu0.8S
Boehmite	0.50	9.08	8.58	AlOOH
Brochantite	-2.37	12.85	15.22	Cu4(OH)6SO4
Brucite	-3.98	12.86	16.84	Mg(OH)2
Bunsenite	-4.02	8.43	12.45	NiO
Ca(VO3)2	-10.23	-4.57	5.66	Ca(VO3)2
Ca2V2O7	-8.82	8.68	17.50	Ca2V2O7
Ca2V2O7:2H2O	-12.87	8.68	21.55	Ca2V2O7:2H2O
Ca3(AsO4)2:4H2O	-10.44	11.86	22.30	Ca3(AsO4)2:4H2O
Ca3(VO4)2	-17.03	21.93	38.96	Ca3(VO4)2
Ca3(VO4)2:4H2O	-17.93	21.93	39.86	Ca3(VO4)2:4H2O
CaCrO4	-17.68	-19.94	-2.27	CaCrO4
Calcite	0.64	-7.84	-8.48	CaCO3
CaMoO4	-2.32	-10.27	-7.95	CaMoO4
Carnotite	-4.09	-3.86	0.23	KUO2VO4
CaSeO3:2H2O	-5.14	-2.33	2.81	CaSeO3:2H2O
CaSeO4:2H2O	-13.06	-16.08	-3.02	CaSeO4:2H2O
Cd(BO2)2	-13.05	-3.21	9.84	Cd(BO2)2
Cd(OH)2	-5.74	7.90	13.64	Cd(OH)2
Cd(OH)2(am)	-5.83	7.90	13.73	Cd(OH)2
Cd3(OH)2(SO4)2	-20.94	-14.23	6.71	Cd3(OH)2(SO4)2
Cd3(OH)4SO4	-17.82	4.74	22.56	Cd3(OH)4SO4
Cd4(OH)6SO4	-15.76	12.64	28.40	Cd4(OH)6SO4
CdCl2	-14.63	-15.29	-0.66	CdCl2
CdCl2:1H2O	-13.60	-15.29	-1.69	CdCl2:1H2O
CdCl2:2.5H2O	-13.38	-15.29	-1.91	CdCl2:2.5H2O
CdF2	-16.38	-17.59	-1.21	CdF2
Cdmetal(alpha)	-28.17	-14.65	13.51	Cd
Cdmetal(gamma)	-28.27	-14.65	13.62	Cd
CdMoO4	-1.46	-15.61	-14.15	CdMoO4
CdOHCl	-7.23	-3.69	3.54	CdOHCl
CdSe	-10.27	-30.47	-20.20	CdSe
CdSeO4:2H2O	-19.57	-21.42	-1.85	CdSeO4:2H2O
CdSO4	-10.89	-11.06	-0.17	CdSO4
CdSO4:1H2O	-9.34	-11.06	-1.73	CdSO4:1H2O
CdSO4:2.67H2O	-9.19	-11.06	-1.87	CdSO4:2.67H2O
Cerussite	-0.81	-13.94	-13.13	PbCO3
CH4(g)	-70.26	-111.30	-41.05	CH4
Chalcanthite	-8.37	-11.01	-2.64	CuSO4:5H2O
Chalcocite	-41.87	-76.79	-34.92	Cu2S
Chalcopyrite	-99.72	-134.99	-35.27	CuFeS2
Claudetite	-67.32	-70.39	-3.06	As4O6
Clausthalite	-4.13	-31.23	-27.10	PbSe
Co(BO2)2	-29.59	-2.52	27.07	Co(BO2)2
Co(OH)2	-4.51	8.58	13.09	Co(OH)2
Co(OH)3	-10.23	-12.54	-2.31	Co(OH)3
CO2(g)	-2.94	-21.09	-18.15	CO2
Co3(AsO4)2	-15.16	-2.13	13.03	Co3(AsO4)2
Co3O4	-6.00	-16.49	-10.50	Co3O4
CoCl2	-22.87	-14.61	8.27	CoCl2
CoCl2:6H2O	-17.14	-14.61	2.54	CoCl2:6H2O
CoCO3	-2.52	-12.50	-9.98	CoCO3
CoF2	-15.31	-16.91	-1.60	CoF2
CoF3	-49.31	-50.77	-1.46	CoF3
CoFe2O4	24.81	21.28	-3.53	CoFe2O4
CoMoO4	-7.17	-14.93	-7.76	CoMoO4
CoO	-5.00	8.58	13.59	CoO
CoS(alpha)	-59.50	-66.94	-7.44	CoS
CoS(beta)	-55.87	-66.94	-11.07	CoS
CoSe	-13.59	-29.79	-16.20	CoSe
CoSeO3	-8.31	-6.99	1.32	CoSeO3
CoSeO4:6H2O	-19.21	-20.74	-1.53	CoSeO4:6H2O
CoSO4	-13.18	-10.38	2.80	CoSO4
CoSO4:6H2O	-7.91	-10.38	-2.47	CoSO4:6H2O
Cotunnite	-11.27	-16.05	-4.78	PbCl2
Covellite	-45.27	-67.57	-22.30	CuS
Cr(OH)2	-18.79	-7.97	10.82	Cr(OH)2
Cr(OH)3	-0.98	0.36	1.34	Cr(OH)3
Cr(OH)3(am)	1.11	0.36	-0.75	Cr(OH)3
Cr2O3	3.07	0.71	-2.36	Cr2O3
CrCl2	-45.26	-31.16	14.09	CrCl2
CrCl3	-49.54	-34.43	15.11	CrCl3
CrF3	-26.54	-37.88	-11.34	CrF3
Crmetal	-61.01	-30.53	30.48	Cr
CrO3	-29.98	-33.19	-3.21	CrO3
Cryolite	-17.41	-51.25	-33.84	Na3AlF6
Cu(OH)2	-0.72	7.95	8.67	Cu(OH)2
Cu2Se(alpha)	6.16	-39.64	-45.80	Cu2Se
Cu2SO4	-18.28	-20.23	-1.95	Cu2SO4
Cu3(AsO4)2:2H2O	-10.12	-4.02	6.10	Cu3(AsO4)2:2H2O
Cu3Se2	-6.57	-70.06	-63.49	Cu3Se2
CuCO3	-1.63	-13.13	-11.50	CuCO3
CuCr4	-19.79	-25.23	-5.44	CuCr4
CuF	-8.47	-13.38	-4.91	CuF
CuF2	-18.65	-17.54	1.12	CuF2
CuF2:2H2O	-12.99	-17.54	-4.55	CuF2:2H2O
Cumetal	-3.15	-11.91	-8.76	Cu
CuMoO4	-2.48	-15.56	-13.08	CuMoO4
CuOCuSO4	-13.36	-3.06	10.30	CuOCuSO4
Cupricferrite	14.67	20.65	5.99	CuFe2O4
Cuprite	0.14	-1.27	-1.41	Cu2O
Cuprousferrite	14.63	5.72	-8.92	CuFeO2
CuSe	2.68	-30.42	-33.10	CuSe
CuSe2	-12.87	-46.24	-33.37	CuSe2
CuSeO3:2H2O	-8.13	-7.62	0.51	CuSeO3:2H2O
CuSeO4:5H2O	-18.93	-21.37	-2.44	CuSeO4:5H2O
CuSO4	-13.95	-11.01	2.94	CuSO4
Diaspore	2.20	9.08	6.87	AlOOH
Djurleite	-42.26	-76.18	-33.92	Cu0.066Cu1.868S
Dolomite(disordered)	0.47	-16.07	-16.54	CaMg(CO3)2
Dolomite(ordered)	1.02	-16.07	-17.09	CaMg(CO3)2
Epsomite	-3.98	-6.11	-2.13	MgSO4:7H2O
Fe(OH)2	-5.46	8.10	13.56	Fe(OH)2
Fe(OH)2.7Cl.3	5.91	2.87	-3.04	Fe(OH)2.7Cl.3
Fe(VO3)2	-5.99	-9.71	-3.72	Fe(VO3)2
Fe2(OH)4SeO3	-4.43	-2.87	1.55	Fe2(OH)4SeO3
Fe2(SeO3)3:2H2O	-13.39	-34.02	-20.63	Fe2(SeO3)3:2H2O
Fe2(SO4)3	-40.47	-44.20	-3.73	Fe2(SO4)3
Fe3(OH)8	0.58	20.80	20.22	Fe3(OH)8
FeAsO4:2H2O	-7.99	-7.59	0.40	FeAsO4:2H2O
FeCr2O4	1.62	8.82	7.20	FeCr2O4
FeMoO4	-5.32	-15.41	-10.09	FeMoO4
Ferrihydrite	3.16	6.35	3.19	Fe(OH)3
Ferroselite	-27.49	-46.09	-18.60	FeSe2
FeS(ppt)	-64.47	-67.42	-2.95	FeS
FeSe	-19.27	-30.27	-11.00	FeSe
Fluorite	-1.74	-12.24	-10.50	CaF2
Galena	-54.41	-68.38	-13.97	PbS
Gibbsite	0.79	9.08	8.29	Al(OH)3
Goethite	5.86	6.35	0.49	FeOOH
Goslarite	-7.46	-9.47	-2.01	ZnSO4:7H2O
Greenockite	-53.26	-67.62	-14.36	CdS
Greigite	-236.25	-281.29	-45.03	Fe3S4
Gummite	-7.34	0.34	7.67	UO3
Gypsum	-1.11	-5.72	-4.61	CaSO4:2H2O
H-Jarosite	-6.78	-18.88	-12.10	(H3O)Fe3(SO4)2(OH)6
H2MoO4	-10.64	-23.51	-12.88	H2MoO4
H2S(g)	-67.51	-75.52	-8.01	H2S
H2Se(g)	-33.41	-38.37	-4.96	H2Se
Halite	-7.82	-6.21	1.60	NaCl
Hausmannite	-8.38	52.65	61.03	Mn3O4
Hematite	14.12	12.70	-1.42	Fe2O3
Hercynite	3.37	26.26	22.89	FeAl2O4
Huntite	-2.55	-32.52	-29.97	CaMg3(CO3)4
Hydrocerussite	-1.96	-20.73	-18.77	Pb3(OH)2(CO3)2
Hydromagnesite	-11.28	-20.04	-8.77	Mg5(CO3)4(OH)2:4H2O
K-Alum	-18.97	-24.14	-5.17	KAl(SO4)2:12H2O
K-Jarosite	0.63	-14.17	-14.80	KFe3(SO4)2(OH)6
K2Cr2O7	-39.71	-56.95	-17.24	K2Cr2O7
K2CrO4	-23.25	-23.76	-0.51	K2CrO4
K2MoO4	-17.35	-14.09	3.26	K2MoO4
K2SeO4	-19.17	-19.90	-0.73	K2SeO4
Langite	-4.64	12.85	17.49	Cu4(OH)6SO4:H2O
Larnakite	-4.24	-4.67	-0.43	PbO:PbSO4
Laurionite	-5.07	-4.45	0.62	PbOHCl
Lepidocrocite	4.98	6.35	1.37	FeOOH
Lime	-19.45	13.25	32.70	CaO
Litharge	-5.55	7.15	12.69	PbO
Mackinawite	-63.82	-67.42	-3.60	FeS
Maghemite	6.31	12.70	6.39	Fe2O3
Magnesioferrite	8.70	25.56	16.86	Fe2MgO4
Magnesite	-0.77	-8.23	-7.46	MgCO3
Magnetite	17.40	20.80	3.40	Fe3O4
Malachite	0.13	-5.18	-5.31	Cu2(OH)2CO3
Manganite	-4.03	21.31	25.34	MnOOH
Massicot	-5.75	7.15	12.89	PbO
Matlockite	-8.22	-17.19	-8.97	PbClF
Melanothallite	-21.49	-15.24	6.26	CuCl2
Melanterite	-8.65	-10.86	-2.21	FeSO4:7H2O
Mg(OH)2(active)	-5.93	12.86	18.79	Mg(OH)2
Mg(VO3)2	-16.23	-4.95	11.28	Mg(VO3)2
Mg2V2O7	-18.45	7.91	26.36	Mg2V2O7
MgCr2O4	-2.63	13.57	16.20	MgCr2O4
MgCrO4	-25.71	-20.33	5.38	MgCrO4
MgF2	-4.50	-12.63	-8.13	MgF2
MgMoO4	-8.80	-10.65	-1.85	MgMoO4
MgSeO3:6H2O	-5.77	-2.71	3.06	MgSeO3:6H2O
MgSeO4:6H2O	-15.27	-16.47	-1.20	MgSeO4:6H2O
Minium	-29.53	43.99	73.52	Pb3O4
Mirabilite	-7.09	-8.20	-1.11	Na2SO4:10H2O
Mn(VO3)2	-12.68	-7.78	4.90	Mn(VO3)2
Mn2(SO4)3	-59.27	-64.98	-5.71	Mn2(SO4)3
Mn3(AsO4)2:8H2O	-10.29	2.21	12.50	Mn3(AsO4)2:8H2O
MnCl2:4H2O	-15.87	-13.16	2.72	MnCl2:4H2O
MnS(grn)	-65.66	-65.49	0.17	MnS
MnS(pnk)	-68.83	-65.49	3.34	MnS
MnSe	-31.84	-28.34	3.50	MnSe
MnSeO3	-6.67	-5.54	1.13	MnSeO3
MnSeO3:2H2O	-6.52	-5.54	0.98	MnSeO3:2H2O
MnSeO4:5H2O	-17.24	-19.29	-2.05	MnSeO4:5H2O
MnSO4	-11.52	-8.93	2.58	MnSO4
Monteponite	-7.20	7.90	15.10	CdO

MoO3	-15.51	-23.51	-8.00	MoO3
Morenosite	-8.39	-10.54	-2.14	NiSO4:7H2O
MoS2	-126.85	-197.11	-70.26	MoS2
Na-Jarosite	-2.30	-13.50	-11.20	NaFe3(SO4)2(OH)6
Na2Cr2O7	-45.72	-55.61	-9.90	Na2Cr2O7
Na2CrO4	-25.36	-22.43	2.93	Na2CrO4
Na2Mo2O7	-19.67	-36.26	-16.60	Na2Mo2O7
Na2MoO4	-14.24	-12.75	1.49	Na2MoO4
Na2MoO4:2H2O	-13.97	-12.75	1.22	Na2MoO4:2H2O
Na2SeO3:5H2O	-15.11	-4.81	10.30	Na2SeO3:5H2O
Na2SeO4	-19.84	-18.56	1.28	Na2SeO4
Na3VO4	-29.44	7.24	36.68	Na3VO4
Na4V2O7	-33.69	3.71	37.40	Na4V2O7
Nantokite	-5.50	-12.23	-6.73	CuCl
Natron	-9.01	-10.32	-1.31	Na2CO3:10H2O
NaVO3	-7.38	-3.53	3.86	NaVO3
Nesquehonite	-3.56	-8.23	-4.67	MgCO3:3H2O
Ni(OH)2	-4.37	8.43	12.79	Ni(OH)2
Ni3(AsO4)2:8H2O	-18.30	-2.60	15.70	Ni3(AsO4)2:8H2O
Ni4(OH)6SO4	-17.25	14.75	32.00	Ni4(OH)6SO4
NiCO3	-5.79	-12.66	-6.87	NiCO3
NiMoO4	-3.94	-15.08	-11.14	NiMoO4
NiS(alpha)	-61.49	-67.09	-5.60	NiS
NiS(beta)	-55.99	-67.09	-11.10	NiS
NiS(gamma)	-54.29	-67.09	-12.80	NiS
NiSe	-12.25	-29.95	-17.70	NiSe
NiSeO3:2H2O	-9.96	-7.14	2.81	NiSeO3:2H2O
NiSeO4:6H2O	-19.38	-20.90	-1.52	NiSeO4:6H2O
Nsutite	-10.27	7.24	17.50	MnO2
O2(g)	-37.98	45.11	83.09	O2
Orpiment	-200.70	-261.76	-61.07	As2S3
Otavite	-1.18	-13.18	-12.00	CdCO3
Pb(BO2)2	-10.48	-3.96	6.52	Pb(BO2)2
Pb(OH)2	-1.00	7.15	8.15	Pb(OH)2
Pb10(OH)6O(CO3)6	-46.30	-55.06	-8.76	Pb10(OH)6O(CO3)6
Pb2(OH)3Cl	-6.10	2.70	8.79	Pb2(OH)3Cl
Pb2O(OH)2	-11.90	14.29	26.19	Pb2O(OH)2
Pb2O3	-24.19	36.85	61.04	Pb2O3
Pb2OCO3	-6.24	-6.79	-0.56	Pb2OCO3
Pb2V2O7	-1.62	-3.52	-1.90	Pb2V2O7
Pb3(AsO4)2	-12.24	-6.44	5.80	Pb3(AsO4)2
Pb3(VO4)2	-2.52	3.62	6.14	Pb3(VO4)2
Pb3O2CO3	-10.67	0.35	11.02	Pb3O2CO3
Pb3O2SO4	-8.21	2.47	10.69	Pb3O2SO4
Pb4(OH)6SO4	-11.48	9.62	21.10	Pb4(OH)6SO4
Pb4O3SO4	-12.26	9.62	21.88	Pb4O3SO4
PbCrO4	-13.44	-26.04	-12.60	PbCrO4
PbF2	-10.90	-18.34	-7.44	PbF2
Pbmetal	-19.65	-15.41	4.25	Pb
PbMoO4	-0.75	-16.37	-15.62	PbMoO4
PbO:0.3H2O	-5.83	7.15	12.98	PbO:0.33H2O
PbSeO4	-15.34	-22.18	-6.84	PbSeO4
Periclase	-8.72	12.86	21.58	MgO
Phosgenite	-10.18	-29.99	-19.81	PbCl2:PbCO3
Plattnerite	-19.90	29.70	49.60	PbO2
Portlandite	-9.56	13.25	22.80	Ca(OH)2
Pyrite	-101.88	-120.39	-18.51	FeS2
Pyrochroite	-5.16	10.03	15.19	Mn(OH)2
Pyrolusite	-8.79	32.59	41.38	MnO2
Realgar	-84.65	-104.40	-19.75	AsS
Retgersite	-8.50	-10.54	-2.04	NiSO4:6H2O
Rhodochrosite	-0.47	-11.05	-10.58	MnCO3
Rutherfordine	-6.25	-20.75	-14.50	UO2CO3
Schoepite	-5.66	0.34	5.99	UO2(OH)2:H2O
Semetal(am)	-8.71	-15.82	-7.11	Se
Semetal(hex	-8.11	-15.82	-7.71	Se

SeO2	-15.70	-15.57	0.12	SeO2
SeO3	-50.37	-29.33	21.04	SeO3
Siderite	-2.74	-12.98	-10.24	FeCO3
Smithsonite	-1.59	-11.59	-10.00	ZnCO3
Sphalerite	-54.58	-66.03	-11.45	ZnS
Spinel	-5.83	31.01	36.85	MgAl2O4
Sulfur	-50.82	-52.97	-2.14	S
Tenorite	0.31	7.95	7.64	CuO
Thenardite	-8.53	-8.20	0.32	Na2SO4
Thermonatrite	-10.96	-10.32	0.64	Na2CO3:H2O
Tyuyamunite	-7.98	-3.90	4.08	Ca(UO2)2(VO4)2
U3O8	-14.98	6.10	21.08	U3O8
U4O9	-26.44	-29.46	-3.02	U4O9
UF4	-34.44	-63.98	-29.54	UF4
UF4:2.5H2O	-31.26	-63.98	-32.72	UF4:2.5H2O
UO2(am)	-13.94	-13.00	0.93	UO2
UO2(OH)2(beta)	-5.28	0.34	5.61	UO2(OH)2
UO2SeO4:4H2O	-26.74	-28.99	-2.25	UO2SeO4:4H2O
UO3	-7.36	0.34	7.70	UO3
Uraninite	-8.33	-13.00	-4.67	UO2
V(OH)3	-16.45	-8.86	7.59	V(OH)3
V2O5	-16.45	-17.81	-1.36	V2O5
V3O5	-34.23	-32.40	1.84	V3O5
V4O7	-42.86	-35.68	7.19	V4O7
V6O13	-37.69	-98.55	-60.86	V6O13
VCl2	-62.20	-43.33	18.87	VCl2
VCl3	-67.08	-43.65	23.43	VCl3
VF4	-69.19	-54.26	14.93	VF4
Vmetal	-86.72	-42.69	44.03	V
VO	-34.90	-20.14	14.76	VO
VO(OH)2	-8.43	-3.28	5.15	VO(OH)2
VO2Cl	-23.34	-20.50	2.84	VO2Cl
VOCl	-31.61	-20.46	11.15	VOCl
VOCl2	-39.23	-26.47	12.76	VOCl2
VOSO4	-25.86	-22.25	3.61	VOSO4
Witherite	-2.97	-11.54	-8.57	BaCO3
Wurtzite	-57.08	-66.03	-8.95	ZnS
Zincite	-1.84	9.49	11.33	ZnO
Zincosite	-13.40	-9.47	3.93	ZnSO4
Zn(BO2)2	-9.90	-1.61	8.29	Zn(BO2)2
Zn(OH)2	-2.71	9.49	12.20	Zn(OH)2
Zn(OH)2(am)	-2.98	9.49	12.47	Zn(OH)2
Zn(OH)2(beta)	-2.26	9.49	11.75	Zn(OH)2
Zn(OH)2(epsilon)	-2.04	9.49	11.53	Zn(OH)2
Zn(OH)2(gamma)	-2.24	9.49	11.73	Zn(OH)2
Zn2(OH)2SO4	-7.48	0.02	7.50	Zn2(OH)2SO4
Zn2(OH)3Cl	-7.80	7.39	15.19	Zn2(OH)3Cl
Zn3(AsO4)2:2.5H2O	-13.05	0.60	13.65	Zn3(AsO4)2:2.5H2O
Zn3O(SO4)2	-28.36	-9.45	18.91	Zn3O(SO4)2
Zn4(OH)6SO4	-9.39	19.01	28.40	Zn4(OH)6SO4
Zn5(OH)8Cl2	-14.22	24.28	38.50	Zn5(OH)8Cl2
ZnCl2	-20.75	-13.70	7.05	ZnCl2
ZnCO3:1H2O	-1.33	-11.59	-10.26	ZnCO3:1H2O
ZnF2	-15.46	-16.00	-0.53	ZnF2
Znmetal	-38.85	-13.06	25.79	Zn
ZnMoO4	-3.89	-14.02	-10.13	ZnMoO4
ZnO(active)	-1.69	9.49	11.19	ZnO
ZnS(am)	-56.98	-66.03	-9.05	ZnS
ZnSe	-14.48	-28.88	-14.40	ZnSe
ZnSeO4:6H2O	-18.31	-19.83	-1.52	ZnSeO4:6H2O
ZnSO4:1H2O	-8.83	-9.47	-0.64	ZnSO4:1H2O

**For a gas, SI = log10(fugacity). Fugacity = pressure * phi / 1 atm.
For ideal gases, phi = 1.

End of simulation.

Reading input data for simulation 2.

End of Run after 0.254 Seconds.

Appendix L Summary of AMD Investigations

L.1 Kinetic column leach test results

APPENDIX A-1: Leachate assay results for the Barbara column leach tests: PAF1

Parameters		Sample #16993 - PAF1														Average (wks 4-52)
		Initial	Week 4	Week 8	Week 12	Week 16	Week 20	Week 24	Week 28	Week 32	Week 36	Week 40	Week 44	Week 48	Week 52	
Volume	mls	612	496	489	477	553	555	551	542	543	546	545	549	555	559	535
pH	-	7.7	7.7	7.3	7.3	6.8	7.1	7.2	7.3	7.4	7.4	7.5	7.4	7.4	7.5	7.3
EC	µS/cm	231	496	621	625	381	395	391	429	445	441	436	376	371	366	444
Alkalinity	mg/l	29	15	19	16	18	11	14	14	16	13	15	16	17	22	16
Acidity	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ag	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Al	mg/l	0.07	0.11	0.04	0.04	0.01	0.01	0.04	0.03	0.02	0.02	0.02	0.03	0.04	0.02	0.03
As	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
B	mg/l	0.05	0.05	0.28	0.08	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.07
Ba	mg/l	0.03	0.02	0.04	0.04	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.02	0.02	0.024
Be	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Ca	mg/l	43	44	54	67	40	89	85	76	80	80	77	60	70	67	68
Cd	mg/l	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Cl	mg/l	28	6	5	2	1	1	1	1	1	1	1	1	1	1	2
Co	mg/l	0.001	0.013	0.018	0.020	0.007	0.02	0.01	0.01	0.007	0.008	0.008	0.006	0.007	0.007	0.011
Cr	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cu	mg/l	0.01	0.13	0.06	0.05	0.03	0.07	0.05	0.04	0.038	0.030	0.033	0.031	0.033	0.028	0.048
F	mg/l	0.3	0.9	1.0	0.8	0.5	0.6	0.4	0.4	0.6	0.3	0.4	0.2	0.3	0.3	0.5
Fe	mg/l	0.05	0.21	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06
Hg	mg/l	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
K	mg/l	17	14	16	14	11	18	15	14	14	15	13	12	12	13	14
Mg	mg/l	12	29	28	30	17	28	20	15	15	14	12	8	8	8	18
Mn	mg/l	0.06	0.14	0.08	0.07	0.03	0.05	0.05	0.04	0.04	0.044	0.04	0.036	0.04	0.04	0.05
Mo	mg/l	0.002	0.006	0.004	0.003	0.002	0.002	0.002	0.002	0.003	0.002	0.002	0.003	0.002	0.003	0.003
Na	mg/l	30	19	15	13	6	9	6	5	3	3	2	2	1	1	7
Ni	mg/l	0.005	0.017	0.024	0.027	0.009	0.020	0.012	0.006	0.005	0.004	0.005	0.004	0.004	0.004	0.011
P	mg/l	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pb	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sb	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Se	mg/l	0.01	0.06	0.04	0.04	0.02	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02
Si	mg/l	0.6	1.1	1.9	1.5	1.0	1.4	3.4	1.5	1.5	1.8	1.3	1.5	1.5	1.6	1.6
Sn	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
SO_4	mg/l	113	247	310	275	157	273	334	265	228	233	185	164	155	197	233
Sr	mg/l	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.10	0.09	0.09	0.08	0.08	0.08	0.10
Th	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Tl	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
U	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zn	mg/l	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

Underline indicates that the concentration is less than the limit of detection

APPENDIX A-2: Leachate assay results for the Barbara column leach tests: NAF1

Parameters		Sample #16995 - NAF1														Average (wks 4-52)
		Initial	Week 4	Week 8	Week 12	Week 16	Week 20	Week 24	Week 28	Week 32	Week 36	Week 40	Week 44	Week 48	Week 52	
Volume	mls	614	503	496	491	549	551	548	546	549	551	555	557	560	561	540
pH	-	8.5	8.1	7.6	7.5	7.3	7.4	7.4	7.5	7.6	7.6	7.7	7.6	7.6	7.6	7.6
EC	µS/cm	119	126	135	139	105	121	126	142	152	140	139	128	125	131	131
Alkalinity	mg/l	40	26	27	23	19	26	22	19	24	22	23	21	22	25	23
Acidity	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ag	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Al	mg/l	0.1	0.3	0.3	0.3	0.1	0.2	0.2	0.23	0.17	0.19	0.15	0.15	0.16	0.14	0.2
As	mg/l	0.001	0.001	0.002	0.003	0.002	0.003	0.004	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.003
B	mg/l	0.05	0.05	0.3	0.08	0.05	0.18	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.08
Ba	mg/l	0.032	0.003	0.006	0.005	0.003	0.003	0.003	0.005	0.003	0.003	0.003	0.002	0.003	0.002	0.003
Be	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Ca	mg/l	43	5	8	10	10	12	10	16	12	14	12	12	14	11	11
Cd	mg/l	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Cl	mg/l	28	2	5	1	1	1	1	1	1	1	1	1	1	1	1
Co	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cr	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cu	mg/l	0.005	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
F	mg/l	0.3	0.2	0.3	0.2	0.1	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Fe	mg/l	0.1	0.2	0.2	0.1	0.05	0.1	0.1	0.1	0.08	0.05	0.08	0.05	0.05	0.05	0.10
Hg	mg/l	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
K	mg/l	17	10	14	6	8	7	4	6	5	5	4	4	3	3	6
Mg	mg/l	12	2	2	1	1	1	1	1	1	1	1	1	1	1	1
Mn	mg/l	0.06	0.07	0.07	0.04	0.03	0.02	0.007	0.005	0.004	0.002	0.002	0.002	0.001	0.001	0.019
Mo	mg/l	0.002	0.015	0.009	0.008	0.008	0.005	0.005	0.007	0.007	0.004	0.003	0.004	0.004	0.004	0.006
Na	mg/l	30	9	5	4	4	6	2	4	2	2	1	1	1	1	3
Ni	mg/l	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
P	mg/l	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.000
Pb	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sb	mg/l	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Se	mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Si	mg/l	0.6	0.9	1.5	0.9	0.7	1.1	3	1.1	0.9	1.1	0.7	1.0	1.0	1.0	1.2
Sn	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
SO_4	mg/l	113	19	30	17	24	21	33	36	16	18	12	9	11	10	20
Sr	mg/l	0.09	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Th	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Tl	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
U	mg/l	0.001	0.006	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zn	mg/l	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.01	0.005	0.005	0.005	0.005	0.005	0.005

Underline indicates that the concentration is less than the limit of detection

APPENDIX A-3: Leachate assay results for the Barbara column leach tests: NAF2

Parameters		Sample #16996 - NAF2														Average (wks 4-52)
		Initial	Week 4	Week 8	Week 12	Week 16	Week 20	Week 24	Week 28	Week 32	Week 36	Week 40	Week 44	Week 48	Week 52	
Volume	mls	602	510	500	496	512	515	520	532	535	539	542	551	559	563	529
pH	-	8.2	8.0	7.5	7.5	7.3	7.4	7.5	7.5	7.6	7.5	7.6	7.5	7.5	7.6	7.5
EC	µS/cm	111	149	179	175	139	141	145	210	222	225	221	196	187	182	182
Alkalinity	mg/l	31	31	29	24	20	22	27	21	23	26	25	23	24	25	25
Acidity	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ag	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Al	mg/l	0.07	0.32	0.29	0.22	0.10	0.18	0.17	0.17	0.14	0.14	0.09	0.15	0.13	0.14	0.17
As	mg/l	0.001	0.006	0.015	0.021	0.018	0.030	0.030	0.033	0.035	0.036	0.029	0.034	0.029	0.029	0.027
B	mg/l	0.05	0.05	0.3	0.1	0.05	0.08	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.08
Ba	mg/l	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Be	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Ca	mg/l	43	6	11	17	13	20	21	29	30	35	28	21	23	20	21
Cd	mg/l	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Cl	mg/l	28	5	2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1
Co	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cr	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cu	mg/l	0.01	0.003	0.005	0.005	0.001	0.004	0.003	0.005	0.004	0.002	0.005	0.003	0.002	0.005	0.004
F	mg/l	0.3	0.3	0.4	0.3	0.1	0.2	0.1	0.1	0.1	0.1	0.3	0.1	0.1	0.1	0.2
Fe	mg/l	0.1	0.2	0.2	0.1	0.05	0.1	0.1	0.1	0.07	0.06	0.08	0.07	0.07	0.07	0.10
Hg	mg/l	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
K	mg/l	17	16	14	14	10	13	10	9	10	11	9	8	7	7	11
Mg	mg/l	12	3	4	4	3	4	3	4	3	4	3	2	2	2	3
Mn	mg/l	0.06	0.02	0.03	0.02	0.01	0.01	0.01	0.01	0.003	0.002	0.002	0.002	0.001	0.001	0.008
Mo	mg/l	0.002	0.01	0.008	0.008	0.005	0.005	0.004	0.007	0.006	0.007	0.004	0.004	0.004	0.005	0.006
Na	mg/l	30	10	6	5	3	4	2	2	2	4	1	1	1	1	3
Ni	mg/l	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
P	mg/l	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pb	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sb	mg/l	0.001	0.003	0.003	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Se	mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Si	mg/l	0.6	0.9	1.6	1.1	0.9	1.2	3.4	1.4	1.3	1.6	1.2	1.7	1.4	1.4	1.5
Sn	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
SO_4	mg/l	113	30	52	52	36	50	65	74	59	64	43	26	30	29	47
Sr	mg/l	0.09	0.01	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.02	0.02	0.03
Th	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Tl	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
U	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zn	mg/l	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

Underline indicates that the concentration is less than the limit of detection

APPENDIX A-4: Leachate assay results for the Barbara column leach tests: NAF3 (previously PAF2)

Parameters		Sample #16994 - NAF3														Average (wks 4-52)
		Initial	Week 4	Week 8	Week 12	Week 16	Week 20	Week 24	Week 28	Week 32	Week 36	Week 40	Week 44	Week 48	Week 52	
Volume	mls	609	510	499		-	-	-	-	-	-	-	-	-	-	505
pH	-	7.9	8.1	7.7		-	-	-	-	-	-	-	-	-	-	7.9
EC	µS/cm	109	101	96		-	-	-	-	-	-	-	-	-	-	99
Alkalinity	mg/l	28	28	34		-	-	-	-	-	-	-	-	-	-	31
Acidity	mg/l	-	-	-		-	-	-	-	-	-	-	-	-	-	-
Ag	mg/l	0.001	0.001	0.001		-	-	-	-	-	-	-	-	-	-	0.001
Al	mg/l	0.07	0.4	1.0		-	-	-	-	-	-	-	-	-	-	0.7
As	mg/l	0.001	0.01	0.01		-	-	-	-	-	-	-	-	-	-	0.012
B	mg/l	0.05	0.05	0.3		-	-	-	-	-	-	-	-	-	-	0.16
Ba	mg/l	0.03	0.009	0.01		-	-	-	-	-	-	-	-	-	-	0.011
Be	mg/l	0.001	0.001	0.001		-	-	-	-	-	-	-	-	-	-	0.001
Ca	mg/l	43	1	1		-	-	-	-	-	-	-	-	-	-	1
Cd	mg/l	0.0001	0.0001	0.0001		-	-	-	-	-	-	-	-	-	-	0.0001
Cl	mg/l	28	5	3		-	-	-	-	-	-	-	-	-	-	4
Co	mg/l	0.001	0.003	0.003		-	-	-	-	-	-	-	-	-	-	0.003
Cr	mg/l	0.001	0.001	0.001		-	-	-	-	-	-	-	-	-	-	0.001
Cu	mg/l	0.005	0.1	0.2		-	-	-	-	-	-	-	-	-	-	0.14
F	mg/l	0.3	0.8	0.8		-	-	-	-	-	-	-	-	-	-	0.8
Fe	mg/l	0.05	0.5	1.1		-	-	-	-	-	-	-	-	-	-	0.8
Hg	mg/l	0.0001	0.0001	0.0001		-	-	-	-	-	-	-	-	-	-	0.0001
K	mg/l	17	1	3		-	-	-	-	-	-	-	-	-	-	2
Mg	mg/l	12	1	1		-	-	-	-	-	-	-	-	-	-	1
Mn	mg/l	0.06	0.02	0.02		-	-	-	-	-	-	-	-	-	-	0.02
Mo	mg/l	0.002	0.01	0.01		-	-	-	-	-	-	-	-	-	-	0.011
Na	mg/l	30	16	15		-	-	-	-	-	-	-	-	-	-	16
Ni	mg/l	0.005	0.001	0.002		-	-	-	-	-	-	-	-	-	-	0.002
P	mg/l	1	1	1		-	-	-	-	-	-	-	-	-	-	1
Pb	mg/l	0.001	0.001	0.001		-	-	-	-	-	-	-	-	-	-	0.001
Sb	mg/l	0.001	0.001	0.001		-	-	-	-	-	-	-	-	-	-	0.001
Se	mg/l	0.01	0.01	0.01		-	-	-	-	-	-	-	-	-	-	0.01
Si	mg/l	1	3	5		-	-	-	-	-	-	-	-	-	-	3.965
Sn	mg/l	0.001	0.001	0.001		-	-	-	-	-	-	-	-	-	-	0.001
SO_4	mg/l	113	6	8		-	-	-	-	-	-	-	-	-	-	7
Sr	mg/l	0.09	0.002	0.003		-	-	-	-	-	-	-	-	-	-	0.003
Th	mg/l	0.001	0.001	0.001		-	-	-	-	-	-	-	-	-	-	0.001
Tl	mg/l	0.001	0.001	0.001		-	-	-	-	-	-	-	-	-	-	0.001
U	mg/l	0.001	0.001	0.001		-	-	-	-	-	-	-	-	-	-	0.001
Zn	mg/l	0.005	0.005	0.005		-	-	-	-	-	-	-	-	-	-	0.005

Column terminated

Underline indicates that the concentration is less than the limit of detection

APPENDIX A-5: Leachate assay results for the Barbara column leach tests: NAF4

Parameters		Sample #17920 - NAF4														Average (wks 4-52)
		Initial	Week 4	Week 8	Week 12	Week 16	Week 20	Week 24	Week 28	Week 32	Week 36	Week 40	Week 44	Week 48	Week 52	
Volume	mls	593	552	561	552	556	554	558	552	556	561	560	563	561	566	558
pH	-	7.9	7.1	7.3	7.4	7.4	7.6	7.5	7.5	7.4	7.4	7.6	7.5	7.5	7.6	7.4
EC	µS/cm	531	649	616	611	776	795	784	769	711	689	655	550	530	530	667
Alkalinity	mg/l	32	20	24	19	21	23	28	25	24	26	30	30	29	28	25
Acidity	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ag	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/l	0.07	0.02	0.04	0.01	0.02	0.02	0.02	0.04	0.01	0.01	0.01	<0.01	<0.01	<0.01	0.02
As	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
B	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ba	mg/l	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.01	0.03	0.02	0.02	0.02	0.02
Be	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ca	mg/l	43	57	150	170	144	162	165	217	167	103	147	160	131	122	146
Cd	mg/l	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cl	mg/l	28	30	34	27	14	6	3	2	<1	<1	<1	<1	<1	<1	9
Co	mg/l	0.001	<0.001	0.001	0.002	0.0	0.002	0.003	0.005	0.004	0.002	0.003	0.003	0.002	0.002	0.002
Cr	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	mg/l	0.005	0.009	0.02	0.02	0.02	0.026	0.026	0.036	0.026	0.021	0.023	0.017	0.014	0.019	0.021
F	mg/l	0.3	0.3	0.6	0.6	0.6	0.8	0.5	<0.1	0.4	0.3	0.4	0.4	0.4	0.3	0.4
Fe	mg/l	0.05	<0.05	0.11	<0.05	0.06	<0.05	<0.05	0.08	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.06
Hg	mg/l	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	mg/l	17	17	30	24	22	22	22	25	23	14	18	18	17	16	21
Mg	mg/l	12	22	38	40	35	37	36	42	28	14	22	22	19	18	29
Mn	mg/l	0.06	0.07	0.1	0.2	0.2	0.21	0.21	0.38	0.26	0.13	0.23	0.19	0.13	0.13	0.19
Mo	mg/l	0.002	0.004	0.003	0.004	0.003	0.003	0.002	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.002
Na	mg/l	30	32	37	32	21	15	9	7	4	2	2	1	1	<1	13
Ni	mg/l	0.005	0.001	0.002	0.001	<0.001	0.001	<0.001	0.002	0.003	0.001	0.002	0.002	<0.001	0.001	0.001
P	mg/l	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pb	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sb	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se	mg/l	<0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Si	mg/l	0.6	0.5	1.0	2.5	0.9	0.9	1.1	1.0	1.0	0.7	1.0	1	1	1	1.0
Sn	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SO_4	mg/l	113	224	482	615	533	551	531	628	499	244	443	434	365	331	452
Sr	mg/l	0.09	0.11	0.19	0.21	0.15	0.16	0.14	0.17	0.14	0.07	0.11	0.10	0.08	0.08	0.13
Th	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Tl	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
U	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	mg/l	<0.005	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Underline indicates that the concentration is less than the limit of detection

APPENDIX A-6: Leachate assay results for the Barbara column leach tests: ROM1

Parameters		Sample #16997 - ROM1														Average (wks 4-52)
		Initial	Week 4	Week 8	Week 12	Week 16	Week 20	Week 24	Week 28	Week 32	Week 36	Week 40	Week 44	Week 48	Week 52	
Volume	mls	603	499	503	499	495	500	510	521	525	528	536	540	550	553	520
pH	-	8.0	8.0	7.8	7.7	7.3	7.3	7.4	7.5	7.6	7.5	7.6	7.6	7.5	7.7	7.6
EC	µS/cm	136	131	185	183	158	162	169	141	156	155	149	138	129	128	153
Alkalinity	mg/l	34	30	25	22	20	24	25	23	25	24	26	24	25	24	24
Acidity	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ag	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Al	mg/l	0.1	0.7	2	0.5	0.4	0.7	1	0.6	0.9	0.9	1.0	0.7	0.8	0.71	0.86
As	mg/l	0.001	0.005	0.006	0.005	0.004	0.006	0.006	0.004	0.004	0.004	0.003	0.004	0.003	0.003	0.004
B	mg/l	0.05	0.05	0.3	0.2	0.09	0.3	0.1	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.10
Ba	mg/l	0.03	0.02	0.04	0.03	0.02	0.03	0.03	0.03	0.04	0.04	0.04	0.03	0.04	0.04	0.03
Be	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Ca	mg/l	43	2	4	6	5	5	3	3	3	2	3	2	2	3	3
Cd	mg/l	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Cl	mg/l	28	3	2	2	1	3	1	1	1	1	1	1	1	1	1
Co	mg/l	0.001	0.002	0.005	0.002	0.001	0.003	0.004	0.004	0.006	0.008	0.006	0.005	0.007	0.007	0.005
Cr	mg/l	0.001	0.001	0.003	0.001	0.001	0.001	0.002	0.001	0.002	0.001	0.002	0.002	0.004	0.001	0.002
Cu	mg/l	0.005	0.4	0.6	0.3	0.1	0.4	0.5	0.5	0.8	1.0	0.8	0.6	1.0	0.8	0.6
F	mg/l	0.3	2	2	1	1	1	0.7	0.5	0.8	0.5	0.1	0.3	0.3	0.3	0.8
Fe	mg/l	0.05	1	3	0.6	0.5	0.9	1.5	0.8	1.2	1.1	1.4	0.9	1.1	0.96	1.1
Hg	mg/l	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
K	mg/l	17	3	4	4	4	5	3	3	3	3	3	3	3	3	3
Mg	mg/l	12	2	4	6	5	5	3	2	3	2	3	2	3	3	3
Mn	mg/l	0.06	0.04	0.05	0.02	0.01	0.03	0.04	0.05	0.06	0.08	0.07	0.05	0.07	0.07	0.05
Mo	mg/l	0.002	0.02	0.01	0.01	0.009	0.006	0.004	0.003	0.004	0.002	0.001	0.001	0.001	0.001	0.005
Na	mg/l	30	18	24	24	18	16	13	10	10	8	7	6	6	6	13
Ni	mg/l	0.005	0.001	0.003	0.001	0.001	0.002	0.002	0.001	0.002	0.002	0.003	0.001	0.004	0.002	0.002
P	mg/l	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pb	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sb	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Se	mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Si	mg/l	1	5	6	6	6	7	14	5	5	6	4	4	4	4	6
Sn	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
SO_4	mg/l	113	22	62	58	44	31	32	16	12	8	5	4	4	4	23
Sr	mg/l	0.09	0.008	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Th	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Tl	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
U	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zn	mg/l	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

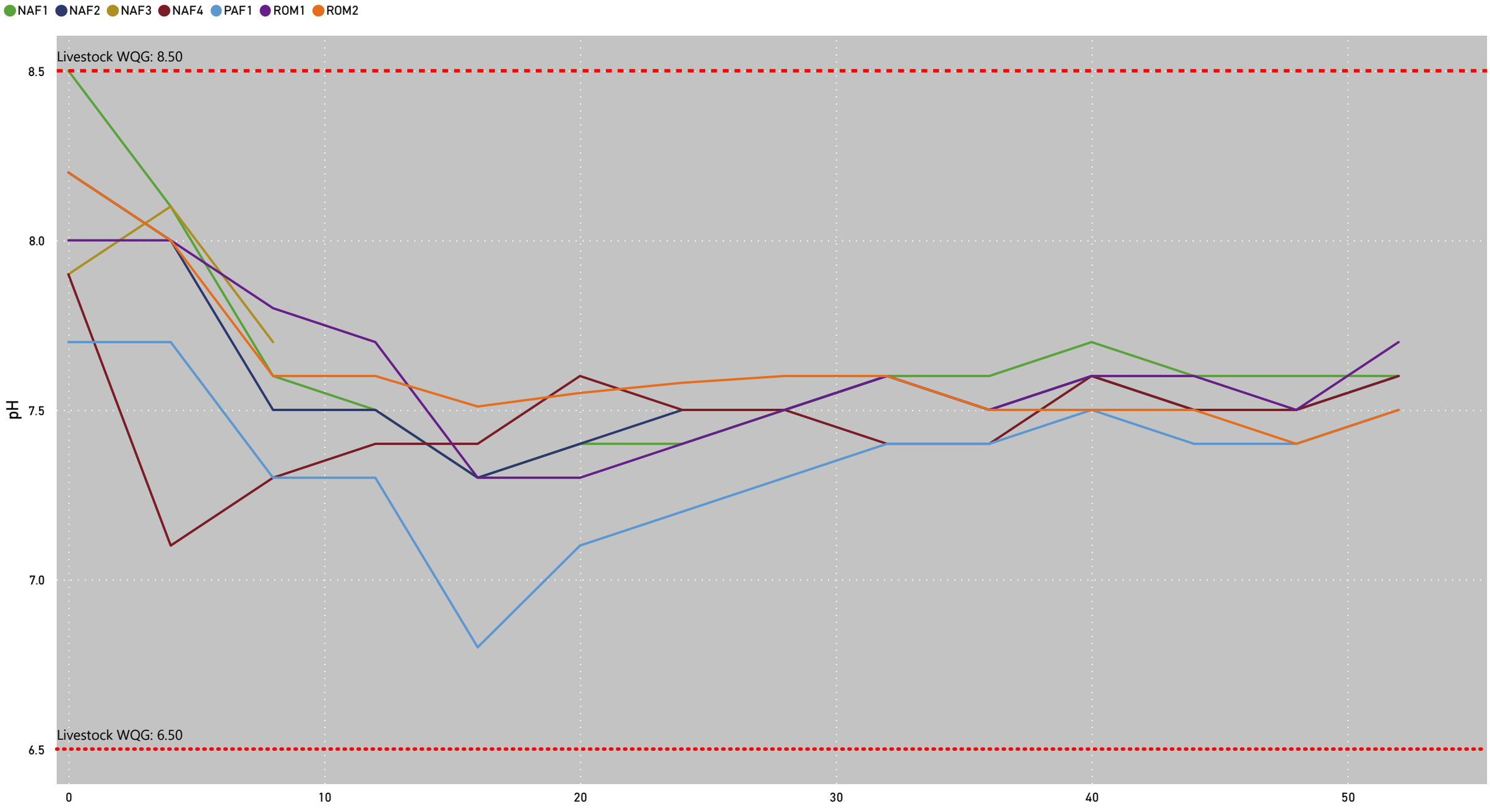
Underline indicates that the concentration is less than the limit of detection

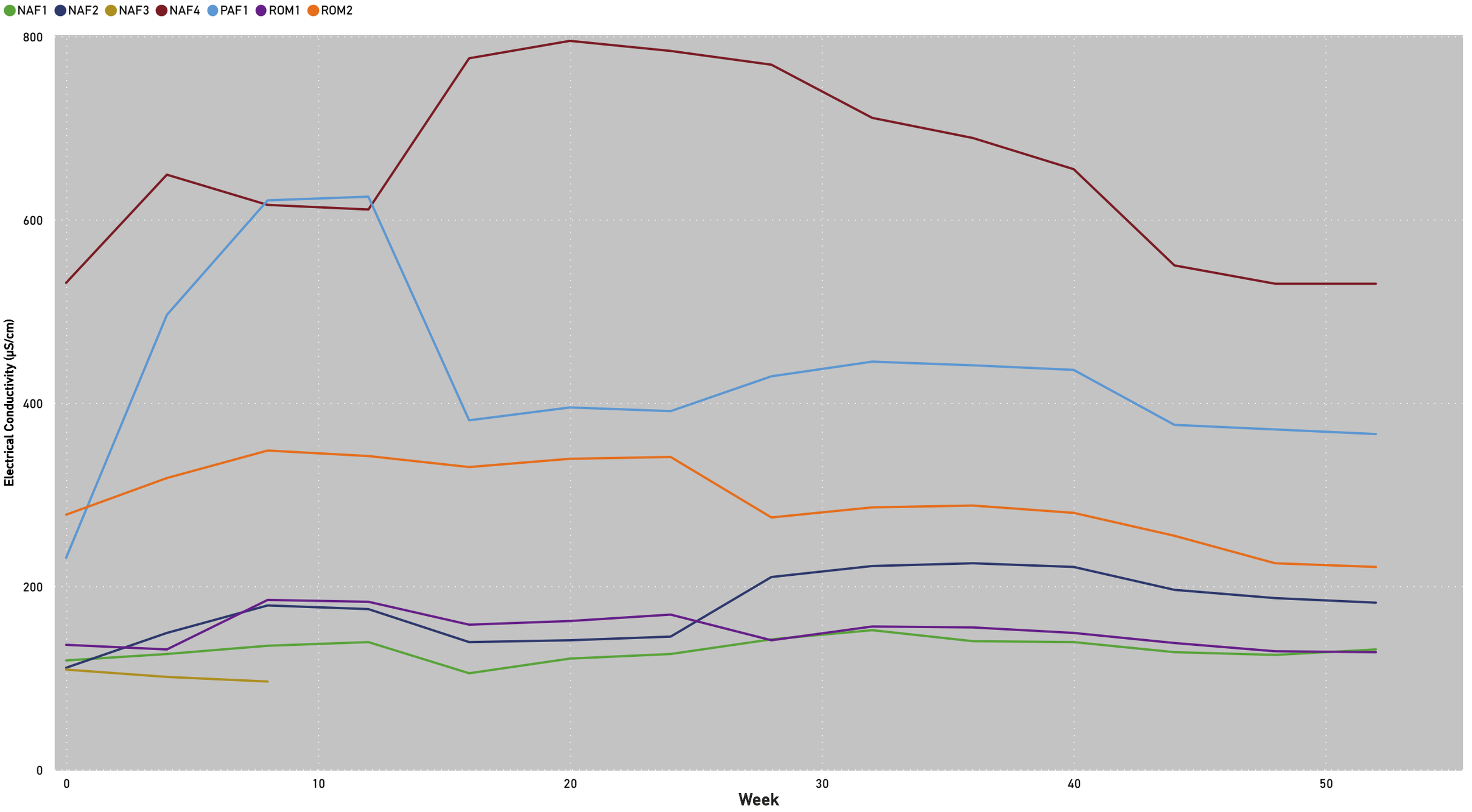
APPENDIX A-7: Leachate assay results for the Barbara column leach tests: ROM2

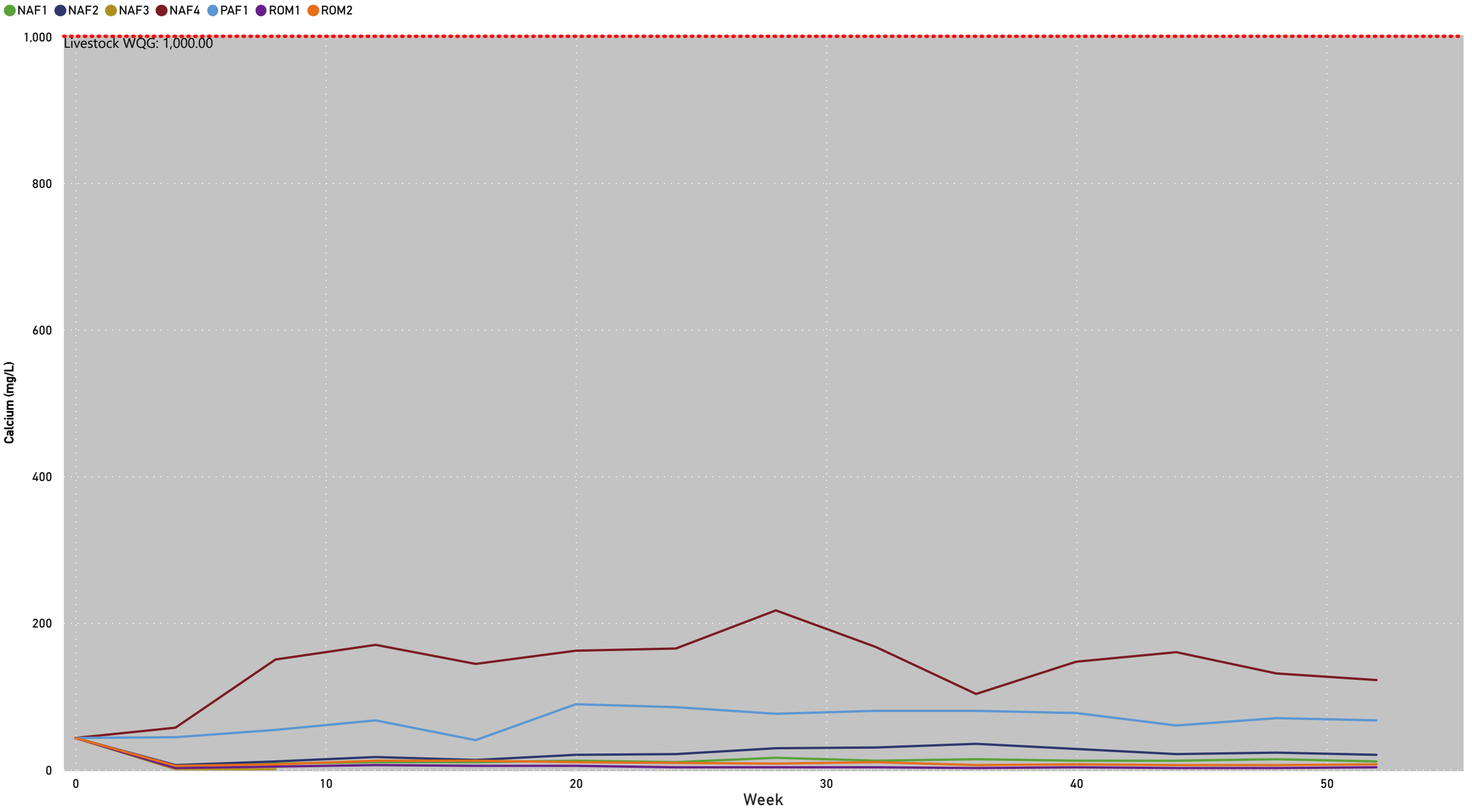
Parameters		Sample #16998 - ROM2														Average (wks 4-52)
		Initial	Week 4	Week 8	Week 12	Week 16	Week 20	Week 24	Week 28	Week 32	Week 36	Week 40	Week 44	Week 48	Week 52	
Volume	mls	611	509	502	497	508	510	516	525	521	525	531	540	545	551	522
pH	-	8.2	8.0	7.6	7.6	7.51	7.55	7.58	7.6	7.6	7.5	7.5	7.5	7.4	7.5	7.6
EC	µS/cm	278	318	348	342	330	339	341	275	286	288	280	255	225	221	296
Alkalinity	mg/l	68	51	40	37	37	32	30	28	33	30	31	29	28	32	34
Acidity	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ag	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Al	mg/l	0.1	0.8	2.0	0.2	0.3	0.3	0.4	0.2	0.3	0.6	0.5	0.4	0.6	0.3	0.5
As	mg/l	0.001	0.006	0.006	0.003	0.003	0.003	0.004	0.003	0.003	0.004	0.003	0.003	0.002	0.002	0.003
B	mg/l	0.05	0.05	0.2	0.1	0.06	0.07	0.08	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.07
Ba	mg/l	0.03	0.03	0.04	0.03	0.03	0.02	0.03	0.02	0.03	0.02	0.03	0.02	0.03	0.02	0.03
Be	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Ca	mg/l	43	5	7	12	12	10	9	8	10	6	7	6	6	7	8
Cd	mg/l	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Cl	mg/l	28	3	3	1	1	1	1	1	1	1	1	1	1	1	1
Co	mg/l	0.001	0.004	0.004	0.001	0.001	0.001	0.001	0.001	0.002	0.005	0.004	0.003	0.006	0.003	0.003
Cr	mg/l	0.001	0.002	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cu	mg/l	0.005	0.5	0.5	0.1	0.1	0.2	0.2	0.2	0.2	0.6	0.5	0.3	0.7	0.3	0.3
F	mg/l	0.3	3	2	2	1.4	1.3	1.0	0.8	1.2	0.7	0.1	0.4	0.4	0.4	1.1
Fe	mg/l	0.05	1	2	0.3	0.3	0.4	0.4	0.3	0.3	0.6	0.7	0.5	0.7	0.5	0.6
Hg	mg/l	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
K	mg/l	17	5	8	7	8	9	7	5	6	5	4	5	4	4	6
Mg	mg/l	12	5	8	10	12	10	8	7	8	5	6	5	5	5	7
Mn	mg/l	0.06	0.04	0.03	0.006	0.002	0.01	0.01	0.01	0.012	0.04	0.03	0.02	0.05	0.022	0.021
Mo	mg/l	0.002	0.01	0.01	0.008	0.007	0.005	0.003	0.003	0.004	0.002	0.001	0.001	0.001	0.001	0.005
Na	mg/l	30	47	45	41	34	27	24	19	20	13	12	10	8	8	24
Ni	mg/l	0.005	0.001	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001
P	mg/l	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pb	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sb	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Se	mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Si	mg/l	0.6	6	6	5	5	5	17	4	4	5	3	4	3	4	5.463
Sn	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
SO_4	mg/l	113	79	120	121	115	77	88	63	55	25	19	15	13	20	62
Sr	mg/l	0.09	0.02	0.04	0.05	0.04	0.03	0.04	0.03	0.04	0.02	0.03	0.03	0.02	0.03	0.031
Th	mg/l	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Tl	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
U	mg/l	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zn	mg/l	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

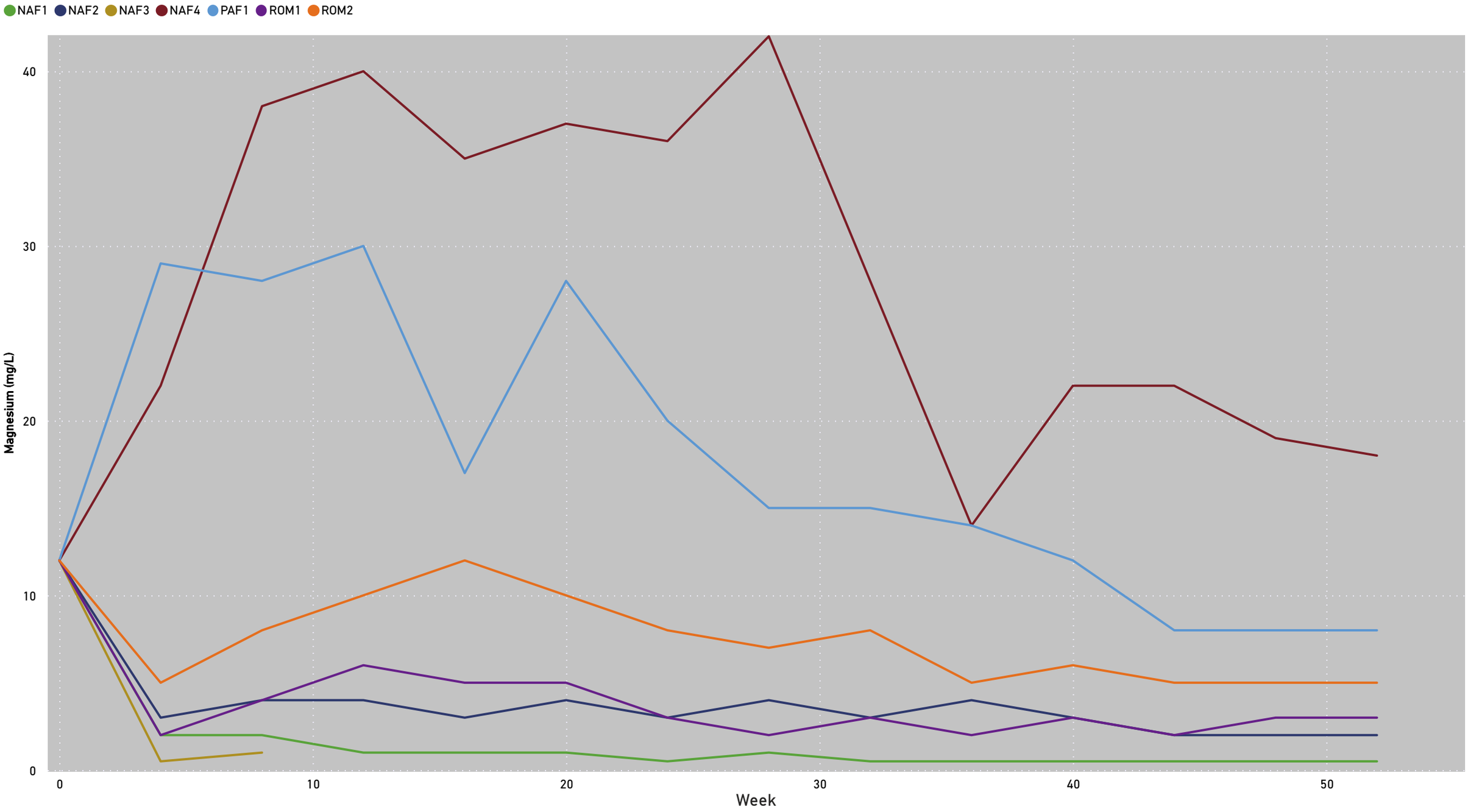
Underline indicates that the concentration is less than the limit of detection

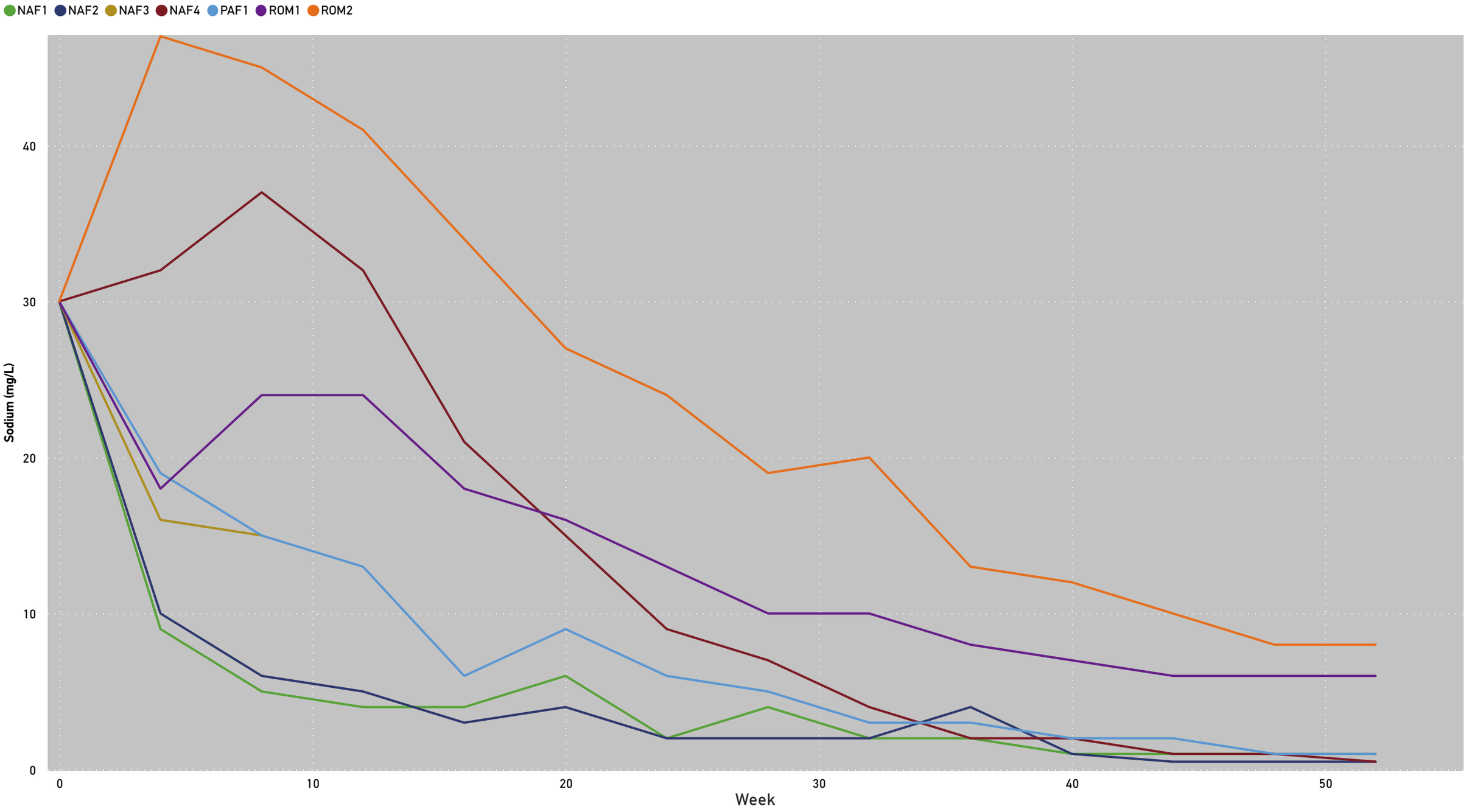
L.2 Kinetic column leach test results versus livestock drinking water quality guidelines

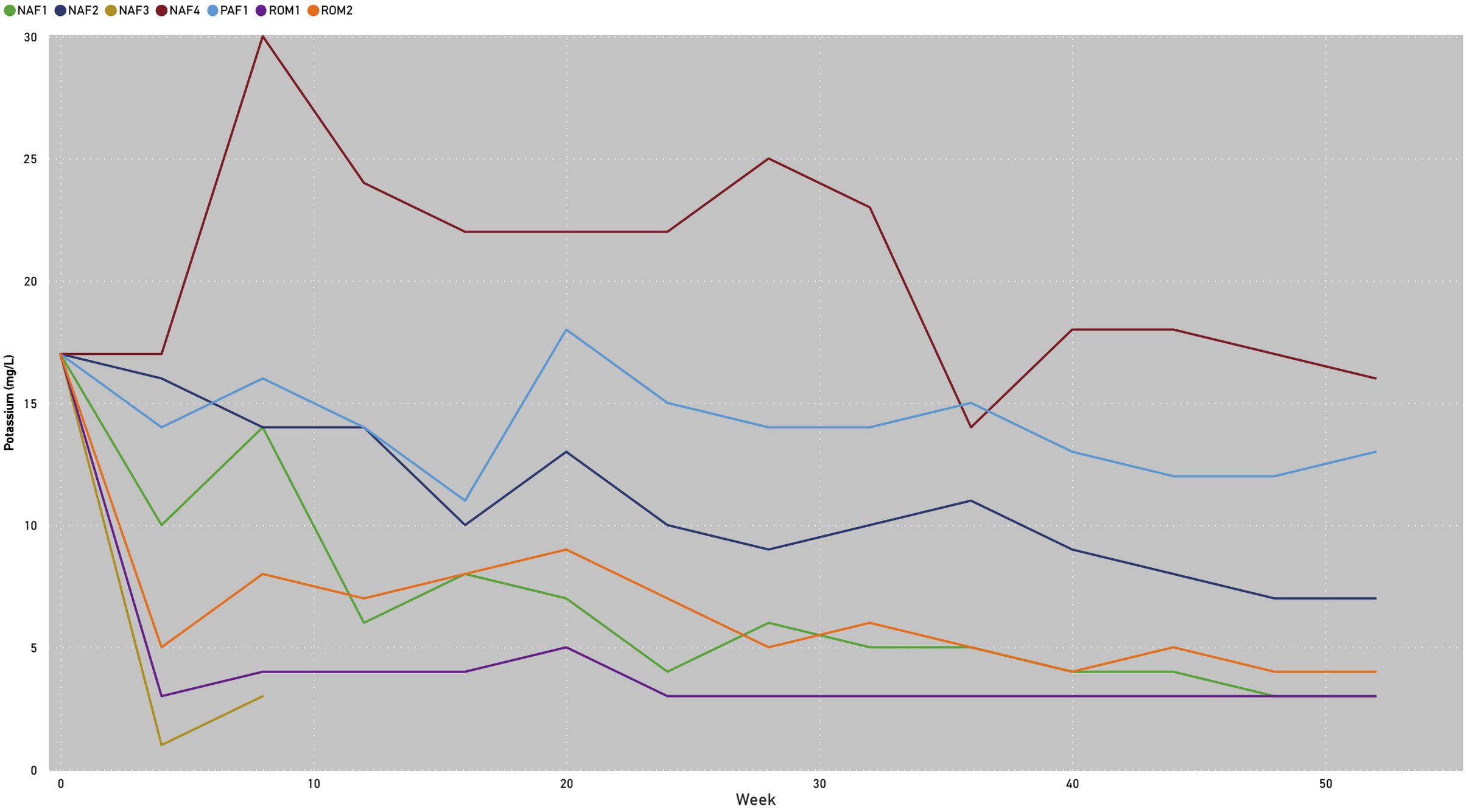

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
Livestock WQG: 8.50
Livestock WQG: 6.50
pH
8.5
8.0
7.5
7.0
6.5
0
10
20
30
40
50

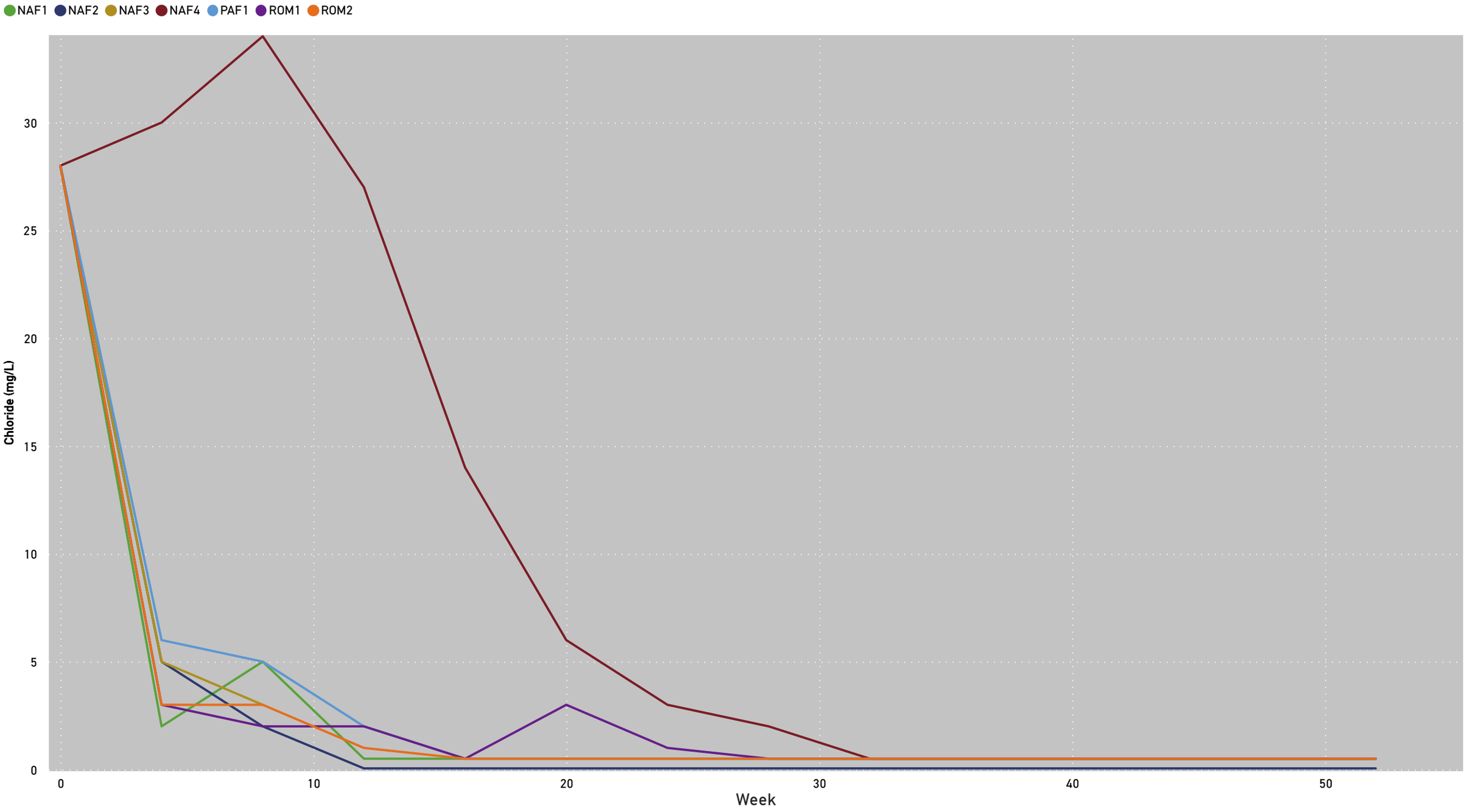

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
800
600
400
200
0
Electrical Conductivity (µS/cm)
0
10
20
30
40
50
Week

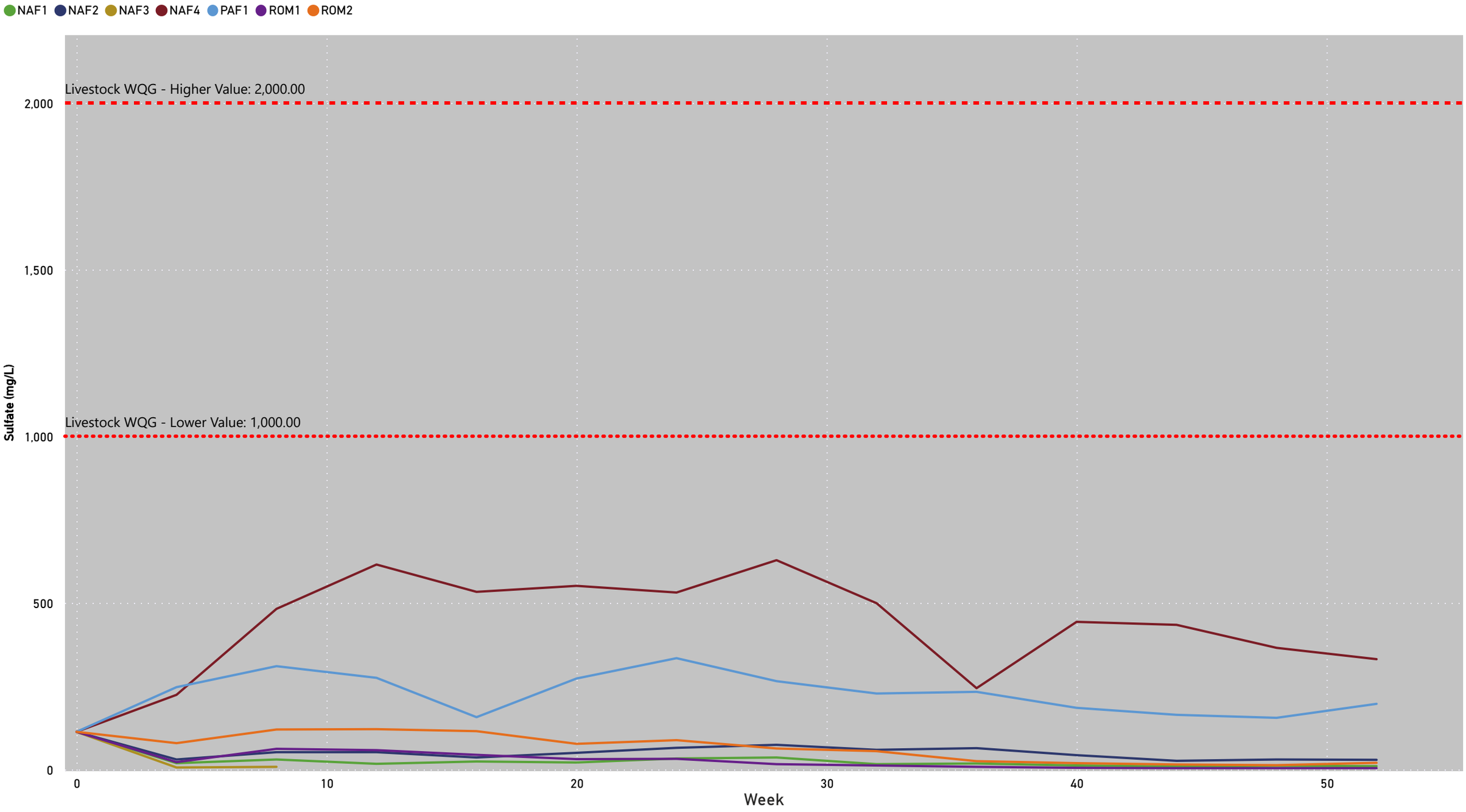

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
1,000
800
600
400
200
0
Livestock WQG: 1,000.00
Calcium (mg/L)
0
10
20
30
40
50
Week

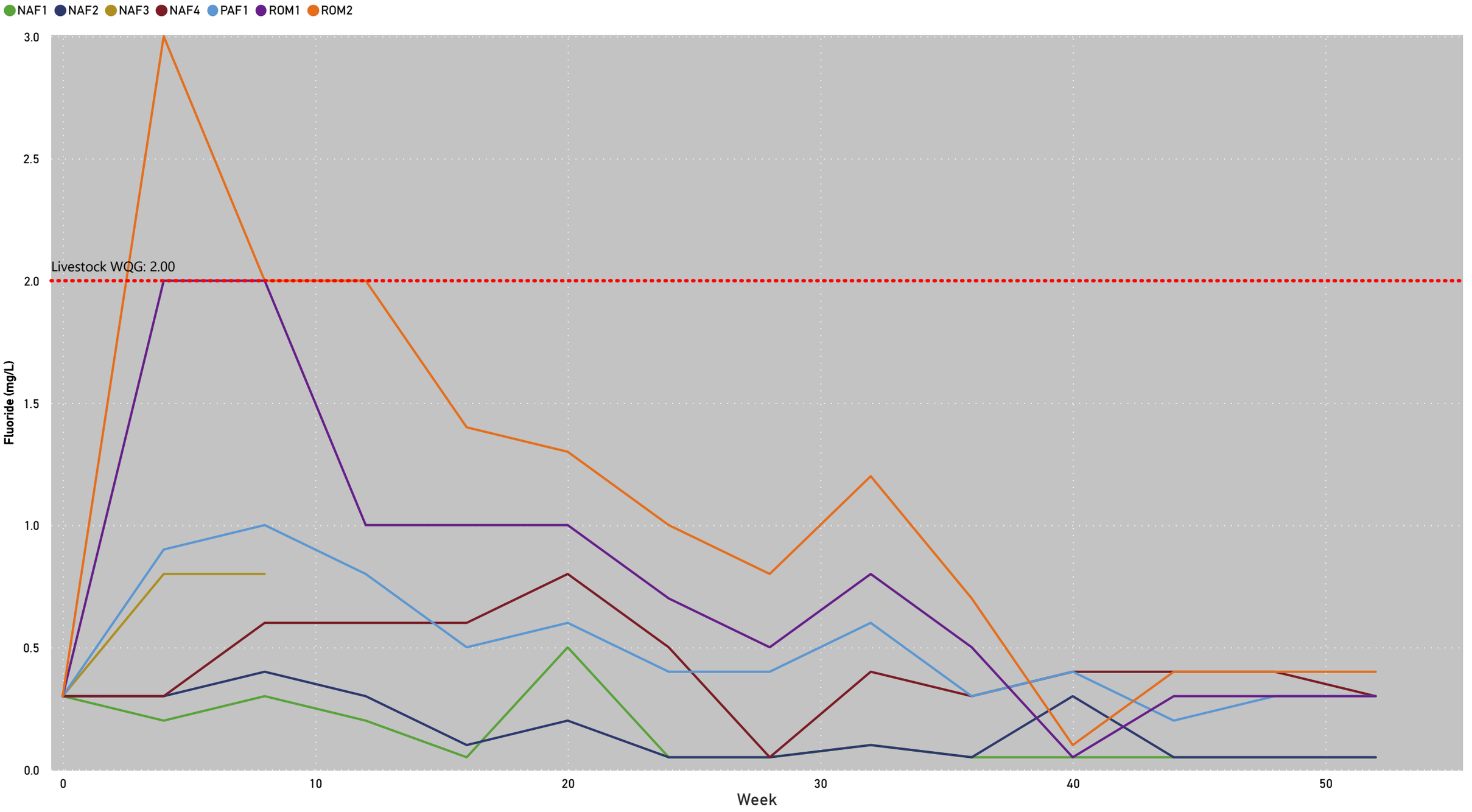

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
Magnesium (mg/L)
0
10
20
30
40
0
10
20
30
40
50
Week

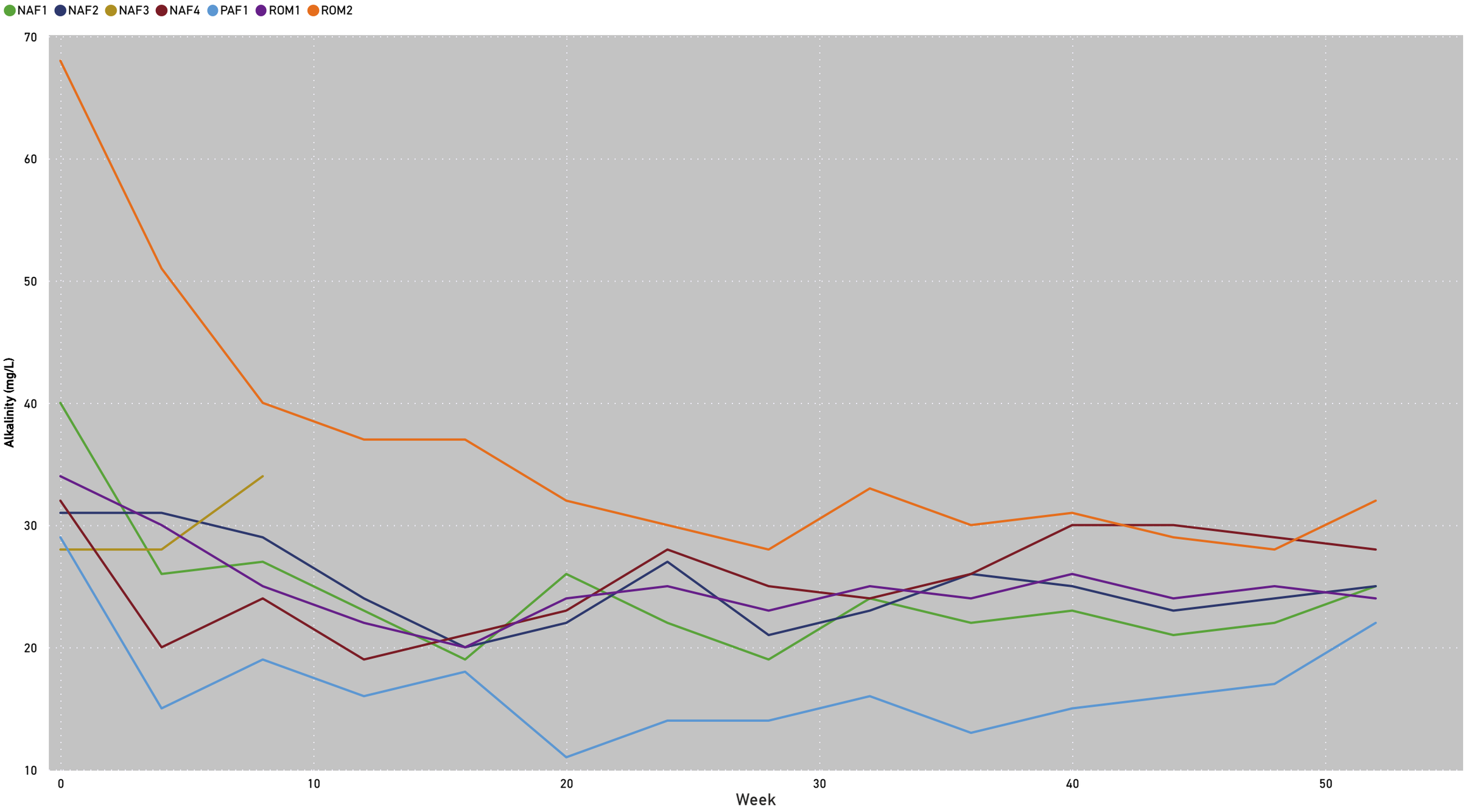

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
Sodium (mg/L)
0
10
20
30
40
0
10
20
30
40
50
Week

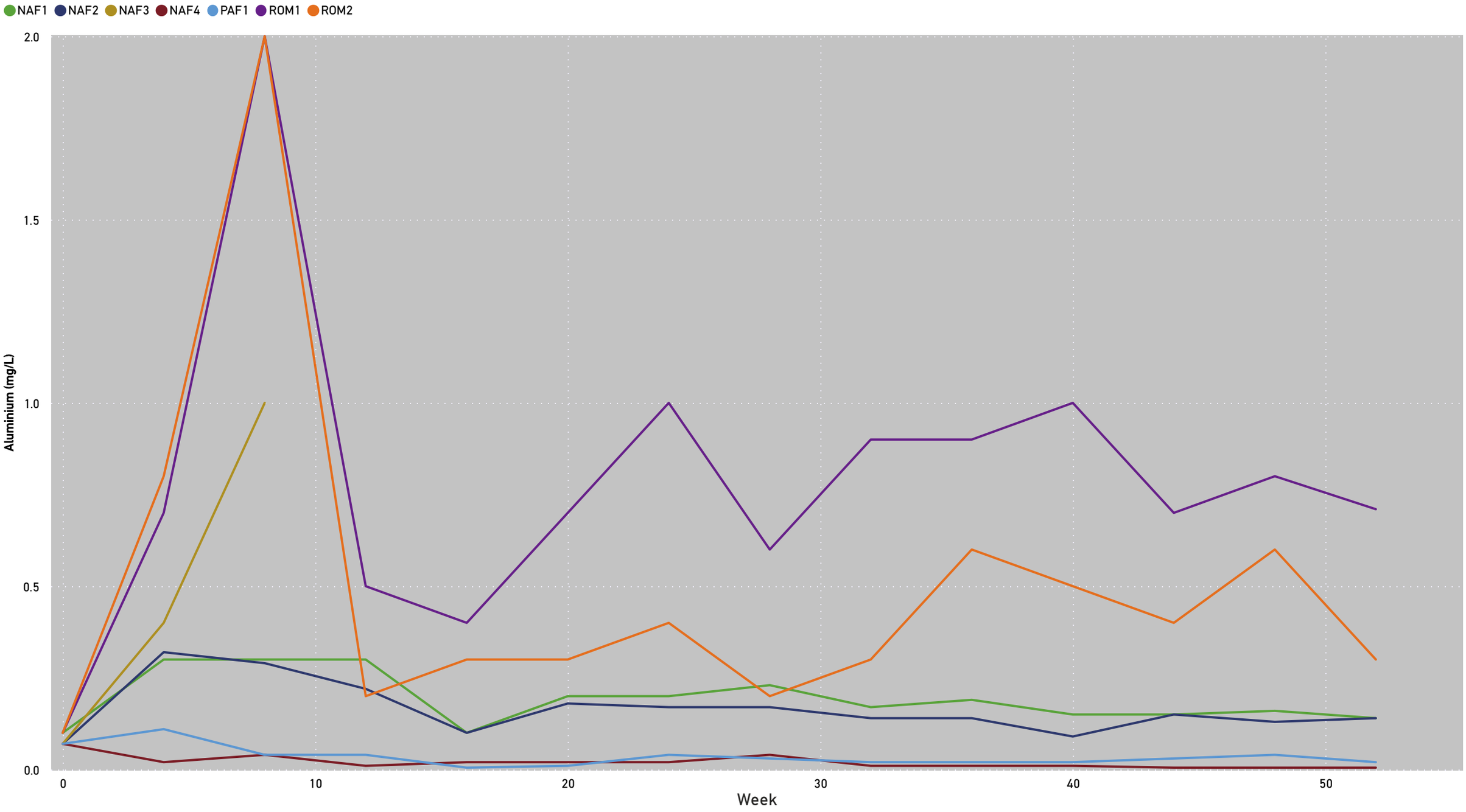

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
Potassium (mg/L)
30
25
20
15
10
5
0
0
10
20
30
40
50
Week

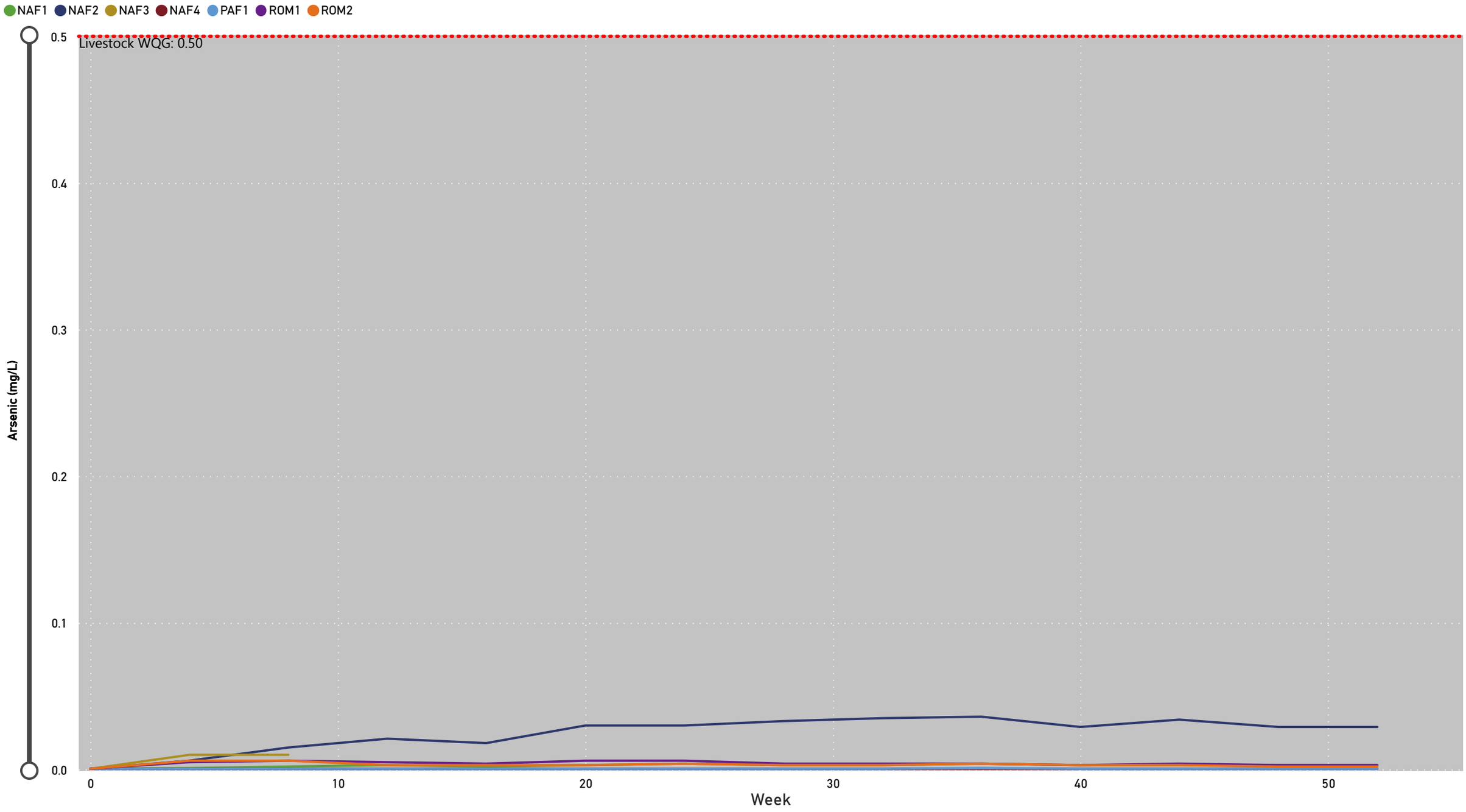

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
Chloride (mg/L)
0
5
10
15
20
25
30
0
10
20
30
40
50
Week

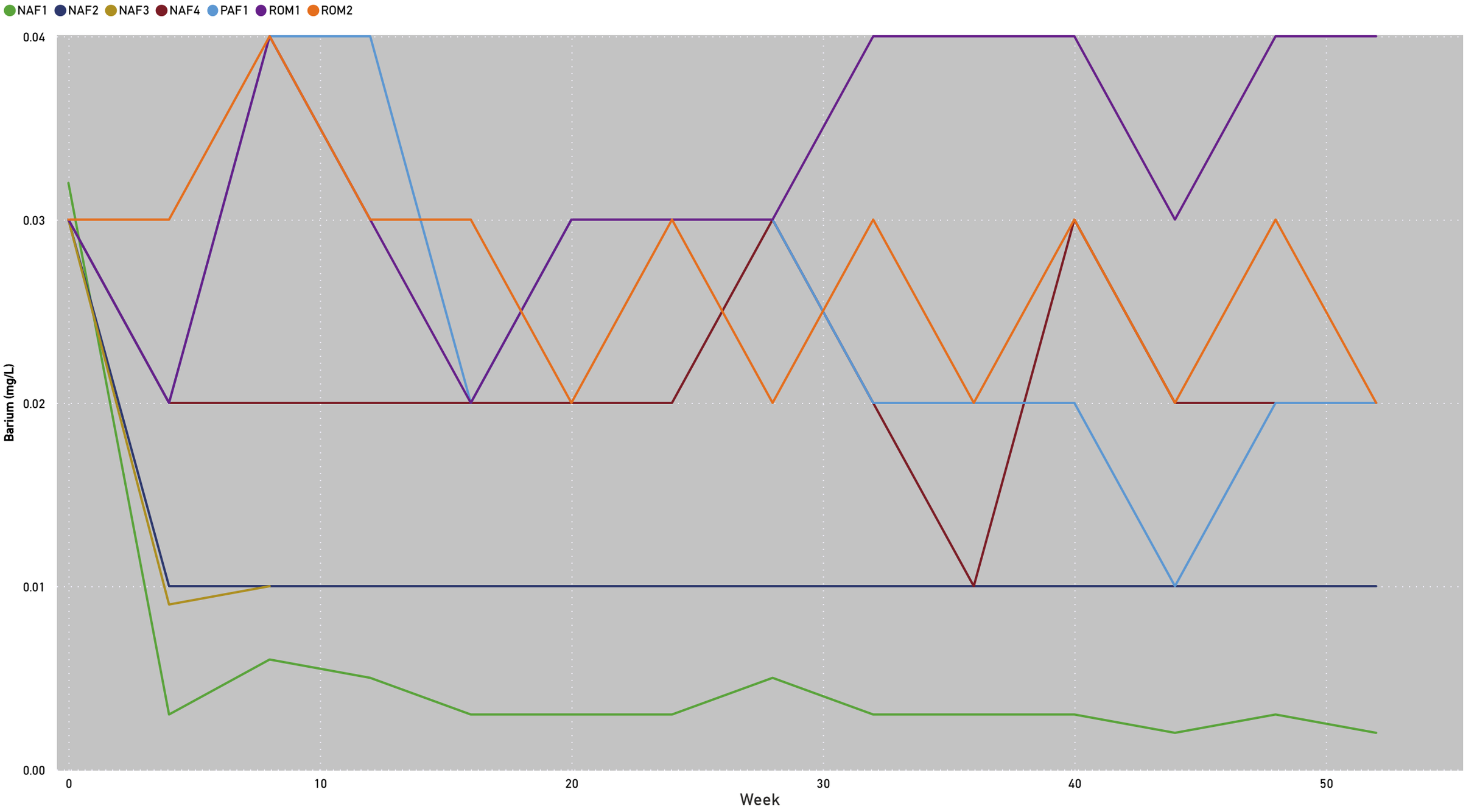

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
Livestock WQG - Higher Value: 2,000.00
Livestock WQG - Lower Value: 1,000.00
Sulfate (mg/L)
2,000
1,500
1,000
500
0
0
10
20
30
40
50
Week

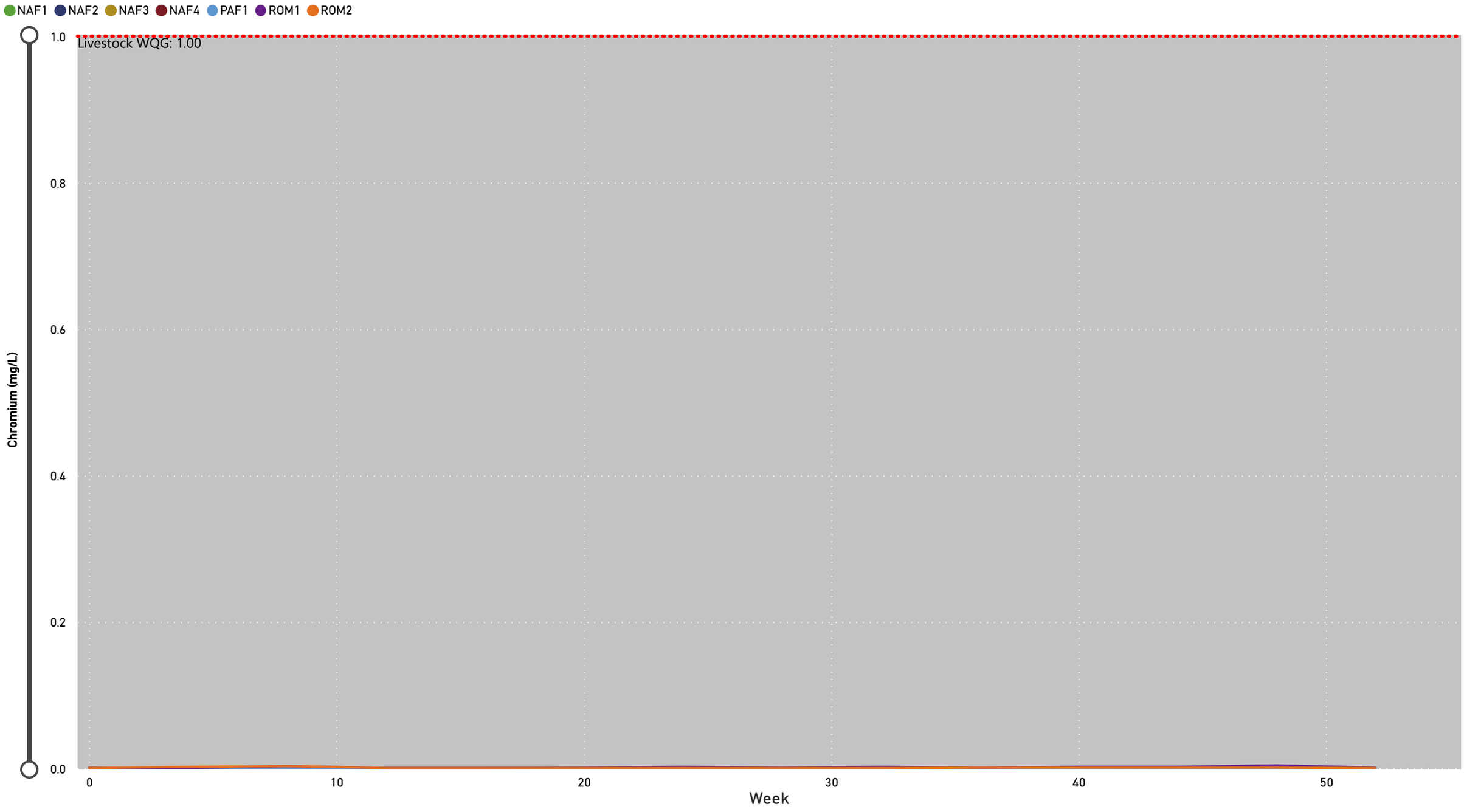

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
Livestock WQG: 2.00
Fluoride (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
Week

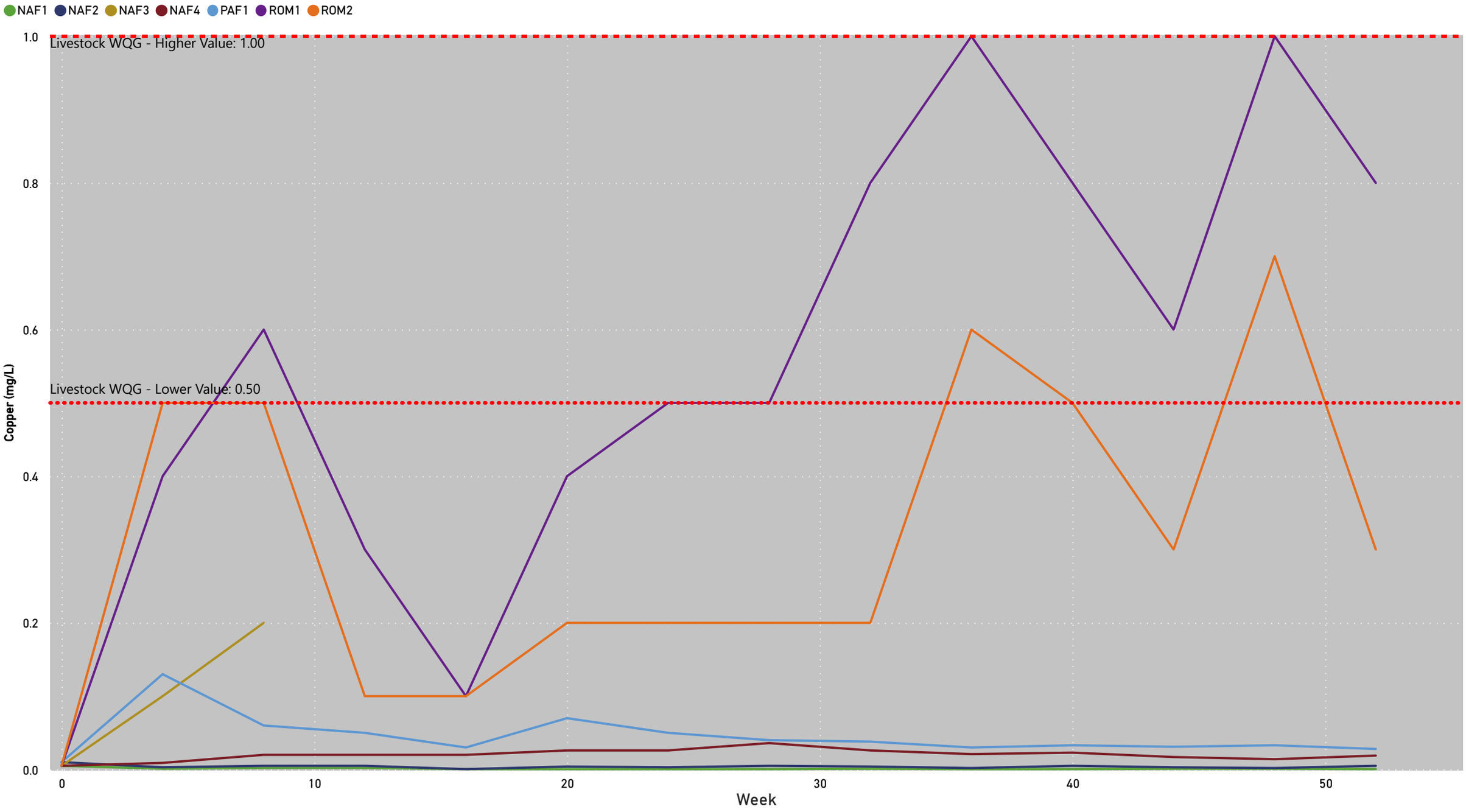

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
70
60
50
40
30
20
10
Alkalinity (mg/L)
0
10
20
30
40
50
Week

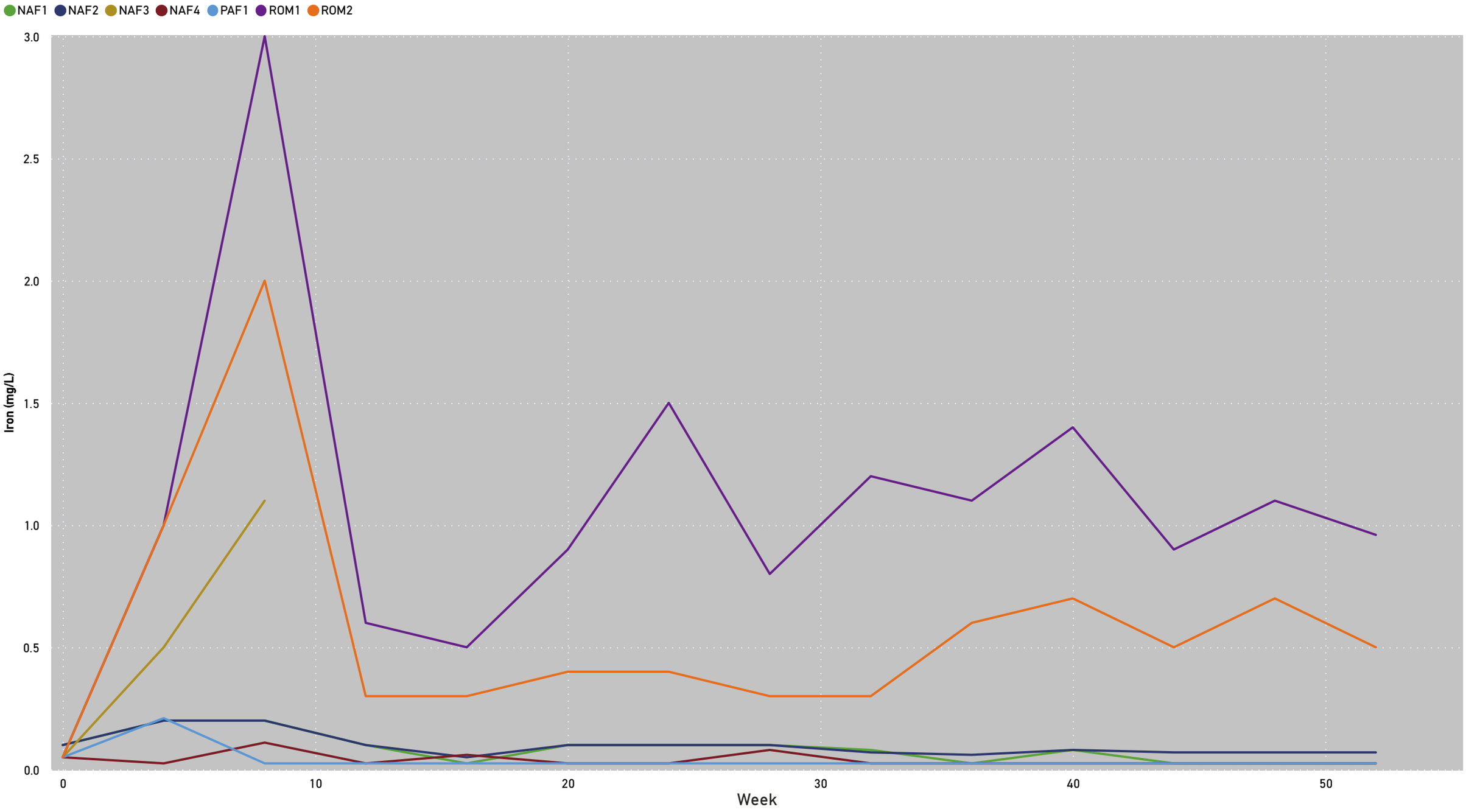

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
2.0
1.5
1.0
0.5
0.0
Aluminium (mg/L)
0
10
20
30
40
50
Week

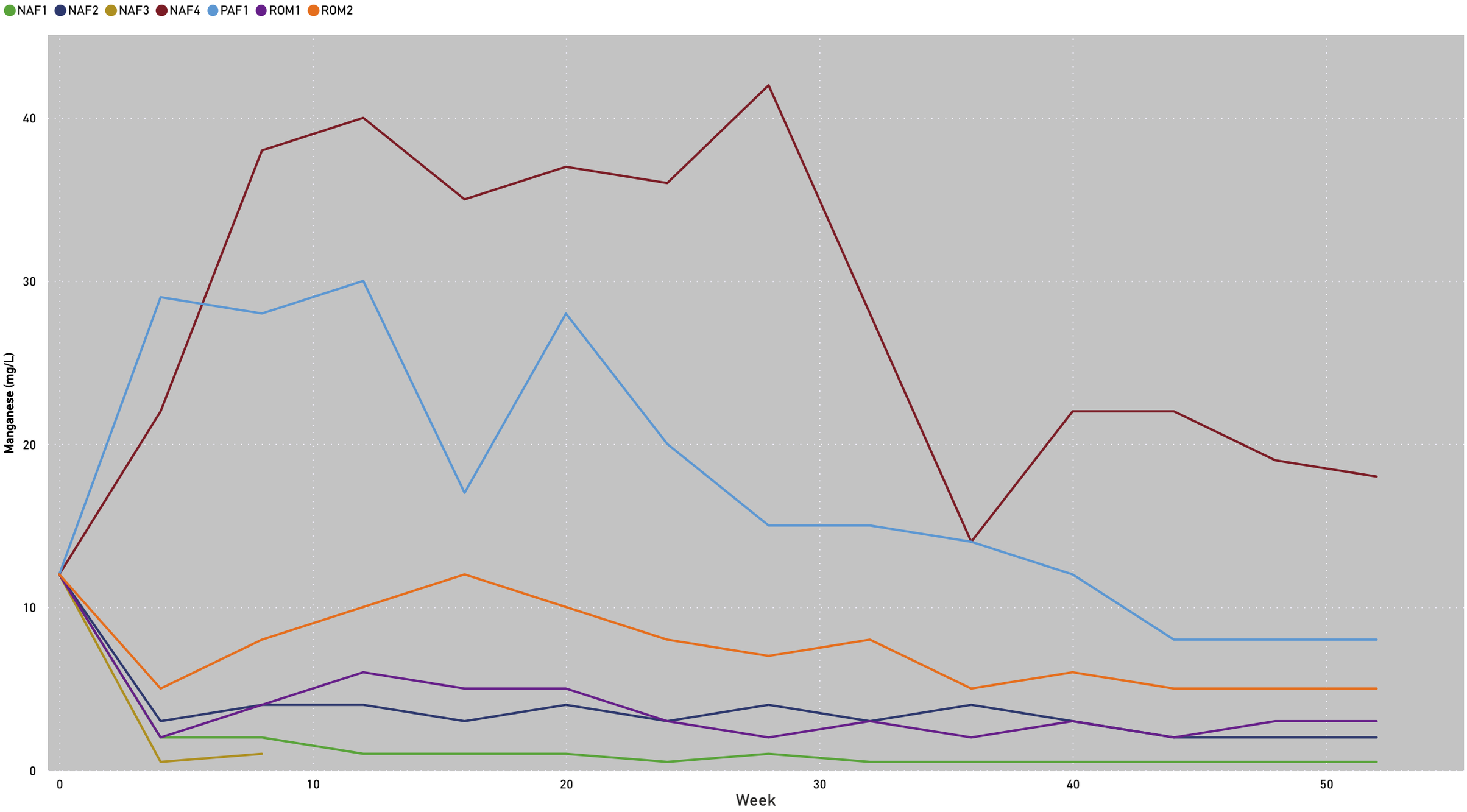

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
Livestock WQG: 0.50
Arsenic (mg/L)
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
Week

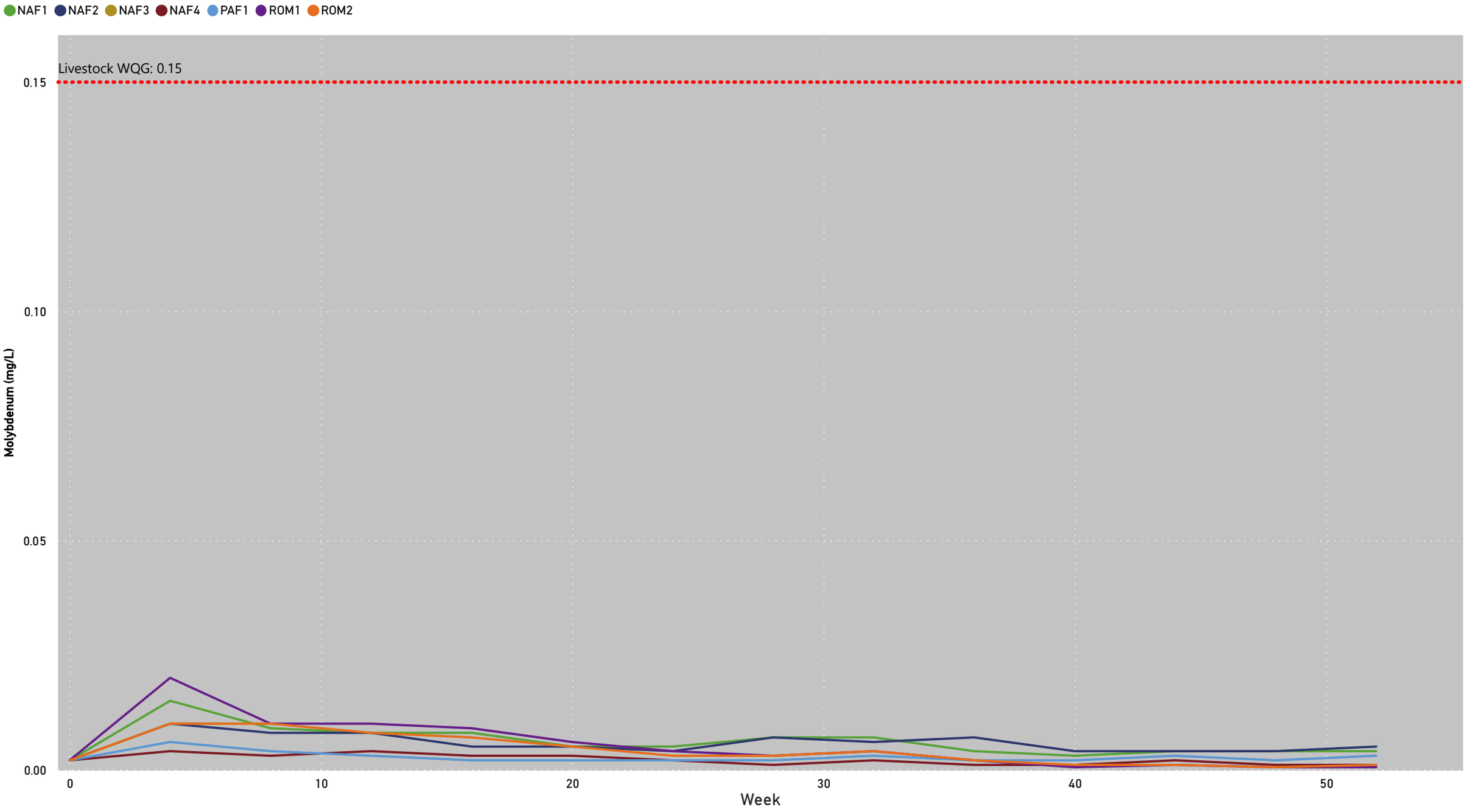

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
0.04
0.03
0.02
0.01
0.00
Barium (mg/L)
0
10
20
30
40
50
Week

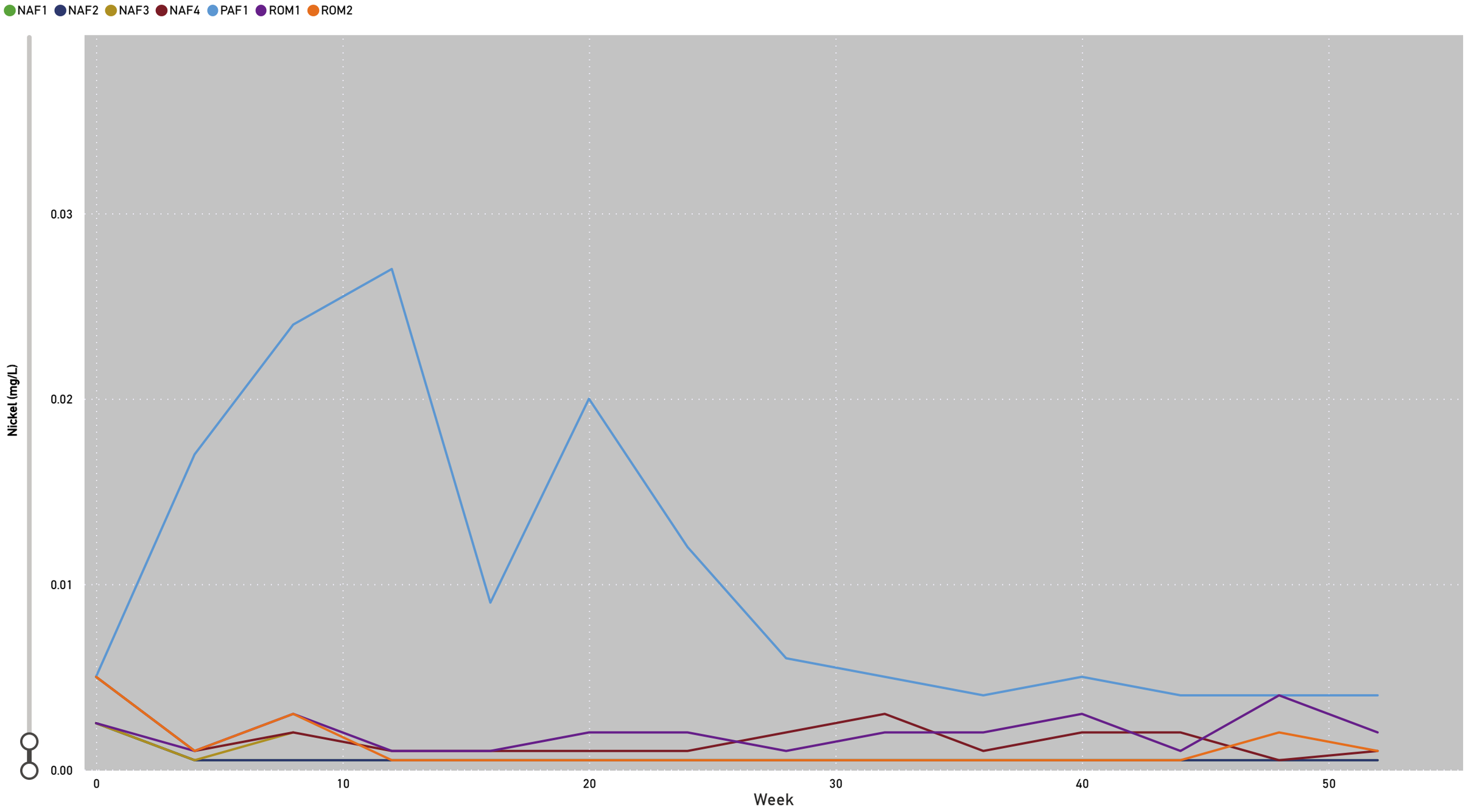

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
Livestock WQG: 1.00
Chromium (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
Week

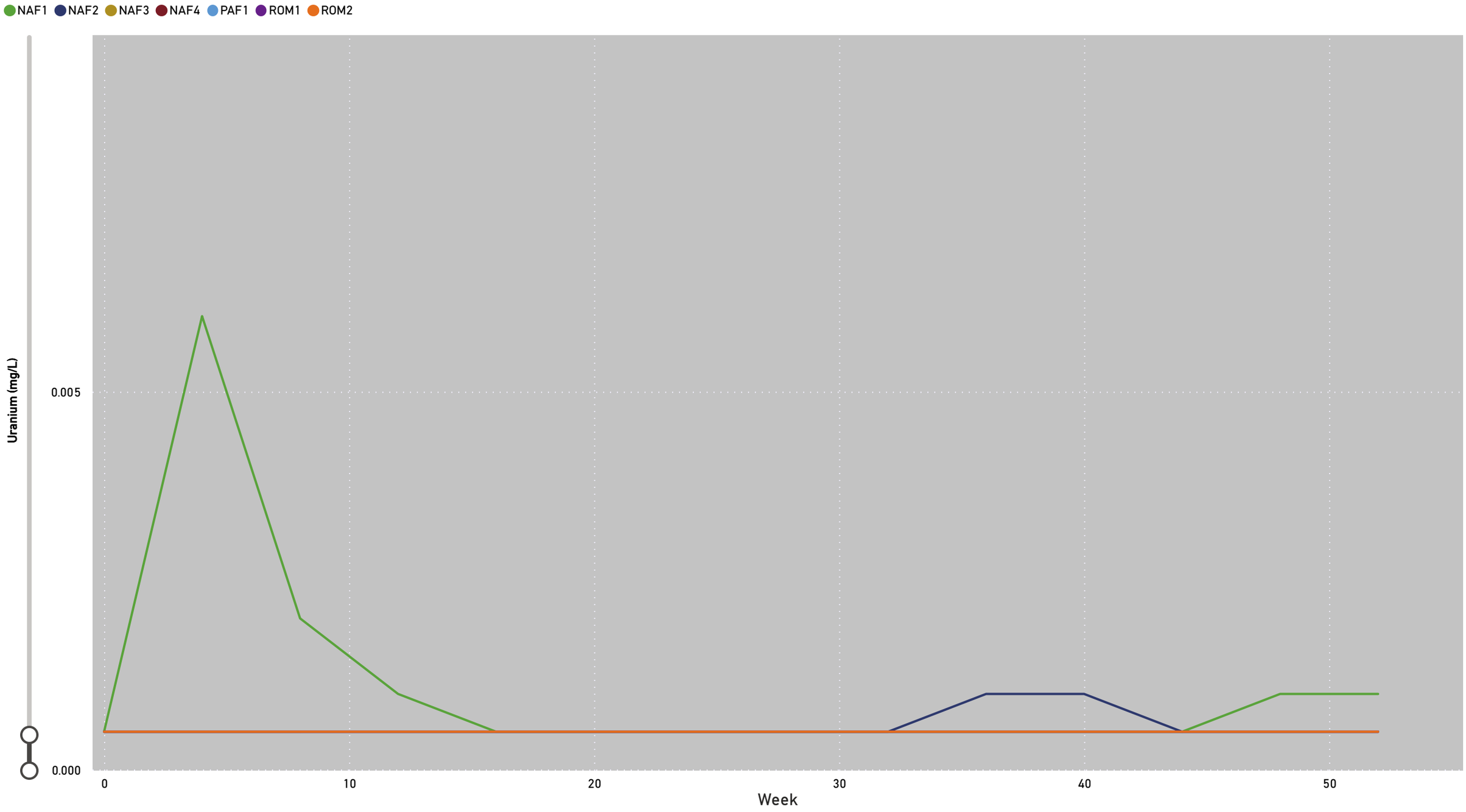

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
Livestock WQG - Higher Value: 1.00
Livestock WQG - Lower Value: 0.50
Copper (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
Week

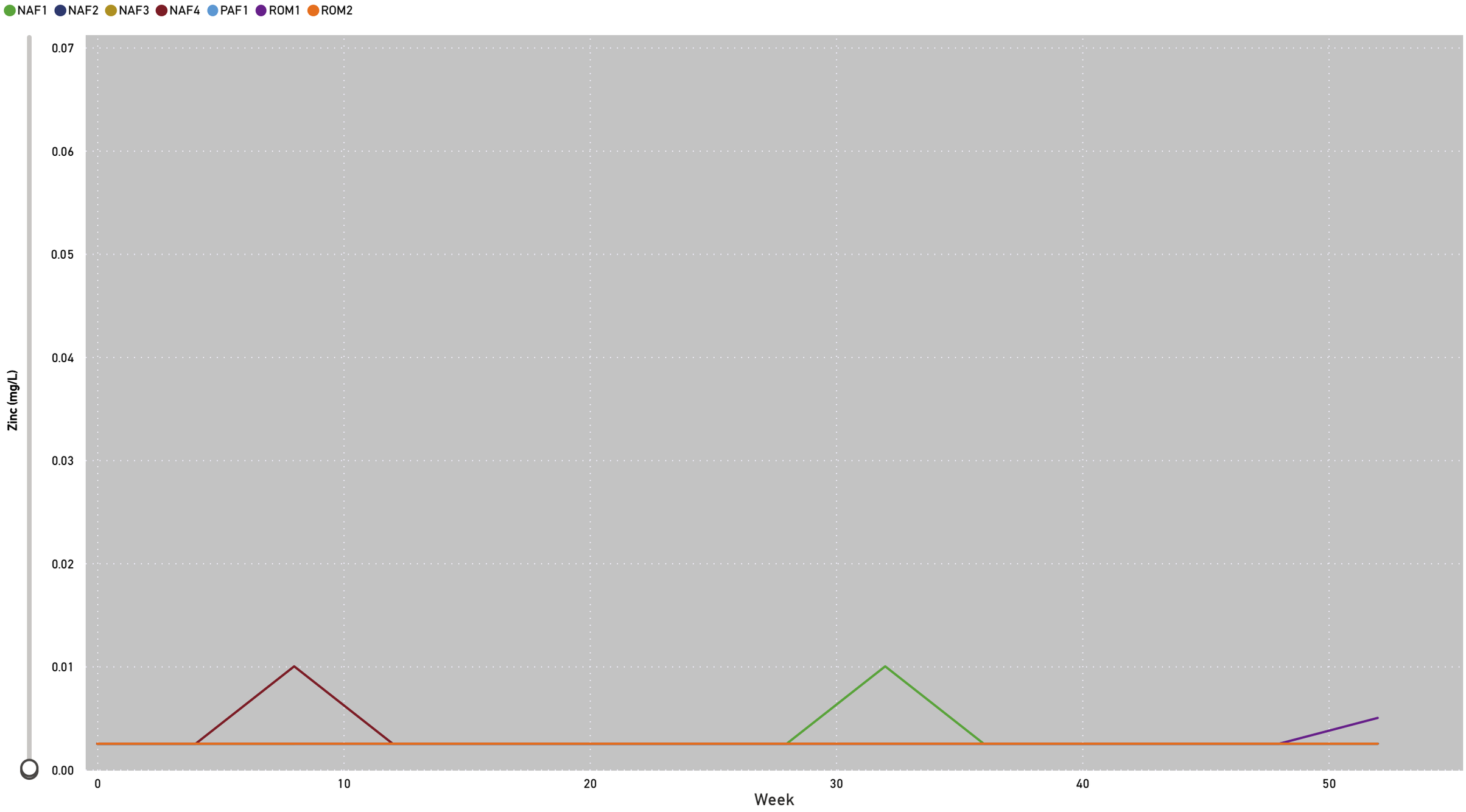

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Iron (mg/L)
0
10
20
30
40
50
Week


NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
Manganese (mg/L)
0
10
20
30
40
0
10
20
30
40
50
Week


NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
Livestock WQG: 0.15
0.15
0.10
0.05
0.00
Molybdenum (mg/L)
0
10
20
30
40
50
Week


NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
Nickel (mg/L)
0.03
0.02
0.01
0.00
0
10
20
30
40
50
Week

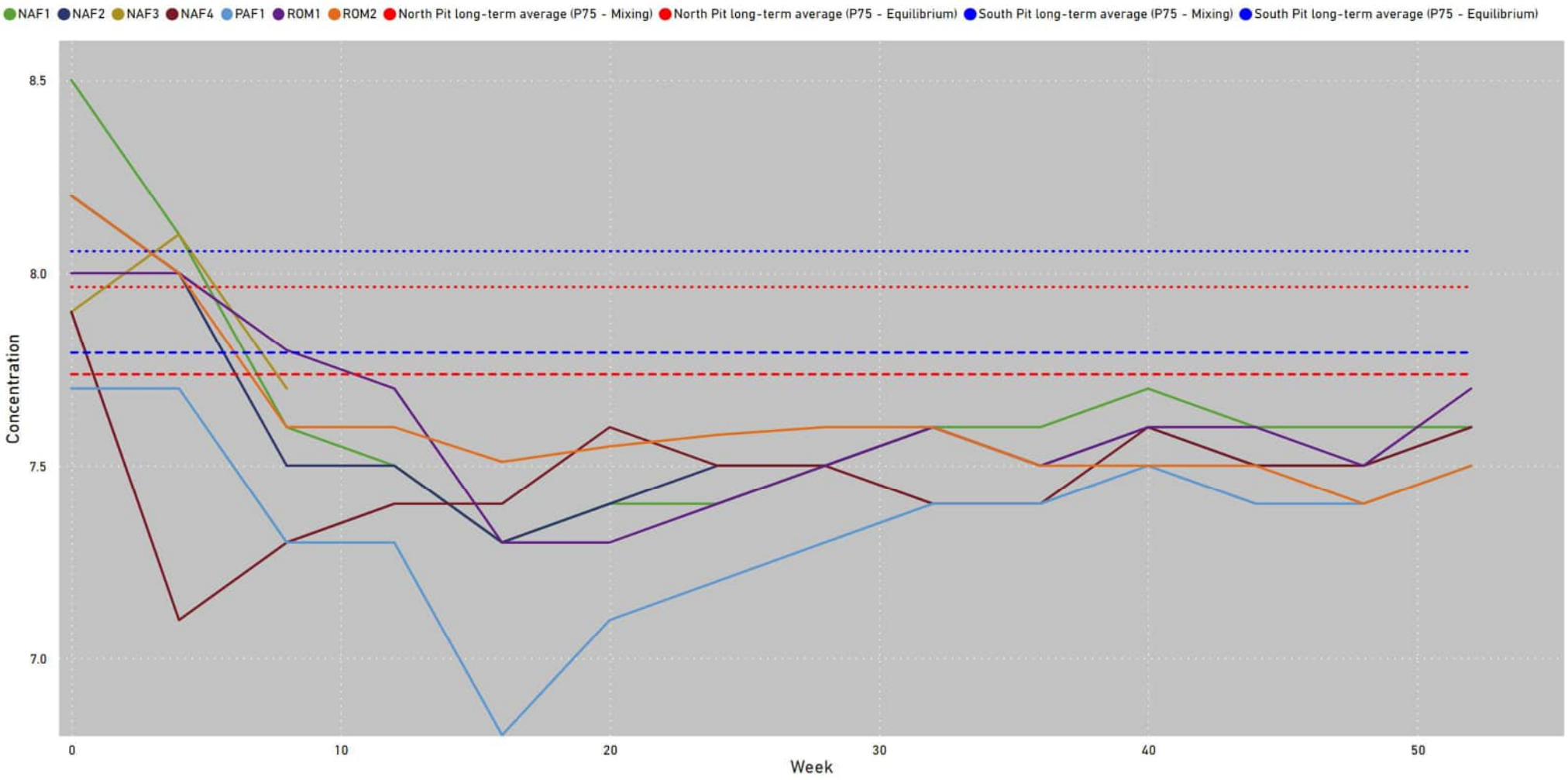

NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
Uranium (mg/L)
0.005
0.000
0
10
20
30
40
50
Week


NAF1
NAF2
NAF3
NAF4
PAF1
ROM1
ROM2
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Zinc (mg/L)
0
10
20
30
40
50
Week

L.3 Kinetic column leach test results versus open pit final void water quality

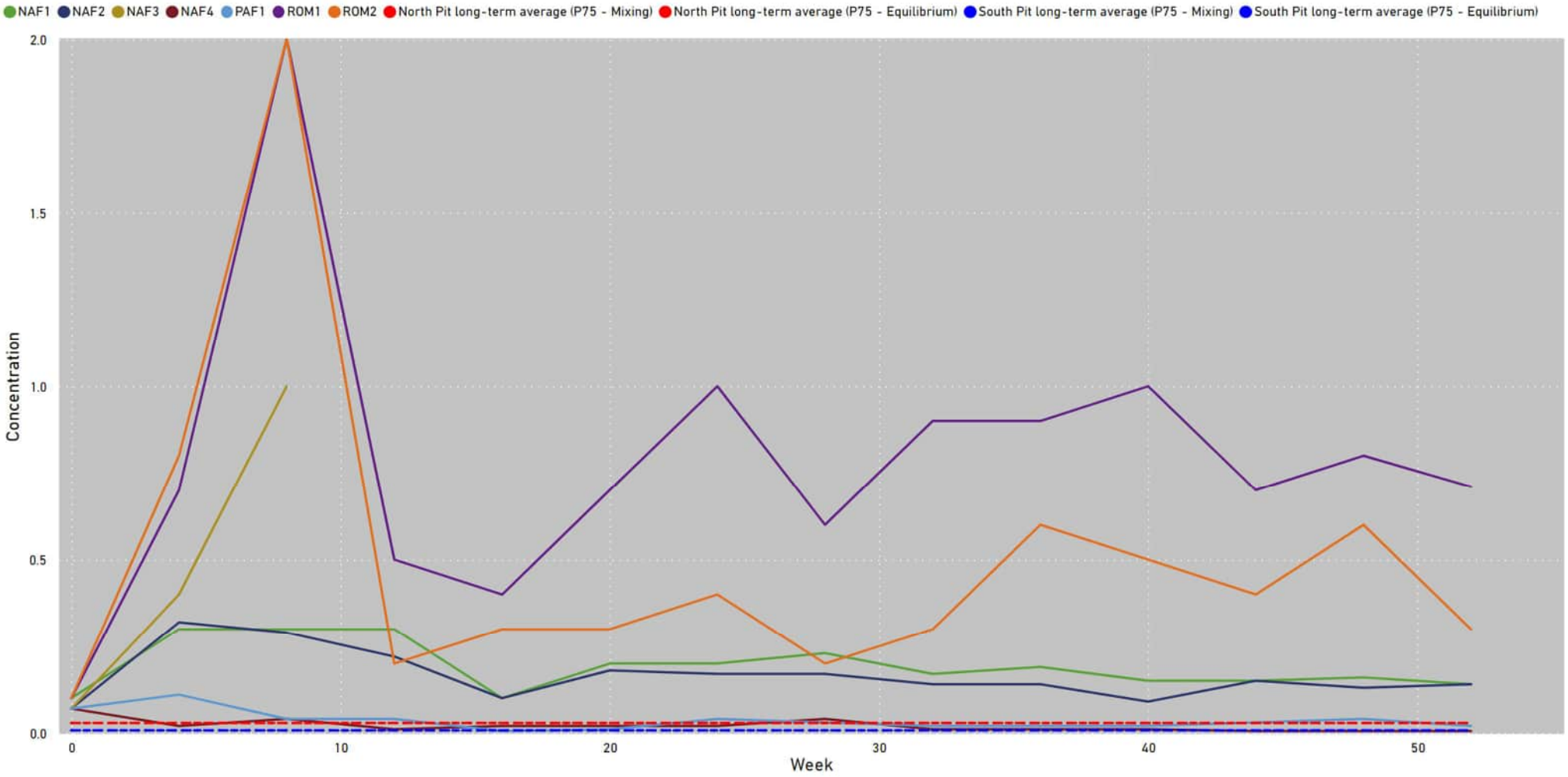
Parameter (Units)

pH (mg/L)



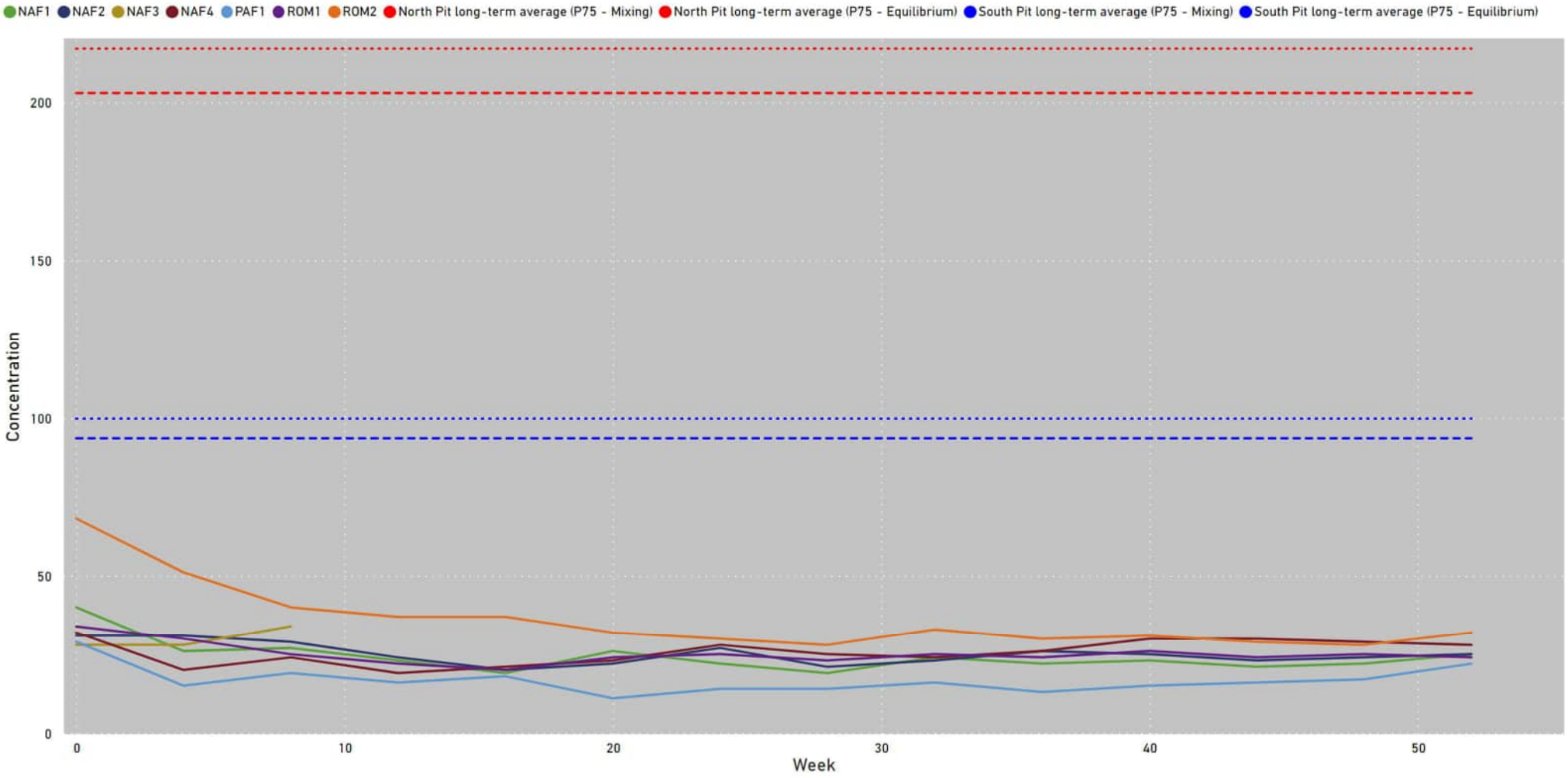
Parameter (Units)

Al (mg/L)



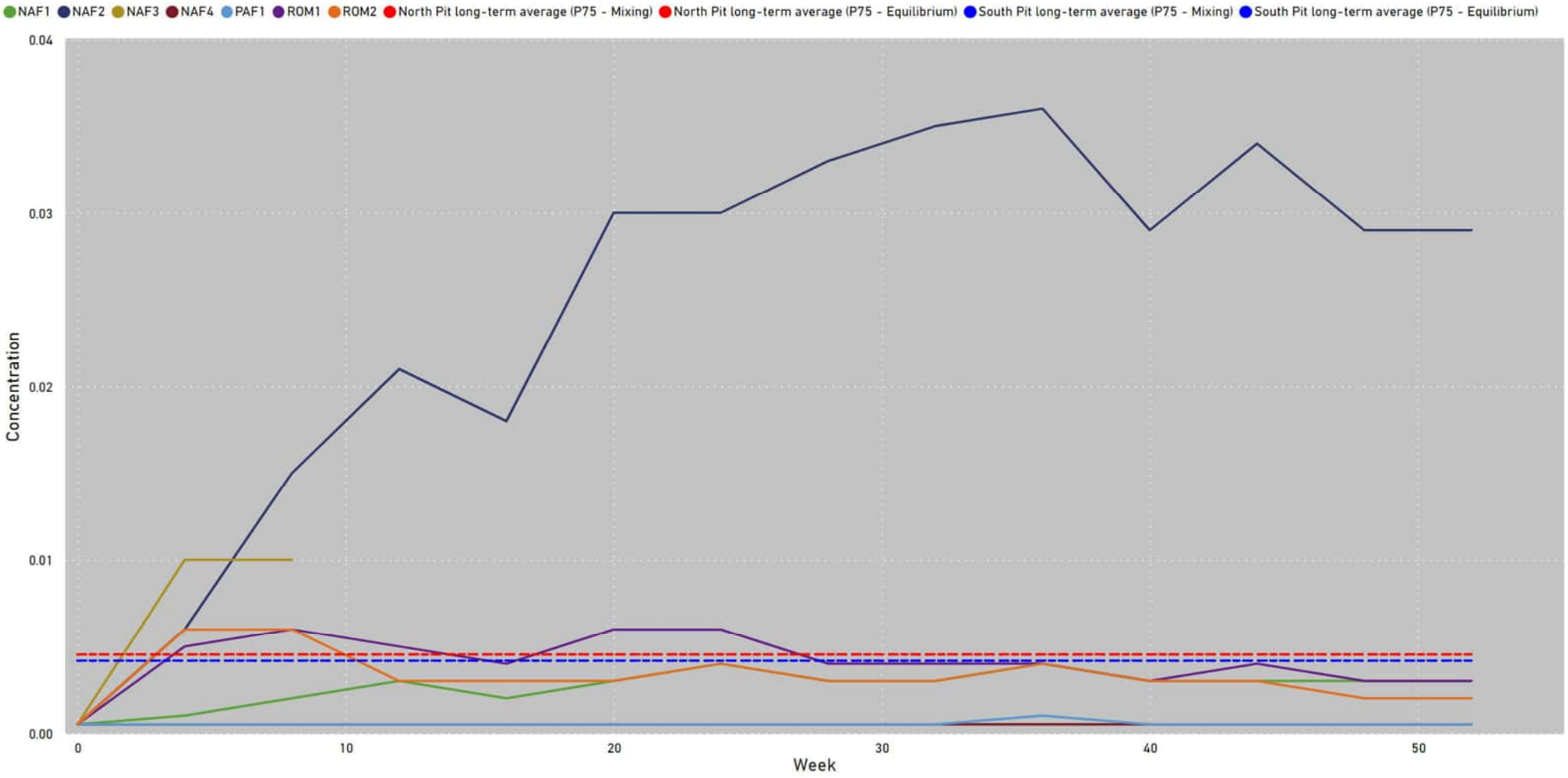
Parameter (Units)

Alkalinity (mg/L)



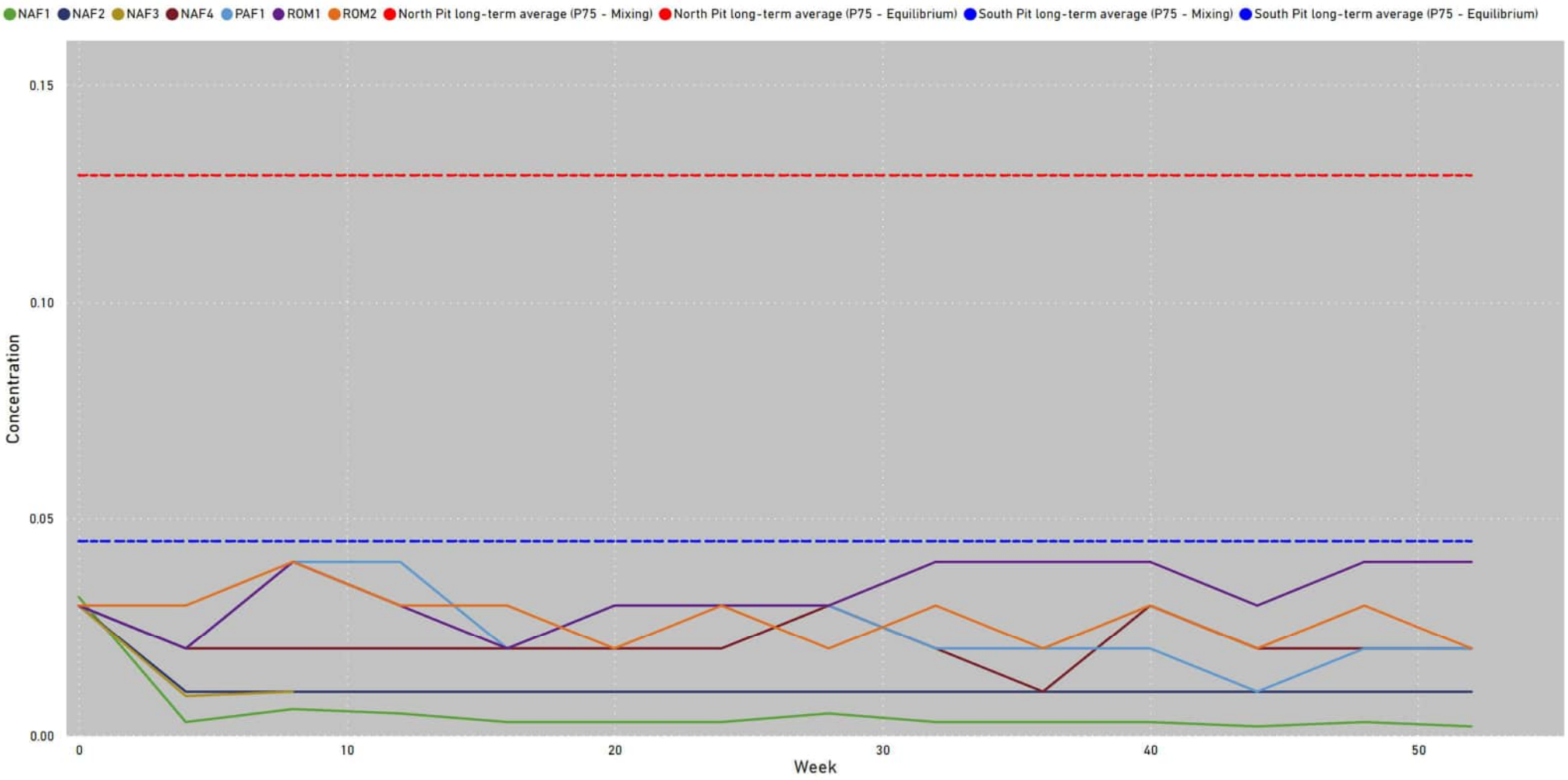
Parameter (Units)

As (mg/L)



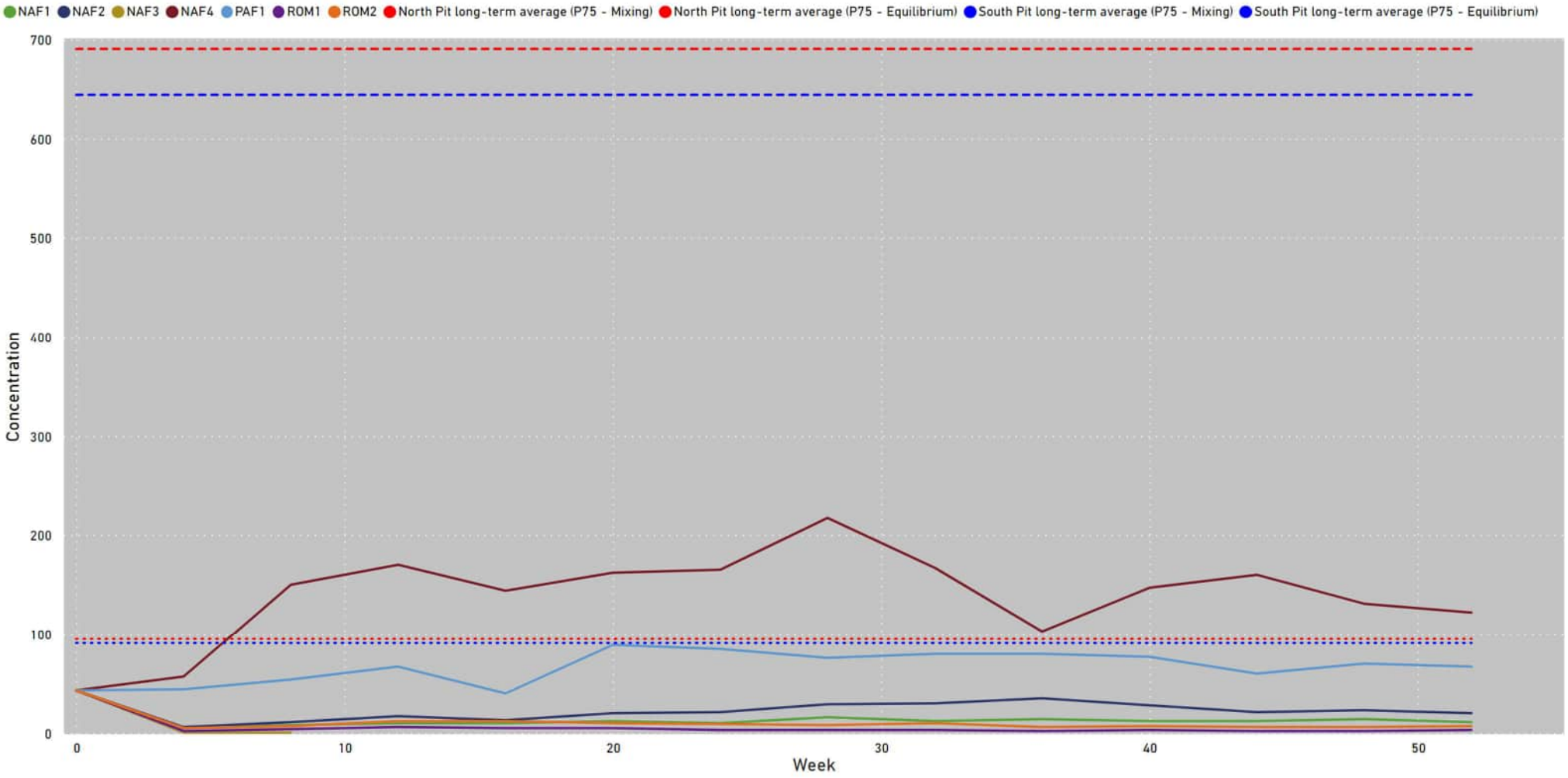
Parameter (Units)

Ba (mg/L)



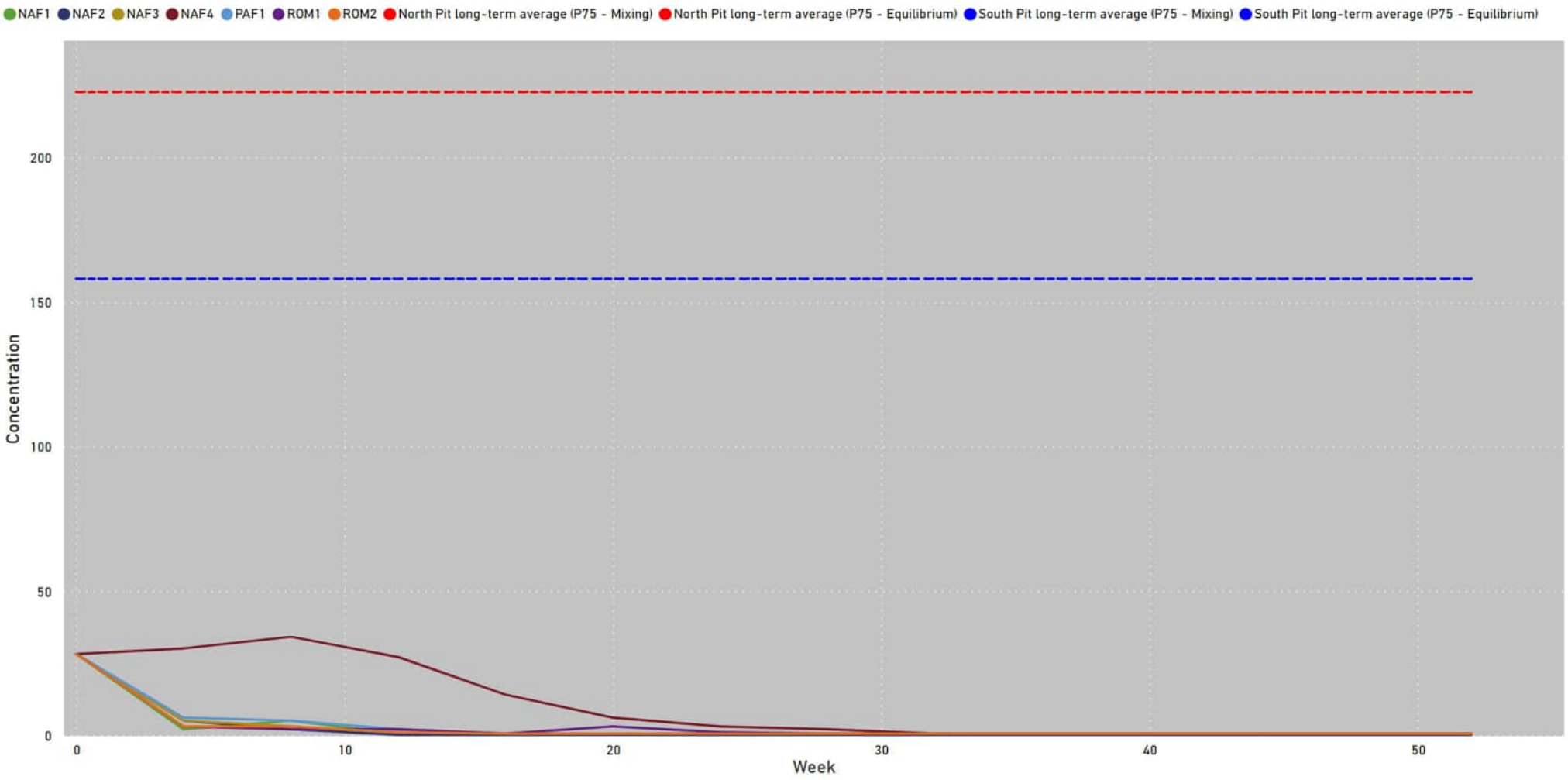
Parameter (Units)

Ca (mg/L)



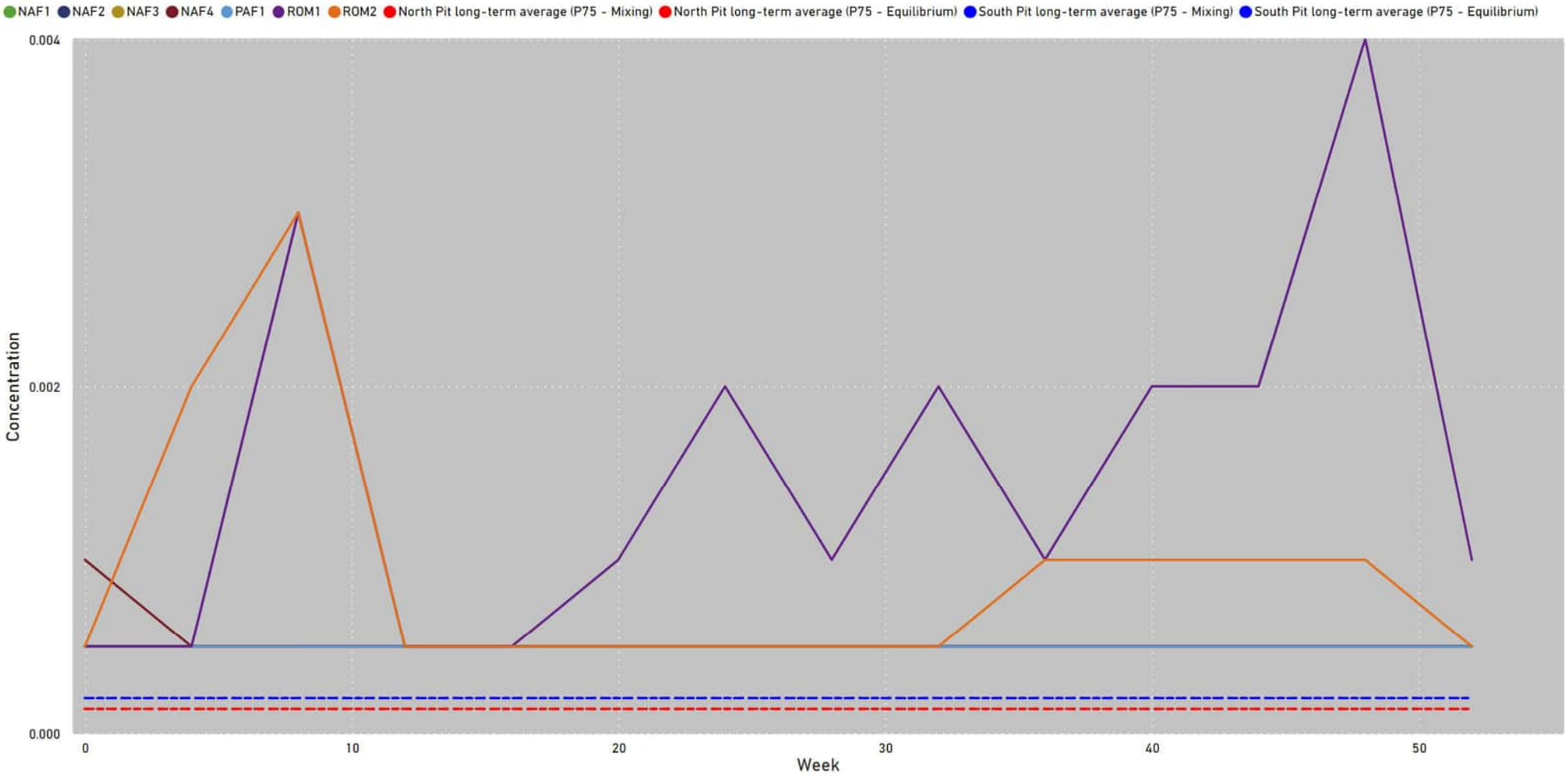
Parameter (Units)

Cl (mg/L)



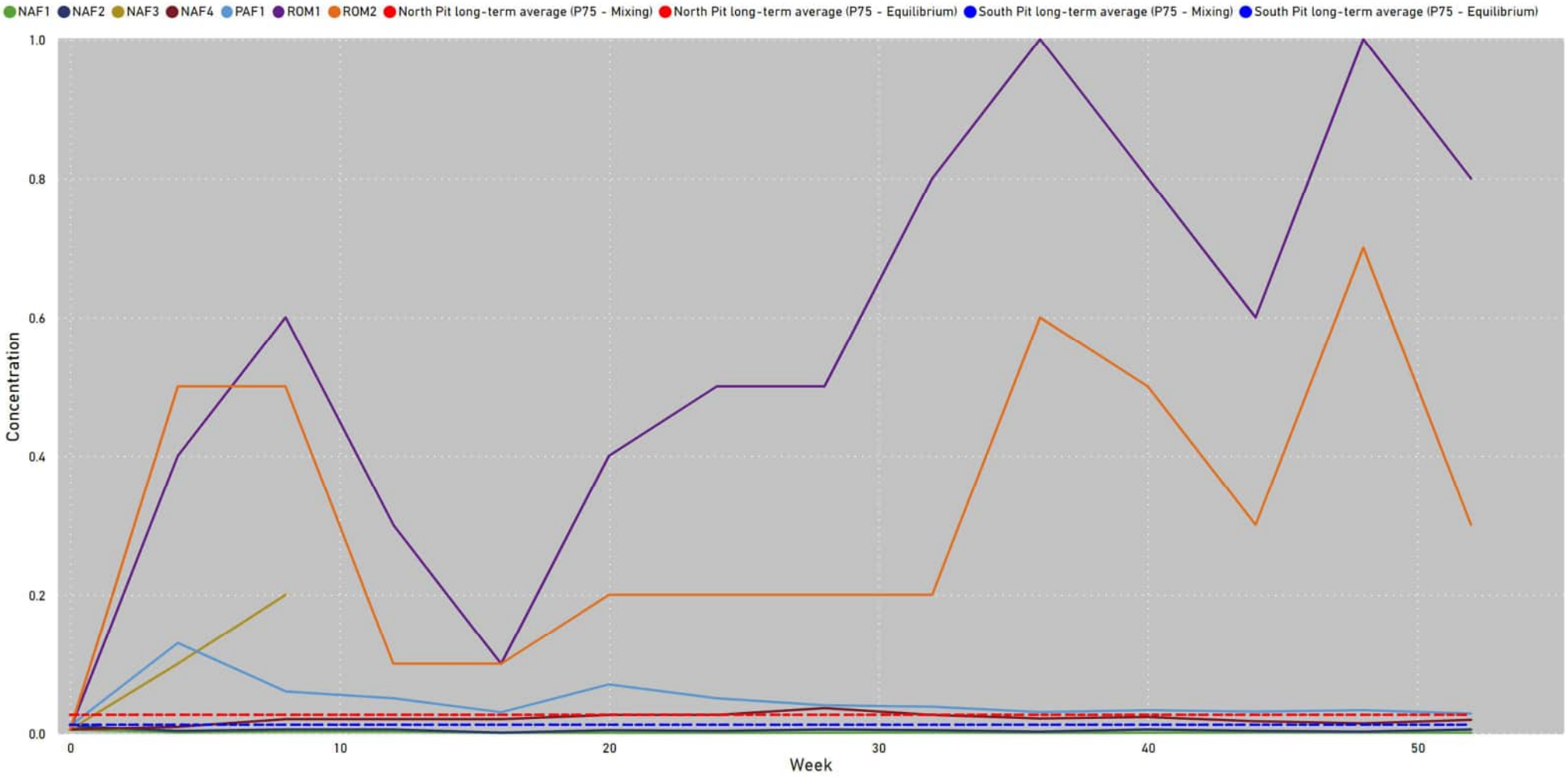
Parameter (Units)

Cr (mg/L)



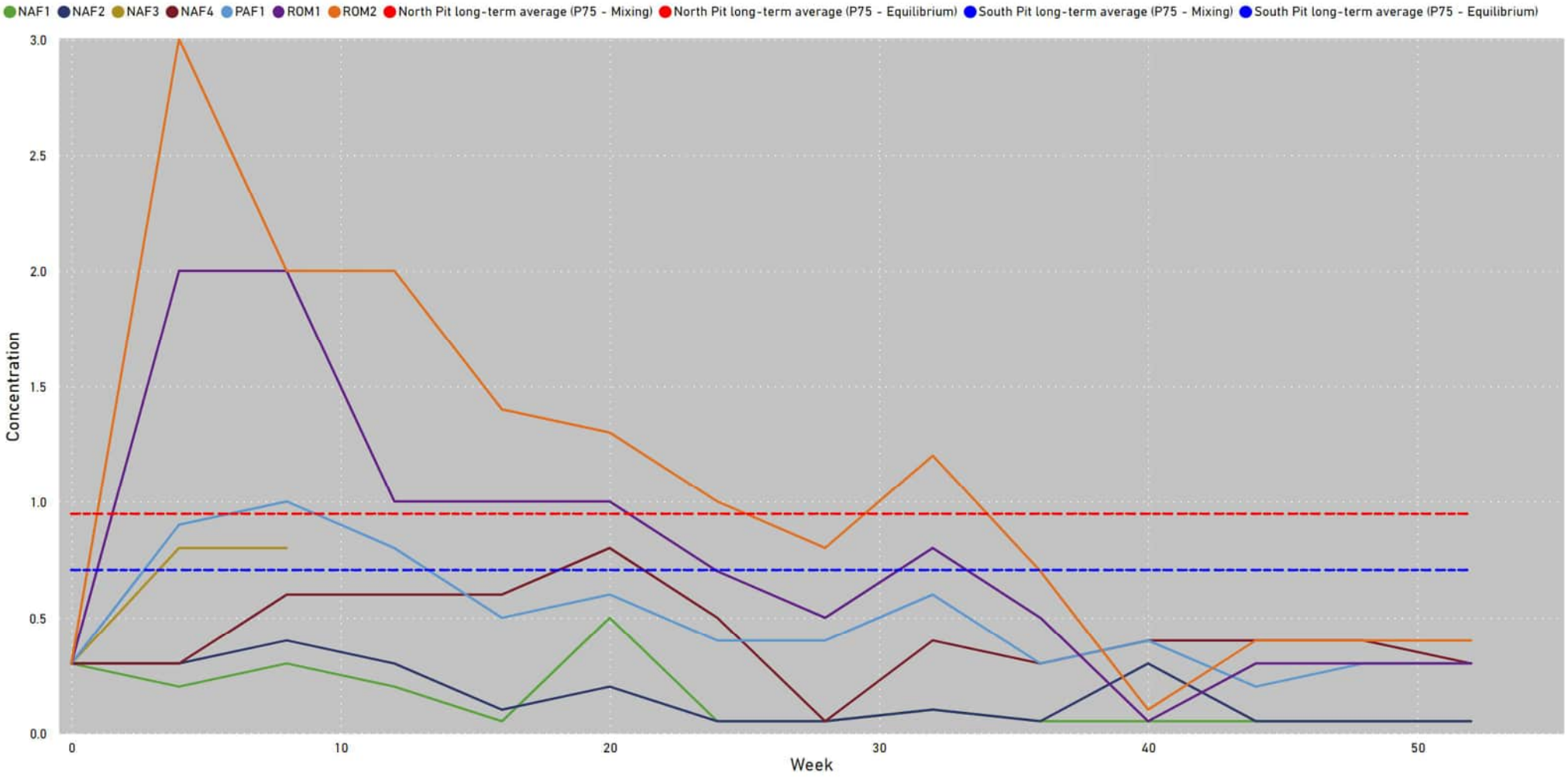
Parameter (Units)

Cu (mg/L)



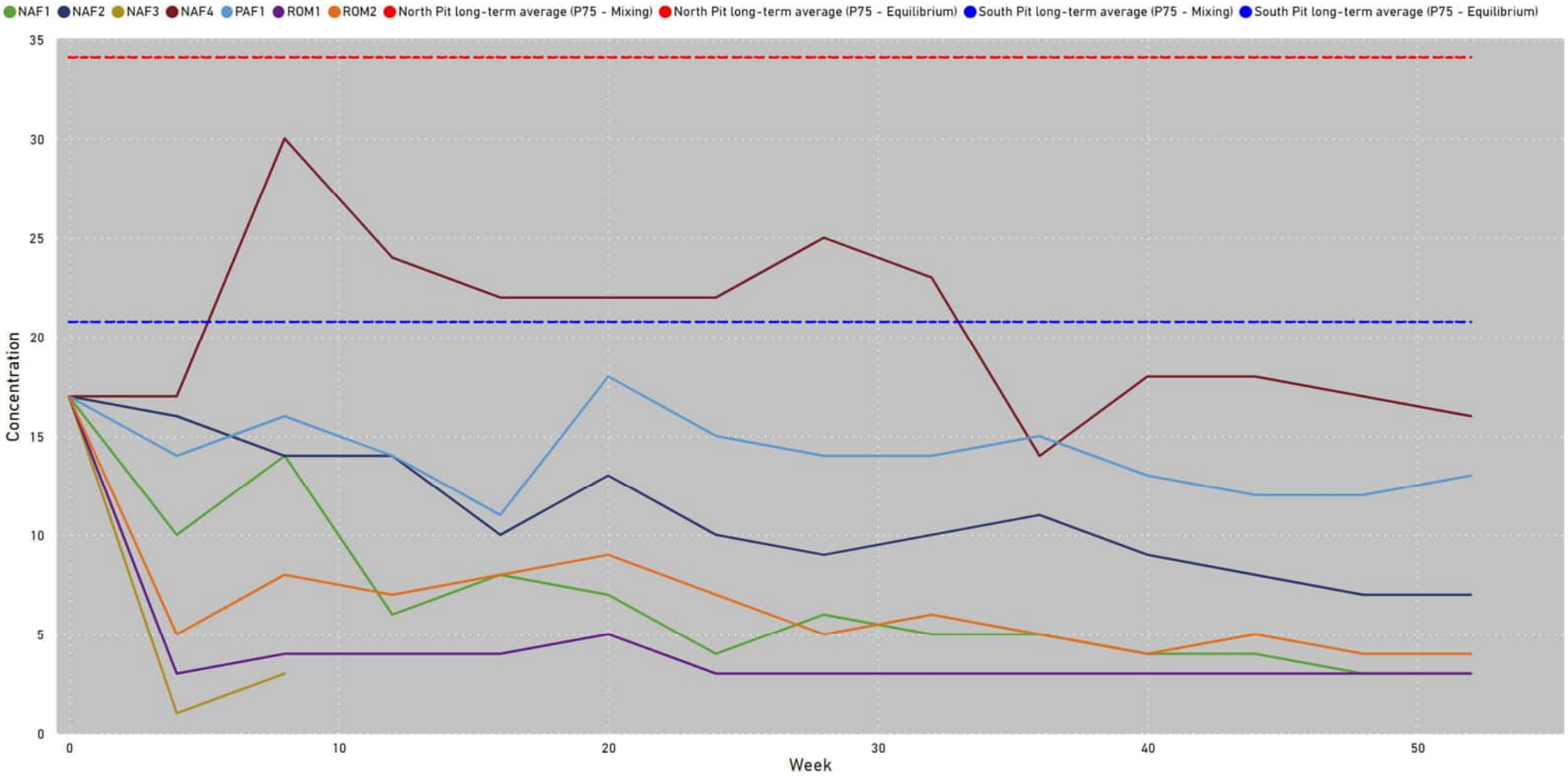
Parameter (Units)

F (mg/L)



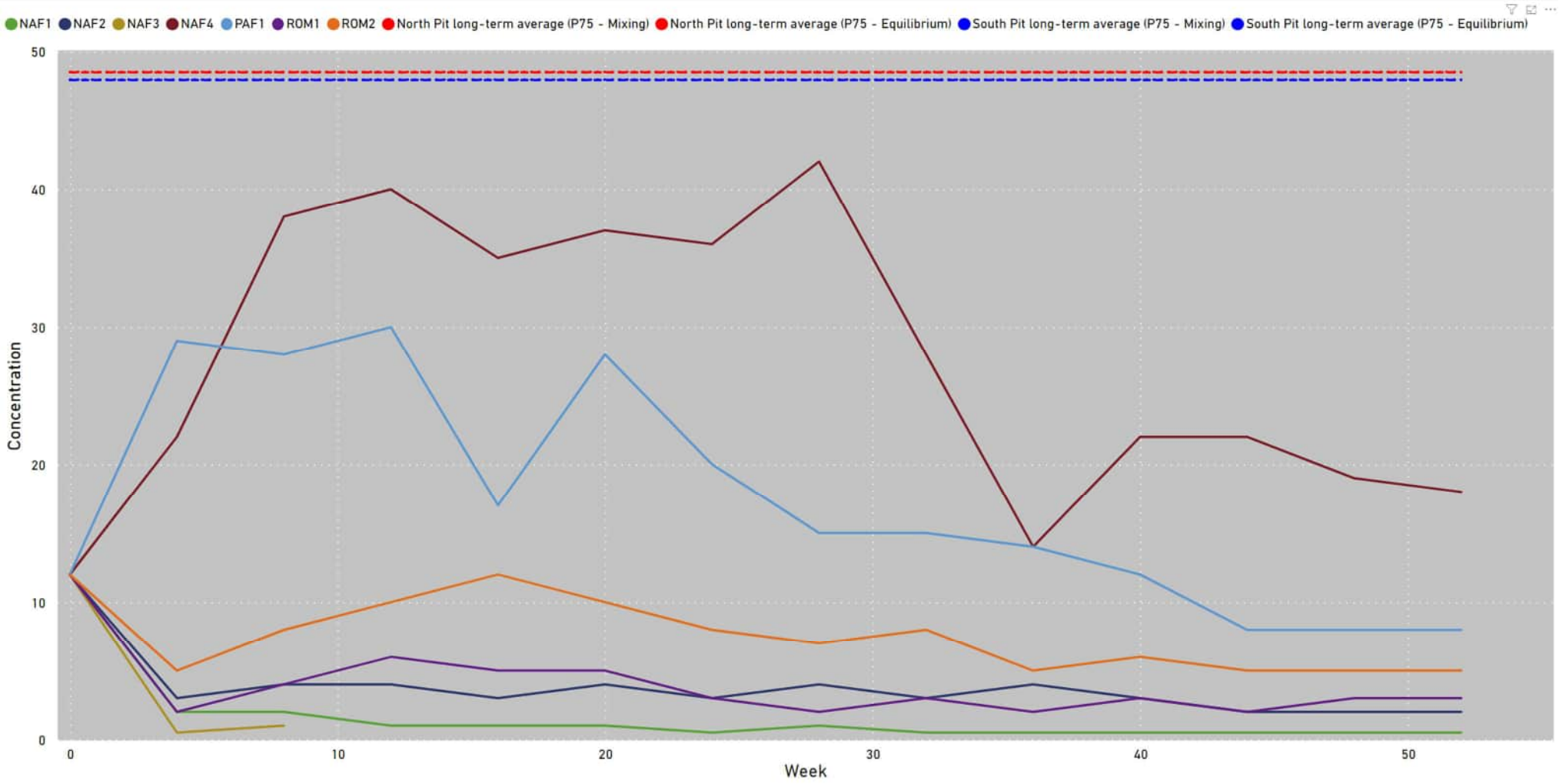
Parameter (Units)

K (mg/L)



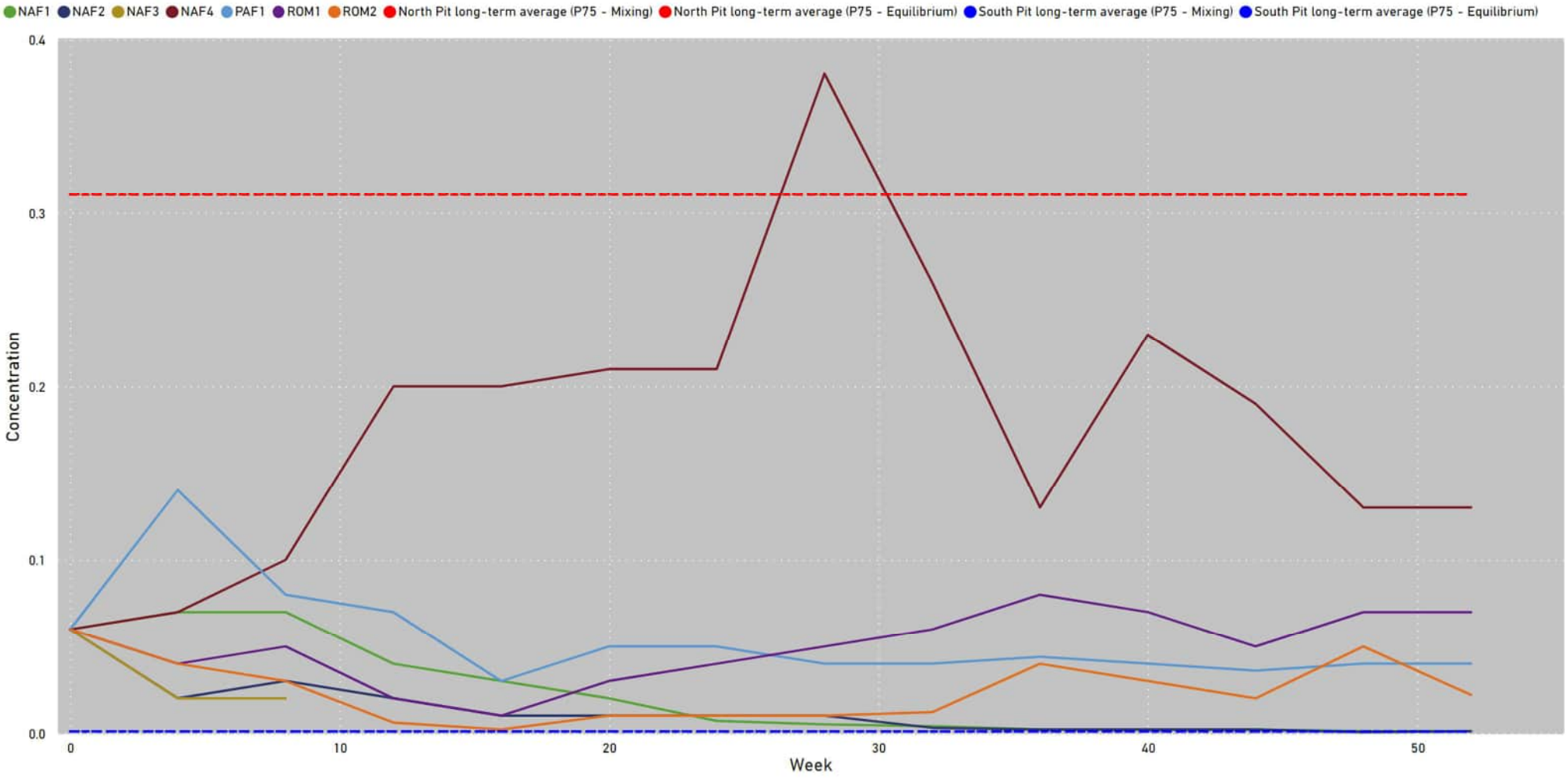
Parameter (Units)

Mg (mg/L)



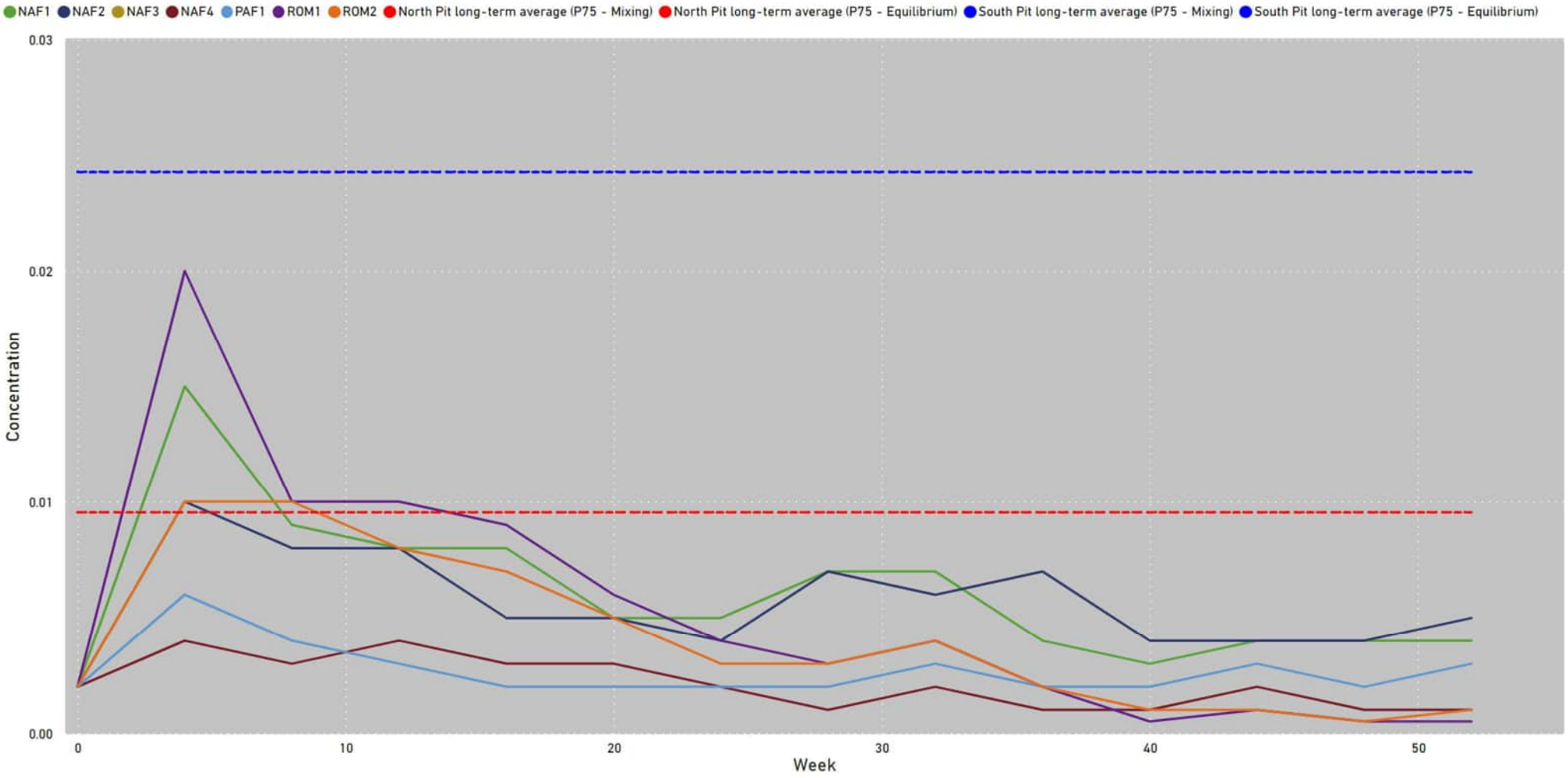
Parameter (Units)

Mn (mg/L)



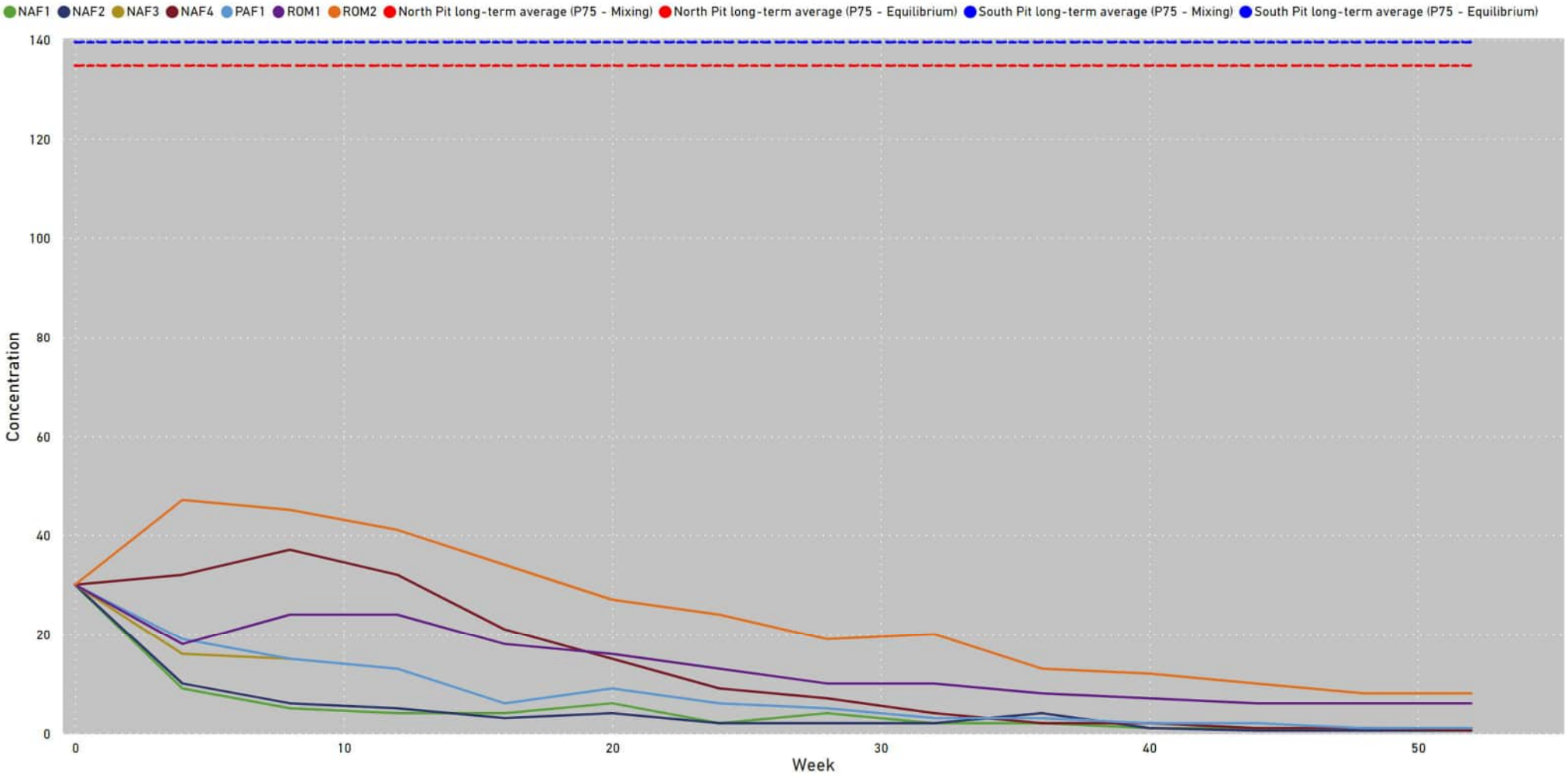
Parameter (Units)

Mo (mg/L)



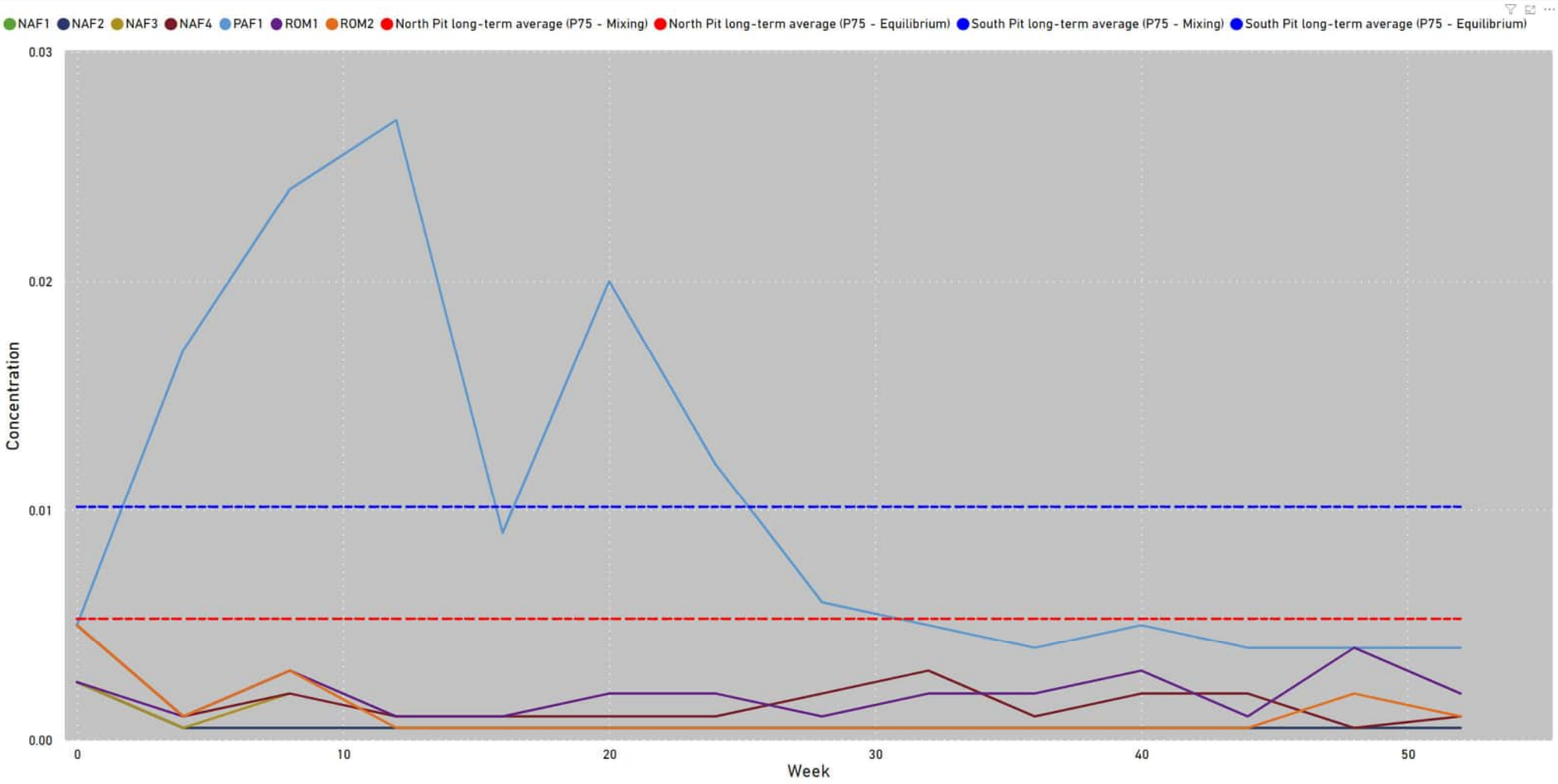
Parameter (Units)

Na (mg/L)



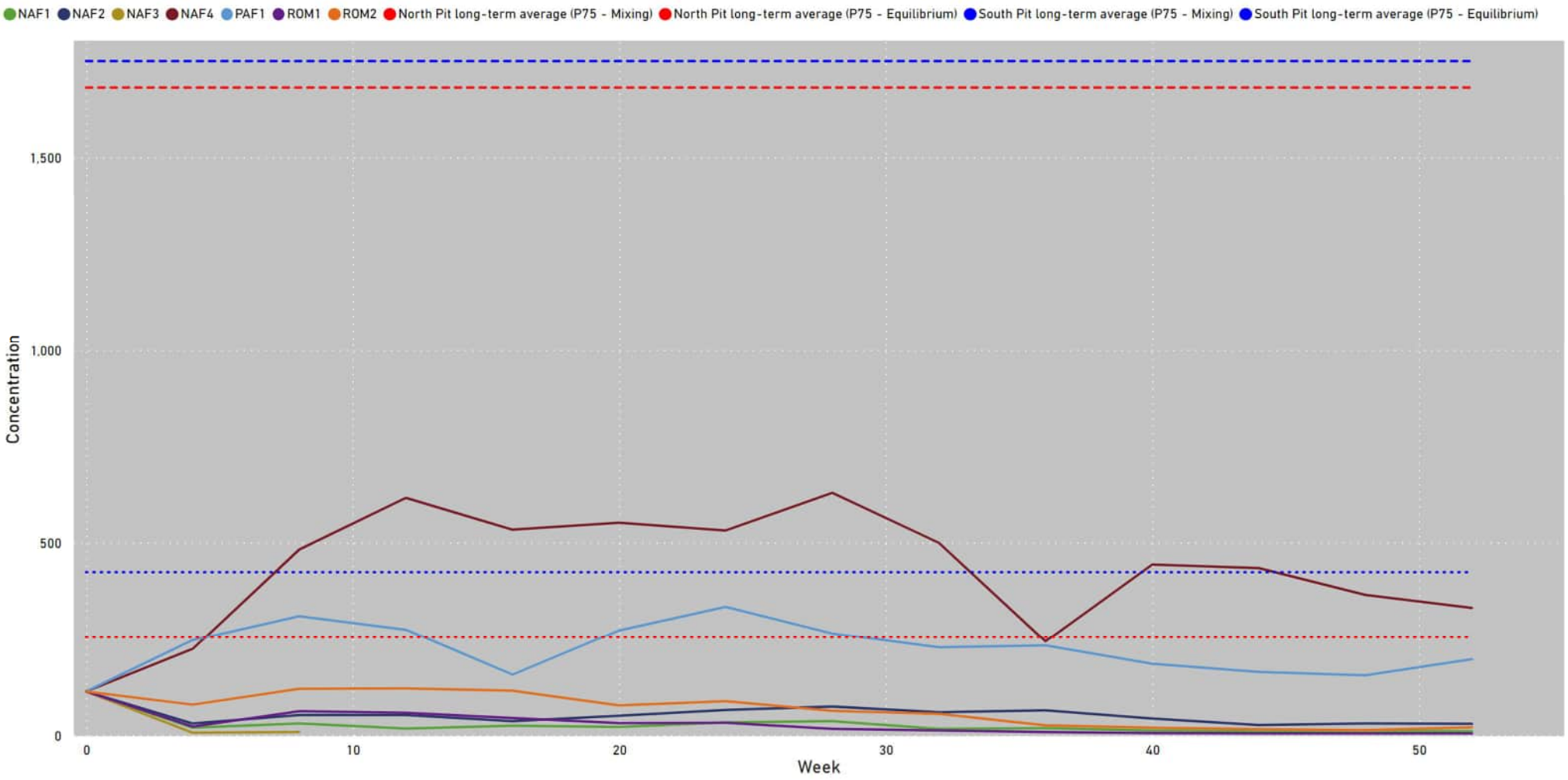
Parameter (Units)

Ni (mg/L)



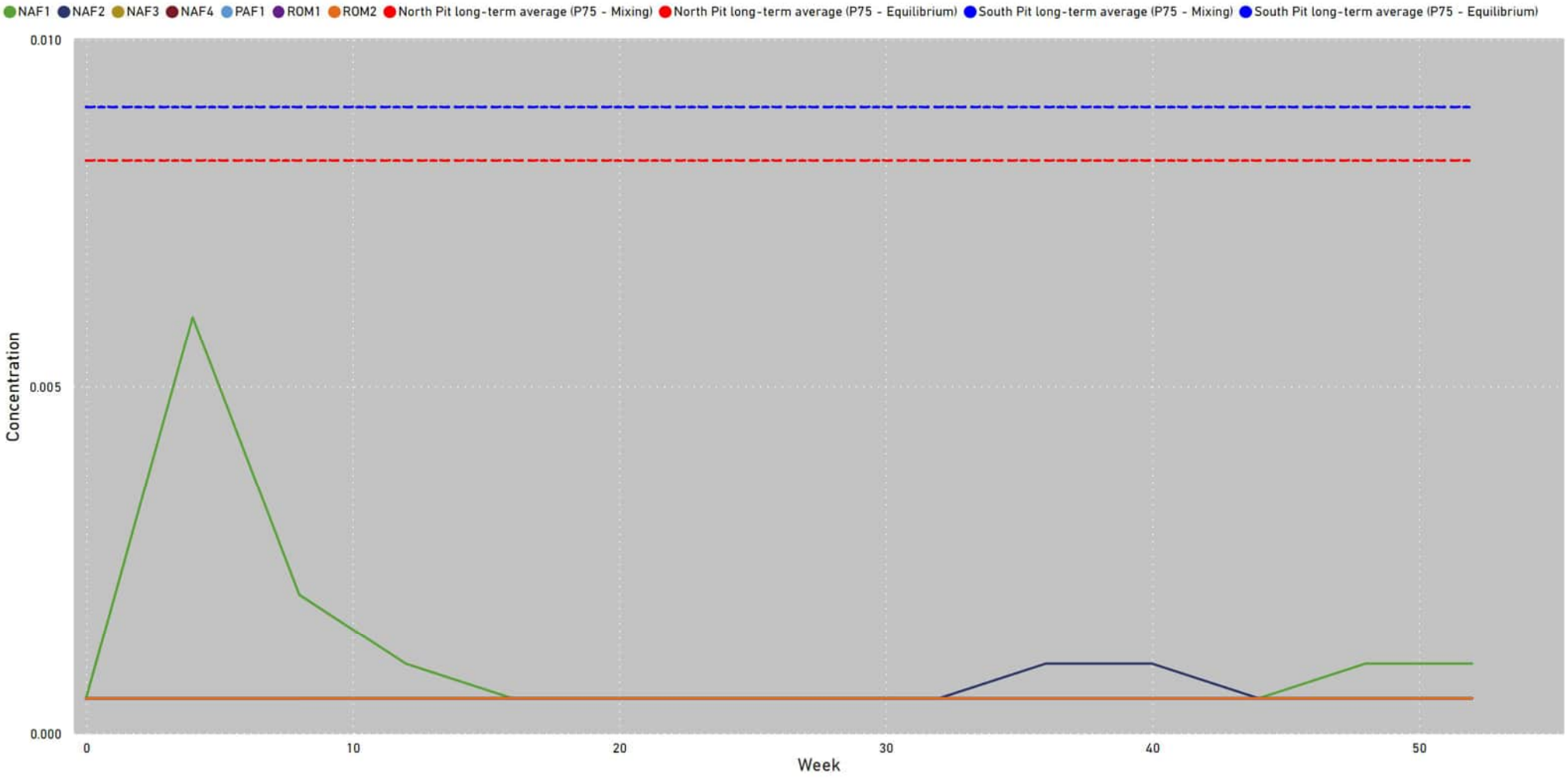
Parameter (Units)

SO4 (mg/L)



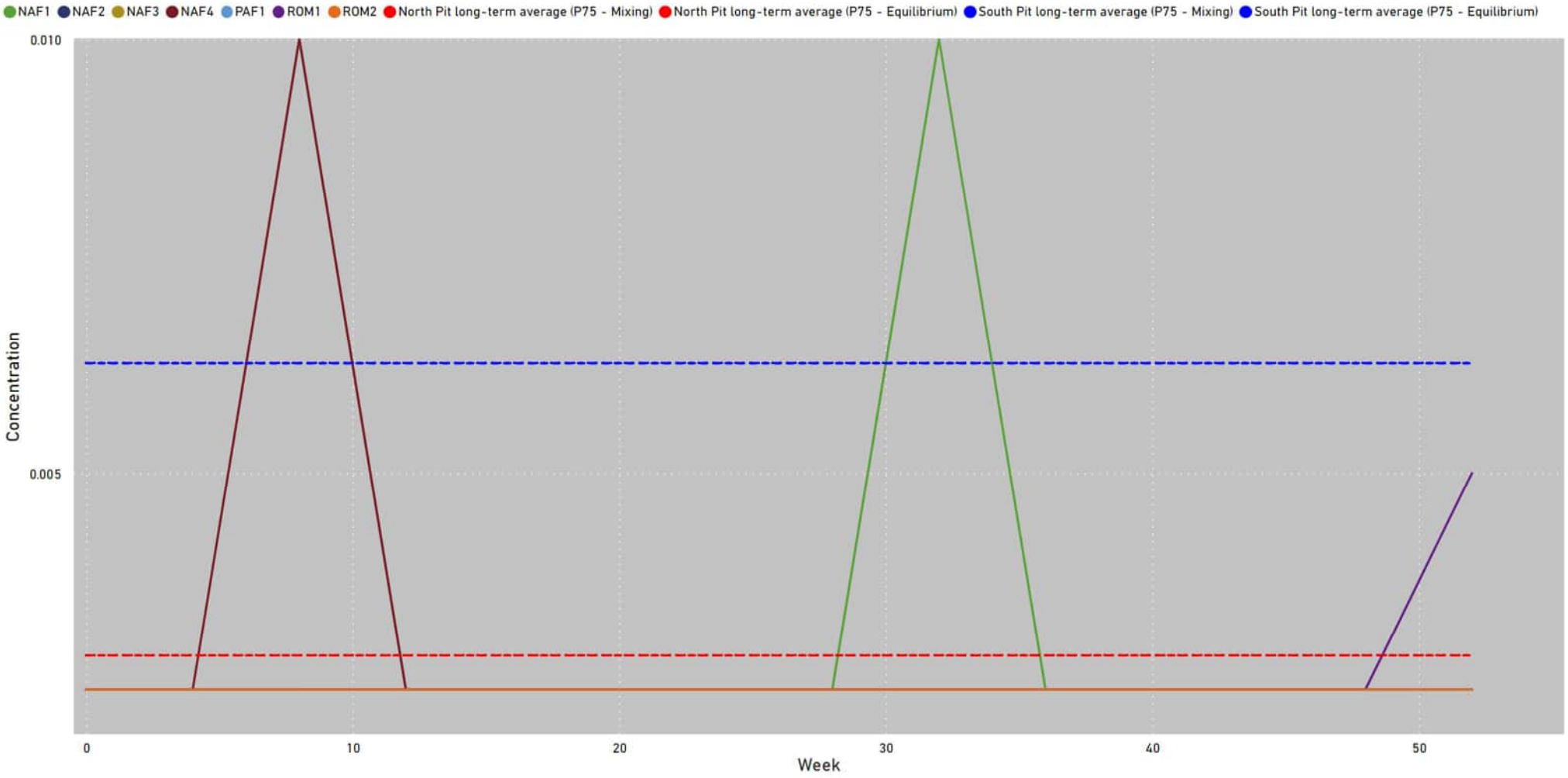
Parameter (Units)

U (mg/L)



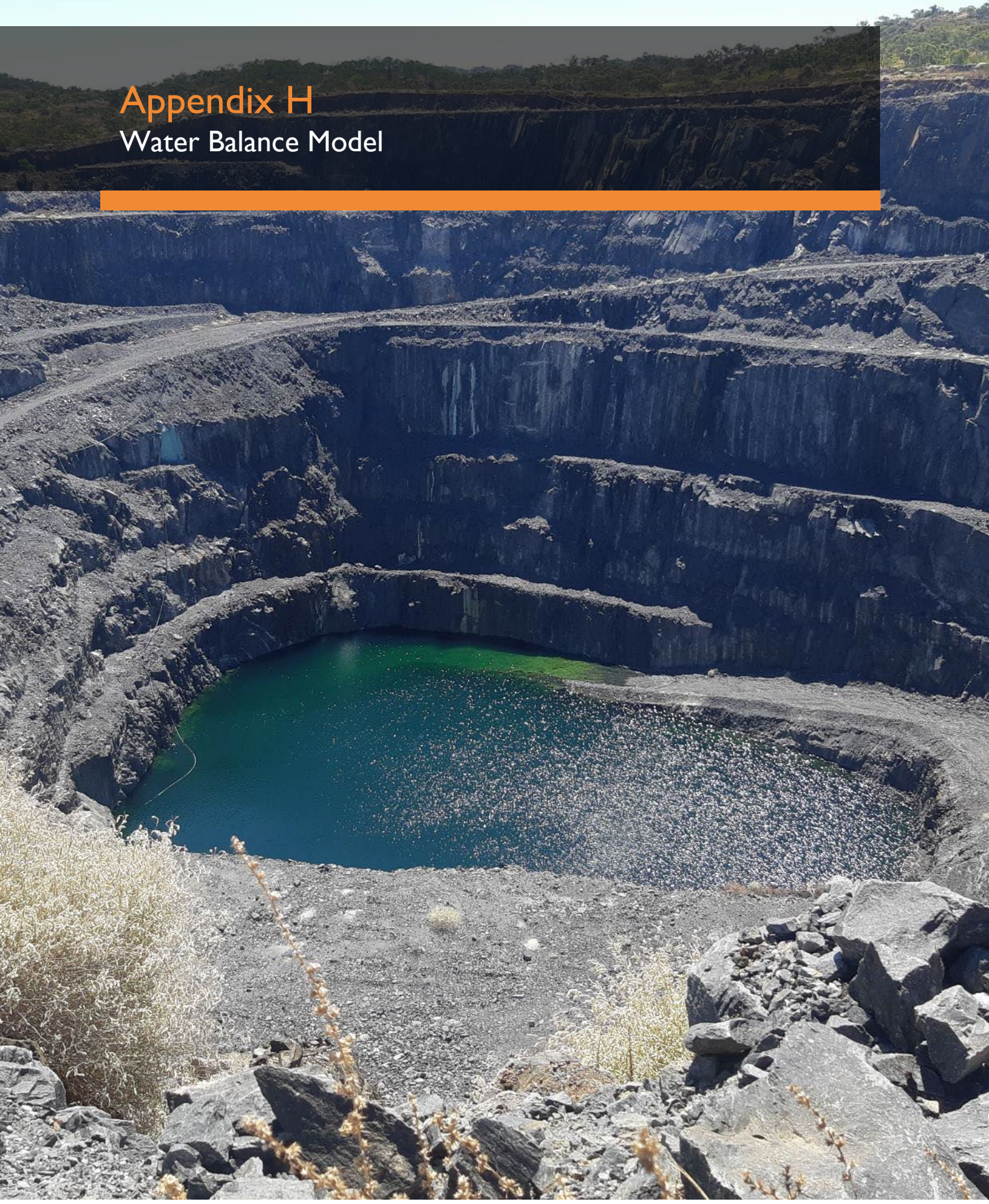
Parameter (Units)

Zn (mg/L)



This page is intentionally blank.

Appendix H
Water Balance Model



REPORT

AERIS RESOURCES LIMITED

Barbara Copper Project
WMP Update for Underground Workings – Water Balance Model

118131.16.R03
MARCH 2024

TAILINGS.WATER.WASTE.

Document Control

Project Name:	Barbara Copper Project
Document Title:	WMP Update for Underground Workings – Water Balance Model
File Location:	M:\Synergy\Projects\118\118131 Barbara Copper Project\16 WMP Update for Underground\Documents\R03 - WBM\Text\118131.16.R03_Rev0.docx
Document Number:	118131.16.R03_Rev0

Revision History

Revision	Issue	Issue Date	Prepared by	Reviewed by
A	Draft Issue	22 February 2024	James Parker	Nicola Logan
0	Final Issue	1 March 2024	James Parker	Nicola Logan

Issue Register

Distribution List	Date
Aeris Resources, WMV Environmental	22 February 2024, 1 March 2024

ATC Williams Company Details

Prepared By:	James Parker
Approved By:	Nicola Logan
Address:	Ground Floor, 16-20 Edmondstone Street, Newmarket QLD 4051
Tel:	07 3352 7222
Email:	brisbane@atcwilliams.com.au

© ATC Williams Pty Ltd (ATCW). All rights reserved.

ATCW has prepared this document solely for the use of the person or company to whom it is addressed, each as expressly stated in the document. No other party should rely on this document without the prior written consent of ATCW. No responsibility or liability to any third party is accepted for any damages howsoever arising out of the use of this report by any third party.

Your attention is drawn to Conditions of Report attached to this document. These conditions are an integral part of the document and must be reproduced with every copy.

TAILINGS.WATER.WASTE.

CONTENTS

1 INTRODUCTION 1

1.1 Background 1
1.2 Outcomes 1

2 WATER BALANCE MODEL 2

2.1 Water Balance Model Development 2
2.2 Model Structure and Inputs 2
2.2.1 Climatic Data 3
2.2.2 Catchment Delineation 3
2.2.3 Groundwater Inflows 4
2.2.4 Storage Curve Data and Initial Conditions 8
2.2.5 Initial Storage Conditions 12
2.2.6 Pump Transfers and Source Priority 12
2.2.7 Site Water Demands 12
2.2.8 South Pit and Underground Workings Interaction 13
2.2.9 Simulation Period 13
2.3 Model Development 13

3 RESULTS 15

3.1 South Pit 15
3.2 Underground Workings 17
3.3 North Pit 19
3.4 WRD Sediment Dam 21

4 SUMMARY AND CONCLUSION 24

REFERENCES 25

TAILINGS.WATER.WASTE.

TABLES

TABLE 1: SITE WATER BALANCE – RAINFALL AND EVAPORATION INPUT DATA 3
TABLE 2: CATCHMENT DETAILS 3
TABLE 3: NORTH PIT GROUNDWATER INFLOW ESTIMATES 5
TABLE 4: SOUTH PIT GROUNDWATER INFLOW ESTIMATES 6
TABLE 5: UNDERGROUND WORKINGS GROUNDWATER INFLOW ESTIMATES 7
TABLE 6: INITIAL WATER STORAGE INPUTS 12
TABLE 7: PUMP TRANSFER CONFIGURATION 12
TABLE 8: AWBM MODEL PARAMETERS 14

DIAGRAMS

DIAGRAM 1: WATER BALANCE MODEL PROCESS FLOW DIAGRAM 2
DIAGRAM 2: CATCHMENT DELINEATION 4
DIAGRAM 3: NORTH PIT STORAGE CURVE 9
DIAGRAM 4: SOUTH PIT STORAGE CURVE 9
DIAGRAM 5: WRD SEDIMENT DAM STORAGE CURVE 10
DIAGRAM 6: UNDERGROUND WORKINGS –ESTIMATED STORAGE CURVE 11
DIAGRAM 7: UNDERGROUND WORKINGS – NET STORAGE OVER TIME 11
DIAGRAM 8: AWBM FOR RUNOFF CALCULATIONS 13
DIAGRAM 9: SOUTH PIT WATER SURFACE ELEVATION (2025 TO 2050) 15
DIAGRAM 10: SOUTH PIT WATER SURFACE ELEVATION (2025 TO 2029) 16
DIAGRAM 11: SOUTH PIT ACCUMULATED GROUNDWATER INFLOWS 16
DIAGRAM 12: SOUTH PIT PUMP FLOW TO UG 17
DIAGRAM 13: UNDERGROUND WORKINGS ACCUMULATED VOLUMES 18
DIAGRAM 14: UNDERGROUND WORKINGS GROUNDWATER INFLOWS 18
DIAGRAM 15: NORTH PIT WATER SURFACE ELEVATION (2025 TO 2050) 19
DIAGRAM 16: NORTH PIT WATER SURFACE ELEVATION (2025 TO 2029) 20
DIAGRAM 17: NORTH PIT ACCUMULATED GROUNDWATER INFLOWS 20
DIAGRAM 19: NORTH PIT PUMP FLOWS TO UG 21
DIAGRAM 20: WRD SEDIMENT DAM WATER SURFACE ELEVATION (2025 T0 2050) 22
DIAGRAM 21: WRD SEDIMENT DAM WATER SURFACE ELEVATION (2025 T0 2029) 22
DIAGRAM 22: CUMMULATIVE PUMP FLOWS TO SOUTH PIT 23
DIAGRAM 23: WRD SEDIMENT DAMPUMP FLOWS TO UG 23

TAILINGS.WATER.WASTE.

1 INTRODUCTION

1.1 Background

The purpose of this report is to provide a summary of the operational water balance model (WBM) to support an EA amendment at the Barbara Copper Project (BCP). The BCP is currently in care and maintenance (C&M), pending technical investigations to allow for the re-commencement of mineral ore extraction by means of proposed new Underground Workings (UG). This would be accessed via a new portal located within the South Pit.

1.2 Outcomes

The intention of the operational WBM is to provide guidance on the following:

- Time taken to dewater to South Pit to allow for ore extraction at the base of the South Pit (Crown Pillar).
- Estimation of total groundwater entering the North Pit, South Pit and Underground Workings.
- Identify conditions under which the site has the potential to be in a water deficit.

TAILINGS.WATER.WASTE.

2 WATER BALANCE MODEL

2.1 Water Balance Model Development

A water balance model was developed using GoldSim Pro (GoldSim V14.0) to assess the impacts of:

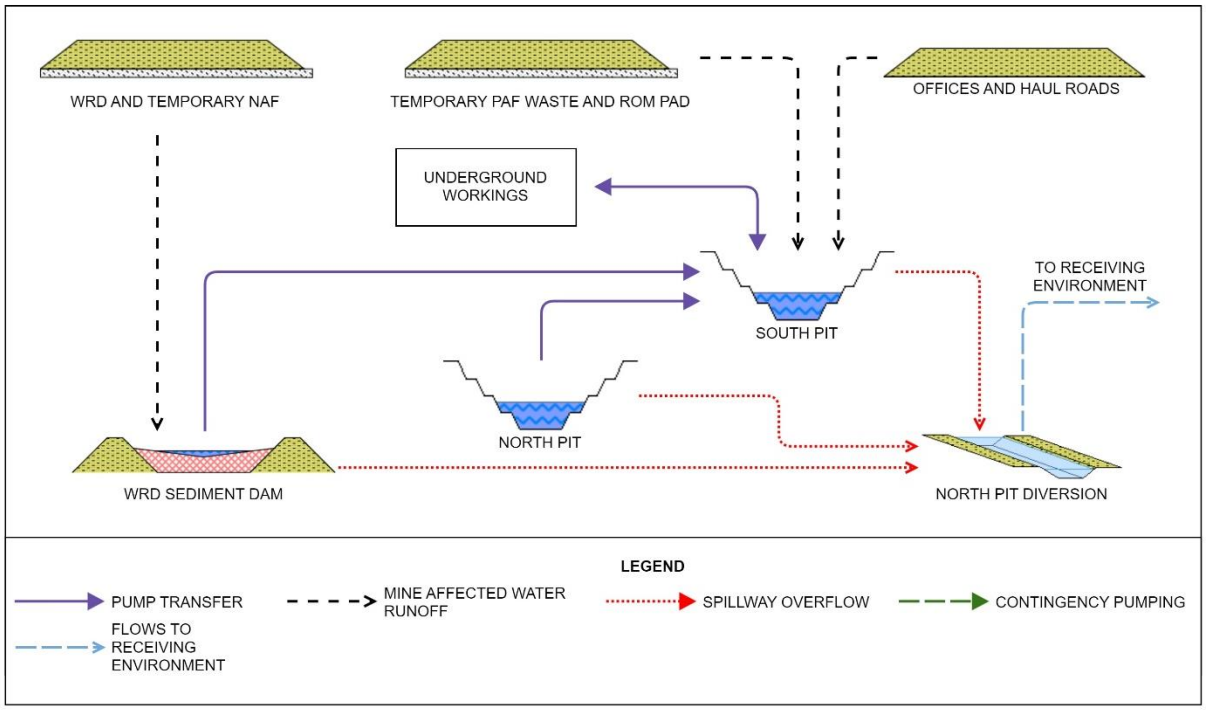
- surface water runoff, (both mine impacted and non-impacted).
- evaporation and groundwater inflows to the Pit.
- groundwater into the Underground Workings.
- surface water from the Pit to the underground working via the stopes at the base of the Pit and the backfilled Portal.

GoldSim is a dynamic probabilistic simulation program, which uses a range of parameters to represent the catchment surface water system. Simulations are then run using a time series of daily rainfall data to estimate the balance of water across the modelled water system over time and a range of climate conditions. The water balance model reflects the effects of stormwater runoff, evaporation, and groundwater inflows/outflows at the site.

2.2 Model Structure and Inputs

The process flow diagram for the BCP site is depicted in **Diagram 1,** representing the major water pathways at site. For clarity, **Diagram 1** does not depict rainfall, evaporation, or groundwater interactions, although these have been included in the modelling. Primary water balance inputs applying to each of the elements in the model development are described in the following sub-sections.

DIAGRAM 1: WATER BALANCE MODEL PROCESS FLOW DIAGRAM



TAILINGS.WATER.WASTE.

2.2.1 Climatic Data

Climate data specific to the site was obtained from the SILO Data-drill **[1]**. The key parameters from the data-drill are explained in **Table 1**.

TABLE 1: SITE WATER BALANCE – RAINFALL AND EVAPORATION INPUT DATA

Climate Data	Data Source	Comments
Daily Rainfall Rate (mm/day)	Rainfall data obtained from the SILO Data Drill Program for the Site Location (1889 - 2024)	Applied over dam surface areas, and as an input parameter for the estimation of surface runoff (AWBM).
Daily Evaporation Rate (mm/day)	Continuous record from SILO Data Drill formed by conjoining: CLIMARC estimates (1889 – 1957) and Class A Evaporation Data from proximate weather stations within the region (1889 – 2024).	Evaporation Data is scaled by evaporation factors for each site storage to reflect water storage conditions and expected water quality.
Daily Evapo-Transpiration Rate (mm/day)	As calculated by the FAO short crop reference methodology, assuming a wind speed of 2 m/s.	Potential evapo-transpiration is calculated based on temperature, vapour pressure and solar global exposure parameters derived from climatic data and is adopted as a reasonable estimate of potential evapotranspiration losses from ground surfaces within the model.

2.2.2 Catchment Delineation

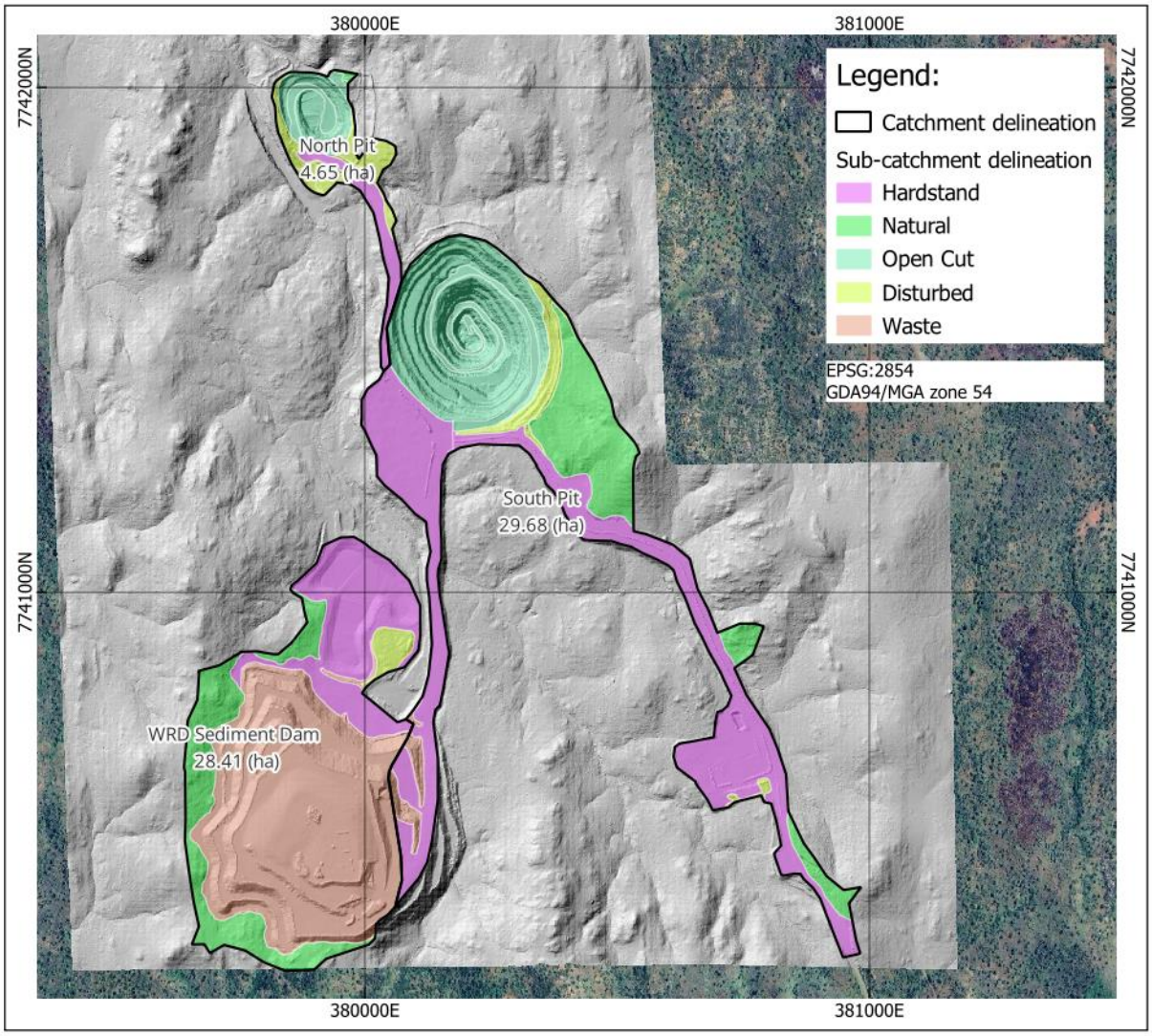
Catchment delineation and estimation was performed using survey data and aerial photography. The catchments are depicted in **Diagram 2**. **Table 2** provides a summary of the catchment areas which were used to inform the AWBM generation of surface runoff volumes.

TABLE 2: CATCHMENT DETAILS

Surface Runoff Type	Catchments (ha)		
	North Pit	South Pit	WRD Sediment Dam
Natural (Undisturbed)	0.05	5.30	4.80
Disturbed	1.51	1.30	0.61
Hardstand	1.15	13.07	5.66
Open Cut	1.94	9.29	-
Waste	0.00	0.71	17.33
Surface Water Area (at full supply)	1.50	8.20	3.00
Catchment Area	4.65	29.68	28.41

TAILINGS.WATER.WASTE.

DIAGRAM 2: CATCHMENT DELINEATION



2.2.3 Groundwater Inflows

Groundwater interaction with the North Pit, South Pit and UG Workings is considered likely to occur. Inflows to the North Pit, South Pit and UG Workings from the surrounding groundwater systems could occur, with the direction of flow determined by the pit water level compared to the aquifer phreatic head. It is possible that the pit voids could spill during periods of significant rainfall, depending on their initial water level prior to the rainfall event/s.

Detailed groundwater inflow estimates were undertaken by WMV Environmental **[2]** for operational conditions, where active dewatering occurs, and under recovery conditions, where dewatering ceases and groundwater begins to return to 'pre-operational' levels.

Active dewatering occurs from 01/01/2025, when the Underground Workings will commence, to 31/10/2029, when the Underground Workings will cease, and the groundwater conditions will start recovering.

The groundwater flow estimates for the North Pit, South Pit and Underground Workings for operational and recovery scenarios are reproduced in **Table 3** to **Table 5**. Additionally, groundwater flow estimates for the Underground Workings (**Table 5**) contain the projected dates when these inflow rates are expected to occur. Full details can be found in WMV Environmental' s 'Groundwater Technical Report' **[3]**. The South Pit was determined to be a regional groundwater sink.

TAILINGS.WATER.WASTE.

As noted by WMV **[3]**, the estimates of groundwater inflow to the Pit and Underground Workings represent the groundwater that resided in the orebody prior to mining, with long term natural recharge expected to be much slower. As such, the inflows estimates are considered to be conservative.

TABLE 3: NORTH PIT GROUNDWATER INFLOW ESTIMATES

Elevation (m AHD)	Operational Conditions - Groundwater Inflow (L/s)	Recovery Conditions - Groundwater Inflow (L/s)
316	0.064	0.021
314	0.060	0.024
312	0.058	0.027
310	0.052	0.028
308	0.048	0.030
306	0.046	0.031
304	0.043	0.032
302	0.041	0.033
300	0.039	0.033
298	0.037	0.034
296	0.034	0.033
295	0.019	0.018

TAILINGS.WATER.WASTE.

TABLE 4: SOUTH PIT GROUNDWATER INFLOW ESTIMATES

Elevation (m AHD)	Operational Conditions - Groundwater Inflow (L/s)	Recovery Conditions - Groundwater Inflow (L/s)
334	0.612	0.031
330	0.595	0.050
325	0.578	0.073
320	0.545	0.092
315	0.522	0.110
310	0.498	0.126
305	0.469	0.138
300	0.429	0.145
295	0.403	0.154
290	0.392	0.164
285	0.380	0.174
280	0.342	0.171
275	0.315	0.171
270	0.302	0.176
265	0.288	0.178
260	0.268	0.176
255	0.246	0.171
250	0.230	0.169
245	0.217	0.167
240	0.198	0.160
235	0.178	0.151
230	0.164	0.144
225	0.149	0.136
220	0.130	0.123
215	0.072	0.071
212	0.046	0.046

TAILINGS.WATER.WASTE.

TABLE 5: UNDERGROUND WORKINGS GROUNDWATER INFLOW ESTIMATES

Elevation (m AHD)	Projected Date	Operational Conditions - Groundwater Inflow (L/s)	Recovery Conditions - Groundwater Inflow (L/s)
306	1/01/2025	0.012	0.014
291	1/02/2025	0.016	0.021
265	1/03/2025	0.023	0.029
241	1/04/2025	0.031	0.036
221	1/05/2025	0.037	0.043
200	1/06/2025	0.048	0.050
193	1/09/2025	0.051	0.058
171	1/10/2025	0.057	0.063
153	1/11/2025	0.065	0.067
146	1/12/2025	0.072	0.072
146	1/01/2026	0.075	0.080
130	1/02/2026	0.079	0.081
125	1/03/2026	0.089	0.094
112	1/08/2026	0.095	0.099
101	1/09/2026	0.100	0.103
93	1/10/2026	0.104	0.107
85	1/11/2026	0.108	0.117
64	1/12/2026	0.116	0.120
55	1/01/2027	0.121	0.129
34	1/02/2027	0.128	0.131
26	1/03/2027	0.131	0.131
21	1/04/2027	0.138	0.146
2	1/05/2027	0.199	0.199

TAILINGS.WATER.WASTE.

2.2.4 Storage Curve Data and Initial Conditions

Storage curves were derived for both North Pit, South Pit and WRD Sediment Dam from the provided survey data. The resulting storage curves are depicted in **Diagram 3**, **Diagram 4** and **Diagram 5**.

The storage volume of the Underground Workings varies over the duration of the underground campaign. The development of the underground storage capacity over time is depicted in **DIAGRAM 6**: UNDERGROUND WORKINGS –ESTIMATED STORAGE CURVE

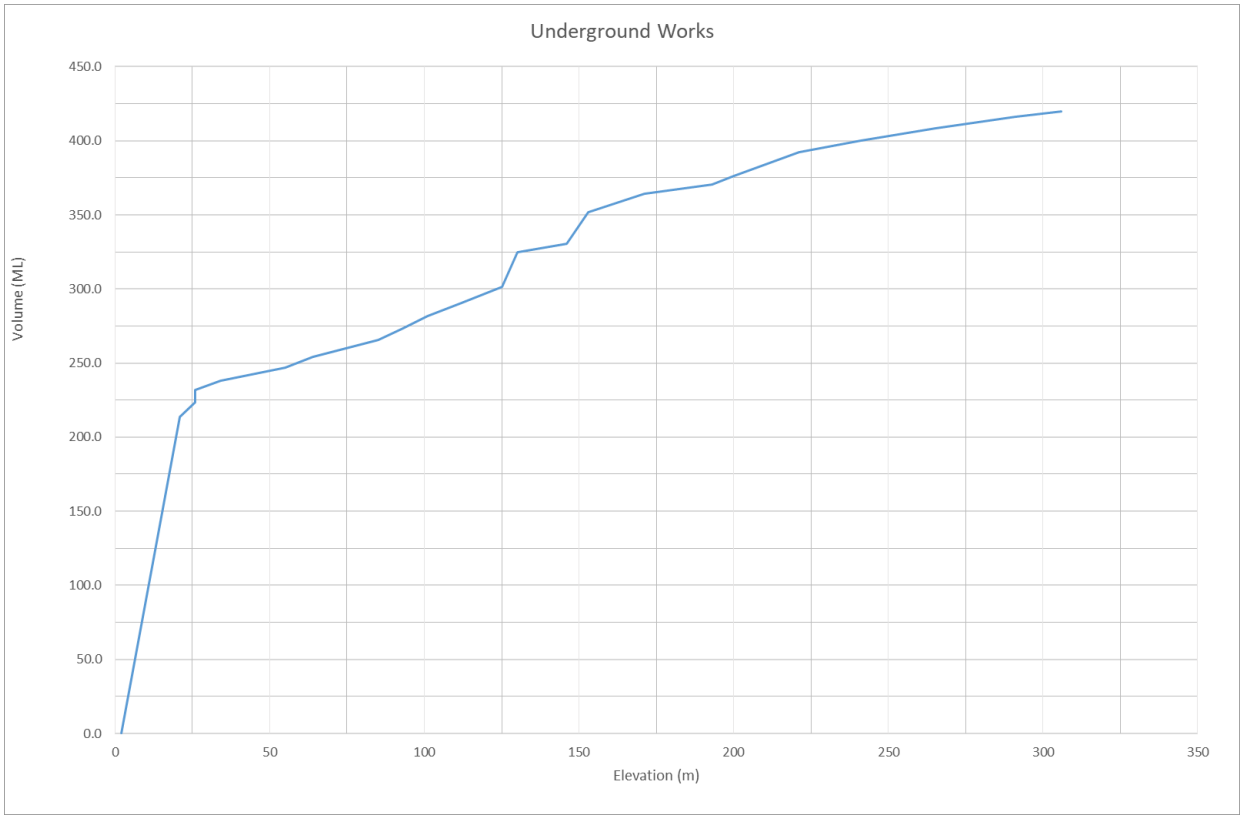


Diagram 7. The volume available in the Underground Workings comprises:

- backfilled stopes with a 30% voids ratio, representing the backfill conditions of crushed rock of various sizes. This will not occupy the entire backfilled area.
- open stopes, not backfilled with rock.

TAILINGS.WATER.WASTE.

DIAGRAM 3: NORTH PIT STORAGE CURVE

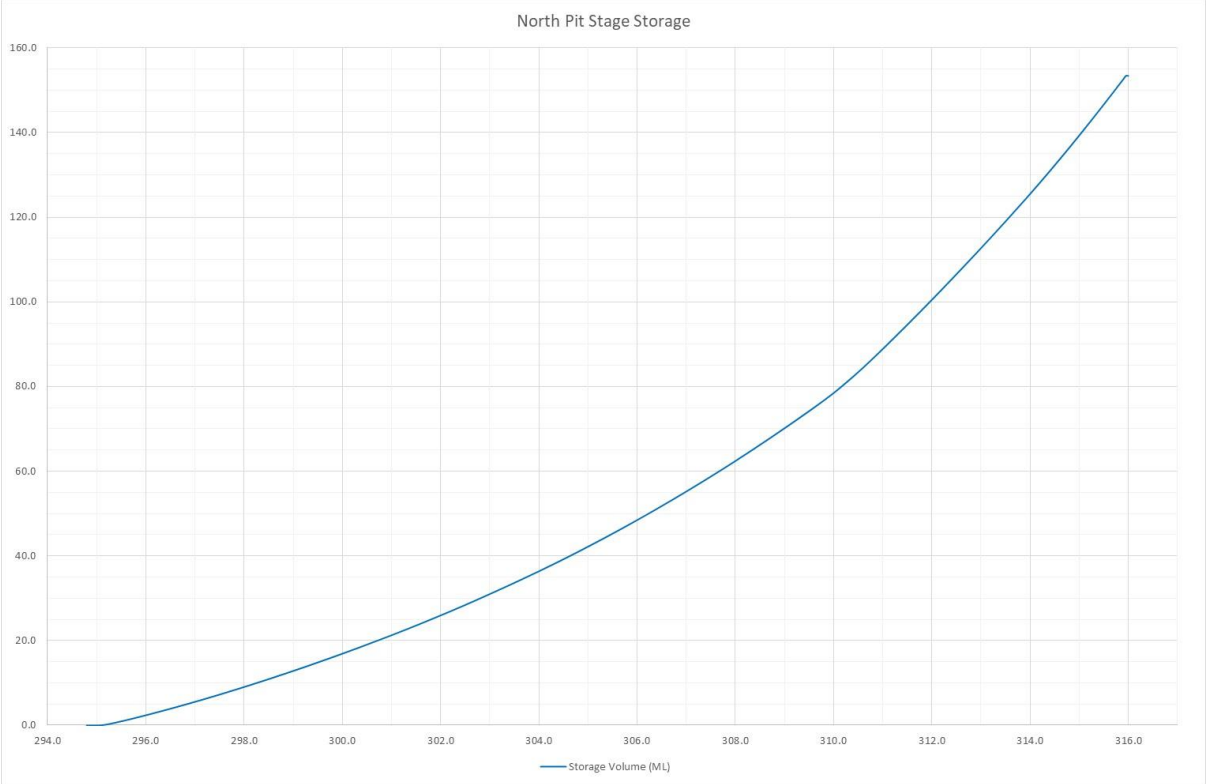
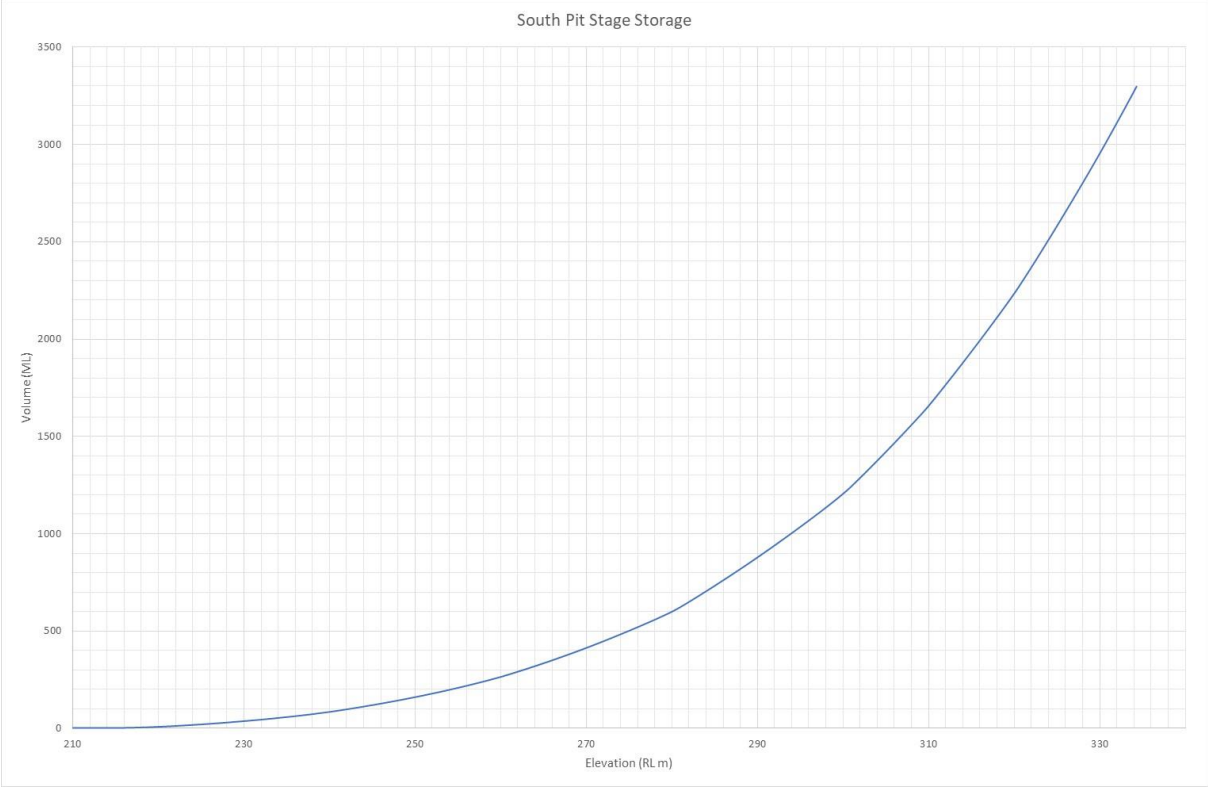
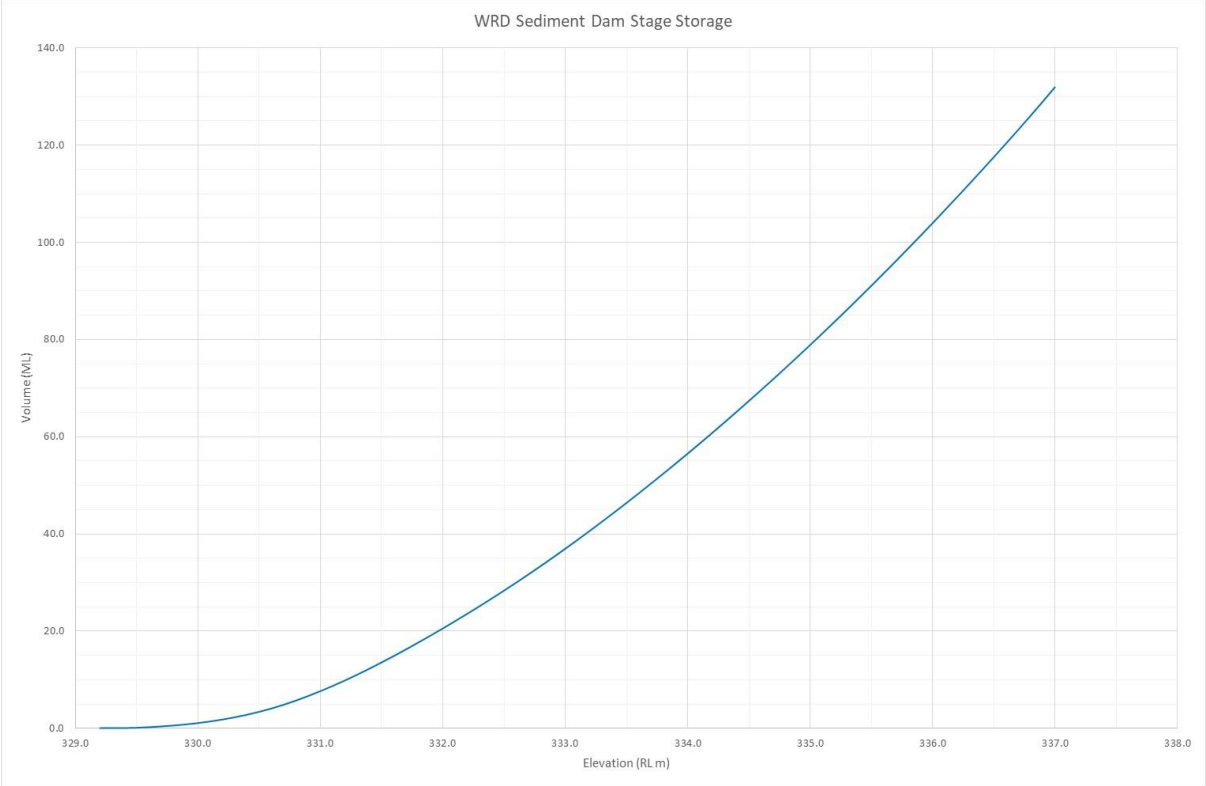


DIAGRAM 4: SOUTH PIT STORAGE CURVE



TAILINGS.WATER.WASTE.

DIAGRAM 5: WRD SEDIMENT DAM STORAGE CURVE



TAILINGS.WATER.WASTE.

DIAGRAM 6: UNDERGROUND WORKINGS –ESTIMATED STORAGE CURVE

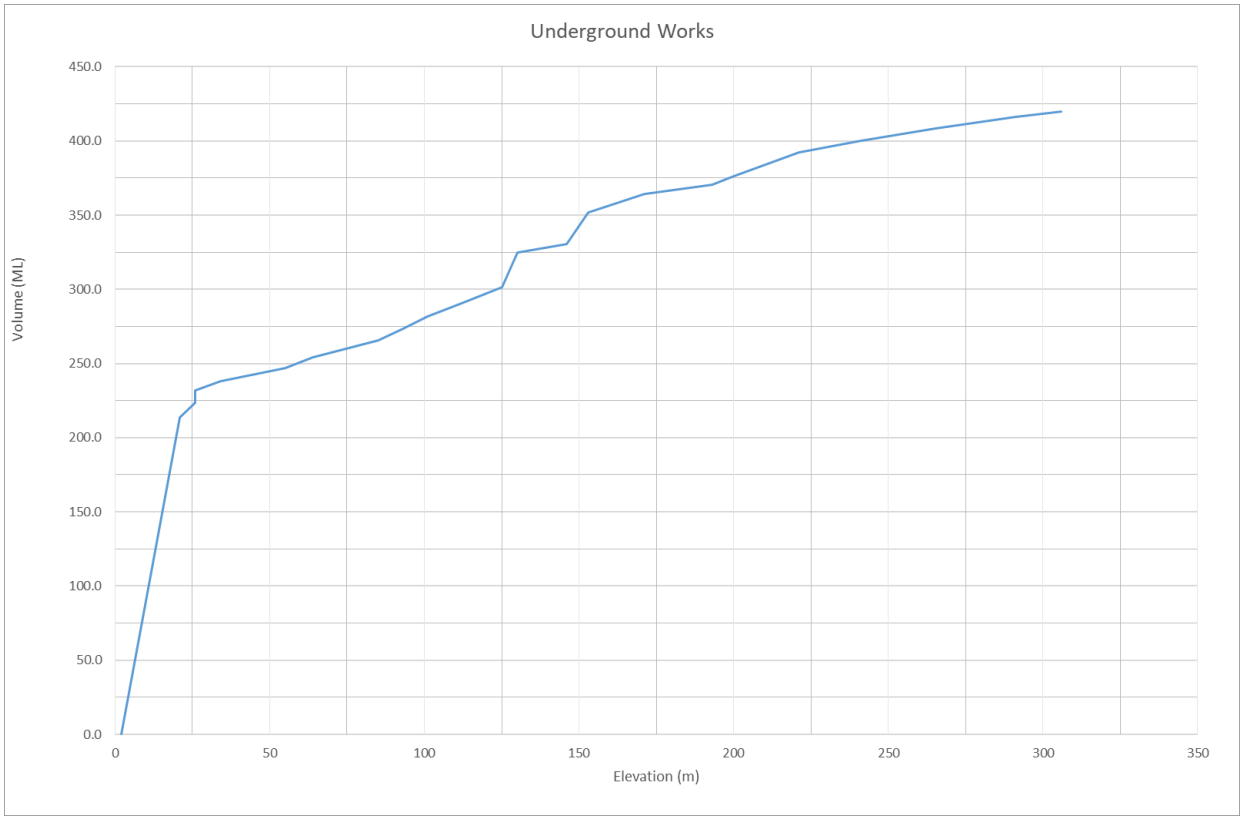
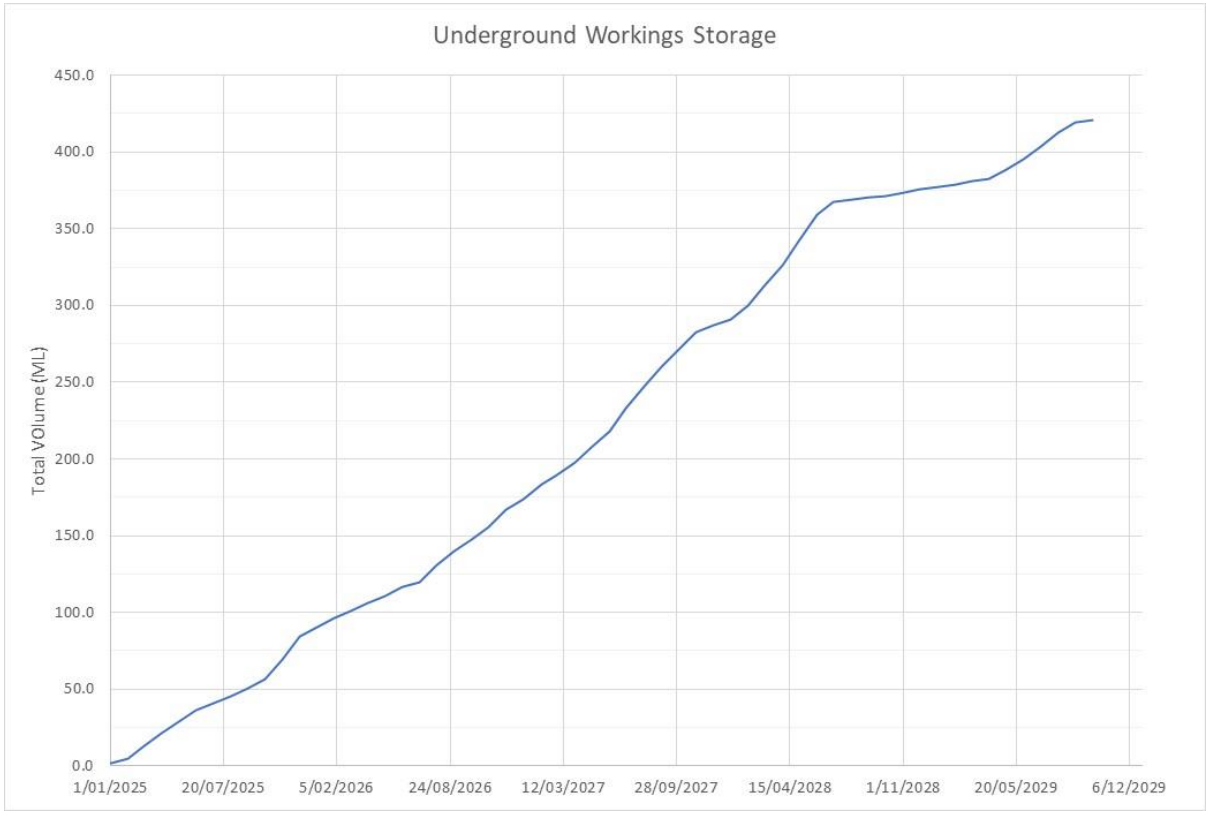


DIAGRAM 7: UNDERGROUND WORKINGS – NET STORAGE OVER TIME



TAILINGS.WATER.WASTE.

2.2.5 Initial Storage Conditions

Initial storage volumes were provided by Aeris, derived from water levels surveyed on 30 October 2023 **[4]** and are presented in **Table 6**. These values were applied at the simulation commencement of 01/01/2025.

TABLE 6: INITIAL WATER STORAGE INPUTS

Parameter	North Pit	South Pit	WRD Sediment Dam
Initial Volume* (ML)	67.0 (RL 308.58 m)	165.7 (RL 250.80 m)	44.4 (RL 333.38)
Total Capacity (ML)	131.0	3,296.4	153.3
Overflow Level (m)	RL 316.0 m	RL 334.3 m	RL 337.0 m

2.2.6 Pump Transfers and Source Priority

In discussion with Aeris, the following pumped transfer conditions and priorities were developed:

1st – Source water for the UG circuit and dust suppression directly from the South Pit. This will assist to dewater the South Pit to allow access to the ore at the base of the pit (crown pillar) approximately 18 months after operations recommence.

2nd – When the South Pit is sufficiently dewatered, water will be sourced from either the WRD Sediment Dam or North Pit based on which storage has the lowest available capacity remaining. Consideration is also given to the need to comply with Design Storage Allowance (DSA) requirements by 1 November each year.

3rd – Pump transfers from the North Pit and the WRD Sediment Dam will be initiated when water levels in these storages reach a critical water level. Pumping will be suspended once the water levels fall to a predetermined deactivation point. This arrangement is expected to remain operational for 2 years following the cessation of mining activities (until 31/12/2031). Details regarding activation/deactivation thresholds and pumping rates are provided in **Table 7**.

TABLE 7: PUMP TRANSFER CONFIGURATION

Source	Destination	Pump Transfer Rate	Activation Level	Deactivation Level	Destination Cease Pumping Level
North Pit	South Pit	66 L/s	RL 311 m	RL 310 m	RL 333 m
WRD Sediment Dam	South Pit	30 L/s	RL 334 m	RL 333 m	RL 333 m

2.2.7 Site Water Demands

There will be no on-site ore processing, and as such the primary uses for water onsite will be the UG circuit, and dust suppression on haul roads and the site access road. Aeris has confirmed that the UG circuit will consume approximately 0.35 ML/day, with dust suppression expected to consume approximately 5 ML/month (equating to approximately 0.2 ML/day). These estimates are based upon Aeris' experience at the Mt Colin site **[5]**.

TAILINGS.WATER.WASTE.

2.2.8 South Pit and Underground Workings Interaction

In addition to groundwater inflows there is a potential for water ingress to the UG workings via the Portal and the Crown Pillar at the base of the Pit.

The portal is located at 310 m AHD and is located approximately 60 m above the latest recorded water level in the pit. The water level in the South Pit has never been above 250 m AHD. As the South Pit will be actively dewatered, the water level in the South Pit will be maintained well below the portal level. As such, interaction via the Portal is not considered to be likely.

The crown pillar at the base of the South Pit is the location of the richest ore deposit. Once the crown pillar is removed, the South Pit and Underground Workings become, in effect, a single storage. This has been represented in the model by allowing all runoff reporting to the South Put from 01/11/2029 to pass to the Underground. The Underground will have to fill to the level of 210 m AHD before the South Pit starts to fill.

2.2.9 Simulation Period

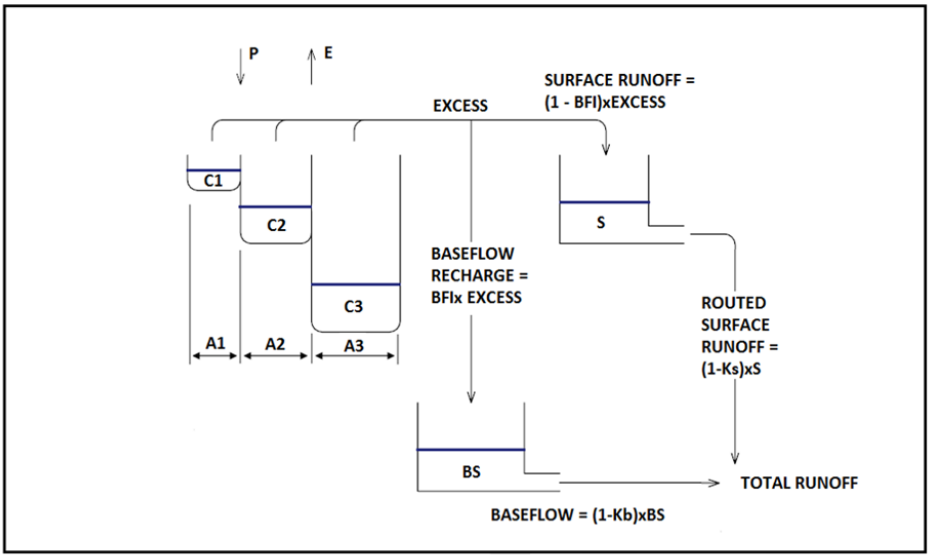
The model was run from the period 01/01/2025 to 31/10/2029, with the site under operational conditions, and from 01/11/2029 to 31/12/2050 to represent the closure conditions where groundwater levels recover to pre operational conditions.

2.3 Model Development

The Australian Water Balance Model (AWBM) was used to simulate daily runoff from rainfall, generated within the various sub-catchment types that are present on the project site. **Diagram 8** represents a schematic of the AWBM model, reproduced from Boughton (2004) **[6]**.

The catchment types and AWBM model parameters used to simulate these different catchment types and the average yields from these catchment areas are summarised in **Table 8**. Model parameters have been selected based on experience with similar water balance model studies and are considered to be conservative in the context of an uncalibrated model.

DIAGRAM 8: AWBM FOR RUNOFF CALCULATIONS



Where:

C1 - C3	= Surface Storage Capacities
A1 - A3	= Partial Areas Represented by Surface Storages
BFI	= Baseflow Index
K_b	= Daily Baseflow Recession Constant
BS	= Current Volume in Baseflow Store
K_s	= Daily Surface Flow Recession Constant
S	= Current Volume in Surface Store Routing

TAILINGS.WATER.WASTE.

TABLE 8: AWBM MODEL PARAMETERS

AWBM Parameters	Split Areas (sum=1.0)			Storage Capacities (mm)			Ks (day^{-1})	BFI	Kb (day^{-1})
	A1	A2	A3	C1	C2	C3			
Natural	0.13	0.43	0.43	12	120	250	0	0	1
Hardstand	1.00	0.00	0.00	10	0	0	0	0	1
Waste	0.20	0.80	0.00	10	300	300	0	0	1
Open Cut	0.10	0.90	0.00	5	20	20	0	0	1
Disturbed	0.10	0.30	0.60	20	55	100	0	0	1

TAILINGS.WATER.WASTE.

3 RESULTS

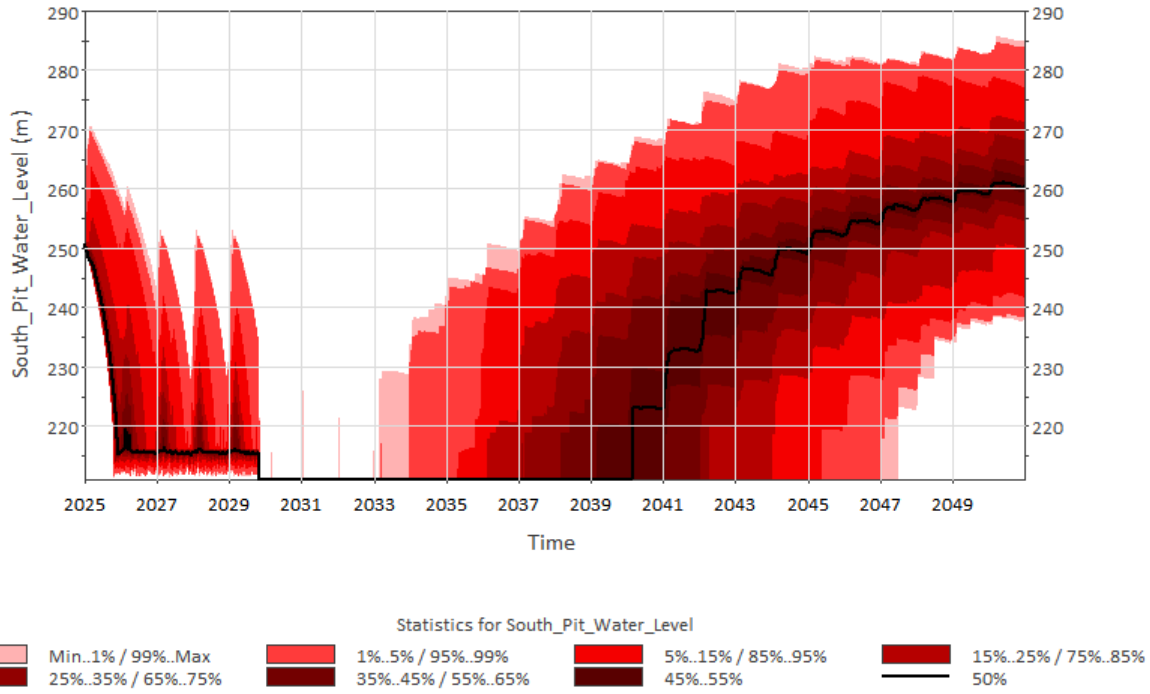
The results of the WBM simulations are discussed in the following sections, for each structure at the BCP.

3.1 South Pit

The modelled water surface elevation in the South Pit is presented in **Diagram 9** (2025 to 2050) and **Diagram 10** (2025 to 2029). The following observations can be made in relation to **Diagram 9** and **Diagram 10:**

- Under median climatic conditions, the South Pit is rapidly dewatered by October 2025 to meet site water demands.
- Under median climatic conditions, the South Pit does not store any water until February 2041, as all rainfall and runoff enters the Underground Workings as the crown pillar has been removed.
- The maximum modelled water level in the South Pit is 290 m AHD, under the 99th percentile realisation. As the pit crest is 334 m AHD, this indicates the South Pit does not overtop or spill. The level of 290 m AHD is only reached in sequentially very wet years.
- The long term median water level in the South Pit is approximately 260 m AHD, approximately 10 metres above the current recorded water level.
- The South remains a groundwater sink, with no modelled outflows.

DIAGRAM 9: SOUTH PIT WATER SURFACE ELEVATION (2025 TO 2050)



TAILINGS.WATER.WASTE.

DIAGRAM 10: SOUTH PIT WATER SURFACE ELEVATION (2025 TO 2029)

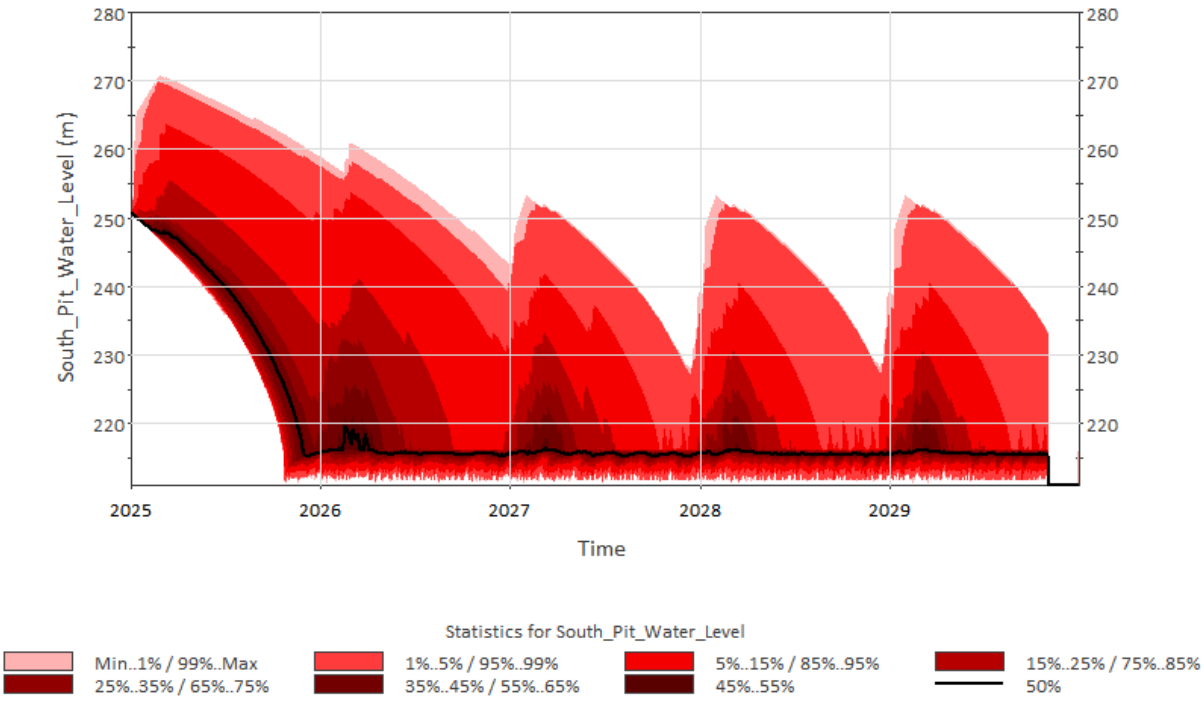
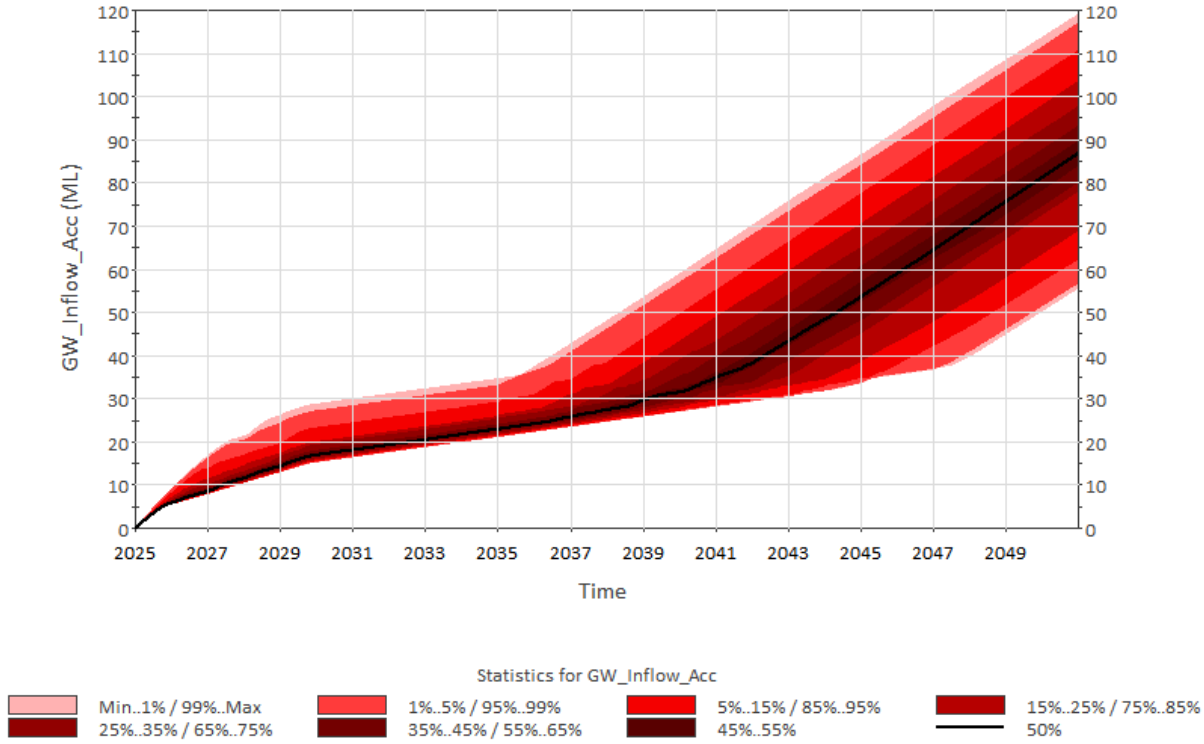


Diagram 11 illustrates the predicted accumulated groundwater inflow to the South Pit between 2025 and 2050. The median value is approximately 83 ML, or 3.32 ML/year.

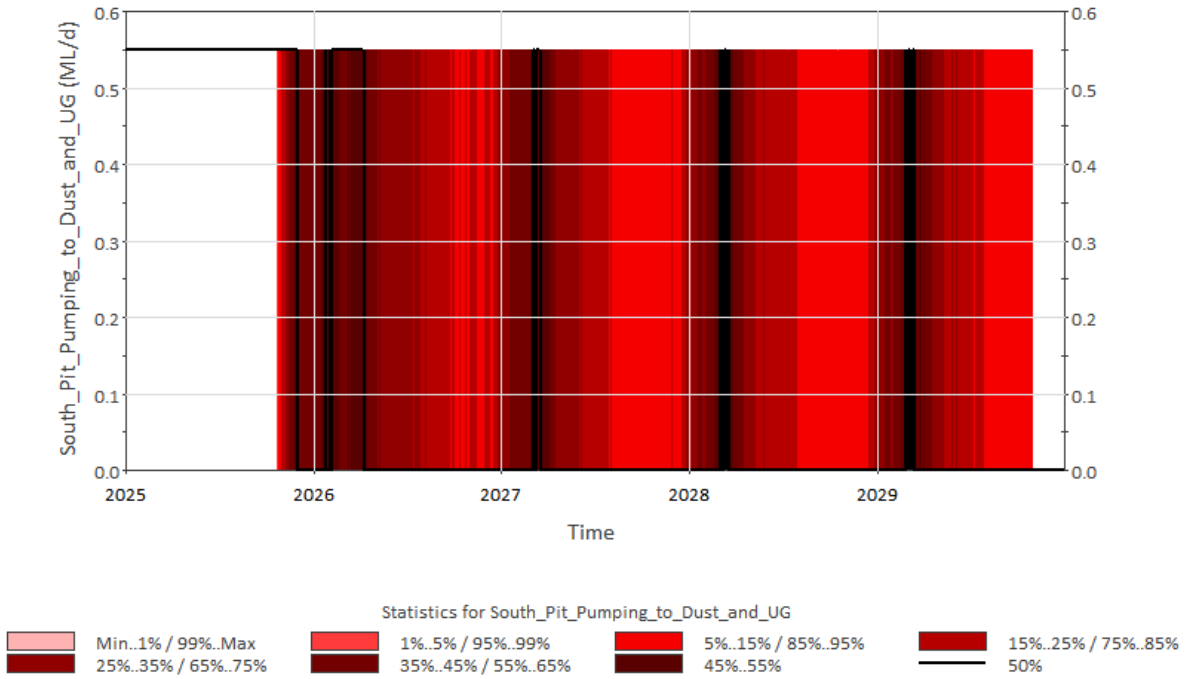
DIAGRAM 11: SOUTH PIT ACCUMULATED GROUNDWATER INFLOWS



TAILINGS.WATER.WASTE.

There were no modelled groundwater outflows from the South Pit as the South Pit is a regional groundwater sink. As can be seen in **Diagram 12**, the 0.55 ML/day of site water demands are met by the South Pit from January 2025 to October 2025. Beyond October 2025, the South Pit meets site water demands when water is available in the South Pit.

DIAGRAM 12: SOUTH PIT PUMP FLOW TO UG



3.2 Underground Workings

Diagram 13 depicts the accumulated volumes in the Underground. The following observations can be made in relation to **Diagram 13:**

- Under operational conditions the Underground Workings do not store any water between 2025 and 2029, as they are being actively dewatered.
- Under median climatic conditions the Underground Workings commence filling in 2030 and are completely filled by 2040. This is primarily driven by water ingress from the South Pit, connected to the Underground Workings via the removal of the crown pillar.

Diagram 14 depicts the variation in groundwater inflow over time. From this diagram, the following insights can be derived**:**

- Given the complexity of the Underground Workings, characterised by changes in available volume over time, the use of stage storage curves was not adopted in the WBM. Instead, the model incorporates projections of groundwater inflow over time as detailed in **Table 5**. This explains the lack of variability between the groundwater estimations of different realizations until the cease of mine operations (2029), as showed on **Diagram 14**. After the mine ceases its operations, the WBM calculates the groundwater inflows based on the estimated stage storage of UG Workings.
- The median accumulated groundwater inflow into the Underground Workings between 2025 and 2050 is approximately 20 ML, or 4.11 ML/year.
- The remainder of the water required to fill the Underground Workings is supplied by inflows from the South Pit.

TAILINGS.WATER.WASTE.

DIAGRAM 13: UNDERGROUND WORKINGS ACCUMULATED VOLUMES

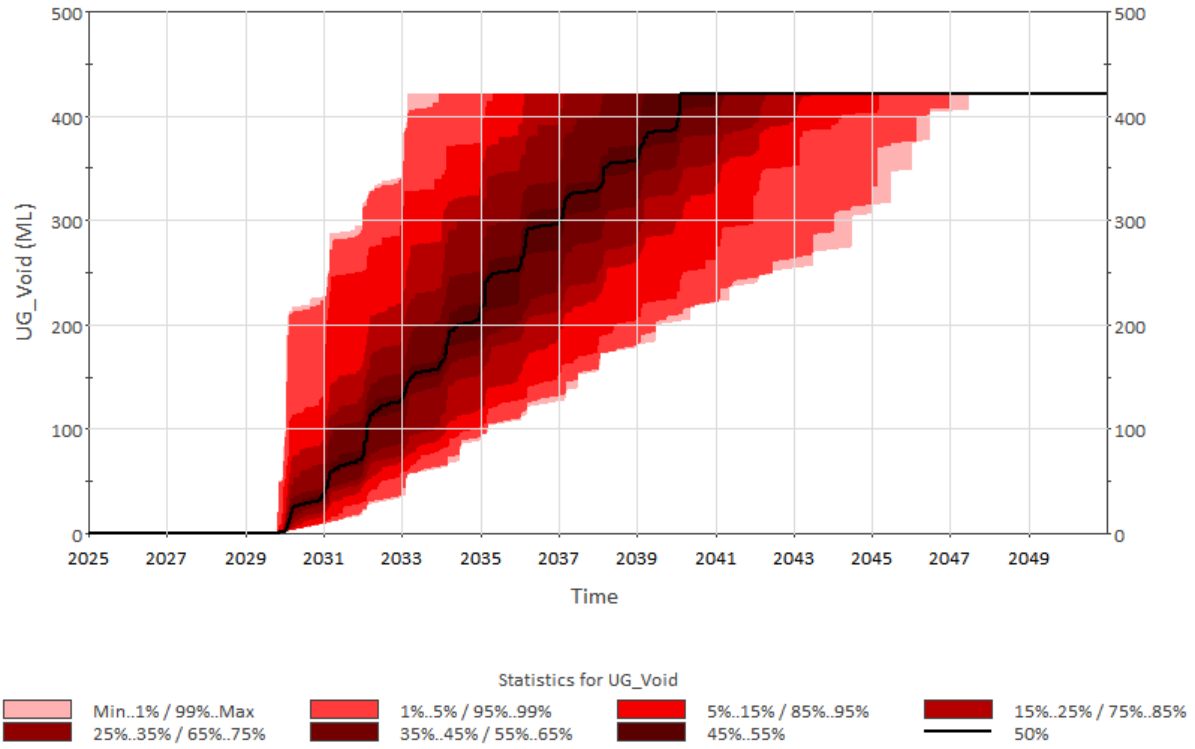
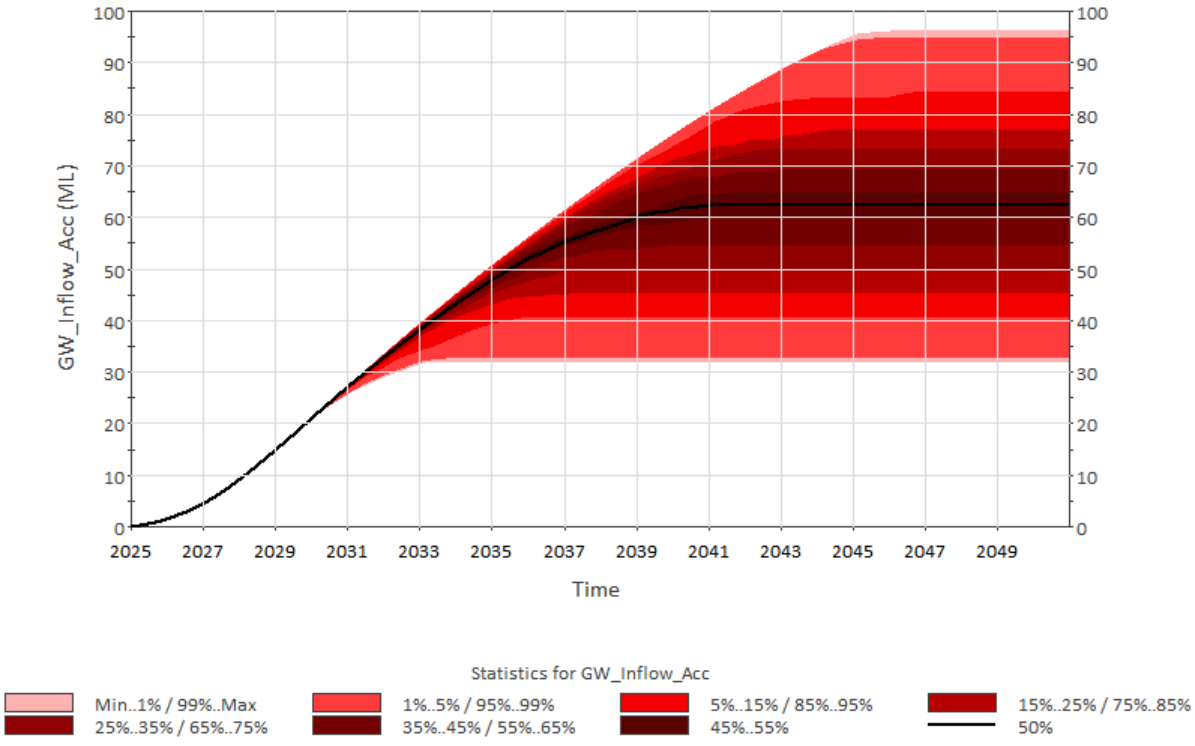


DIAGRAM 14: UNDERGROUND WORKINGS GROUNDWATER INFLOWS



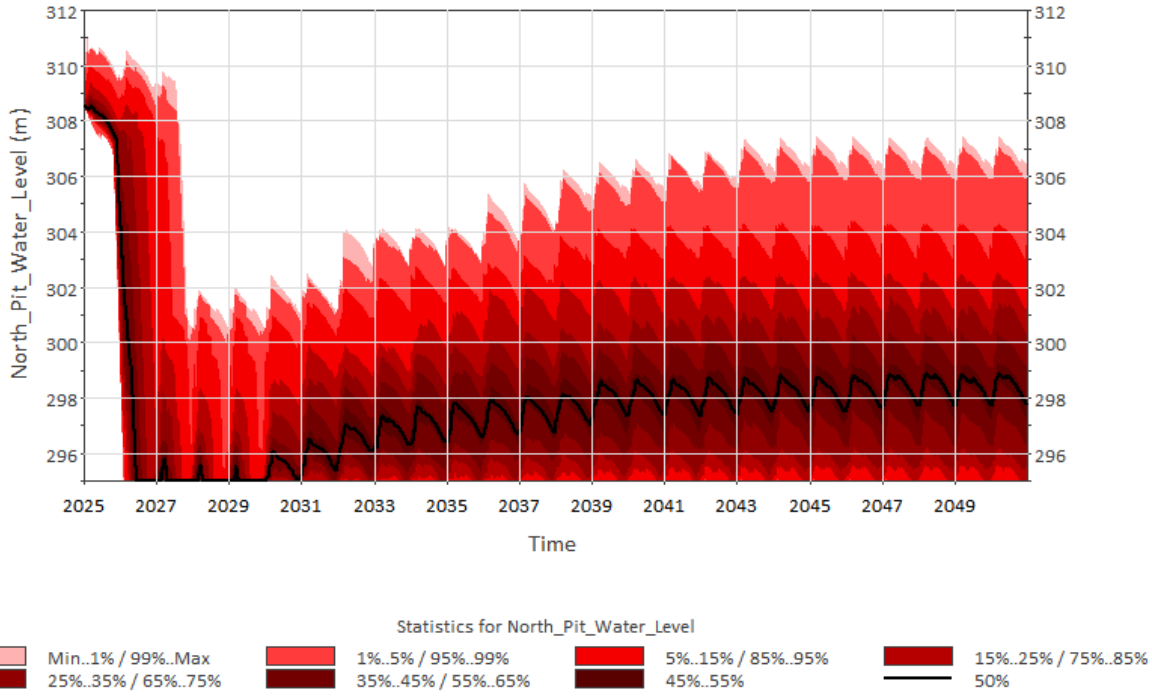
TAILINGS.WATER.WASTE.

3.3 North Pit

Diagram 15 and **Diagram 16** depict the modelled water surface elevation in the South Pit. The following observations can be made in relation to **Diagram 15** and **Diagram 16:**

- Under median climatic conditions, the North Pit is rapidly dewatered by March 2026 to meet site water demands.
- Under median climatic conditions, between March 2026 and October 2029 (excluding the January-March period each year), the North Pit is dry, indicating the site may be in a net water deficit.
- The maximum modelled water level in the North Pit is 307 m AHD. As the pit crest is 316 m AHD, this indicates the North Pit does not overtop or spill. The level of 307 m AHD is only reached in sequentially very wet years.
- The long term median water level in the North Pit varies between 298 m AHD to 299 m AHD, approximately 10 metres below the current recorded water level.

DIAGRAM 15: NORTH PIT WATER SURFACE ELEVATION (2025 TO 2050)



TAILINGS.WATER.WASTE.

DIAGRAM 16: NORTH PIT WATER SURFACE ELEVATION (2025 TO 2029)

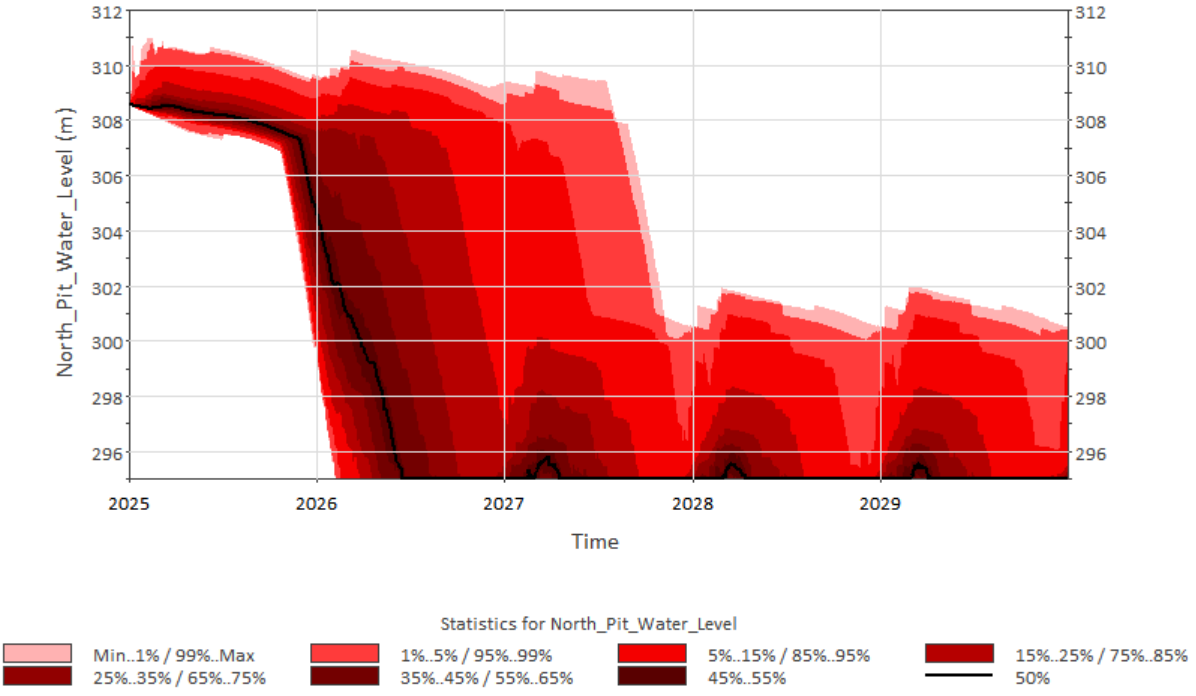
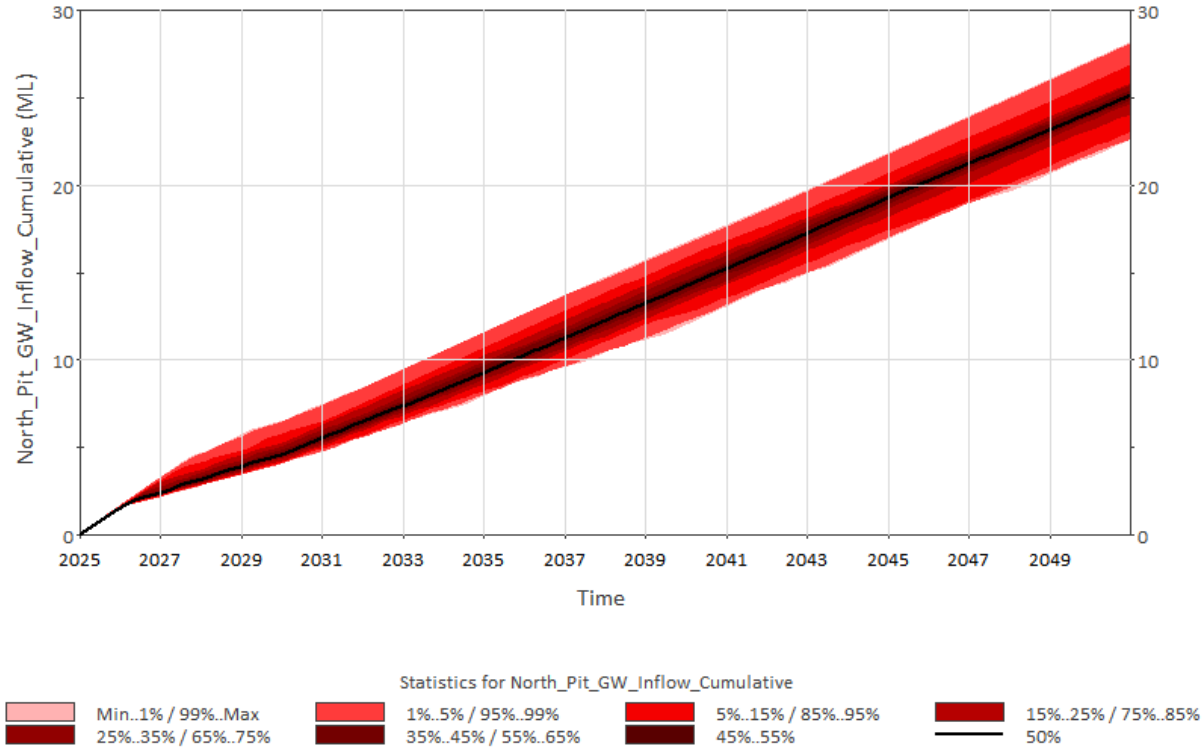


Diagram 17 illustrates that the median accumulated groundwater inflow into the North Pit between 2025 and 2050 is approximately 25 ML, or 1 ML/year.

DIAGRAM 17: NORTH PIT ACCUMULATED GROUNDWATER INFLOWS

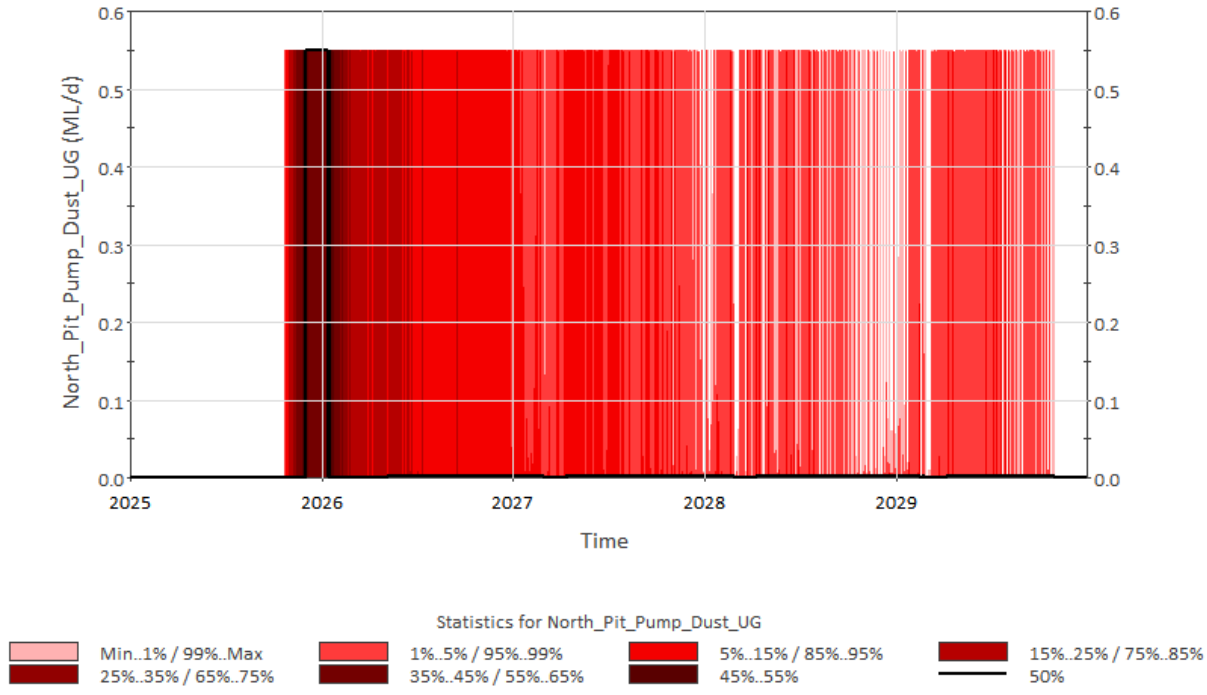


TAILINGS.WATER.WASTE.

Additionally, under median climatic conditions there are no pump transfers from the North Pit to the South Pit. Pump transfers occur during three realisations where rainfall exceeds the median historical record.

Diagram 18 illustrates that under median climatic conditions, pump transfers from the North Pit assist in meeting site water demands beyond October 2025 (when the South Pit is effectively dewatered).

DIAGRAM 18: NORTH PIT PUMP FLOWS TO UG



3.4 WRD Sediment Dam

Diagram 19 and **Diagram 20** depicts the modelled water surface elevation in the WRD Sediment Dam. The following observations can be made in relation to **Diagram 19** and **Diagram 20:**

- Under median climatic conditions, the WRD Sediment Dam is dewatered by October 2026.
- Under median climatic conditions, between October 2026 and October 2029 (excluding January-March each year), there are periods where the WRD Sediment Dam dry, indicating the site may be in a net water deficit.
- The maximum modelled water level in the WRD Sediment Dam is 336.8 m AHD. The spillway level is at 336.8m AHD. There are 2 realisations where the WRD Sediment Dam spills. This only occurs in sequentially very wet years.
- The long term median water level in the WRD Sediment Dam varies between 330 m AHD to 331.2 m AHD, approximately 2.5 metres below the current recorded water level.

Due to the presence of the HDPE liner on the WRD Sediment Dam, no groundwater inflows or outflows were modelled.

TAILINGS.WATER.WASTE.

DIAGRAM 19: WRD SEDIMENT DAM WATER SURFACE ELEVATION (2025 T0 2050)

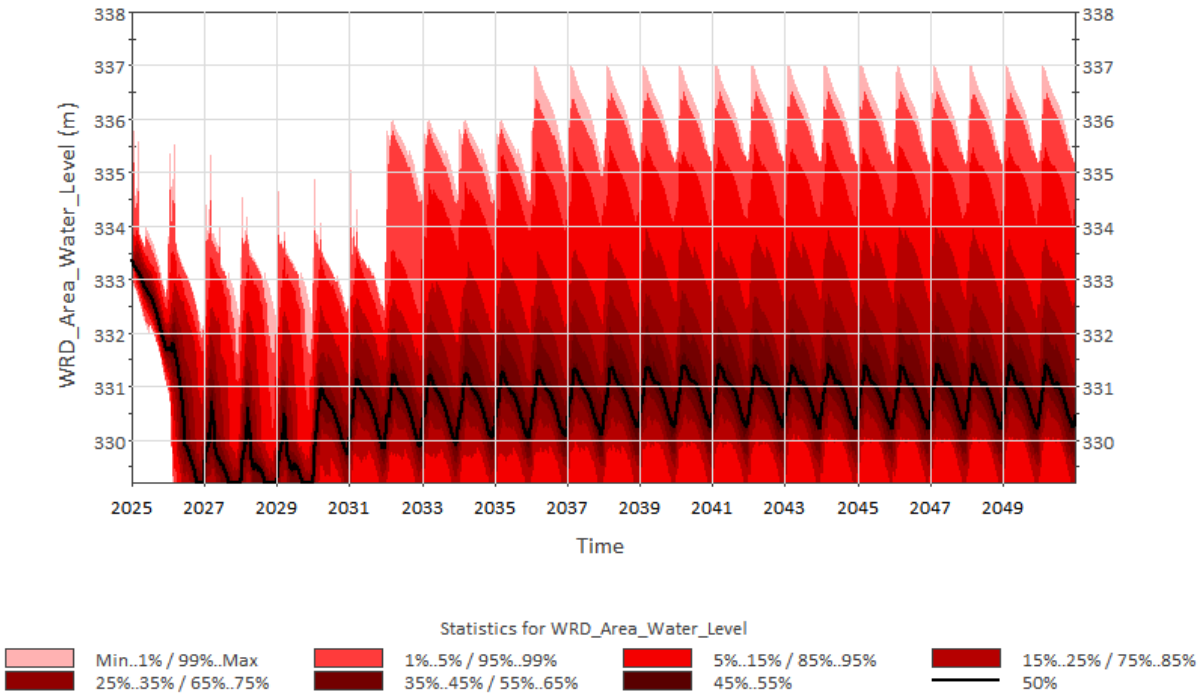


DIAGRAM 20: WRD SEDIMENT DAM WATER SURFACE ELEVATION (2025 T0 2029)

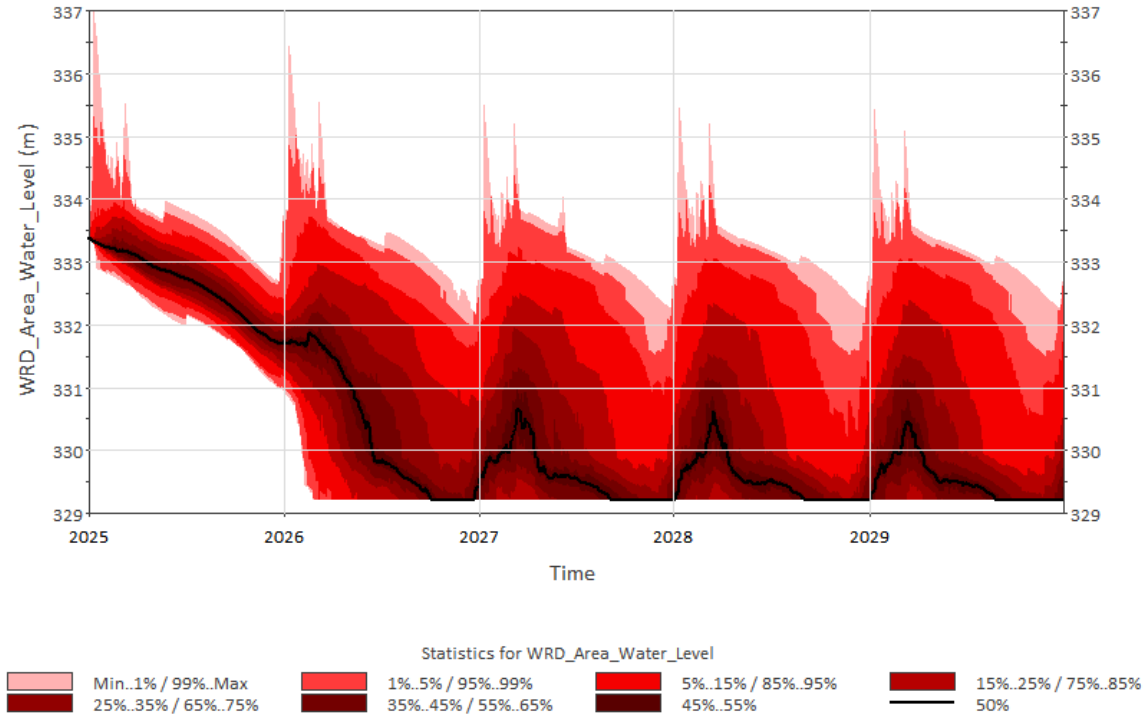


Diagram 21 illustrates that under median climatic conditions, there are no pump transfers from the WRD Sediment Dam to the South Pit. Pump transfers occurs in years where rainfall exceeds the median historical record.

TAILINGS.WATER.WASTE.

DIAGRAM 21: CUMMULATIVE PUMP FLOWS TO SOUTH PIT

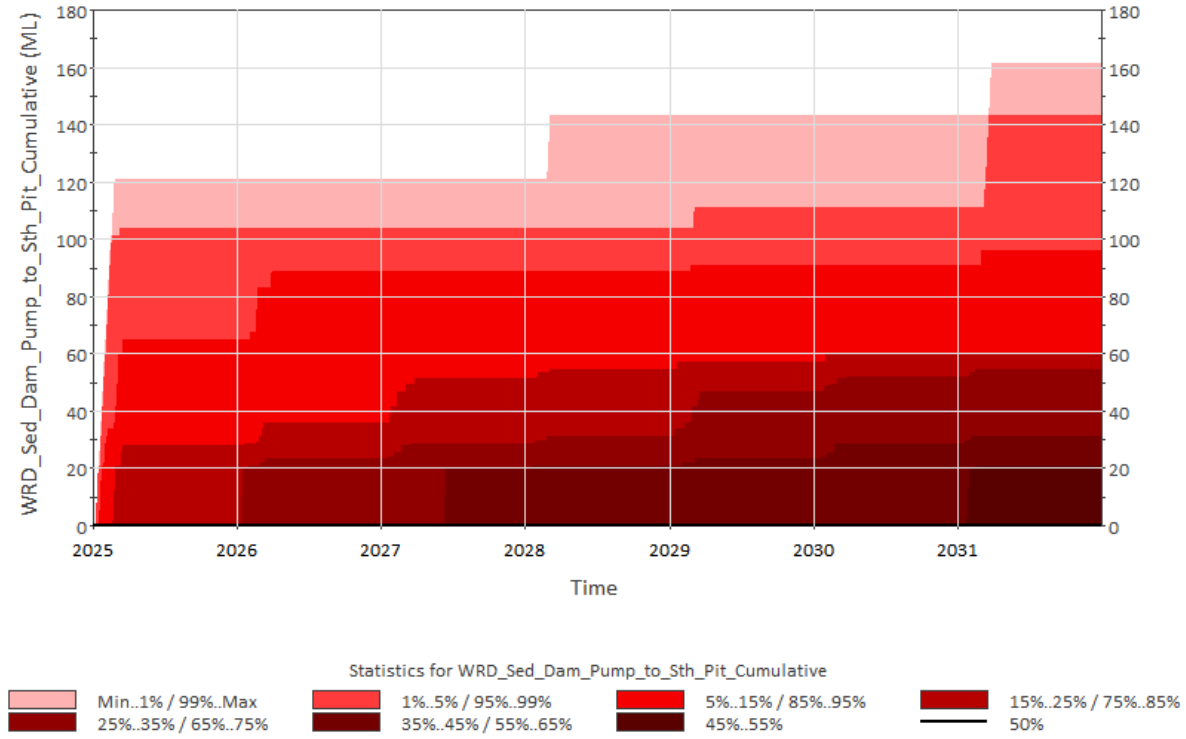
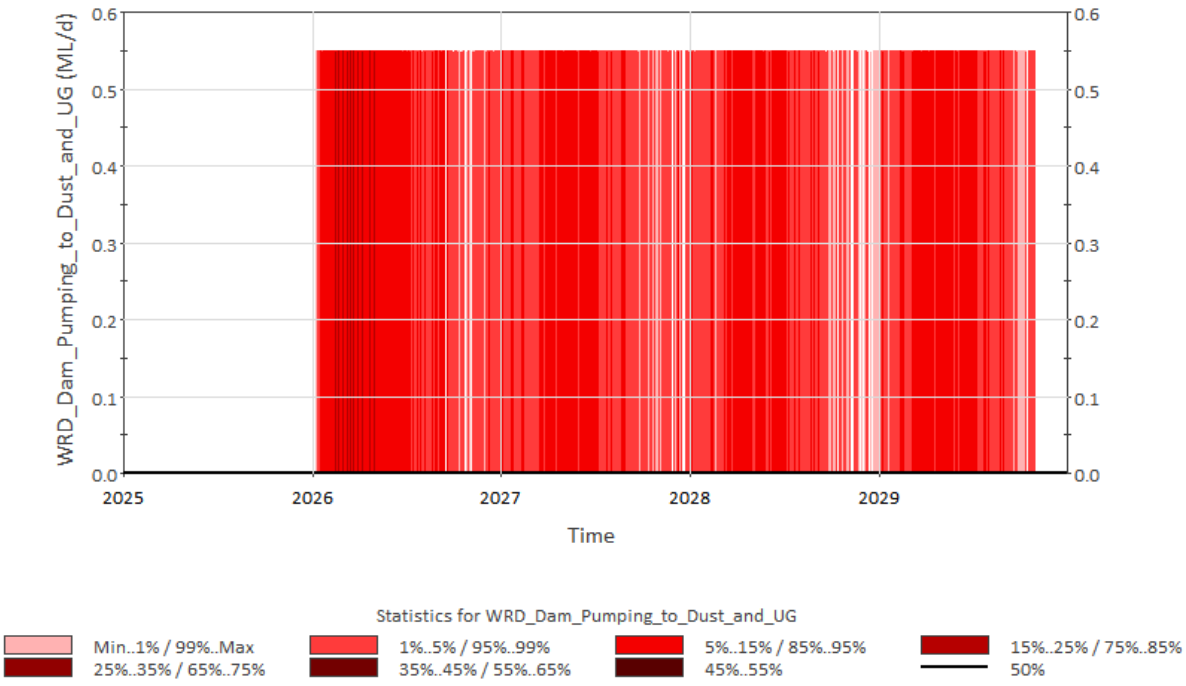


Diagram 22 illustrates that under median climatic conditions, pump transfers from the WRD Sediment Dam assist in meeting site water demands beyond October 2025 (when the South Pit is effectively dewatered).

DIAGRAM 22: WRD SEDIMENT DAMPUMP FLOWS TO UG



TAILINGS.WATER.WASTE.

4 SUMMARY AND CONCLUSION

The results of the WBM undertaken as part of the assessment of the Underground Workings indicates the following:

The South Pit is rapidly dewatered by October 2025 to meet site water demands, whereupon the North Pit and WRD Sediment Dam are used as sources to meet the site water demands.

Modelling indicates that under median climatic conditions, the site may have the potential to be in a net water deficit in the dryer months of 2027, 2028 and 2029.

The Underground Workings receives all rainfall and runoff from the South Pit from 2029. Under median climatic conditions, the Underground Workings takes ten years from 2029 to 2039 to fill. After the Underground Workings fill, the South Pit then begins to fill.

By 2050, under median rainfall conditions, the South Pit water level reaches approximately 260 m AHD, which is approximately 75 m below the pit crest. During the 95th percentile wet years, the maximum modelled water level in the South Pit is approximately 290 m AHD, which is 45 m below the pit crest. Therefore, the South Pit is not predicted to overtop or spill during operations or closure conditions.

By 2050, under median rainfall conditions, the North Pit water level reaches approximately 298 m AHD to 299 m AHD, which is approximately 17 m below the pit crest. During the 95th percentile wet years, the maximum modelled water level in the North Pit is 307 m AHD, which is approximately 9 m below the pit crest. Therefore, the North Pit is not predicted to overtop or spill during operations or closure conditions.

The WRD Sediment Dam was observed to overtop in two realisations during operational conditions, with no overtopping occurring during closure conditions.

TAILINGS.WATER.WASTE.

REFERENCES

[1] The Long Paddock (2024), SILO Data Drill for Cell -20.45, 139.85, accessed 25th January 2024 March 2023, https://www.longpaddock.qld.gov.au/silo/gridded-data/, Queensland Government.

[2] WMV Environmental (2024a), 'BCP UG EA GW Inflow Calculations (v1.1 - 2024_02_19).xls', 19 February 2024.

[3] WMV Environmental (2024b), 'Barbara Copper Project UG EA Amendment . Groundwater Technical Report, February 2024.

[4] Aeris (2024). '231030_Barbara Dam Survey Information.xls', 30 October 2023.

[5] Eason, D. (2024) 'RE: Aeris Resources, Barbara Copper Project - underground EA amendment application',23rd January 2024.

[6] Boughton, W.C. (2004). 'The Australian Water Balance Model. Environmental Modelling & Software', Vol. 19, pp943-956.

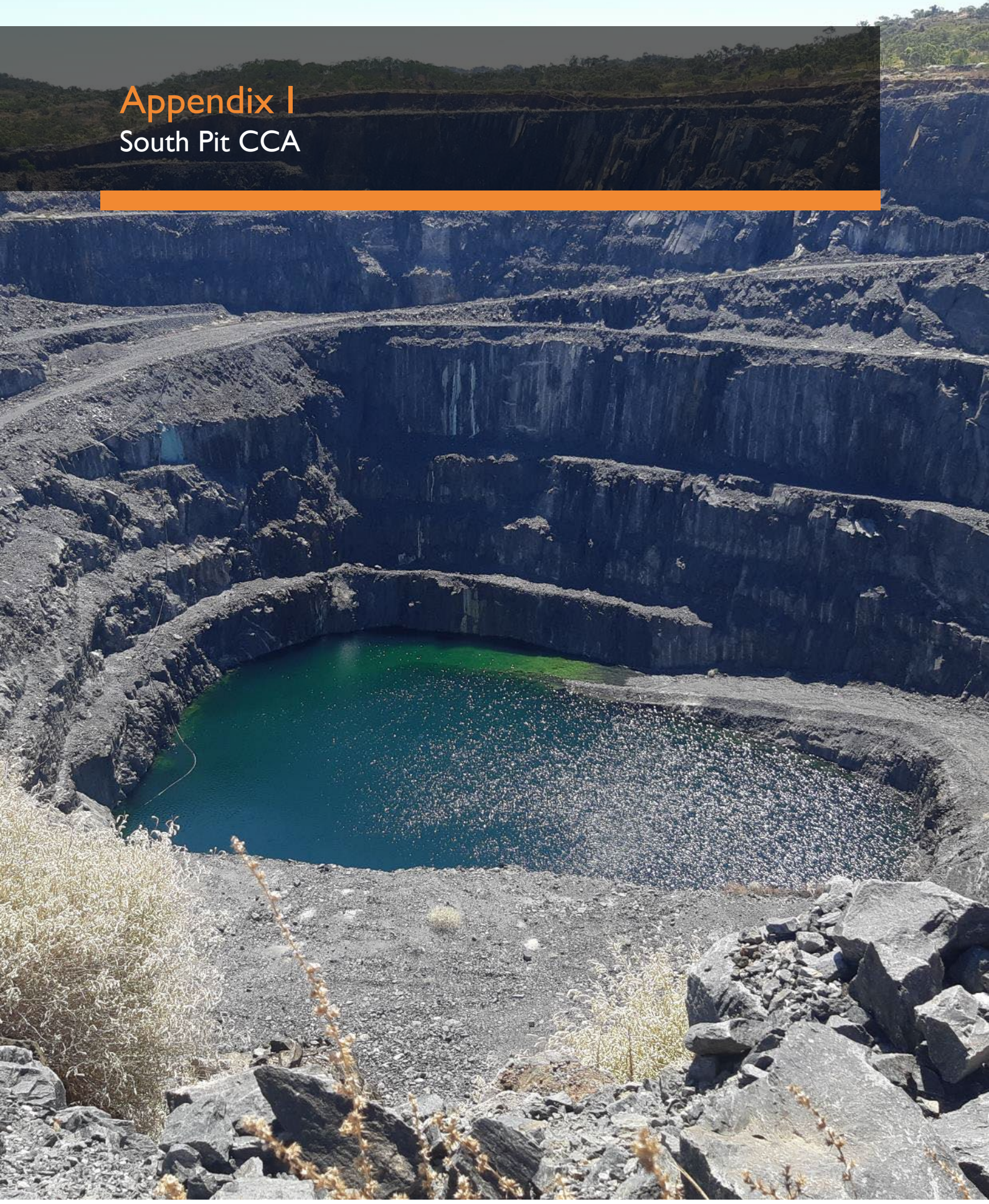
CONDITIONS OF REPORT

1. This report must be read in its entirety.
2. This report has been prepared by ATCW for the purposes stated herein and ATCW's experience, having regard to assumptions that can reasonably be expected to make in accordance with sound professional principles. ATCW does not accept responsibility for the consequences of extrapolation, extension or transference of the findings and recommendations of this report to different sites, cases, or conditions.
3. This document has been prepared based in part on information which was provided to ATCW by the client and/or others and which is not under our control. ATCW does not warrant or guarantee the accuracy of this information. The user of the document is cautioned that fundamental input assumptions upon which the document is based may change with time. It is the user's responsibility to ensure that these assumptions are valid.
4. Unless specifically agreed otherwise in the contract of engagement, ATCW retains Intellectual Property Rights over the contents of the document. The client is granted a licence to use the report for the purposes for which it was commissioned.

TAILINGS.WATER.WASTE.

This page is intentionally blank.

Appendix I
South Pit CCA



REPORT

AERIS RESOURCES
ABN: 64 130 641 691

Barbara Copper Project
Consequence Category Assessment – South Pit

118131-17R01-rev0
MAY 2024

TAILINGS.WATER.WASTE.

Document Control

Project Name:	Barbara Copper Project
Document Title:	Consequence Category Assessment – South Pit
File Location:	M:\Synergy\Projects\118\118131 Barbara Copper Project\17 2024 CCA\Documents\R01\Text\118131-17R01-rev0.docx
Document Number:	118131-17R01-revA

Revision History

Revision	Issue	Issue Date	Prepared by	Reviewed by
Rev 0	Final	16/05/2024	Enzo Aguilera Pettinelli	Naomi Tyack/ Freeternity Rusinga

Issue Register

Distribution List	Date
Aeris Resources Limited	16 May 2024

ATC Williams Company Details

Prepared By:	Enzo Aguilera Pettinelli & Naomi Tyack
Approved By:	
Address:	Level 1, 16-20 Edmondstone Street, Newmarket QLD 4051
Tel:	07 3352 7222
Email:	brisbane@atcwilliams.com.au

© ATC Williams Pty Ltd (ATCW). All rights reserved.

ATCW has prepared this document solely for the use of the person or company to whom it is addressed, each as expressly stated in the document. No other party should rely on this document without the prior written consent of ATCW. No responsibility or liability to any third party is accepted for any damages howsoever arising out of the use of this report by any third party.

Your attention is drawn to Conditions of Report attached to this document. These conditions are an integral part of the document and must be reproduced with every copy.

TAILINGS.WATER.WASTE.

CONTENTS

1 INTRODUCTION 1

1.1 Location 1
1.2 Background 2
1.3 Scope 2
1.4 Guidelines and Available Site Data 3

2 SITE DESCRIPTION AND REGIONAL SETTING 4

2.1 Site Layout 4
2.2 Configuration and Details of South Pit 5
2.3 Regional Watercourses 7
2.4 Climatic Conditions 8
2.5 Subsurface Conditions and Groundwater Levels 8
2.6 Water Quality Data 8

3 WATER QUALITY ASSESSMENT 10

3.1 Introduction 10
3.2 South Pit Water Quality 10
3.3 Summary 10

4 WATER BALANCE ASSESSMENT 11

4.1 Introduction 11
4.2 South Pit Key Findings: 11
4.3 Conclusion 11

5 GENERAL ENVIRONMENTAL HARM ASSESSMENT 12

5.1 Potential Surface Environment Impacts 12
5.1.1 Matters of National Environmental Significance 13
5.1.2 Matters of State Environmental Significance 13
5.1.3 High Ecological Value Wetlands and Waterways 14
5.1.4 Aquatic Conservation Significance 14
5.1.5 Groundwater Supply 14

6 CONSEQUENCE CATEGORY ASSESSMENT 18

6.1 Basis of the Consequence Category Assessment 18
6.2 Consequence Category Assessment Regulatory Requirements 18

7 CONSEQUENCE CATEGORY ASSESSMENT 20

8 CONSEQUENCE CATEGORY ASSESSMENT SUMMARY 22

REFERENCES 23

TAILINGS.WATER.WASTE.

TABLES

TABLE 1: DISTURBANCE AREAS 2
TABLE 2: ESTIMATED PERSONNEL AT BCP 2
TABLE 3: SOUTH PIT CONFIGURATION 6
TABLE 4: SOUTH PIT WATER QUALITY DATA 9
TABLE 5: MNES LISTED CRITICALLY ENDANGERED AND ENDANGERED ANIMALS 13
TABLE 6: REGISTERED LOCAL BOREHOLES ON ML90241 AND SURROUNDING AREA 14
TABLE 7: CONSEQUENCE CATEGORY ASSESSMENT CRITERIA 19
TABLE 8: CONSEQUENCE CATEGORY ASSESSMENT – SOUTH PIT 21
TABLE 9: CONSEQUENCE CATGEORY ASSESSMENT SUMMARY – NORTH PIT, SOUTH PIT, WRD SEIDMENT DAM 22

CHARTS

CHART 1: AVERAGE ANNUAL RAINFALL AND EVAPORATION FOR THE BCP 8

GRAPHS

GRAPH 1: WRD SEDIMENT DAM WATER SURFACE ELEVATION (2025 T0 2050) 11

DIAGRAMS

DIAGRAM 1: SITE LOCATION 1
DIAGRAM 2: SITE LAYOUT 5
DIAGRAM 3: REGIONAL WATERCOURSES 7
DIAGRAM 4: BORES WITHIN ML90241 AND SURROUNDING AREA 17

APPENDICES

APPENDIX A: WATER BALANCE MODEL INPUTS AND RESULTS

APPENDIX B: EPBC ACT PROTECTED MATTER REPORT

APPENDIX C: ENVIRONMENTAL REPORTS - MATTERS OF STATE ENVIRONMENTAL SIGNIFICANCE

APPENDIX D: ENVIRONMENTAL REPORTS - BIODIVERSITY AND CONSERVATION VALUES – BIODIVERSITY PLANNING ASSESSMENTS AND AQUATIC CONSERVATION ASSESSMENTS

APPENDIX E: ENVIRONMENTAL REPORTS - REGIONAL ECOSYSTEMS – BIODIVERSITY STATUS

APPENDIX F: FORM OF CERTIFICATION

TAILINGS.WATER.WASTE.

1 INTRODUCTION

1.1 Location

Aeris Resources Limited (Aeris) owns and operates the Barbara Copper Project (BCP), located on mining lease ML90241 within the Mt Isa City Council, and is licensed under Environmental Authority (EA) EPML02840015 (Effective Date: 30 September 2022) **[1]**. The BCP is located approximately 49 km northeast of Mt Isa and is accessed via Lake Julie Road from the Barkly Highway. The BCP is located at the upstream extents of an unnamed tributary of the Leichardt River. The unnamed tributary of Leichardt River and the Leichardt River are located in the Gulf Rivers Basin, which discharges into the Gulf of Carpentaria. The location of the BCP relative to Mt Isa and Cloncurry is shown in **DIAGRAM** 1.

DIAGRAM 1: SITE LOCATION

TAILINGS.WATER.WASTE.

1.2 Background

Table H1 within the EA **[1]** lists the consequence category of the North Pit, South Pit and WRD Sediment Dam (named WRD Dam) all as 'Significant'. This was based upon the original Consequence Category Assessment (CCA) for the BCP undertaken by URS in 2014 **[2]**.

Within the EA **[1]**, Table A1 lists the maximum disturbance area permitted for the North Pit, South Pit and WRD Dam. These are reproduced in **TABLE 1** as well as the 'as constructed' disturbance areas.

TABLE 1: DISTURBANCE AREAS

Structure	EA Disturbance Area (ha)	As Constructed Disturbed Area (ha)
North Pit	3.3	3.3
South Pit	10.2	10.2
WRD Sediment Dam	6.0	6.0

Due to the proposed underground workings to be undertaken via a portal within the South Pit, it is required that a new CCA be undertaken for the water storage structures on the site due to its change in operations. This report provides a reassessment of the CCA for the South Pit only. Updates to the CCA's for the North Pit, WRD Sediment Dam, and the on-site levees will be provided in a separate report. The CCA's will be carried out in accordance with the 'Manual for assessing consequence categories and hydraulic performance of structures' **[3]**.

It is expected that personnel will be constantly present at BCP once the underground workings commence. An estimation from Aeris Resources of the personnel present at BCP once the underground workings start is summarized in **TABLE 2.**

TABLE 2: ESTIMATED PERSONNEL AT BCP

Structure	Day Shift	Night Shift
Office	11	0
Underground	9	9
Workshop	5	2
ROM	2	0

1.3 Scope

Conditions H1 to H3 of the EA **[1]** state the following:

H1 – The consequence category of any structure must be assessed by a suitably qualified and experienced person in accordance with the 'Manual for Assessing Consequence Categories and Hydraulic Performance of Structures' (EM635) ***[3]*** *at the following times:*

a) prior to the design and construction of the structure, if it is not an existing structure; or

b) if it is an existing structure, prior to the adoption of this schedule; or

c) prior to any change in its purpose or the nature of its stored contents.

H2 - A consequence assessment report and certification must be prepared for each structure assessed and the report may include a consequence assessment for more than one structure.

H3 - Certification must be provided by the suitably qualified and experienced person who undertook the assessment, in the form set out in the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635) ***[3].***

TAILINGS.WATER.WASTE.

The purpose of this report is to identify all necessary inputs to reassess the consequence category of the South Pit.

1.4 Guidelines and Available Site Data

This assessment was undertaken against the following reference guidelines:

- Department of the Environment and Science (2022), Environmental Authority EPML02840015 (Effective Date 30 September 2022), Queensland Government. **[1]**
- Queensland Parliament (2018), *Environmental Protection Act 1994*, 1 January 2018 Reprint, Queensland Government. **[4]**
- Department of Natural Resources, Mines and Energy (2018), 'Guideline for failure impact assessment of water dams', November 2018, Queensland Government. **[5]**

The following data and inputs were used in the preparation of this assessment:

- Beck, H.E., N.E. Zimmermann, T.R. McVicar, N. Vergopolan, A. Berg, E.F. Wood (2018), 'Present and future Köppen-Geiger climate classification maps at 1-km resolution', Scientific Data 5:180214, doi:10.1038/sdata.2018.214 (2018). **[6]**
- SILO Data Drill for Cell -20.40 (latitude), 139.85 (longitude) of evaporation data and patched rainfall for the period 01/01/1889 to31/12/2023. **[7]**
- WMV Environmental (2024b), 'Barbara Copper Project UG EA Amendment . Groundwater Technical Report, February 2024. **[8]**
- Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ). (2000), *National Water Quality Management Strategy – Paper No. 4: Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Natural Resource Ministerial Council, Australia **[9]**
- 'EPBC Act Protected Matters Report', 15 May 2024, Department of Agriculture. Water and the Environment and Energy. **[10]**
- 'Environmental Reports – Matters of State Environmental Significance', 14 May 2024, Department of Environment and Science. **[11]**
- 'Environmental Reports – Biodiversity and Conservation Values – Biodiversity Planning Assessments and Aquatic Conservation Assessments', 14 May 2024, Department of Environment and Science. **[12]**
- 'Environmental Reports – Regional Ecosystems – Biodiversity Status', 14 May 2024, Department of Environment and Science. **[13]**
- ATC Williams (2024), 'Barbara Copper Project –WMP Update for Underground Workings – Water Balance Model', Ref: 118131.16.R03, dated March 2024. **[14]**
- ATC Williams (2023), 'Barbara Copper Project – Progressive Rehabilitation and Closure Planning - Geochemical assessment of the North Pit, South Pit and the WRD Sediment Dam', Ref: 18131.12.M02, dated April 2023**. [15]**

TAILINGS.WATER.WASTE.

2 SITE DESCRIPTION AND REGIONAL SETTING

2.1 Site Layout

The existing infrastructure at the BCP includes the following:

- North Pit
- South Pit
- Waste Rock Dump (WRD)
- WRD Sediment Dam
- ROM Pad (to be removed upon closure)
- Light Infrastructure Area (LIA) (including workshops and maintenance areas)
- Several Diversion Drains, located at the following locations:
  - West of the North Pit
  - North of the North Pit
  - East of the South Pit;
  - East of the WRD Sediment Dam and;
  - West of the WRD Sediment Dam.

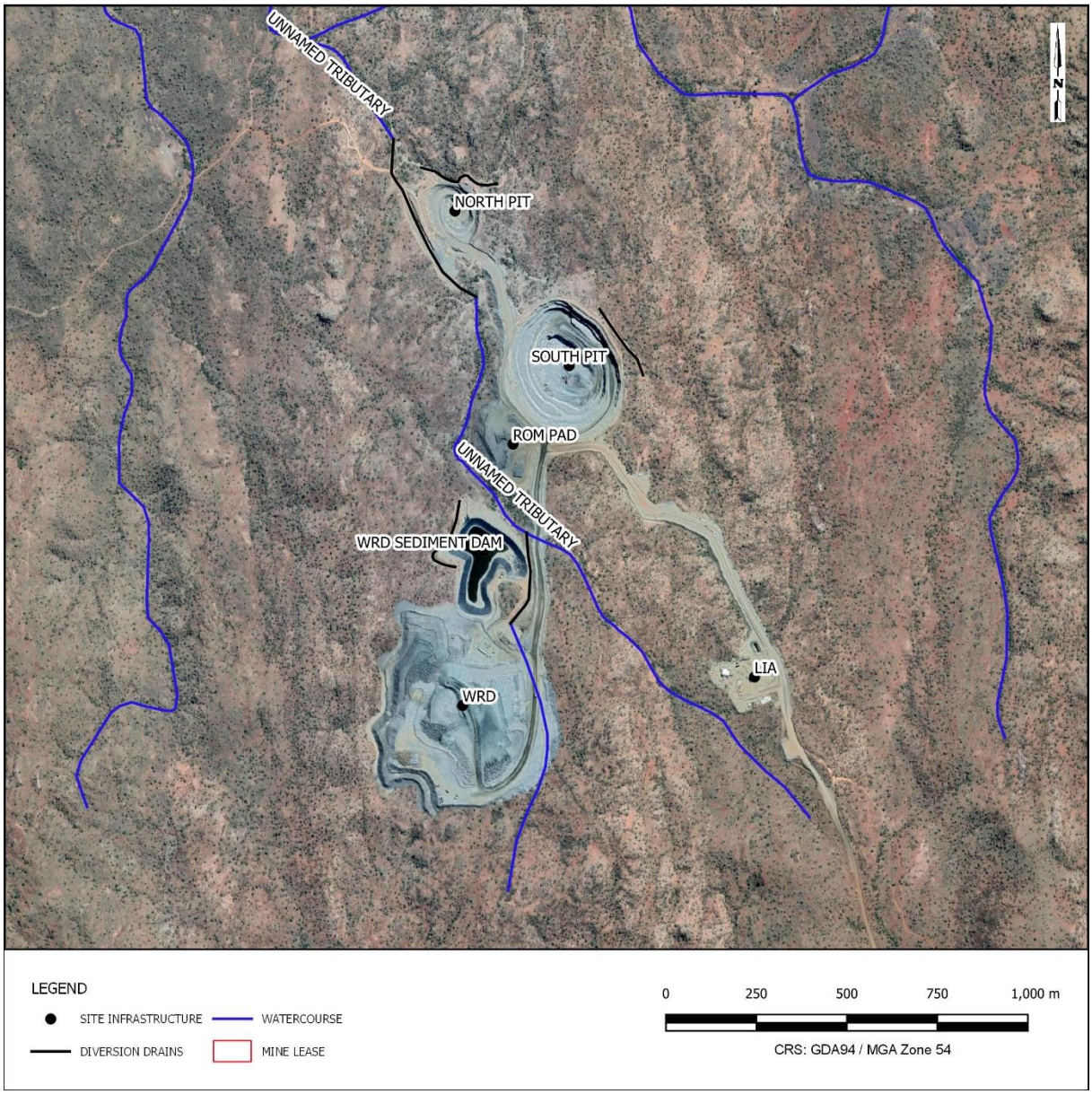
Transfer pumps and pipelines will be reinstalled on the site to allow management of the stored water for use in the underground operations. The layout of the mine is shown on **DIAGRAM 2.**

The BCP is located on the western and eastern banks of the unnamed tributary of the Leichardt River, which runs in an approximate southeast to northwest direction. The route of this unnamed tributary was formalised by the construction of two permanent diversion drains. The most upstream (southerly) diversion is to the east of the WRD Sediment Dam and the most downstream (northerly) diversion is to the west of the North Pit. The two diversion drains, and an associated levee at the North Pit were sized to convey flows up to and including the 0.1% AEP design storm event.

The North Pit, South Pit, Run of Mine (ROM) Pad, Light Infrastructure Area (LIA) (including site offices and workshop area) are located on the eastern bank of the unnamed tributary of the Leichardt River. The WRD and WRD Sediment Dam are located on the western bank of the unnamed tributary of the Leichardt River.

TAILINGS.WATER.WASTE.

DIAGRAM 2: SITE LAYOUT



2.2 Configuration and Details of South Pit

The South Pit is formed in excavation and is located to the east of the unnamed tributary traversing the site. The Underground Workings will be accessed from a portal located within the South Pit, at an elevation of RL 310 m AHD. The final void configuration of the South Pit is summarised in **TABLE 3**

TAILINGS.WATER.WASTE.

TABLE 3: SOUTH PIT CONFIGURATION

Feature	Value
Pit Rim elevation	RL 334.3 m
Pit Base elevation	RL 211.5 m
Total Pit Capacity to Rim/Spillway	3,272 ML
Portal Entry elevation	RL 310 m
Total Storage Capacity to Portal Entry	1,655 ML
Approximate Pit depth	122.5 m
Pit Water Level*	RL 250.8 m
Pit Extents	10.2 ha

*As at 30 October 2023

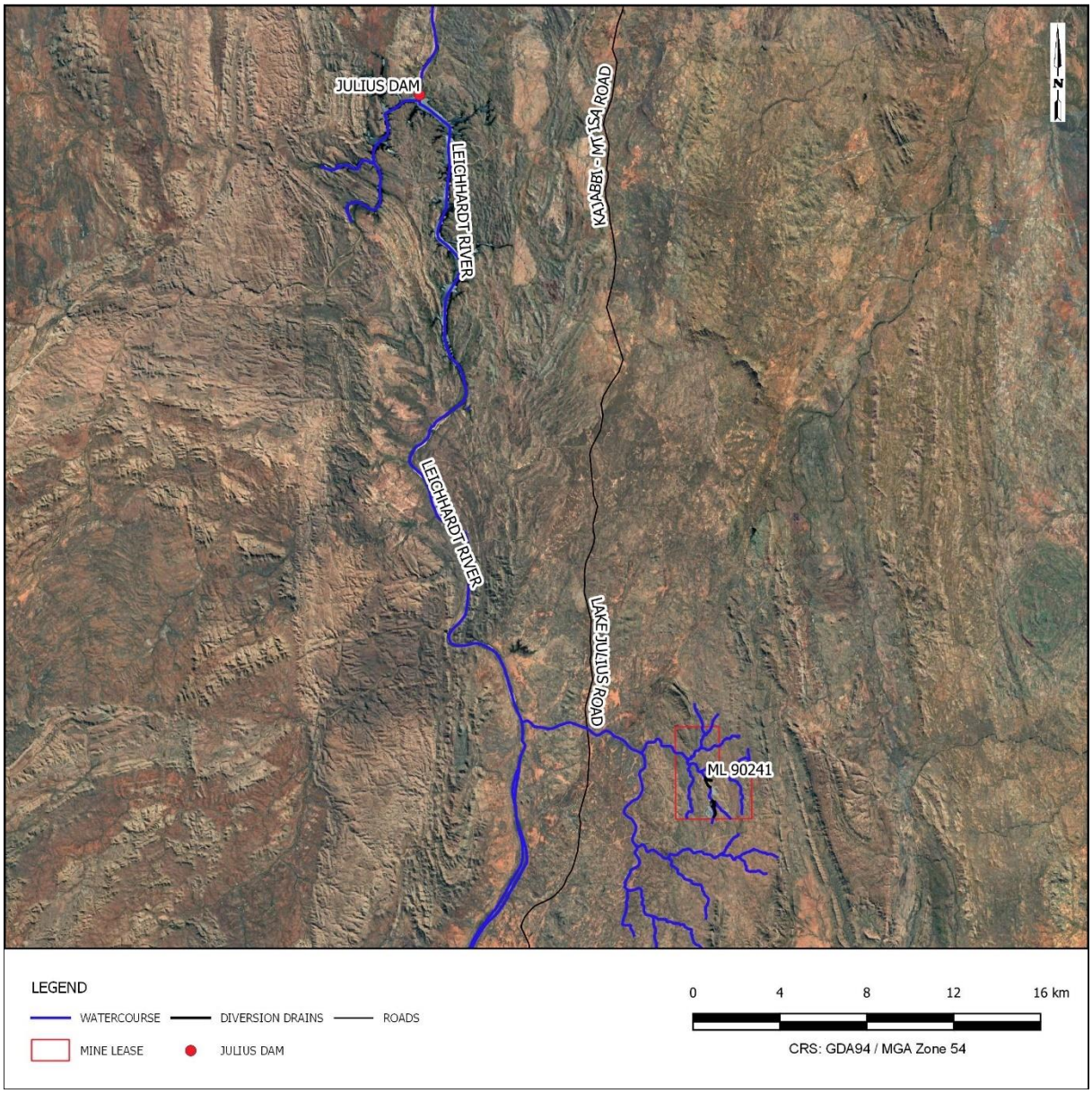
TAILINGS.WATER.WASTE.

2.3 Regional Watercourses

The unnamed tributary of the Leichardt River conveys flows to the Leichardt River approximately 9.5 km to the west-northwest of the BCP. All tributaries east of the Leichardt River within ML 90241 are unnamed. As such, when the unnamed tributary of the Leichardt River is hereafter referred to, it refers to the flow path through the BCP site and its continuing flow path to the Leichardt River.

Excluding the BCP, there are no dams or engineered structures on the unnamed tributary of the Leichardt River which might impact the characteristics of surface water runoff or flood behaviour. Approximately 35 km north of the confluence of the unnamed tributary of the Leichardt River with the Leichardt River, the Leichardt River is impounded by the Julius Dam. The location of the unnamed tributary of the Leichardt River, the Leichardt River, Julius Dam and the BCP mining lease are depicted on **DIAGRAM 3**

DIAGRAM 3: REGIONAL WATERCOURSES

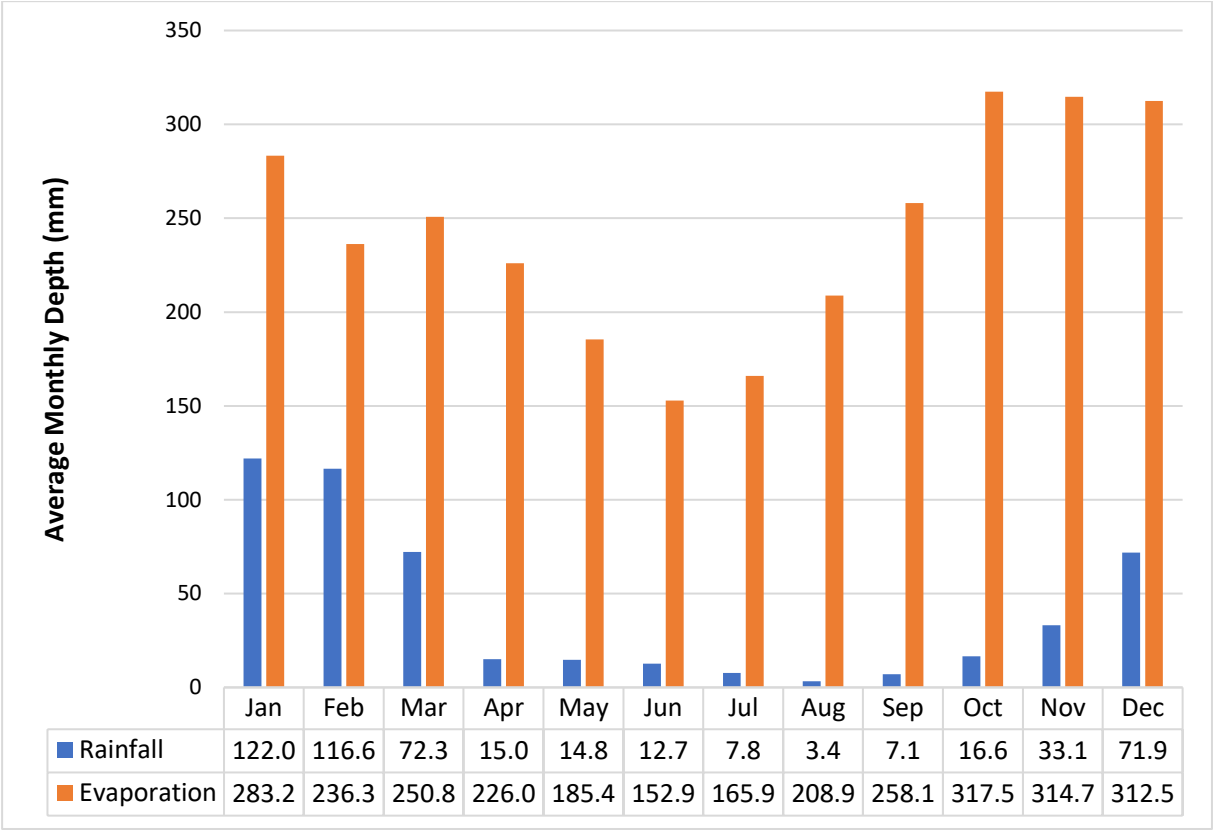


TAILINGS.WATER.WASTE.

2.4 Climatic Conditions

The Köppen Climate classification of the region is a hot, arid steppe climate (BSh) **[6]**. Highly variable rainfall occurs in the summer/wet season, which is typically hot and humid. The data obtained from the SILO Data Drill (The Long Paddock, 2024) **[7]** indicates that the mean annual rainfall for the region is 493 mm. The mean annual evaporation for the region is 2,912 mm. The highest monthly rainfall occurs mostly in December through to March, as illustrated in **CHART 1**. The lowest monthly rainfall occurs in the dry winter months of April to October. **CHART 1** indicates that monthly evaporation rates exceed rainfall year-round at the BCP site.

CHART 1: AVERAGE ANNUAL RAINFALL AND EVAPORATION FOR THE BCP



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	122.0	116.6	72.3	15.0	14.8	12.7	7.8	3.4	7.1	16.6	33.1	71.9
Evaporation	283.2	236.3	250.8	226.0	185.4	152.9	165.9	208.9	258.1	317.5	314.7	312.5

2.5 Subsurface Conditions and Groundwater Levels

According to WMV environmental **[8]**, the BCP mine site is hosted within the Leichardt Metamorphics within the Kalkadoon-Leichhardt belt of the Mt Isa Inlier. The area is structurally complex, with structural repetition of stratigraphic units and wrench faulting common. Rock types at Barbara include felsic volcanics (forming the hills), dolerite/amphibolite (in the drainages/valleys)

As noted by WMV environmental **[8]**, depth to groundwater in October 2013 were recorded between 7 to 37 m below ground level. It's also noted that prior to the commencement of mining, the contours and potentiometric surface profile show that, provided hydraulic continuity exists throughout the Leichhardt Metamorphics. Groundwater flow will be from south-west to north-east within the Barbara Shear Zone.

Further, there is little to no potential for the development of alluvial aquifers at the project site **[8]**, with the potential for recharge from rainfall being minimal .

2.6 Water Quality Data

Water quality sampling within the South Pit has been undertaken four (4) times between 2021 and 2024.

TAILINGS.WATER.WASTE.

A review of sampling data in relation to the ANZECC stock water limits **[9]** identified for the South Pit that all sampled analytes were within the ANZECC stock water limits.

A summary of the sampled data from April 2021 to March 2024 for the South is summarised in **TABLE 4**.

TABLE 4: SOUTH PIT WATER QUALITY DATA

Quality Parameter	Unit	ANZECC Stock Water Limit	Sampling Date			
			18/04/2021	18/07/2021	02/11/2021	06/03/2024
pH Value	pH Unit	5.0 - 9.0	8.11	8.1	8.09	7.95
EC	µS/cm	2,680/5,970	1,380	1,630	1,520	1290
Turbidity	NTU	N/A	0.7	0.8	1	1.0
Sulfate as SO4	Mg/L	1,000	580	683	713	498
Chloride	mg/L	N/A	23	27	22	20
Dissolved Major Cations						
Calcium	mg/L	1,000	125	169	153	101
Magnesium	mg/L	N/A	52	66	60	48
Sodium	mg/L	N/A	93	114	101	97
Potassium	mg/L	N/A	31	32	25	12
Dissolved Metals	mg/L					
Arsenic	mg/L	0.5	0.004	0.007	0.006	0.014
Barium	mg/L	N/A	0.045	0.04	0.04	0.053
Beryllium	mg/L	N/A	-	-	-	-
Bismuth	mg/L	N/A	<0.001	<0.001	<0.001	<0.001
Chromium	mg/L	1	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	1	0.005	0.016	0.012	<0.001
Copper	mg/L	1	0.023	0.018	0.012	0.008
Molybdenum	mg/L	0.15	0.047	0.054	0.043	0.020
Nickel	mg/L	1	0.013	0.031	0.024	0.005
Selenium	mg/L	0.02	<0.01	<0.01	<0.01	0.02
Uranium	mg/L	0.2	-	-	-	0.007
Vanadium	mg/L	N/A	0.008	0.01	0.008	-
Boron	mg/L	5	-	-	-	-
Iron	mg/L	N/A	-	-	-	-
Other						
Fluoride	mg/L	2	1.4	1.3	1.1	0.7
Nitrite as N	mg/L	30	-	-	-	-
Nitrate as N	Mg/L	400	-	-	-	-

TAILINGS.WATER.WASTE.

3 WATER QUALITY ASSESSMENT

3.1 Introduction

In 2023, as part of the PRCP for the BCP Project, ATC Williams developed water quality models (WQMs) for the North Pit, South Pit, and WRD Sediment Dam by linking the output of the 2023 Goldsim WBM **[16]** with a PHREEQC geochemical model (USGS, ver. 3.6.2.15100) **[15]**. Although these models did not include the proposed underground workings, they were reviewed by WMV environmental, who considered that the results are relevant for assessing the final void water quality in the open pits and WRD Sediment Dam.

Three water balance scenarios were evaluated for the water quality assessment, corresponding with the following Goldsim™ WBM stochastical results:

- Median climatic conditions (50th percentile or P50).
- Interquartile climatic conditions (25th and 75th percentiles).

Higher probabilities for the site were not considered since increased rainfall and groundwater discharge into the pit void and lower evaporation rates would result in an improved water quality and represent a lower risk to the downstream environment or closure condition.

Additionally, two main geochemical scenarios were considered:

- The first scenario included mixing different water types and evaporative processes, called the ‘mixing’ model.
- The second scenario included speciation equilibrium modelling, primarily focusing on gypsum precipitation, called the ‘equilibrium’ model.

Key assumptions included maintaining pH values of the site water quality solutions, no stratification within the pit void, and focusing on bulk water chemistry.

3.2 South Pit Water Quality

Appendix J of the WVM Groundwater Technical Report **[8]** details the long-term water quality in the South Pit, summarized as follows:

- Solute concentrations remained below ANZECC 2000 Water Quality Guideline [9] values for livestock watering.
- Main physical processes impacting solute levels were rainfall runoff dilution, groundwater inflow, and evaporation concentration.
- Groundwater inflow played a moderate role, comprising ±20% of total inflows, and buffered the effects of evaporation on solute concentrations.

3.3 Summary

The water quality modelling indicated that solute concentrations in both models remained below the ANZECC 2000 Water Quality Guideline values for livestock watering. Long-term water quality in the pit was influenced by climatic conditions and geochemical reactions, stabilizing over time. Short-term variations are determined by the net flow balance between rainfall runoff, groundwater inflow, and evaporation. Based on the WQM results, the South is suitable as PMLUs for livestock watering

TAILINGS.WATER.WASTE.

4 WATER BALANCE ASSESSMENT

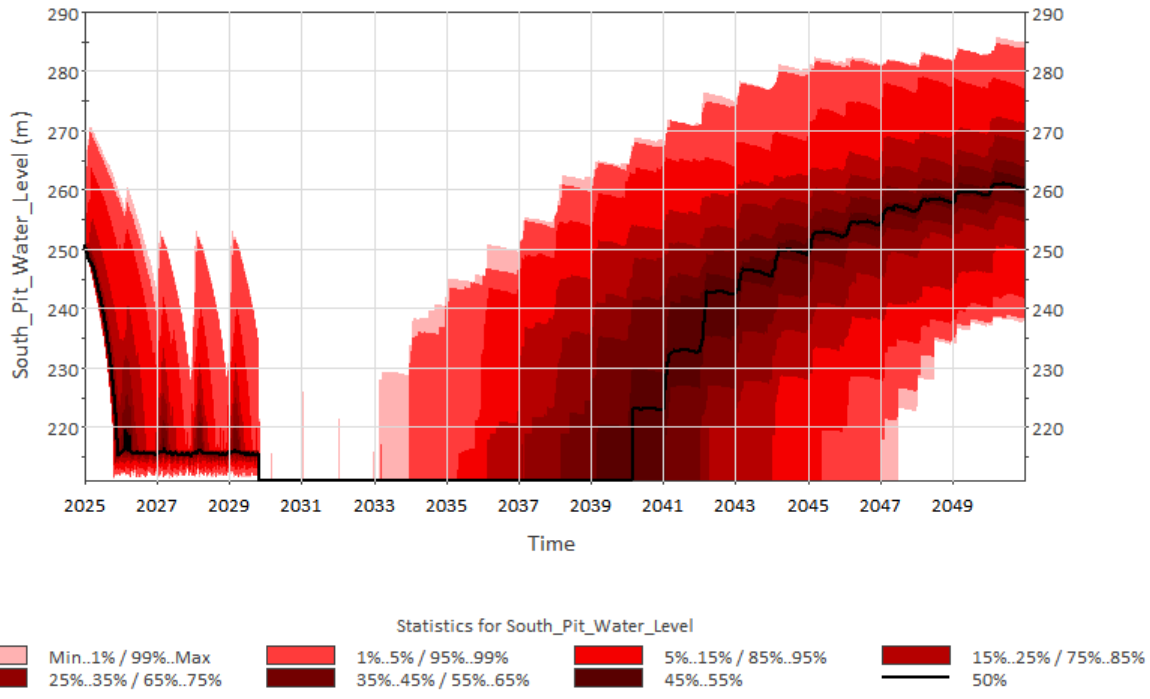
4.1 Introduction

In 2024, ATCW [14] updated the WBM developed in 2023 for the Progressive Rehabilitation and Closure Planning Assessment [16]. This new WBM included the re-commencement of mineral ore extraction through proposed new Underground Workings (UG), accessed via a new portal located within the South Pit at 310 m AHD. It was assumed in the WBM that mining activities would commence at the beginning of 2025 and cease at the end of October 2029.

4.2 South Pit Key Findings:

- The South Pit is rapidly dewatered by October 2025 to meet site water demands.
- The Underground Workings receives all rainfall and runoff from the South Pit from 2029. Under median climatic conditions, the Underground Workings takes ten years from 2029 to 2039 to fill. After the Underground Workings fill, the South Pit then begins to fill.
- The maximum modelled water level in the South Pit is 290 m AHD under the 99th percentile scenario, well below the pit crest at 334 m AHD, and the portal entrance at 310 m AHD, indicating no risk of overtopping.
- The South Pit remains a groundwater sink with no outflows, maintaining a long-term median water level of approximately 260 m AHD by 2050 as indicated in **GRAPH 1**.

GRAPH 1: WRD SEDIMENT DAM WATER SURFACE ELEVATION (2025 T0 2050)



4.3 Conclusion

The water balance model indicates that there is no risk of overtopping for the South Pit under both operational conditions. The predicted water levels remain below the respective pit crests and portal elevation, ensuring safe containment and management of water volumes throughout the simulation period.

TAILINGS.WATER.WASTE.

5 GENERAL ENVIRONMENTAL HARM ASSESSMENT

In assessing the consequence category for the failure of a structure in accordance with the Manual **[3]**, the assessment was undertaken against the following 'environmental harms':

- harm to humans,
- general environment harm, and;
- general economic loss or property damage.

When considering general environmental harm, the receiving environment for the failure of a structure includes, but is not limited to, ephemeral waterways, creeks and rivers and the groundwater system. The main receiving environment for a failure of a regulated structure within a 10 km flow path downstream to the north includes:

- unnamed tributaries of the Leichardt River; and
- the Leichardt River.

The Leichardt River is impounded by the Julius Dam approximately 34 km northwest of the North Pit.

In accordance with the Manual **[3]**, the Consequence Category Assessment (General Environmental Harm) is concerned with effects to areas with 'Significant Values' and 'Moderate Values' within the receiving environment. The values are defined as follows.

- Significant Values
  - Matters of National Environmental Significance (MNES)
  - Matters of State Environmental Significance (MSES)
  - High Ecological Value (HEV) waters as per the Queensland Environmental Protection (Water) Policy 2009 (EPP Water) **[4]**
- Moderate Values
  - Slightly or moderately disturbed waters as per the EPP Water **[4]**
  - Wetland of general ecological significance (GES) as mapped on the Queensland Government referable wetland mapping.
  - Riverine areas, springs or lakes and associated flora and fauna.

The characteristics and exposure of these receiving environments has been taken from the environmental assessment reports in **Appendix B**, **Appendix C**, **Appendix D** and **Appendix E**.

5.1 Potential Surface Environment Impacts

The relevant characteristics of the unnamed tributary of the Leichardt River and the Leichardt River in the context of environmental values, were assessed from the following sources:

- Matters of National Environmental Significance
- Matters of State Environmental Significance
- High Ecological Value Wetlands and Waterways
- Aquatic Conservation Significance
- Registered Private Bores

The relevant information from each of these data sources are discussed in the following sub-sections.

TAILINGS.WATER.WASTE.

5.1.1 Matters of National Environmental Significance

The Protected Matter Report (PMR) **[10]** for the project area is provided in **Appendix B.** The report lists the MNES that may occur within a 10 km buffer of the centre of the mine. It includes locations downstream of the project area, as well as locations in adjacent catchments to the north, east and south.

There are no World Heritage Properties, National Heritage Places, Wetlands of International Importance, Great Barrier Reef Marine Park, Commonwealth Marine Areas or Listed Threatened Ecological Communities listed for the receiving environment in the PMR **[10]**.

The PMR **[10]** contains 17 Listed Threatened Species and 12 Migratory Species listed for the receiving environment. The critically endangered and endangered animals listed in the PMR **[10]** report are summarised in **TABLE 5.**

TABLE 5: MNES LISTED CRITICALLY ENDANGERED AND ENDANGERED ANIMALS

Name	Scientific Name	Status	Presence	Location
Curlew Sandpiper	Calidris Ferruginea	Critically Endangered	Species or species habitat may occur within area (Bird)	Within 10km of the center of the mine
Red Goshawk	Erythrotriorchis radiatus	Endangered	Species or species habitat may occur within area (Bird)	Within 10km of the center of the mine
Gouldian Finch	Erythrura gouldiae	Endangered	Species or species habitat may occur within area (Bird)	Within 10km of the center of the mine
Within 10km of the center of the mineNight Parrot	Pezoporus occidentalis	Endangered	Species or species habitat likely to occur within area (Bird)	Within 10km of the center of the mine
Australian Painted Snipe	Rostratula australis	Endangered	Species or species habitat may occur within area (Bird)	Within 10km of the center of the mine
Common Greenshank	Tringa nebularia	Endangered	Species or species habitat may occur within area (Bird)	Within 10km of the center of the mine
Gulf Snapping Turtle	Elseya lavarackorum	Endangered	Species or species habitat known to occur within area (Reptile)	Within 10km of the center of the mine
Mertens' Water Monitor	Varanus mertensi	Endangered	Species or species habitat known to occur within area (Reptile)	Within 10km of the center of the mine

5.1.2 Matters of State Environmental Significance

There are several areas of Matters of State Environmental Significance (MSES) **[11]** within ML90241 pertaining to:

TAILINGS.WATER.WASTE.

- Wildlife Habitat (special least concern),
- Wildlife Habitat (endangered or vulnerable),
- Regulated vegetation (intersecting a watercourse) along the unnamed tributary of the Leichardt River between from the WRD Dam north beyond the North Pit; and,
- Regulated vegetation (essential habitat) along the unnamed tributary of the Leichardt River between from the WRD Dam north beyond the North Pit.

These areas are shown in the MSES documentation in **Appendix C – Map 3a** and **Map 4**.

5.1.3 High Ecological Value Wetlands and Waterways

Assessment of the available data MSES data **[11]** (**Appendix C**) showed that no High Ecological Value (HEV) wetlands or waterways were identified within ML90241.

5.1.4 Aquatic Conservation Significance

The unnamed tributary of the Leichardt River and the Leichardt River are located in the Northwest Highlands bioregion, the Mount Isa Inlier subregion, which falls within the Leichardt River catchment. The unnamed tributary of the Leichardt River and Leichardt River were assessed against the characteristics for riverine areas, lakes and springs, as per the Queensland Government Wetland Maps **[12].**

Review of the available wetland mapping **[13]**, MNES **[10]**, MSES **[11]**, Biodiversity and Conservation Values **[12]** and Regional Ecosystems **[13]** did not identify any riverine waterbodies in the unnamed tributary of the Leichardt River and Leichardt River.

The unnamed tributary of the Leichardt River and Leichardt River were identified as areas of 'Medium' riverine subcatchment significance as depicted in **Appendix D – Map 5**. 'Medium' riverine values refer to riverine wetlands in deepwater habitat in a natural or artificial channel.

5.1.5 Groundwater Supply

TABLE 6 provides a summary of the local registered private boreholes within ML90241 and adjacent to the site. The location of the boreholes related to the site are shown on Error! Reference source not found..The identified bores within ML90241 relate to mine water supply and mine monitoring/compliance.

TABLE 6: REGISTERED LOCAL BOREHOLES ON ML90241 AND SURROUNDING AREA

Local Bore Locations and Details					
Bore*	**Coordinates (GDA94, Zone 54)**	**Location on Site**	**Date Drilled**	**Type/Role**	**Facility Status**
RN146948	379834 E 7742692 N	750 m North of the North Pit.	26/01/2014	Sub-Artesian Facility - Mine Monitoring	Existing
RN146949	380043 E 7742054 N	150 m Northeast of the North Pit.	30/01/2014	Sub-Artesian Facility - Mine Monitoring	Existing
RN146950	380432 E 7741097 N	450 m East of WRD Sediment Dam	31/01/2014	Sub-Artesian Facility - Mine Monitoring	Existing
RN146951	380948 E 7740252 N	470 m of LIA.	1/02/2014	Sub-Artesian Facility - Mine Monitoring	Existing

TAILINGS.WATER.WASTE.

Local Bore Locations and Details					
Bore*	**Coordinates (GDA94, Zone 54)**	**Location on Site**	**Date Drilled**	**Type/Role**	**Facility Status**
RN146952	379480 E 7742395 N	615 m Northwest of the North pit.	2/02/2014	Sub-Artesian Facility - Mine Monitoring	Existing
RN146953	379859 E 7741935 N	West end of North Pit	4/02/2014	Sub-Artesian Facility - Water Supply	Existing
RN146954	380052 E 7741711 N	Northwest end of South Pit	5/02/2014	Sub-Artesian Facility - Water Supply	Existing
RN163352	380292 E 7740939 N	300 m East of WRD Sediment Dam.	4/10/2014	Sub-Artesian Facility - Mine Monitoring	Existing
RN163353	379272 E 7742097 N	650 m West of the North Pit	25/09/2014	Sub-Artesian Facility - Mine Monitoring	Abandoned or destroyed
RN163354	380026 E 7738835 N	1.7 km South of WRD	26/09/2014	Sub-Artesian Facility - Mine Monitoring	Existing
RN163355	380075 E 7738643 N	1.9 km South of WRD	27/09/2014	Sub-Artesian Facility - Mine Monitoring	Abandoned or destroyed
RN163356	381035 E 7739043 N	1.6 km South of LIA.	28/09/2014	Sub-Artesian Facility - Mine Monitoring	Abandoned or destroyed
RN163358	376027 E 7740643 N	3.9 km West of WRD.	3/10/2014	Sub-Artesian Facility - Mine Monitoring	Abandoned or destroyed
RN163359	379991 E 7741485 N	West end of South Pit.	4/10/2014	Sub-Artesian Facility - Mine Monitoring	Abandoned or destroyed
RN163360	379912 E 7741279 N	West end of ROM Pad.	4/10/2014	Sub-Artesian Facility - Mine Monitoring	Abandoned or destroyed
RN163368	381018 E 7739042 N	1.6 km South of LIA.	28/09/2014	Sub-Artesian Facility - Mine Monitoring	Abandoned or destroyed
RN163369	380611 E 7740824 N	200 m North of LIA	29/09/2014	Sub-Artesian Facility - Mine Monitoring	Abandoned or destroyed
RN163370	376835 E 7744820 N	4.2 km Northwest of the North Pit.	1/10/2014	Sub-Artesian Facility - Mine Monitoring	Existing

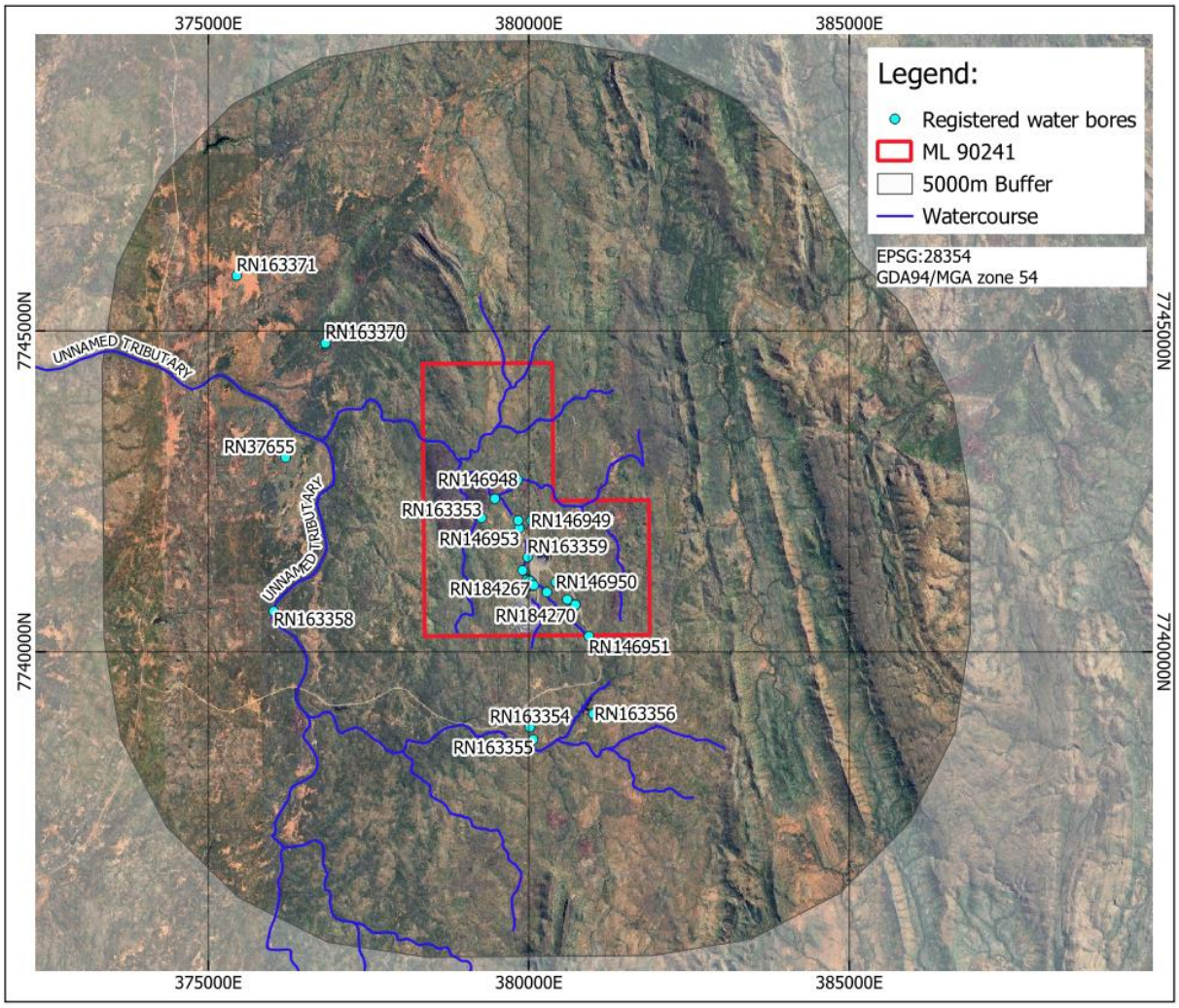
TAILINGS.WATER.WASTE.

Local Bore Locations and Details					
Bore*	**Coordinates (GDA94, Zone 54)**	**Location on Site**	**Date Drilled**	**Type/Role**	**Facility Status**
RN163371	375440 E 7745847 N	5.9 km Northwest of the North Pit.	02/10/2014	Sub-Artesian Facility - Mine Monitoring	Abandoned or destroyed
RN184264	379984 E 7741131 N	North end of WRD Sediment Dam	15/07/2019	Sub-Artesian Facility - Mine Monitoring	Existing
RN184265	379984 E 7741131 N	North end of WRD Sediment Dam	15/07/2019	Sub-Artesian Facility - Mine Monitoring	Existing
RN184266	380022 E 7741115 N	North end of WRD Sediment Dam	16/07/2019	Sub-Artesian Facility - Mine Monitoring	Existing
RN184267	380022 E 7741115 N	North end of WRD Sediment Dam.	16/07/2019	Sub-Artesian Facility - Mine Monitoring	Existing
RN184269	380085 E 7741047 N	North end of WRD Sediment Dam	16/07/2019	Sub-Artesian Facility - Mine Monitoring	Existing
RN184270	380736 E 7740742 N	North end of LIA	26/07/2019	Sub-Artesian Facility - Mine Monitoring	Existing
RN184271	380736 E 7740742 N	North end of LIA	26/07/2019	Sub-Artesian Facility - Mine Monitoring	Existing
RN184272	379844 E 7742057 N	North end of North Pit.	28/07/2019	Sub-Artesian Facility - Water Supply	Existing
RN37655	376213 E 7743038 N	3.8 km West northwest of the North Pit.	8/10/1971	Sub-Artesian Facility - No Data	Abandoned or destroyed

*Details extracted from WMV, “Barbara Copper Project UG EA Amendment” **[8]**

TAILINGS.WATER.WASTE.

DIAGRAM 4: BORES WITHIN ML90241 AND SURROUNDING AREA



TAILINGS.WATER.WASTE.

6 CONSEQUENCE CATEGORY ASSESSMENT

6.1 Basis of the Consequence Category Assessment

The BCP site was assessed against the requirements of the Manual **[3]** for site conditions during operation of the underground workings. This involved a desktop review of potential harm associated with failure-to-contain scenarios.

No site inspections were carried out specifically for this assessment. However, ATCW staff are familiar with the site from previous inspections performed on WRD Sediment dam in 2021 [17] and 2022 [18]. Aeris has confirmed that there are no significant changes since the last inspection. We have verified this through the inspection of satellite images.

6.2 Consequence Category Assessment Regulatory Requirements

The Manual sets out the requirements of the administering authority, the Queensland Government Department of Environment and Science (DES) for a consequence category assessment and certification of the design of regulated structures, constructed as part of environmentally relevant activities under the Environmental Protection Act (1994) **[4].**

The purpose of the Manual is to:

- guide the assessment of the Consequence Category of all structures constructed as part of activities that require an EA or development approval;
- guide the determination of the structure/s that require formal documentation; and
- provide approved methods for specifying the design performance and monitoring requirements for those structures.

Assessment criteria for CCA is based on the following failure event scenarios.

- Failure to Contain – Seepage

  Spills or release to ground/groundwater via seepage from the floor and/or sides of the structure. This is only relevant to water storage structures constructed after 29 March 2016 and as such has not been included in this CCA review.

- Failure to Contain – Overtopping

  Spills or releases from the structure that result from loss of containment due to overtopping of the structure.

- Failure to Contain – Dam Break

  Collapse of the structure due to any possible cause.

Under these scenarios, several modes of failure are possible as described below:

- A failure to contain scenario means a release from the structure that results from loss of containment due to excessive seepage, overtopping of the structure and/or other deficiencies in the passive water management elements associated with each storage. Although such a failure mechanism is typically non-flood producing, failure to contain events may involve the release of contaminants, which could endanger environmental values or human life/wellbeing.
- A dam break scenario involves the partial or complete collapse of a structure due to any possible cause. This scenario is not relevant to the South Pit because there is not a dam wall.

The basis for assessment of Consequence Category from the Manual is reproduced in **TABLE 7.**

TAILINGS.WATER.WASTE.

TABLE 7: CONSEQUENCE CATEGORY ASSESSMENT CRITERIA

Environmental Harm	Consequence Category		
	High	**Significant**	**Low**
Harm to Humans	Location such that people are routinely present in the failure path and if present loss of life to greater than 10 people is expected[8]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario.	Location such that people are routinely present in the failure path and if present loss of life to 1 person or greater but less than 10 people is expected[7]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario.	Location such that people are not routinely present in the failure path and loss of life is not expected[7]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario.
	Location such that contamination of waters (surface and/or groundwater[9]) used for human consumption could result in the health of 20 or more people being affected[10].	Location such that contamination of waters (surface and/or groundwater[8]) used for human consumption could result in the health of 10 or more people but less than 20 people being affected[9].	Location such that contamination of waters (surface and/or groundwater[8]) used for human consumption could result in the health of less than 10 people being affected[9].
General environmental harm	Location such that: a) Contaminants may be released to areas of MNES, MSES or HEV waters that are not already authorised to be disturbed to at least the same extent under other conditions of this authority subject to any applicable offset commitment (Significant Values); and b) Adverse effects[11] on Significant Values are likely; and c) The adverse effects[10] are likely to cause at least one of the following: i) loss or damage or remedial costs greater than $50,000,000; or ii) remediation of damage is likely to take 3 years or more; or iii) permanent alteration to existing ecosystems; or iv) the area of damage (including downstream effects) is likely to be at least 5 km².	Location such that contaminants may be released so that adverse effects[10] (that are not already authorised to be disturbed to at least the same extent under other conditions of the authority subject to any applicable offset commitment) either: a) Would be likely to be caused to Significant Values but those adverse effects[10] would not be likely to meet the thresholds for the High Consequence Category and instead would be likely to cause at least one of the following: i) loss or damage or remedial costs greater than $10,000,000 but less than $50,000,000; or ii) remediation of damage is likely to take more than 6 months but less than 3 years; or iii) significant alteration to existing ecosystems; or iv) the area of damage (including downstream effects) is likely to be at least 1km2 but less than 5 km². or b) Would be likely to be caused to environmental values classed as slightly or moderately disturbed waters[12], wetland of general ecological significance[13], riverine areas, springs or lakes and associated flora and fauna (Moderate Values), and the adverse effects[10] are likely to cause at least one of the following: i) loss or damage or remedial costs greater than $20,000,000; or ii) remediation of damage is likely to take more than 1 year; or iii) significant alteration to existing ecosystems; or the area of damage (including downstream effects) is likely to be at least 2 km².	Location such that either: a) Contaminants are unlikely to be released to areas of Significant Values or Moderate Values; or b) Contaminants are likely to be released to those areas, but would be unlikely to meet any of the minimum thresholds specified for the Significant Consequence Category for adverse effects[10]
General economic loss or property damage	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require $10 million or greater in rehabilitation, compensation, repair or rectification costs[14].	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require $1 million and greater but less than $10 million in rehabilitation, compensation, repair or rectification costs[13].	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require less than $1 million in rehabilitation, compensation, repair or rectification costs[13] .

7 To be used for all failure event scenarios

8.'People routinely present in the failure path' could be considered to be people who occupy buildings or other places of occupation that lie within the failure impact zone. For the purposes of this Manual, this should refer to people other than site personnel engaged by the resource operation and located on the tenements and tenure associated with the resource operation; for other ERAs, it would be the 'premises referred to in the authority'. It should be noted that while this is appropriate for the assessment of consequence categories in accordance with this Manual, adherence to the requirements of this Manual does not limit, amend or change in any way, any other requirements to be complied with under relevant health and safety acts or legislation that requires the safety of site personnel to be considered.

9 When considering potential impacts on groundwater, it is not envisaged that a full hydrogeological assessment will be required in all cases. Any consideration of potential impacts on groundwater systems should consider the water quality of the potential receiving aquifer as well as the quality of fluid stored in the regulated dam. Existing groundwater drawdown in areas surrounding resource operations (e.g. drawdown as a result of mine pit or underground mine dewatering) can also be considered when assessing the consequence of dam seepage on groundwater systems.

10 'An adverse effect on human health means a physiological effect on human health and does not include an impact on the quality of downstream water that merely negatively affects taste and which is unlikely to cause persons to become physically ill.

11 Adverse effects includes chronic and acute effects where an acute effect is on living organism/s which results in severe symptoms that develop rapidly, and a chronic effect is an adverse effect on a living organism/s which develops slowly. In some instances, it may be necessary to carry out or reference existing ecological/toxicological studies to assess the impacts of contaminants on living organisms.

12 See Water EPP for definitions

13 Wetland of general ecological significance' means a wetland shown on a map of referable wetland as a 'general ecologically significant wetland' or 'wetland of other environmental value'.

14 This does not include the holder's own mine or gas production, on-site industrial or commercial assets, the holder's workers' accommodation, agricultural facilities on the holder's land such as a farm shed or farm dam or infrastructure solely for servicing the holder.

TAILINGS.WATER.WASTE.

7 CONSEQUENCE CATEGORY ASSESSMENT

Assessments against the failure scenarios in the Manual for the South Pit is contained in **TABLE 8**.

TAILINGS.WATER.WASTE.

TABLE 8: CONSEQUENCE CATEGORY ASSESSMENT – SOUTH PIT

Environmental Harm	Consequence Category		
	Failure to Contain - Seepage	**Failure to Contain - Overtopping**	**Failure to Contain - Dam Break**
Harm to Humans	Seepage failure of the South Pit would likely not cause harm to humans as no bores registered for human consumption or usage located within 5 km of the South Pit. **Consequence Category assessed as Low.**	Water within the South Pit is comprised of direct rainfall over the pit extent and groundwater inflows. In the event of an overtopping failure, flows would enter mine portal. There will be nine site personnel presents in the potential failure path or impact zone at all times. However, as presented in Appendix A, the WBM indicates that the peak water surface elevation in the void would not reach the portal elevation (310 m AHD) under operational conditions. **Consequence Category assessed as Low.**	A release of water from the South Pit due to a Dam Break is not a credible failure scenario. **Consequence Category is assessed as N/A.**
General environmental harm	Waters contained in the South Pit will be comprised of direct rainfall over the pit extent and groundwater inflows. Water balance modelling indicated there is no seepage outflow due to the long-term lake water level being below the groundwater inflow level. **Consequence Category assessed as Low.**	Water within the South Pit is comprised of direct rainfall over the pit extent and groundwater inflows. Under operational conditions, an overtopping failure would result in flows entering the underground workings via the portal. However, the WBM simulations indicate that the void would not reach the spill elevation at the portal. **Consequence Category assessed as Low.**	A release of water from the South Pit due to a Dam Break is not a credible failure scenario. **Consequence Category is assessed as N/A.**
General economic loss or property damage	It was assessed that failure to contain – seepage would not result in general economic loss or property damage as no third-party assets are located near to the South Pit. **Consequence Category assessed as Low.**	In the event of an overtopping failure, flows would enter the portal to the underground workings. Water Balance Model simulations indicates that the void would not reach the spill elevation under operating conditions. **Consequence Category assessed as Low.**	A release of water from the South Pit due to a Dam Break is not a credible failure scenario. **Consequence Category is assessed as N/A.**
Overall Consequence Category	**LOW**	**LOW**	**N/A**

TAILINGS.WATER.WASTE.

8 CONSEQUENCE CATEGORY ASSESSMENT SUMMARY

TABLE 9 summarises the CCA outcomes for the South Pit.

TABLE 9: CONSEQUENCE CATGEORY ASSESSMENT SUMMARY – NORTH PIT, SOUTH PIT, WRD SEIDMENT DAM

Failure Scenario	South Pit
Failure to Contain – Seepage	Low
Failure to Contain – Overtopping	Low
Failure to Contain - Dam Break	N/A
Overall	Low
Regulated Structure, as defined in the Manual	N

As can be seen in **TABLE 9**, the South Pit have been assessed as Low, and therefore not considered to be a regulated structure.

However, it is recommended that, Aeris develop an Emergency Action Plan for the South Pit to address potential risks should water levels rise above the modelled scenarios. This plan should include:

- Regular Monitoring: Continuous monitoring of water levels in the South Pit.
- Trigger Levels: Defined trigger levels for initiating emergency actions when water levels approach or exceed the modelled maximum of 290 m AHD.
- Emergency Procedures: Specific actions for rapid water management and mitigation to prevent overtopping.

TAILINGS.WATER.WASTE.

REFERENCES

[1] Department of Environment and Science (2020), Environmental Authority EPML02840015 (Effective Date 3 February 2020), Queensland Government.

[2] URS (2014), 'Barbara Copper Project Water Management Strategy', Ref: 42627360/01/2, dated 26 November 2014.

[3] Department of Environment and Science (2024), 'Manual for Assessing Consequence Categories and Hydraulic Performance of Structures', ESR/2016/1933, February 2024, version 5.03, Queensland Government.

[4] Queensland Parliament (2018), Environmental Protection Act 1994, 1 January 2018 Reprint, Queensland Government.

[5] Department of Natural Resources, Mines and Energy (2018), 'Guideline for failure impact assessment of water dams', November 2018, Queensland Government.

[6] Beck, H.E., N.E. Zimmermann, T.R. McVicar, N. Vergopolan, A. Berg, E.F. Wood (2018), 'Present and future Köppen-Geiger climate classification maps at 1-km resolution', *Scientific Data* 5:180214, doi:10.1038/sdata.2018.214 (2018).

[7] The Long Paddock (2024), SILO Data Drill for Cell -20.40, 139.85, accessed February 2024, https://www.longpaddock.qld.gov.au/silo/gridded-data/, Queensland Government

[8] WMV Environmental (2024b), 'Barbara Copper Project UG EA Amendment . Groundwater Technical Report, February 2024.

[9] Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ). (2000), National Water Quality Management Strategy – Paper No. 4: Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Natural Resource Ministerial Council, Australia

[10] Department of Agriculture, Water and the Environment (2024), 'EPBC Act Protected Matter Report', accessed 15 May 2024 for a 10km buffer of the centre of the mine, http://www.environment.gov.au/epbc/pmst/, Australian Government.

[11] Department of Environment and Science (2024a), 'Environmental Reports - Matters of State Environmental Significance', accessed 14 May 2024 for ML90241, https://apps.des.qld.gov.au/report-request/environment/, Queensland Government.

[12] Department of Environment and Science (2024b), 'Environmental Reports - Biodiversity and Conservation Values – Biodiversity Planning Assessments and Aquatic Conservation Assessments', accessed 14 May 2024 for ML90241, https://apps.des.qld.gov.au/report-request/environment/, Queensland Government.

[13] Department of Environment and Science (2024c), 'Environmental Reports - Regional Ecosystems – Biodiversity Status', accessed 14 May 2024 for ML90241, https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/descriptions, Queensland Government.

[14] ATC Williams (2024), 'Barbara Copper Project –WMP Update for Underground Workings – Water Balance Model', Ref: 118131.16.R03, dated March 2024.

[15] ATC Williams (2023), 'Aeris Resources - Barbara Copper Project – Progressive Rehabilitation and Closure Planning - Geochemical assessment of the North Pit, South Pit and the WRD Sediment Dam', Ref: 18131.12.M02, dated April 2023.

[16] ATC Williams (2023b), 'Aeris Resources - Barbara Copper Project - Progressive Rehabilitation and Closure Planning – Water Management Plan and Water Balance Model', Ref: 118131.12.R03 – dated 17 February 2023.

[17] ATC Williams (2021). "Barbara Copper Project – 2021 Annual Inspection of Regulated Dams", Ref 118131.11.R001-0, dated 3 December 2021.

[18] ATC Williams (2022). "Barbara Copper Project – 2022 Annual Inspection of Regulated Dams", Ref 118131.14.R001, unissued.

CONDITIONS OF REPORT

1. This report must be read in its entirety.
2. This report has been prepared by ATCW for the purposes stated herein and ATCW's experience, having regard to assumptions that can reasonably be expected to make in accordance with sound professional principles. ATCW does not accept responsibility for the consequences of extrapolation, extension or transference of the findings and recommendations of this report to different sites, cases, or conditions.
3. This document has been prepared based in part on information which was provided to ATCW by the client and/or others and which is not under our control. ATCW does not warrant or guarantee the accuracy of this information. The user of the document is cautioned that fundamental input assumptions upon which the document is based may change with time. It is the user's responsibility to ensure that these assumptions are valid.

Unless specifically agreed otherwise in the contract of engagement, ATCW retains Intellectual Property Rights over the contents of the document. The client is granted a licence to use the report for the purposes for which it was commissioned.

TAILINGS.WATER.WASTE.

APPENDICES

APPENDIX A – WATER BALANCE MODEL INPUTS AND RESULTS

REPORT

AERIS RESOURCES LIMITED

Barbara Copper Project
WMP Update for Underground Workings – Water Balance Model

118131.16.R03
MARCH 2024

TAILINGS.WATER.WASTE.

Document Control

Project Name:	Barbara Copper Project
Document Title:	WMP Update for Underground Workings – Water Balance Model
File Location:	M:\Synergy\Projects\118\118131 Barbara Copper Project\16 WMP Update for Underground\Documents\R03 - WBM\Text\118131.16.R03_Rev0.docx
Document Number:	118131.16.R03_Rev0

Revision History

Revision	Issue	Issue Date	Prepared by	Reviewed by
A	Draft Issue	22 February 2024	James Parker	Nicola Logan
0	Final Issue	1 March 2024	James Parker	Nicola Logan

Issue Register

Distribution List	Date
Aeris Resources, WMV Environmental	22 February 2024, 1 March 2024

ATC Williams Company Details

Prepared By:	James Parker
Approved By:	Nicola Logan
Address:	Ground Floor, 16-20 Edmondstone Street, Newmarket QLD 4051
Tel:	07 3352 7222
Email:	brisbane@atcwilliams.com.au

© ATC Williams Pty Ltd (ATCW). All rights reserved.

ATCW has prepared this document solely for the use of the person or company to whom it is addressed, each as expressly stated in the document. No other party should rely on this document without the prior written consent of ATCW. No responsibility or liability to any third party is accepted for any damages howsoever arising out of the use of this report by any third party.

Your attention is drawn to Conditions of Report attached to this document. These conditions are an integral part of the document and must be reproduced with every copy.

TAILINGS.WATER.WASTE.

CONTENTS

1 INTRODUCTION 1

1.1 Background 1
1.2 Outcomes 1

2 WATER BALANCE MODEL 2

2.1 Water Balance Model Development 2
2.2 Model Structure and Inputs 2
2.2.1 Climatic Data 3
2.2.2 Catchment Delineation 3
2.2.3 Groundwater Inflows 4
2.2.4 Storage Curve Data and Initial Conditions 8
2.2.5 Initial Storage Conditions 12
2.2.6 Pump Transfers and Source Priority 12
2.2.7 Site Water Demands 12
2.2.8 South Pit and Underground Workings Interaction 13
2.2.9 Simulation Period 13
2.3 Model Development 13

3 RESULTS 15

3.1 South Pit 15
3.2 Underground Workings 17
3.3 North Pit 19
3.4 WRD Sediment Dam 21

4 SUMMARY AND CONCLUSION 24

REFERENCES 25

TAILINGS.WATER.WASTE.

TABLES

TABLE 1: SITE WATER BALANCE – RAINFALL AND EVAPORATION INPUT DATA 3
TABLE 2: CATCHMENT DETAILS 3
TABLE 3: NORTH PIT GROUNDWATER INFLOW ESTIMATES 5
TABLE 4: SOUTH PIT GROUNDWATER INFLOW ESTIMATES 6
TABLE 5: UNDERGROUND WORKINGS GROUNDWATER INFLOW ESTIMATES 7
TABLE 6: INITIAL WATER STORAGE INPUTS 12
TABLE 7: PUMP TRANSFER CONFIGURATION 12
TABLE 8: AWBM MODEL PARAMETERS 14

DIAGRAMS

DIAGRAM 1: WATER BALANCE MODEL PROCESS FLOW DIAGRAM 2
DIAGRAM 2: CATCHMENT DELINEATION 4
DIAGRAM 3: NORTH PIT STORAGE CURVE 9
DIAGRAM 4: SOUTH PIT STORAGE CURVE 9
DIAGRAM 5: WRD SEDIMENT DAM STORAGE CURVE 10
DIAGRAM 6: UNDERGROUND WORKINGS –ESTIMATED STORAGE CURVE 11
DIAGRAM 7: UNDERGROUND WORKINGS – NET STORAGE OVER TIME 11
DIAGRAM 8: AWBM FOR RUNOFF CALCULATIONS 13
DIAGRAM 9: SOUTH PIT WATER SURFACE ELEVATION (2025 TO 2050) 15
DIAGRAM 10: SOUTH PIT WATER SURFACE ELEVATION (2025 TO 2029) 16
DIAGRAM 11: SOUTH PIT ACCUMULATED GROUNDWATER INFLOWS 16
DIAGRAM 12: SOUTH PIT PUMP FLOW TO UG 17
DIAGRAM 13: UNDERGROUND WORKINGS ACCUMULATED VOLUMES 18
DIAGRAM 14: UNDERGROUND WORKINGS GROUNDWATER INFLOWS 18
DIAGRAM 15: NORTH PIT WATER SURFACE ELEVATION (2025 TO 2050) 19
DIAGRAM 16: NORTH PIT WATER SURFACE ELEVATION (2025 TO 2029) 20
DIAGRAM 17: NORTH PIT ACCUMULATED GROUNDWATER INFLOWS 20
DIAGRAM 19: NORTH PIT PUMP FLOWS TO UG 21
DIAGRAM 20: WRD SEDIMENT DAM WATER SURFACE ELEVATION (2025 T0 2050) 22
DIAGRAM 21: WRD SEDIMENT DAM WATER SURFACE ELEVATION (2025 T0 2029) 22
DIAGRAM 22: CUMMULATIVE PUMP FLOWS TO SOUTH PIT 23
DIAGRAM 23: WRD SEDIMENT DAMPUMP FLOWS TO UG 23

TAILINGS.WATER.WASTE.

1 INTRODUCTION

1.1 Background

The purpose of this report is to provide a summary of the operational water balance model (WBM) to support an EA amendment at the Barbara Copper Project (BCP). The BCP is currently in care and maintenance (C&M), pending technical investigations to allow for the re-commencement of mineral ore extraction by means of proposed new Underground Workings (UG). This would be accessed via a new portal located within the South Pit.

1.2 Outcomes

The intention of the operational WBM is to provide guidance on the following:

- Time taken to dewater to South Pit to allow for ore extraction at the base of the South Pit (Crown Pillar).
- Estimation of total groundwater entering the North Pit, South Pit and Underground Workings.
- Identify conditions under which the site has the potential to be in a water deficit.

TAILINGS.WATER.WASTE.

2 WATER BALANCE MODEL

2.1 Water Balance Model Development

A water balance model was developed using GoldSim Pro (GoldSim V14.0) to assess the impacts of:

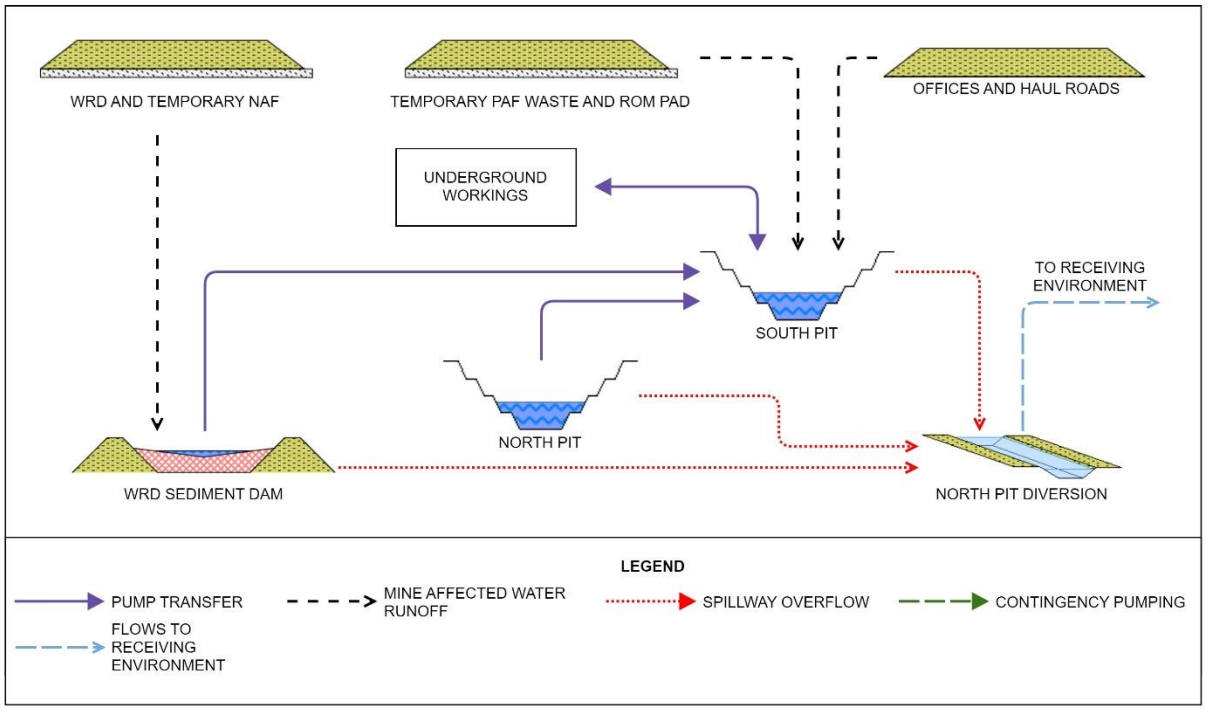
- surface water runoff, (both mine impacted and non-impacted).
- evaporation and groundwater inflows to the Pit.
- groundwater into the Underground Workings.
- surface water from the Pit to the underground working via the stopes at the base of the Pit and the backfilled Portal.

GoldSim is a dynamic probabilistic simulation program, which uses a range of parameters to represent the catchment surface water system. Simulations are then run using a time series of daily rainfall data to estimate the balance of water across the modelled water system over time and a range of climate conditions. The water balance model reflects the effects of stormwater runoff, evaporation, and groundwater inflows/outflows at the site.

2.2 Model Structure and Inputs

The process flow diagram for the BCP site is depicted in **Diagram 1,** representing the major water pathways at site. For clarity, **Diagram 1** does not depict rainfall, evaporation, or groundwater interactions, although these have been included in the modelling. Primary water balance inputs applying to each of the elements in the model development are described in the following sub-sections.

DIAGRAM 1: WATER BALANCE MODEL PROCESS FLOW DIAGRAM



TAILINGS.WATER.WASTE.

2.2.1 Climatic Data

Climate data specific to the site was obtained from the SILO Data-drill **[1]**. The key parameters from the data-drill are explained in **Table 1**.

TABLE 1: SITE WATER BALANCE – RAINFALL AND EVAPORATION INPUT DATA

Climate Data	Data Source	Comments
Daily Rainfall Rate (mm/day)	Rainfall data obtained from the SILO Data Drill Program for the Site Location (1889 - 2024)	Applied over dam surface areas, and as an input parameter for the estimation of surface runoff (AWBM).
Daily Evaporation Rate (mm/day)	Continuous record from SILO Data Drill formed by conjoining: CLIMARC estimates (1889 – 1957) and Class A Evaporation Data from proximate weather stations within the region (1889 – 2024).	Evaporation Data is scaled by evaporation factors for each site storage to reflect water storage conditions and expected water quality.
Daily Evapo-Transpiration Rate (mm/day)	As calculated by the FAO short crop reference methodology, assuming a wind speed of 2 m/s.	Potential evapo-transpiration is calculated based on temperature, vapour pressure and solar global exposure parameters derived from climatic data and is adopted as a reasonable estimate of potential evapotranspiration losses from ground surfaces within the model.

2.2.2 Catchment Delineation

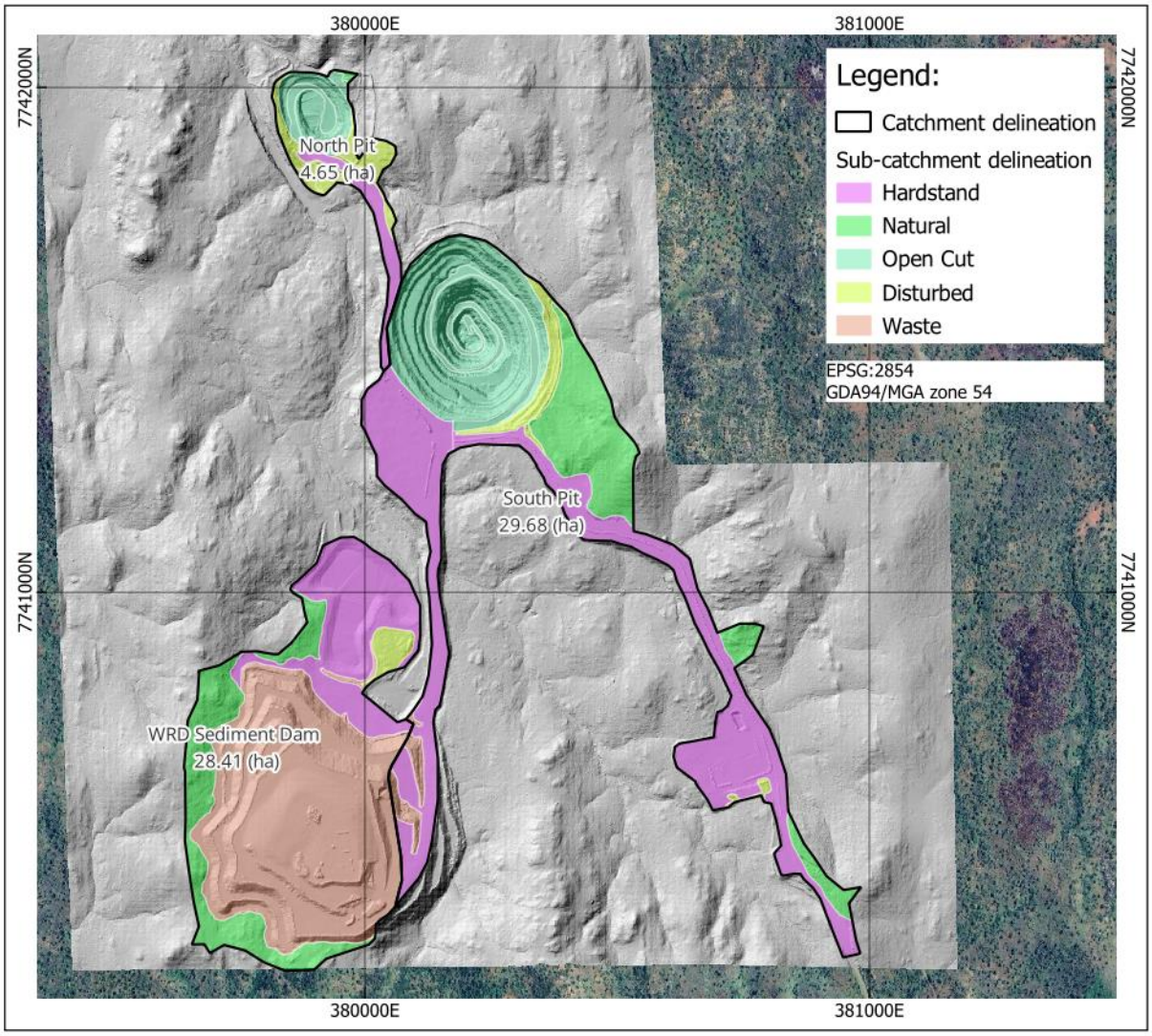
Catchment delineation and estimation was performed using survey data and aerial photography. The catchments are depicted in **Diagram 2**. **Table 2** provides a summary of the catchment areas which were used to inform the AWBM generation of surface runoff volumes.

TABLE 2: CATCHMENT DETAILS

Surface Runoff Type	Catchments (ha)		
	North Pit	South Pit	WRD Sediment Dam
Natural (Undisturbed)	0.05	5.30	4.80
Disturbed	1.51	1.30	0.61
Hardstand	1.15	13.07	5.66
Open Cut	1.94	9.29	-
Waste	0.00	0.71	17.33
Surface Water Area (at full supply)	1.50	8.20	3.00
Catchment Area	4.65	29.68	28.41

TAILINGS.WATER.WASTE.

DIAGRAM 2: CATCHMENT DELINEATION



2.2.3 Groundwater Inflows

Groundwater interaction with the North Pit, South Pit and UG Workings is considered likely to occur. Inflows to the North Pit, South Pit and UG Workings from the surrounding groundwater systems could occur, with the direction of flow determined by the pit water level compared to the aquifer phreatic head. It is possible that the pit voids could spill during periods of significant rainfall, depending on their initial water level prior to the rainfall event/s.

Detailed groundwater inflow estimates were undertaken by WMV Environmental **[2]** for operational conditions, where active dewatering occurs, and under recovery conditions, where dewatering ceases and groundwater begins to return to 'pre-operational' levels.

Active dewatering occurs from 01/01/2025, when the Underground Workings will commence, to 31/10/2029, when the Underground Workings will cease, and the groundwater conditions will start recovering.

The groundwater flow estimates for the North Pit, South Pit and Underground Workings for operational and recovery scenarios are reproduced in **Table 3** to **Table 5**. Additionally, groundwater flow estimates for the Underground Workings (**Table 5**) contain the projected dates when these inflow rates are expected to occur. Full details can be found in WMV Environmental' s 'Groundwater Technical Report' **[3]**. The South Pit was determined to be a regional groundwater sink.

TAILINGS.WATER.WASTE.

As noted by WMV **[3]**, the estimates of groundwater inflow to the Pit and Underground Workings represent the groundwater that resided in the orebody prior to mining, with long term natural recharge expected to be much slower. As such, the inflows estimates are considered to be conservative.

TABLE 3: NORTH PIT GROUNDWATER INFLOW ESTIMATES

Elevation (m AHD)	Operational Conditions - Groundwater Inflow (L/s)	Recovery Conditions - Groundwater Inflow (L/s)
316	0.064	0.021
314	0.060	0.024
312	0.058	0.027
310	0.052	0.028
308	0.048	0.030
306	0.046	0.031
304	0.043	0.032
302	0.041	0.033
300	0.039	0.033
298	0.037	0.034
296	0.034	0.033
295	0.019	0.018

TAILINGS.WATER.WASTE.

TABLE 4: SOUTH PIT GROUNDWATER INFLOW ESTIMATES

Elevation (m AHD)	Operational Conditions - Groundwater Inflow (L/s)	Recovery Conditions - Groundwater Inflow (L/s)
334	0.612	0.031
330	0.595	0.050
325	0.578	0.073
320	0.545	0.092
315	0.522	0.110
310	0.498	0.126
305	0.469	0.138
300	0.429	0.145
295	0.403	0.154
290	0.392	0.164
285	0.380	0.174
280	0.342	0.171
275	0.315	0.171
270	0.302	0.176
265	0.288	0.178
260	0.268	0.176
255	0.246	0.171
250	0.230	0.169
245	0.217	0.167
240	0.198	0.160
235	0.178	0.151
230	0.164	0.144
225	0.149	0.136
220	0.130	0.123
215	0.072	0.071
212	0.046	0.046

TAILINGS.WATER.WASTE.

TABLE 5: UNDERGROUND WORKINGS GROUNDWATER INFLOW ESTIMATES

Elevation (m AHD)	Projected Date	Operational Conditions - Groundwater Inflow (L/s)	Recovery Conditions - Groundwater Inflow (L/s)
306	1/01/2025	0.012	0.014
291	1/02/2025	0.016	0.021
265	1/03/2025	0.023	0.029
241	1/04/2025	0.031	0.036
221	1/05/2025	0.037	0.043
200	1/06/2025	0.048	0.050
193	1/09/2025	0.051	0.058
171	1/10/2025	0.057	0.063
153	1/11/2025	0.065	0.067
146	1/12/2025	0.072	0.072
146	1/01/2026	0.075	0.080
130	1/02/2026	0.079	0.081
125	1/03/2026	0.089	0.094
112	1/08/2026	0.095	0.099
101	1/09/2026	0.100	0.103
93	1/10/2026	0.104	0.107
85	1/11/2026	0.108	0.117
64	1/12/2026	0.116	0.120
55	1/01/2027	0.121	0.129
34	1/02/2027	0.128	0.131
26	1/03/2027	0.131	0.131
21	1/04/2027	0.138	0.146
2	1/05/2027	0.199	0.199

TAILINGS.WATER.WASTE.

2.2.4 Storage Curve Data and Initial Conditions

Storage curves were derived for both North Pit, South Pit and WRD Sediment Dam from the provided survey data. The resulting storage curves are depicted in **Diagram 3**, **Diagram 4** and **Diagram 5**.

The storage volume of the Underground Workings varies over the duration of the underground campaign. The development of the underground storage capacity over time is depicted in **DIAGRAM 6**: UNDERGROUND WORKINGS –ESTIMATED STORAGE CURVE

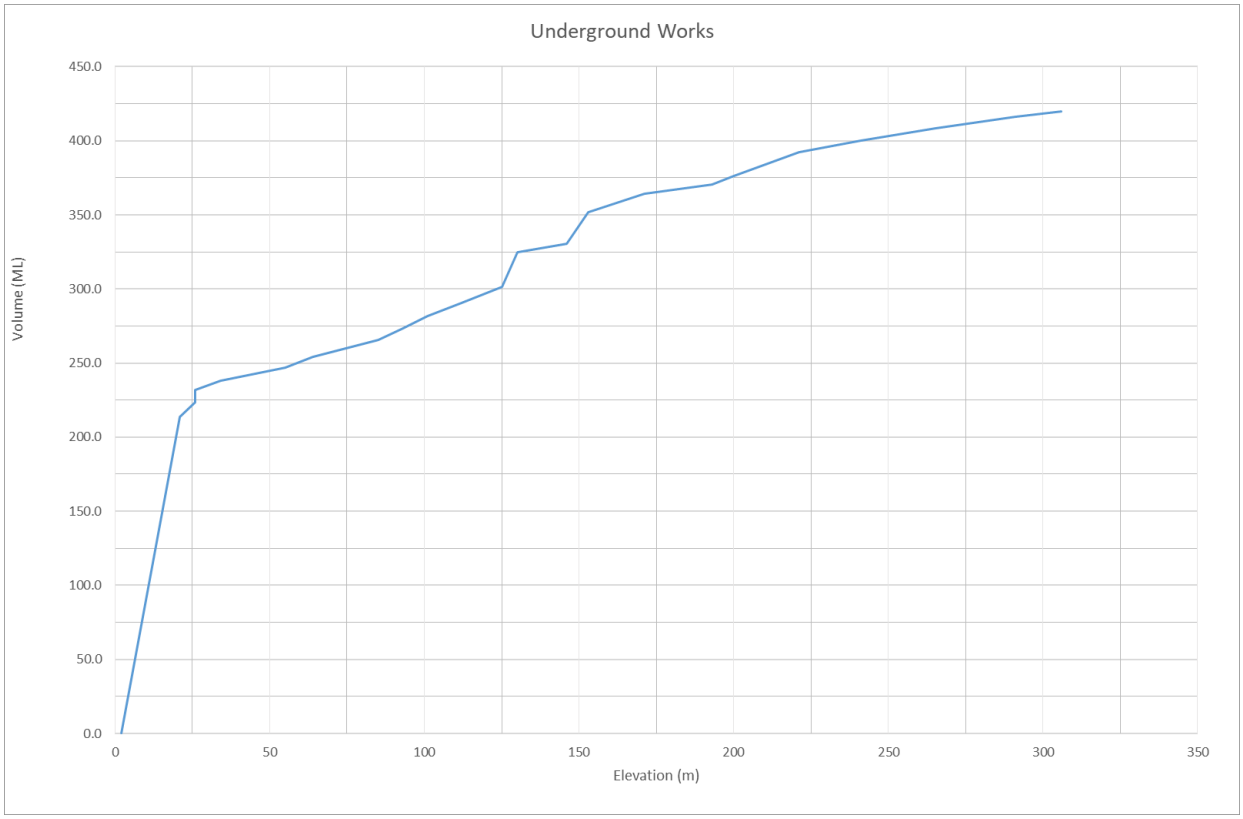


Diagram 7. The volume available in the Underground Workings comprises:

- backfilled stopes with a 30% voids ratio, representing the backfill conditions of crushed rock of various sizes. This will not occupy the entire backfilled area.
- open stopes, not backfilled with rock.

TAILINGS.WATER.WASTE.

DIAGRAM 3: NORTH PIT STORAGE CURVE

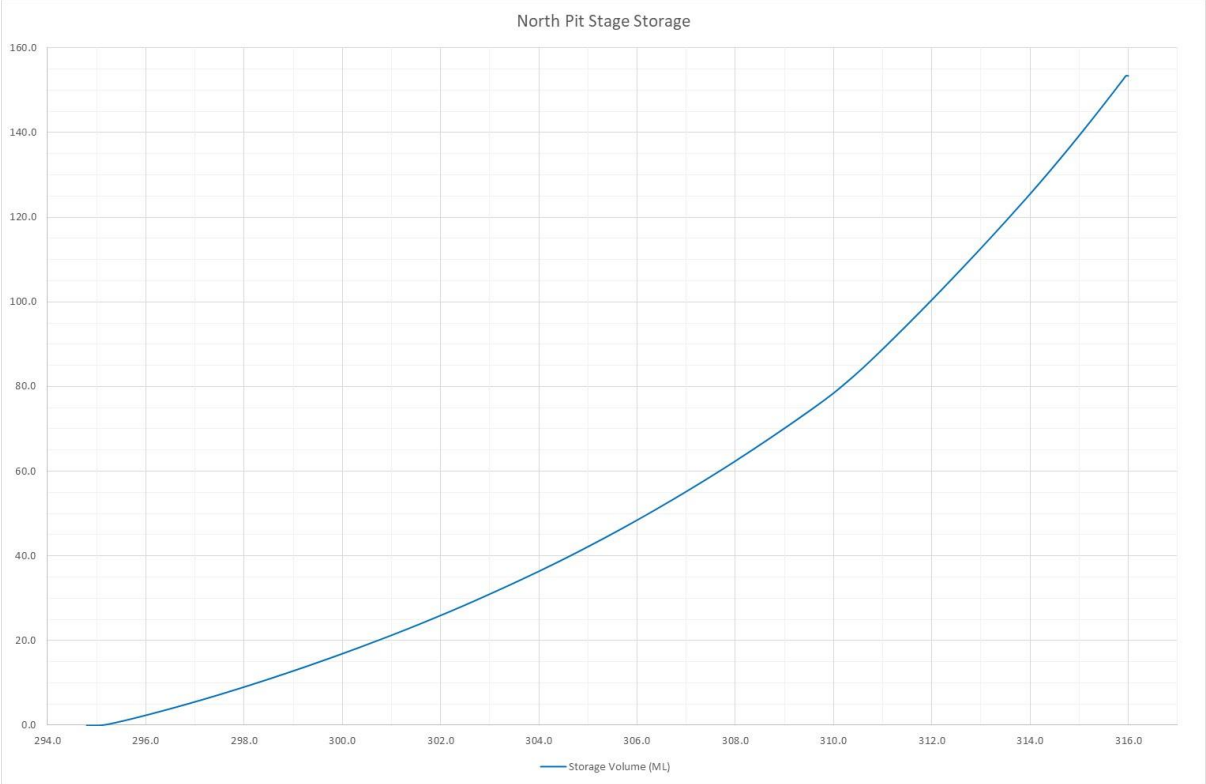
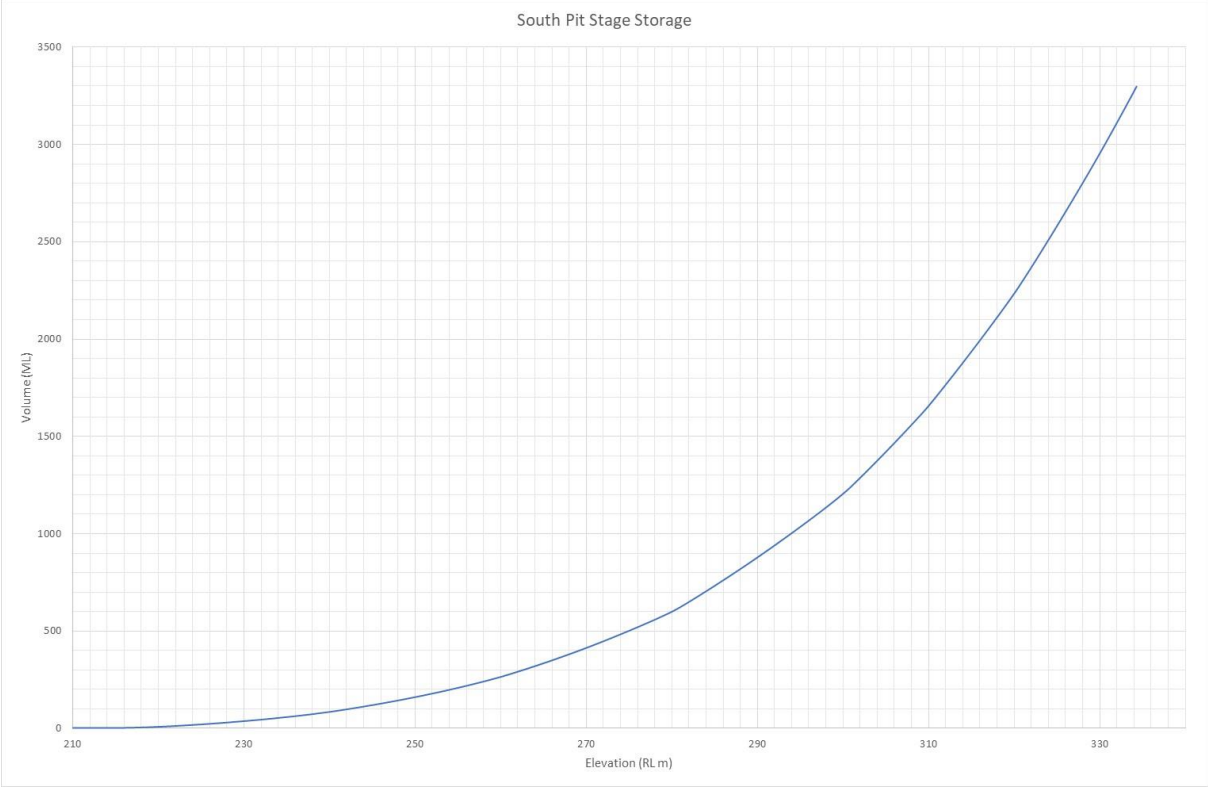
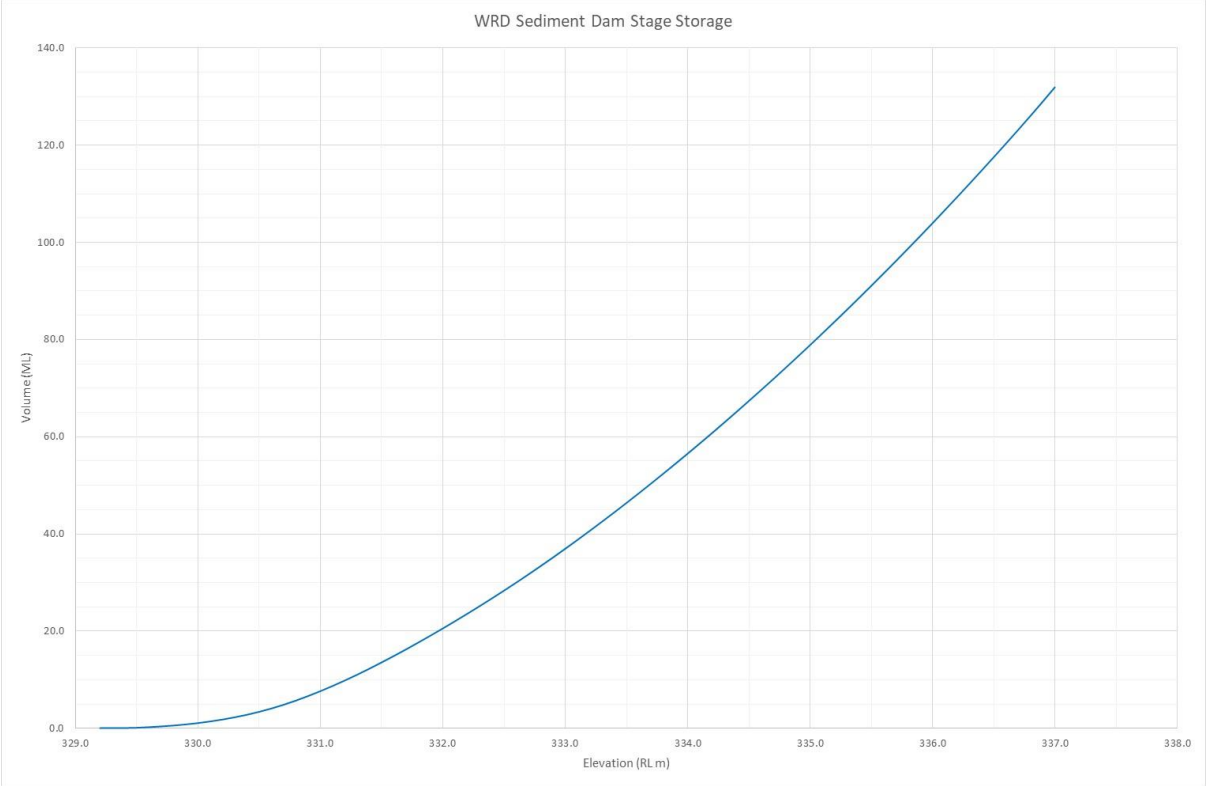


DIAGRAM 4: SOUTH PIT STORAGE CURVE



TAILINGS.WATER.WASTE.

DIAGRAM 5: WRD SEDIMENT DAM STORAGE CURVE



TAILINGS.WATER.WASTE.

DIAGRAM 6: UNDERGROUND WORKINGS –ESTIMATED STORAGE CURVE

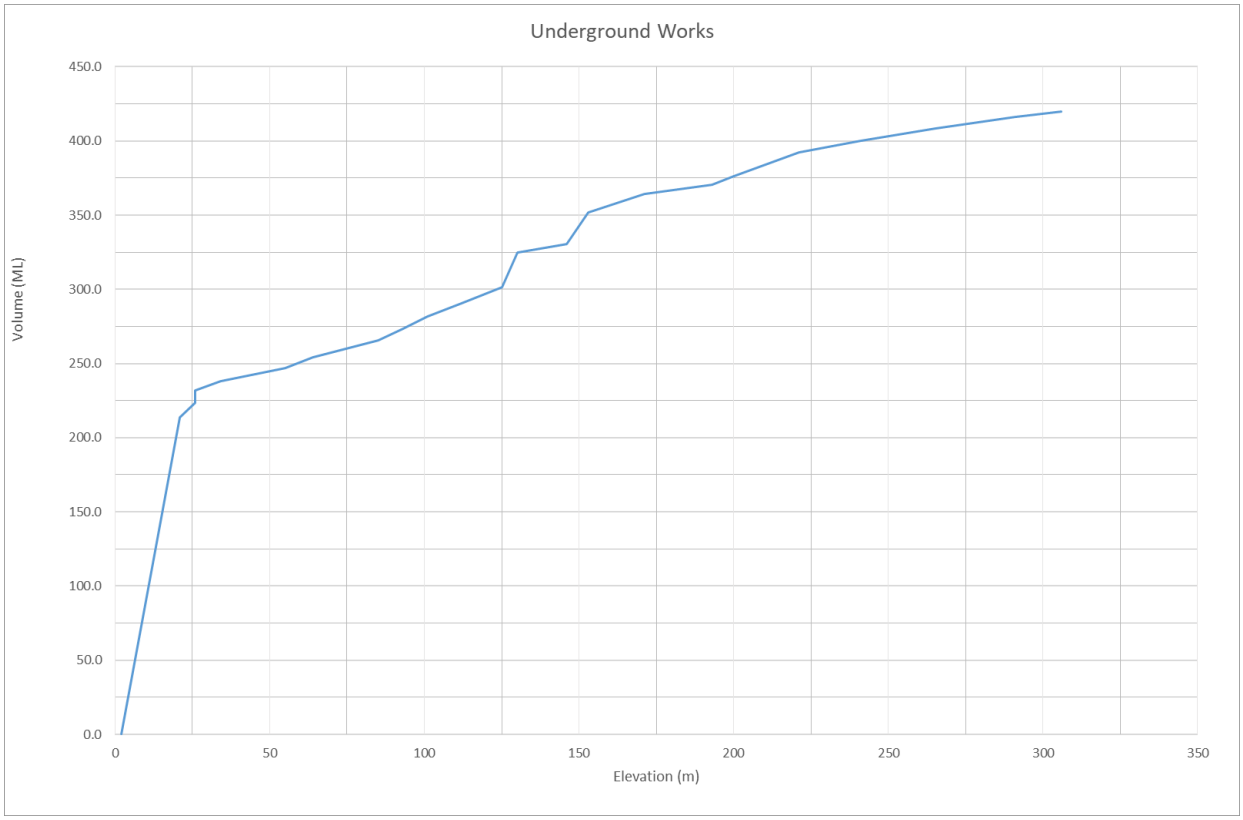
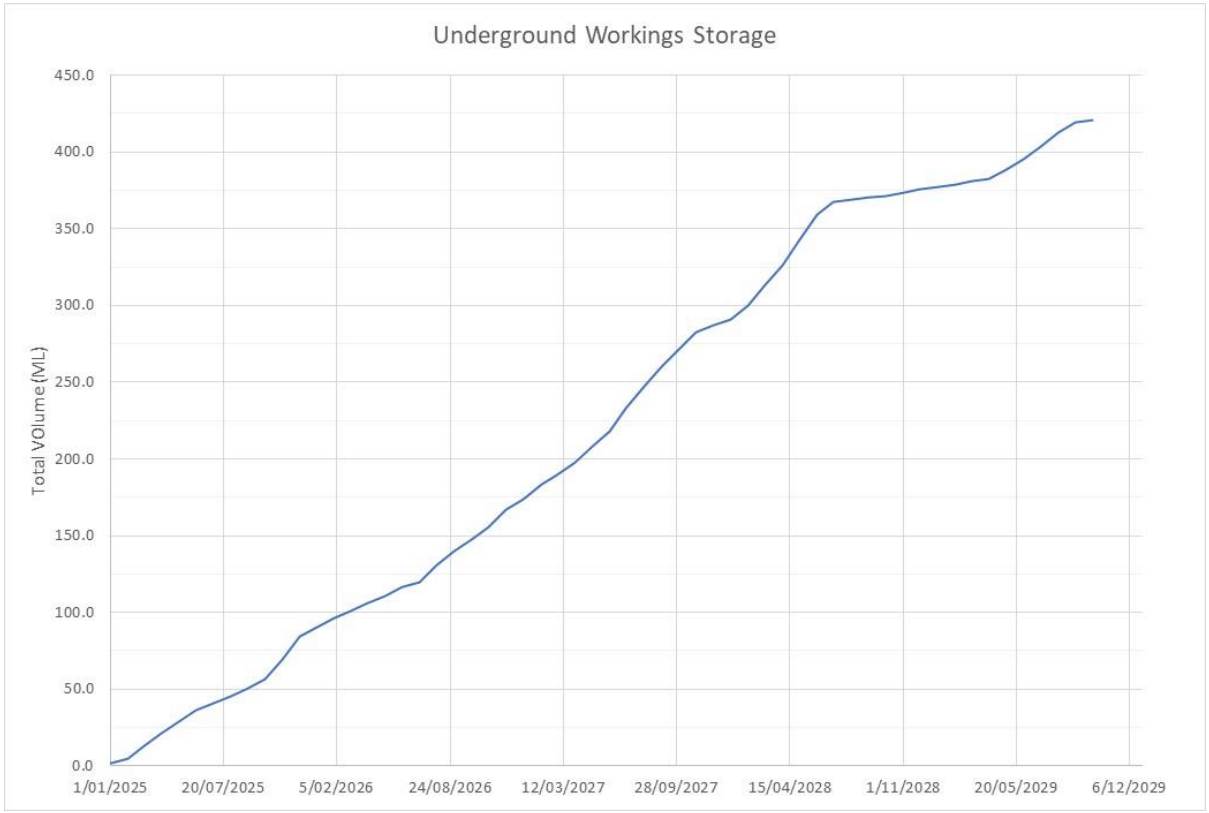


DIAGRAM 7: UNDERGROUND WORKINGS – NET STORAGE OVER TIME



TAILINGS.WATER.WASTE.

2.2.5 Initial Storage Conditions

Initial storage volumes were provided by Aeris, derived from water levels surveyed on 30 October 2023 **[4]** and are presented in **Table 6**. These values were applied at the simulation commencement of 01/01/2025.

TABLE 6: INITIAL WATER STORAGE INPUTS

Parameter	North Pit	South Pit	WRD Sediment Dam
Initial Volume* (ML)	67.0 (RL 308.58 m)	165.7 (RL 250.80 m)	44.4 (RL 333.38)
Total Capacity (ML)	131.0	3,296.4	153.3
Overflow Level (m)	RL 316.0 m	RL 334.3 m	RL 337.0 m

2.2.6 Pump Transfers and Source Priority

In discussion with Aeris, the following pumped transfer conditions and priorities were developed:

1st – Source water for the UG circuit and dust suppression directly from the South Pit. This will assist to dewater the South Pit to allow access to the ore at the base of the pit (crown pillar) approximately 18 months after operations recommence.

2nd – When the South Pit is sufficiently dewatered, water will be sourced from either the WRD Sediment Dam or North Pit based on which storage has the lowest available capacity remaining. Consideration is also given to the need to comply with Design Storage Allowance (DSA) requirements by 1 November each year.

3rd – Pump transfers from the North Pit and the WRD Sediment Dam will be initiated when water levels in these storages reach a critical water level. Pumping will be suspended once the water levels fall to a predetermined deactivation point. This arrangement is expected to remain operational for 2 years following the cessation of mining activities (until 31/12/2031). Details regarding activation/deactivation thresholds and pumping rates are provided in **Table 7**.

TABLE 7: PUMP TRANSFER CONFIGURATION

Source	Destination	Pump Transfer Rate	Activation Level	Deactivation Level	Destination Cease Pumping Level
North Pit	South Pit	66 L/s	RL 311 m	RL 310 m	RL 333 m
WRD Sediment Dam	South Pit	30 L/s	RL 334 m	RL 333 m	RL 333 m

2.2.7 Site Water Demands

There will be no on-site ore processing, and as such the primary uses for water onsite will be the UG circuit, and dust suppression on haul roads and the site access road. Aeris has confirmed that the UG circuit will consume approximately 0.35 ML/day, with dust suppression expected to consume approximately 5 ML/month (equating to approximately 0.2 ML/day). These estimates are based upon Aeris' experience at the Mt Colin site **[5]**.

TAILINGS.WATER.WASTE.

2.2.8 South Pit and Underground Workings Interaction

In addition to groundwater inflows there is a potential for water ingress to the UG workings via the Portal and the Crown Pillar at the base of the Pit.

The portal is located at 310 m AHD and is located approximately 60 m above the latest recorded water level in the pit. The water level in the South Pit has never been above 250 m AHD. As the South Pit will be actively dewatered, the water level in the South Pit will be maintained well below the portal level. As such, interaction via the Portal is not considered to be likely.

The crown pillar at the base of the South Pit is the location of the richest ore deposit. Once the crown pillar is removed, the South Pit and Underground Workings become, in effect, a single storage. This has been represented in the model by allowing all runoff reporting to the South Put from 01/11/2029 to pass to the Underground. The Underground will have to fill to the level of 210 m AHD before the South Pit starts to fill.

2.2.9 Simulation Period

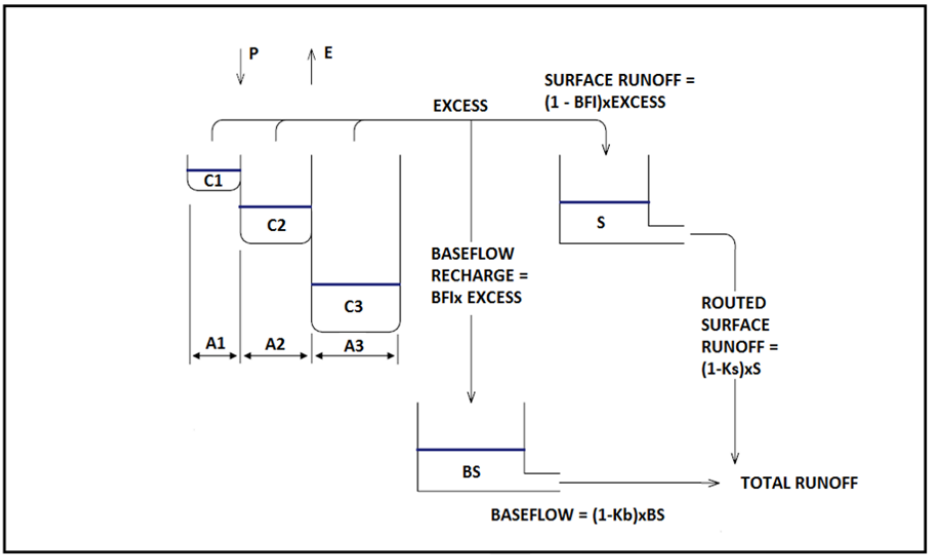
The model was run from the period 01/01/2025 to 31/10/2029, with the site under operational conditions, and from 01/11/2029 to 31/12/2050 to represent the closure conditions where groundwater levels recover to pre operational conditions.

2.3 Model Development

The Australian Water Balance Model (AWBM) was used to simulate daily runoff from rainfall, generated within the various sub-catchment types that are present on the project site. **Diagram 8** represents a schematic of the AWBM model, reproduced from Boughton (2004) **[6]**.

The catchment types and AWBM model parameters used to simulate these different catchment types and the average yields from these catchment areas are summarised in **Table 8**. Model parameters have been selected based on experience with similar water balance model studies and are considered to be conservative in the context of an uncalibrated model.

DIAGRAM 8: AWBM FOR RUNOFF CALCULATIONS



Where:

C1 - C3	= Surface Storage Capacities
A1 - A3	= Partial Areas Represented by Surface Storages
BFI	= Baseflow Index
K_b	= Daily Baseflow Recession Constant
BS	= Current Volume in Baseflow Store
K_s	= Daily Surface Flow Recession Constant
S	= Current Volume in Surface Store Routing

TAILINGS.WATER.WASTE.

TABLE 8: AWBM MODEL PARAMETERS

AWBM Parameters	Split Areas (sum=1.0)			Storage Capacities (mm)			Ks (day^{-1})	BFI	Kb (day^{-1})
	A1	A2	A3	C1	C2	C3			
Natural	0.13	0.43	0.43	12	120	250	0	0	1
Hardstand	1.00	0.00	0.00	10	0	0	0	0	1
Waste	0.20	0.80	0.00	10	300	300	0	0	1
Open Cut	0.10	0.90	0.00	5	20	20	0	0	1
Disturbed	0.10	0.30	0.60	20	55	100	0	0	1

TAILINGS.WATER.WASTE.

3 RESULTS

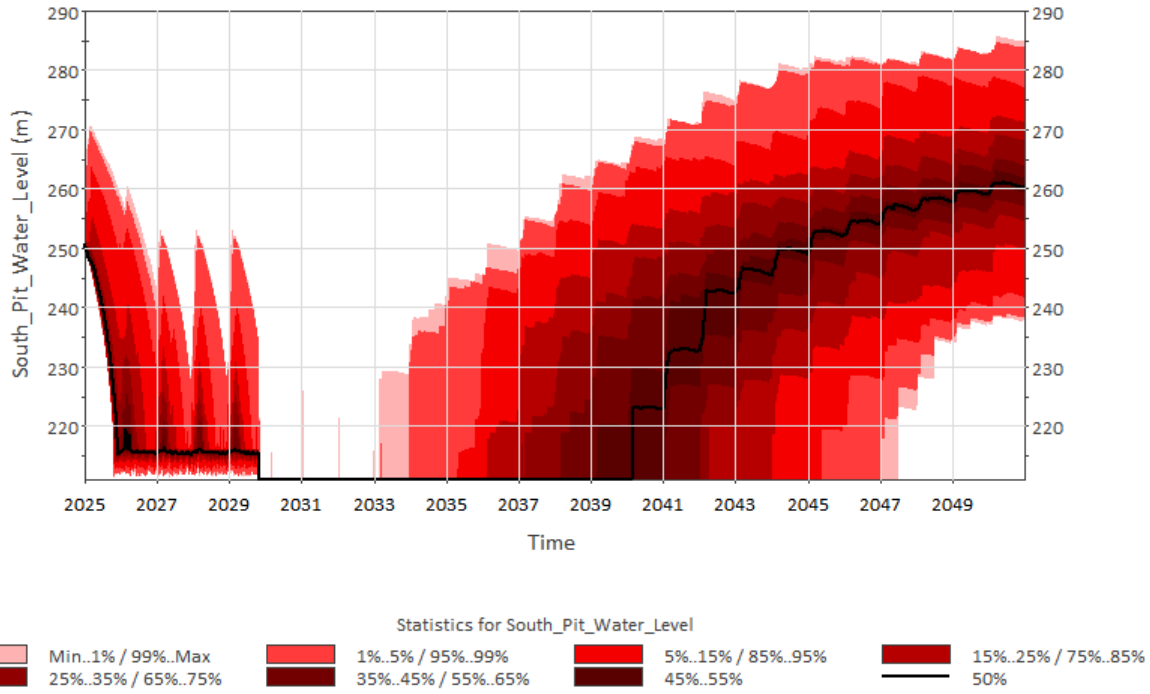
The results of the WBM simulations are discussed in the following sections, for each structure at the BCP.

3.1 South Pit

The modelled water surface elevation in the South Pit is presented in **Diagram 9** (2025 to 2050) and **Diagram 10** (2025 to 2029). The following observations can be made in relation to **Diagram 9** and **Diagram 10:**

- Under median climatic conditions, the South Pit is rapidly dewatered by October 2025 to meet site water demands.
- Under median climatic conditions, the South Pit does not store any water until February 2041, as all rainfall and runoff enters the Underground Workings as the crown pillar has been removed.
- The maximum modelled water level in the South Pit is 290 m AHD, under the 99th percentile realisation. As the pit crest is 334 m AHD, this indicates the South Pit does not overtop or spill. The level of 290 m AHD is only reached in sequentially very wet years.
- The long term median water level in the South Pit is approximately 260 m AHD, approximately 10 metres above the current recorded water level.
- The South remains a groundwater sink, with no modelled outflows.

DIAGRAM 9: SOUTH PIT WATER SURFACE ELEVATION (2025 TO 2050)



TAILINGS.WATER.WASTE.

DIAGRAM 10: SOUTH PIT WATER SURFACE ELEVATION (2025 TO 2029)

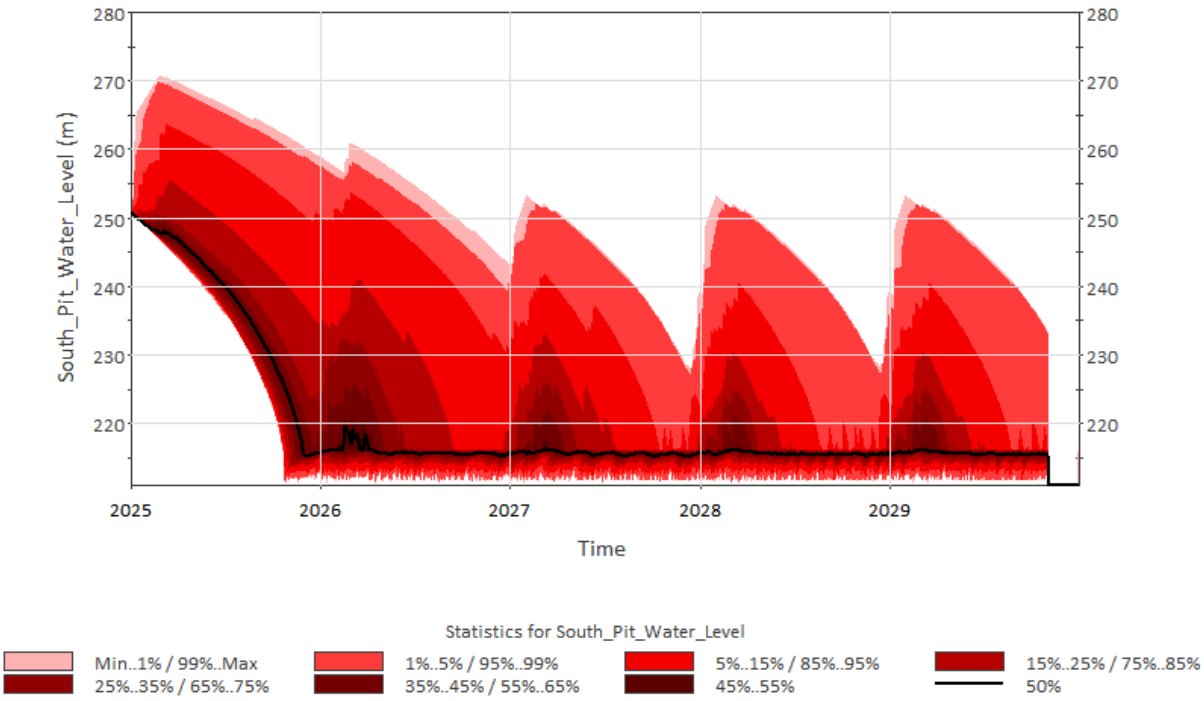
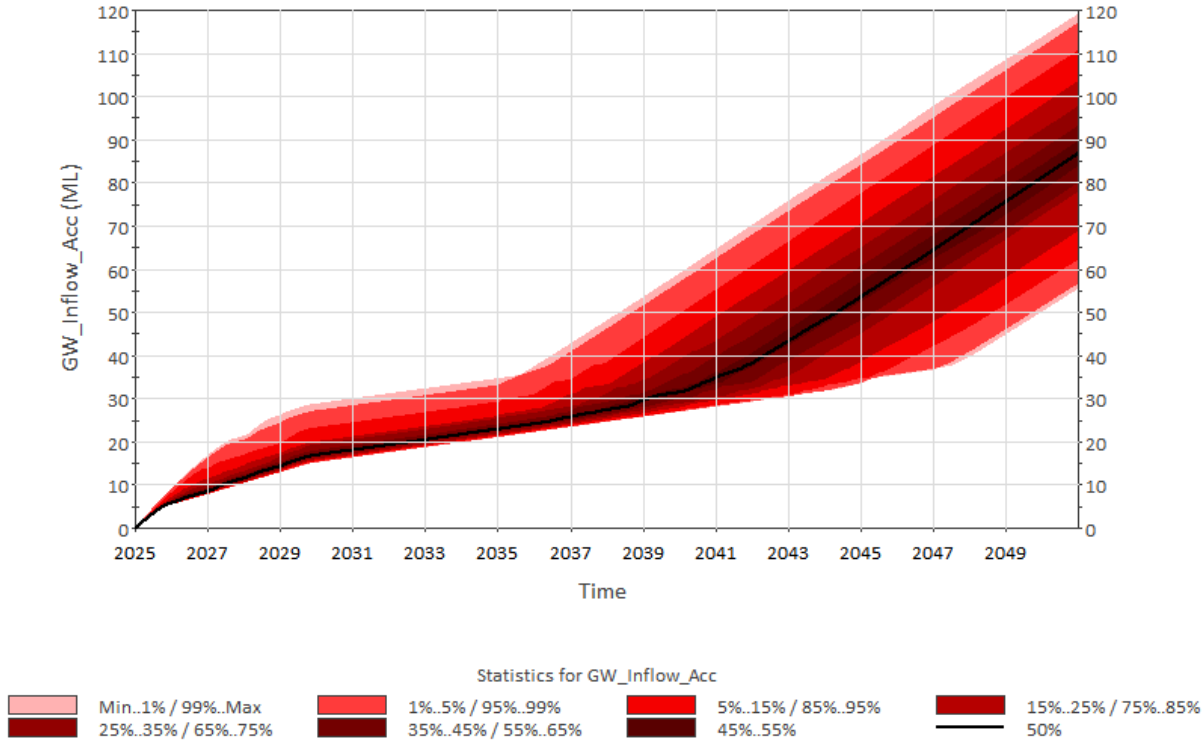


Diagram 11 illustrates the predicted accumulated groundwater inflow to the South Pit between 2025 and 2050. The median value is approximately 83 ML, or 3.32 ML/year.

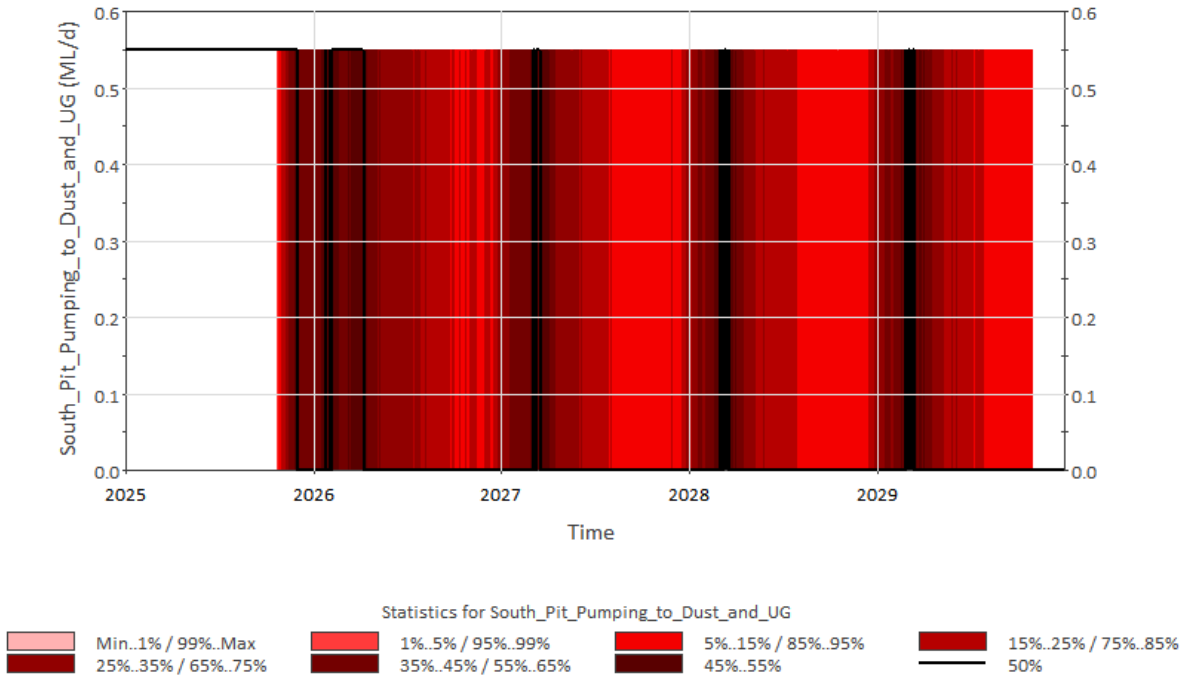
DIAGRAM 11: SOUTH PIT ACCUMULATED GROUNDWATER INFLOWS



TAILINGS.WATER.WASTE.

There were no modelled groundwater outflows from the South Pit as the South Pit is a regional groundwater sink. As can be seen in **Diagram 12**, the 0.55 ML/day of site water demands are met by the South Pit from January 2025 to October 2025. Beyond October 2025, the South Pit meets site water demands when water is available in the South Pit.

DIAGRAM 12: SOUTH PIT PUMP FLOW TO UG



3.2 Underground Workings

Diagram 13 depicts the accumulated volumes in the Underground. The following observations can be made in relation to **Diagram 13:**

- Under operational conditions the Underground Workings do not store any water between 2025 and 2029, as they are being actively dewatered.
- Under median climatic conditions the Underground Workings commence filling in 2030 and are completely filled by 2040. This is primarily driven by water ingress from the South Pit, connected to the Underground Workings via the removal of the crown pillar.

Diagram 14 depicts the variation in groundwater inflow over time. From this diagram, the following insights can be derived**:**

- Given the complexity of the Underground Workings, characterised by changes in available volume over time, the use of stage storage curves was not adopted in the WBM. Instead, the model incorporates projections of groundwater inflow over time as detailed in **Table 5**. This explains the lack of variability between the groundwater estimations of different realizations until the cease of mine operations (2029), as showed on **Diagram 14**. After the mine ceases its operations, the WBM calculates the groundwater inflows based on the estimated stage storage of UG Workings.
- The median accumulated groundwater inflow into the Underground Workings between 2025 and 2050 is approximately 20 ML, or 4.11 ML/year.
- The remainder of the water required to fill the Underground Workings is supplied by inflows from the South Pit.

TAILINGS.WATER.WASTE.

DIAGRAM 13: UNDERGROUND WORKINGS ACCUMULATED VOLUMES

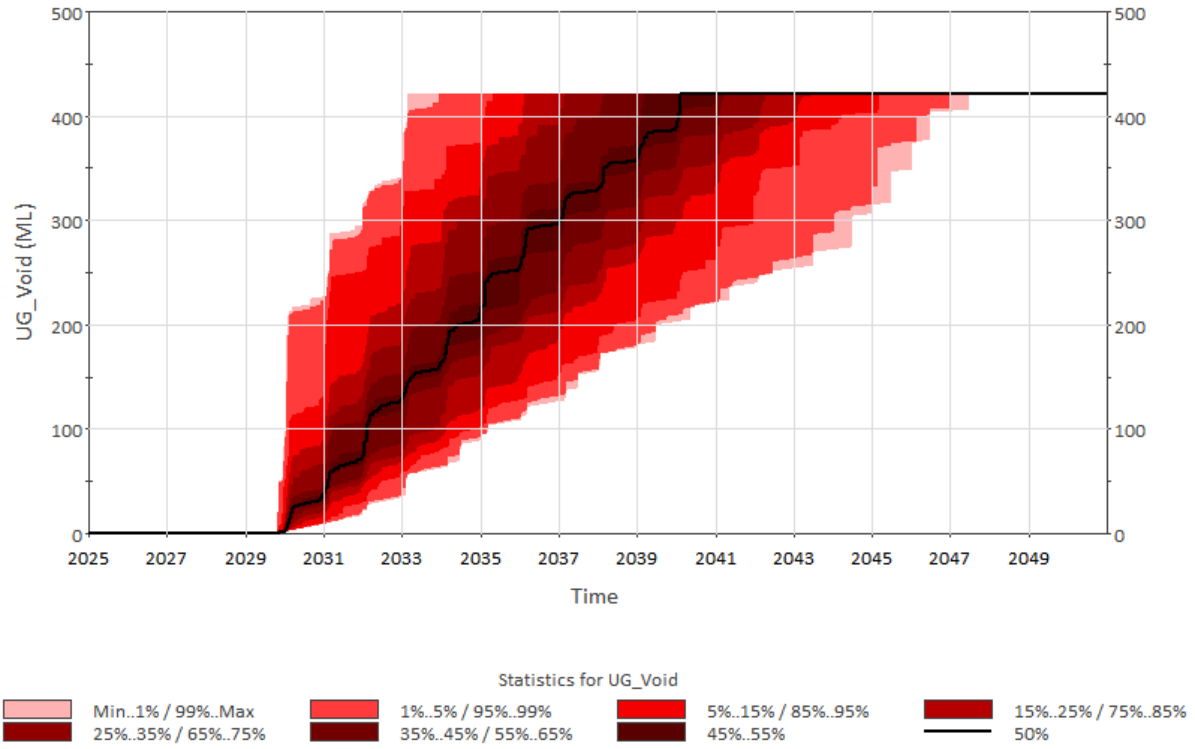
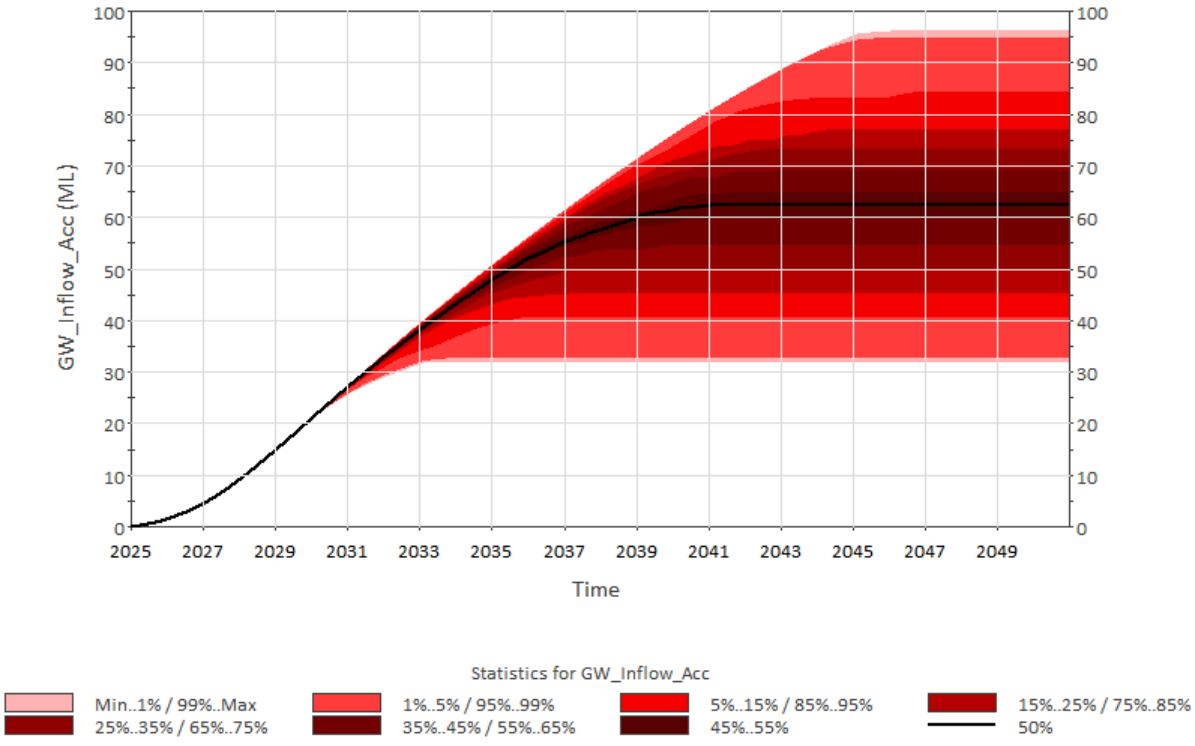


DIAGRAM 14: UNDERGROUND WORKINGS GROUNDWATER INFLOWS



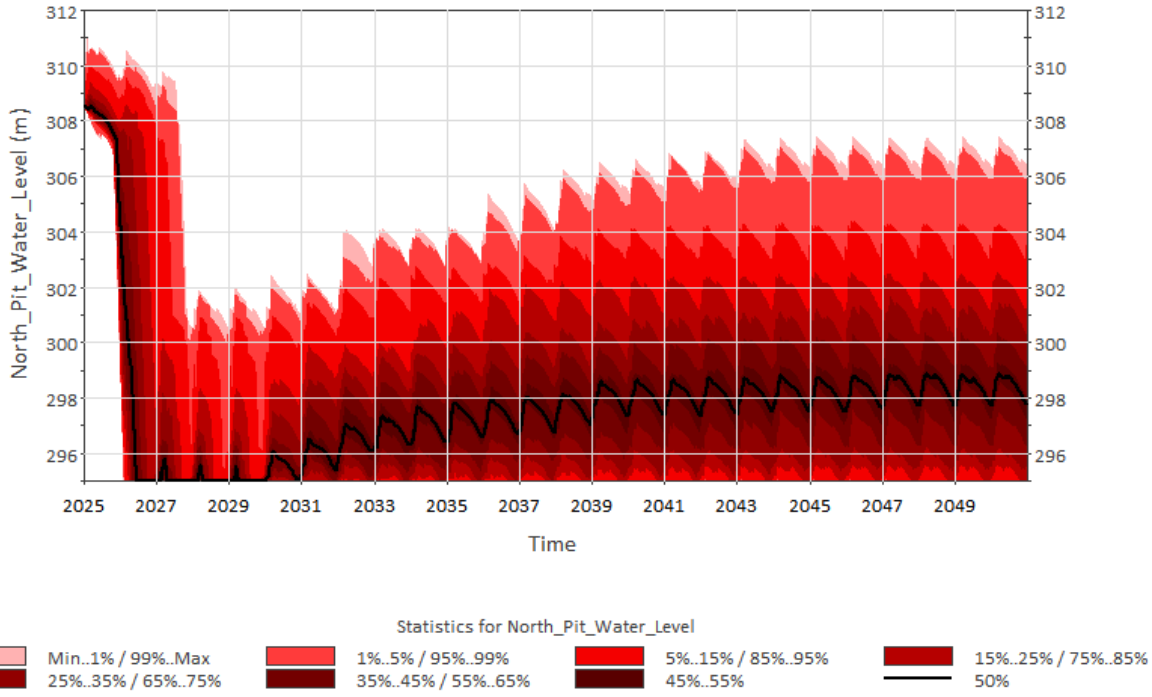
TAILINGS.WATER.WASTE.

3.3 North Pit

Diagram 15 and **Diagram 16** depict the modelled water surface elevation in the South Pit. The following observations can be made in relation to **Diagram 15** and **Diagram 16:**

- Under median climatic conditions, the North Pit is rapidly dewatered by March 2026 to meet site water demands.
- Under median climatic conditions, between March 2026 and October 2029 (excluding the January-March period each year), the North Pit is dry, indicating the site may be in a net water deficit.
- The maximum modelled water level in the North Pit is 307 m AHD. As the pit crest is 316 m AHD, this indicates the North Pit does not overtop or spill. The level of 307 m AHD is only reached in sequentially very wet years.
- The long term median water level in the North Pit varies between 298 m AHD to 299 m AHD, approximately 10 metres below the current recorded water level.

DIAGRAM 15: NORTH PIT WATER SURFACE ELEVATION (2025 TO 2050)



TAILINGS.WATER.WASTE.

DIAGRAM 16: NORTH PIT WATER SURFACE ELEVATION (2025 TO 2029)

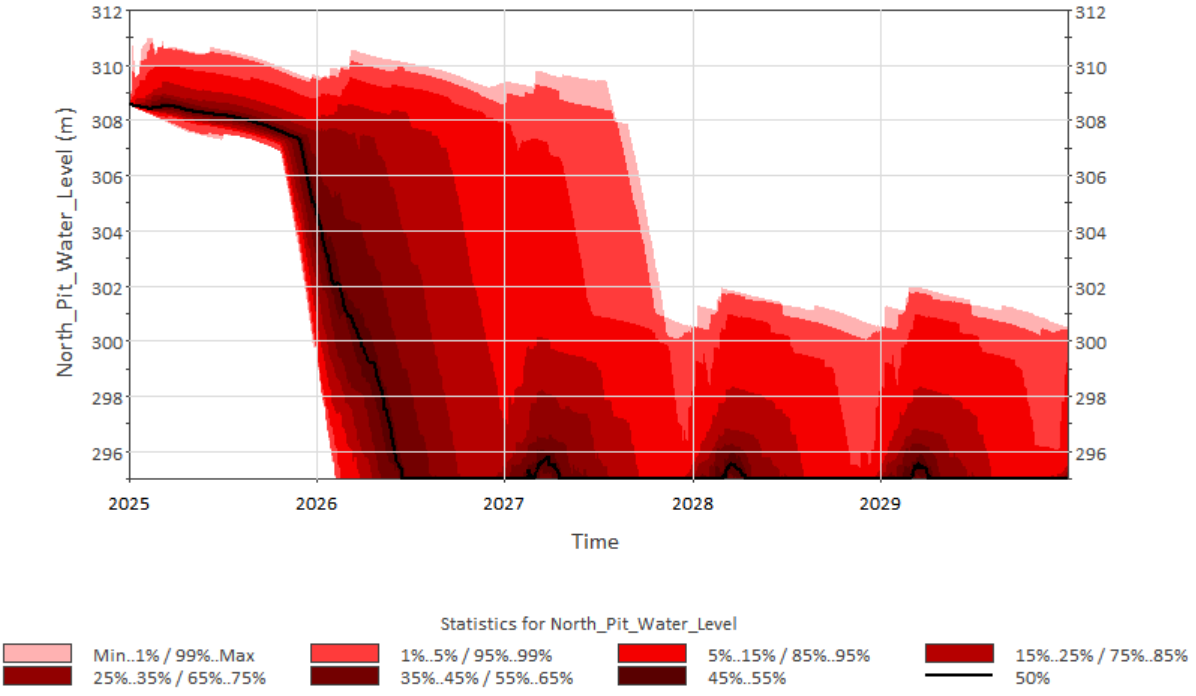
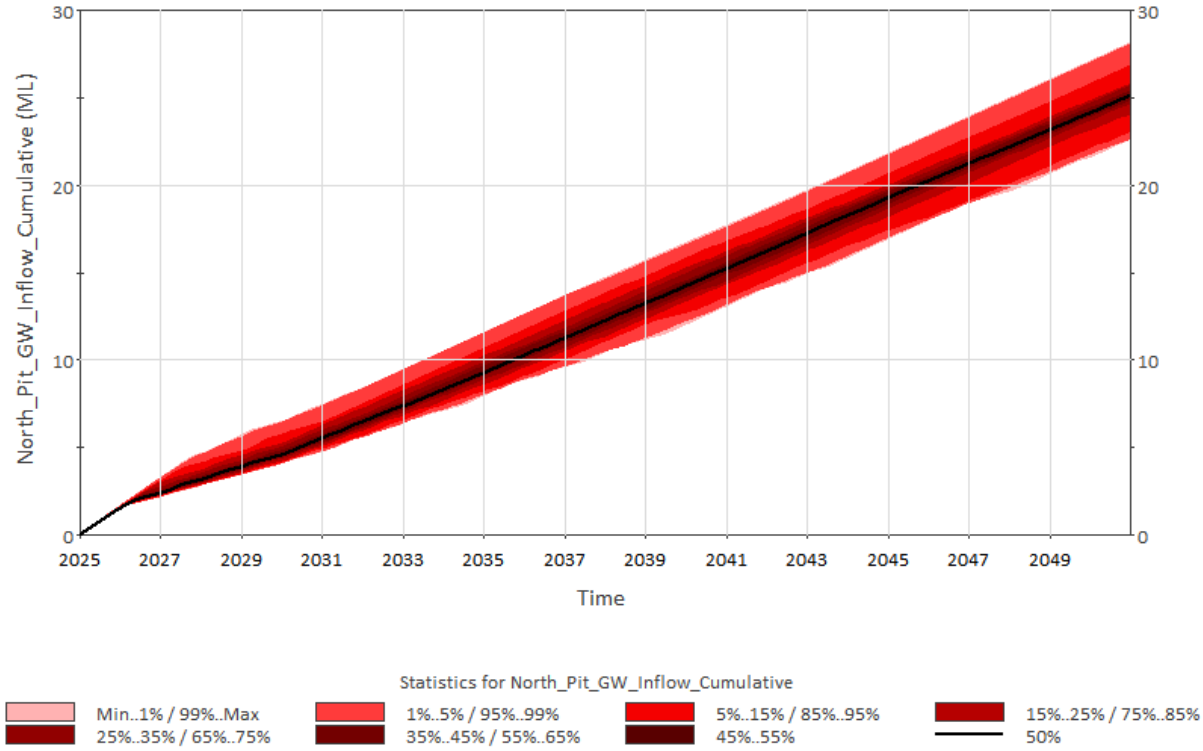


Diagram 17 illustrates that the median accumulated groundwater inflow into the North Pit between 2025 and 2050 is approximately 25 ML, or 1 ML/year.

DIAGRAM 17: NORTH PIT ACCUMULATED GROUNDWATER INFLOWS

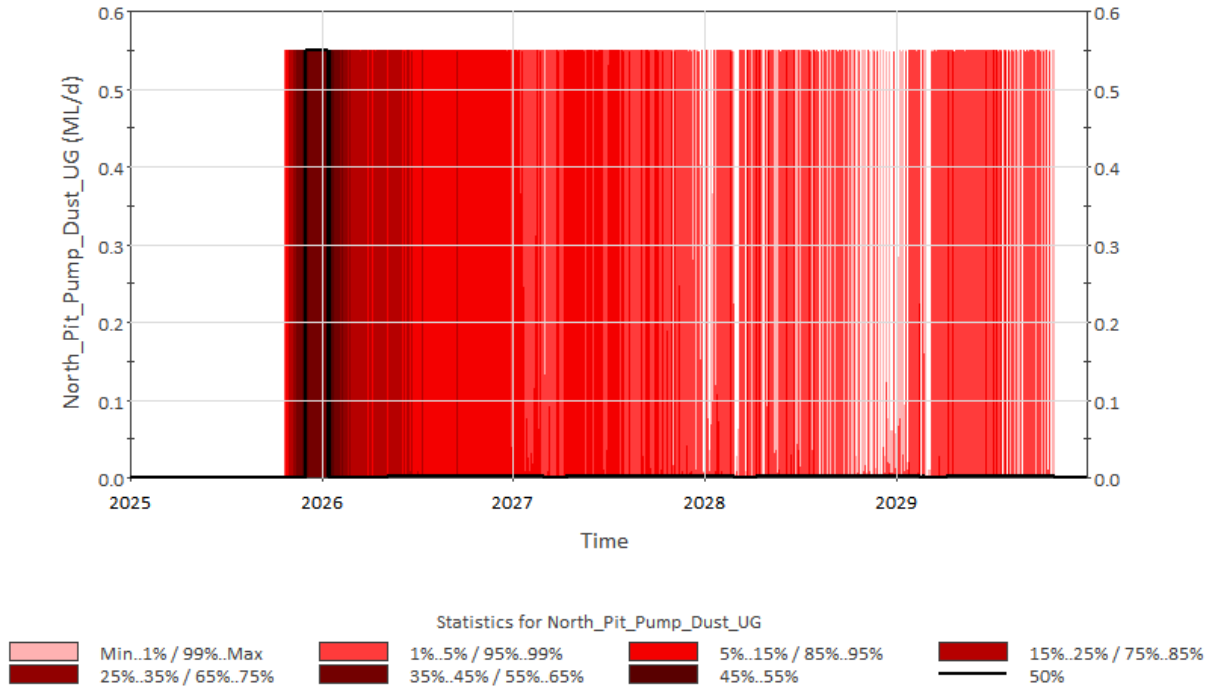


TAILINGS.WATER.WASTE.

Additionally, under median climatic conditions there are no pump transfers from the North Pit to the South Pit. Pump transfers occur during three realisations where rainfall exceeds the median historical record.

Diagram 18 illustrates that under median climatic conditions, pump transfers from the North Pit assist in meeting site water demands beyond October 2025 (when the South Pit is effectively dewatered).

DIAGRAM 18: NORTH PIT PUMP FLOWS TO UG



3.4 WRD Sediment Dam

Diagram 19 and **Diagram 20** depicts the modelled water surface elevation in the WRD Sediment Dam. The following observations can be made in relation to **Diagram 19** and **Diagram 20:**

- Under median climatic conditions, the WRD Sediment Dam is dewatered by October 2026.
- Under median climatic conditions, between October 2026 and October 2029 (excluding January-March each year), there are periods where the WRD Sediment Dam dry, indicating the site may be in a net water deficit.
- The maximum modelled water level in the WRD Sediment Dam is 336.8 m AHD. The spillway level is at 336.8m AHD. There are 2 realisations where the WRD Sediment Dam spills. This only occurs in sequentially very wet years.
- The long term median water level in the WRD Sediment Dam varies between 330 m AHD to 331.2 m AHD, approximately 2.5 metres below the current recorded water level.

Due to the presence of the HDPE liner on the WRD Sediment Dam, no groundwater inflows or outflows were modelled.

TAILINGS.WATER.WASTE.

DIAGRAM 19: WRD SEDIMENT DAM WATER SURFACE ELEVATION (2025 T0 2050)

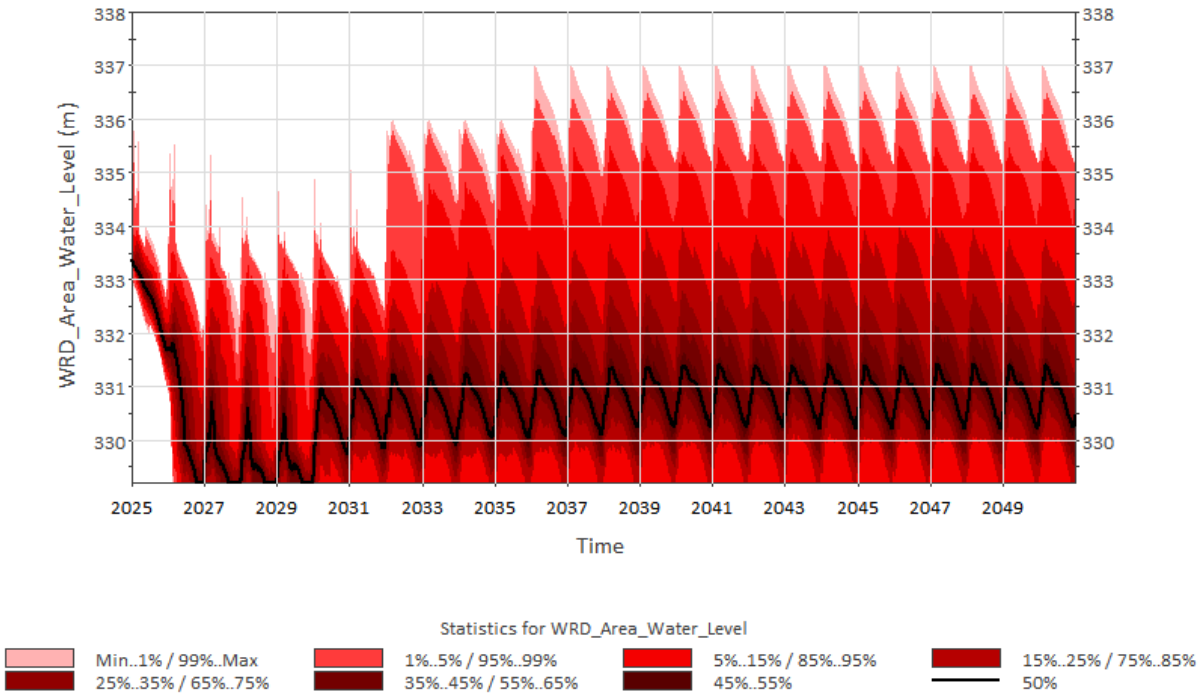


DIAGRAM 20: WRD SEDIMENT DAM WATER SURFACE ELEVATION (2025 T0 2029)

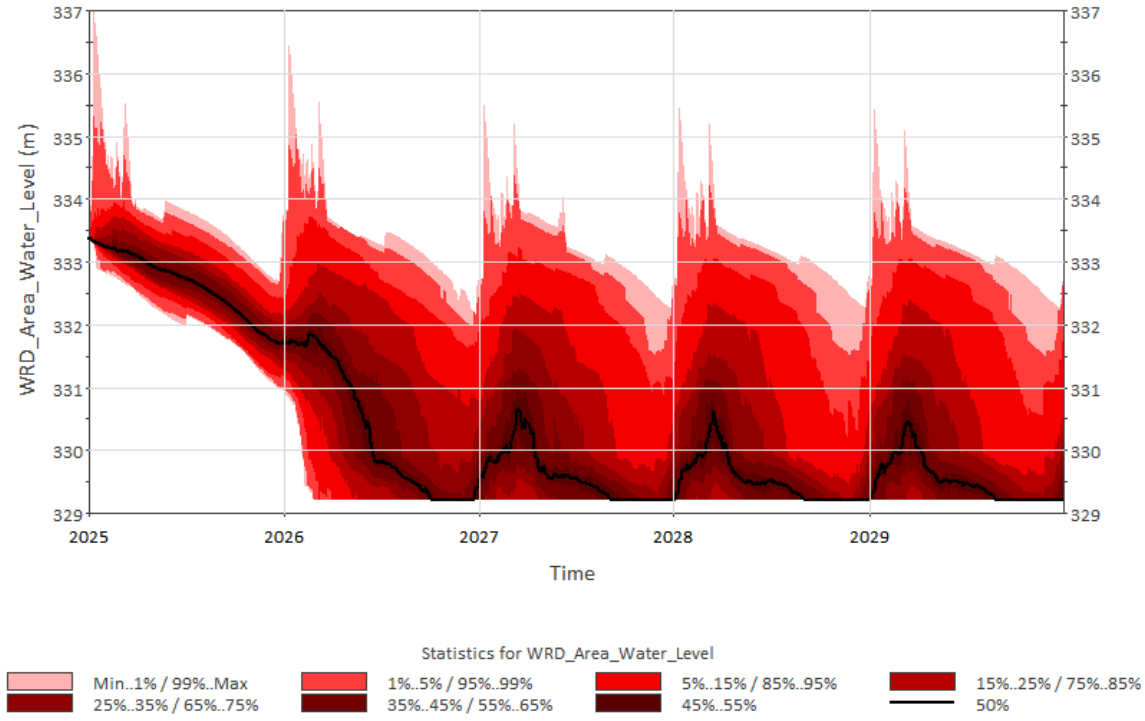


Diagram 21 illustrates that under median climatic conditions, there are no pump transfers from the WRD Sediment Dam to the South Pit. Pump transfers occurs in years where rainfall exceeds the median historical record.

TAILINGS.WATER.WASTE.

DIAGRAM 21: CUMMULATIVE PUMP FLOWS TO SOUTH PIT

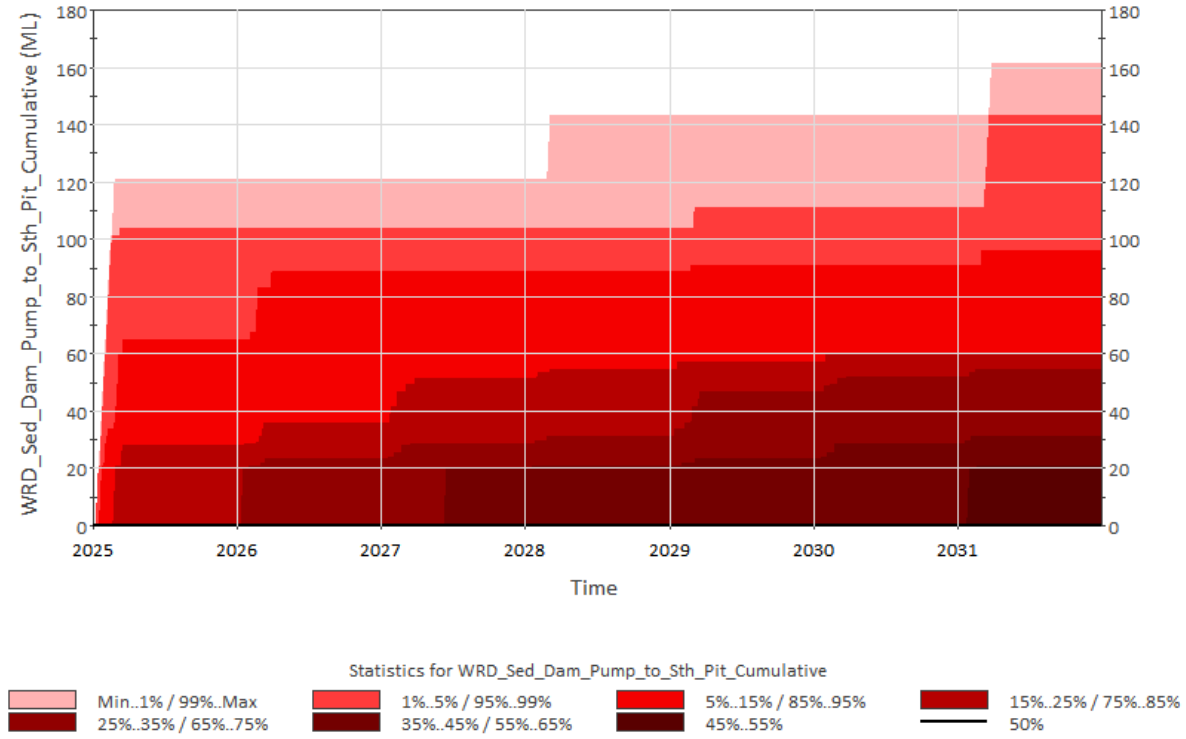
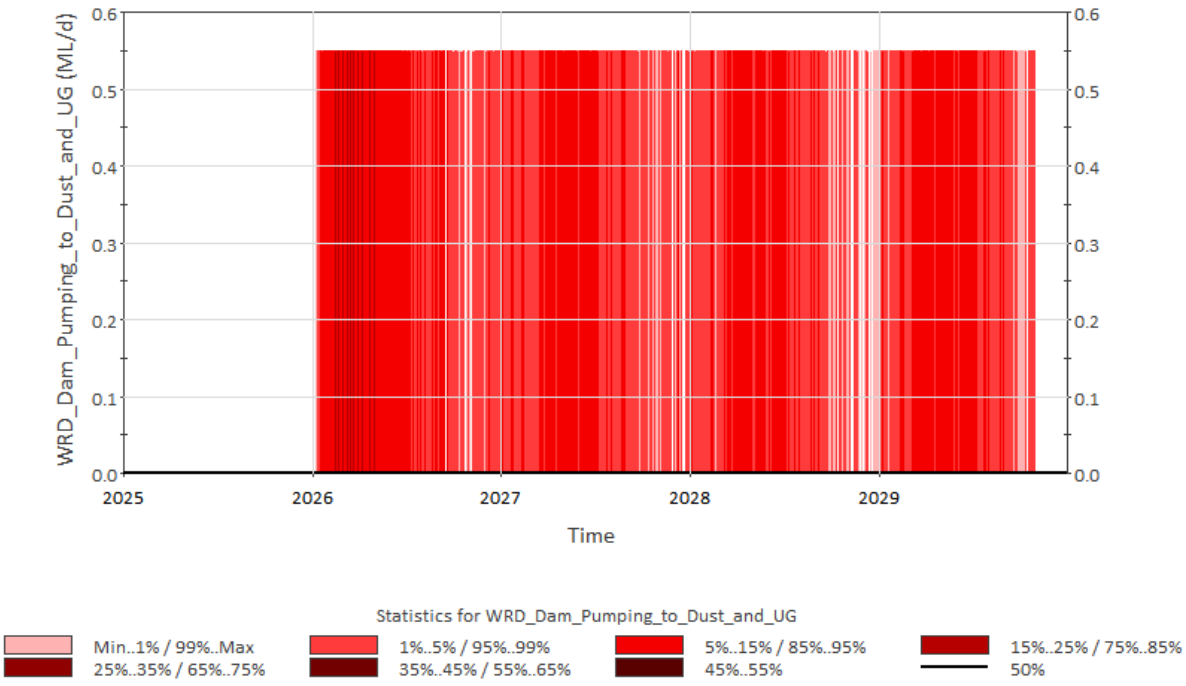


Diagram 22 illustrates that under median climatic conditions, pump transfers from the WRD Sediment Dam assist in meeting site water demands beyond October 2025 (when the South Pit is effectively dewatered).

DIAGRAM 22: WRD SEDIMENT DAMPUMP FLOWS TO UG



TAILINGS.WATER.WASTE.

4 SUMMARY AND CONCLUSION

The results of the WBM undertaken as part of the assessment of the Underground Workings indicates the following:

The South Pit is rapidly dewatered by October 2025 to meet site water demands, whereupon the North Pit and WRD Sediment Dam are used as sources to meet the site water demands.

Modelling indicates that under median climatic conditions, the site may have the potential to be in a net water deficit in the dryer months of 2027, 2028 and 2029.

The Underground Workings receives all rainfall and runoff from the South Pit from 2029. Under median climatic conditions, the Underground Workings takes ten years from 2029 to 2039 to fill. After the Underground Workings fill, the South Pit then begins to fill.

By 2050, under median rainfall conditions, the South Pit water level reaches approximately 260 m AHD, which is approximately 75 m below the pit crest. During the 95th percentile wet years, the maximum modelled water level in the South Pit is approximately 290 m AHD, which is 45 m below the pit crest. Therefore, the South Pit is not predicted to overtop or spill during operations or closure conditions.

By 2050, under median rainfall conditions, the North Pit water level reaches approximately 298 m AHD to 299 m AHD, which is approximately 17 m below the pit crest. During the 95th percentile wet years, the maximum modelled water level in the North Pit is 307 m AHD, which is approximately 9 m below the pit crest. Therefore, the North Pit is not predicted to overtop or spill during operations or closure conditions.

The WRD Sediment Dam was observed to overtop in two realisations during operational conditions, with no overtopping occurring during closure conditions.

TAILINGS.WATER.WASTE.

REFERENCES

[1] The Long Paddock (2024), SILO Data Drill for Cell -20.45, 139.85, accessed 25th January 2024 March 2023, https://www.longpaddock.qld.gov.au/silo/gridded-data/, Queensland Government.

[2] WMV Environmental (2024a), 'BCP UG EA GW Inflow Calculations (v1.1 - 2024_02_19).xls', 19 February 2024.

[3] WMV Environmental (2024b), 'Barbara Copper Project UG EA Amendment . Groundwater Technical Report, February 2024.

[4] Aeris (2024). '231030_Barbara Dam Survey Information.xls', 30 October 2023.

[5] Eason, D. (2024) 'RE: Aeris Resources, Barbara Copper Project - underground EA amendment application',23rd January 2024.

[6] Boughton, W.C. (2004). 'The Australian Water Balance Model. Environmental Modelling & Software', Vol. 19, pp943-956.

CONDITIONS OF REPORT

1. This report must be read in its entirety.
2. This report has been prepared by ATCW for the purposes stated herein and ATCW's experience, having regard to assumptions that can reasonably be expected to make in accordance with sound professional principles. ATCW does not accept responsibility for the consequences of extrapolation, extension or transference of the findings and recommendations of this report to different sites, cases, or conditions.
3. This document has been prepared based in part on information which was provided to ATCW by the client and/or others and which is not under our control. ATCW does not warrant or guarantee the accuracy of this information. The user of the document is cautioned that fundamental input assumptions upon which the document is based may change with time. It is the user's responsibility to ensure that these assumptions are valid.
4. Unless specifically agreed otherwise in the contract of engagement, ATCW retains Intellectual Property Rights over the contents of the document. The client is granted a licence to use the report for the purposes for which it was commissioned.

TAILINGS.WATER.WASTE.

APPENDIX B – EPBC ACT PROTECTED MATTER REPORT

TAILINGS.WATER.WASTE.

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 15-May-2024

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	17
Listed Migratory Species:	12

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	17
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	1
Key Ecological Features (Marine):	None
Biologically Important Areas:	None
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Listed Threatened Species			[Resource Information]
Status of Conservation Dependent and Extinct are not MNES under the EPBC Act. Number is the current name ID.			
Scientific Name	Threatened Category	Presence Text	Buffer Status
BIRD			
Calidris acuminata Sharp-tailed Sandpiper [874]	Vulnerable	Species or species habitat may occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
Erythrotriorchis radiatus Red Goshawk [942]	Endangered	Species or species habitat may occur within area	In feature area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat may occur within area	In feature area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area	In feature area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat likely to occur within area	In feature area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Tringa nebularia			
Common Greenshank, Greenshank [832]	Endangered	Species or species habitat may occur within area	In buffer area only
MAMMAL			
Macroderma gigas			
Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Macrotis lagotis			
Greater Bilby [282]	Vulnerable	Species or species habitat may occur within area	In feature area
Sminthopsis douglasi			
Julia Creek Dunnart [305]	Vulnerable	Species or species habitat may occur within area	In feature area
PLANT			
Eucalyptus nudicaulis			
Mt Isa Mallee [55399]	Endangered	Species or species habitat may occur within area	In buffer area only
REPTILE			
Acanthophis hawkei			
Plains Death Adder [83821]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Elseya lavarackorum			
Gulf Snapping Turtle [67197]	Endangered	Species or species habitat may occur within area	In feature area
Varanus mertensi			
Mertens' Water Monitor, Mertens's Water Monitor [1568]	Endangered	Species or species habitat known to occur within area	In feature area
SHARK			
Pristis pristis			
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area	In feature area

Listed Migratory Species			[Resource Information]
Scientific Name	Threatened Category	Presence Text	Buffer Status
Migratory Marine Birds			
Apus pacificus			
Fork-tailed Swift [678]		Species or species habitat likely to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Migratory Marine Species			
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area	In feature area
Migratory Terrestrial Species			
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area	In buffer area only
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area	In feature area
Motacilla flava Yellow Wagtail [644]		Species or species habitat likely to occur within area	In feature area
Migratory Wetlands Species			
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area
Calidris acuminata Sharp-tailed Sandpiper [874]	Vulnerable	Species or species habitat may occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area	In feature area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area	In feature area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area	In feature area
Tringa nebularia Common Greenshank, Greenshank [832]	Endangered	Species or species habitat may occur within area	In buffer area only

Other Matters Protected by the EPBC Act

Listed Marine Species			[Resource Information]
Scientific Name	Threatened Category	Presence Text	Buffer Status
Bird			
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area	In feature area
Bubulcus ibis as Ardea ibis Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area	In feature area
Calidris acuminata Sharp-tailed Sandpiper [874]	Vulnerable	Species or species habitat may occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area	In feature area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Chalcites osculans as Chrysococcyx osculans			
Black-eared Cuckoo [83425]		Species or species habitat likely to occur within area overfly marine area	In feature area
Charadrius veredus			
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area overfly marine area	In feature area
Glareola maldivarum			
Oriental Pratincole [840]		Species or species habitat may occur within area overfly marine area	In feature area
Haliaeetus leucogaster			
White-bellied Sea-Eagle [943]		Species or species habitat may occur within area	In feature area
Hirundo rustica			
Barn Swallow [662]		Species or species habitat may occur within area overfly marine area	In buffer area only
Merops ornatus			
Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area	In feature area
Motacilla cinerea			
Grey Wagtail [642]		Species or species habitat may occur within area overfly marine area	In feature area
Motacilla flava			
Yellow Wagtail [644]		Species or species habitat likely to occur within area overfly marine area	In feature area
Rostratula australis as Rostratula benghalensis (sensu lato)			
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
[Tringa nebularia](#) Common Greenshank, Greenshank [832]	Endangered	Species or species habitat may occur within area overfly marine area	In buffer area only
Reptile			
[Crocodylus johnstoni](#) Freshwater Crocodile, Johnston's Crocodile, Johnstone's Crocodile [1773]		Species or species habitat may occur within area	In feature area

Extra Information

EPBC Act Referrals [Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Controlled action				
[CopperString Project](#)	2010/5581	Controlled Action	Completed	In feature area

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact us page.

© Commonwealth of Australia
Department of Climate Change, Energy, the Environment and Water
GPO Box 3090
Canberra ACT 2601 Australia
+61 2 6274 1111

APPENDIX C – ENVIRONMENTAL REPORTS – MATTERS OF STATE ENVIRONMENTAL SIGNIFICANCE

Queensland Government

Department of Environment, Science and Innovation

Environmental Reports

Matters of State Environmental Significance

For the selected area of interest

Longitude: 139.849851 Latitude: -20.424877 with 2 kilometre radius

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or area of interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "central coordinates" option, the resulting assessment area encompasses an area extending for a 2km radius from the point of interest.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no values have been identified within the site.

The information presented in this report should be considered as a guide only and a field survey may be required to validate values on the ground.

Please direct queries about these reports to: Planning.Support@des.qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.

Table of Contents

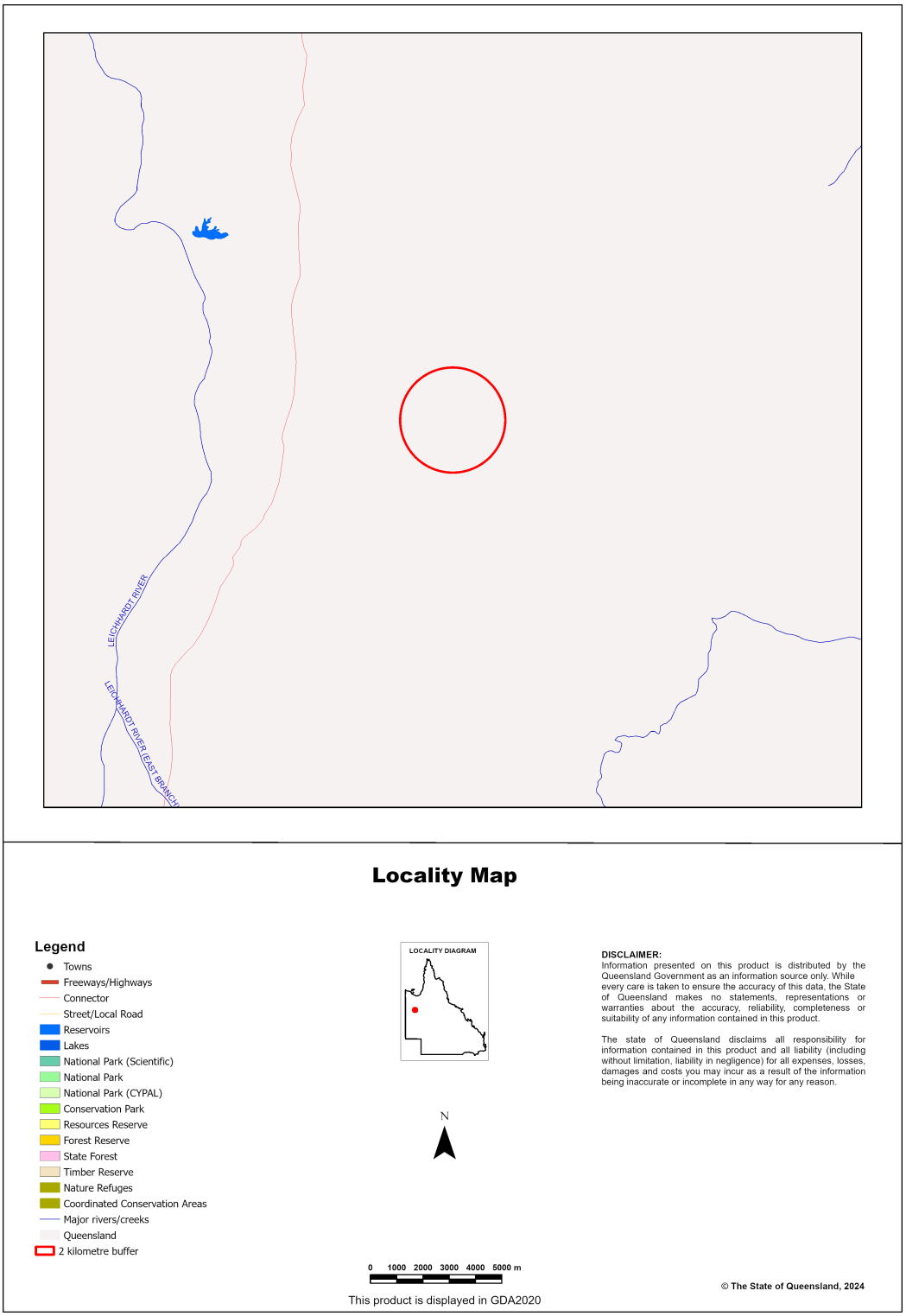
Assessment Area Details 4
Matters of State Environmental Significance (MSES) 5
MSES Categories 5
MSES Values Present 6
Additional Information with Respect to MSES Values Present 6
MSES - State Conservation Areas 6
MSES - Wetlands and Waterways 7
MSES - Species 7
MSES - Regulated Vegetation 10
MSES - Offsets 11
Maps 12
Map 1 - MSES - State Conservation Areas 12
Map 2 - MSES - Wetlands and Waterways 13
Map 3a - MSES - Species - Threatened (endangered or vulnerable) wildlife and special least concern animals 14
Map 3b - MSES - Species - Koala habitat area (SEQ) 15
Map 3c - MSES - Species - Wildlife habitat (sea turtle nesting areas) 16
Map 4 - MSES - Regulated Vegetation 17
Map 5 - MSES - Offset Areas 18
Appendices 19
Appendix 1 - Matters of State Environmental Significance (MSES) methodology 19
Appendix 2 - Source Data 20
Appendix 3 - Acronyms and Abbreviations 21

Assessment Area Details

The following table provides an overview of the area of interest (AOI) with respect to selected topographic and environmental values.

Table 1: Summary table, details for AOI: Longitude: 139.849851 Latitude: -20.424877 with 2 kilometre radius, with area 1256.64 ha

Local Government(s)	Catchment(s)	Bioregion(s)	Subregion(s)
Mount Isa City	Leichhardt	Northwest Highlands	Mount Isa Inlier



Matters of State Environmental Significance (MSES)

MSES Categories

Queensland's State Planning Policy (SPP) includes a biodiversity State interest that states:

'The sustainable, long-term conservation of biodiversity is supported. Significant impacts on matters of national or state environmental significance are avoided, or where this cannot be reasonably achieved; impacts are minimised and residual impacts offset.'

The MSES mapping product is a guide to assist implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations.

The SPP defines matters of state environmental significance as:

- Protected areas (including all classes of protected area except coordinated conservation areas) under the *Nature Conservation Act 1992;*

- Marine parks and land within a 'marine national park', 'conservation park', 'scientific research', 'preservation' or 'buffer' zone under the Marine Parks Act 2004 ;

- Areas within declared fish habitat areas that are management A areas or management B areas under the Fisheries Regulation 2008;

- *Threatened wildlife under the Nature Conservation Act 1992* and special least concern animals under the Nature Conservation (Wildlife) Regulation 2006;

- Regulated vegetation under the *Vegetation Management Act 1999* that is:

  - Category B areas on the regulated vegetation management map, that are 'endangered' or 'of concern' regional ecosystems;
  - Category C areas on the regulated vegetation management map that are 'endangered' or 'of concern' regional ecosystems;
  - Category R areas on the regulated vegetation management map;
  - Regional ecosystems that intersect with watercourses identified on the vegetation management watercourse and drainage feature map;
  - Regional ecosystems that intersect with wetlands identified on the vegetation management wetlands map;

- Strategic Environmental Areas under the *Regional Planning Interests Act 2014* ;

- Wetlands in a wetland protection area of wetlands of high ecological significance shown on the Map of Queensland Wetland Environmental Values under the Environment Protection Regulation 2019;

- Wetlands and watercourses in high ecological value waters defined in the Environmental Protection (Water) Policy 2009, schedule 2;
- Legally secured offset areas.

MSES Values Present

The MSES values that are present in the area of interest are summarised in the table below:

Table 2: Summary of MSES present within the AOI

1a Protected Areas- estates	0 ha	0.0%
1b Protected Areas- nature refuges	0 ha	0.0%
1c Protected Areas- special wildlife reserves	0 ha	0.0%
2 State Marine Parks- highly protected zones	0 ha	0.0%
3 Fish habitat areas (A and B areas)	0 ha	0.0%
4 Strategic Environmental Areas (SEA)	0 ha	0.0%
5 High Ecological Significance wetlands on the Map of Queensland Wetland Environmental Values	0 ha	0.0%
6a High Ecological Value (HEV) wetlands	0 ha	0.0%
6b High Ecological Value (HEV) waterways	0 km	Not applicable
7a Threatened (endangered or vulnerable) wildlife	1194.38 ha	95.0%
7b Special least concern animals	475.96 ha	37.9%
7c i Koala habitat area - core (SEQ)	0 ha	0.0%
7c ii Koala habitat area - locally refined (SEQ)	0 ha	0.0%
7d Sea turtle nesting areas	0 km	Not applicable
8a Regulated Vegetation - Endangered/Of concern in Category B (remnant)	0 ha	0.0%
8b Regulated Vegetation - Endangered/Of concern in Category C (regrowth)	0 ha	0.0%
8c Regulated Vegetation - Category R (GBR riverine regrowth)	0 ha	0.0%
8d Regulated Vegetation - Essential habitat	1202.06 ha	95.7%
8e Regulated Vegetation - intersecting a watercourse	22.9 km	Not applicable
8f Regulated Vegetation - within 100m of a Vegetation Management Wetland	0 ha	0.0%
9a Legally secured offset areas- offset register areas	0 ha	0.0%
9b Legally secured offset areas- vegetation offsets through a Property Map of Assessable Vegetation	0 ha	0.0%

Additional Information with Respect to MSES Values Present

MSES - State Conservation Areas

1a. Protected Areas - estates

(No results)

1b. Protected Areas - nature refuges

(No results)

1c. Protected Areas - special wildlife reserves

(No results)

2. State Marine Parks - highly protected zones

(No results)

3. Fish habitat areas (A and B areas)

(No results)

Refer to **Map 1 - MSES - State Conservation Areas** for an overview of the relevant MSES.

MSES - Wetlands and Waterways

4. Strategic Environmental Areas (SEA)

(No results)

5. High Ecological Significance wetlands on the Map of Queensland Wetland Environmental Values

(no results)

6a. Wetlands in High Ecological Value (HEV) waters

(no results)

6b. Waterways in High Ecological Value (HEV) waters

(no results)

Refer to **Map 2 - MSES - Wetlands and Waterways** for an overview of the relevant MSES.

MSES - Species

7a. Threatened (endangered or vulnerable) wildlife

Values are present

7b. Special least concern animals

Values are present

7c i. Koala habitat area - core (SEQ)

Not applicable

7c ii. Koala habitat area - locally refined (SEQ)

Not applicable

7d. Wildlife habitat (sea turtle nesting areas)

Not applicable

Threatened (endangered or vulnerable) wildlife habitat suitability models

Species	Common name	NCA status	Presence
Boronia keysii	Keys boronia	V	None
Calyptorhynchus lathami	Glossy black cockatoo	V	None
Casuarius casuarius johnsonii	Sthn population cassowary	E	None
Crinia tinnula	Wallum froglet	V	None
Denisonia maculata	Ornamental snake	V	None
Euastacus bindal	Mount Elliot crayfish	CR	None
Euastacus binzayedi		CR	None
Euastacus eungella		E	None
Euastacus hystricosus		E	None
Euastacus jagara	Jagara hairy crayfish	CR	None
Euastacus maidae		CR	None
Euastacus monteithorum		E	None
Euastacus robertsi		E	None
Taudactylus pleione	Kroombit tinkerfrog	E	None
Litoria freycineti	Wallum rocketfrog	V	None
Litoria olongburensis	Wallum sedgefrog	V	None
Macadamia integrifolia		V	None
Melaleuca irbyana	swamp tea-tree	E	None
Macadamia ternifolia		V	None
Macadamia tetraphylla	bopple nut	V	None
Petrogale penicillata	brush-tailed rock-wallaby	V	None
Petrogale coenensis	Cape York rock-wallaby	V	None
Petrogale purpureicollis	purple-necked rock-wallaby	V	Core
Petrogale sharmani	Sharmans rock-wallaby	V	None
Petrogale xanthopus celeris	yellow-footed rock-wallaby (Qld subspecies)	V	None
Petaurus gracilis	Mahogany Glider	E	None
Petrogale persephone	Proserpine rock-wallaby	E	None
Phascolarctos cinereus	Koala - outside SEQ*	E	None
Pezoporus wallicus wallicus	Eastern ground parrot	V	None
Xeromys myoides	Water Mouse	V	None

*For koala model, this includes areas outside SEQ. Check 7c SEQ koala habitat for presence/absence.

Threatened (endangered or vulnerable) wildlife species records

Scientific name	Common name	NCA status	EPBC status	Migratory status
Varanus mertensi	Mertens' water monitor	E	None	None

Special least concern animal species records

Scientific name	Common name	Migratory status
Tachyglossus aculeatus	short-beaked echidna	None

Shorebird habitat (critically endangered/endangered/vulnerable)

Not applicable

Shorebird habitat (special least concern)

Not applicable

**Nature Conservation Act 1992 (NCA) Status- Endangered (E), Vulnerable (V) or Special Least Concern Animal (SL). Environment Protection and Biodiversity Conservation Act 1999 (EPBC) status: Critically Endangered (CE) Endangered (E), Vulnerable (V)*

Migratory status (M) - China and Australia Migratory Bird Agreement (C), Japan and Australia Migratory Bird Agreement (J), Republic of Korea and Australia Migratory Bird Agreement (R), Bonn Migratory Convention (B), Eastern Flyway (E)

To request a species list for an area, or search for a species profile, access Wildlife Online at:

https://www.qld.gov.au/environment/plants-animals/species-list/

Refer to **Map 3a - MSES - Species - Threatened (endangered or vulnerable) wildlife and special least concern animals** and **Map 3b - MSES - Species - Koala habitat area (SEQ)** and **Map 3c - MSES - Wildlife habitat (sea turtle nesting areas)** for an overview of the relevant MSES.

MSES - Regulated Vegetation

For further information relating to regional ecosystems in general, go to:

https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/

For a more detailed description of a particular regional ecosystem, access the regional ecosystem search page at:

https://environment.ehp.qld.gov.au/regional-ecosystems/

8a. Regulated Vegetation - Endangered/Of concern in Category B (remnant)

Not applicable

8b. Regulated Vegetation - Endangered/Of concern in Category C (regrowth)

Not applicable

8c. Regulated Vegetation - Category R (GBR riverine regrowth)

Not applicable

8d. Regulated Vegetation - Essential habitat

Values are present

8e. Regulated Vegetation - intersecting a watercourse**

A vegetation management watercourse is mapped as present

8f. Regulated Vegetation - within 100m of a Vegetation Management wetland

Not applicable

Refer to **Map 4 - MSES - Regulated Vegetation** for an overview of the relevant MSES.

MSES - Offsets

9a. Legally secured offset areas - offset register areas

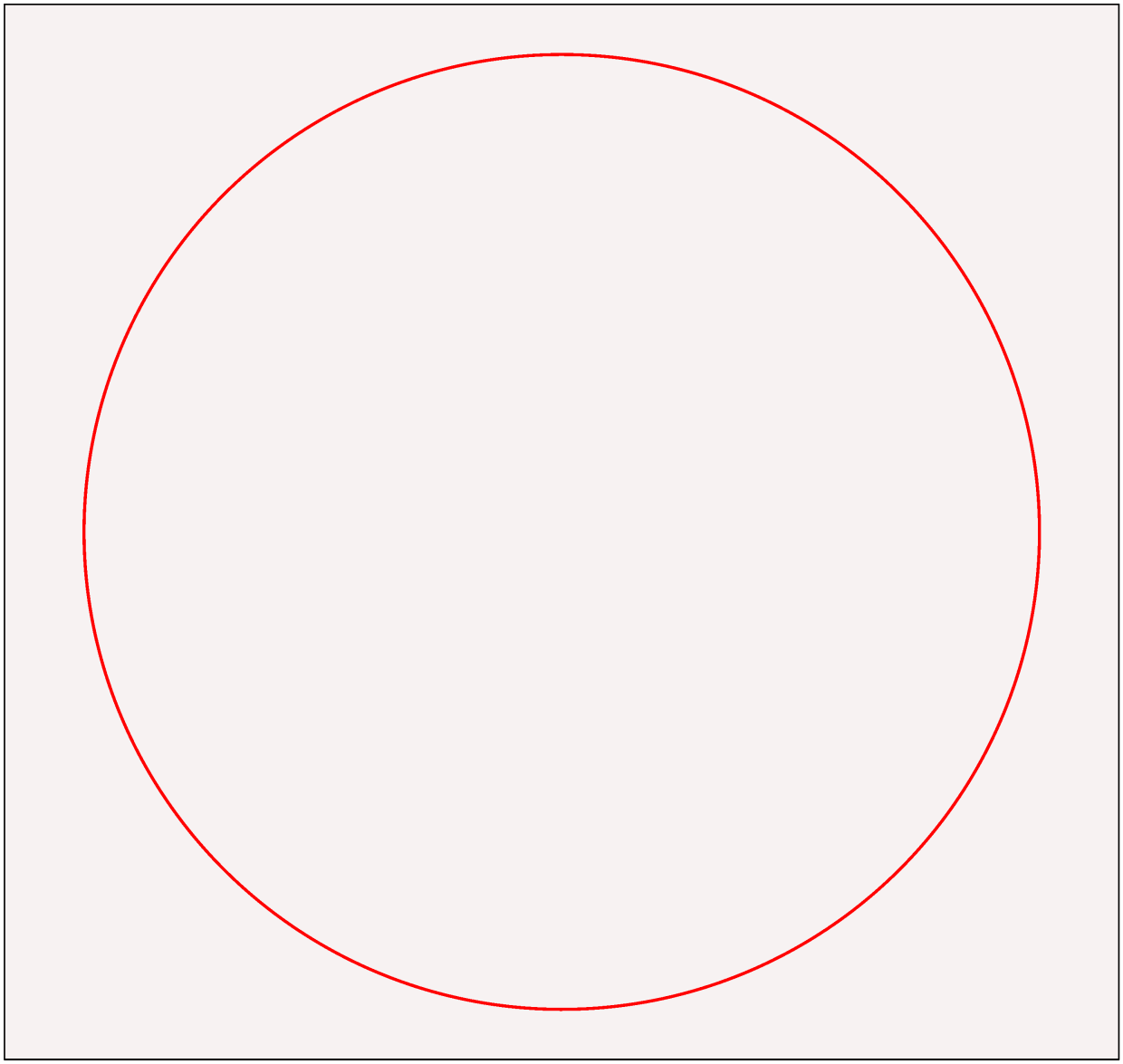
(No results)

9b. Legally secured offset areas - vegetation offsets through a Property Map of Assessable Vegetation

(No results)

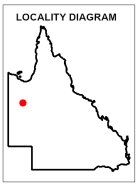
Refer to **Map 5 - MSES - Offset Areas** for an overview of the relevant MSES.

Map 1 - MSES - State Conservation Areas



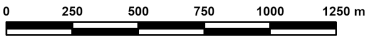
MSES - State Conservation Areas

- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Protected area (estates, nature refuges, special wildlife reserves)
- Declared fish habitat area (A and B areas)
- Marine park (highly protected)
- 2 kilometre buffer



Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

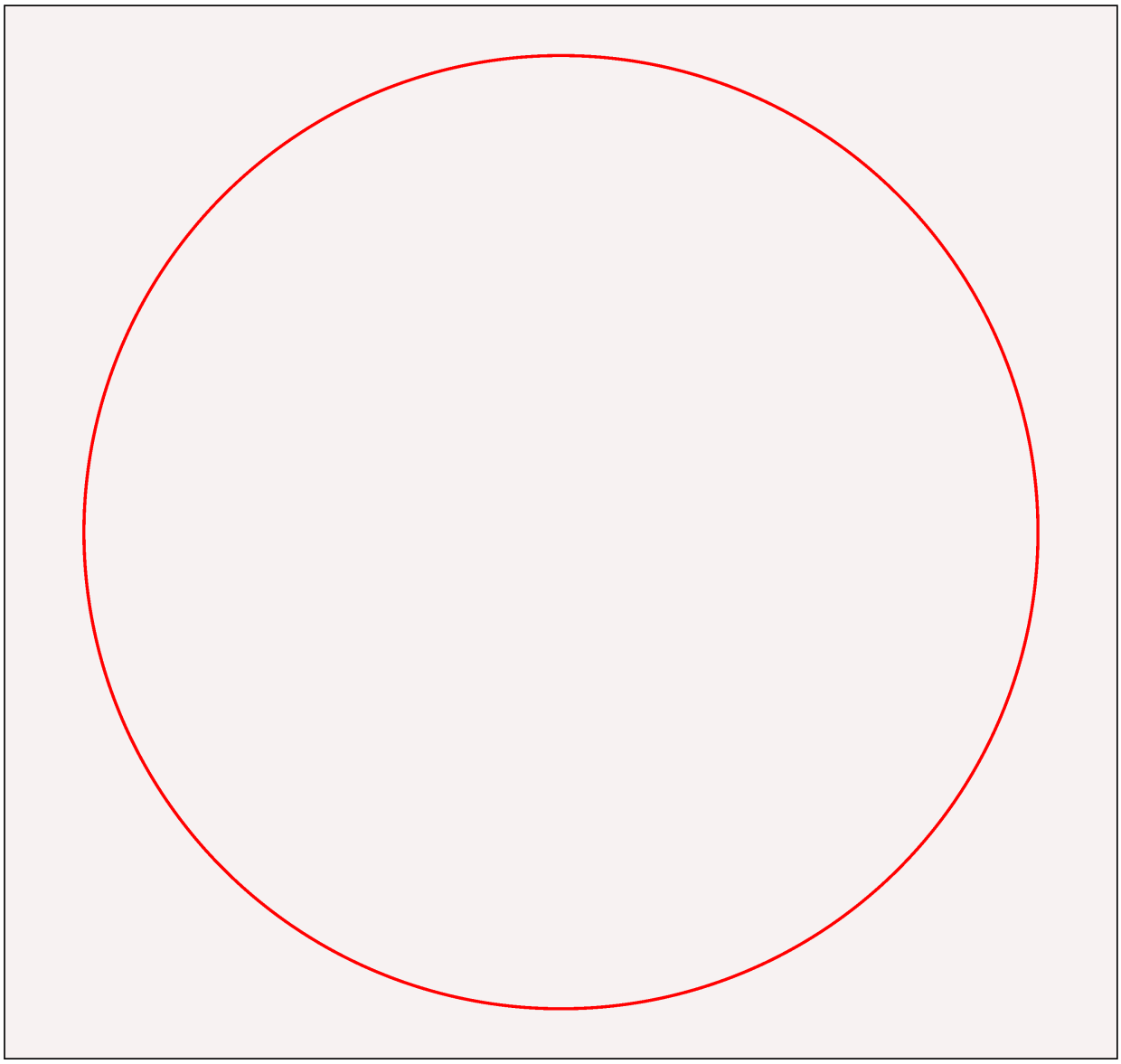
The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.



This product is displayed in GDA2020

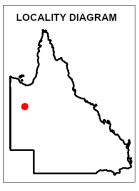
© The State of Queensland, 2024

Map 2 - MSES - Wetlands and Waterways



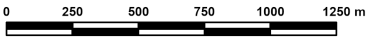
MSES - Wetlands and Waterways

- ▲ Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Declared high ecological value waters (watercourse)
- Strategic environmental area (designated precinct)
- Declared high ecological value waters (wetland)
- High ecological significance wetlands
- 2 kilometre buffer



Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the state of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

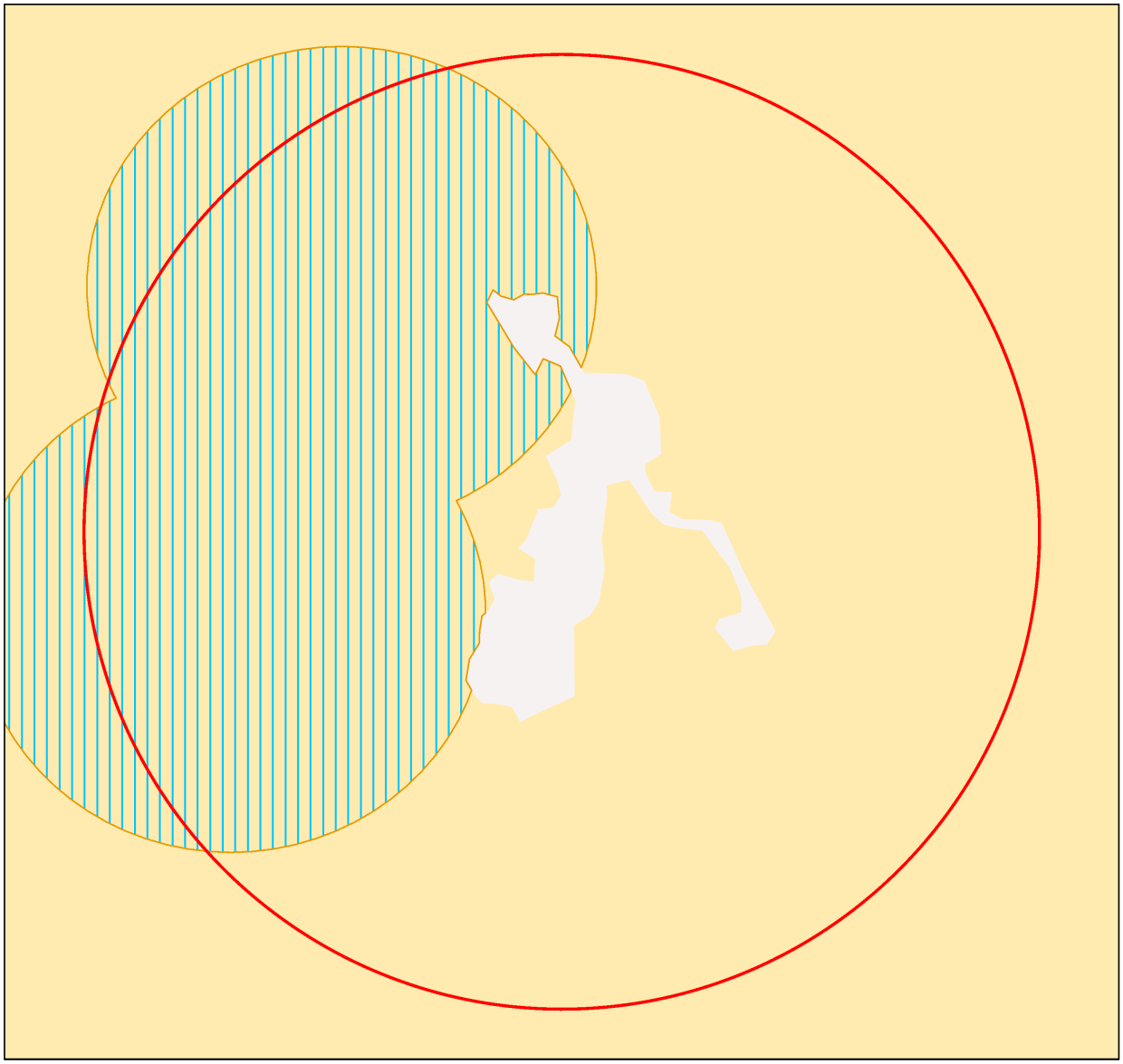
The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.



This product is displayed in GDA2020

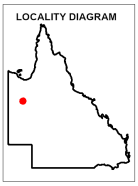
© The State of Queensland, 2024

Map 3a - MSES - Species - Threatened (endangered or vulnerable) wildlife and special least concern animals



MSES - Species
Threatened (endangered or vulnerable) wildlife and special least concern animals

- ▲ Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Wildlife habitat (special least concern)
- Wildlife habitat (endangered or vulnerable)
- 2 kilometre buffer



N

0 250 500 750 1000 1250 m

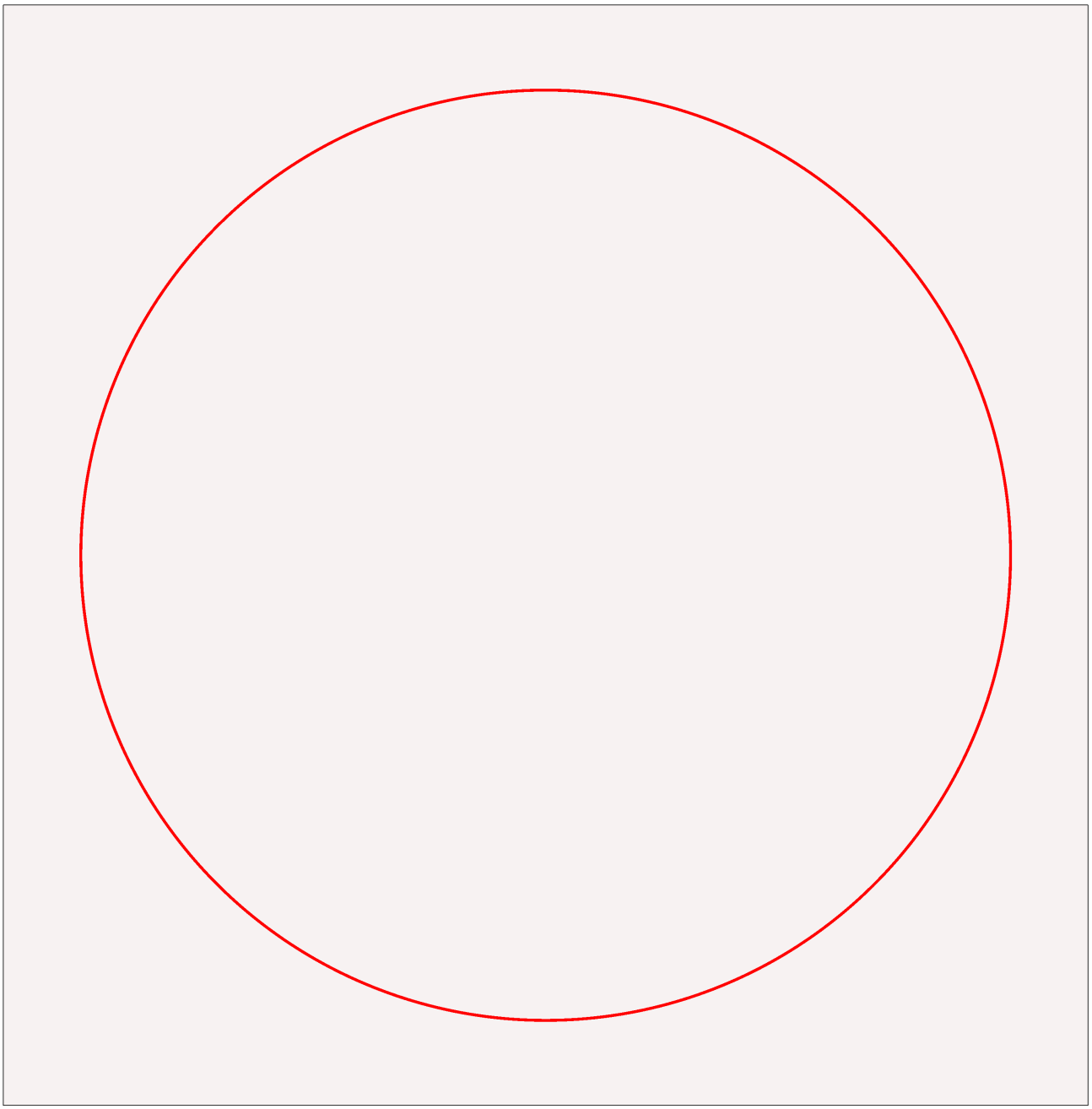
This product is displayed in GDA2020

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the state of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2024

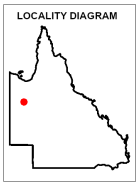
Map 3b - MSES - Species - Koala habitat area (SEQ)



MSES - Species
Koala habitat area (SEQ)

- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Koala habitat area (core)
- Koala habitat area (locally refined)
- 2 kilometre buffer

LOCALITY DIAGRAM



While every care is taken to ensure the accuracy of this product, the Department of Environment, Science and Innovation acting on behalf of the State of Queensland makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which you might incur as a result of the data being inaccurate or incomplete in any way and for any reason. Due to varying sources of data, spatial locations may not coincide when overlaid.

The represented layers for SEQ 'koala habitat area-core' and 'koala habitat area- locally refined' in MSES are sourced directly from the regulatory mapping under the Nature Conservation (Koala) Conservation Plan 2017. Whilst every effort is made to ensure the information remains current, there may be delays between updating versions. Please refer to the original mapping for the most recent version. See https://environment.des.qld.gov.au/wildlife/animals/living-with/koalas/mapping

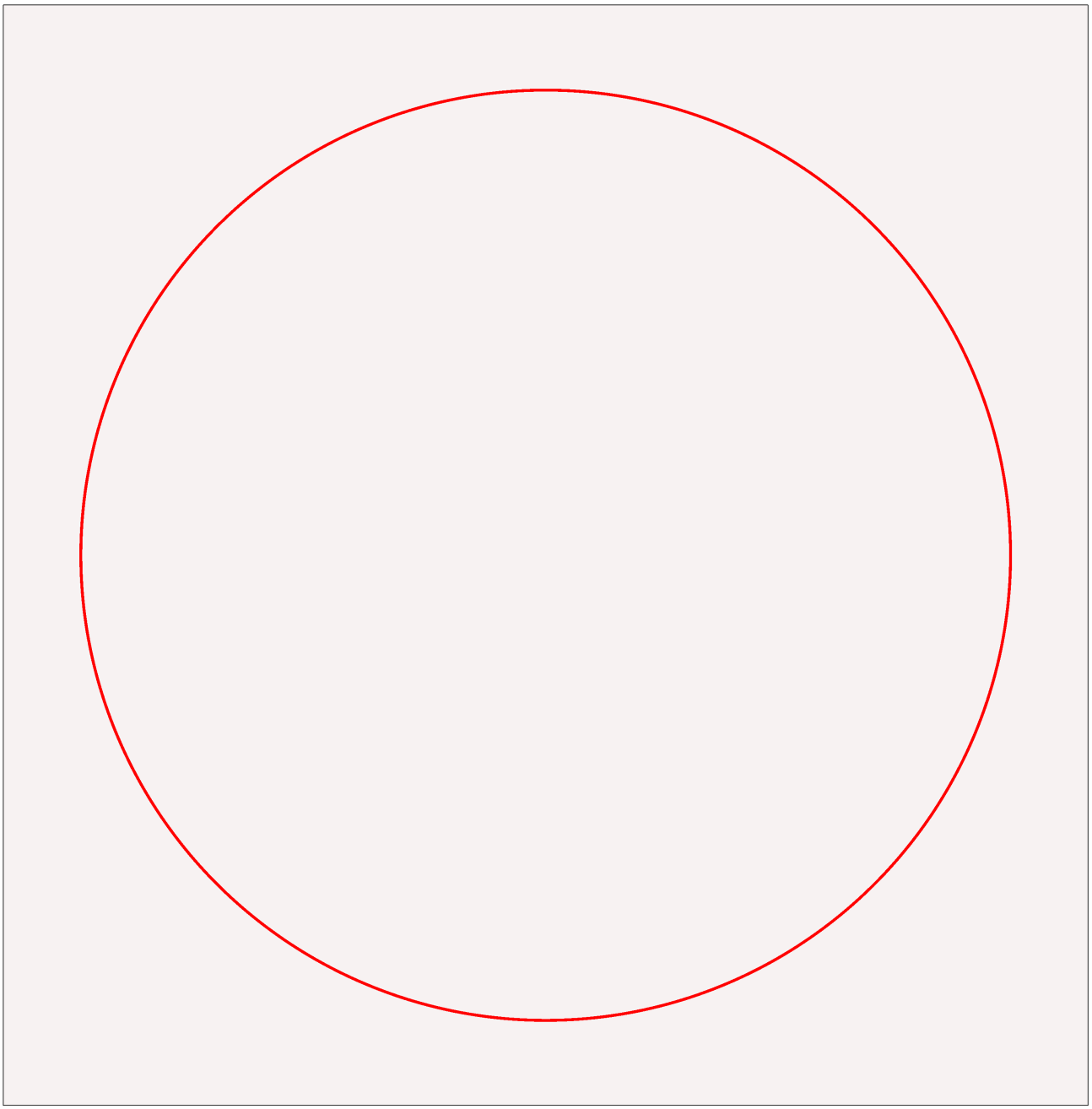
The koala habitat mapping within South East Queensland uses regional ecosystem linework compiled at a scale varying from 1:25,000 to 1:100,000. Linework should be used as a guide only. The positional accuracy of regional ecosystem data mapped at a scale of 1:100,000 is +/- 100 metres.

© The State of Queensland, 2024

0 240 480 720 960 1,200 m

This product is displayed in GDA2020

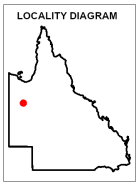
Map 3c - MSES - Species - Wildlife habitat (sea turtle nesting areas)



MSES - Wildlife habitat (sea turtle nesting areas)

- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Wildlife habitat (sea turtle nesting areas)
- 2 kilometre buffer

LOCALITY DIAGRAM



While every care is taken to ensure the accuracy of this product, the Department of Environment, Science and Innovation acting on behalf of the State of Queensland makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which you might incur as a result of the data being inaccurate or incomplete in any way and for any reason. Due to varying sources of data, spatial locations may not coincide when overlaid.

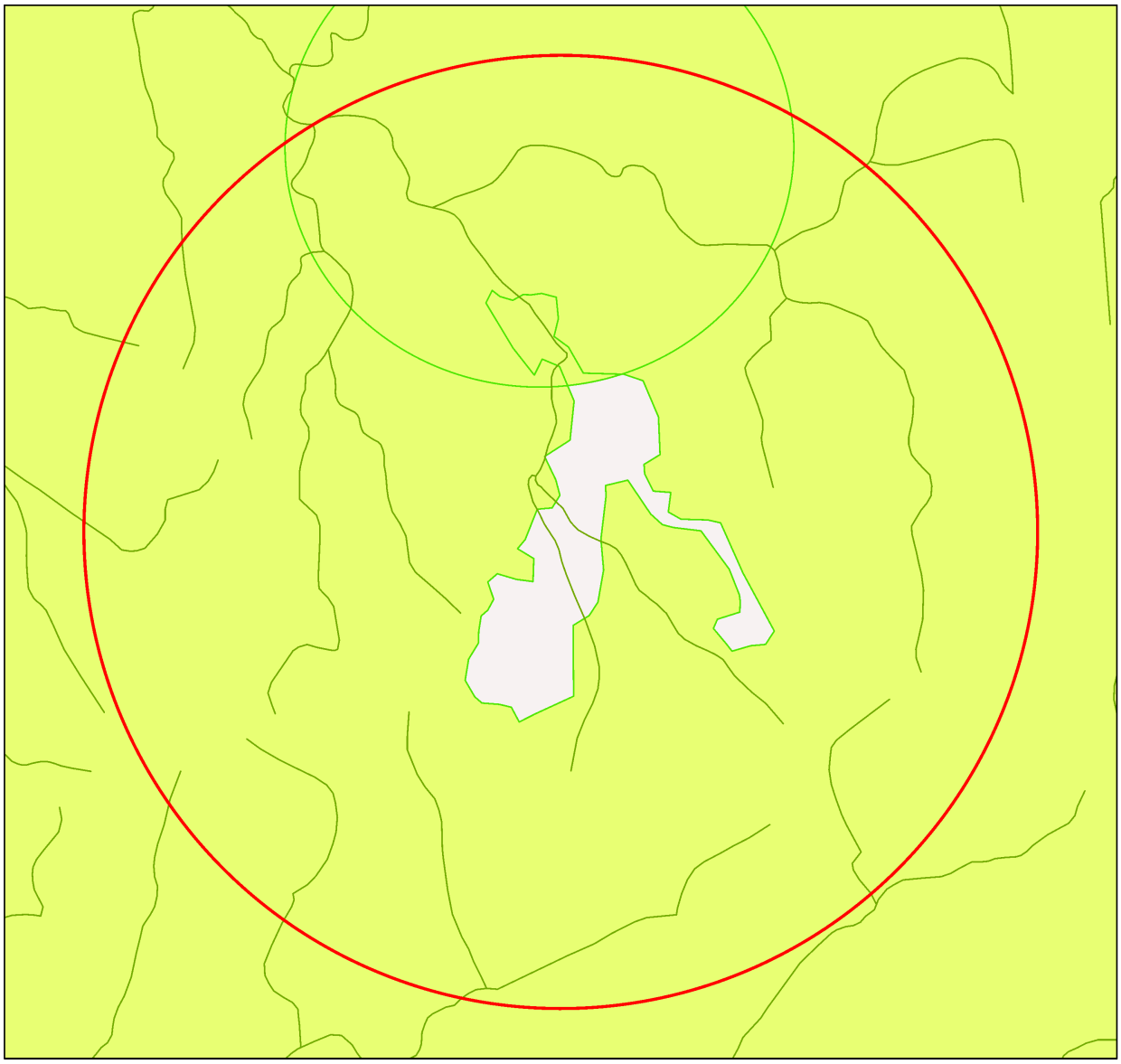
MSES mapping of sea turtle nesting areas identifies beaches where the recorded number of turtle nests are over 1% of the turtle species or genetic stock. The linework is also deliberately extended along nearby rocky coastlines and headlands to recognise that significant numbers of nesting adults and hatchlings can become disoriented by light pollution from development on rocky coastlines and headlands while navigating offshore from nesting beaches.

0 240 480 720 960 1,200 m

© The State of Queensland, 2024

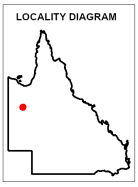
This product is displayed in GDA2020

Map 4 - MSES - Regulated Vegetation



MSES - Regulated Vegetation

- ▲ Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Regulated vegetation (intersecting a watercourse)
- Regulated vegetation (100m from wetland)
- Regulated vegetation (category B - endangered or of concern)
- Regulated vegetation (category C - endangered or of concern)
- Regulated vegetation (category R - GBR riverine)
- Regulated vegetation (essential habitat)
- 2 kilometre buffer



N

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the state of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

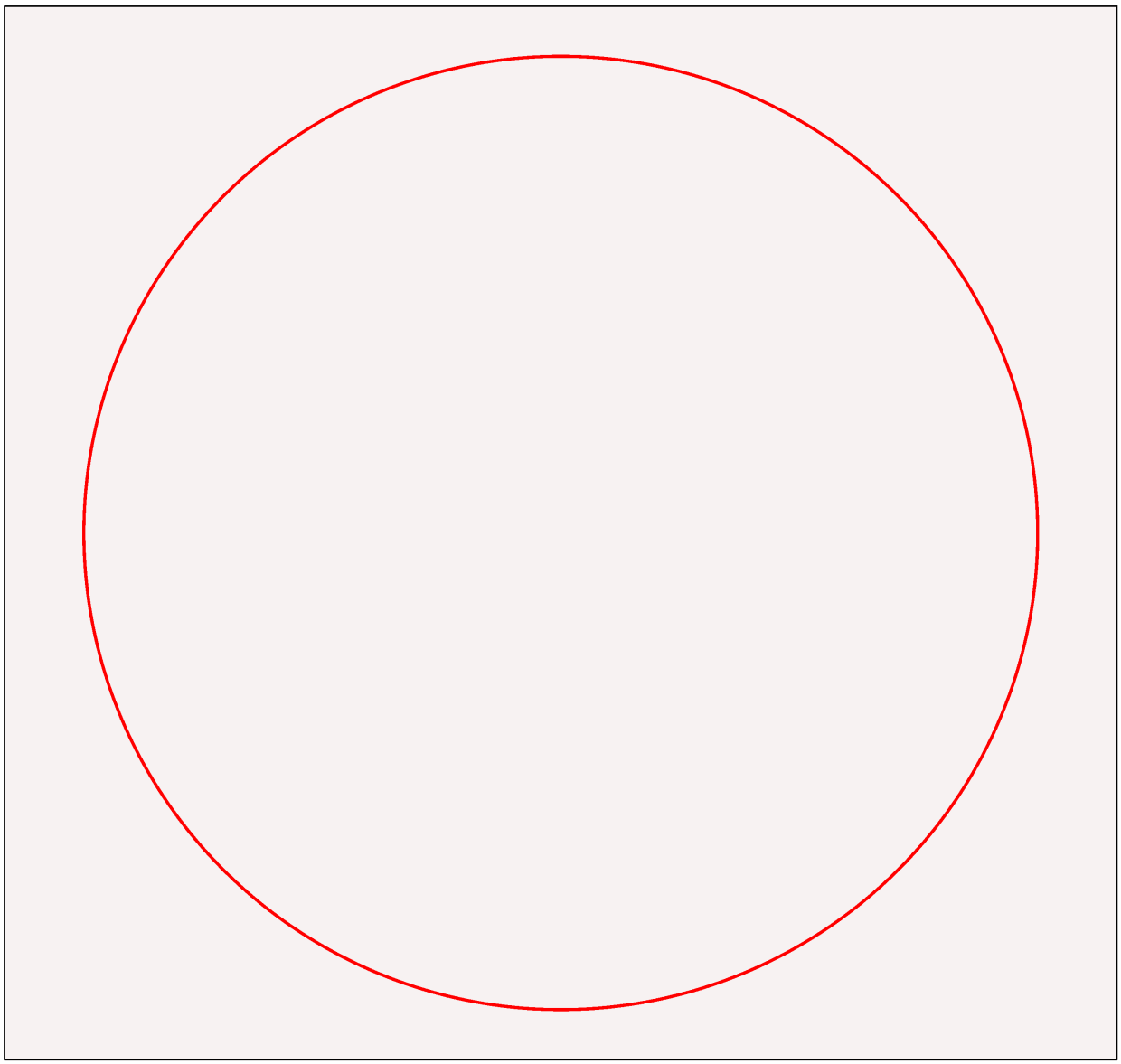
The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

0 250 500 750 1000 1250 m

This product is displayed in GDA2020

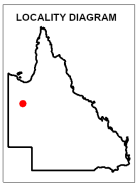
© The State of Queensland, 2024

Map 5 - MSES - Offset Areas



MSES - Offsets

- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Legally secured offset area (offset register)
- Legally secured offset area (vegetation offsets)
- 2 kilometre buffer



N

0 250 500 750 1000 1250 m

This product is displayed in GDA2020

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2024

Appendices

Appendix 1 - Matters of State Environmental Significance (MSES) methodology

MSES mapping is a regional-scale representation of the definition for MSES under the State Planning Policy (SPP). Its primary purpose is to support implementation of the SPP biodiversity policy.

MSES mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations.

MSES mapping does not determine whether state or local development assessment is required. For state assessment triggers refer to the Development Assessment Mapping System (DAMS). For local assessment triggers, refer to the relevant local planning scheme.

The Queensland Government's "Method for mapping - matters of state environmental significance can be downloaded from:

http://www.ehp.qld.gov.au/land/natural-resource/method-mapping-mses.html .

Appendix 2 - Source Data

The datasets listed below are available on request from:

http://qldspatial.information.qld.gov.au/catalogue/custom/index.page

- Matters of State environmental significance

Note: MSES mapping is not based on new or unique data. The primary mapping product draws data from a number of underlying environment databases and geo-referenced information sources. MSES mapping is a versioned product that is updated generally on a twice-yearly basis to incorporate the changes to underlying data sources. Several components of MSES mapping made for the current version may differ from the current underlying data sources. To ensure accuracy, or proper representation of MSES values, it is strongly recommended that users refer to the underlying data sources and review the current definition of MSES in the State Planning Policy, before applying the MSES mapping.

Individual MSES layers can be attributed to the following source data available at QSpatial:

MSES layers	**current QSpatial data (http://qspatial.information.qld.gov.au)**
Protected Areas-Estates, Nature Refuges, Special Wildlife Reserves	- Protected areas of Queensland - Nature Refuges - Queensland - Special Wildlife Reserves- Queensland
Marine Park-Highly Protected Zones	Moreton Bay marine park zoning 2008
Fish Habitat Areas	Queensland fish habitat areas
Strategic Environmental Areas-designated	Regional Planning Interests Act - Strategic Environmental Areas
HES wetlands	Map of Queensland Wetland Environmental Values
Wetlands in HEV waters	HEV waters: - EPP Water intent for waters Source Wetlands: - Queensland Wetland Mapping (Current version 5) Source Watercourses: - Vegetation management watercourse and drainage feature map (1:100000 and 1:250000)
Wildlife habitat (threatened and special least concern)	-WildNet database species records - habitat suitability models (various) - SEQ koala habitat areas under the Koala Conservation Plan 2019
VMA regulated regional ecosystems	Vegetation management regional ecosystem and remnant map
VMA Essential Habitat	Vegetation management - essential habitat map
VMA Wetlands	Vegetation management wetlands map
Legally secured offsets	Vegetation Management Act property maps of assessable vegetation. For offset register data-contact DES
Regulated Vegetation Map	Vegetation management - regulated vegetation management map

Appendix 3 - Acronyms and Abbreviations

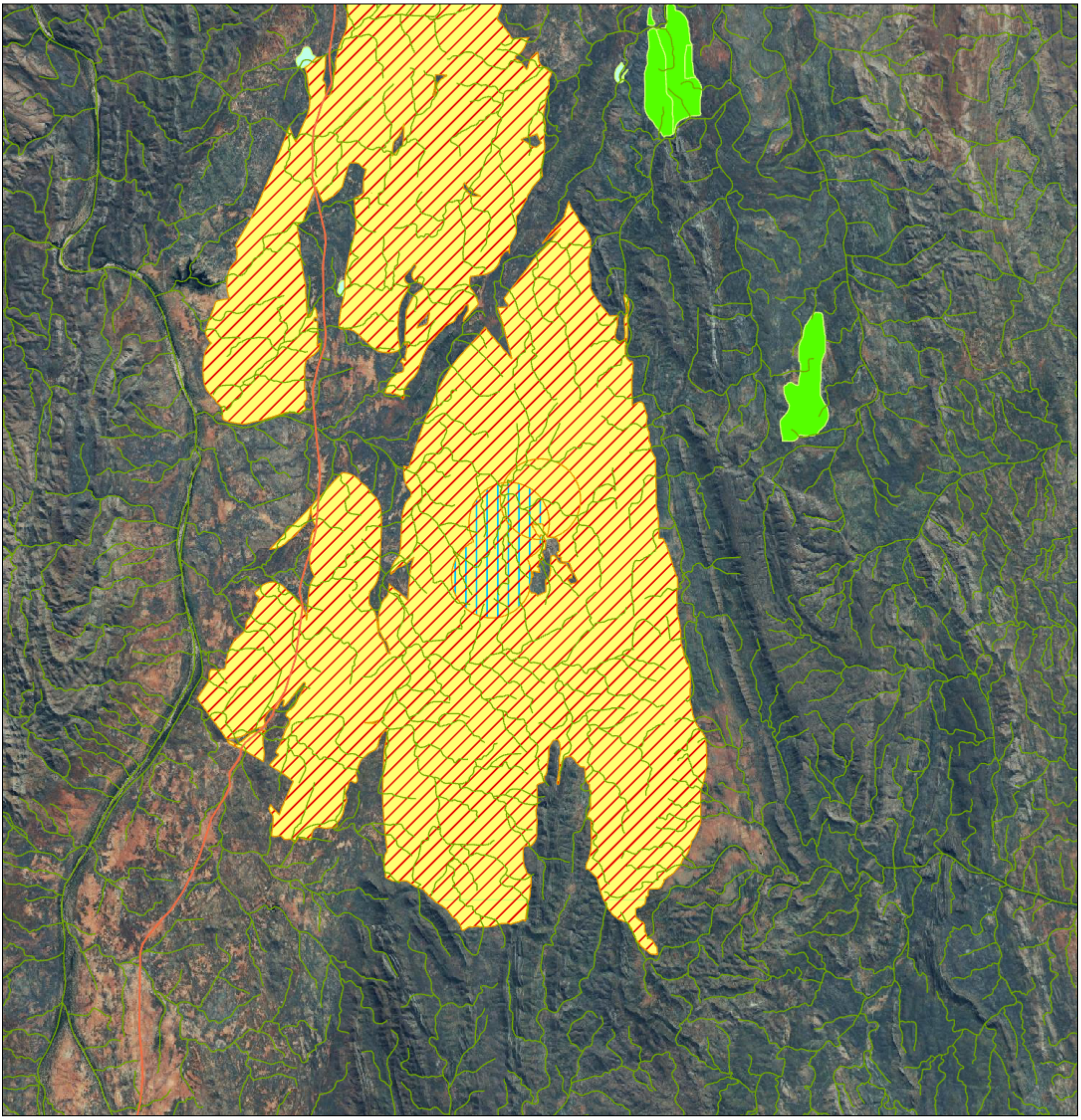
AOI	- Area of Interest
DESI	- Department of Environment, Science and Innovation
EP Act	- Environmental Protection Act 1994
EPP	- Environmental Protection Policy
GDA94	- Geocentric Datum of Australia 1994
GEM	- General Environmental Matters
GIS	- Geographic Information System
MSES	- Matters of State Environmental Significance
NCA	- Nature Conservation Act 1992
RE	- Regional Ecosystem
SPP	- State Planning Policy
VMA	- Vegetation Management Act 1999

118131.17 Barbara Copper Project

Matters of State Environmental Significance 15 May 2024

20°17'59"S 139°43'15"E

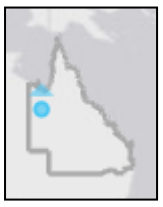
20°17'59"S 139°58'37"E



20°32'53"S 139°43'15"E

20°32'53"S 139°58'37"E

A product of Queensland Globe



Includes material © State of Queensland 2024. You are responsible for ensuring that the map is suitable for your purposes. The State of Queensland makes no representation or warranties in relation to the map contents and disclaims all liability.

If imagery is displayed, imagery includes material © CNES reproduced under license from Airbus DS, all rights reserved © 21AT © Earth-i, all rights reserved, © Planet Labs PBC, 2023

Legend located on next page

N

0 2.5 km

Scale: 1:100000

Printed at: A3

Print date: 15/5/2024

Not suitable for accurate measurement.

Projection: Web Mercator EPSG 102100 (3857)

For more information, visit https://qldglobe.information.qld.gov.au/help-info/Contact-us.html

Queensland Government

Department of Resources

118131.17 Barbara Copper Project

Matters of State Environmental Significance 15 May 2024

Legend

MSES protected area [estates]

MSES protected area [nature refuges]

MSES marine park [highly protected]

MSES declared fish habitat area [A and B areas]

MSES legally secured offset area [offset register]

MSES legally secured offset area [vegetation offsets]

MSES regulated vegetation [defined watercourse]

MSES declared high ecological value waters [watercourse]

MSES declared high ecological value waters [wetland]

MSES high ecological significance wetlands

MSES strategic environmental area [designated precinct]

MSES regulated vegetation [category B - endangered or of concern]

MSES regulated vegetation [category C- endangered or of concern]

MSES regulated vegetation [category R- GBR riverine]

MSES regulated vegetation [essential habitat]

MSES regulated vegetation [100m from wetland]

MSES wildlife habitat [endangered or vulnerable]

MSES wildlife habitat [special least concern animal]

MSES wildlife habitat [SEQ koala habitat - core]

MSES wildlife habitat [SEQ koala habitat - locally refined]

MSES protected area [special wildlife reserves]

MSES wildlife habitat [sea turtle nesting areas]

Cities and Towns

Roads and tracks

- Motorway
- Highway
- Secondary
- Connector
- Local
- Restricted Access Road
- Mall
- Busway
- Bikeway
- Restricted Access Bikeway
- Walkway
- Restricted Access Walkway
- Non-vehicular Track
- Track
- Restricted Access Track
- Ferry
- Proposed Thoroughfare

Attribution

Earthstar Geographics

Includes material © State of Queensland (Department of Resources); © Commonwealth of Australia (Geoscience Australia); © 21AT, © Earth-i, all rights reserved, 2024.

© State of Queensland (Department of Environment and Science) 2022

© State of Queensland (Department of Resources) 2023

© State of Queensland (Department of Resources) 2024

© State of Queensland (Department of Resources) 2022

APPENDIX D – ENVIRONMENTAL REPORTS – BIODIVERSITY AND CONSERVATION VALUES – BIODIVERSITY PLANNING ASSESSMENTS AND AQUATIC CONSERVATION ASSESSMENTS

TAILINGS.WATER.WASTE.

Queensland Government

Department of Environment, Science and Innovation

Environmental Reports

Biodiversity and Conservation Values

Biodiversity Planning Assessments and Aquatic Conservation Assessments

For the selected area of interest

Longitude: 139.849851 Latitude: -20.424877 with 2 kilometre buffer

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or Area of Interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "Central co-ordinates" option, the resulting assessment area encompasses an area extending from 2km radius from the point of interest.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 2020). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no values have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Please direct queries about these reports to: biodiversity.planning@des.qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.

Table of Contents

Summary Information 4
Biodiversity Planning Assessments 6
  Introduction 6
  Diagnostic Criteria 6
  Other Essential Criteria 8
Aquatic Conservation Assessments 12
  Introduction 12
  Explanation of Criteria 12
  Riverine Wetlands 13
  Non-riverine Wetlands 14
Threatened and Priority Species 16
  Introduction 16
  Threatened Species 16
  BPA Priority Species 16
  ACA Priority Species 17
Maps 18
  Map 1 - Locality Map 18
  Map 2 - Biodiversity Planning Assessment (BPA) 19
  Map 3 - Corridors 20
  Map 4 - Wetlands and waterways 21
  Map 5 - Aquatic Conservation Assessment (ACA) - riverine 22
  Map 6 - Aquatic Conservation Assessment (ACA) - non-riverine 23
References 24
Appendices 25
  Appendix 1 - Source Data 25
  Appendix 2 - Acronyms and Abbreviations 26

Summary Information

Tables 1 to 8 provide an overview of the AOI with respect to selected topographic and environmental values.

Table 1: Details for area of interest: Longitude: 139.849851 Latitude: -20.424877 with 2 kilometre buffer, with area 1256.64 ha

Local Government(s)
Mount Isa City
Bioregion(s)
Northwest Highlands
Subregion(s)
Mount Isa Inlier
Catchment(s)
Leichhardt

The following table identifies available Biodiversity Planning Assessments (BPAs) and Aquatic Conservation Assessments (ACAs) with respect to the AOI.

Table 2: Available Biodiversity Planning and Aquatic Conservation Assessments

Biodiversity Planning Assessment(s)	Aquatic Conservation Assessment(s) (riverine)	Aquatic Conservation Assessment(s) (non-riverine)
Northwest Highlands v1.1	Southern Gulf Catchments v1.1	Southern Gulf Catchments v.1.1

Table 3: Remnant regional ecosystems within the AOI as per the Qld Herbarium's 'biodiversity status'

Biodiversity Status	Area (Ha)	% of AOI
Endangered	0.00	0.00
Of concern	0.00	0.00
No concern at present	1,193.56	94.98

The following table identifies the extent and proportion of the user specified area of interest (AOI) which is mapped as being of "State", "Regional" or "Local" significance via application of the Queensland Department of Environment,Science and Innovation's *Biodiversity Assessment and Mapping Methodology* (BAMM).

Table 4: Summary table, biodiversity significance

Biodiversity Status	Area (Ha)	% of AOI
State	1,255.81	99.93

Table 5: Non-riverine wetlands intersecting the AOI

(No Records)

NB. The figures presented in the table above are derived from the relevant non-riverine Aquatic Conservation Assessment(s). Later releases of wetland mapping produced via the Queensland Wetland Mapping Program may provide more recent information in regards to wetland extent.

Table 6: Named waterways intersecting the AOI

(No Records)

Refer to **Map 1** for general locality information.

The following two tables identify the extent and proportion of the user specified AOI which is mapped as being of "Very High", "High", "Medium", "Low", or "Very Low" aquatic conservation value for riverine and non-riverine wetlands via application of the Queensland Department of Environment, Science and Innovation's *Aquatic Biodiversity Assessment and Mapping Method* (AquaBAMM).

Table 7: Summary table, aquatic conservation significance (riverine)

Aquatic conservation significance (riverine wetlands)	Area (Ha)	% of AOI
Medium	1,255.81	99.93

Table 8: Summary table, aquatic conservation significance (non-riverine)

(No Records)

Biodiversity Planning Assessments

Introduction

The Department of Environment, Science and Innovation (DESI) attributes biodiversity significance on a bioregional scale through a Biodiversity Planning Assessment (BPA). A BPA involves the integration of ecological criteria using the *Biodiversity assessment and Mapping Methodology* (BAMM) and is developed in two stages: 1) **diagnostic criteria**, and 2) **expert panel criteria**. The diagnostic criteria are based on existing data which is reliable and uniformly available across a bioregion, while the expert panel criteria allows for the refinement of the mapped information from the diagnostic output by incorporating local knowledge and expert opinion.

The BAMM methodology has application for identifying areas with various levels of significance solely for biodiversity reasons. These include threatened ecosystems or taxa, large tracts of habitat in good condition, ecosystem diversity, landscape context and connection, and buffers to wetlands or other types of habitat important for the maintenance of biodiversity or ecological processes. While natural resource values such as dryland salinity, soil erosion potential or land capability are not dealt with explicitly, they are included to some extent within the biodiversity status of regional ecosystems recognised by the DESI. Biodiversity Planning Assessments (BPAs) assign three levels of overall biodiversity significance.

- **State significance** - areas assessed as being significant for biodiversity at the bioregional or state scales. They also include areas assessed by other studies/processes as being significant at national or international scales. In addition, areas flagged as being of State significance due to the presence of endangered, vulnerable and/or near threatened taxa, are identified as "State Habitat for EVNT taxa".
- **Regional significance** - areas assessed as being significant for biodiversity at the subregional scale. These areas have lower significance for biodiversity than areas assessed as being of State significance.
- **Local significance and/or other values** - areas assessed as not being significant for biodiversity at state or regional scales. Local values are of significance at the local government scale.

For further information on released BPAs and a copy of the underlying methodology, go to:

http://www.qld.gov.au/environment/plants-animals/biodiversity/planning/

The GIS results can be downloaded from the Queensland Spatial Catalogue at:

https://qldspatial.information.qld.gov.au/catalogue/custom/index.page

The following table identifies the extent and proportion of the user specified AOI which is mapped as being of "State", "Regional" or "Local" significance via application of the BAMM.

Table 9: Summary table, biodiversity significance

Biodiversity Status	Area (Ha)	% of AOI
State	1,255.81	99.93

Refer to **Map 2** for further information.

Diagnostic Criteria

Diagnostic criteria are based on existing data which is reliable and uniformly available across a bioregion. These criteria are diagnostic in that they are used to filter the available data and provide a "first-cut" or initial determination of biodiversity significance. This initial assessment is then combined through a second group of other essential criteria.

A description of the individual diagnostic criteria is provided in the following sections.

Criteria A. Habitat for EVNT taxa: Classifies areas according to their significance based on the presence of endangered, vulnerable and/or rare (EVNT) taxa. EVNT taxa are those scheduled under the *Nature Conservation Act 1992* and/or the *Environment Protection and Biodiversity Conservation Act 1999*. It excludes highly mobile fauna taxa which are instead considered in Criterion H and brings together information on EVNT taxa using buffering of recorded sites or habitat suitability models (HSM) where available.

Criteria B. Ecosystem value: Classifies on the basis of biodiversity status of regional ecosystems, their extent in protected areas (presence of poorly conserved regional ecosystems), the presence of significant wetlands; and areas of national importance such as the presence of Threatened Ecological Communities, World Heritage areas and Ramsar

sites. Ecosystem value is applied at a bioregional (**B1**) and regional (**B2**) scale.

Criteria C. Tract size: Measures the relative size of tracts of vegetation in the landscape. The size of any tract is a major indicator of ecological significance, and is also strongly correlated with the long-term viability of biodiversity values. Larger tracts are less susceptible to ecological edge effects and are more likely to sustain viable populations of native flora and fauna than smaller tracts.

Criteria D. Relative size of regional ecosystems: Classifies the relative size of each regional ecosystem unit within its bioregion (**D1**) and its subregion (**D2**). Remnant units are compared with all other occurrences with the same regional ecosystem. Large examples of a regional ecosystem are more significant than smaller examples of the same regional ecosystem because they are more representative of the biodiversity values particular to the regional ecosystem, are more resilient to the effects of disturbance, and constitute a significant proportion of the total area of the regional ecosystem.

Criteria F. Ecosystem diversity: Is an indicator of the number of regional ecosystems occurring within an area. An area with high ecosystem diversity will have many regional ecosystems and ecotones relative to other areas within the bioregion.

Criteria G. Context and connection: Represents the extent to which a remnant unit incorporates, borders or buffers areas such as significant wetlands, endangered ecosystems; and the degree to which it is connected to other vegetation.

A summary of the biodiversity status based upon the diagnostic criteria is provided in the following table.

Table 10: Summary of biodiversity significance based upon diagnostic criteria with respect to the AOI

Biodiversity significance	Description	Area (Ha)	% of AOI
Regional	Remnant contains at least 1 Vulnerable or Near Threatened species (A)	821.66	65.39
State	Remnant contains an RE that is one of the largest of its type in the bioregion (D1) & Remnant has high connectivity or buffers an endangered RE or Sig. Wetland (G)	434.15	34.55

Assessment of diagnostic criteria with respect to the AOI

The following table reflects an assessment of the individual diagnostic criteria noted above in regards to the AOI.

Table 11: Assessment of individual diagnostic criteria with respect to the AOI

Diagnostic Criteria	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
A: Habitat for EVNT Taxa	0.00	0.00	1,255.81	99.93	0.00	0.00	0.00	0.00
B1: Ecosystem Value (Bioregion)	0.00	0.00	0.00	0.00	1,255.81	99.93	0.00	0.00
B2: Ecosystem Value (Subregion)	0.00	0.00	0.00	0.00	1,255.81	99.93	0.00	0.00
C: Tract Size	0.00	0.00	1,255.81	99.93	0.00	0.00	0.00	0.00
D1: Relative RE Size (Bioregion)	434.15	34.55	93.31	7.43	482.29	38.38	246.07	19.58
D2: Relative RE Size (Subregion)	434.15	34.55	93.31	7.43	482.29	38.38	246.07	19.58
F: Ecosystem Diversity	0.00	0.00	1,255.81	99.93	0.00	0.00	0.00	0.00

Diagnostic Criteria	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
G: Context and Connection	1,255.81	99.93	0.00	0.00	0.00	0.00	0.00	0.00

Other Essential Criteria

Other essential criteria (also known as expert panel criteria) are based on non-uniform information sources and which may rely more upon expert opinion than on quantitative data. These criteria are used to provide a "second-cut" determination of biodiversity significance, which is then combined with the diagnostic criteria for an overall assessment of relative biodiversity significance. A summary of the biodiversity status based upon the other essential criteria is provided in the following table.

Table 12: Summary of biodiversity significance based upon other essential criteria with respect to the AOI

Biodiversity significance	Description	Area (Ha)	% of AOI
State	Remnant contains Core Habitat for Priority Taxa (H) & Remnant forms part of a bioregional corridor (J)	188.68	15.01
State	Remnant forms part of a bioregional corridor (J)	1,067.13	84.92

A description of each of the other essential criteria and associated assessment in regards to the AOI is provided in the following sections.

Criteria H. Essential and general habitat for priority taxa: Priority taxa are those which are at risk or of management concern, taxa of scientific interest as relictual (ancient or primitive), endemic taxa or locally significant populations (such as a flying fox camp or heronry), highly specialised taxa whose habitat requirements are complex and distributions are not well correlated with any particular regional ecosystem, taxa important for maintaining genetic diversity (such as complex spatial patterns of genetic variation, geographic range limits, highly disjunct populations), taxa critical for management or monitoring of biodiversity (functionally important or ecological indicators), or economic and culturally important taxa.

Criteria I. Special biodiversity values: areas with special biodiversity values are important because they contain multiple taxa in a unique ecological and often highly biodiverse environment. Areas with special biodiversity values can include the following:

- Ia - centres of endemism - areas where concentrations of taxa are endemic to a bioregion or subregion are found.
- Ib - wildlife refugia (Morton *et al*. 1995), for example, islands, mound springs, caves, wetlands, gorges, mountain ranges and topographic isolates, ecological refuges, refuges from exotic animals, and refuges from clearing. The latter may include large areas that are not suitable for clearing because of land suitability/capability.
- Ic - areas with concentrations of disjunct populations.
- Id - areas with concentrations of taxa at the limits of their geographic ranges.
- Ie - areas with high species richness.
- If - areas with concentrations of relictual populations (ancient and primitive taxa).
- Ig - areas containing REs with distinct variation in species composition associated with geomorphology and other environmental variables.
- Ih - an artificial waterbody or managed/manipulated wetland considered by the panel/s to be of ecological significance.
- Ii - areas with a high density of hollow-bearing trees that provide habitat for animals.
- Ij - breeding or roosting sites used by a significant number of individuals.
- Ik - climate change refuge.

The following table identifies the value and extent area of the Other Essential Criteria H and I within the AOI.

Table 13: Relative importance of expert panel criteria (H and I) used to access overall biodiversity significance with respect to the AOI

Expert Panel	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
H: Core Habitat Priority Taxa	188.68	15.01	0.00	0.00	223.08	17.75	0.00	17.75
Ia: Centres of Endemism	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ib: Wildlife Refugia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ic: Disjunct Populations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Id: Limits of Geographic Ranges	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ie: High Species Richness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
If: Relictual Populations	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ig: Variation in Species Composition	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ih: Artificial Wetland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ii: Hollow Bearing Trees	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ij: Breeding or Roosting Site	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ik: Climate Refugia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

NB. Whilst biodiversity values associated with Criteria I may be present within the site (refer to tables 12 and 15), for the New England Tableland and Central Queensland Coast BPAs, area and % area figures associated with Criteria Ia through to Ij cannot be listed in the table above (due to slight variations in data formats between BPAs).

Criteria J. Corridors: areas identified under this criterion qualify either because they are existing vegetated corridors important for contiguity, or cleared areas that could serve this purpose if revegetated. Some examples of corridors include riparian habitats, transport corridors and "stepping stones".

Bioregional and subregional conservation corridors have been identified in the more developed bioregions of Queensland through the BPAs, using an intensive process involving expert panels. Map 3 displays the location of corridors as identified under the Statewide Corridor network. The Statewide Corridor network incorporates BPA derived corridors and for bioregions where no BPA has been assessed yet, corridors derived under other planning processes. *Note: as a result of updating and developing a statewide network, the alignment of corridors may differ slightly in some instances when compared to those used in individual BPAs.*

The functions of these corridors are:

- **Terrestrial** Bioregional corridors, in conjunction with large tracts of remnant vegetation, maintain ecological and evolutionary processes at a landscape scale, by:

- Maintaining long term evolutionary/genetic processes that allow the natural change in distributions of species and connectivity between populations of species over long periods of time;
- Maintaining landscape/ecosystems processes associated with geological, altitudinal and climatic gradients, to allow for ecological responses to climate change;
- Maintaining large scale seasonal/migratory species processes and movement of fauna;
- Maximising connectivity between large tracts/patches of remnant vegetation;
- Identifying key areas for rehabilitation and offsets; and

- **Riparian** Bioregional Corridors also maintain and encourage connectivity of riparian and associated ecosystems.

The location of the corridors is determined by the following principles:

- Terrestrial

  - Complement riparian landscape corridors (i.e. minimise overlap and maximise connectivity);
  - Follow major watershed/catchment and/or coastal boundaries;
  - Incorporate major altitudinal/geological/climatic gradients;
  - Include and maximise connectivity between large tracts/patches of remnant vegetation;
  - Include and maximise connectivity between remnant vegetation in good condition; and

- Riparian

  - Located on the major river or creek systems within the bioregion in question.

The total extent of remnant vegetation triggered as being of "State", "Regional" or "Local" significance due to the presence of an overlying BPA derived terrestrial or riparian corridor within the AOI, is provided in the following table. For further information on how remnant vegetation is triggered due to the presence of an overlying BPA derived corridor, refer to the relevant landscape BPA expert panel report(s).

Table 14: Extent of triggered remnant vegetation due to the presence of BPA derived corridors with respect to the AOI

Biodiversity Significance	Area (Ha)	% of AOI
State	1,255.81	99.93

NB: area figures associated with the extent of corridor triggered remnant vegetation are only available for those bioregions where a BPA has been undertaken.

Refer to **Map 3** for further information.

Threatening process/condition (Criteria K) - areas identified by experts under this criterion may be used to amend (upgrade or downgrade) biodiversity significance arising from the "first-cut" analysis. The condition of remnant vegetation is affected by threatening processes such as weeds, ferals, grazing and burning regime, selective timber harvesting/removal, salinity, soil erosion, and climate change.

Assessment of Criteria K with respect to the AOI is not currently included in the "Biodiversity and Conservation Values" report, as it has not been applied to the majority of Queensland due to data/information limitations and availability.

Special Area Decisions

Expert panel derived "Special Area Decisions" are used to assign values to Other Essential Criteria. The specific decisions which relate to the AOI in question are listed in the table below.

Table 15: Expert panel decisions for assigning levels of biodiversity significance with respect to the AOI

Decision Number	Description	Panel Recommended Significance	Criteria Values
nwh_l_16	Terrestrial bioregional corridors (landscape connections) Refer to Figures 4, 5 and 6	State	Criteria J (landscape connections): State

Expert panel decision descriptions:

Decision Number	Description
nwh_l_16	The broad purpose of landscape-scale connections is to provide for ecological and evolutionary processes at a bioregional scale. Maintaining connectivity across a landscape, either through "continuous linkages" or via “stepping-stones” of remnant vegetation, is important for the long-term conservation of biodiversity. For further information regarding the broad principles and intent, as well as more specific information relating to the Northwest Highlands terrestrial corridor network, refer to Section 3.3.2.1Terrestrial corridors and Table 14.

Aquatic Conservation Assessments

Introduction

The Aquatic Biodiversity Assessment and Mapping Method or AquaBAMM (Clayton *et al.* 2006), was developed to assess conservation values of wetlands in queensland, and may also have application in broader geographical contexts. It is a comprehensive method that uses available data, including data resulting from expert opinion, to identify relative wetland conservation/ecological values within a specified study area (usually a catchment). The product of applying this method is an Aquatic Conservation Assessment (ACA) for the study area.

An ACA using AquaBAMM is non-social, non-economic and identifies the conservation/ecological values of wetlands at a user-defined scale. It provides a robust and objective conservation assessment using criteria, indicators and measures that are founded upon a large body of national and international literature. The criteria, each of which may have variable numbers of indicators and measures, are naturalness (aquatic), naturalness (catchment), diversity and richness, threatened species and ecosystems, priority species and ecosystems, special features, connectivity and representativeness. An ACA using AquaBAMM is a powerful decision support tool that is easily updated and simply interrogated through a geographic information system (GIS).

Where they have been conducted, ACAs can provide a source of baseline wetland conservation/ecological information to support natural resource management and planning processes. They are useful as an independent product or as an important foundation upon which a variety of additional environmental and socio-economic elements can be added and considered (i.e. an early input to broader 'triple-bottom-line' decision-making processes). An ACA can have application in:

- determining priorities for protection, regulation or rehabilitation of wetlands and other aquatic ecosystems
- on-ground investment in wetlands and other aquatic ecosystems
- contributing to impact assessment of large-scale development (e.g. dams)
- water resource and strategic regional planning prcesses

For a detailed explanation of the methodology please refer to the summary and expert panel reports relevant to the ACA utilised in this assessment. These reports can be accessed at Wetland *Info*:

http://wetlandinfo.des.qld.gov.au/wetlands/assessment/assessment-methods/aca

The GIS results can be downloaded from the Queensland Spatial Catalogue at:

https://qldspatial.information.qld.gov.au/catalogue/custom/index.page

Explanation of Criteria

Under the AquaBAMM, eight criteria are assessed to derive an overall conservation value. Similar to the Biodiversity Assessment and Mapping Methodology, the criteria may be primarily diagnostic (quantitative) or primarily expert opinion (qualitative) in nature. The following sections provide a brief description of each of the 8 criteria.

Criteria 1. Naturalness - Aquatic: This attribute reflects the extent to which a wetland's (riverine, non-riverine, estuarine) aquatic state of naturalness is affected through relevant influencing indicators which include: presence of exotic flora and fauna; presence of aquatic communities; degree of habitat modification and degree of hydrological modification.

Criteria 2. Naturalness - Catchment: The naturalness of the terrestrial systems of a catchment can have an influence on many wetland characteristics including: natural ecological processes e.g. nutrient cycling, riparian vegetation, water chemistry, and flow. The indicators utilised to assess this criterion include: presence of exotic flora and/or fauna; riparian, catchment and flow modification.

Criteria 3. Naturalness - Diversity and Richness: This criterion is common to many ecological assessment methods and can include both physical and biological features. It includes such indicators as species richness, riparian ecosystem richness and geomorphological diversity.

Criteria 4. Threatened Species and Ecosystems: This criterion evaluates ecological rarity characteristics of a wetland. This includes both species rarity and rarity of communities / assemblages. The communities and assemblages are best represented by regional ecosystems. Species rarity is determined by NCA and EPBC status with Endangered, Vulnerable or Near-threatened species being included in the evaluation. Ecosystem rarity is determined by regional ecosystem biodiversity status i.e. Endangered, Of Concern, or Not of Concern.

Criteria 5. Priority Species and Ecosystems: Priority flora and fauna species lists are expert panel derived. These are aquatic, semi-aquatic and riparian species which exhibit at least 1 particular trait in order to be eligible for consideration. For flora species the traits included:

- It forms significant macrophyte beds (in shallow or deep water).
- It is an important food source.
- It is important/critical habitat.
- It is implicated in spawning or reproduction for other fauna and/or flora species.
- It is at its distributional limit or is a disjunct population.
- It provides stream bank or bed stabilisation or has soil binding properties.
- It is a small population and subject to threatening processes.

Fauna species are included if they meet at least one of the following traits:

- It is endemic to the study area (>75 per cent of its distribution is in the study area/catchment).
- It has experienced, or is suspected of experiencing, a serious population decline.
- It has experienced a significant reduction in its distribution and has a naturally restricted distribution in the study area/catchment.
- It is currently a small population and threatened by loss of habitat.
- It is a significant disjunct population.
- It is a migratory species (other than birds).
- A significant proportion of the breeding population (>one per cent for waterbirds, >75 per cent other species) occurs in the waterbody (see Ramsar criterion 6 for waterbirds).
- Limit of species range.

See the individual expert panel reports for the priority species traits specific to an ACA.

Criteria 6. Special Features: Special features are areas identified by flora, fauna and ecology expert panels which exhibit characteristics beyond those identified in other criteria and which the expert panels consider to be of the highest ecological importance. Special feature traits can relate to, but are not solely restricted to geomorphic features, unique ecological processes, presence of unique or distinct habitat, presence of unique or special hydrological regimes e.g. spring-fed streams. Special features are rated on a 1 - 4 scale (4 being the highest).

Criteria 7. Connectivity: This criterion is based on the concept that appropriately connected aquatic ecosystems are healthy and resilient, with maximum potential biodiversity and delivery of ecosystem services.

Criteria 8. Representativeness: This criterion applies primarily to non-riverine assessments, evaluates the rarity and uniqueness of a wetland type in relation to specific geographic areas. Rarity is determined by the degree of wetland protection within "protected Areas" estate or within an area subject to the *Fisheries Act 1994*, *Coastal Protection and Management Act 1995*, or *Marine Parks Act 2004*. Wetland uniqueness evaluates the relative abundance and size of a wetland or wetland management group within geographic areas such as catchment and subcatchment.

Riverine Wetlands

Riverine wetlands are all wetlands and deepwater habitats within a channel. The channels are naturally or artificially created, periodically or continuously contain moving water, or connecting two bodies of standing water. AquaBAMM, when applied to riverine wetlands uses a discrete spatial unit termed subsections. A subsection can be considered as an area which encompasses discrete homogeneous stream sections in terms of their natural attributes (i.e. physical, chemical, biological and utilitarian values) and natural resources. Thus in an ACA, an aquatic conservation significance score is calculated for each subsection and applies to all streams within a subsection, rather than individual streams as such.

Please note, the area figures provided in Tables 16 and 17, are derived using the extent of riverine subsections within the AOI. Refer to **Map 5** for further information. A summary of the conservation significance of riverine wetlands within the AOI is provided in the following table.

Table 16: Overall level/s of riverine aquatic conservation significance

Aquatic conservation significance (riverine wetlands)	Area (Ha)	% of AOI
Medium	1,255.81	99.93

The individual aquatic conservation criteria ratings for riverine wetlands within the AOI are listed below.

Table 17: Level/s of riverine aquatic conservation significance based on selected criteria

Criteria	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
1. Naturalness aquatic	0.00	0.00	1,255.81	99.93	0.00	0.00	0.00	0.00
2. Naturalness catchment	0.00	0.00	1,255.81	99.93	0.00	0.00	0.00	0.00
3. Diversity and richness	0.00	0.00	0.00	0.00	1,255.81	99.93	0.00	0.00
4. Threatened species and ecosystems	1,255.81	99.93	0.00	0.00	0.00	0.00	0.00	0.00
5. Priority species and ecosystems	0.00	0.00	1,231.41	97.99	0.00	0.00	0.00	0.00
6. Special features	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7. Connectivity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8. Representativeness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The table below lists and describes the relevant expert panel decisions used to assign conservation significance values to riverine wetlands within the AOI.

Table 18: Expert panel decisions for assigning overall levels of riverine aquatic conservation significance

Decision number	Special feature	Catchment	Criteria/Indicator/Measure	Conservation rating (1-4)
(No Records)				

4 is the highest rating/value

Expert panel decision descriptions:

Decision Number	Description
(No Records)	

Non-riverine Wetlands

Non-riverine wetlands include both lacustrine and palustrine wetlands, however, do not currently incorporate estuarine, marine or subterranean wetland types. A summary of the conservation significance of non-riverine wetlands within the AOI is provided in the following table. Refer to **Map 6** for further information.

Table 19: Overall level/s of non-riverine aquatic conservation significance

(No Records)

The following table provides an assessment of non-riverine wetlands within the AOI and associated aquatic conservation criteria values.

Table 20: Level/s of non-riverine aquatic conservation significance based on selected criteria

Criteria	Very High Rating - Area (Ha)	Very High Rating - % of AOI	High Rating - Area (Ha)	High Rating - % of AOI	Medium Rating - Area (Ha)	Medium Rating - % of AOI	Low Rating - Area (Ha)	Low Rating - % of AOI
1. Naturalness aquatic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Naturalness catchment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Diversity and richness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Threatened species and ecosystems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5. Priority species and ecosystems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6. Special features	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7. Connectivity	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8. Representativeness	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The table below lists and describes the relevant expert panel decisions used to assign conservation significance values to non-riverine wetlands within the AOI.

Table 21: Expert panel decisions for assigning overall levels of non-riverine aquatic conservation significance.

Decision number	Special feature	Catchment	Criteria/Indicator/ Measure	Conservation rating (1-4)
(No Records)				

4 is the highest rating/value

Expert panel decision descriptions:

Decision Number	Description
(No Records)	

Threatened and Priority Species

Introduction

This chapter contains a list of threatened and priority flora and/or fauna species that have been recorded on, or within 4km of the Assessment Area.

The information presented in this chapter with respect to species presence is derived from compiled databases developed primarily for the purpose of BPAs and ACAs. Data is collated from a number of sources and is updated periodically.

It is important to note that the list of species provided in this report, may differ when compared to other reports generated from other sources such as the State government's WildNet, Herbrecs or the federal government's EPBC database for a number of reasons.

Records for threatened and priority species are filtered and checked based on a number of rules including:

- Taxonomic nomenclature - current scientific names and status,
- Location - cross-check co-ordinates with location description,
- Taxon by location - requires good knowledge of the taxon and history of the record,
- Duplicate records - identify and remove,
- Expert panels - check records and provide new records,
- Flora cultivated records excluded,
- Use precise records less than or equal to 2000m,
- Use recent records greater than or equal to 1975 animals, greater than or equal to 1950 plants.

Threatened Species

Threatened species are those species classified as "Endangered" or "Vulnerable" under the *Environment Protection and Biodiversity Conservation Act 1999* or "Endangered", "Vulnerable" or "Near threatened" under the *Nature Conservation Act 1992*.

The following threatened species have been recorded on, or within approximately 4km of the AOI.

Table 22: Threatened species recorded on, or within 4km of the AOI

Species	Common name	NCA status	EPBC status	Back on Track rank	Migratory species*	Wetland species**	Identified flora/fauna
Petrogale purpureicollis	purple-necked rock-wallaby	V		Low			FA
Varanus mertensi	Mertens' water monitor	E				I	FA

NB. Please note that the threatened species listed in this section are based upon the most recently compiled DESI internal state-wide threatened species dataset. This dataset may contain additional records that were not originally available for inclusion in the relevant individual BPAs and ACAs.

**JAMBA - Japan-Australia Migratory Bird Agreement; CAMBA - China-Australia Migratory Bird Agreement; ROKAMBA - Republic of Korea-Australia Migratory Bird Agreement; CMS - Convention on the Conservation of Migratory Species.*

***I - wetland indicator species; D - wetland dependent species.*

BPA Priority Species

A list of BPA priority species that have been recorded on, or within approximately 4km of the AOI is contained in the following table.

Table 23: Priority species recorded on, or within 4km of the AOI

Species	Common name	Identified flora/fauna
Brachychiton collinus		FL
Ctenotus striaticeps	stripe-headed finesnout ctenotus	FA
Egernia hosmeri	Hosmer's skink	FA
Eucalyptus leucophylla		FL
Gehyra robusta	robust dtella	FA
Litoria coplandi	sandstone frog	FA
Litoria watjulumensis	giant rocketfrog	FA
Planigale ingrami	long-tailed planigale	FA
Varanus mertensi	Mertens' water monitor	FA

NB. Please note that the list of priority species is based on those species identified in the BPAs, however records for these species may be more recent than the originals used. furthermore, the BPA priority species databases are updated from time to time. At each update, the taxonomic details for all species are amended as necessary to reflect current taxonomic name and/or status changes.

ACA Priority Species

A list of ACA priority species used in riverine and non-riverine ACAs that have been recorded on, or within approximately 4km of the AOI are contained in the following tables.

Table 24: Priority species recorded on, or within 4 km of the AOI - riverine

Species	Common name	Identified flora/fauna
Melaleuca bracteata		FL
Varanus mertensi	Mertens' water monitor	FA

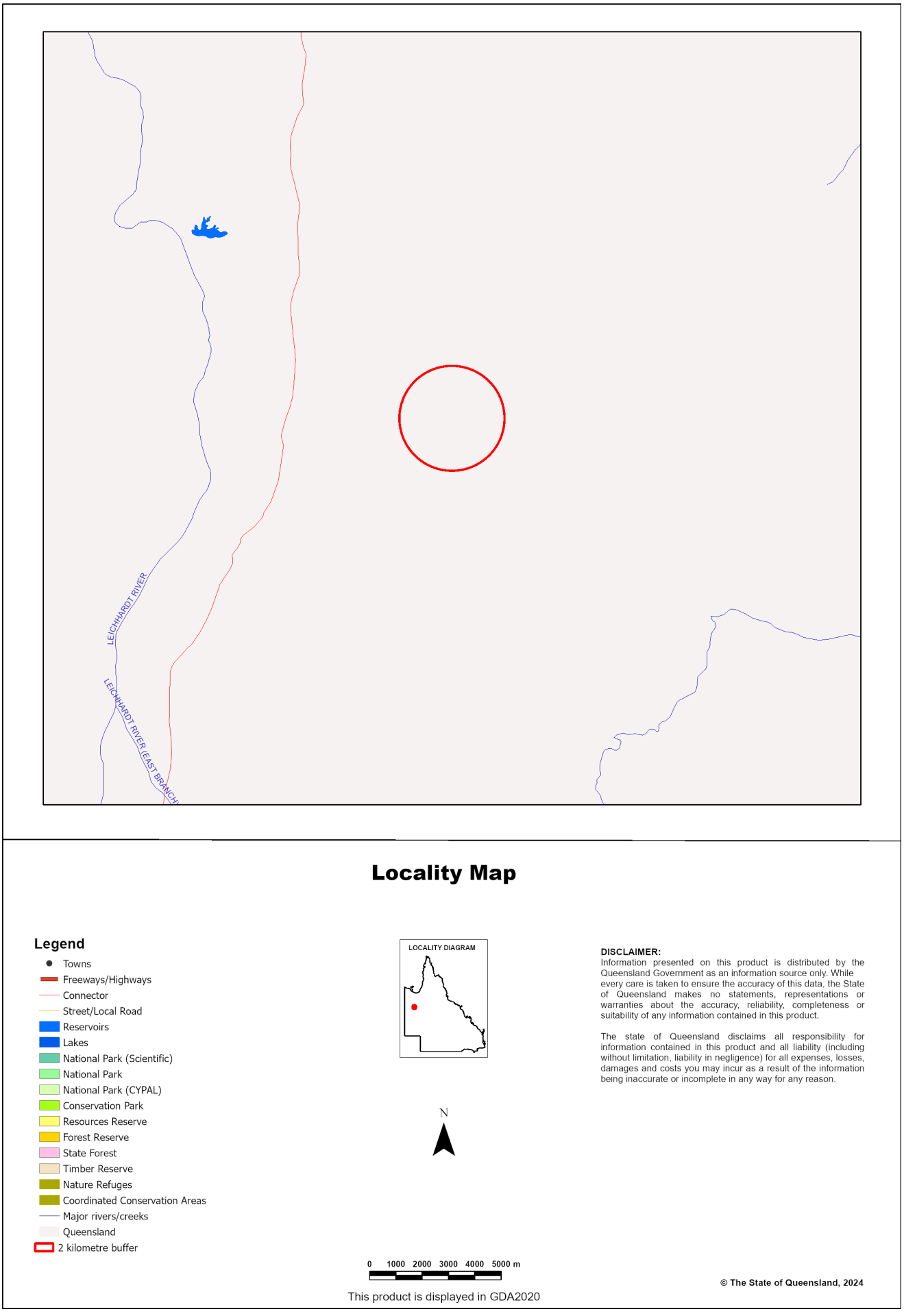
Table 25: Priority species recorded on, or within 4 km of the AOI - non-riverine

Species	Common name	Identified flora/fauna
Melaleuca bracteata		FL
Varanus mertensi	Mertens' water monitor	FA

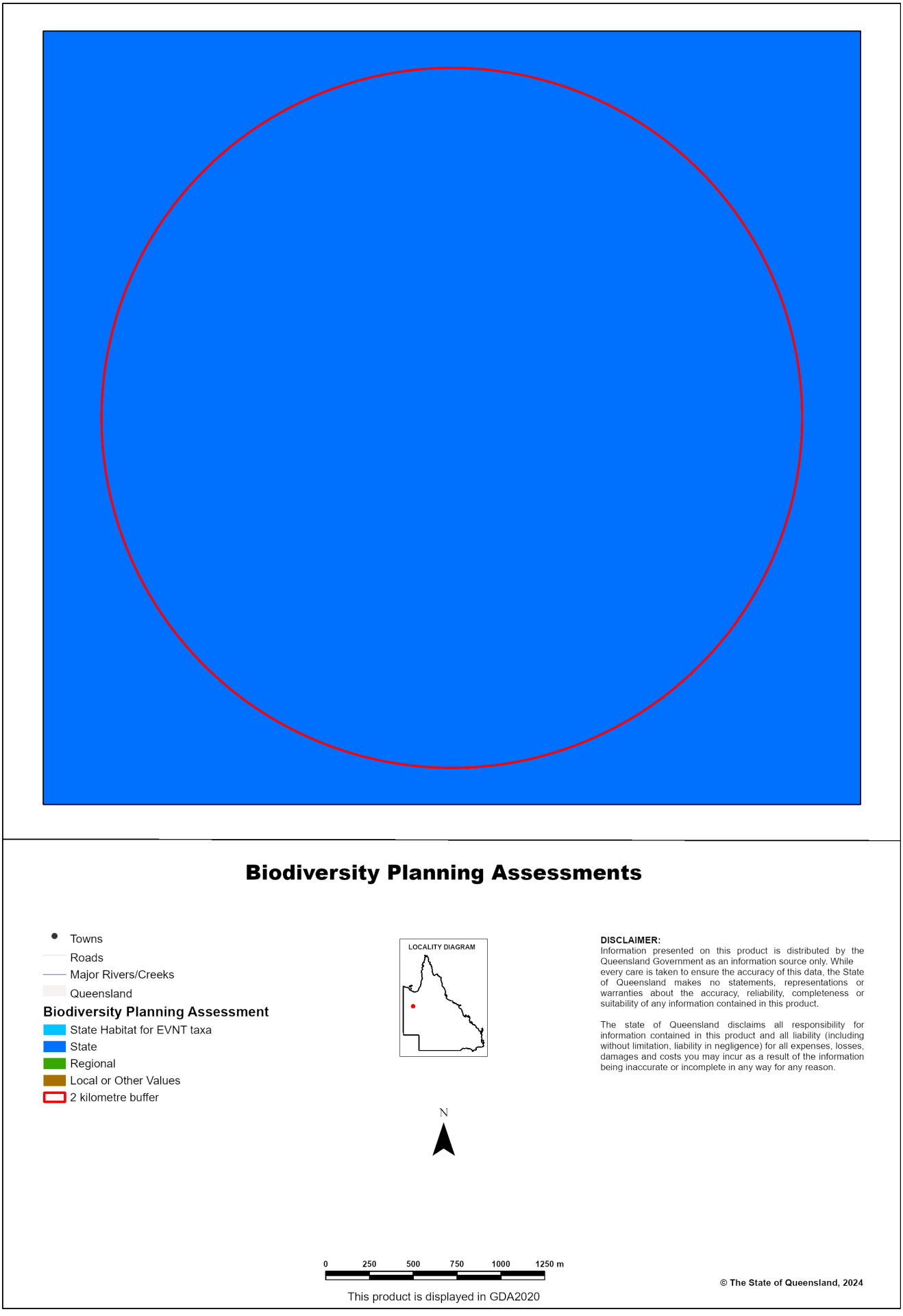
NB. Please note that the priority species records used in the above two tables are comprised of those adopted for the released individual ACAs. The ACA riverine and non-riverine priority species databases are updated from time to time to reflect new release of ACAs. At each update, the taxonomic details for all ACAs records are amended as necessary to reflect current taxonomic name and/or status changes.

Maps

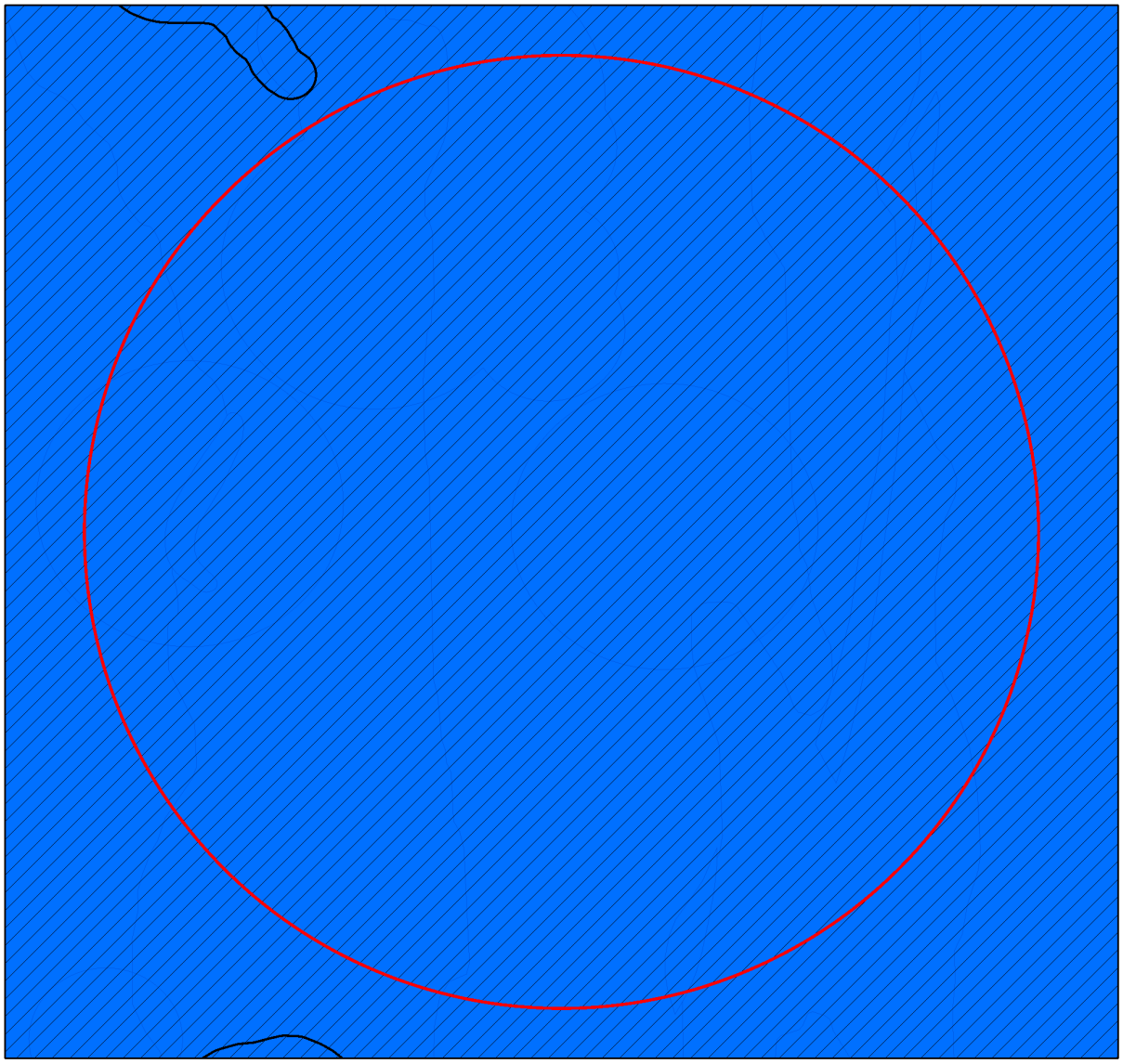
Map 1 - Locality Map



Map 2 - Biodiversity Planning Assessment (BPA)



Map 3 - Corridors



Corridors

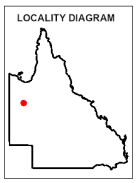
- Towns
- Roads
- Queensland
- Major Rivers/Creeks

Corridors
- State
- Regional

Corridor Triggered Vegetation
- State
- Regional
- Local

Core Area Vegetation
- Brigalow Belt Only
- 2 kilometre buffer

LOCALITY DIAGRAM



N

0 250 500 750 1000 1250 m

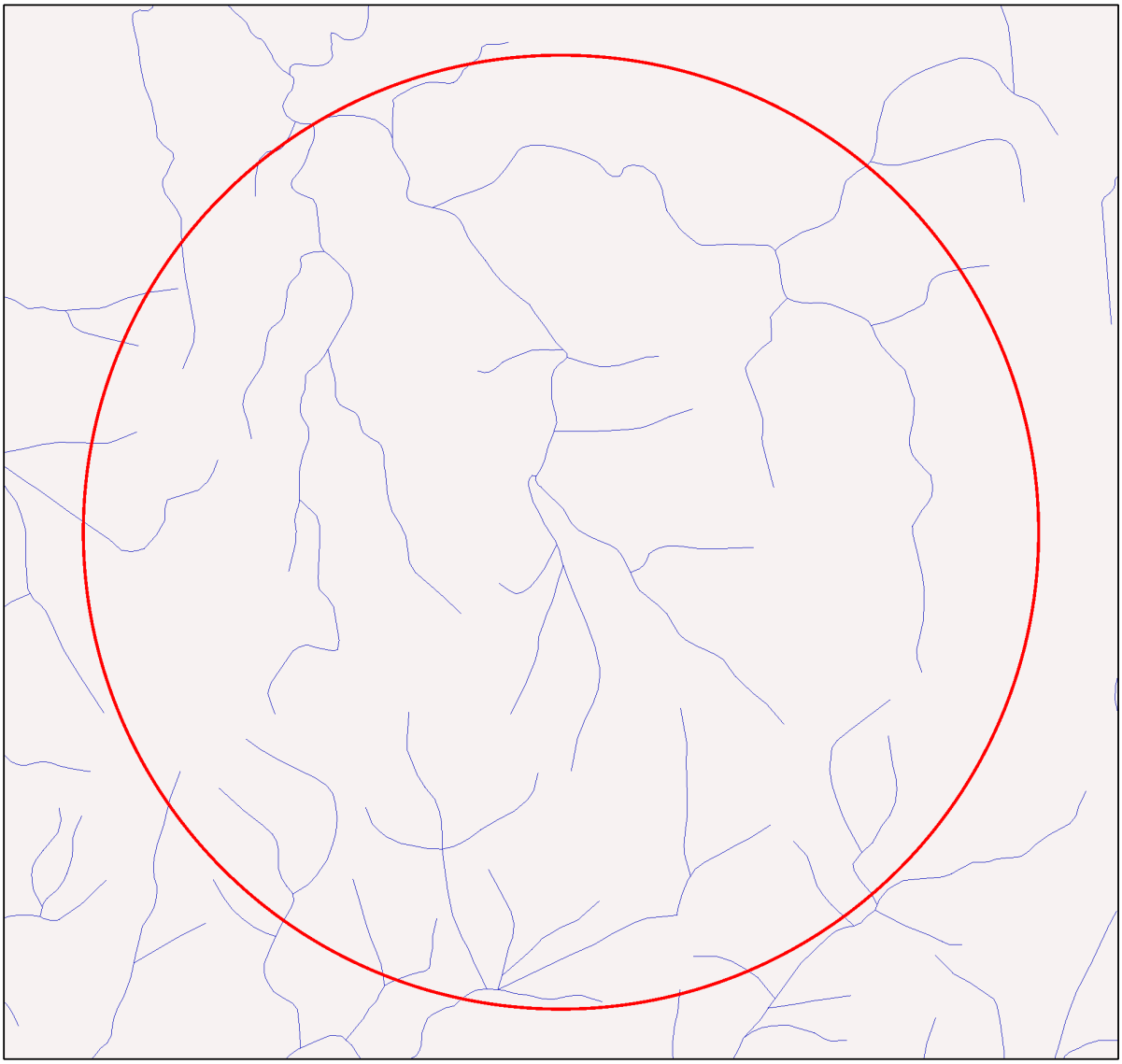
This product is displayed in GDA2020

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2024

Map 4 - Wetlands and waterways



Wetlands and Waterways

- Towns
- Roads
- Springs
- Rivers/Creeks
- Directory of Important Wetlands
- Ramsar Sites - QLD

Wetland Type

Hydrologically natural Wetlands

- Lacustrine Wetlands (hydrologically natural)
- Palustrine Wetlands (hydrologically natural)
- Riverine Wetlands (hydrologically natural)
- Intertidal Wetlands (hydrologically natural)
- Subtidal Wetlands (hydrologically natural)
- Intertidal/Subtidal Wetlands (hydrologically natural)

Hydrologically Modified and Artificial Wetlands

- Lacustrine Wetlands (hydrologically modified or artificial)
- Palustrine Wetlands (hydrologically modified or artificial)
- Riverine Wetlands (hydrologically modified or artificial)
- Intertidal Wetlands (hydrologically modified or artificial)
- Subtidal Wetlands (hydrologically modified or artificial)
- Intertidal/Subtidal Wetlands (hydrologically modified or artificial)

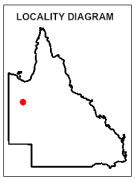
Subdominant Wetlands

- Subdominant Wetlands (51 - 80%)

Contains Wetlands

- Contains Wetlands (1 - 50%)
- Queensland
- 2 kilometre buffer

LOCALITY DIAGRAM



N

0 250 500 750 1000 1250 m

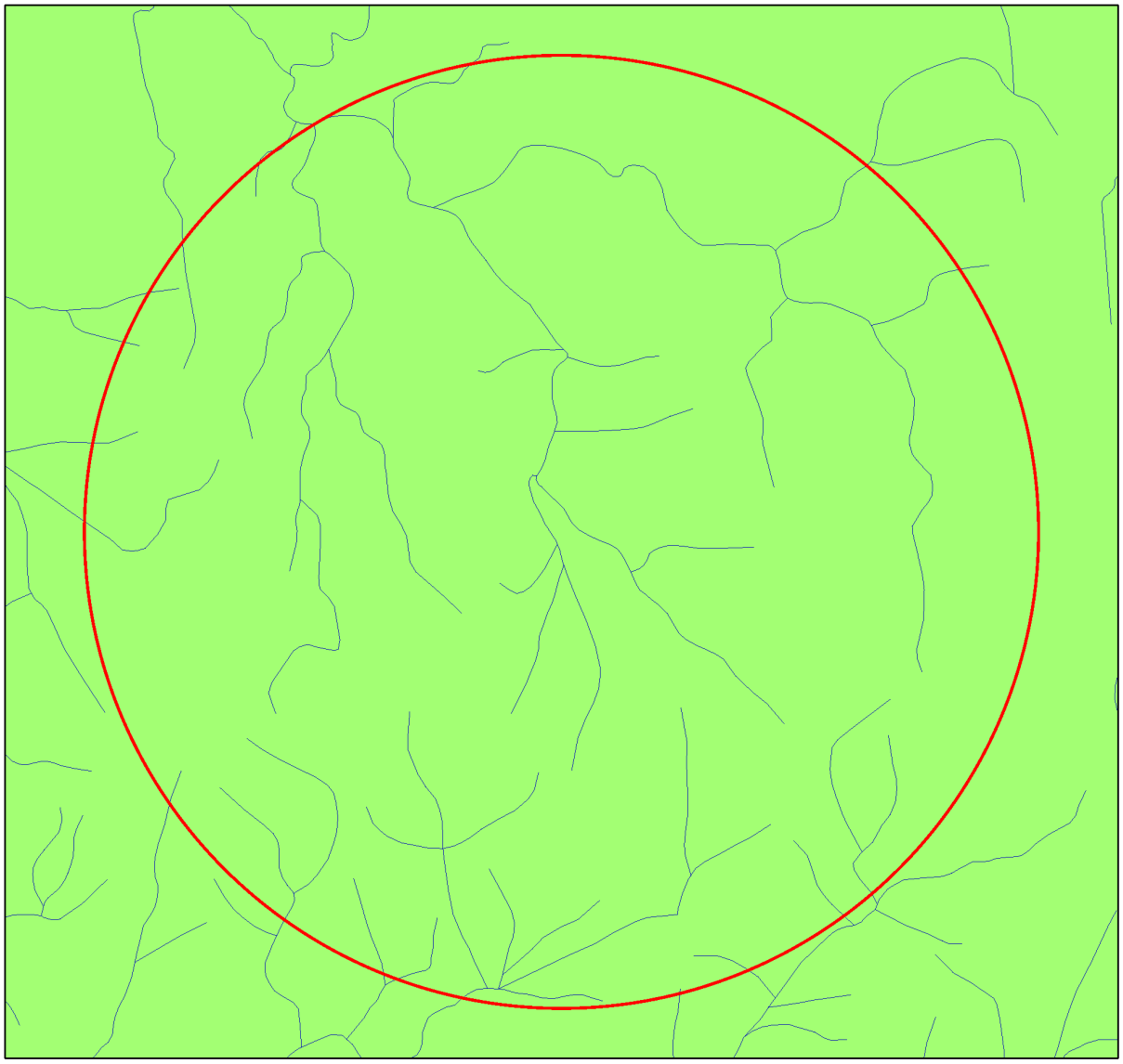
This product is displayed in GDA2020

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2024

Map 5 - Aquatic Conservation Assessment (ACA) - riverine



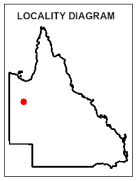
Aquatic Conservation Assessment (ACA) - riverine

- Towns
- Roads
- Rivers/Creeks
- Queensland

ACA Riverine - Subcatchment Significance

- Very High
- High
- Medium
- Low
- Very Low
- 2 kilometre buffer

LOCALITY DIAGRAM



N

0 250 500 750 1000 1250 m

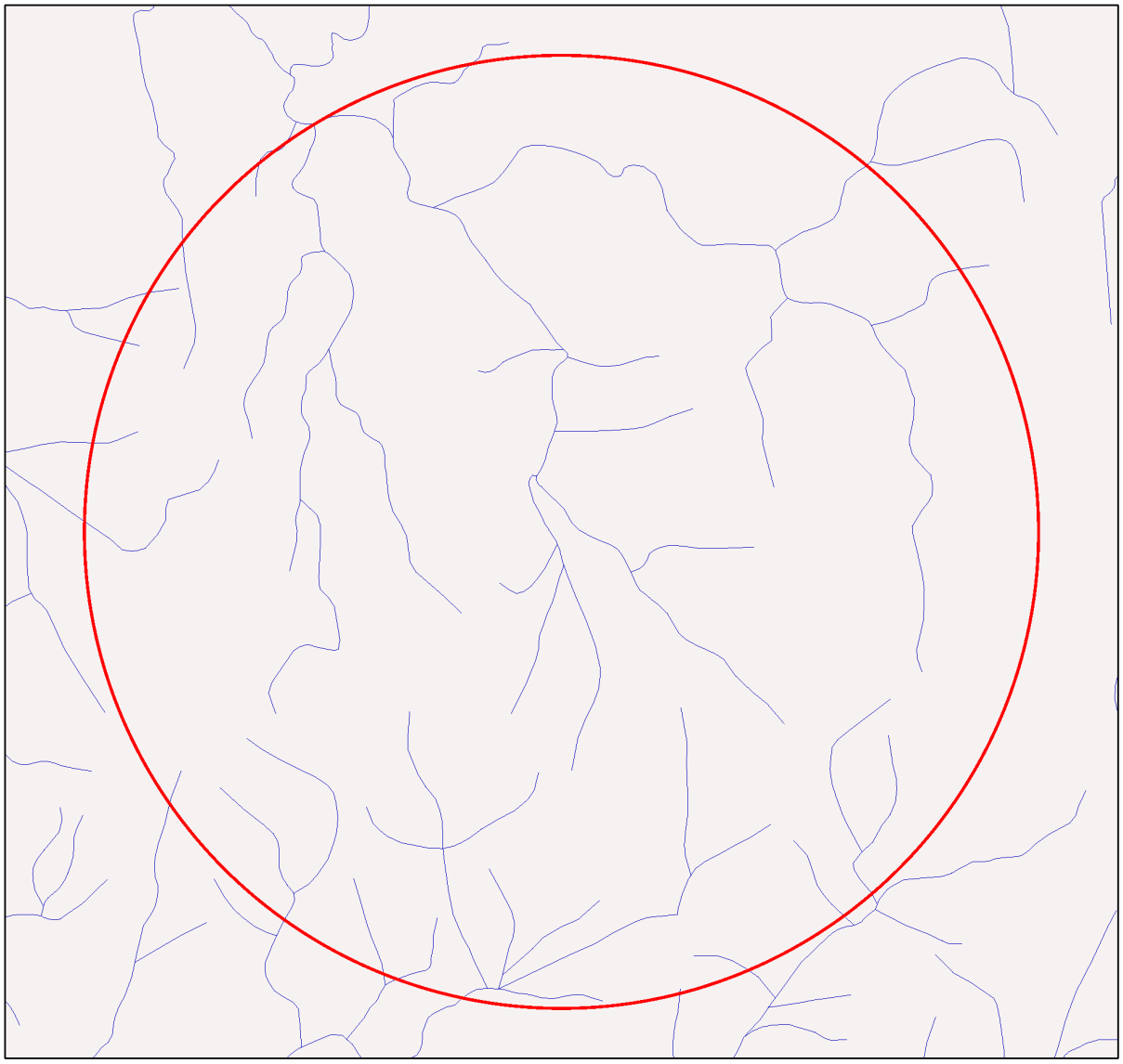
This product is displayed in GDA2020

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2024

Map 6 - Aquatic Conservation Assessment (ACA) - non-riverine



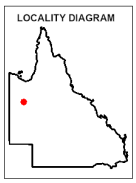
Aquatic Conservation Assessment (ACA) - nonriverine

- Towns
- Roads
- Rivers/Creeks
- Queensland

ACA Non-riverine

- Very High
- High
- Medium
- Low
- Very Low
- 2 kilometre buffer

LOCALITY DIAGRAM



N

0 250 500 750 1000 1250 m

This product is displayed in GDA2020

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2024

References

Clayton, P.D., Fielder, D.F., Howell, S. and Hill, C.J. (2006) *Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool for wetlands with trial application in the Burnett River catchment.* Published by the Environmental Protection Agency, Brisbane. ISBN 1-90928-07-3. Available at

http://wetlandinfo.des.qld.gov.au/wetlands/assessment/assessment-methods/aca/

Environment and Heritage Protection 2014*, Biodiversity Assessment and Mapping Methodology.* Version 2.2. Department of Environment and Heritage Protection, Brisbane.

Morton, S. R., Short, J. and Barker, R. D. with an Appendix by G.F. Griffin and G. Pearce (1995). *Refugia for Biological Diversity in Arid and Semi-arid Australia. Biodiversity Series*, Paper No. 4, Biodiversity Unit, Environment Australia.

Sattler, P.S. and Williams, R.D. (eds) (1999). *The Conservation Status of Queensland's Bioregional Ecosystems*. Environmental Protection Agency, Brisbane.

Appendices

Appendix 1 - Source Data

Theme	Datasets
Aquatic Conservation Assessments Non-riverine*	Combination of the following datasets: Cape York Peninsula Non-riverine v1.1 Eastern Gulf of Carpentaria v1.1 Great Barrier Reef Catchment Non-riverine v1.3 Lake Eyre and Bulloo Basins v1.1 QMDBB Non-riverine ACA v2.1 Southeast Queensland ACA v1.1 WBB Non-riverine ACA v1.1 Southern Gulf Catchments Non-riverine ACA v1.1
Aquatic Conservation Assessments Riverine*	Combination of the following datasets: Cape York Peninsula Riverine v1.1 Eastern Gulf of Carpentaria v1.1 Great Barrier Reef Catchment Riverine v1.1 Lake Eyre and Bulloo Basins v1.1 QMDBB Riverine ACA v2.1 Southeast Queensland ACA v1.1 WBB Riverine ACA v1.1 Southern Gulf Catchments Riverine ACA v1.1
Biodiversity Planning Assessments*	Combination of the following datasets: Brigalow Belt BPA v2.1 Cape York Peninsula BPA v1.1 Central Queensland Coast BPA v1.3 Channel Country BPA v1.1 Desert Uplands BPA v1.3 Einasleigh Uplands BPA v1.1 Gulf Plains BPA v1.1 Mitchell Grass Downs BPA v1.1 Mulga Lands BPA v1.4 New England Tableland v2.3 Northwest Highlands v1.1 Southeast Queensland v4.1 Wet Tropics v1.1
Statewide BPA Corridors*	Statewide corridors v1.6
Threatened Species	An internal DESI database compiled from Wildnet, Herbrecs, Corveg, the QLD Museum, as well as other incidental sources.
BPA Priority Species	An internal DESI database compiled from Wildnet, Herbrecs, Corveg, the QLD Museum, as well as other incidental sources.
ACA Priority Species	An internal DESI database compiled from Wildnet, Herbrecs, Corveg, the QLD Museum, as well as other incidental sources.

These datasets are available at:
http://dds.information.qld.gov.au/DDS

Appendix 2 - Acronyms and Abbreviations

AOI	- Area of Interest
ACA	- Aquatic Conservation Assessment
AQUABAMM	- Aquatic Biodiversity Assessment and Mapping Methodology
BAMM	- Biodiversity Assessment and Mapping Methodology
BoT	- Back on Track
BPA	- Biodiversity Planning Assessment
CAMBA	- China-Australia Migratory Bird Agreement
DESI	- Department of Environment, Science and Innovation
EPBC	- *Environment Protection and Biodiversity Conservation Act 1999*
EVNT	- Endangered, Vulnerable, Near Threatened
GDA2020	- Geocentric Datum of Australia 2020
GIS	- Geographic Information System
JAMBA	- Japan-Australia Migratory Bird Agreement
NCA	- *Nature Conservation Act 1992*
RE	- Regional Ecosystem
REDD	- Regional Ecosystem Description Database
ROKAMBA	- Republic of Korea-Australia Migratory Bird Agreement

APPENDIX E – ENVIRONMENTAL REPORTS – REGIONAL ECOSYSTEMS – BIODIVERSITY STATUS

Queensland Government

Department of Environment, Science and Innovation

Environmental Reports

Regional Ecosystems

Biodiversity Status

For the selected area of interest
Longitude: 139.849851 Latitude: -20.424877 with 2 kilometre buffer

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or area of interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "central coordinates" option, the resulting assessment area encompasses an area extending for a 2km radius from the input coordinates.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 2020). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no values have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Important Note to User

Information presented in this report is based upon the Queensland Herbarium & Biodiversity Science's Regional Ecosystem framework. The Biodiversity Status has been used to depict the extent of "Endangered", "Of Concern" and "No Concern at Present" regional ecosystems in all cases, rather than the classes used for the purposes of the *Vegetation Management Act 1999* (VMA). Mapping and figures presented in this document reflect the Queensland Herbarium & Biodiversity Science's Remnant and Pre-clearing Regional Ecosystem Datasets, and not the certified mapping used for the purpose of the VMA.

For matters relevant to vegetation management under the VMA, please refer to the Department of Resources website https://www.resources.qld.gov.au/

Please direct queries about these reports to: Queensland.Herbarium@qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.

CC BY

Table of Contents

Summary Information 4
Regional Ecosystems 5
1. Introduction 5
2. Remnant Regional Ecosystems 6
3. Remnant Regional Ecosystems by Broad Vegetation Group 7
4. Technical and BioCondition Benchmark Descriptions 8
Maps 10
Map 1 - Location 10
Map 2 - Remnant 2021 regional ecosystems 11
Map 3 - Pre-clearing regional ecosystems 12
Map 4 - Remnant 2021 regional ecosystems by BVG (5M) 13
Map 5 - Pre-clearing regional ecosystems by BVG (5M) 14
Map 6 - Wetlands and waterways 15
Links and Other Information Sources 16
References 16
Appendices 17
Appendix 1 - Source Data 17
Appendix 2 - Acronyms and Abbreviations 18

Summary Information

The following table provides an overview of the AOI with respect to selected topographic and environmental themes. Refer to **Map 1** for locality information.

Table 1: Details for area of interest:
Longitude: 139.849851 Latitude: -20.424877 with 2 kilometre buffer, with area 1256.64 ha

Local Government(s)	Catchment(s)	Bioregion(s)	Subregion(s)
Mount Isa City	Leichhardt	Northwest Highlands	Mount Isa Inlier

The table below summarizes the extent of remnant vegetation classed as "Endangered", "Of concern" and "No concern at present" regional ecosystems classified by Biodiversity Status within the area of interest (AOI).

Table 2: Summary table, biodiversity status of regional ecosystems within the AOI

Biodiversity Status	Area (Ha)	% of AOI
Endangered	0.00	0.00
Of concern	0.00	0.00
No concern at present	1,193.56	94.98
Total remnant vegetation	1,193.56	94.98

Refer to **Map 2** for further information.

Regional Ecosystems

1. Introduction

Regional ecosystems are vegetation communities in a bioregion that are consistently associated with particular combinations of geology, landform and soil (Sattler and Williams 1999). Descriptions of Queensland's Regional ecosystems are available online from the Regional Ecosystem Description Database (REDD). Descriptions are compiled from a broad range of information sources including vegetation, land system and geology survey and mapping and detailed vegetation site data. The regional ecosystem classification and descriptions are reviewed as new information becomes available. A number of vegetation communities may form a single regional ecosystem and may be distinguished by differences in structure or sub-dominant species in the ecologically dominant layer. Vegetation communities with different dominant species in the ecologically dominant layer may be amalgamated in to a regional ecosystem if they are not mappable and predictable in the landscape at 1:100 000 scale. Vegetation communities may be mappable at a scale larger than 1:100 000. Vegetation communities within a regional ecosystem are denoted by a letter following the regional ecosystem code (e.g. a, b, c). Vegetation communities and regional ecosystems are amalgamated into a higher level classification of broad vegetation groups (BVGs).

A published methodology for survey and mapping of regional ecosystems across Queensland (Neldner et al 2023) provides further details on regional ecosystem concepts and terminology.

This report provides information on the type, status, and extent of vegetation communities, regional ecosystems and broad vegetation groups present within a user specified area of interest. Please note, for the purpose of this report, the Biodiversity Status is used. This report has not been developed for application of the *Vegetation Management Act 1999* (VMA). Additionally, information generated in this report has been derived from the Queensland Herbarium & Biodiversity Science's Regional Ecosystem Mapping, and not the regulated mapping certified for the purposes of the VMA. If your interest/matter relates to regional ecosystems and the VMA, users should refer to the Department of Resources website https://www.resources.qld.gov.au/.

With respect to the Queensland Biodiversity Status,

"Endangered" regional ecosystems are described as those where:

- remnant vegetation is less than 10 per cent of its pre-clearing extent across the bioregion; or 10-30% of its pre-clearing extent remains and the remnant vegetation is less than 10,000 hectares, or
- less than 10 per cent of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss*, or
- 10-30 percent of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss and the remnant vegetation is less than 10,000 hectares; or
- it is a rare** regional ecosystem subject to a threatening process.***

"Of concern" regional ecosystems are described as those where:

- the degradation criteria listed above for 'Endangered' regional ecosystems are not met and,
- remnant vegetation is 10-30 per cent of its pre-clearing extent across the bioregion; or more than 20 per cent of its pre-clearing extent remains and the remnant extent is less than 10,000 hectares, or
- 10-30 percent of its pre-clearing extent remains unaffected by moderate degradation and/or biodiversity loss.****

and "No concern at present" regional ecosystems are described as those where:

- remnant vegetation is over 30 percent of its pre-clearing extent across the bioregion, and the remnant area is greater than 10,000 hectares, and
- the degradation criteria listed above for 'Endangered' or 'Of concern' regional ecosystems are not met.

**Severe degradation and/or biodiversity loss is defined as: floristic and/or faunal diversity is greatly reduced but unlikely to recover within the next 50 years even with the removal of threatening processes; or soil surface is severely degraded, for example, by loss of A horizon, surface expression of salinity; surface compaction, loss of organic matter or sheet erosion.*

***Rare regional ecosystem: pre-clearing extent (<1000 ha); or patch size (<100 ha and of limited total extent across its range).*

****Threatening processes are those that are reducing or will reduce the biodiversity and ecological integrity of a regional ecosystem. For example, clearing, weed invasion, fragmentation, inappropriate fire regime or grazing pressure, or infrastructure development.*

*****Moderate degradation and/or biodiversity loss is defined as: floristic and/or faunal diversity is greatly reduced but unlikely to recover within the next 20 years even with the removal of threatening processes; or soil surface is moderately degraded.*

2. Remnant Regional Ecosystems

The following table identifies the remnant regional ecosystems and vegetation communities mapped within the AOI and provides their short descriptions, Biodiversity Status, and remnant extent within the selected AOI. Please note, where heterogeneous vegetated patches (mixed patches of remnant vegetation mapped as containing multiple regional ecosystems) occur within the AOI, they have been split and listed as individual regional ecosystems (or vegetation communities where present) for the purposes of the table below. In such instances, associated area figures have been generated based upon the estimated proportion of each regional ecosystem (or vegetation community) predicted to be present within the larger mixed patch.

Table 3: Remnant regional ecosystems, description and status within the AOI

Regional Ecosystem	Short Description	BD Status	Area (Ha)	% of AOI
1.11.2a	Eucalyptus leucophloia low open woodland	No concern at present	621.74	49.48
1.11.3a	Corymbia terminalis and/or Eucalyptus leucophylla low open woodland on metamorphics	No concern at present	377.10	30.01
1.11.3b	Corymbia terminalis and/or Eucalyptus leucophylla low open woodland on metamorphics	No concern at present	163.44	13.01
1.11.8	Terminalia aridicola and/or Corymbia aspera low open woodland to low woodland, usually with vine-scrub species, on rock outcrops	No concern at present	31.28	2.49
non-remnant	None	None	62.25	4.95

Refer to **Map 2** for further information. **Map 3** also provides a visual estimate of the distribution of regional ecosystems present before clearing.

Table 4 provides further information in regards to the remnant regional ecosystems present within the AOI. Specifically, the extent of remnant vegetation remaining within the bioregion, the 1:1,000,000 broad vegetation group (BVG) classification, whether the regional ecosystem is identified as a wetland, and extent of representation in Queensland's Protected Area Estate. For a description of the vegetation communities within the AOI and classified according to the 1:1,000,000 BVG, refer to **Table 6**.

Table 4: Remnant regional ecosystems within the AOI, additional information

Regional Ecosystem	Remnant Extent	BVG (1 Million)	Wetland	Representation in protected estate
1.11.2a	Pre-clearing 1245000 ha; Remnant 2021 1239000 ha	19a	Not a Wetland	Low
1.11.3a	Pre-clearing 662000 ha; Remnant 2021 658000 ha	19b	Not a Wetland	No representation
1.11.3b	Pre-clearing 662000 ha; Remnant 2021 658000 ha	19b	Not a Wetland	No representation

Regional Ecosystem	Remnant Extent	BVG (1 Million)	Wetland	Representation in protected estate
1.11.8	Pre-clearing 30000 ha; Remnant 2021 30000 ha	27c	Not a Wetland	No representation
non-remnant	None	None	None	None

Representation in Protected Area Estate: High greater than 10% of pre-clearing extent is represented; Medium 4 - 10% is represented; Low less than 4% is represented, No representation.

The distribution of mapped wetland systems within the area of interest is displayed in **Map 6**.

The following table lists known special values associated with a regional ecosystem type.

Table 5: Remnant regional ecosystems within the AOI, special values

Regional Ecosystem	Special Values
1.11.2a	1.11.2: Potential habitat for NCA listed species: Eucalyptus nudicaulis, Ipomoea antonschmidii, Solanum carduiforme, Trachymene glandulosa.
1.11.3a	1.11.3: Potential habitat for NCA listed species: Eucalyptus nudicaulis.
1.11.3b	1.11.3: Potential habitat for NCA listed species: Eucalyptus nudicaulis.
1.11.8	1.11.8: Potential habitat for NCA listed species: Eucalyptus nudicaulis.
non-remnant	None

3. Remnant Regional Ecosystems by Broad Vegetation Group

BVGs are a higher-level grouping of vegetation communities. Queensland encompasses a wide variety of landscapes across temperate, wet and dry tropics and semi-arid climatic zones. BVGs provide an overview of vegetation communities across the state or a bioregion and allow comparison with other states. There are three levels of BVGs which reflect the approximate scale at which they are designed to be used: the 1:5,000,000 (national), 1:2,000,000 (state) and 1:1,000,000 (regional) scales.

A comprehensive description of BVGs is available at: https://publications.qld.gov.au/dataset/redd/resource/

The following table provides a description of the 1:1,000,000 BVGs present and their associated extent within the AOI.

Table 6: Broad vegetation groups (1 million) within the AOI

BVG (1 Million)	Description	Area (Ha)	% of AOI
None	None	62.25	4.95

BVG (1 Million)	Description	Area (Ha)	% of AOI
19a	Low open woodlands dominated by Eucalyptus leucophloia (snappy gum) with Triodia spp. dominated ground layer, mainly on hills and ranges.	621.74	49.48
19b	Low open woodlands dominated by Eucalyptus leucophylla (Cloncurry box) or less extensively Corymbia terminalis (long-fruited bloodwood) low open woodlands and related associations, mainly lower slopes and valleys.	540.54	43.01
27c	Low open woodlands dominated by a variety of species including Grevillea striata (beefwood), Acacia spp., Terminalia spp. or Cochlospermum spp.	31.28	2.49

Refer to **Map 4** for further information. **Map 5** also provides a representation of the distribution of vegetation communities as per the 1:5,000,000 BVG believed to be present prior to European settlement.

4. Technical and BioCondition Benchmark Descriptions

Technical descriptions provide a detailed description of the full range in structure and floristic composition of regional ecosystems (e.g. 11.3.1) and their component vegetation communities (e.g. 11.3.1a, 11.3.1b). See: http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/technical-descriptions/

The descriptions are compiled using site survey data from the Queensland Herbarium & Biodiversity Science's QBEIS database. Distribution maps, representative images (if available) and the pre-clearing and remnant extent (hectares) of each vegetation community derived from the regional ecosystem mapping data are included. The technical descriptions should be used in conjunction with the fields from the regional ecosystem description database (REDD) for a full description of the regional ecosystem.

Technical descriptions include data on canopy height, canopy cover and native plant species composition of the predominant layer, which are attributes relevant to assessment of the remnant status of vegetation under the *Vegetation Management Act 1999*. However, as technical descriptions reflect the full range in structure and floristic composition across the climatic, natural disturbance and geographic range of the regional ecosystem, local reference sites should be used for remnant assessment where possible (Neldner et al. 2023 (PDF)* section 3.3 of: https://www.qld.gov.au/__data/assets/pdf_file/0033/459186/methodology-mapping-surveying-v7.pdf

The technical descriptions are subject to review and are updated as additional data becomes available.

When conducting a BioCondition assessment, these technical descriptions should be used in conjunction with BioCondition benchmarks for the specific regional ecosystem, or component vegetation community. http://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks/

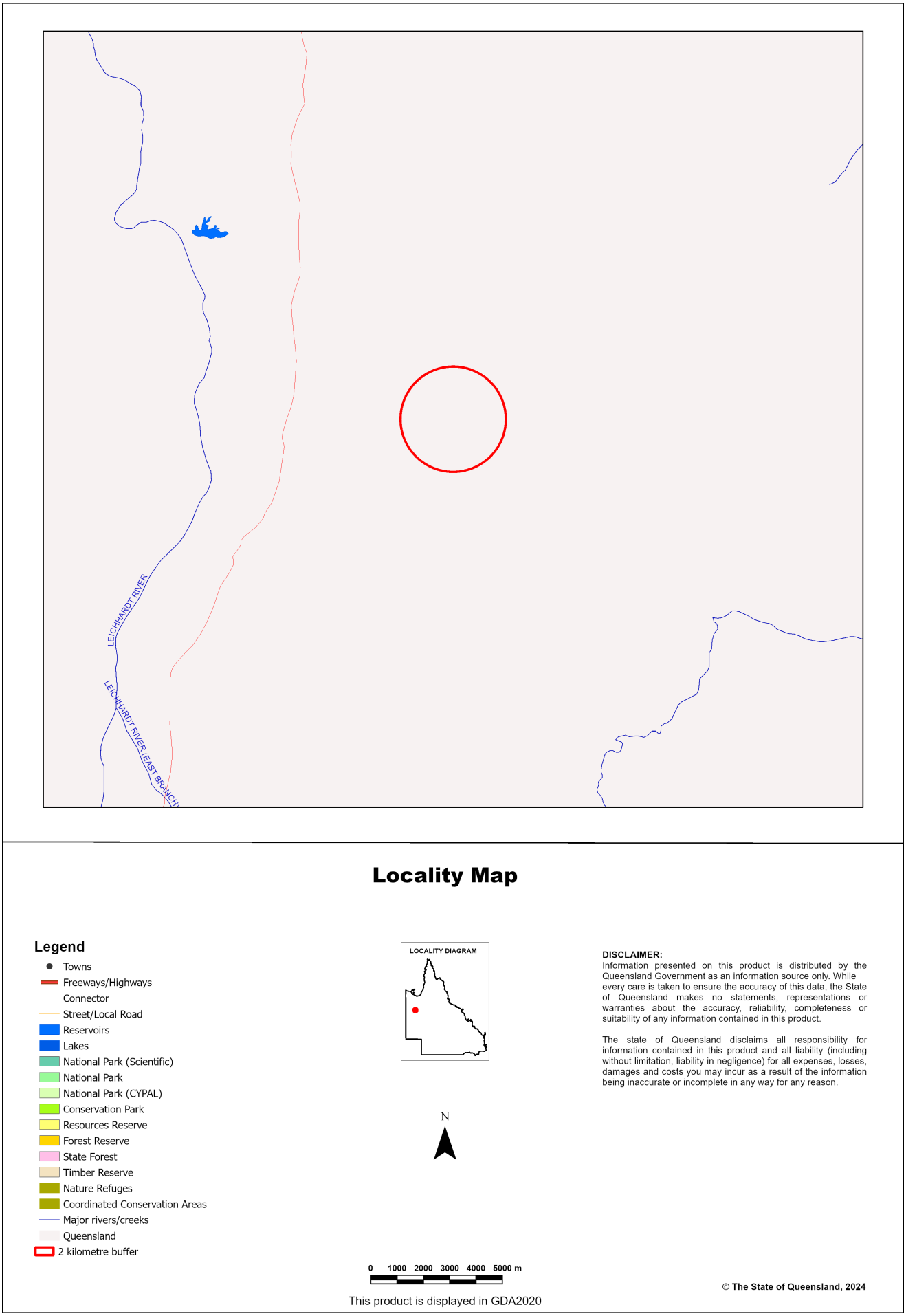
Benchmarks are based on a combination of quantitative and qualitative information and should be used as a guide only. Benchmarks are specific to one regional ecosystem vegetation community, however, the natural variability in structure and floristic composition under a range of climatic and natural disturbance regimes has been considered throughout the geographic extent of the regional ecosystem. Local reference sites should be used for this spatial and temporal (seasonal and annual) variability.

Table 7: List of remnant regional ecosystems within the AOI for which technical and biocondition benchmark descriptions are available

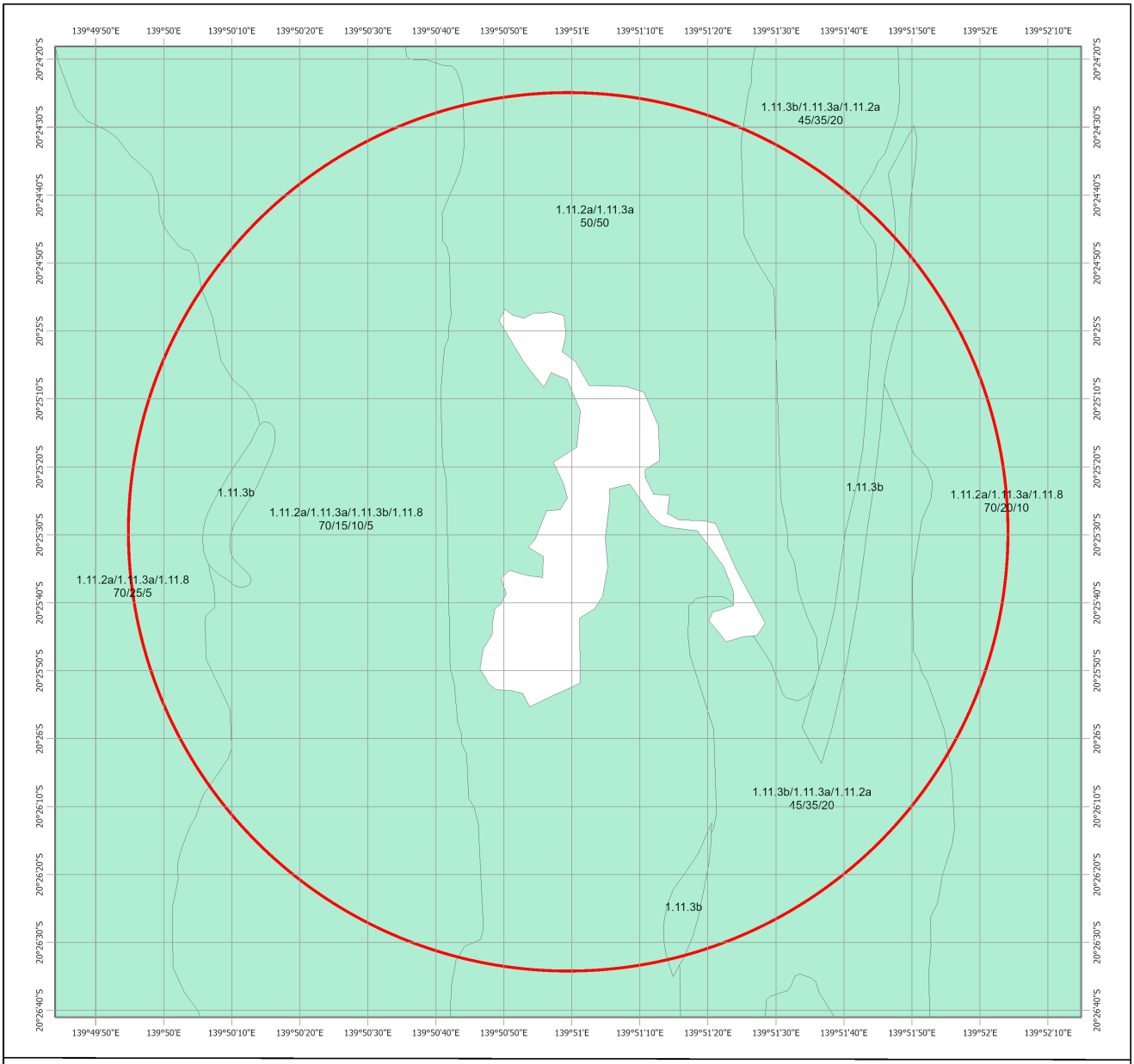
Regional ecosystems mapped as within the AOI	Technical Descriptions	Biocondition Benchmarks
1.11.2a	Available	Not currently available
1.11.3a	Available	Not currently available
1.11.3b	Available	Not currently available
1.11.8	Available	Not currently available
non-remnant	Not currently available	Not currently available

Maps

Map 1 - Location



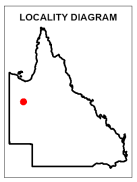
Map 2 - Remnant 2021 regional ecosystems

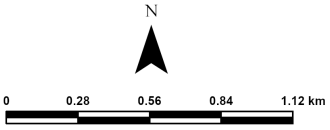


Remnant 2021 Regional Ecosystems

Biodiversity Status

- Endangered - Dominant vegetation
- Endangered - Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-dominant
- No concern at present
- Non-remnant vegetation, cultivated or built environment
- Plantation
- Water
- Cadastral Boundaries
- 2 kilometre buffer



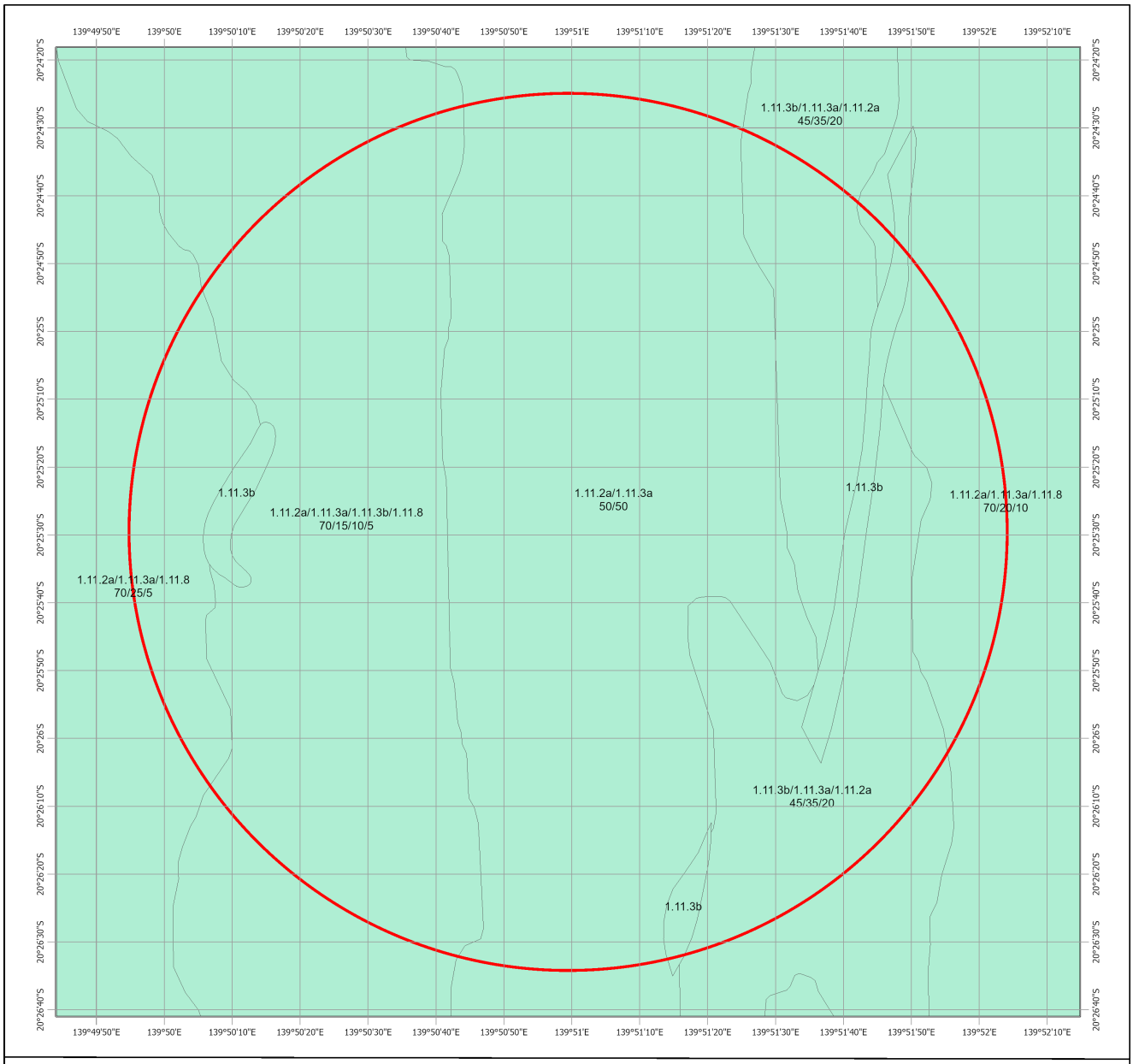


This product is projected into GDA2020

Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The polygons are labelled by regional ecosystem (RE); where more than one RE occurs, the percentage of each is labelled. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

© The State of Queensland, 2024

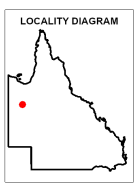
Map 3 - Pre-clearing regional ecosystems



Pre-clearing Regional Ecosystems

Biodiversity Status

- Endangered - Dominant vegetation
- Endangered - Sub-dominant
- Of Concern - Dominant
- Of Concern - Sub-dominant
- No concern at present
- Water
- Cadastral Boundaries
- 2 kilometre buffer



N

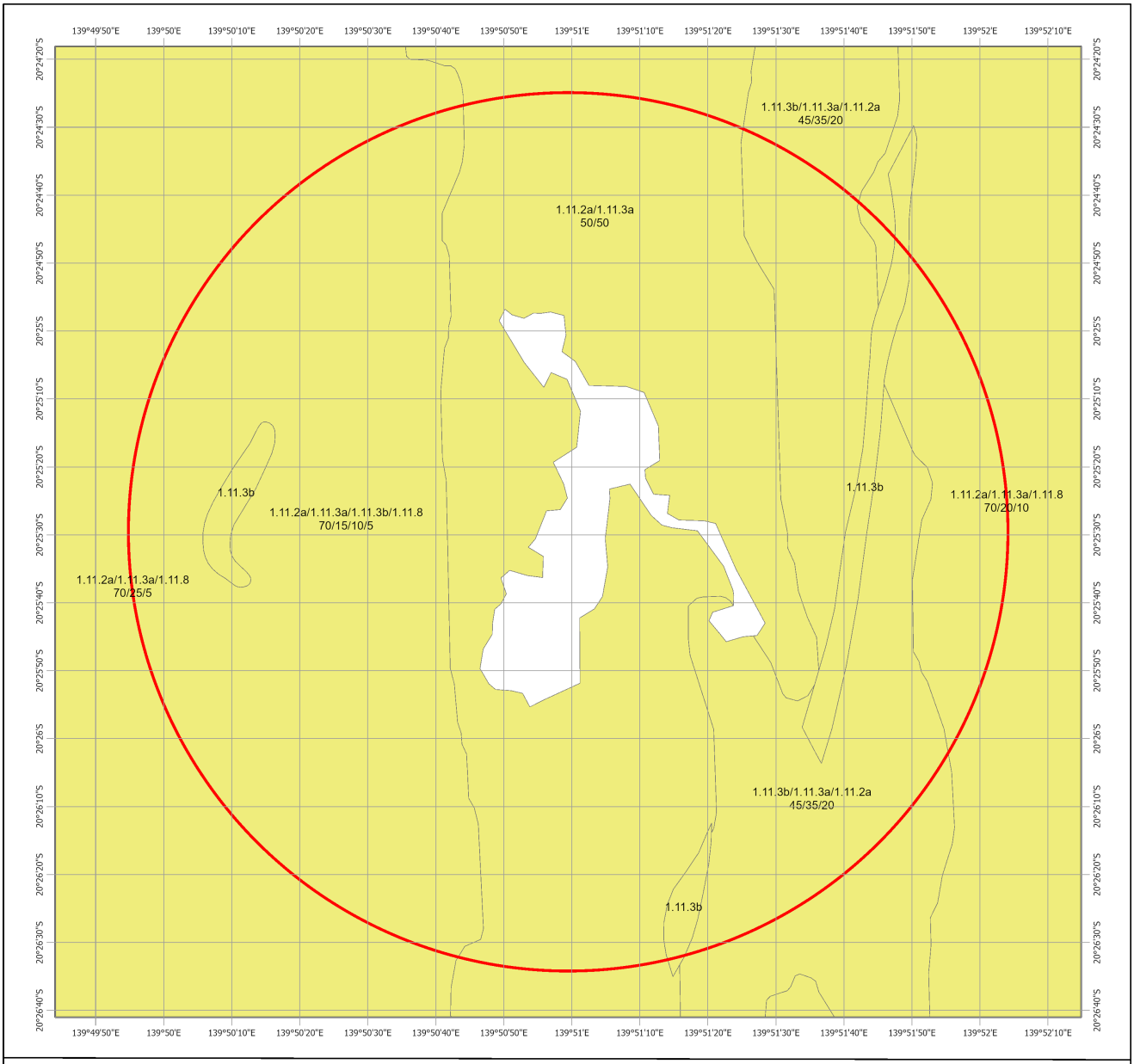
0 0.28 0.56 0.84 1.12 km

This product is displayed in GDA2020

Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The polygons are labelled by regional ecosystem (RE); where more than one RE occurs, the percentage of each is labelled. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

© The State of Queensland, 2024

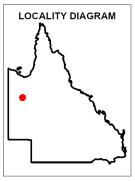
Map 4 - Remnant 2021 regional ecosystems by BVG (5M)



Remnant 2021 Regional Ecosystems coloured by Broad Vegetation Groups

Broad Vegetation Groups
BVG5M Description (BVG1M codes)

- 1. Rainforests and scrubs (1-7b)
- 2. Wet eucalypt open forests (8-8b)
- 3. Eucalypt woodlands to open forests (mainly eastern Qld) (9-15b)
- 4. Eucalypt open forests to woodlands on floodplains (16-16d)
- 5. Eucalypt dry woodlands on inland depositional plains (17-18d)
- 6. Eucalypt low open woodlands usually with spinifex understorey (19-19d)
- 7. Callitris woodland - open forests (20a)
- 8. Melaleuca open woodlands on depositional plains (21-22c)
- 9. Acacia aneura (mulga) dominated open forests, woodlands and shrublands (23-23b)
- 10. Other acacia dominated open forests, woodlands and shrublands (24-26a)
- 11. Mixed species woodlands, open woodland - (inland bioregions) includes wooded downs (27-27c)
- 12. Other coastal communities or heaths (28-29b)
- 13. Tussock grasslands, forblands (30-32b)
- 14. Hummock grasslands (33-33b)
- 15. Wetlands (swamps and lakes) (34-34g)
- 16. Mangroves and saltmarshes (35-35b)
- Non-remnant vegetation, cultivated or built environment
- Water
- Cadastral Boundaries
- 2 kilometre buffer



N

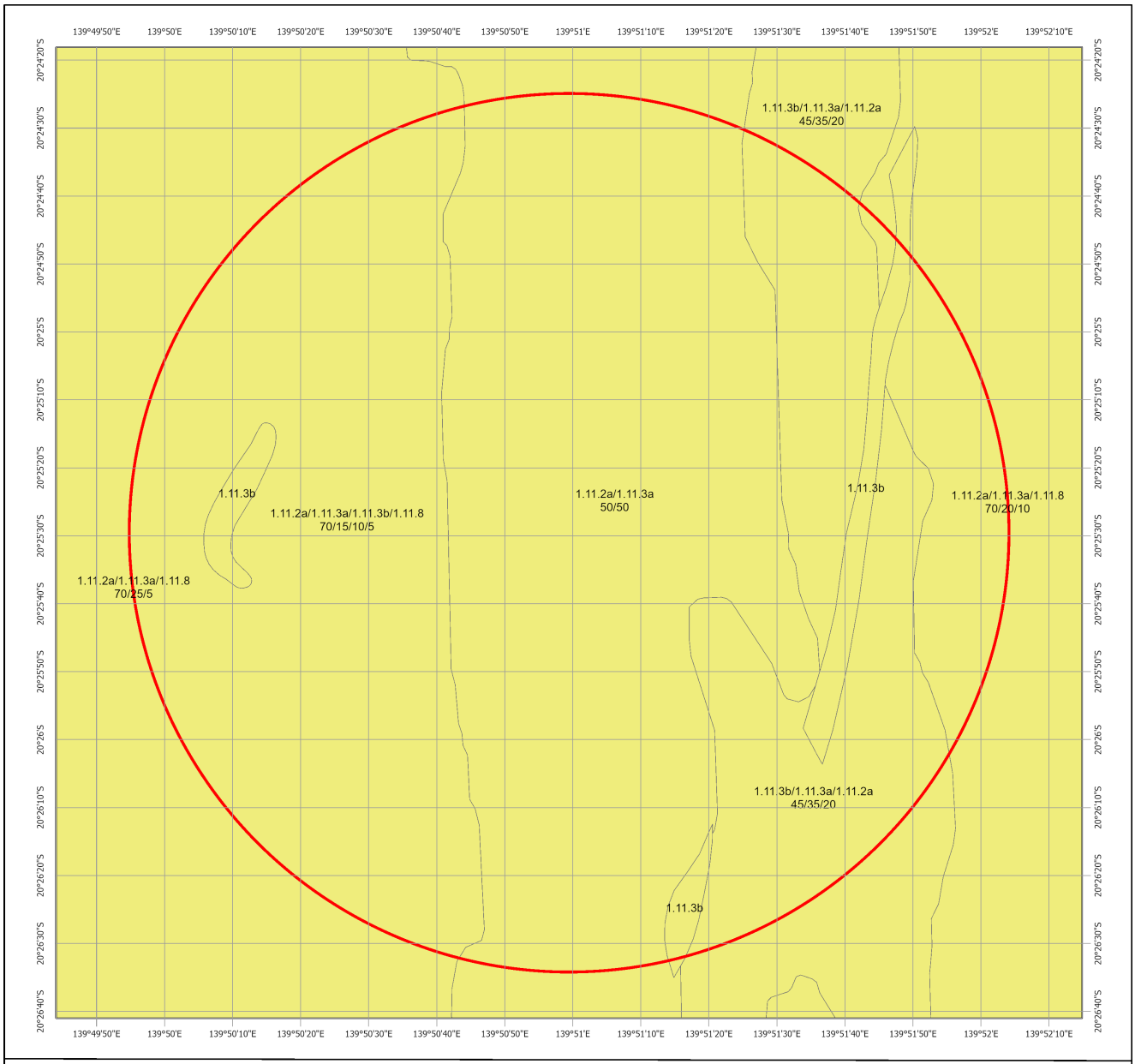
0 0.28 0.55 0.83 1.1 km

This product is displayed in GDA2020

Broad Vegetation Groups (BVG) of Queensland are applied by look up table to the regional ecosystem vegetation communities. Each polygon is coloured by the dominant BVG5M and the component regional ecosystems labelled. Where more than one regional ecosystem occurs, the percentage of each is labelled. Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.
The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.
Remnant woody vegetation is defined as vegetation that has not been cleared or vegetation that has been cleared but where the dominant canopy has >70% of the height and >50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy.
Non-remnant vegetation includes regrowth and disturbed native vegetation.

© The State of Queensland, 2024

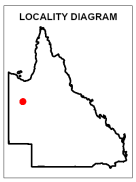
Map 5 - Pre-clearing regional ecosystems by BVG (5M)

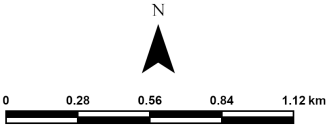


Pre-clearing Regional Ecosystems coloured by Broad Vegetation Groups

Broad Vegetation Groups
BVG5M Description (BVG1M codes)

- 1. Rainforests and scrubs (1-7b)
- 2. Wet eucalypt open forests (8-8b)
- 3. Eucalypt woodlands to open forests (mainly eastern Qld) (9-15b)
- 4. Eucalypt open forests to woodlands on floodplains (16-16d)
- 5. Eucalypt dry woodlands on inland depositional plains (17-18d)
- 6. Eucalypt low open woodlands usually with spinifex understorey (19-19d)
- 7. Callitris woodland - open forests (20a)
- 8. Melaleuca open woodlands on depositional plains (21-22c)
- 9. Acacia aneura (mulga) dominated open forests, woodlands and shrublands (23-23b)
- 10. Other acacia dominated open forests, woodlands and shrublands (24-26a)
- 11. Mixed species woodlands, open woodland - (inland bioregions) includes wooded downs (27-27c)
- 12. Other coastal communities or heaths (28-29b)
- 13. Tussock grasslands, forblands (30-32b)
- 14. Hummock grasslands (33-33b)
- 15. Wetlands (swamps and lakes) (34-34g)
- 16. Mangroves and saltmarshes (35-35b)
- Water
- Cadastral Boundaries
- 2 kilometre buffer



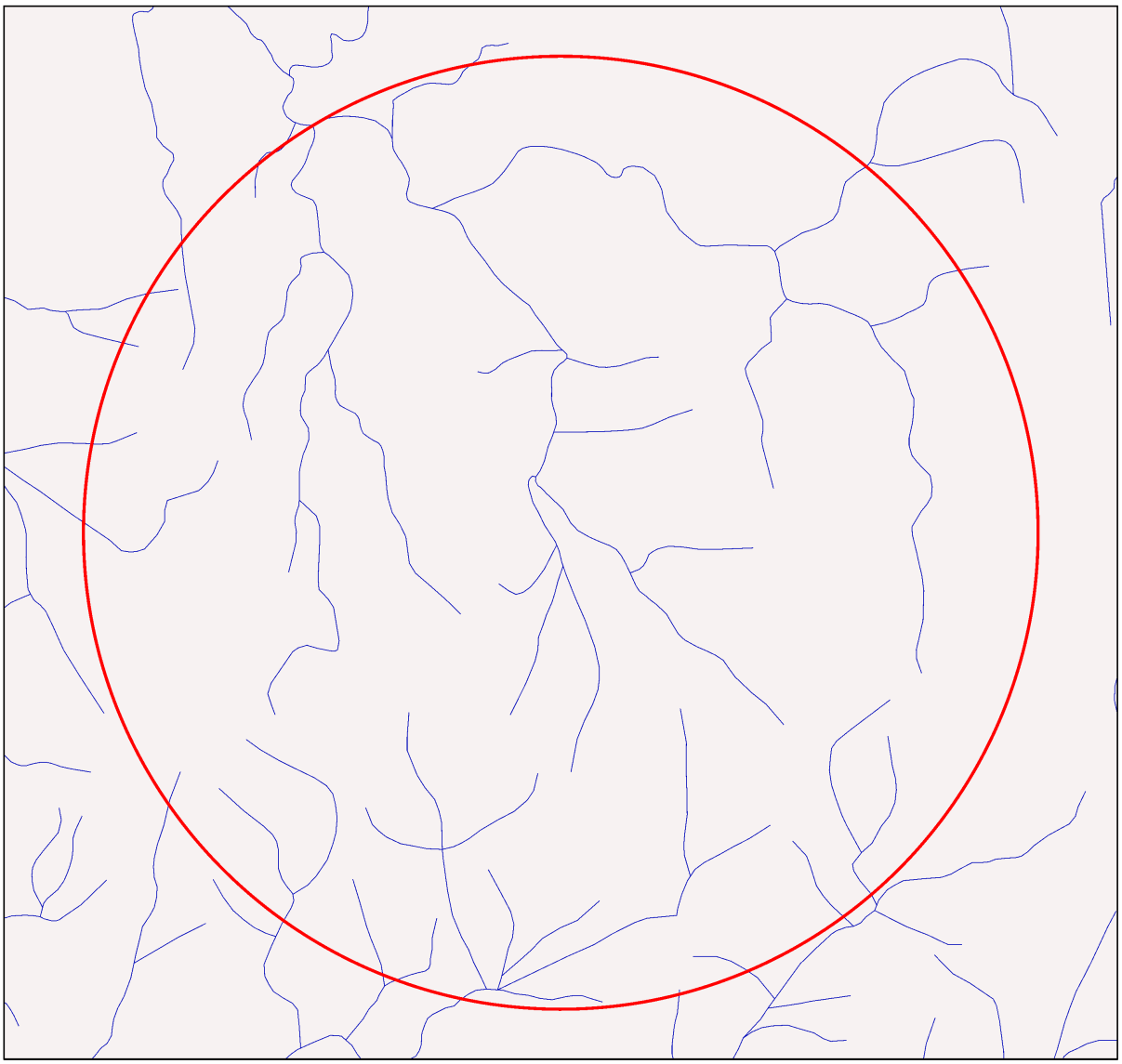


This product is displayed in GDA2020

Broad Vegetation Groups (BVG) of Queensland are applied by look up table to the regional ecosystem vegetation communities. Each polygon is coloured by the dominant BVG5M and the component regional ecosystems labelled. Where more than one regional ecosystem occurs, the percentage of each is labelled.
Regional ecosystem mapping over the majority of Queensland is produced at a scale of 1:100,000. At this scale, the minimum remnant polygon area is 5 hectares or minimum remnant width of 75 metres. Regional ecosystem linework reproduced at a scale greater than 1:100,000, except in designated areas, should be used as a guide only. The precision of polygon boundaries or positional accuracy of linework is 100 metres.
Regional ecosystems are defined as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. The label consists of 3 components: bioregion, land zone, and vegetation community – the dominant canopy species. e.g.: RE 12.3.3. Descriptions of REs are found online. Use the search term "Regional Ecosystem Framework".
Regional ecosystem mapping at 1:100,000 map scale is derived from the following sources: 1:80,000 B&W 1960's aerial photography, Landsat TM imagery, geology, soils, land systems data, field survey and historical records.

© The State of Queensland, 2024

Map 6 - Wetlands and waterways



Wetlands and Waterways

- Towns
- Roads
- Springs
- Rivers/Creeks
- Directory of Important Wetlands
- Ramsar Sites - QLD

Wetland Type

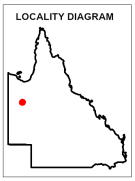
Hydrologically natural Wetlands
- Lacustrine Wetlands (hydrologically natural)
- Palustrine Wetlands (hydrologically natural)
- Riverine Wetlands (hydrologically natural)
- Intertidal Wetlands (hydrologically natural)
- Subtidal Wetlands (hydrologically natural)
- Intertidal/Subtidal Wetlands (hydrologically natural)

Hydrologically Modified and Artificial Wetlands
- Lacustrine Wetlands (hydrologically modified or artificial)
- Palustrine Wetlands (hydrologically modified or artificial)
- Riverine Wetlands (hydrologically modified or artificial)
- Intertidal Wetlands (hydrologically modified or artificial)
- Subtidal Wetlands (hydrologically modified or artificial)
- Intertidal/Subtidal Wetlands (hydrologically modified or artificial)

Subdominant Wetlands
- Subdominant Wetlands (51 - 80%)

Contains Wetlands
- Contains Wetlands (1 - 50%)
- Queensland
- 2 kilometre buffer

LOCALITY DIAGRAM



N

0 250 500 750 1000 1250 m

This product is displayed in GDA2020

DISCLAIMER:
Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

The state of Queensland disclaims all responsibility for information contained in this product and all liability (including without limitation, liability in negligence) for all expenses, losses, damages and costs you may incur as a result of the information being inaccurate or incomplete in any way for any reason.

© The State of Queensland, 2024

Links and Other Information Sources

The Department of Environment, Science and Innovation's Website - http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/ provides further information on the regional ecosystem framework, including access to links to the Regional Ecosystem Database, Broad Vegetation Group Definitions, Regional Ecosystem and Land zone descriptions.

Descriptions of the broad vegetation groups of Queensland can be downloaded from: https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/broad-vegetation

The methodology for mapping regional ecosystems can be downloaded from: https://www.qld.gov.au/__data/assets/pdf_file/0033/459186/methodology-mapping-surveying-v7.pdf

Technical descriptions for regional ecosystems can be obtained from: http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/technical-descriptions/

Benchmarks can be obtained from: http://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks/

For further information associated with the remnant regional ecosystem dataset used by this report, refer to the metadata associated with the Biodiversity status of pre-clearing and Remnant Regional Ecosystems of Queensland dataset (version listed in **Appendix 1**) which is available through the Queensland Spatial Catalogue, Queensland Spatial Catalogue : Queensland Government (information.qld.gov.au)

The Queensland Globe is a mapping and data application. As an interactive online tool, Queensland Globe allows you to view and explore Queensland maps, imagery (including up-to-date satellite images) and other spatial data, including regional ecosystem mapping. To further view and explore regional ecosystems over an area of interest, access the Biota Globe (a component of the Queensland Globe). The Queensland Globe can be accessed via the following link: https://qldglobe.information.qld.gov.au/

References

Neldner, V.J., Niehus, R.E., Wilson, B.A., McDonald, W.J.F., Ford, A.J. and Accad, A. (2023). The Vegetation of Queensland. Descriptions of Broad Vegetation Groups. Version 6.0. Queensland Herbarium, Department of Environment and Science. (https://publications.qld.gov.au/dataset/redd/resource/78209e74-c7f2-4589-90c1-c33188359086)

Neldner, V.J., Wilson, B.A., Dillewaard, H.A., Ryan, T.S., Butler, D.W., McDonald, W.J.F, Richter,D., Addicott, E.P. and Appelman, C.N. (2023) Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland. Version 7.0. Updated December 2023. Queensland Herbarium, Queensland Department of Environment, Science and Innovation, Brisbane. (https://www.qld.gov.au/__data/assets/pdf_file/0033/459186/methodology-mapping-surveying-v7.pdf).

Sattler, P.S. and Williams, R.D. (eds) (1999). *The Conservation Status of Queensland's Bioregional Ecosystems.* Environmental Protection Agency, Brisbane.

Appendices

Appendix 1 - Source Data

The dataset listed below is available for download from:
http://www.qld.gov.au/environment/plants-animals/plants/ecosystems/download/

- Regional Ecosystem Description Database

The datasets listed below are available for download from:
Queensland Spatial Catalogue : Queensland Government (information.qld.gov.au)

- Biodiversity status of pre-clearing and 2021 remnant regional ecosystems of Queensland
- Pre-clearing Vegetation Communities and Regional Ecosystems of Queensland
- Queensland Wetland Data Version - Wetland lines
- Queensland Wetland Data Version - Wetland points
- Queensland Wetland Data Version - Wetland areas
- Pre-clearing broad vegetation groups of Queensland
- Remnant 2021 broad vegetation groups of Queensland

Appendix 2 - Acronyms and Abbreviations

AOI - Area of Interest
GIS - Geographic Information System
RE - Regional Ecosystem
REDD - Regional Ecosystem Description Database
VMA - *Vegetation Management Act 1999*

APPENDIX F – FORM OF CERTIFICATION

TAILINGS.WATER.WASTE.

Form of certification (Consequence Category Assessment)

Name of Registered Professional Engineer providing certification:

Freeternity Rusinga

Address of Registered Professional Engineer providing certification:

ATC Williams Pty Ltd
Ground Floor, 16-20 Edmondstone St,
Newmarket, Qld 4051

Statement of relevant experience

I hereby state that I am a Registered Professional Engineer of Queensland (Number 23966) and meet the requirements of the definition of a 'suitably qualified and experienced person'.

Statement of Certification

All relevant material relied upon by me, including subsidiary certification of specialist components, where required by the environmental authority, is provided and/or referenced in the attached report "Barbara Copper Project - Consequence Category Assessment – South Pit"; Reference 118131.17.R01-revA, dated 16 May 2024.

I hereby certify that the consequence assessment "Barbara Copper Project - Consequence Category Assessment"; Reference 118131.17.R01-revA, dated 16 May 2024 provides an assessment of the South Pit at the Barbara Copper Project in accordance with the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures published as ESR/2016/1933 Version 5.03, 23 February 2024.

This consequence assessment has concluded that the South Pit has a 'Low' consequence category and is therefore not considered to be a regulated structure.

I, Freeternity Rusinga, declare that the information provided as part of this certification is true to the best of my knowledge. I acknowledge that it is an offence under section 480 of the Environmental Protection Act 1994 to give the administering authority a document containing information that I know is false, misleading or incomplete in a material particular.

Signed:

Freeternity Rusinga RPEQ #23966

Date: 16 May 2024

This page is intentionally blank.

Appendix J

Memorandum: Groundwater Impact Assessment — Sensitivity / Uncertainty Analysis and Long-term Water Quality

Technical Memorandum

WMV Environmental Pty Ltd
PO Box 597
Cannon Hill QLD 4170

From:	Willy Van Vaerenbergh
To:	Gemma Brown, Principal Environment & Mine Closure Planning
Cc:	David Eason, Senior Environment & Community Advisor
Date:	30 May 2024
Project:	J23011 – BCP UG EA Amendment and PRCP
Re:	Groundwater impact assessment – sensitivity/uncertainty analysis and long-term water quality

1 Introduction

1.1 Barbara Copper Project

The Barbara Copper Project (BCP or the Project) is a former open-cut copper and gold mine located within Mining Lease (ML) ML90241. BCP is authorised under Environmental Authority (EA) EPML02840015 for resource activities relevant to mining metals (copper, lead, silver, zinc, gold and iron ore). The Project is an open-cut copper mine that has extracted approximately 772,000 tonnes of ore. The mine operated from June 2019 until March 2021 and was placed in care and maintenance in April 2021.

Aeris Resources Limited (Aeris Resources, the proponent) plans to extract a significant copper-gold resource that remains under the South Pit through underground (UG) mining. Round Oak Minerals Pty Limited (Round Oak Minerals), wholly owned by Aeris Resources, is the EA holder.

1.2 EA amendment application

On 4 April 2024, Round Oak Minerals submitted to the Department of Environment, Science and Innovation (DESI) an amendment application for an environmental authority and a PRCP schedule. This submission included a Groundwater Technical Report (WMV Environmental, March 2024).

On 18 April 2024, DESI provided Round Oak Minerals with a "*Not properly made amendment application*" notice. The notice was issued because the application was missing information required by sections 226, 226A and 226B of the *Environmental Protection Act 1994* (EP Act). Attachment 1 of the notice details the specific issues.

Table 1 presents the issues in the notice addressed by WMV Environmental in this technical memo.

Table 1 Reasons for 'not properly made' application addressed in this technical memo

Legislative requirement under the EP Act	Reason	Action (s)
Section 226A(1)(f)(iii) The amendment application must include an assessment of the likely impact of the proposed amendment on the environmental values, including a description of the risk and likely magnitude of impacts on the environmental values.	The application did not provide a description of the risk and likely magnitude of impacts on the environmental values: • A risk assessment of impacts from underground mining, including drawdown impacts and blind stopes, to terrestrial groundwater dependent ecosystems (GDEs) has not been provided.	Provide a risk assessment of impacts from underground mining, including drawdown impacts and blind stopes, to terrestrial GDEs.
Section 226B An amendment application for a PRCP schedule must be accompanied by an amended rehabilitation planning part that complies with section 126C in relation to the proposed amendment. Section 126C(1)(e) A proposed PRC plan must for each proposed PMLU for land, state the proposed methods or techniques for rehabilitating the land to a stable condition in a way that supports the rehabilitation milestones under the proposed PRCP schedule.	The application must, for each proposed post-mining land use for land, state the applicant's proposed methods or techniques for rehabilitating the land to a stable condition in a way that supports the rehabilitation milestones under the proposed PRCP schedule: • South Pit currently has a post mine land use (PMLU) of water storage. The applicant has not provided information detailing how the proposed amendment, of commencing underground mining under South Pit, will continue to achieve this PMLU. - The Groundwater Technical Report (J23011-RP01 - BCP UG EA (Final v2.00) provides void water quality modelling for 25 years. This timeframe is not considered sufficient to demonstrate that the PMLU can sustain a post-mine land use of water storage in the long term. - Appendix E Memorandum: Barbara Total Carbon Assays provided within the supporting document notes that further samples are recommended and that pulp samples are awaiting further tests. Therefore, the veracity of the water quality modelling to demonstrate the PMLU can be achieved is unclear due to the possible lack of waste rock data its potential interactions with groundwater following deposition in the underground workings.	Provide void water modelling that demonstrates that the PMLU can sustain a post-mine land use of water storage in the long term that supports the rehabilitation milestones. Discuss proposed amendments to timeframes within the PRCP Schedule, including proposed methods or techniques for rehabilitating the land to a stable condition in a way that supports the rehabilitation milestones. Provide justified management practices that will be implemented to make the reduced timeframes realistic and attainable.

Legislative requirement under the EP Act	Reason	Action (s)
	As the amendments to timeframes within the PRCP Schedule have not been discussed within the supporting documents, the applicant has not stated proposed methods or techniques for rehabilitating the land to a stable condition in a way that supports the rehabilitation milestones. Additionally, the applicant did not provide any justification that management practices will be implemented to make the reduced timeframes realistic and attainable.	

Further communication with DESI identified additional concerns regarding "*the lack of sensitivity analyses being conducted on the groundwater models. Understanding the potential variation in model output/s based on the varied input/s would assist with the decision making. This can be achieved by considering a range of realistic scenarios (both during the past and current predictions)*".

1.3 Structure of technical memorandum

This technical memo has been structured to address DESI's issues and concerns and includes the following Sections:

- Appendix A: Discussion on analytical vs numerical groundwater models, as summarised in Section 2
- Appendix B: Sensitivity analysis on analytical models, as summarised in Section 3
- Section 4: Assessment of impacts on terrestrial GDEs
- Section 5: Long-term final void water quality

The Groundwater Technical Report (WMV Environmental, March 2024), included in the EA amendment application and the BCP UG PRCP application, provides a detailed description of BCP's environmental settings (including geology and hydrogeology), the environmental monitoring results, a hydrogeological conceptual model and a detailed groundwater impact assessment. This memo must be considered in conjunction with this Groundwater Technical Report.

2 Analytical vs numerical groundwater models

The assessment of the final void hydrogeology and groundwater impact assessment, as described in the Groundwater Technical Report, was based on:

- final void water balance modelling (ATC William, 2023ba, ATC Williams, 2024)
- water quality modelling of the open pits and WRD Sediment Dam undertaken by ATC Williams (ATC William, 2023b) with further interpretation of the data by WMV Environmental (2023)
- underground workings final void water quality modelling.

The groundwater impact assessment required groundwater modelling either to provide input data for water balance and water quality models or to allow direct assessment of potential impacts.

WMV Environmental's approach to groundwater modelling included the initial development of analytical models instead of 3D numerical groundwater models. This approach and its justification are discussed in detail in Appendix A.

Given the fact that groundwater at BCP is primarily associated with the orebody itself, the relative impermeability (i.e. low hydraulic conductivity) of the aquifers and the short duration of the underground mining (i.e. four years), analytical models are considered appropriate for the initial assessment of groundwater impact assessment.

3 Sensitivity analysis on analytical models

3.1 Introduction

Sensitivity analyses on the analytical model results have been undertaken in response to DESI's comments. Appendix B provides a detailed discussion of the approach and outcomes of the sensitivity analyses.

With respect to the sensitivity/uncertainty analyses of the analytical models, the following needs to be considered:

- The analytical model used to assess the potential impacts of mining on groundwater-dependent ecosystems calculates the level and extent of drawdown around open pits and voids. The horizontal hydraulic conductivity is the only model parameter on which a sensitivity analysis can be undertaken.
- The analytical model used to calculate groundwater inflows into the open pits/voids provides input into the water balance and quality models. Model input parameters for sensitivity analysis include rainfall recharge and horizontal and vertical hydraulic conductivity. An additional input parameter is the radius of influence, which the previous analytical model calculates.
- Input parameters for the water quality models include the water balance volumes, calculated through the Goldsim water balance models, and analyte concentrations of rainfall, runoff and groundwater inflow. As the analyte concentrations are based on literature values (for rainfall) or actual observed concentrations (e.g. 95th percentile of analysis data for surface water and groundwater), no sensitivity/uncertainty analysis is undertaken on the water quality input data.

Sensitivity/uncertainty analyses have been undertaken on two key input parameters of the analytical models, i.e. the horizontal hydraulic conductivity and the rainfall recharge to groundwater. The hydraulic conductivity has been changed by an order of magnitude, whilst the rainfall recharge coefficient has been changed by a factor of five, resulting in nine different sensitivity scenarios.

3.2 Sensitivity/uncertainty analysis of drawdown radius of influence

With respect to the sensitivity analysis:

- Void geometry is calculated from Aeris's actual and planned void dimensions. No sensitivity analysis is undertaken on this parameter.
- Drawdown in the void has been calculated as the difference between the regional, pre-mining groundwater level and the base of the void during and post-mining.
- The value of saturated hydraulic conductivity was obtained from site investigations undertaken in 2013. Sensitivity analyses have been undertaken on this parameter.

As the rainfall recharge coefficient is not a parameter in Sichardt's equation, only three scenarios have been considered. The sensitivity analysis results are discussed in Appendix B.1.4. As per Sichardt's equation, the higher the horizontal hydraulic conductivity, the larger the drawdown. It is noted that the calculated radii are considered conservative and overestimate the actual radius of influence.

Overall, the potential radius of influence would be much less than the empirically calculated radius and remain within the ML boundaries. Gauging of existing groundwater monitoring bores (BAWB01 to BAWB07, BAWBR01 to BAWBR03) does not show a significant impact of open-cut mining on groundwater levels.

The sensitivity analysis indicates that uncertainty in the hydraulic parameters does not affect the conclusions regarding the potential impact on terrestrial GDEs (Section 4).

3.3 Sensitivity/uncertainty analysis of groundwater inflows into voids

The analytical models calculating groundwater inflows into the voids are based on the model by Marinelli and Nicolli. The key parameters in the Marinelli and Niccoli model are the void geometry, the radius of influence, the rainfall recharge rate, the hydraulic and vertical conductivities, the pre-mining saturated thickness above the base of the void and the depth of water in the void.

With respect to the sensitivity analysis:

- Void geometry is calculated from Aeris's actual and planned void dimensions. No sensitivity analysis was undertaken on this parameter.
- The value of hydraulic conductivity was obtained from site investigations undertaken in 2013. Sensitivity analyses have been undertaken on this parameter.
- As the vertical hydraulic conductivity was set at 10% of the horizontal conductivity, no additional sensitivity analysis was undertaken on this parameter.
- A sensitivity analysis of rainfall recharge has been undertaken.
- The radius of influence has been calculated using Sichardt's equation. This model uses the hydraulic conductivity value. The two analytical models have been linked so that the sensitivity analysis on hydraulic conductivity filters through to the sensitivity analysis on the radius of influence.

The sensitivity analysis results are discussed in Appendix B.1.5. The sensitivity analysis results show that groundwater inflows under Scenarios 7, 8 and 9 (i.e. with a horizontal hydraulic conductivity of 2.29 10^{-07} m/s) are more significant than under the other scenarios, mainly due to the increased horizontal conductivity. This increased conductivity has a two-fold and double effect, i.e. increasing the radius of influence (which affects the Zone 1 flow calculations) and the flow in Zone 2 calculations. The modelled groundwater inflows under these three scenarios are considered unrealistic. Whilst there are no specific measurements of groundwater inflow into the open pits or pit dewatering pumping rates, visual observations by site personnel during mining did not support the calculated groundwater inflows.

The results show that the groundwater inflow rates adopted in the Goldsim water balance models are generally at the upper end of the inflows under scenarios 4 and 6, whilst inflows under scenarios 1 and 3 are generally lower than the Goldsim water balance model groundwater inflows.

3.4 Impact of uncertainty on analytical modelling results

The sensitivity analyses show that the groundwater inflows used in the water balance and quality models are in the upper ranges of the realistic scenarios. Sensitivity analyses indicate that this groundwater inflow may be at a lesser rate than currently adopted.

The impact of the uncertainty regarding groundwater inflow rates (i.e. lower than currently adopted) is considered minimal as:

- Lower groundwater inflow rates would result in a slightly longer recovery time of groundwater levels in the open pits and underground voids.
- The underground void will be filled with water by 2023, i.e. 7 years after the commencement of underground mining. Slower groundwater inflow rates may increase this period, but not to the extent that it will affect the final water quality in the underground voids. Water quality in the underground voids depends largely on the groundwater quality, which does not change with the duration of inflow into the underground voids.
- Groundwater inflow is a minor component of total inflow (i.e. <10%) in the North and South Pits. Surface water runoff and direct rainfall are the major inflow components. A reduction in groundwater inflow rates would not significantly alter the water balance modelling results of the pits and, therefore, not significantly affect the results of the water quality modelling.
- There is no groundwater inflow into the WRD Sediment Dam.

4 Assessment of impacts on terrestrial GDEs

The above sensitivity analyses on the radius of drawdown influence around the open pits and underground void indicate that, under worst-case scenario 7, the maximum drawdown extent would be as follows:

- North pit: ±90m
- South pit: ±275m
- Underground voids: ±480m

It is noted that the drawdown extent would reduce with time post-mining as water levels in the open pits and underground void recover. In addition, the actual radius of influence would be less than the empirically calculated radius and remain within the ML boundaries. Gauging of existing groundwater monitoring bores (BAWB01 to BAWB07, BAWBR01 to BAWBR03) does not show a significant impact of open-cut mining on groundwater levels.

Publicly available data from the BOM indicates that the nearest mapped terrestrial GDEs are outside the maximum drawdown extent, as shown in Figure 1. The terrestrial GDEs nearest to the voids are "low potential GDEs". Based on the modelled drawdown extents, the proposed underground mining operations will not pose a risk to the identified terrestrial GDEs.

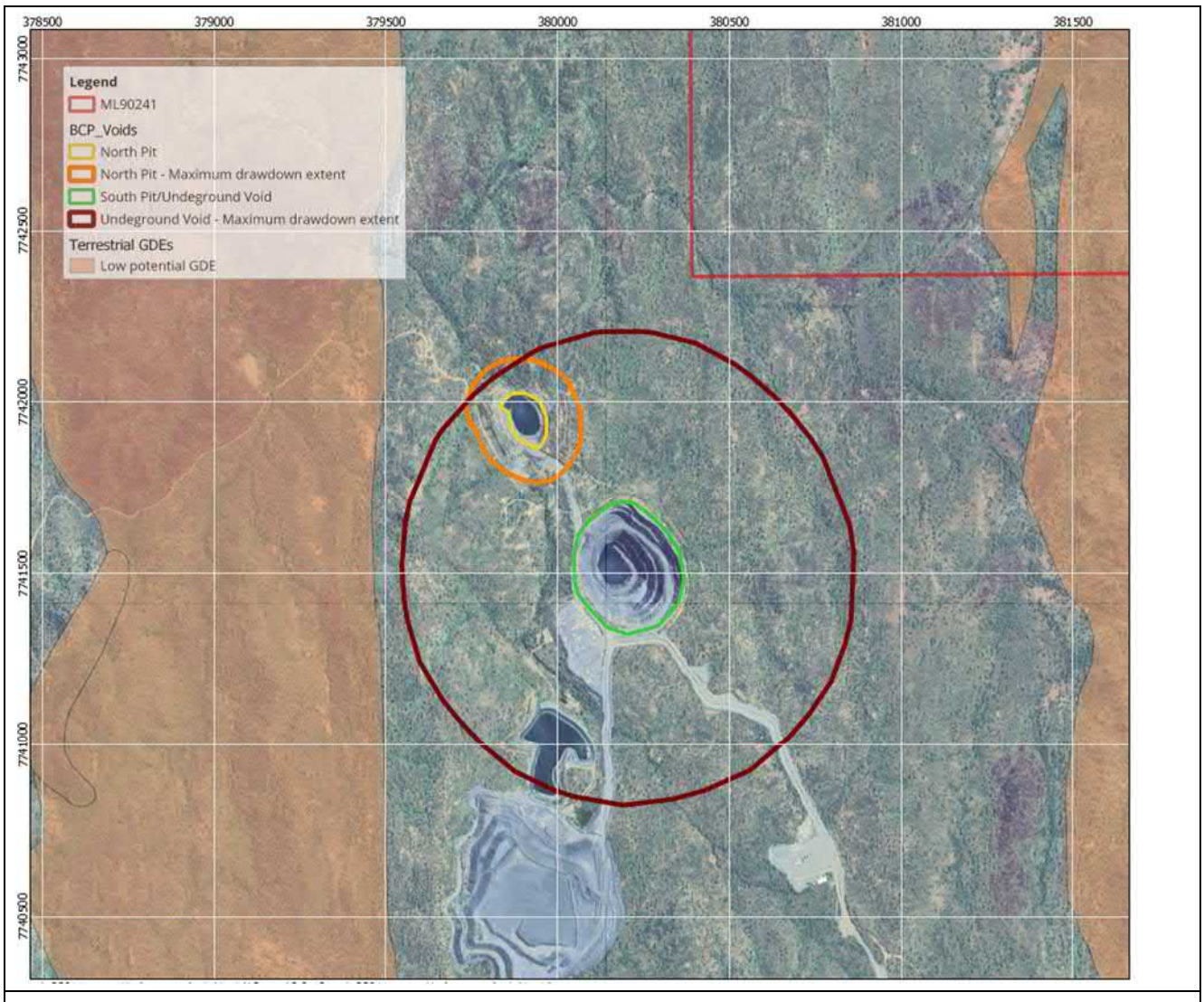


Figure 1 Location of terrestrial GDEs and maximum drawdown extent

5 Long-term final void water quality

5.1 Updated Goldsim Water Balance Model

To assist with assessing the long-term water quality in the final voids, the existing Goldsim Water Balance Model (WBM), developed by ATC Williams, was extended to 200 years.

The results of the long-term WBM can be summarised as follows:

- The average water level in the South Pit at the end of the 200-year simulation is 292m AHD, reaching a maximum elevation of 299m AHD (35.3 m below the crest) (Figure 2).
- The average water level in North Pit at the end of the 200-year simulation is 302m AHD, reaching a maximum elevation of 307.6 m AHD (8.4 m below the crest) (Figure 3).
- The water level in the WRD sediment dam reaches an average elevation of 332 m AHD, spilling on average once every 30 years (Figure 4).

It is noted that the climate data used in the original WBM (130 years) was extended by repeating the data of the last 30 years to cover 200 years. The extended period was wetter than the previous 130-year period, accounting for the rare spills of the WRD sediment dam.

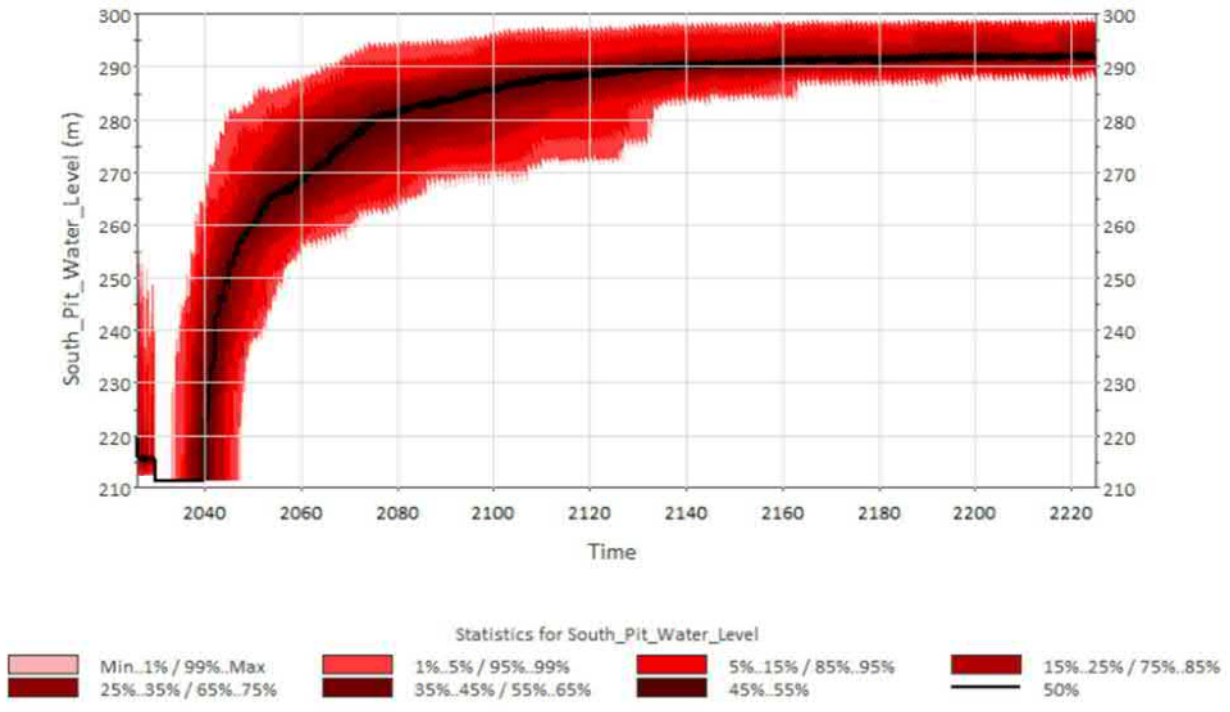


Figure 2 Long-term (200 yrs) South Pit water levels

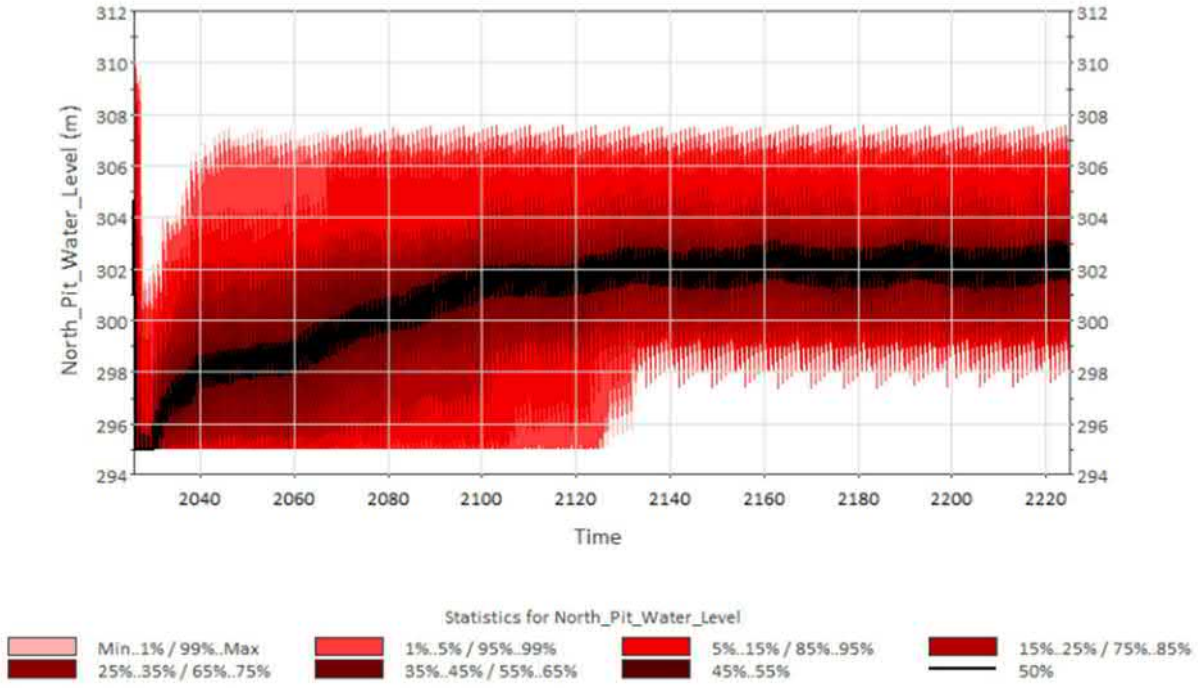


Figure 3 Long-term (200 yrs) North Pit water levels

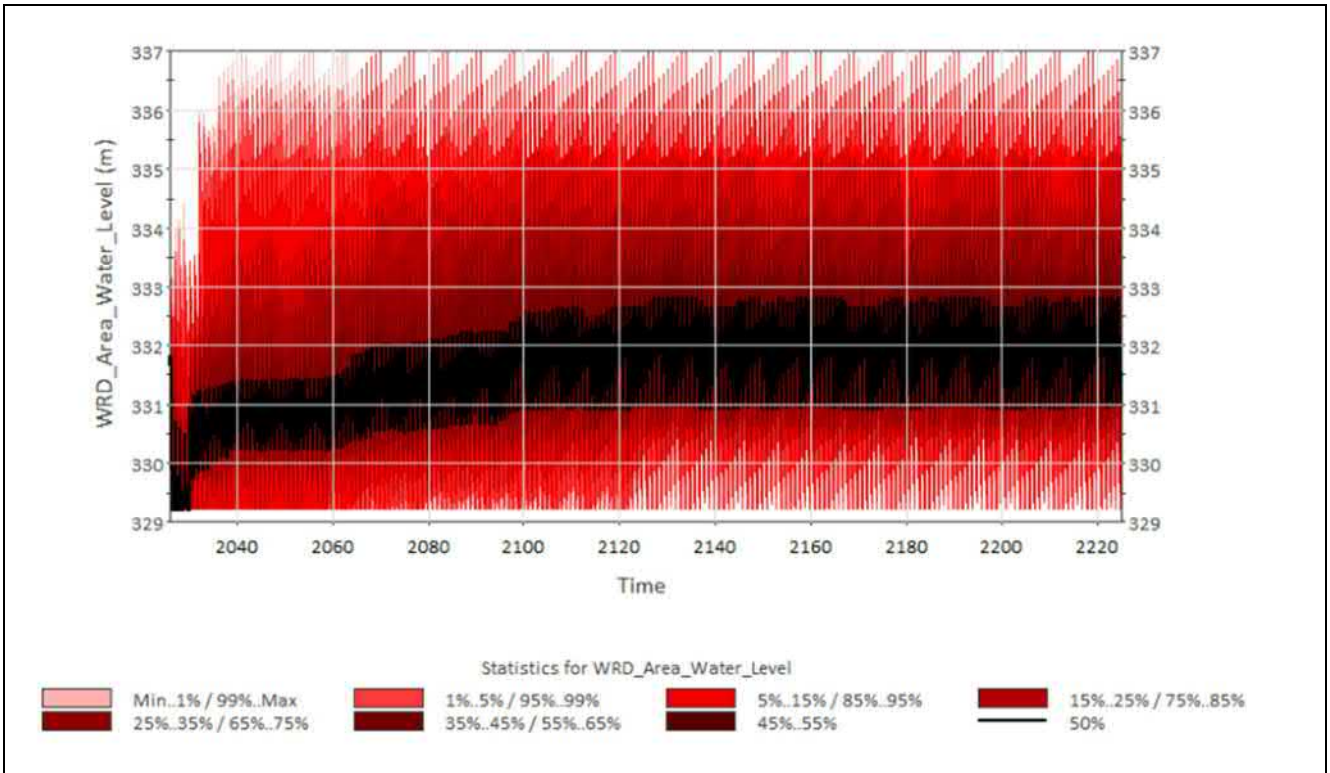


Figure 4 Long-term (200 yrs) WRD Sediment Dam water levels

5.2 Underground void long-term water quality

To assess the long-term water quality in the underground void, the 200-year WBM was used to simulate the underground void water balance under five (5) climate scenarios representing the 5%, 25%, 50%, 75% and 100% rainfall and evaporation time series, as follows:

- Rainfall and evaporation time series/scenarios representing the 5th, 25th, 50th, 75th and 100th percentile (a.k.a. the P05, P25, P50, P75 and P100 scenarios) were generated using the probabilistic 200-year WBM developed by ATC Williams.
- ATC Williams ran the 200-year WBM model in a deterministic mode for each scenario to obtain detailed water balance volumes (i.e. inflows, storages and outflows) for the underground workings.
- A mixing model was developed for each scenario, using the water balance volumes and water quality characteristics of the different components to calculate the long-term water quality in the underground workings.

As the input analyte concentrations are based on literature values (for rainfall) or actual observed concentrations (e.g. 95th percentile of analysis data for surface water and groundwater), no sensitivity/uncertainty analysis is undertaken on the water quality input data.

Appendix C presents time series graphs of analyte concentrations in the underground void for each climate scenario. The time series of the modelled results indicate the following:

- Initial water quality is determined by the water quality of the water transferred into the UG voids (i.e. initial transfer of water from the North Pit, transfers from the WRD Sediment Dam and semi-regular transfers of water from the South Pit).
- Mid- to long-term water quality is governed by the mixing of the transferred water with groundwater inflow.
- Water quality in the underground void reaches long-term stability after approximately 16 years.

The results indicate that long-term stability in underground void water quality is reached after ±2041 when the underground void is completely filled with groundwater. Table 2 presents the long-term water quality compared against the ANZECC Livestock Water Quality Guidelines and the PRCP schedule PRCP EPML02840015 – Water quality limits for North and South Pits and WRD Sediment Dam. The results show that long-term water quality within the UG workings remains below these guideline values.

The results of the mixing modelling indicate that groundwater quality in the UG voids remains below the relevant water quality guidelines values (livestock watering and PRCP criteria for voids) and that the underground workings are suitable for a livestock watering PLMU.

Table 2 Modelled long-term UG workings final void water quality concentrations (mg/L)

Analyte	Guideline values	P05	P25	P50	P75	P100
Aluminium	5 (1)	0.0424	0.0503	0.0437	0.0503	0.0484
Arsenic	0.5 (1)(2)	0.0028	0.0026	0.0028	0.0026	0.0027
Barium	-	0.1838	0.1796	0.1846	0.1821	0.1868
Boron	5 (1)	0.0709	0.0829	0.0728	0.0811	0.0773
Cadmium	0.01 (1)(2)	0.0033	0.0040	0.0032	0.0043	0.0041

Analyte	Guideline values	P05	P25	P50	P75	P100
Calcium	500 [2] 1000 [1]	69.4	71.0	68.7	65.1	61.6
Chloride	-	55.4	50.8	54.7	49.5	50.5
Chromium	1 [1]	0.0081	0.0071	0.0080	0.0075	0.0081
Cobalt	1 [1]	0.0040	0.0037	0.0040	0.0038	0.0040
Copper	1 [1][2]	0.0479	0.0516	0.0475	0.0541	0.0532
Fluoride	2 [1][2]	0.7568	0.7868	0.7599	0.7639	0.7480
Lead	0.1 [1][2]	0.0204	0.0251	0.0202	0.0269	0.0254
Magnesium	150 [2] 2000 [1]	47.2	44.5	46.3	41.0	40.1
Manganese	1 [2]	0.0390	0.0478	0.0388	0.0510	0.0483
Molybdenum		0.0069	0.0064	0.0065	0.0050	0.0042
Nickel	1 [1]	0.0057	0.0055	0.0057	0.0055	0.0057
Potassium	-	39.0529	35.6874	38.8327	36.2957	38.0237
Selenium		0.0067	0.0059	0.0061	0.0031	0.0016
Sodium	-	181.7	177.9	180.4	170.1	167.9
Sulfate	2,000 [1]	127.4	119.4	119.2	83.4	63.5
Total Dissolved Solids	5,000 [1][2]	648.7	628.0	640.7	589.0	576.4
Uranium	0.2 [1]	0.0069	0.0070	0.0069	0.0068	0.0067
Vanadium	ND [1]	0.0013	0.0016	0.0014	0.0016	0.0015
Zinc	20 [1][2]	0.0937	0.1138	0.0943	0.1190	0.1132

[1] ANZECC 2000 Livestock (beef cattle) drinking water quality guidelines

[2] PRCP schedule PRCP EPML02840015 – Tabe 5: Water quality limits for North and South Pits and WRD Sediment Dam

5.3 Open pits long-term water quality

5.3.1 Introduction

In 2023 and as part of the preparation of the PRCP for the BCP Project, ATC Williams developed water quality models (WQMs) for the North Pit, South Pit and WRD Sediment Dam by linking the output of the Goldsim WBM with a PHREEQC (USGS, ver. 3.6.2.15100) geochemical model. It is noted that these WQMs did not include the proposed underground workings. However, the results of these WQMs are still considered relevant and representative.

Given the complexity of linking the Goldsim probabilistic output to PHREEQC, three different water balance scenarios were evaluated, corresponding with the following Goldsim™ WBM stochastical results:

- The median climatic conditions that correspond with an occurrence probability of 50% (i.e. 50th percentile or P50).
- Interquartile climatic conditions that correspond with 25th percentile (occurrence probability of 75% or P75) and 75th percentile (occurrence probability of 25% or P25) climatic conditions.

Higher probabilities were not considered since increased rainfall, groundwater discharge into the pit void, and lower evaporation rates would result in improved water quality and represent a lower risk to the downstream environment or closure condition.

With respect to the geochemical process, the modelling included speciation equilibrium modelling, i.e. the precipitation/dissolution of minerals from/into solution when the different water types are mixed. In the first instance, only the mineral phase considered was gypsum, whereby gypsum precipitation could occur if calcium and sulphate concentrations in the mixed water were sufficiently elevated. This model is denoted as the "equilibrium" model.

5.3.2 Validity of the 2023 water quality models

The timeframe of the 2023 water balance and quality models was 58 years (i.e. from mid-2022 to early-2080). The modelling results are discussed in the report "*Barbara Copper Project Progressive Rehabilitation and Closure Plan. Water Quality Assessment of North Pit, South Pit and WRD Sediment Dam*" (WMV Environmental, March 2023) that was included in the 2023 PRCP submission and are summarised in the report "*Barbara Copper Project UG EA Amendment. Groundwater Technical Report*" (WMV Environmental, March 2024) that was included in the BP Underground Workings EA Amendment Application. Appendix D presents the 2023 water quality modelling results for the open pits and WRD sediment dam.

The water levels in the South Pit, North Pit and WRD Sediment Dam for each climate scenario obtained from the long-term (200 yrs) water balance model are presented in Figure 5, Figure 6 and Figure 7, respectively. The modelling results indicate that for most climate scenarios, the water levels in the open pits and WRD sediment dam reach long-term stability (i.e. water levels only influenced by the interaction between rainfall and evaporation) after ±50 years (i.e. by 2075-2080).

Including the underground void in the recent model does not affect the long-term water balance and water quality in the North Pit, South Pit and WRD Sediment Dam. The only interaction between the South Pit and the underground void consists of dewatering the pit to gain access to the underground void. Once the underground mining is complete, such dewatering is no longer required, and the water levels in the South Pit will recover, as per the original 2023 water balance/quality models.

The results of the 2023 water quality model are considered relevant and representative of the post-underground mining operations given that:

- the long-term water balance modelling results indicate stabilisation of water levels in the open pits and sediment dam after ±50 years
- the underground mining only has a minor impact on the mid- to long-term water levels in the open pits and WRD sediment dam
- the 2023 water quality model demonstrates that water quality in the pits and sediment dam remains below the ANZECC livestock drinking water guidelines.

The 2023 water quality modelling indicates that the modelled solute concentrations at all times and for both models (i.e. mixing and equilibrium models) remain below the applicable ANZECC 2000 Water Quality Guideline values for livestock watering.

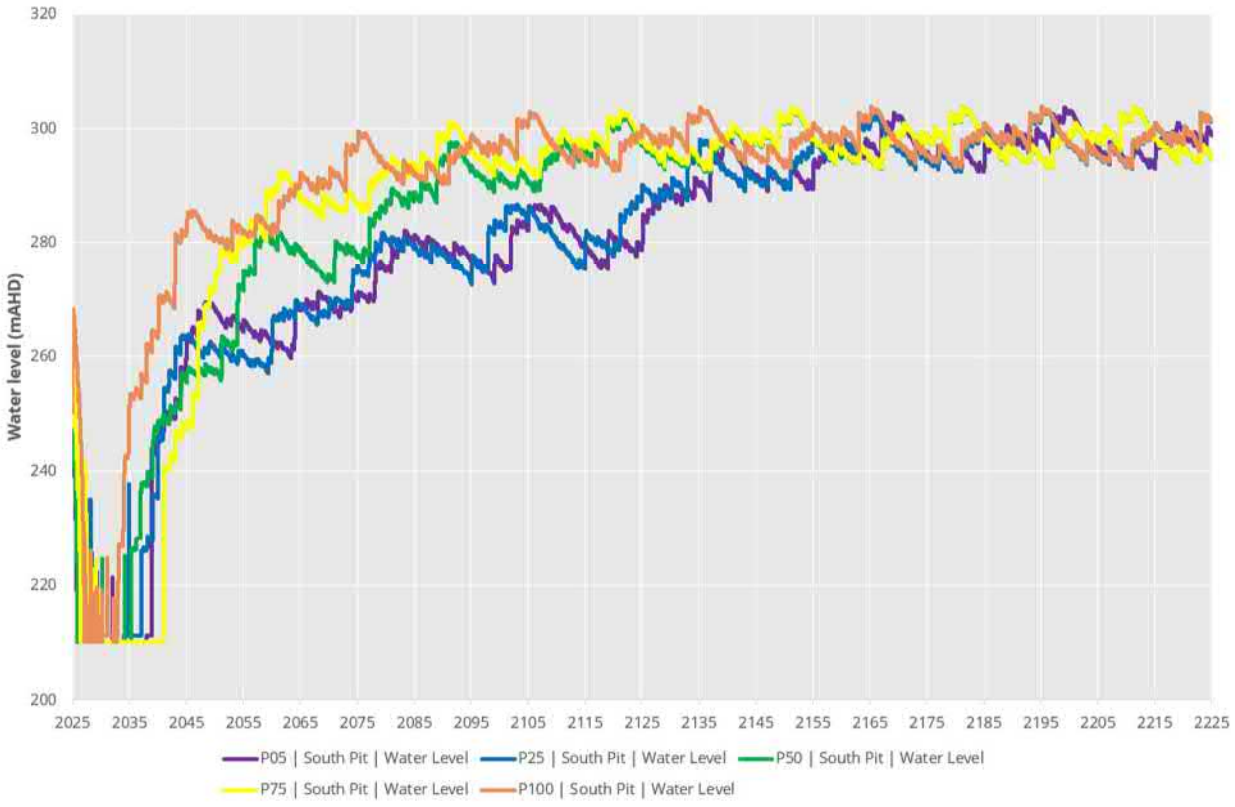


Figure 5 Long-term (200 yrs) South Pit water levels (5 climate scenarios)

Figure 6 Long-term (200 yrs) North Pit water levels (5 climate scenarios)

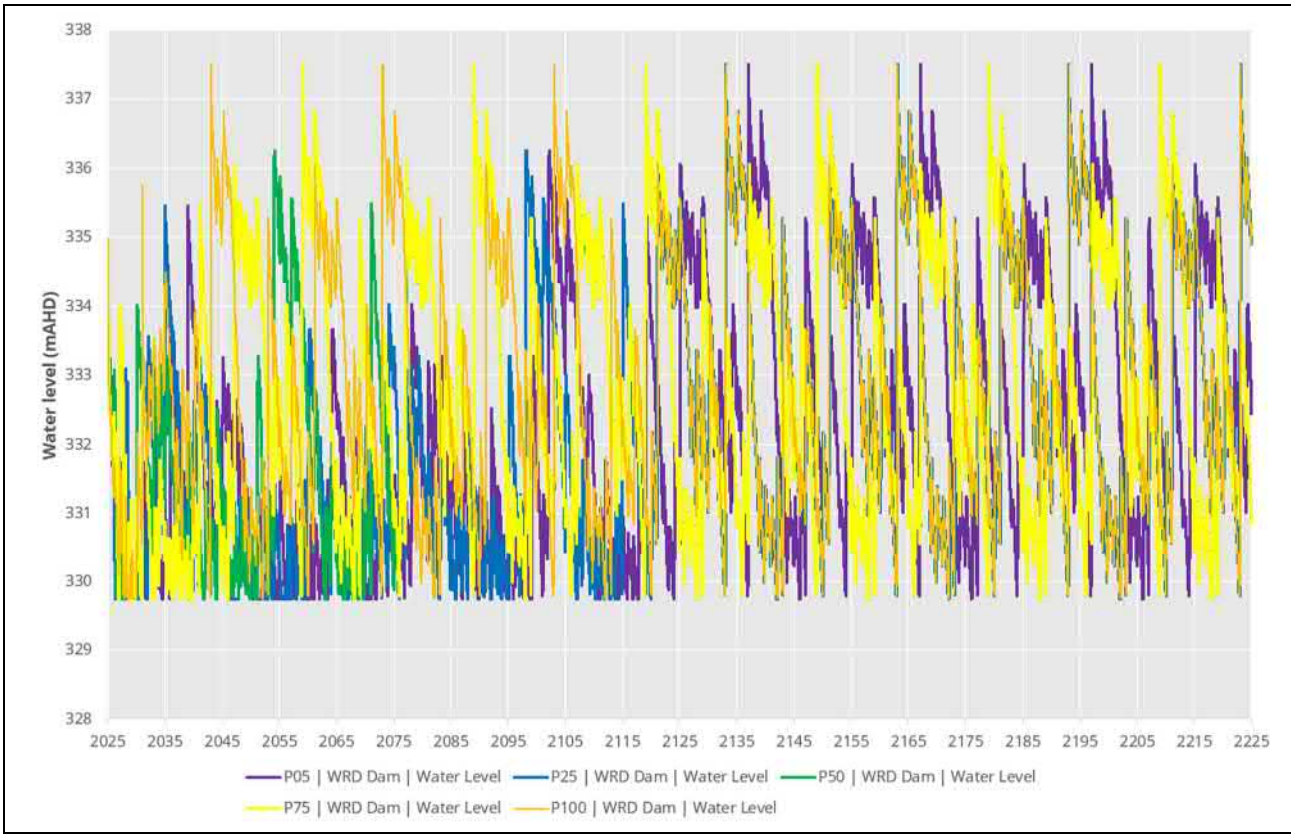


Figure 7 Long-term (200 yrs) WRD Sediment Dam water levels (5 climate scenarios)

5.3.3 Statistical extrapolation of water quality results

The 2023 modelled water quality results (Appendix D.2) indicate that the analyte concentrations in the open pits and sediment dam generally stabilise after 55 years, with water quality determined by the interaction between rainfall, runoff and evaporation. This is demonstrated by the asymptotic flattening of the water quality time series.

Statistical extrapolation/curve fitting of the 2023 modelling results and trends was undertaken to assess the long-term (i.e. 200-yrs) water quality. As the water quality modelling results of the P25 scenario (i.e. 75% percentile), statistical curve fitting was applied to this data.

Appendix D.3 presents the results of the statistical curve fitting for the North Pit, South Pit and WRD Sediment Dam. The curve-fitting equations were used to extrapolate the water quality results from 55 years to 200 years (i.e. from 21,080 to 73,049 days). Table 3 presents the extrapolated results, together with the ANZECC Livestock Water Quality Guidelines and the PRCP schedule PRCP EPML02840015 – Water quality limits for North and South Pits and WRD Sediment Dam.

Table 3 Extraplated long-term (200-yrs) final void water quality concentrations (mg/L)

Analyte	Guideline values	Extrapolated concentration after 200 years		
		North Pit	South Pit	WRD Sediment Dam
Calcium	500 (2) 1000 (1)	192.8	108.0	5.4
Magnesium	150 (2) 2000 (1)	114.2	67.2	2.4
Sodium	-	308.2	208.1	37.9
Potassium	-	80.9	25.3	1.6

Analyte	Guideline values	Extrapolated concentration after 200 years		
		North Pit	South Pit	WRD Sediment Dam
Sulfate	2,000 (1)	298.3	507.5	25.3
Chloride	-	755.0	270.8	5.9
Fluoride	2 (1)(2)	1.2	0.8	0.06
Aluminium	5 (1)	0.0793	0.0091	<LOR
Arsenic	0.5 (1)(2)	0.0127	0.0043	0.0002
Barium	-	0.3421	0.0668	<LOR
Chromium	1 (1)	0.0005	0.0004	<LOR
Copper	1 (1)(2)	0.0423	0.0149	0.0005
Manganese	1 (2)	1.0261	0.0019	<LOR
Molybdenum	0.15 (1)	0.0148	0.0256	0.0025
Nickel	1 (1)	0.0060	0.041	0.0004
Total Dissolved Solids	5,000 (1)(2)	2179	1430	49.7
Uranium	0.2 (1)	0.0203	0.0123	0.003
Zinc	20 (1)(2)	0.0096	0.0130	<LOR
pH	6.5 - 8.5	7.849	8.03	8.35

(1) ANZECC 2000 Livestock (beef cattle) drinking water quality guidelines

(2) PRCP schedule PRCP EPML02840015 – Tabe 5: Water quality limits for North and South Pits and WRD Sediment Dam

The long-term (200-yrs) water quality levels remain below the adopted guidelines.

5.3.4 Conclusions

Long-term water quality in the pits and voids is determined by climatic conditions and geochemical reactions and tends to stabilise. The net flow balance between rainfall runoff plus groundwater inflow and evaporation determines short-term variations.

Based on the WQM results, the North Pit, South Pit and WRD Sediment Dam are considered suitable as PMLUs for livestock watering.

6 References

Barnett et al. (2012). *Australian groundwater modelling guidelines.* Waterlines report, National Water Commission, Canberra.

Cook, P., Black, S., Cote, C., Kahe, M., Linge, K., Oldham, C., . . . Wallis, I. (2021). *Hydrological and geochemical processes and closure options for below water table open pit.* CRC TiME Limited.

Hill, M. (2006). The practical use of simplicity in developing groundwater models. *Groundwater, 44(6)*, 775-81.

Marinelli, F., & Niccoli, W. (2000). Simple Analytical Equations for Estimating Groundwater Inflow to a Mine Pit. *Groundwater, 39*(No. 2), 311-314.

State of Queensland. Department of Natural Resources, Mines and Energy. (October 2020). *Guideline. Quantifying the volume of associated water taken under a mining lease or mineral development licence.*

WMV Environmental. (March 2024). *Barbara Copper Project UG EA Amendment. Groundwater Technical Report.* Prepared for Aeris Resources Limited.

7 Limitations

This technical memo has been prepared by WMV Environmental Pty Ltd for Round Oak Minerals Ltd/Aeris Resources Limited and may only be used and relied upon by Round Oak Minerals Ltd/Aeris Resources Limited for the purpose agreed between WMV Environmental and Round Oak Minerals Ltd/Aeris Resources Limited as set out in this memo.

WMV Environmental Pty Ltd accepts no duty of care or liability to any third parties who may use or rely on this memo other than as expressly agreed by WMV Environmental Pty Ltd. Without limiting the foregoing sentence in any way, in no circumstances will WMV Environmental Pty Ltd be liable to any third party whether that liability arises in contract, tort (including negligence or breach of statutory duty) or otherwise for any loss whatsoever arising out of or in any way related to this site investigation project. WMV Environmental Pty Ltd consents to the Department of Environment, Science and Innovation considering this memo.

The services undertaken by WMV Environmental Pty Ltd in connection with preparing this memowere limited to those specifically detailed in the memoand are subject to the scope limitations set out in the memo.

The opinions, conclusions, and recommendations in this memoare based on conditions encountered and information reviewed at the date of preparation of the memo. Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this memo. WMV Environmental Pty Ltd does not accept responsibility arising from, or in connection with, any change to the site conditions. WMV Environmental Pty Ltd is also not responsible for updating this memoif the site conditions change.

The opinions, conclusions and any recommendations in this memo are based on assumptions made by WMV Environmental Pty Ltd described in this memo. WMV Environmental Pty Ltd disclaims liability arising from any of the assumptions being incorrect.

For the purposes of this memo, WMV Environmental Pty Ltd may have relied upon previous investigations carried out and a review of available reports. It is assumed by WMV Environmental Pty Ltd that all relevant information and reports have been provided by those persons from whom it has been requested and that such information provided is accurate.

Any advice, opinions, or recommendations contained in this document should be read and relied upon only in the context of the document as a whole and should be considered current to the date of this document. WMV Environmental Pty Ltd believes that its opinions are reasonably supported by the testing and analysis that have been done and that those opinions have been developed according to the professional standard of care for the environmental consulting profession in this area at this time.

That standard of care may change, and new methods and practices of exploration, testing, analysis and remediation may develop in the future, which might produce different results. WMV Environmental Pty Ltd professional opinions contained in this document are subject to modification if additional information is obtained through further investigation, observations, or testing and analysis during any future assessment or remedial activities.

This document may only be reproduced in its entirety.

Appendix A Analytical models versus numerical models

A.1 Analytical model justification

A.1.1 Introduction

The assessment of the final void hydrogeology and groundwater impact assessment, as described in the Groundwater Technical Report, was based on:

- final void water balance modelling (ATC William, 2023ba, ATC Williams, 2024)
- water quality modelling of the open pits and WRD Sediment Dam undertaken by ATC Williams (ATC William, 2023b) with further interpretation of the data by WMV Environmental (2023)
- underground workings final void water quality modelling.

The final void hydrogeology and groundwater impact assessment included the following:

1. An assessment of the extent and level of drawdown from the open pits and proposed underground mining and potential impacts on surface water bodies.
1. An assessment of the level of groundwater inflow into the open pits and underground workings as input into the water balance model.
2. An assessment of final void water quality and impacts on environmental values.
3. An assessment of final underground workings water quality and impacts on environmental values.
4. An open pits stratification assessment

Items 1 to 4 required groundwater modelling either to provide input data for water balance and water quality models or to allow direct assessment of potential impacts.

WMV Environmental's approach to groundwater modelling included the initial development of analytical models instead of 3D numerical groundwater models. This approach was based on the following considerations:

- The hydrogeological conceptual model developed for BCP forms the basis for the analytical models. Any numerical groundwater model would be based on the same conceptual model.
- Groundwater models can be simple, like one-dimensional analytical solutions, spreadsheet models or very sophisticated three-dimensional models. It is recommended to start with a simple model as long as the model concept satisfies the modelling objectives, and then the model complexity can be increased (Hill, 2006).
- Analytical models are based on the same scientific equations and calculations as numerical models but include some simplifications (e.g. steady-state models only). The analytical models represent the open pits and underground workings as large-diameter wells with a radius and depth representative of the final void volume and depth during the different stages of mining/dewatering.
- A complex, 3D numerical model does not guarantee better results or predictions than analytical models. Analytical models can be applied relatively quickly to assess groundwater impacts at a high level. If the risks to the receiving environment, as determined through the analytical models, are low/negligible and manageable, it is not necessary to implement more complex numerical groundwater models.

Given the fact that groundwater at BCP is primarily associated with the orebody itself, the relative impermeability (i.e. low hydraulic conductivity) of the aquifers and the short duration of the underground mining (i.e. four years), analytical models are considered appropriate for the initial assessment of groundwater impact assessment.

The analytical models have been used to assess groundwater impacts under steady-state conditions. Steady-state models are generally used when the long-term average state of a groundwater system is to be known, while transient groundwater models are useful when one needs to observe the system in a short time. The groundwater impact assessment aims to assess potential long-term risks over time frames from 25 to 200 years after closure. Therefore, steady-state analytical models are considered appropriate.

A.1.2 References to the use of analytical models

Several documents refer to the use of analytical models.

The guideline "*Quantifying the volume of associated water taken under a mining lease or mineral development licence*" (State of Queensland. Department of Natural Resources, Mines and Energy., October 2020) was prepared under the *Mineral Resources Act 1989* and *Mineral Resources Regulation 2013* to assist mining tenure holders to measure, estimate and report the volume of associated water taken.

The three approved methods under section 31A(2)(b) of the Regulation that can be used to estimate and quantify associated water taken during mining operations or after mine closure are:

- water balance calculations
- numerical groundwater models
- analytical groundwater models.

The guideline recognises that:

> *Using an analytical groundwater model is most suited to simple mine situations to overcome the data requirements and costs associated with numerical groundwater models. The analytical solutions, specifically developed to estimate the fluxes of associated water to mines, described by Marinelli and Niccoli (2000), Powers et al (2007) and Hazel (2009) are in common usage for estimating groundwater flow to mines.*
>
> *....*
>
> *These analytical groundwater solutions have many simplifying assumptions, commonly including steady state conditions and uniform aquifer properties. It is noted that natural hydrogeological systems include complexities that may violate the simplifying assumptions of analytical models. For that reason, care is needed when choosing to use an analytical method because they can potentially provide relatively low accuracy estimates.*

The *Australian Groundwater Modelling Guidelines* (Barnett et al, 2012) provide some information on the use of analytical versus numerical models, as follows:

- An analytical model makes simplifying assumptions (e.g. properties of the aquifer are considered to be constant in space and time) to enable a solution of a given problem, e.g. the level of groundwater inflow into the open pits and underground workings.
- Numerical models are usually solved by a computer and are usually more computationally demanding than analytical models.
- Analytical and numerical models can each be beneficial, depending on the objectives of a particular project.
- Guiding Principle 11.8: Analytical solutions should be used to develop an understanding of the nature of surface water–groundwater interaction prior to regional scale numerical modelling, or in parallel with such modelling as a way of checking the numerical modelling.

The report "*Hydrological and geochemical processes and closure options for below water table open pit mines*" (Cook, et al., 2021) discusses the use of analytical versus numerical models. The report acknowledges that several analytical models have been specifically developed to estimate the volumes of groundwater required to be pumped to dewater large mines and the extent of drawdown (e.g., Marinelli and Niccoli, 2000; Thiess).

A.2 Sichardt's equation for radius of influence

A "radius of influence" is defined as the maximum distance at which drawdown can be detected with the usual measure devices in the field (Dragoni, 1999). Empirical, analytical formulas can be used to calculate the radius of influence around a void that can be represented by a large diameter pumping well.

The radius of influence, R, can be estimated using Sichardt's equation (Powers, 1992) as follows:

$$R = 3000\ (H - h)\sqrt{K_{sat}} + r_0$$

with: R = radius of influence [m]

H = groundwater level at extent of drawdown (i.e. regional groundwater level) [mAHD]

h = water level in the void [mAHD]

s = (H – h) = drawdown in the void

K_{sat} = saturated hydraulic conductivity [m/s]

r_o = equivalent well radius, calculated taking into consideration the void geometry as

$$r_0 = \sqrt{\frac{a \times b}{\pi}}$$ with a= average height of the void; b = average width of the void

A.3 Marinelli and Niccoli equation for groundwater inflow

Plate 1 presents the conceptual model used by the analytical equations of Marinelli and Niccoli to calculate the groundwater inflow into a mine pit.

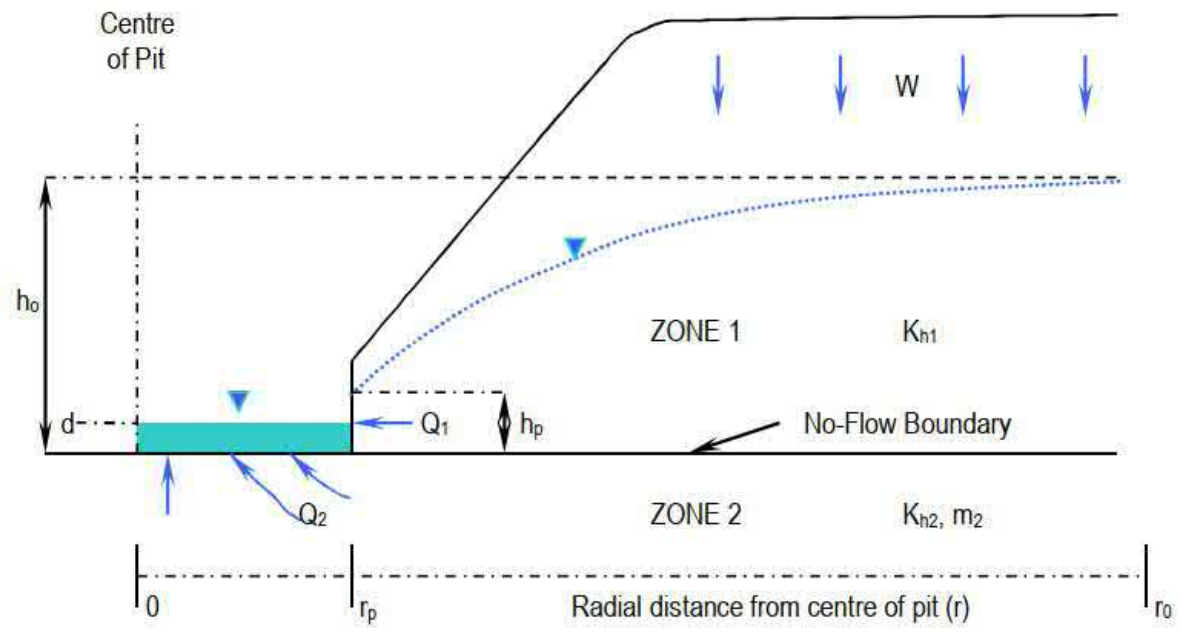


Plate 1 Mine pit inflow conceptual model (Marinelli & Niccoli, 2000)

With Marinelli and Niccoli's method, groundwater flow into a mine pit/underground works is divided into two zones, with Zone 1 representing lateral flow through the pit/underground workings walls and Zone 2 the inflows from the base of the pit/underground working. Table A.1 presents the equations and assumptions used to calculate the groundwater inflows from each zone.

Table A.1 Groundwater inflow into mine pit equations and assumptions

Zone 1	Zone 2
Inflow Equations	
$Q_1 = W \pi (r_0^2 - r_p^2)$	$Q_2 = 4 r_p \left(\frac{K_{h2}}{m_2}\right) (h_0 - d)$ $m_2 = \sqrt{\frac{K_{h2}}{m_2}}$
Q_1 = volumetric flow rate from Zone 1 W = recharge flux r_0 = radius of influence r_p = effective pit radius	Q_2 = volumetric flow rate from Zone 2 K_{h2} = horizontal hydraulic conductivity K_{v2} = vertical hydraulic conductivity m_2 = anisotropy parameter h_0 = pre-mining saturated thickness above base of Zone 1 d = depth of water in pit
Assumptions	

Zone 1	Zone 2
• Pit walls are approximated as a circular cylinder. • Groundwater flow is horizontal and the Dupuit-Forchheimer approximation can be used to account for changes in saturated thickness due to depression of the water table. • The static (pre-mining) water table is approximately horizontal. • Uniform distributed recharge occurs across the site as a result of surface infiltration from rainfall. • All recharge within the radius of influence (cone of depression), of the pit is assumed to be captured by the pit. • Groundwater flow toward the pit is axially symmetric. • The aquifer is infinite in extent (i.e. the cone of depression does not encounter any zero recharge boundaries).	• Hydraulic head is initially uniform (hydrostatic) throughout Zone 2. Initial head is equal to the elevation of the initial water table in Zone 1. • The disk sink has a constant hydraulic head equal to the elevation of the pit lake water surface. If the pit is completely dewatered, the disk sink head is equal to elevation of the pit bottom. • Flow to the disk sink is three-dimensional and axially symmetric. • Materials within Zone 2 are anisotropic, and the principal coordinate directions for hydraulic conductivity are horizontal and vertical.

Appendix B Sensitivity/uncertainty analysis

B.1 Approach to sensitivity/uncertainty analyses

B.1.1 Introduction

Table B.1 presents the analytical models/equations used for the groundwater impact assessment and the parameters/variables used in the analytical equations.

The main groundwater-related calculations that are used directly for the impact assessment or feed into other models are:

- calculations of the extent and level of drawdown (i.e. radius of influence) during and post-mining to:
  - assess potential impacts on GDEs
  - provide input into groundwater inflow into voids calculations
- calculations of groundwater inflows into open pits and underground voids to provide input into water balance model calculations.

The results of the water balance models provide the inputs for the water quality models.

Table B.2 presents the values of the parameters adopted in the analytical models/equations.

Table B.1 Analytical models/equations and input parameters/variables

Purpose	Extent and level of drawdown around voids	Groundwater inflow into voids	BCP Water Balance Model	Final void water quality model – Pits and Sediment Dam	Underground void water quality model	PAF disposal to underground voids
Analytical model /equations	Sichardt's equation	Marinelli & Nicolli, 2000	ATC Williams Goldsim WBMs (2023 and 2024)	ATCW 2023 PHREEQC model, linked to WBMs	ATCW Goldsim WBM (2024) + Mixing model	PHREEQC mass balance/mixing model
Calculations						
Calculated Parameters	Radius of drawdown influence	Groundwater inflow by depth	BCP water balance	Open pit and sediment dam long-term water quality	Long-term BCP water balance + underground void water quality	Long-term underground void water quality
Input Parameters						
Water balance volumes	✗	✗	Calculated	✓	Calculated	✓
Groundwater inflow	✗	Calculated	✓	✗	✓	✗
Rainfall recharge to groundwater	✗	✓	✗	✗	✗	✗
Radius of influence	Calculated	✓	✗	✗	✗	✗
Equivalent void radius	✓	✓	✗	✗	✗	✗
Horizontal hydraulic conductivity	✓	✓	✗	✗	✗	✗
Vertical hydraulic conductivity	✗	✓	✗	✗	✗	✗
Pre-mining groundwater levels/ saturated thickness	✓	✓	✗	✗	✗	✗
Water level/volume in void	✓	✓	✗	✗	✗	✓
Water quality (input)	✗	✗	✗	✓	✓	✓
Water quality (output)	✗	✗	✗	Calculated	Calculated	Calculated

✓: required as input parameter ✗: not required as input parameter

Table B.2 Analytical models/equations input parameter values

Parameter	Adopted value	North Pit	South Pit	Underground Void	Source/ comments
Rainfall recharge to groundwater	0.000025 m/day	NA	NA	NA	Assumed 2% of long-term annual rainfall in Mt Isa (461 mm/year)
Radius of influence – open pits	NA	100m	200m	NA	Based on the distance from the centre of the north pit to groundwater bore BAWB04, considered to represent the actual extent of the cone of depression due to mining.
Radius of influence – underground void	NA	NA	NA	100m	Based on the distance from the centre of the north pit to groundwater bore BAWB04, considered to represent the actual extent of the cone of depression due to mining.
Equivalent void radius	NA	Calculated	Calculated	Calculated	Calculated from open pits and underground void dimensions.
Horizontal hydraulic conductivity	2.29 10^{-08} m/s or 0.00198 m/day	NA	NA	NA	Based on 2013/2014 site investigations Assumed to decrease with depth.
Vertical hydraulic conductivity	0.00020 m/day	NA	NA	NA	10% of horizontal hydraulic conductivity
Pre-mining groundwater levels/ saturated thickness					
Water level/volume in void	NA	Calculated	Calculated	Calculated	Calculated based on void geometry, initial water storage volume and net water balance (i.e. difference between inflow and outflow as determined through the WBM).
Water quality (input)					

The input parameter values are considered appropriate and are, to the extent possible, based on existing data and information. The analytical modelling undertaken to date is described in detail in the Groundwater Technical Report (WMV Environmental, March 2024).

Sensitivity/uncertainty analyses were not undertaken, as it was considered that steady-state analytical models are generally conservative. Steady-state models do not take into account limitations and constraints associated with specific yield and storativity of the aquifer or with physical boundary conditions.

As mentioned above, DESI raised a concern regarding "*the lack of sensitivity analyses being conducted on the groundwater models. Understanding the potential variation in model output/s based on the varied input/s would assist with the decision making. This can be achieved by considering a range of realistic scenarios (both during the past and current predictions)*".

To address DESI's concerns, the results of sensitivity analyses on the analytical models are presented in this technical memo.

B.1.2 Sensitivity/uncertainty analysis for analytical models

As detailed in the Australian Groundwater Modelling Guidelines (Barnett et al, 2012) :

> *Guiding Principle 5.5: Sensitivity analysis should be performed to compare model outputs with different sets of reasonable parameter estimates, both during the period of calibration (the past) and during predictions (in the future).*

Section 5.5 of the Australian Groundwater Modelling Guidelines provides more detail regarding sensitivity analyses and their relationship with uncertainty analyses. However, it must be noted that the description and proposed approach relate to 2-D or 3-D numerical calibrated groundwater models. As part of the calibration or predictive stage, model parameters can be changed either manually or through specialised software (e.g. PEST) to assess the influence of the parameter changes on the model calibration or predictions.

With respect to the sensitivity/uncertainty analyses of the analytical models, the following needs to be considered:

- The analytical model used to assess the potential impacts of mining on groundwater-dependent ecosystems calculates the level and extent of drawdown around open pits and voids. The horizontal hydraulic conductivity is the only model parameter on which a sensitivity analysis can be undertaken.
- The analytical model used to calculate groundwater inflows into the open pits/voids provides input into the water balance and quality models. Model input parameters for sensitivity analysis include rainfall recharge and horizontal and vertical hydraulic conductivity. An additional input parameter is the radius of influence, which the previous analytical model calculates.
- Input parameters for the water quality models include the water balance volumes, calculated through the Goldsim water balance models, and analyte concentrations of rainfall, runoff and groundwater inflow. As the analyte concentrations are based on literature values (for rainfall) or actual observed concentrations (e.g. 95th percentile of analysis data for surface water and groundwater), no sensitivity/uncertainty analysis is undertaken on the water quality input data.

Given that the output of the first analytical model (i.e. the extent and level of drawdown) provides an input into the second analytical model (i.e. calculation of groundwater inflow into open pits and voids), a combined sensitivity/uncertainty analysis has been undertaken.

B.1.3 Sensitivity/uncertainty analysis scenarios

Sensitivity/uncertainty analyses have been undertaken on two key input parameters of the analytical models, i.e. the horizontal hydraulic conductivity and the rainfall recharge to groundwater. The hydraulic conductivity has been changed by an order of magnitude, whilst the rainfall recharge coefficient has been changed by a factor of five. Table B.3 shows the parameter values adopted for the nine sensitivity analysis scenarios.

Table B.3 Sensitivity analysis scenarios and parameter values

	Horizontal hydraulic conductivity (m/s)		
Rainfall Recharge Coefficient (% of annual rainfall)	$2.29x10^{-09}$	$2.29x10^{-08}$	$2.29x10^{-07}$
0.4%	Scenario 1	Scenario 4	Scenario 7
2%	Scenario 2	Scenario 5	Scenario 8
10%	Scenario 3	Scenario 6	Scenario 9

It is noted that Scenario 5, highlighted in the above table, comprises the base scenario and parameters currently used in the analytical modelling described in the Groundwater Technical Report (WMV Environmental, March 2024).

B.1.4 Sensitivity/uncertainty analysis of drawdown radius of influence

A "radius of influence" is defined as the maximum distance at which drawdown can be detected with the usual measure devices in the field (Dragoni, 1999). Empirical, analytical formulas can be used to calculate the radius of influence around a void that can be represented by a large diameter pumping well.

The radius of influence, R, can be estimated using Sichardt's equation, as further detailed in Appendix A.1. The key parameters in Sichardt's equation are the void geometry, the drawdown in the void and the saturated hydraulic conductivity.

With respect to the sensitivity analysis:

- Void geometry is calculated from Aeris's actual and planned void dimensions. No sensitivity analysis is undertaken on this parameter.
- Drawdown in the void has been calculated as the difference between the regional, pre-mining groundwater level and the base of the void during and post mining.
- The value of saturated hydraulic conductivity was obtained from site investigations undertaken in 2013. Sensitivity analyses have been undertaken on this parameter.

As the rainfall recharge coefficient is not a parameter in Sichardt's equation, only three scenarios have been considered, i.e. Scenario 1, Scenario 4 and Scenario 7.

Sensitivity analysis results

Figure B.1, Figure B.2 and Figure B.3 show the modelled radius of drawdown influence (i.e. maximum extent) under the three adopted scenarios for the North Pit, South Pit and Underground Void, respectively.

As per Sichardt's equation, the higher the horizontal hydraulic conductivity, the larger the extent of drawdown. It is noted that the calculated radii are considered conservative and an overestimate of the actual radius of influence as:

- The empirical equations apply to "steady-state" (i.e. indefinite time) conditions only, without consideration of the temporal influence of storativity within the aquifers.
- The equations do not consider the decrease in saturated hydraulic conductivity with depth or the potential presence of boundary conditions (e.g. faults, lithological barriers).

Overall, the potential radius of influence would be much less than the empirically calculated radius and remain within the ML boundaries. Gauging of existing groundwater monitoring bores (BAWB01 to BAWB07, BAWBR01 to BAWBR03) does not show a significant impact of open-cut mining on groundwater levels.

Whilst the uncertainty in the horizontal hydraulic conductivity may affect the confidence in the analytical model results, this would only be the case for scenario 7, which was modelled with a hydraulic conductivity of $2.29x10^{-07}$ m/s. The modelled radii of influence under Scenario 7 are significantly larger than under Scenario 1 and Scenario 4. This uncertainty would filter through into the groundwater inflow calculations. However, the uncertainty does not affect the conclusions regarding the potential impact on terrestrial GDEs (Section 4).

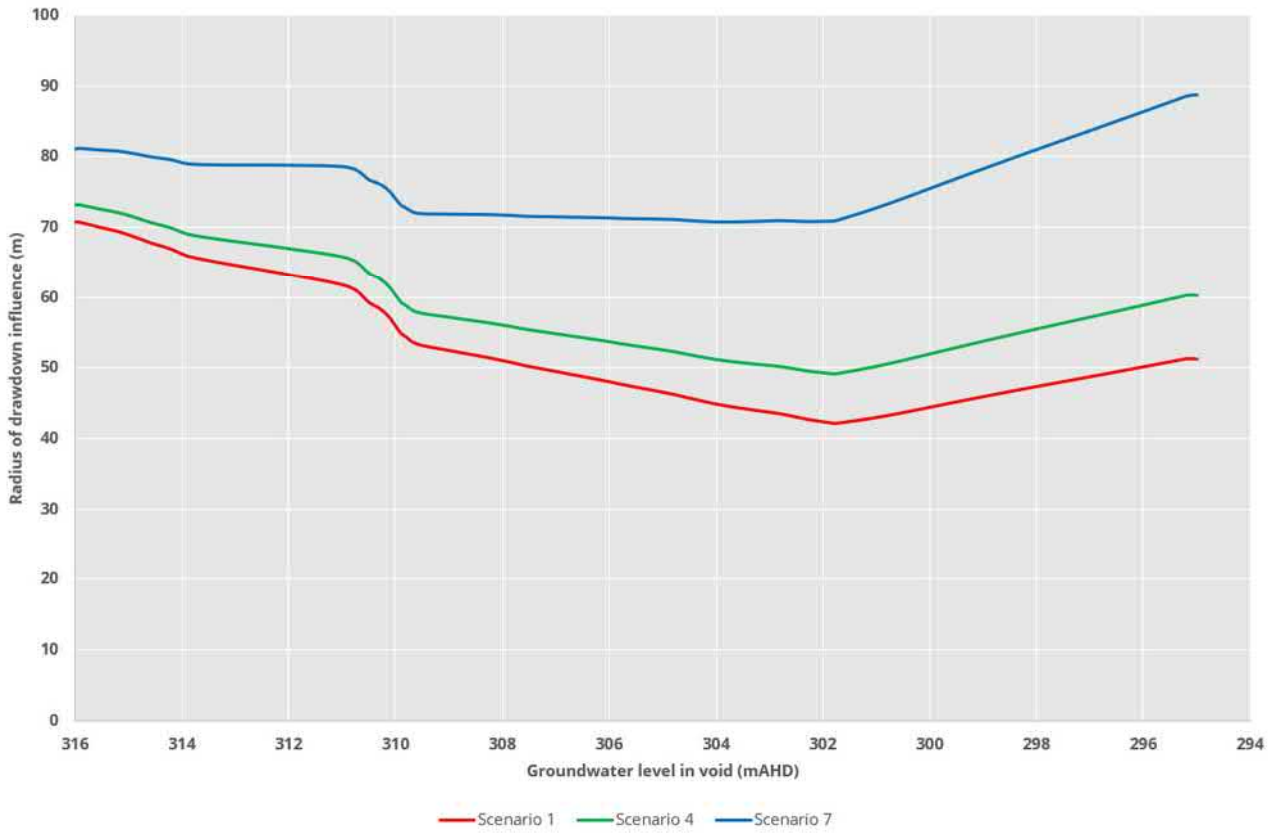


Figure B.1 North Pit radius of drawdown influence

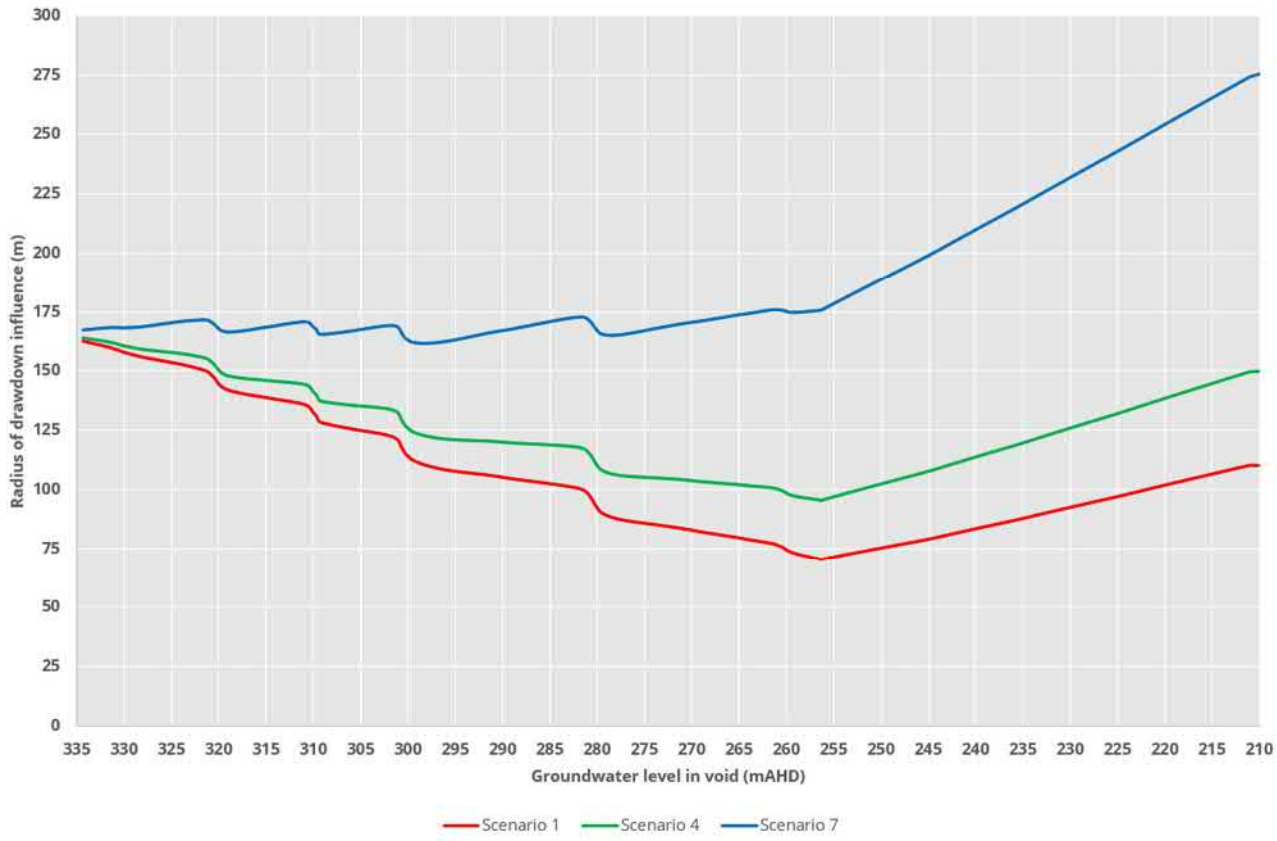


Figure B.2 South Pit radius of drawdown influence

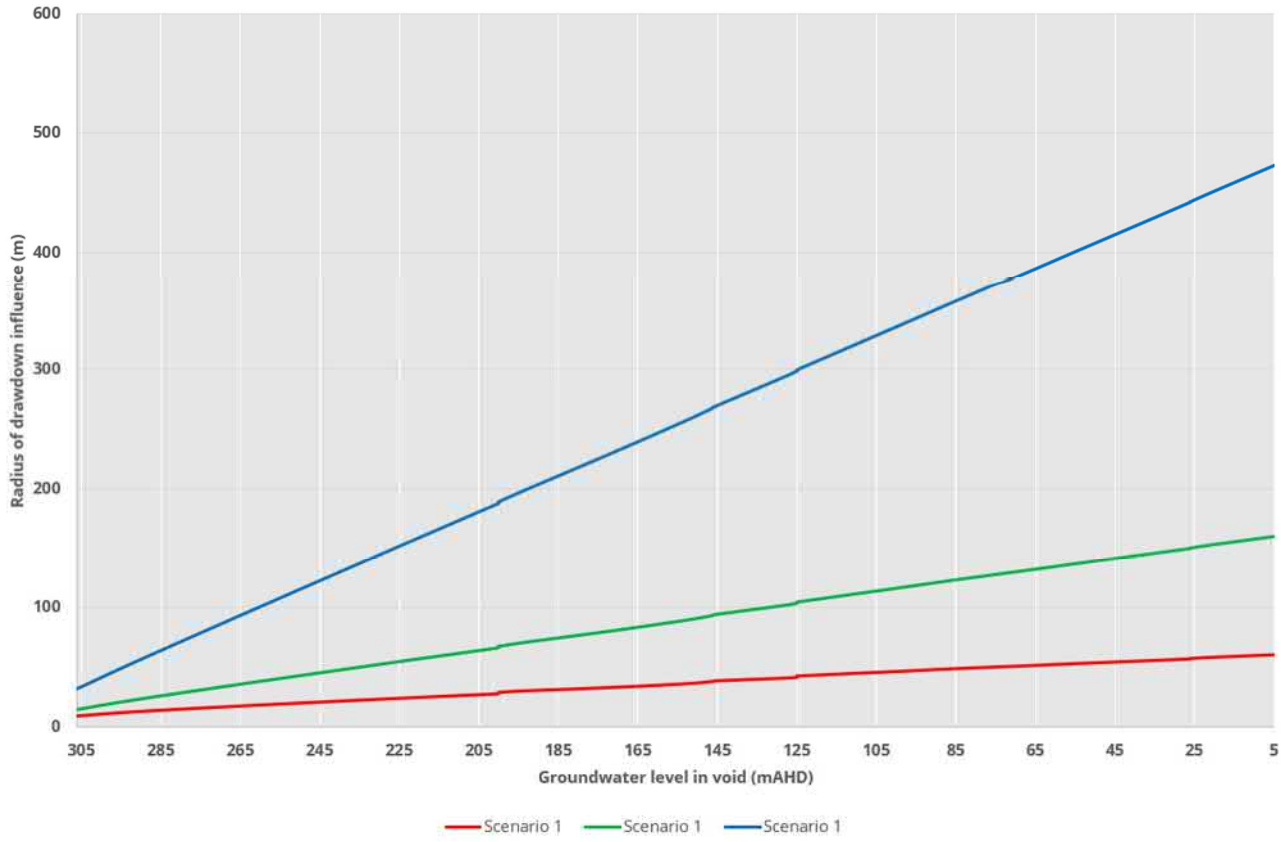


Figure B.3 Underground Void radius of drawdown influence

B.1.5 Sensitivity/uncertainty analysis of groundwater inflows into voids

The analytical models calculating groundwater inflows into the voids are based on the model by Marinelli and Nicolli. Appendix A.3 provides an overview of the Marinelli and Nicolli model.

The key parameters in the Marinelli and Niccoli model are the void geometry, the radius of influence, the rainfall recharge rate, the hydraulic and vertical conductivities, the pre-mining saturated thickness above the base of the void and the depth of water in the void.

With respect to the sensitivity analysis:

- Void geometry is calculated from Aeris's actual and planned void dimensions. No sensitivity analysis was undertaken on this parameter.
- The value of hydraulic conductivity was obtained from site investigations undertaken in 2013. Sensitivity analyses have been undertaken on this parameter.
- As the vertical hydraulic conductivity was set at 10% of the horizontal conductivity, no additional sensitivity analysis was undertaken on this parameter.
- A sensitivity analysis of rainfall recharge has been undertaken.
- Radius of influence has been calculated using Sichardt's equation. This model uses the hydraulic conductivity value. The two analytical models have been linked so that the sensitivity analysis on hydraulic conductivity filters through to the sensitivity analysis on the radius of influence.
- Pre-mining saturated thickness above the base of the void was calculated as the difference between the regional, pre-mining groundwater level and the base of the void during and post mining. No sensitivity analysis was undertaken on this parameter.
- Depth of water in the void was calculated from the void geometry. During mining, the voids are dewatered, and the depth of water has been set at 0 metres. Post-mining, water levels in the void are allowed to recover, and the depth of water has been calculated as the difference between the void level and the base of the void.

The nine scenarios presented in Table B.3 have been considered during the sensitivity analysis.

Sensitivity analysis results

Appendix B.2 includes the results of the sensitivity analysis calculations, with Appendix B.4 presenting examples of the calculations. Appendix B.3 presents graphs of the calculated groundwater inflows into the voids during (i.e. during dewatering) and post (i.e. during recovery) mining.

The sensitivity analysis results show that groundwater inflows under Scenarios 7, 8 and 9 (i.e. with horizontal hydraulic conductivity of 2.29 10^{-07} m/s) are more significant than under the other scenarios, mainly due to the increased horizontal conductivity. This increased conductivity has a two-fold and double effect, i.e. increasing the radius of influence (which affects the Zone 1 flow calculations) and the flow in Zone 2 calculations. The modelled groundwater inflows under these three scenarios are considered unrealistic. Whilst there are no specific measurements of groundwater inflow into the open pits or pit dewatering pumping rates, visual observations by site personnel during mining did not support the calculated groundwater inflows.

Figure B.4, Figure B.5 and Figure B.6 present the calculated inflows under Scenario 1, 3, 4 and 6 together with the groundwater inflow rates adopted in the Goldsim water balance models for the North Pit, South Pit and Underground Void, respectively.

The results show that the groundwater inflow rates adopted in the Goldsim water balance models are generally at the upper end of the inflows under scenarios 4 and 6, whilst inflows under scenarios 1 and 3 are generally lower than the Goldsim water balance model groundwater inflows.

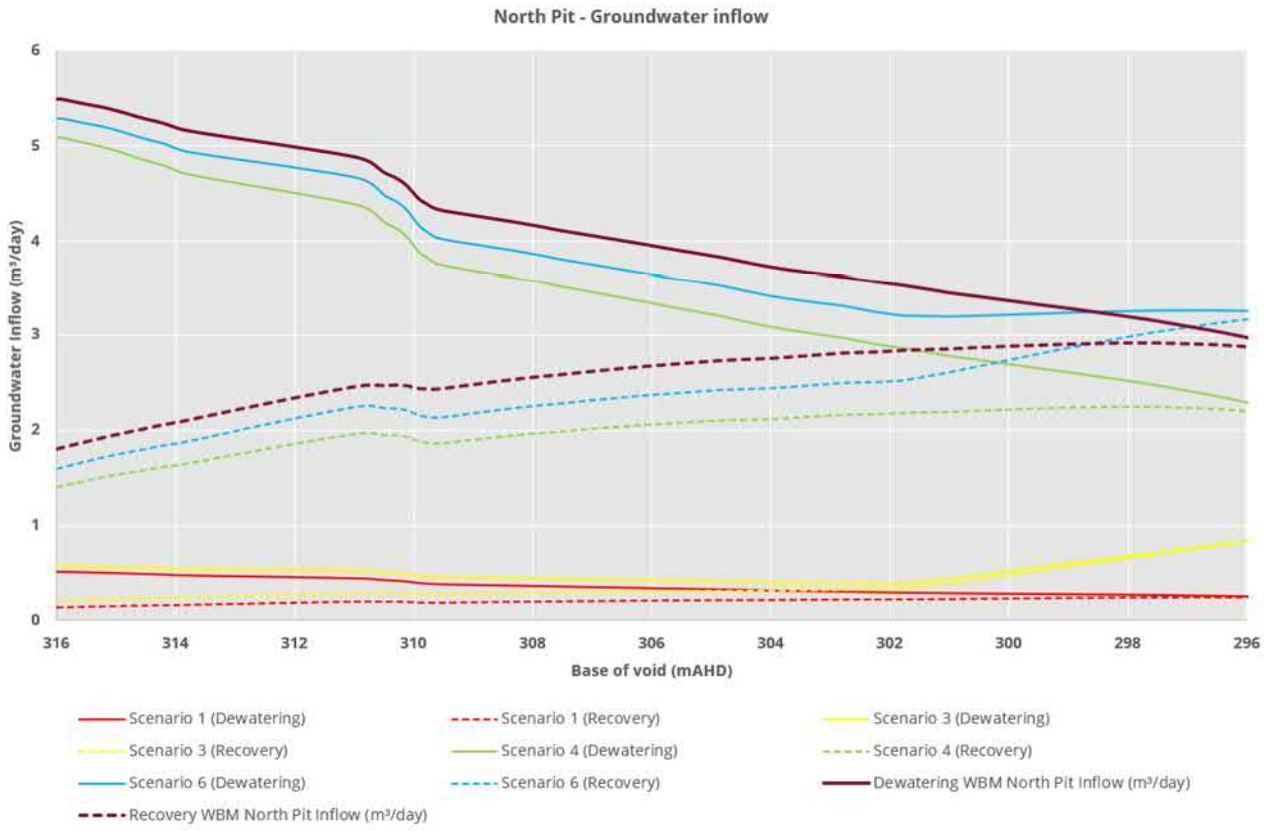


Figure B.4 North Pit groundwater inflows (Scenario 1, 3, 4 and 6 and Goldsim WBM)

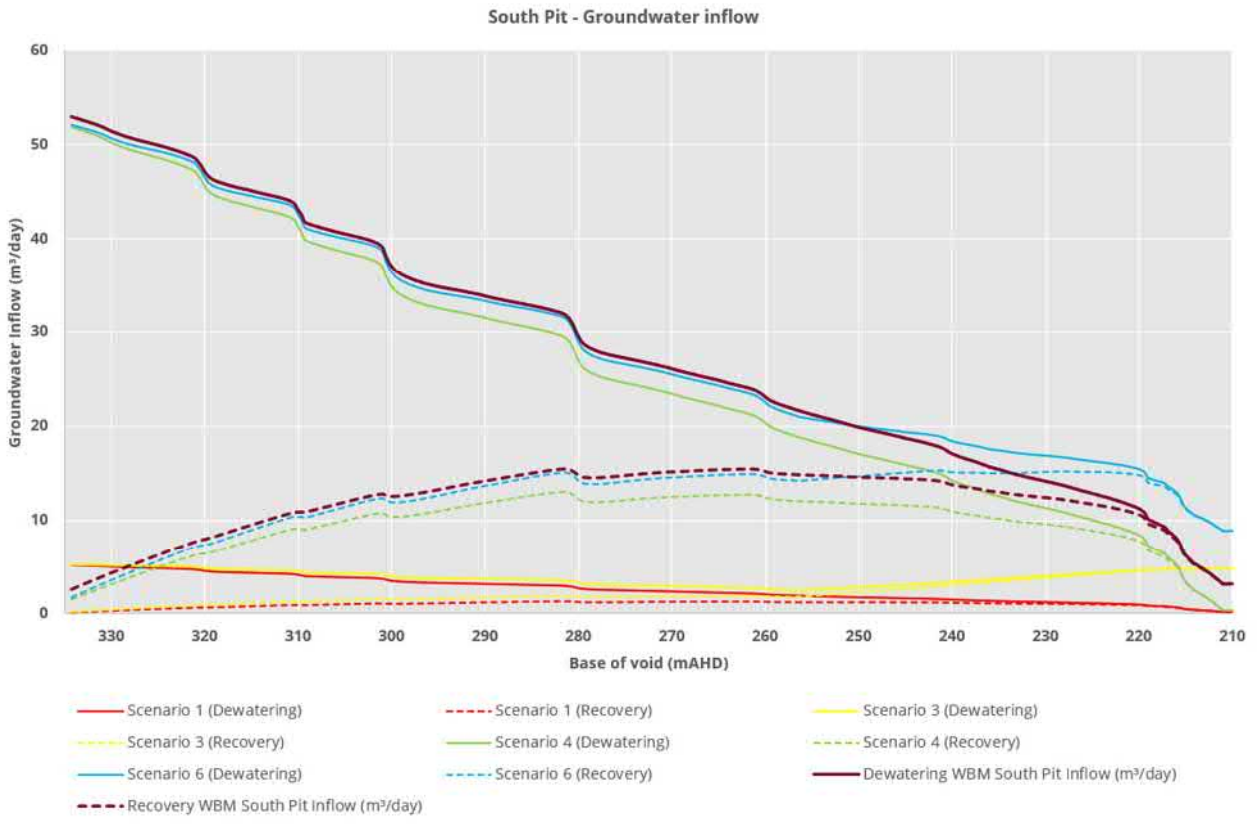


Figure B.5 South Pit groundwater inflows (Scenario 1, 3, 4 and 6 and Goldsim WBM)

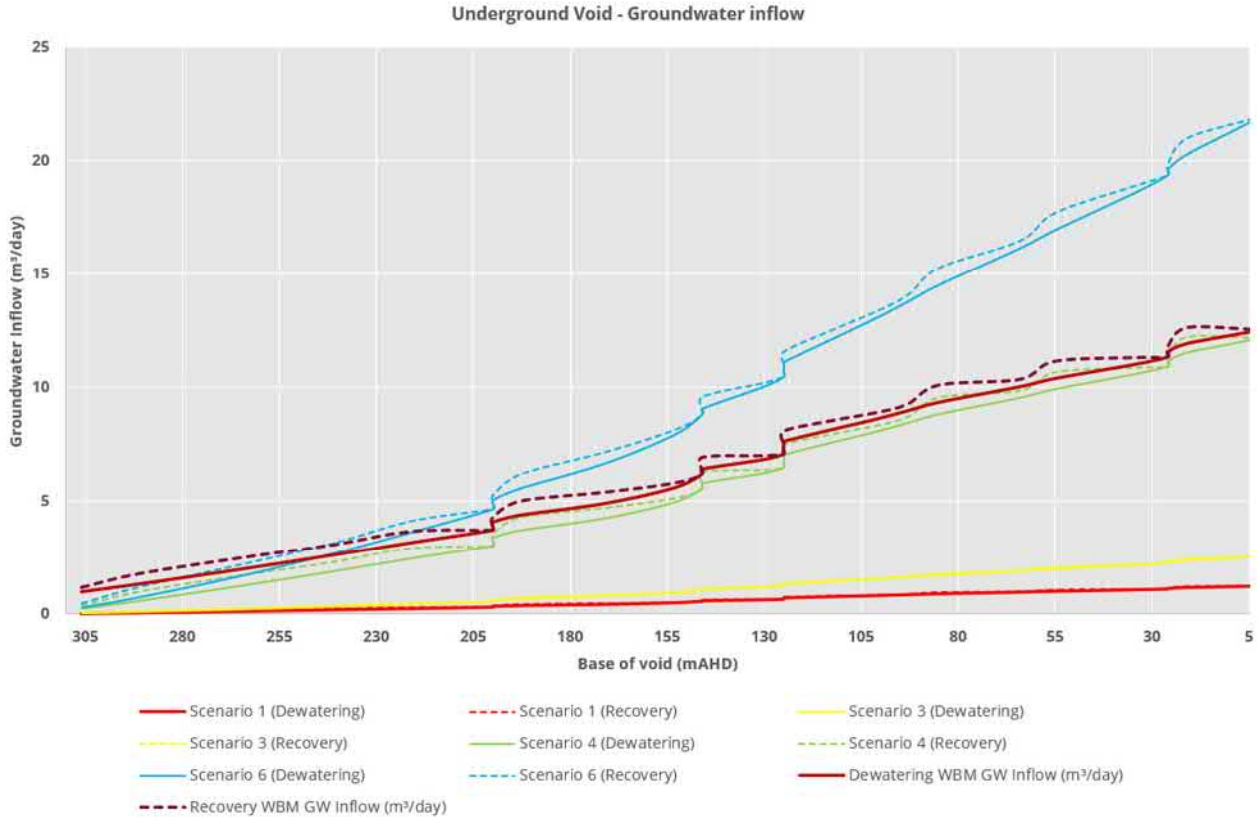


Figure B.6 Underground Void groundwater inflows (Scenario 1, 3, 4 and 6 and Goldsim WBM)

B.2 Sensitivity analyses results

North Pit Sensitivity Analysis Results

Stage	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)
316	70.746	70.746	70.746	70.746	70.746	70.746	73.229	73.229	73.229	73.229	73.229	73.229	81.082	81.082	81.082
315.95	70.753	70.753	70.753	70.753	70.753	70.753	73.252	73.252	73.252	73.252	73.252	73.252	81.154	81.154	81.154
315.9	70.704	70.704	70.704	70.704	70.704	70.704	73.219	73.219	73.219	73.219	73.219	73.219	81.170	81.170	81.170
315.8	70.518	70.518	70.518	70.518	70.518	70.518	73.063	73.063	73.063	73.063	73.063	73.063	81.112	81.112	81.112
315.7	70.332	70.332	70.332	70.332	70.332	70.332	72.909	72.909	72.909	72.909	72.909	72.909	81.056	81.056	81.056
315.6	70.136	70.136	70.136	70.136	70.136	70.136	72.743	72.743	72.743	72.743	72.743	72.743	80.989	80.989	80.989
315.5	69.949	69.949	69.949	69.949	69.949	69.949	72.587	72.587	72.587	72.587	72.587	72.587	80.931	80.931	80.931
315.4	69.776	69.776	69.776	69.776	69.776	69.776	72.446	72.446	72.446	72.446	72.446	72.446	80.888	80.888	80.888
315.3	69.611	69.611	69.611	69.611	69.611	69.611	72.311	72.311	72.311	72.311	72.311	72.311	80.852	80.852	80.852
315.2	69.415	69.415	69.415	69.415	69.415	69.415	72.146	72.146	72.146	72.146	72.146	72.146	80.785	80.785	80.785
315.1	69.197	69.197	69.197	69.197	69.197	69.197	71.960	71.960	71.960	71.960	71.960	71.960	80.696	80.696	80.696
315	68.947	68.947	68.947	68.947	68.947	68.947	71.741	71.741	71.741	71.741	71.741	71.741	80.576	80.576	80.576
314.9	68.688	68.688	68.688	68.688	68.688	68.688	71.513	71.513	71.513	71.513	71.513	71.513	80.446	80.446	80.446
314.8	68.414	68.414	68.414	68.414	68.414	68.414	71.270	71.270	71.270	71.270	71.270	71.270	80.301	80.301	80.301
314.7	68.128	68.128	68.128	68.128	68.128	68.128	71.015	71.015	71.015	71.015	71.015	71.015	80.145	80.145	80.145
314.6	67.852	67.852	67.852	67.852	67.852	67.852	70.770	70.770	70.770	70.770	70.770	70.770	79.998	79.998	79.998
314.5	67.605	67.605	67.605	67.605	67.605	67.605	70.554	70.554	70.554	70.554	70.554	70.554	79.880	79.880	79.880
314.4	67.391	67.391	67.391	67.391	67.391	67.391	70.371	70.371	70.371	70.371	70.371	70.371	79.795	79.795	79.795
314.3	67.166	67.166	67.166	67.166	67.166	67.166	70.177	70.177	70.177	70.177	70.177	70.177	79.699	79.699	79.699
314.2	66.909	66.909	66.909	66.909	66.909	66.909	69.951	69.951	69.951	69.951	69.951	69.951	79.571	79.571	79.571
314.1	66.591	66.591	66.591	66.591	66.591	66.591	69.664	69.664	69.664	69.664	69.664	69.664	79.382	79.382	79.382
314	66.236	66.236	66.236	66.236	66.236	66.236	69.340	69.340	69.340	69.340	69.340	69.340	79.157	79.157	79.157
313.9	65.944	65.944	65.944	65.944	65.944	65.944	69.080	69.080	69.080	69.080	69.080	69.080	78.994	78.994	78.994
313.8	65.759	65.759	65.759	65.759	65.759	65.759	68.926	68.926	68.926	68.926	68.926	68.926	78.938	78.938	78.938
313.7	65.594	65.594	65.594	65.594	65.594	65.594	68.792	68.792	68.792	68.792	68.792	68.792	78.903	78.903	78.903
313.6	65.437	65.437	65.437	65.437	65.437	65.437	68.666	68.666	68.666	68.666	68.666	68.666	78.875	78.875	78.875
313.5	65.296	65.296	65.296	65.296	65.296	65.296	68.555	68.555	68.555	68.555	68.555	68.555	78.862	78.862	78.862
313.4	65.156	65.156	65.156	65.156	65.156	65.156	68.446	68.446	68.446	68.446	68.446	68.446	78.852	78.852	78.852
313.3	65.016	65.016	65.016	65.016	65.016	65.016	68.338	68.338	68.338	68.338	68.338	68.338	78.841	78.841	78.841
313.2	64.878	64.878	64.878	64.878	64.878	64.878	68.231	68.231	68.231	68.231	68.231	68.231	78.832	78.832	78.832
313.1	64.743	64.743	64.743	64.743	64.743	64.743	68.127	68.127	68.127	68.127	68.127	68.127	78.827	78.827	78.827
313	64.609	64.609	64.609	64.609	64.609	64.609	68.024	68.024	68.024	68.024	68.024	68.024	78.822	78.822	78.822
312.9	64.484	64.484	64.484	64.484	64.484	64.484	67.930	67.930	67.930	67.930	67.930	67.930	78.826	78.826	78.826
312.8	64.349	64.349	64.349	64.349	64.349	64.349	67.826	67.826	67.826	67.826	67.826	67.826	78.820	78.820	78.820
312.7	64.227	64.227	64.227	64.227	64.227	64.227	67.735	67.735	67.735	67.735	67.735	67.735	78.827	78.827	78.827
312.6	64.091	64.091	64.091	64.091	64.091	64.091	67.630	67.630	67.630	67.630	67.630	67.630	78.821	78.821	78.821
312.5	63.965	63.965	63.965	63.965	63.965	63.965	67.535	67.535	67.535	67.535	67.535	67.535	78.824	78.824	78.824
312.4	63.827	63.827	63.827	63.827	63.827	63.827	67.428	67.428	67.428	67.428	67.428	67.428	78.815	78.815	78.815
312.3	63.699	63.699	63.699	63.699	63.699	63.699	67.331	67.331	67.331	67.331	67.331	67.331	78.816	78.816	78.816
312.2	63.567	63.567	63.567	63.567	63.567	63.567	67.230	67.230	67.230	67.230	67.230	67.230	78.813	78.813	78.813
312.1	63.427	63.427	63.427	63.427	63.427	63.427	67.121	67.121	67.121	67.121	67.121	67.121	78.803	78.803	78.803
312	63.286	63.286	63.286	63.286	63.286	63.286	67.011	67.011	67.011	67.011	67.011	67.011	78.791	78.791	78.791
311.9	63.148	63.148	63.148	63.148	63.148	63.148	66.904	66.904	66.904	66.904	66.904	66.904	78.782	78.782	78.782
311.8	63.008	63.008	63.008	63.008	63.008	63.008	66.795	66.795	66.795	66.795	66.795	66.795	78.771	78.771	78.771
311.7	62.868	62.868	62.868	62.868	62.868	62.868	66.686	66.686	66.686	66.686	66.686	66.686	78.760	78.760	78.760
311.6	62.731	62.731	62.731	62.731	62.731	62.731	66.580	66.580	66.580	66.580	66.580	66.580	78.753	78.753	78.753

North Pit Sensitivity Analysis Results

Stage	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)
311.5	62.591	62.591	62.591	62.591	62.591	62.591	66.471	66.471	66.471	66.471	66.471	66.471	78.742	78.742	78.742
311.4	62.454	62.454	62.454	62.454	62.454	62.454	66.365	66.365	66.365	66.365	66.365	66.365	78.734	78.734	78.734
311.3	62.301	62.301	62.301	62.301	62.301	62.301	66.243	66.243	66.243	66.243	66.243	66.243	78.710	78.710	78.710
311.2	62.141	62.141	62.141	62.141	62.141	62.141	66.115	66.115	66.115	66.115	66.115	66.115	78.680	78.680	78.680
311.1	61.981	61.981	61.981	61.981	61.981	61.981	65.986	65.986	65.986	65.986	65.986	65.986	78.649	78.649	78.649
311	61.805	61.805	61.805	61.805	61.805	61.805	65.840	65.840	65.840	65.840	65.840	65.840	78.602	78.602	78.602
310.9	61.590	61.590	61.590	61.590	61.590	61.590	65.656	65.656	65.656	65.656	65.656	65.656	78.516	78.516	78.516
310.8	61.266	61.266	61.266	61.266	61.266	61.266	65.363	65.363	65.363	65.363	65.363	65.363	78.321	78.321	78.321
310.7	60.800	60.800	60.800	60.800	60.800	60.800	64.928	64.928	64.928	64.928	64.928	64.928	77.984	77.984	77.984
310.6	60.059	60.059	60.059	60.059	60.059	60.059	64.219	64.219	64.219	64.219	64.219	64.219	77.373	77.373	77.373
310.5	59.299	59.299	59.299	59.299	59.299	59.299	63.490	63.490	63.490	63.490	63.490	63.490	76.742	76.742	76.742
310.4	58.865	58.865	58.865	58.865	58.865	58.865	63.087	63.087	63.087	63.087	63.087	63.087	76.437	76.437	76.437
310.3	58.434	58.434	58.434	58.434	58.434	58.434	62.686	62.686	62.686	62.686	62.686	62.686	76.135	76.135	76.135
310.2	57.839	57.839	57.839	57.839	57.839	57.839	62.123	62.123	62.123	62.123	62.123	62.123	75.669	75.669	75.669
310.1	57.043	57.043	57.043	57.043	57.043	57.043	61.357	61.357	61.357	61.357	61.357	61.357	75.002	75.002	75.002
310	55.970	55.970	55.970	55.970	55.970	55.970	60.316	60.316	60.316	60.316	60.316	60.316	74.059	74.059	74.059
309.9	54.945	54.945	54.945	54.945	54.945	54.945	59.322	59.322	59.322	59.322	59.322	59.322	73.163	73.163	73.163
309.8	54.391	54.391	54.391	54.391	54.391	54.391	58.799	58.799	58.799	58.799	58.799	58.799	72.739	72.739	72.739
309.7	53.772	53.772	53.772	53.772	53.772	53.772	58.211	58.211	58.211	58.211	58.211	58.211	72.249	72.249	72.249
309.6	53.418	53.418	53.418	53.418	53.418	53.418	57.888	57.888	57.888	57.888	57.888	57.888	72.023	72.023	72.023
309.5	53.201	53.201	53.201	53.201	53.201	53.201	57.702	57.702	57.702	57.702	57.702	57.702	71.936	71.936	71.936
309.4	53.049	53.049	53.049	53.049	53.049	53.049	57.582	57.582	57.582	57.582	57.582	57.582	71.914	71.914	71.914
309.3	52.909	52.909	52.909	52.909	52.909	52.909	57.472	57.472	57.472	57.472	57.472	57.472	71.902	71.902	71.902
309.2	52.774	52.774	52.774	52.774	52.774	52.774	57.368	57.368	57.368	57.368	57.368	57.368	71.896	71.896	71.896
309.1	52.643	52.643	52.643	52.643	52.643	52.643	57.268	57.268	57.268	57.268	57.268	57.268	71.894	71.894	71.894
309	52.500	52.500	52.500	52.500	52.500	52.500	57.156	57.156	57.156	57.156	57.156	57.156	71.881	71.881	71.881
308.9	52.366	52.366	52.366	52.366	52.366	52.366	57.054	57.054	57.054	57.054	57.054	57.054	71.876	71.876	71.876
308.8	52.227	52.227	52.227	52.227	52.227	52.227	56.946	56.946	56.946	56.946	56.946	56.946	71.866	71.866	71.866
308.7	52.083	52.083	52.083	52.083	52.083	52.083	56.832	56.832	56.832	56.832	56.832	56.832	71.852	71.852	71.852
308.6	51.950	51.950	51.950	51.950	51.950	51.950	56.730	56.730	56.730	56.730	56.730	56.730	71.847	71.847	71.847
308.5	51.817	51.817	51.817	51.817	51.817	51.817	56.628	56.628	56.628	56.628	56.628	56.628	71.843	71.843	71.843
308.4	51.680	51.680	51.680	51.680	51.680	51.680	56.522	56.522	56.522	56.522	56.522	56.522	71.836	71.836	71.836
308.3	51.537	51.537	51.537	51.537	51.537	51.537	56.411	56.411	56.411	56.411	56.411	56.411	71.822	71.822	71.822
308.2	51.392	51.392	51.392	51.392	51.392	51.392	56.297	56.297	56.297	56.297	56.297	56.297	71.806	71.806	71.806
308.1	51.232	51.232	51.232	51.232	51.232	51.232	56.168	56.168	56.168	56.168	56.168	56.168	71.776	71.776	71.776
308	51.078	51.078	51.078	51.078	51.078	51.078	56.045	56.045	56.045	56.045	56.045	56.045	71.751	71.751	71.751
307.9	50.922	50.922	50.922	50.922	50.922	50.922	55.920	55.920	55.920	55.920	55.920	55.920	71.725	71.725	71.725
307.8	50.764	50.764	50.764	50.764	50.764	50.764	55.793	55.793	55.793	55.793	55.793	55.793	71.695	71.695	71.695
307.7	50.575	50.575	50.575	50.575	50.575	50.575	55.635	55.635	55.635	55.635	55.635	55.635	71.636	71.636	71.636
307.6	50.404	50.404	50.404	50.404	50.404	50.404	55.495	55.495	55.495	55.495	55.495	55.495	71.594	71.594	71.594
307.5	50.247	50.247	50.247	50.247	50.247	50.247	55.369	55.369	55.369	55.369	55.369	55.369	71.566	71.566	71.566
307.4	50.110	50.110	50.110	50.110	50.110	50.110	55.263	55.263	55.263	55.263	55.263	55.263	71.558	71.558	71.558
307.3	49.963	49.963	49.963	49.963	49.963	49.963	55.147	55.147	55.147	55.147	55.147	55.147	71.540	71.540	71.540
307.2	49.823	49.823	49.823	49.823	49.823	49.823	55.038	55.038	55.038	55.038	55.038	55.038	71.529	71.529	71.529
307.1	49.682	49.682	49.682	49.682	49.682	49.682	54.929	54.929	54.929	54.929	54.929	54.929	71.518	71.518	71.518
307	49.537	49.537	49.537	49.537	49.537	49.537	54.814	54.814	54.814	54.814	54.814	54.814	71.502	71.502	71.502

North Pit Sensitivity Analysis Results

Stage	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)
306.9	49.399	49.399	49.399	49.399	49.399	49.399	54.708	54.708	54.708	54.708	54.708	54.708	71.494	71.494	71.494
306.8	49.247	49.247	49.247	49.247	49.247	49.247	54.586	54.586	54.586	54.586	54.586	54.586	71.470	71.470	71.470
306.7	49.103	49.103	49.103	49.103	49.103	49.103	54.474	54.474	54.474	54.474	54.474	54.474	71.456	71.456	71.456
306.6	48.967	48.967	48.967	48.967	48.967	48.967	54.368	54.368	54.368	54.368	54.368	54.368	71.449	71.449	71.449
306.5	48.822	48.822	48.822	48.822	48.822	48.822	54.254	54.254	54.254	54.254	54.254	54.254	71.433	71.433	71.433
306.4	48.677	48.677	48.677	48.677	48.677	48.677	54.140	54.140	54.140	54.140	54.140	54.140	71.417	71.417	71.417
306.3	48.537	48.537	48.537	48.537	48.537	48.537	54.032	54.032	54.032	54.032	54.032	54.032	71.407	71.407	71.407
306.2	48.393	48.393	48.393	48.393	48.393	48.393	53.918	53.918	53.918	53.918	53.918	53.918	71.391	71.391	71.391
306.1	48.243	48.243	48.243	48.243	48.243	48.243	53.799	53.799	53.799	53.799	53.799	53.799	71.371	71.371	71.371
306	48.092	48.092	48.092	48.092	48.092	48.092	53.680	53.680	53.680	53.680	53.680	53.680	71.349	71.349	71.349
305.9	47.934	47.934	47.934	47.934	47.934	47.934	53.552	53.552	53.552	53.552	53.552	53.552	71.320	71.320	71.320
305.8	47.770	47.770	47.770	47.770	47.770	47.770	53.419	53.419	53.419	53.419	53.419	53.419	71.285	71.285	71.285
305.7	47.626	47.626	47.626	47.626	47.626	47.626	53.307	53.307	53.307	53.307	53.307	53.307	71.270	71.270	71.270
305.6	47.472	47.472	47.472	47.472	47.472	47.472	53.184	53.184	53.184	53.184	53.184	53.184	71.246	71.246	71.246
305.5	47.334	47.334	47.334	47.334	47.334	47.334	53.076	53.076	53.076	53.076	53.076	53.076	71.237	71.237	71.237
305.4	47.190	47.190	47.190	47.190	47.190	47.190	52.964	52.964	52.964	52.964	52.964	52.964	71.222	71.222	71.222
305.3	47.055	47.055	47.055	47.055	47.055	47.055	52.860	52.860	52.860	52.860	52.860	52.860	71.216	71.216	71.216
305.2	46.910	46.910	46.910	46.910	46.910	46.910	52.745	52.745	52.745	52.745	52.745	52.745	71.200	71.200	71.200
305.1	46.765	46.765	46.765	46.765	46.765	46.765	52.632	52.632	52.632	52.632	52.632	52.632	71.184	71.184	71.184
305	46.616	46.616	46.616	46.616	46.616	46.616	52.514	52.514	52.514	52.514	52.514	52.514	71.165	71.165	71.165
304.9	46.471	46.471	46.471	46.471	46.471	46.471	52.400	52.400	52.400	52.400	52.400	52.400	71.149	71.149	71.149
304.8	46.321	46.321	46.321	46.321	46.321	46.321	52.281	52.281	52.281	52.281	52.281	52.281	71.128	71.128	71.128
304.7	46.142	46.142	46.142	46.142	46.142	46.142	52.133	52.133	52.133	52.133	52.133	52.133	71.079	71.079	71.079
304.6	45.957	45.957	45.957	45.957	45.957	45.957	51.980	51.980	51.980	51.980	51.980	51.980	71.023	71.023	71.023
304.5	45.784	45.784	45.784	45.784	45.784	45.784	51.838	51.838	51.838	51.838	51.838	51.838	70.979	70.979	70.979
304.4	45.610	45.610	45.610	45.610	45.610	45.610	51.694	51.694	51.694	51.694	51.694	51.694	70.934	70.934	70.934
304.3	45.436	45.436	45.436	45.436	45.436	45.436	51.551	51.551	51.551	51.551	51.551	51.551	70.889	70.889	70.889
304.2	45.266	45.266	45.266	45.266	45.266	45.266	51.412	51.412	51.412	51.412	51.412	51.412	70.849	70.849	70.849
304.1	45.102	45.102	45.102	45.102	45.102	45.102	51.279	51.279	51.279	51.279	51.279	51.279	70.814	70.814	70.814
304	44.946	44.946	44.946	44.946	44.946	44.946	51.154	51.154	51.154	51.154	51.154	51.154	70.787	70.787	70.787
303.9	44.814	44.814	44.814	44.814	44.814	44.814	51.053	51.053	51.053	51.053	51.053	51.053	70.784	70.784	70.784
303.8	44.679	44.679	44.679	44.679	44.679	44.679	50.950	50.950	50.950	50.950	50.950	50.950	70.779	70.779	70.779
303.7	44.550	44.550	44.550	44.550	44.550	44.550	50.852	50.852	50.852	50.852	50.852	50.852	70.779	70.779	70.779
303.6	44.434	44.434	44.434	44.434	44.434	44.434	50.767	50.767	50.767	50.767	50.767	50.767	70.792	70.792	70.792
303.5	44.325	44.325	44.325	44.325	44.325	44.325	50.689	50.689	50.689	50.689	50.689	50.689	70.812	70.812	70.812
303.4	44.212	44.212	44.212	44.212	44.212	44.212	50.607	50.607	50.607	50.607	50.607	50.607	70.829	70.829	70.829
303.3	44.106	44.106	44.106	44.106	44.106	44.106	50.531	50.531	50.531	50.531	50.531	50.531	70.851	70.851	70.851
303.2	43.996	43.996	43.996	43.996	43.996	43.996	50.453	50.453	50.453	50.453	50.453	50.453	70.871	70.871	70.871
303.1	43.895	43.895	43.895	43.895	43.895	43.895	50.382	50.382	50.382	50.382	50.382	50.382	70.899	70.899	70.899
303	43.795	43.795	43.795	43.795	43.795	43.795	50.314	50.314	50.314	50.314	50.314	50.314	70.928	70.928	70.928
302.9	43.691	43.691	43.691	43.691	43.691	43.691	50.241	50.241	50.241	50.241	50.241	50.241	70.954	70.954	70.954
302.8	43.577	43.577	43.577	43.577	43.577	43.577	50.158	50.158	50.158	50.158	50.158	50.158	70.969	70.969	70.969
302.7	43.423	43.423	43.423	43.423	43.423	43.423	50.035	50.035	50.035	50.035	50.035	50.035	70.944	70.944	70.944
302.6	43.278	43.278	43.278	43.278	43.278	43.278	49.921	49.921	49.921	49.921	49.921	49.921	70.928	70.928	70.928
302.5	43.115	43.115	43.115	43.115	43.115	43.115	49.789	49.789	49.789	49.789	49.789	49.789	70.894	70.894	70.894
302.4	42.956	42.956	42.956	42.956	42.956	42.956	49.661	49.661	49.661	49.661	49.661	49.661	70.864	70.864	70.864

North Pit Sensitivity Analysis Results

Stage	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)
302.3	42.800	42.800	42.800	42.800	42.800	42.800	49.536	49.536	49.536	49.536	49.536	49.536	70.837	70.837	70.837
302.2	42.675	42.675	42.675	42.675	42.675	42.675	49.442	49.442	49.442	49.442	49.442	49.442	70.842	70.842	70.842
302.1	42.562	42.562	42.562	42.562	42.562	42.562	49.360	49.360	49.360	49.360	49.360	49.360	70.858	70.858	70.858
302	42.442	42.442	42.442	42.442	42.442	42.442	49.272	49.272	49.272	49.272	49.272	49.272	70.868	70.868	70.868
301.9	42.341	42.341	42.341	42.341	42.341	42.341	49.202	49.202	49.202	49.202	49.202	49.202	70.896	70.896	70.896
301.8	42.222	42.222	42.222	42.222	42.222	42.222	49.113	49.113	49.113	49.113	49.113	49.113	70.906	70.906	70.906
301.7	42.272	42.272	42.272	42.272	42.272	42.272	49.194	49.194	49.194	49.194	49.194	49.194	71.085	71.085	71.085
301.6	42.376	42.376	42.376	42.376	42.376	42.376	49.329	49.329	49.329	49.329	49.329	49.329	71.318	71.318	71.318
301.5	42.480	42.480	42.480	42.480	42.480	42.480	49.464	49.464	49.464	49.464	49.464	49.464	71.551	71.551	71.551
301.4	42.585	42.585	42.585	42.585	42.585	42.585	49.600	49.600	49.600	49.600	49.600	49.600	71.785	71.785	71.785
301.3	42.693	42.693	42.693	42.693	42.693	42.693	49.740	49.740	49.740	49.740	49.740	49.740	72.023	72.023	72.023
301.2	42.805	42.805	42.805	42.805	42.805	42.805	49.882	49.882	49.882	49.882	49.882	49.882	72.264	72.264	72.264
301.1	42.921	42.921	42.921	42.921	42.921	42.921	50.030	50.030	50.030	50.030	50.030	50.030	72.509	72.509	72.509
301	43.046	43.046	43.046	43.046	43.046	43.046	50.186	50.186	50.186	50.186	50.186	50.186	72.763	72.763	72.763
300.9	43.177	43.177	43.177	43.177	43.177	43.177	50.348	50.348	50.348	50.348	50.348	50.348	73.024	73.024	73.024
300.8	43.313	43.313	43.313	43.313	43.313	43.313	50.514	50.514	50.514	50.514	50.514	50.514	73.288	73.288	73.288
300.7	43.451	43.451	43.451	43.451	43.451	43.451	50.684	50.684	50.684	50.684	50.684	50.684	73.556	73.556	73.556
300.6	43.591	43.591	43.591	43.591	43.591	43.591	50.855	50.855	50.855	50.855	50.855	50.855	73.825	73.825	73.825
300.5	43.734	43.734	43.734	43.734	43.734	43.734	51.029	51.029	51.029	51.029	51.029	51.029	74.097	74.097	74.097
300.4	43.882	43.882	43.882	43.882	43.882	43.882	51.208	51.208	51.208	51.208	51.208	51.208	74.375	74.375	74.375
300.3	44.034	44.034	44.034	44.034	44.034	44.034	51.391	51.391	51.391	51.391	51.391	51.391	74.656	74.656	74.656
300.2	44.187	44.187	44.187	44.187	44.187	44.187	51.575	51.575	51.575	51.575	51.575	51.575	74.938	74.938	74.938
300.1	44.340	44.340	44.340	44.340	44.340	44.340	51.759	51.759	51.759	51.759	51.759	51.759	75.220	75.220	75.220
300	44.493	44.493	44.493	44.493	44.493	44.493	51.943	51.943	51.943	51.943	51.943	51.943	75.502	75.502	75.502
299.9	44.645	44.645	44.645	44.645	44.645	44.645	52.126	52.126	52.126	52.126	52.126	52.126	75.784	75.784	75.784
299.8	44.797	44.797	44.797	44.797	44.797	44.797	52.309	52.309	52.309	52.309	52.309	52.309	76.065	76.065	76.065
299.7	44.948	44.948	44.948	44.948	44.948	44.948	52.491	52.491	52.491	52.491	52.491	52.491	76.345	76.345	76.345
299.6	45.099	45.099	45.099	45.099	45.099	45.099	52.673	52.673	52.673	52.673	52.673	52.673	76.625	76.625	76.625
299.5	45.248	45.248	45.248	45.248	45.248	45.248	52.854	52.854	52.854	52.854	52.854	52.854	76.904	76.904	76.904
299.4	45.397	45.397	45.397	45.397	45.397	45.397	53.034	53.034	53.034	53.034	53.034	53.034	77.182	77.182	77.182
299.3	45.546	45.546	45.546	45.546	45.546	45.546	53.213	53.213	53.213	53.213	53.213	53.213	77.460	77.460	77.460
299.2	45.694	45.694	45.694	45.694	45.694	45.694	53.392	53.392	53.392	53.392	53.392	53.392	77.737	77.737	77.737
299.1	45.841	45.841	45.841	45.841	45.841	45.841	53.570	53.570	53.570	53.570	53.570	53.570	78.013	78.013	78.013
299	45.987	45.987	45.987	45.987	45.987	45.987	53.748	53.748	53.748	53.748	53.748	53.748	78.288	78.288	78.288
298.9	46.133	46.133	46.133	46.133	46.133	46.133	53.924	53.924	53.924	53.924	53.924	53.924	78.563	78.563	78.563
298.8	46.278	46.278	46.278	46.278	46.278	46.278	54.101	54.101	54.101	54.101	54.101	54.101	78.838	78.838	78.838
298.7	46.422	46.422	46.422	46.422	46.422	46.422	54.276	54.276	54.276	54.276	54.276	54.276	79.111	79.111	79.111
298.6	46.566	46.566	46.566	46.566	46.566	46.566	54.451	54.451	54.451	54.451	54.451	54.451	79.384	79.384	79.384
298.5	46.709	46.709	46.709	46.709	46.709	46.709	54.625	54.625	54.625	54.625	54.625	54.625	79.657	79.657	79.657
298.4	46.852	46.852	46.852	46.852	46.852	46.852	54.799	54.799	54.799	54.799	54.799	54.799	79.929	79.929	79.929
298.3	46.994	46.994	46.994	46.994	46.994	46.994	54.972	54.972	54.972	54.972	54.972	54.972	80.200	80.200	80.200
298.2	47.135	47.135	47.135	47.135	47.135	47.135	55.144	55.144	55.144	55.144	55.144	55.144	80.470	80.470	80.470
298.1	47.276	47.276	47.276	47.276	47.276	47.276	55.316	55.316	55.316	55.316	55.316	55.316	80.740	80.740	80.740
298	47.416	47.416	47.416	47.416	47.416	47.416	55.487	55.487	55.487	55.487	55.487	55.487	81.009	81.009	81.009
297.9	47.555	47.555	47.555	47.555	47.555	47.555	55.657	55.657	55.657	55.657	55.657	55.657	81.278	81.278	81.278
297.8	47.694	47.694	47.694	47.694	47.694	47.694	55.827	55.827	55.827	55.827	55.827	55.827	81.546	81.546	81.546

North Pit Sensitivity Analysis Results

Stage	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)
297.7	47.833	47.833	47.833	47.833	47.833	47.833	55.997	55.997	55.997	55.997	55.997	55.997	81.814	81.814	81.814
297.6	47.971	47.971	47.971	47.971	47.971	47.971	56.166	56.166	56.166	56.166	56.166	56.166	82.081	82.081	82.081
297.5	48.109	48.109	48.109	48.109	48.109	48.109	56.335	56.335	56.335	56.335	56.335	56.335	82.348	82.348	82.348
297.4	48.246	48.246	48.246	48.246	48.246	48.246	56.503	56.503	56.503	56.503	56.503	56.503	82.614	82.614	82.614
297.3	48.383	48.383	48.383	48.383	48.383	48.383	56.671	56.671	56.671	56.671	56.671	56.671	82.880	82.880	82.880
297.2	48.519	48.519	48.519	48.519	48.519	48.519	56.838	56.838	56.838	56.838	56.838	56.838	83.146	83.146	83.146
297.1	48.656	48.656	48.656	48.656	48.656	48.656	57.006	57.006	57.006	57.006	57.006	57.006	83.412	83.412	83.412
297	48.794	48.794	48.794	48.794	48.794	48.794	57.175	57.175	57.175	57.175	57.175	57.175	83.679	83.679	83.679
296.9	48.933	48.933	48.933	48.933	48.933	48.933	57.345	57.345	57.345	57.345	57.345	57.345	83.947	83.947	83.947
296.8	49.072	49.072	49.072	49.072	49.072	49.072	57.516	57.516	57.516	57.516	57.516	57.516	84.216	84.216	84.216
296.7	49.212	49.212	49.212	49.212	49.212	49.212	57.686	57.686	57.686	57.686	57.686	57.686	84.485	84.485	84.485
296.6	49.352	49.352	49.352	49.352	49.352	49.352	57.857	57.857	57.857	57.857	57.857	57.857	84.754	84.754	84.754
296.5	49.491	49.491	49.491	49.491	49.491	49.491	58.028	58.028	58.028	58.028	58.028	58.028	85.023	85.023	85.023
296.4	49.632	49.632	49.632	49.632	49.632	49.632	58.199	58.199	58.199	58.199	58.199	58.199	85.292	85.292	85.292
296.3	49.773	49.773	49.773	49.773	49.773	49.773	58.371	58.371	58.371	58.371	58.371	58.371	85.562	85.562	85.562
296.2	49.914	49.914	49.914	49.914	49.914	49.914	58.544	58.544	58.544	58.544	58.544	58.544	85.833	85.833	85.833
296.1	50.056	50.056	50.056	50.056	50.056	50.056	58.716	58.716	58.716	58.716	58.716	58.716	86.104	86.104	86.104
296	50.198	50.198	50.198	50.198	50.198	50.198	58.889	58.889	58.889	58.889	58.889	58.889	86.375	86.375	86.375
295.9	50.340	50.340	50.340	50.340	50.340	50.340	59.063	59.063	59.063	59.063	59.063	59.063	86.647	86.647	86.647
295.8	50.482	50.482	50.482	50.482	50.482	50.482	59.236	59.236	59.236	59.236	59.236	59.236	86.918	86.918	86.918
295.7	50.624	50.624	50.624	50.624	50.624	50.624	59.409	59.409	59.409	59.409	59.409	59.409	87.189	87.189	87.189
295.6	50.766	50.766	50.766	50.766	50.766	50.766	59.582	59.582	59.582	59.582	59.582	59.582	87.460	87.460	87.460
295.5	50.907	50.907	50.907	50.907	50.907	50.907	59.754	59.754	59.754	59.754	59.754	59.754	87.731	87.731	87.731
295.4	51.049	51.049	51.049	51.049	51.049	51.049	59.927	59.927	59.927	59.927	59.927	59.927	88.002	88.002	88.002
295.3	51.190	51.190	51.190	51.190	51.190	51.190	60.099	60.099	60.099	60.099	60.099	60.099	88.272	88.272	88.272
295.2	51.331	51.331	51.331	51.331	51.331	51.331	60.271	60.271	60.271	60.271	60.271	60.271	88.542	88.542	88.542
295.1	51.354	51.354	51.354	51.354	51.354	51.354	60.326	60.326	60.326	60.326	60.326	60.326	88.695	88.695	88.695
295	51.261	51.261	51.261	51.261	51.261	51.261	60.264	60.264	60.264	60.264	60.264	60.264	88.731	88.731	88.731

North Pit Sensitivity Analysis Results

Stage	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
316	81.082	81.082	81.082	0.511	0.142	0.521	0.152	0.573	0.203	5.094	1.402	5.127	1.435	5.292	1.599
315.95	81.154	81.154	81.154	0.511	0.143	0.521	0.153	0.573	0.205	5.094	1.410	5.128	1.444	5.293	1.609
315.9	81.170	81.170	81.170	0.511	0.144	0.521	0.154	0.573	0.206	5.090	1.418	5.124	1.451	5.290	1.618
315.8	81.112	81.112	81.112	0.509	0.145	0.520	0.155	0.572	0.208	5.076	1.431	5.109	1.465	5.278	1.633
315.7	81.056	81.056	81.056	0.508	0.146	0.518	0.157	0.571	0.210	5.061	1.445	5.095	1.479	5.265	1.649
315.6	80.989	80.989	80.989	0.506	0.148	0.517	0.158	0.570	0.211	5.046	1.458	5.080	1.492	5.252	1.663
315.5	80.931	80.931	80.931	0.505	0.149	0.516	0.160	0.569	0.213	5.031	1.471	5.066	1.505	5.239	1.678
315.4	80.888	80.888	80.888	0.504	0.150	0.514	0.161	0.569	0.215	5.018	1.484	5.053	1.519	5.227	1.694
315.3	80.852	80.852	80.852	0.502	0.152	0.513	0.163	0.568	0.217	5.005	1.497	5.040	1.533	5.216	1.709
315.2	80.785	80.785	80.785	0.501	0.153	0.512	0.164	0.567	0.219	4.989	1.510	5.025	1.545	5.203	1.723
315.1	80.696	80.696	80.696	0.499	0.154	0.510	0.165	0.566	0.221	4.972	1.522	5.008	1.558	5.188	1.737
315	80.576	80.576	80.576	0.497	0.155	0.508	0.166	0.564	0.222	4.953	1.533	4.989	1.569	5.170	1.750
314.9	80.446	80.446	80.446	0.495	0.156	0.507	0.168	0.563	0.224	4.933	1.544	4.970	1.580	5.152	1.762
314.8	80.301	80.301	80.301	0.493	0.157	0.505	0.169	0.561	0.225	4.912	1.554	4.949	1.591	5.132	1.774
314.7	80.145	80.145	80.145	0.491	0.158	0.502	0.170	0.560	0.227	4.890	1.564	4.927	1.601	5.112	1.785
314.6	79.998	79.998	79.998	0.489	0.159	0.500	0.171	0.558	0.228	4.869	1.574	4.906	1.611	5.092	1.797
314.5	79.880	79.880	79.880	0.487	0.160	0.499	0.172	0.557	0.230	4.850	1.584	4.888	1.622	5.075	1.809
314.4	79.795	79.795	79.795	0.485	0.162	0.497	0.173	0.555	0.232	4.834	1.595	4.871	1.633	5.060	1.822
314.3	79.699	79.699	79.699	0.484	0.163	0.495	0.174	0.554	0.233	4.816	1.606	4.854	1.644	5.044	1.834
314.2	79.571	79.571	79.571	0.482	0.164	0.493	0.175	0.553	0.235	4.796	1.616	4.835	1.654	5.026	1.846
314.1	79.382	79.382	79.382	0.479	0.164	0.491	0.176	0.551	0.236	4.772	1.624	4.811	1.663	5.003	1.855
314	79.157	79.157	79.157	0.477	0.165	0.488	0.177	0.548	0.237	4.745	1.631	4.784	1.670	4.977	1.863
313.9	78.994	78.994	78.994	0.474	0.166	0.486	0.178	0.546	0.238	4.723	1.640	4.762	1.679	4.956	1.873
313.8	78.938	78.938	78.938	0.473	0.167	0.485	0.179	0.545	0.240	4.708	1.651	4.748	1.690	4.943	1.886
313.7	78.903	78.903	78.903	0.472	0.168	0.484	0.180	0.545	0.241	4.695	1.663	4.735	1.702	4.932	1.899
313.6	78.875	78.875	78.875	0.470	0.170	0.483	0.182	0.544	0.243	4.683	1.674	4.723	1.714	4.921	1.913
313.5	78.862	78.862	78.862	0.469	0.171	0.482	0.183	0.543	0.245	4.672	1.686	4.712	1.726	4.912	1.927
313.4	78.852	78.852	78.852	0.468	0.172	0.481	0.184	0.543	0.247	4.660	1.698	4.701	1.739	4.902	1.940
313.3	78.841	78.841	78.841	0.467	0.173	0.480	0.186	0.542	0.248	4.649	1.710	4.690	1.751	4.893	1.954
313.2	78.832	78.832	78.832	0.466	0.174	0.479	0.187	0.542	0.250	4.638	1.722	4.679	1.763	4.884	1.968
313.1	78.827	78.827	78.827	0.465	0.176	0.478	0.188	0.541	0.252	4.627	1.734	4.669	1.775	4.875	1.981
313	78.822	78.822	78.822	0.464	0.177	0.477	0.190	0.541	0.253	4.617	1.746	4.658	1.787	4.866	1.995
312.9	78.826	78.826	78.826	0.463	0.178	0.476	0.191	0.540	0.255	4.606	1.758	4.648	1.799	4.858	2.009
312.8	78.820	78.820	78.820	0.462	0.179	0.475	0.192	0.540	0.257	4.596	1.769	4.638	1.811	4.848	2.022
312.7	78.827	78.827	78.827	0.461	0.180	0.474	0.193	0.539	0.259	4.586	1.781	4.628	1.824	4.840	2.036
312.6	78.821	78.821	78.821	0.460	0.181	0.473	0.195	0.539	0.260	4.575	1.793	4.618	1.835	4.831	2.049
312.5	78.824	78.824	78.824	0.459	0.183	0.472	0.196	0.538	0.262	4.565	1.804	4.608	1.847	4.823	2.062
312.4	78.815	78.815	78.815	0.458	0.184	0.471	0.197	0.538	0.264	4.554	1.815	4.597	1.859	4.814	2.075
312.3	78.816	78.816	78.816	0.457	0.185	0.470	0.198	0.537	0.265	4.543	1.827	4.587	1.871	4.805	2.089
312.2	78.813	78.813	78.813	0.456	0.186	0.469	0.200	0.536	0.267	4.533	1.838	4.576	1.882	4.796	2.102
312.1	78.803	78.803	78.803	0.454	0.187	0.468	0.201	0.536	0.269	4.521	1.849	4.566	1.893	4.787	2.114
312	78.791	78.791	78.791	0.453	0.188	0.467	0.202	0.535	0.270	4.510	1.860	4.555	1.904	4.777	2.127
311.9	78.782	78.782	78.782	0.452	0.189	0.466	0.203	0.535	0.272	4.499	1.871	4.544	1.916	4.768	2.139
311.8	78.771	78.771	78.771	0.451	0.190	0.465	0.204	0.534	0.273	4.488	1.882	4.533	1.927	4.758	2.152
311.7	78.760	78.760	78.760	0.450	0.192	0.464	0.205	0.533	0.275	4.477	1.892	4.522	1.938	4.748	2.164
311.6	78.753	78.753	78.753	0.449	0.193	0.463	0.207	0.533	0.277	4.466	1.903	4.511	1.948	4.739	2.176

North Pit Sensitivity Analysis Results

Stage	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
311.5	78.742	78.742	78.742	0.448	0.194	0.462	0.208	0.532	0.278	4.454	1.913	4.500	1.959	4.729	2.189
311.4	78.734	78.734	78.734	0.447	0.195	0.461	0.209	0.532	0.280	4.443	1.924	4.490	1.970	4.720	2.201
311.3	78.710	78.710	78.710	0.446	0.196	0.460	0.210	0.531	0.281	4.431	1.934	4.478	1.980	4.710	2.212
311.2	78.680	78.680	78.680	0.444	0.197	0.459	0.211	0.530	0.282	4.419	1.943	4.465	1.990	4.698	2.223
311.1	78.649	78.649	78.649	0.443	0.198	0.457	0.212	0.529	0.284	4.406	1.953	4.453	2.000	4.687	2.234
311	78.602	78.602	78.602	0.442	0.199	0.456	0.213	0.528	0.285	4.392	1.962	4.439	2.009	4.675	2.245
310.9	78.516	78.516	78.516	0.440	0.199	0.454	0.214	0.527	0.286	4.375	1.969	4.423	2.017	4.659	2.253
310.8	78.321	78.321	78.321	0.438	0.200	0.452	0.214	0.525	0.287	4.351	1.973	4.398	2.021	4.635	2.258
310.7	77.984	77.984	77.984	0.434	0.200	0.448	0.214	0.521	0.287	4.315	1.972	4.363	2.020	4.600	2.257
310.6	77.373	77.373	77.373	0.428	0.199	0.443	0.213	0.515	0.285	4.260	1.961	4.308	2.009	4.544	2.245
310.5	76.742	76.742	76.742	0.423	0.197	0.437	0.212	0.509	0.284	4.204	1.950	4.251	1.997	4.486	2.232
310.4	76.437	76.437	76.437	0.419	0.197	0.434	0.212	0.506	0.283	4.171	1.949	4.218	1.996	4.453	2.231
310.3	76.135	76.135	76.135	0.416	0.197	0.431	0.212	0.502	0.283	4.138	1.948	4.185	1.995	4.421	2.230
310.2	75.669	75.669	75.669	0.412	0.196	0.426	0.211	0.498	0.282	4.094	1.941	4.141	1.988	4.375	2.222
310.1	75.002	75.002	75.002	0.406	0.195	0.420	0.209	0.491	0.280	4.034	1.927	4.081	1.973	4.314	2.206
310	74.059	74.059	74.059	0.398	0.193	0.412	0.207	0.482	0.277	3.955	1.902	4.001	1.948	4.232	2.179
309.9	73.163	73.163	73.163	0.390	0.190	0.404	0.204	0.473	0.273	3.879	1.879	3.924	1.925	4.153	2.153
309.8	72.739	72.739	72.739	0.386	0.190	0.400	0.203	0.469	0.272	3.837	1.872	3.883	1.917	4.110	2.145
309.7	72.249	72.249	72.249	0.381	0.189	0.395	0.202	0.464	0.271	3.791	1.862	3.836	1.908	4.063	2.134
309.6	72.023	72.023	72.023	0.379	0.188	0.392	0.202	0.461	0.271	3.764	1.862	3.809	1.907	4.036	2.134
309.5	71.936	71.936	71.936	0.377	0.189	0.391	0.203	0.460	0.272	3.747	1.866	3.793	1.912	4.020	2.139
309.4	71.914	71.914	71.914	0.376	0.190	0.390	0.203	0.459	0.273	3.735	1.873	3.781	1.919	4.009	2.147
309.3	71.902	71.902	71.902	0.375	0.190	0.389	0.204	0.458	0.274	3.724	1.880	3.770	1.926	3.999	2.156
309.2	71.896	71.896	71.896	0.374	0.191	0.388	0.205	0.457	0.275	3.713	1.888	3.759	1.934	3.989	2.164
309.1	71.894	71.894	71.894	0.373	0.192	0.387	0.206	0.457	0.276	3.702	1.895	3.749	1.941	3.980	2.173
309	71.881	71.881	71.881	0.371	0.193	0.386	0.207	0.456	0.277	3.691	1.902	3.737	1.948	3.970	2.181
308.9	71.876	71.876	71.876	0.370	0.193	0.384	0.207	0.455	0.278	3.680	1.909	3.727	1.955	3.960	2.189
308.8	71.866	71.866	71.866	0.369	0.194	0.383	0.208	0.454	0.279	3.669	1.915	3.716	1.962	3.950	2.197
308.7	71.852	71.852	71.852	0.368	0.195	0.382	0.209	0.453	0.280	3.657	1.922	3.704	1.969	3.940	2.204
308.6	71.847	71.847	71.847	0.367	0.195	0.381	0.210	0.453	0.281	3.647	1.929	3.694	1.976	3.930	2.212
308.5	71.843	71.843	71.843	0.366	0.196	0.380	0.210	0.452	0.282	3.636	1.936	3.683	1.983	3.921	2.220
308.4	71.836	71.836	71.836	0.365	0.197	0.379	0.211	0.451	0.283	3.625	1.942	3.673	1.990	3.911	2.228
308.3	71.822	71.822	71.822	0.364	0.197	0.378	0.212	0.450	0.284	3.614	1.948	3.661	1.996	3.900	2.235
308.2	71.806	71.806	71.806	0.363	0.198	0.377	0.212	0.449	0.285	3.602	1.954	3.650	2.002	3.890	2.243
308.1	71.776	71.776	71.776	0.361	0.198	0.376	0.213	0.448	0.286	3.589	1.960	3.637	2.008	3.878	2.249
308	71.751	71.751	71.751	0.360	0.199	0.375	0.214	0.448	0.286	3.577	1.965	3.625	2.014	3.867	2.255
307.9	71.725	71.725	71.725	0.359	0.200	0.374	0.214	0.447	0.287	3.565	1.971	3.613	2.019	3.856	2.262
307.8	71.695	71.695	71.695	0.358	0.200	0.372	0.215	0.446	0.288	3.552	1.976	3.601	2.025	3.844	2.268
307.7	71.636	71.636	71.636	0.356	0.200	0.371	0.215	0.444	0.289	3.537	1.980	3.586	2.029	3.830	2.273
307.6	71.594	71.594	71.594	0.355	0.201	0.370	0.216	0.443	0.289	3.524	1.984	3.573	2.033	3.817	2.278
307.5	71.566	71.566	71.566	0.354	0.201	0.368	0.216	0.442	0.290	3.511	1.989	3.560	2.039	3.806	2.284
307.4	71.558	71.558	71.558	0.352	0.202	0.367	0.217	0.441	0.291	3.500	1.995	3.549	2.044	3.796	2.291
307.3	71.540	71.540	71.540	0.351	0.203	0.366	0.217	0.440	0.292	3.488	2.000	3.538	2.050	3.785	2.297
307.2	71.529	71.529	71.529	0.350	0.203	0.365	0.218	0.440	0.292	3.477	2.006	3.527	2.055	3.775	2.303
307.1	71.518	71.518	71.518	0.349	0.204	0.364	0.219	0.439	0.293	3.466	2.011	3.516	2.061	3.765	2.310
307	71.502	71.502	71.502	0.348	0.204	0.363	0.219	0.438	0.294	3.454	2.016	3.504	2.066	3.754	2.316

North Pit Sensitivity Analysis Results

Stage	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
306.9	71.494	71.494	71.494	0.347	0.205	0.362	0.220	0.437	0.295	3.443	2.022	3.493	2.072	3.744	2.322
306.8	71.470	71.470	71.470	0.346	0.205	0.361	0.220	0.436	0.295	3.431	2.026	3.481	2.076	3.733	2.328
306.7	71.456	71.456	71.456	0.344	0.206	0.360	0.221	0.435	0.296	3.420	2.031	3.470	2.081	3.722	2.334
306.6	71.449	71.449	71.449	0.343	0.206	0.359	0.221	0.434	0.297	3.409	2.036	3.459	2.087	3.712	2.340
306.5	71.433	71.433	71.433	0.342	0.207	0.357	0.222	0.433	0.298	3.397	2.041	3.448	2.092	3.701	2.345
306.4	71.417	71.417	71.417	0.341	0.207	0.356	0.222	0.432	0.298	3.385	2.046	3.436	2.096	3.691	2.351
306.3	71.407	71.407	71.407	0.340	0.208	0.355	0.223	0.431	0.299	3.374	2.050	3.425	2.101	3.680	2.356
306.2	71.391	71.391	71.391	0.339	0.208	0.354	0.223	0.431	0.300	3.363	2.055	3.414	2.106	3.670	2.362
306.1	71.371	71.371	71.371	0.338	0.208	0.353	0.224	0.430	0.300	3.351	2.059	3.402	2.110	3.658	2.367
306	71.349	71.349	71.349	0.336	0.209	0.352	0.224	0.429	0.301	3.339	2.063	3.390	2.114	3.647	2.372
305.9	71.320	71.320	71.320	0.335	0.209	0.351	0.225	0.427	0.302	3.326	2.067	3.378	2.118	3.635	2.376
305.8	71.285	71.285	71.285	0.334	0.210	0.349	0.225	0.426	0.302	3.313	2.070	3.365	2.121	3.623	2.380
305.7	71.270	71.270	71.270	0.333	0.210	0.348	0.225	0.425	0.303	3.301	2.074	3.353	2.126	3.613	2.385
305.6	71.246	71.246	71.246	0.331	0.210	0.347	0.226	0.424	0.303	3.289	2.077	3.341	2.129	3.601	2.389
305.5	71.237	71.237	71.237	0.330	0.211	0.346	0.226	0.423	0.304	3.278	2.082	3.330	2.134	3.591	2.394
305.4	71.222	71.222	71.222	0.329	0.211	0.345	0.227	0.423	0.304	3.267	2.085	3.319	2.138	3.580	2.399
305.3	71.216	71.216	71.216	0.328	0.212	0.344	0.227	0.422	0.305	3.256	2.090	3.308	2.142	3.570	2.404
305.2	71.200	71.200	71.200	0.327	0.212	0.343	0.228	0.421	0.306	3.244	2.093	3.297	2.146	3.559	2.408
305.1	71.184	71.184	71.184	0.326	0.212	0.341	0.228	0.420	0.306	3.232	2.097	3.285	2.150	3.548	2.413
305	71.165	71.165	71.165	0.325	0.213	0.340	0.228	0.419	0.307	3.221	2.100	3.273	2.153	3.537	2.417
304.9	71.149	71.149	71.149	0.323	0.213	0.339	0.229	0.418	0.307	3.209	2.104	3.262	2.156	3.526	2.421
304.8	71.128	71.128	71.128	0.322	0.213	0.338	0.229	0.417	0.308	3.197	2.107	3.250	2.160	3.515	2.425
304.7	71.079	71.079	71.079	0.321	0.213	0.337	0.229	0.415	0.308	3.183	2.108	3.236	2.161	3.502	2.427
304.6	71.023	71.023	71.023	0.319	0.214	0.335	0.229	0.414	0.308	3.168	2.109	3.221	2.163	3.488	2.429
304.5	70.979	70.979	70.979	0.318	0.214	0.334	0.229	0.413	0.308	3.155	2.111	3.208	2.164	3.474	2.431
304.4	70.934	70.934	70.934	0.317	0.214	0.332	0.230	0.411	0.309	3.141	2.113	3.194	2.166	3.461	2.433
304.3	70.889	70.889	70.889	0.315	0.214	0.331	0.230	0.410	0.309	3.127	2.114	3.181	2.168	3.448	2.435
304.2	70.849	70.849	70.849	0.314	0.214	0.330	0.230	0.409	0.309	3.114	2.116	3.167	2.169	3.435	2.437
304.1	70.814	70.814	70.814	0.313	0.214	0.329	0.230	0.408	0.309	3.101	2.117	3.154	2.171	3.422	2.439
304	70.787	70.787	70.787	0.311	0.215	0.327	0.230	0.407	0.310	3.088	2.119	3.142	2.173	3.411	2.442
303.9	70.784	70.784	70.784	0.310	0.215	0.326	0.231	0.406	0.310	3.078	2.123	3.131	2.176	3.401	2.446
303.8	70.779	70.779	70.779	0.309	0.215	0.325	0.231	0.405	0.311	3.067	2.126	3.121	2.180	3.391	2.450
303.7	70.779	70.779	70.779	0.308	0.216	0.324	0.231	0.404	0.311	3.056	2.129	3.110	2.183	3.381	2.454
303.6	70.792	70.792	70.792	0.307	0.216	0.323	0.232	0.403	0.312	3.047	2.133	3.101	2.187	3.372	2.458
303.5	70.812	70.812	70.812	0.306	0.216	0.322	0.232	0.403	0.312	3.038	2.137	3.092	2.191	3.364	2.463
303.4	70.829	70.829	70.829	0.305	0.217	0.322	0.233	0.402	0.313	3.028	2.141	3.083	2.195	3.356	2.468
303.3	70.851	70.851	70.851	0.305	0.217	0.321	0.233	0.401	0.314	3.020	2.145	3.074	2.199	3.348	2.473
303.2	70.871	70.871	70.871	0.304	0.218	0.320	0.234	0.400	0.314	3.011	2.149	3.065	2.203	3.340	2.478
303.1	70.899	70.899	70.899	0.303	0.218	0.319	0.234	0.400	0.315	3.002	2.153	3.057	2.208	3.332	2.483
303	70.928	70.928	70.928	0.302	0.218	0.318	0.235	0.399	0.315	2.994	2.157	3.049	2.212	3.325	2.488
302.9	70.954	70.954	70.954	0.301	0.219	0.317	0.235	0.399	0.316	2.985	2.161	3.041	2.216	3.317	2.493
302.8	70.969	70.969	70.969	0.300	0.219	0.317	0.235	0.398	0.317	2.976	2.164	3.031	2.220	3.308	2.497
302.7	70.944	70.944	70.944	0.299	0.219	0.315	0.236	0.397	0.317	2.964	2.166	3.019	2.221	3.297	2.499
302.6	70.928	70.928	70.928	0.298	0.219	0.314	0.236	0.396	0.317	2.952	2.167	3.008	2.223	3.286	2.501
302.5	70.894	70.894	70.894	0.297	0.219	0.313	0.236	0.394	0.317	2.939	2.168	2.995	2.223	3.273	2.502
302.4	70.864	70.864	70.864	0.295	0.220	0.312	0.236	0.393	0.317	2.926	2.168	2.982	2.224	3.261	2.503

North Pit Sensitivity Analysis Results

Stage	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
302.3	70.837	70.837	70.837	0.294	0.220	0.310	0.236	0.392	0.317	2.914	2.169	2.970	2.225	3.249	2.504
302.2	70.842	70.842	70.842	0.293	0.220	0.309	0.236	0.391	0.318	2.904	2.172	2.960	2.227	3.239	2.507
302.1	70.858	70.858	70.858	0.292	0.220	0.309	0.237	0.390	0.318	2.895	2.174	2.951	2.231	3.231	2.511
302	70.868	70.868	70.868	0.291	0.220	0.308	0.237	0.390	0.319	2.885	2.177	2.941	2.233	3.222	2.514
301.9	70.896	70.896	70.896	0.290	0.221	0.307	0.237	0.389	0.319	2.876	2.180	2.933	2.237	3.214	2.518
301.8	70.906	70.906	70.906	0.289	0.221	0.306	0.237	0.388	0.320	2.867	2.183	2.923	2.239	3.205	2.521
301.7	71.085	71.085	71.085	0.289	0.221	0.306	0.239	0.393	0.326	2.857	2.185	2.914	2.243	3.202	2.531
301.6	71.318	71.318	71.318	0.288	0.222	0.307	0.241	0.400	0.334	2.847	2.187	2.906	2.247	3.202	2.542
301.5	71.551	71.551	71.551	0.287	0.222	0.307	0.242	0.407	0.342	2.836	2.189	2.897	2.249	3.200	2.553
301.4	71.785	71.785	71.785	0.286	0.223	0.308	0.244	0.414	0.351	2.825	2.190	2.888	2.253	3.199	2.564
301.3	72.023	72.023	72.023	0.286	0.223	0.308	0.246	0.421	0.359	2.815	2.192	2.879	2.256	3.199	2.576
301.2	72.264	72.264	72.264	0.285	0.224	0.309	0.248	0.428	0.367	2.804	2.193	2.870	2.259	3.198	2.587
301.1	72.509	72.509	72.509	0.284	0.224	0.309	0.249	0.436	0.376	2.792	2.193	2.859	2.260	3.196	2.597
301	72.763	72.763	72.763	0.283	0.224	0.310	0.251	0.444	0.385	2.782	2.195	2.851	2.264	3.196	2.609
300.9	73.024	73.024	73.024	0.283	0.225	0.311	0.253	0.451	0.394	2.773	2.197	2.844	2.268	3.197	2.621
300.8	73.288	73.288	73.288	0.282	0.226	0.311	0.255	0.459	0.402	2.765	2.200	2.837	2.273	3.199	2.634
300.7	73.556	73.556	73.556	0.281	0.226	0.312	0.257	0.466	0.411	2.757	2.203	2.830	2.277	3.200	2.647
300.6	73.825	73.825	73.825	0.281	0.227	0.313	0.259	0.473	0.419	2.749	2.206	2.824	2.282	3.202	2.660
300.5	74.097	74.097	74.097	0.280	0.227	0.314	0.261	0.481	0.428	2.740	2.209	2.817	2.286	3.204	2.673
300.4	74.375	74.375	74.375	0.280	0.228	0.315	0.263	0.489	0.437	2.731	2.211	2.810	2.290	3.205	2.686
300.3	74.656	74.656	74.656	0.279	0.228	0.316	0.265	0.497	0.446	2.722	2.213	2.803	2.294	3.208	2.699
300.2	74.938	74.938	74.938	0.279	0.229	0.316	0.267	0.505	0.456	2.713	2.215	2.796	2.298	3.209	2.711
300.1	75.220	75.220	75.220	0.278	0.229	0.317	0.269	0.513	0.465	2.705	2.218	2.790	2.302	3.212	2.725
300	75.502	75.502	75.502	0.278	0.230	0.318	0.271	0.521	0.474	2.697	2.220	2.783	2.306	3.214	2.738
299.9	75.784	75.784	75.784	0.277	0.231	0.319	0.273	0.529	0.483	2.688	2.223	2.776	2.311	3.216	2.751
299.8	76.065	76.065	76.065	0.277	0.231	0.320	0.275	0.538	0.492	2.679	2.224	2.769	2.314	3.218	2.763
299.7	76.345	76.345	76.345	0.276	0.232	0.321	0.277	0.545	0.501	2.671	2.227	2.763	2.318	3.220	2.776
299.6	76.625	76.625	76.625	0.275	0.232	0.322	0.278	0.554	0.510	2.662	2.228	2.755	2.321	3.222	2.788
299.5	76.904	76.904	76.904	0.275	0.233	0.323	0.280	0.562	0.519	2.653	2.230	2.748	2.325	3.224	2.801
299.4	77.182	77.182	77.182	0.274	0.233	0.324	0.282	0.570	0.528	2.644	2.232	2.741	2.329	3.226	2.813
299.3	77.460	77.460	77.460	0.274	0.234	0.324	0.284	0.577	0.537	2.637	2.234	2.735	2.333	3.229	2.826
299.2	77.737	77.737	77.737	0.273	0.234	0.325	0.286	0.585	0.546	2.628	2.236	2.729	2.336	3.231	2.839
299.1	78.013	78.013	78.013	0.273	0.235	0.326	0.288	0.593	0.555	2.620	2.238	2.722	2.340	3.233	2.851
299	78.288	78.288	78.288	0.272	0.235	0.327	0.290	0.601	0.564	2.612	2.240	2.716	2.344	3.235	2.863
298.9	78.563	78.563	78.563	0.272	0.236	0.328	0.292	0.609	0.573	2.603	2.241	2.709	2.347	3.237	2.875
298.8	78.838	78.838	78.838	0.271	0.236	0.329	0.294	0.617	0.582	2.594	2.242	2.701	2.350	3.239	2.887
298.7	79.111	79.111	79.111	0.271	0.236	0.330	0.295	0.625	0.591	2.585	2.244	2.694	2.353	3.241	2.899
298.6	79.384	79.384	79.384	0.270	0.237	0.330	0.297	0.633	0.600	2.576	2.244	2.687	2.355	3.242	2.911
298.5	79.657	79.657	79.657	0.269	0.237	0.331	0.299	0.641	0.609	2.567	2.245	2.680	2.358	3.244	2.922
298.4	79.929	79.929	79.929	0.269	0.238	0.332	0.301	0.649	0.617	2.558	2.246	2.673	2.361	3.246	2.934
298.3	80.200	80.200	80.200	0.268	0.238	0.333	0.303	0.656	0.626	2.550	2.248	2.666	2.364	3.248	2.946
298.2	80.470	80.470	80.470	0.268	0.238	0.334	0.304	0.664	0.635	2.541	2.249	2.659	2.367	3.249	2.957
298.1	80.740	80.740	80.740	0.267	0.239	0.335	0.306	0.672	0.644	2.532	2.249	2.652	2.369	3.251	2.968
298	81.009	81.009	81.009	0.266	0.239	0.335	0.308	0.680	0.653	2.522	2.249	2.644	2.370	3.252	2.979
297.9	81.278	81.278	81.278	0.266	0.239	0.336	0.310	0.688	0.661	2.513	2.249	2.636	2.373	3.254	2.990
297.8	81.546	81.546	81.546	0.265	0.240	0.337	0.312	0.696	0.671	2.503	2.249	2.628	2.374	3.254	3.000

North Pit Sensitivity Analysis Results

Stage	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
297.7	81.814	81.814	81.814	0.264	0.240	0.338	0.313	0.704	0.679	2.494	2.249	2.621	2.376	3.256	3.011
297.6	82.081	82.081	82.081	0.264	0.240	0.338	0.315	0.712	0.688	2.484	2.249	2.613	2.378	3.257	3.022
297.5	82.348	82.348	82.348	0.263	0.241	0.339	0.317	0.720	0.697	2.474	2.248	2.604	2.379	3.258	3.032
297.4	82.614	82.614	82.614	0.262	0.241	0.340	0.318	0.728	0.706	2.462	2.246	2.595	2.379	3.258	3.041
297.3	82.880	82.880	82.880	0.262	0.241	0.341	0.320	0.736	0.716	2.451	2.244	2.585	2.378	3.257	3.050
297.2	83.146	83.146	83.146	0.261	0.241	0.341	0.322	0.745	0.725	2.440	2.242	2.576	2.379	3.258	3.060
297.1	83.412	83.412	83.412	0.260	0.241	0.342	0.323	0.753	0.734	2.428	2.239	2.566	2.378	3.257	3.069
297	83.679	83.679	83.679	0.259	0.241	0.343	0.325	0.761	0.743	2.417	2.238	2.557	2.378	3.258	3.078
296.9	83.947	83.947	83.947	0.258	0.241	0.344	0.327	0.770	0.753	2.405	2.235	2.547	2.377	3.257	3.087
296.8	84.216	84.216	84.216	0.258	0.241	0.344	0.328	0.778	0.762	2.395	2.233	2.539	2.377	3.258	3.096
296.7	84.485	84.485	84.485	0.257	0.242	0.345	0.330	0.786	0.771	2.384	2.231	2.529	2.377	3.258	3.106
296.6	84.754	84.754	84.754	0.256	0.242	0.346	0.331	0.795	0.780	2.372	2.228	2.520	2.376	3.258	3.114
296.5	85.023	85.023	85.023	0.255	0.242	0.346	0.333	0.803	0.790	2.360	2.225	2.510	2.375	3.258	3.123
296.4	85.292	85.292	85.292	0.254	0.242	0.347	0.335	0.812	0.799	2.347	2.221	2.499	2.372	3.257	3.131
296.3	85.562	85.562	85.562	0.253	0.241	0.348	0.336	0.821	0.809	2.334	2.216	2.488	2.370	3.256	3.138
296.2	85.833	85.833	85.833	0.252	0.241	0.349	0.338	0.830	0.819	2.322	2.212	2.477	2.368	3.255	3.146
296.1	86.104	86.104	86.104	0.251	0.241	0.349	0.339	0.839	0.829	2.308	2.207	2.466	2.365	3.254	3.153
296	86.375	86.375	86.375	0.250	0.241	0.350	0.341	0.848	0.838	2.294	2.202	2.454	2.362	3.253	3.160
295.9	86.647	86.647	86.647	0.249	0.241	0.350	0.342	0.857	0.849	2.279	2.194	2.441	2.356	3.250	3.166
295.8	86.918	86.918	86.918	0.248	0.240	0.351	0.343	0.867	0.859	2.261	2.185	2.425	2.349	3.246	3.170
295.7	87.189	87.189	87.189	0.246	0.240	0.351	0.345	0.877	0.870	2.242	2.174	2.408	2.341	3.241	3.173
295.6	87.460	87.460	87.460	0.245	0.239	0.352	0.346	0.888	0.882	2.221	2.161	2.390	2.330	3.234	3.175
295.5	87.731	87.731	87.731	0.243	0.238	0.352	0.347	0.899	0.894	2.196	2.145	2.368	2.316	3.226	3.174
295.4	88.002	88.002	88.002	0.240	0.235	0.352	0.348	0.913	0.909	2.160	2.117	2.335	2.291	3.209	3.165
295.3	88.272	88.272	88.272	0.234	0.230	0.350	0.347	0.933	0.930	2.091	2.056	2.271	2.236	3.169	3.133
295.2	88.542	88.542	88.542	0.217	0.215	0.343	0.341	0.975	0.973	1.902	1.877	2.092	2.066	3.040	3.015
295.1	88.695	88.695	88.695	0.183	0.182	0.325	0.323	1.032	1.030	1.532	1.516	1.737	1.721	2.761	2.746
295	88.731	88.731	88.731	0.122	0.121	0.281	0.280	1.075	1.074	0.876	0.870	1.098	1.093	2.211	2.205

North Pit Sensitivity Analysis Results

Stage	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Mining - WBM North Pit Inflow (m³/day)	Recovery - WBM North Pit Inflow (m³/day)
316	50.889	13.962	50.998	14.072	51.548	14.621	5.495	1.803
315.95	50.889	14.049	50.999	14.160	51.552	14.713	5.495	1.811
315.9	50.848	14.125	50.959	14.236	51.516	14.793	5.492	1.820
315.8	50.701	14.258	50.814	14.371	51.376	14.933	5.479	1.835
315.7	50.556	14.391	50.669	14.504	51.237	15.072	5.467	1.850
315.6	50.402	14.520	50.516	14.634	51.090	15.208	5.454	1.866
315.5	50.255	14.650	50.371	14.766	50.951	15.345	5.441	1.881
315.4	50.119	14.782	50.236	14.899	50.822	15.484	5.430	1.896
315.3	49.988	14.914	50.106	15.033	50.697	15.624	5.419	1.911
315.2	49.834	15.039	49.953	15.159	50.551	15.756	5.405	1.926
315.1	49.665	15.159	49.786	15.279	50.388	15.882	5.391	1.940
315	49.472	15.269	49.594	15.391	50.201	15.999	5.374	1.954
314.9	49.272	15.377	49.395	15.499	50.008	16.112	5.357	1.968
314.8	49.062	15.479	49.186	15.603	49.804	16.221	5.339	1.981
314.7	48.843	15.577	48.967	15.702	49.590	16.325	5.321	1.994
314.6	48.631	15.676	48.756	15.802	49.384	16.430	5.303	2.007
314.5	48.440	15.781	48.567	15.908	49.199	16.540	5.286	2.020
314.4	48.273	15.892	48.401	16.020	49.039	16.658	5.272	2.034
314.3	48.099	16.000	48.228	16.128	48.871	16.771	5.257	2.047
314.2	47.901	16.098	48.030	16.227	48.678	16.875	5.240	2.060
314.1	47.658	16.180	47.788	16.310	48.441	16.962	5.219	2.071
314	47.388	16.250	47.519	16.382	48.175	17.038	5.196	2.082
313.9	47.165	16.335	47.297	16.468	47.957	17.128	5.177	2.094
313.8	47.019	16.446	47.152	16.579	47.818	17.245	5.164	2.107
313.7	46.889	16.561	47.023	16.695	47.694	17.367	5.153	2.120
313.6	46.764	16.677	46.899	16.813	47.576	17.490	5.142	2.133
313.5	46.650	16.797	46.786	16.933	47.469	17.616	5.132	2.147
313.4	46.537	16.916	46.675	17.053	47.363	17.742	5.123	2.160
313.3	46.425	17.034	46.564	17.173	47.258	17.867	5.113	2.174
313.2	46.314	17.152	46.454	17.292	47.154	17.991	5.103	2.187
313.1	46.205	17.270	46.346	17.411	47.052	18.116	5.094	2.200
313	46.097	17.388	46.239	17.530	46.950	18.241	5.084	2.214
312.9	45.995	17.507	46.139	17.650	46.856	18.367	5.076	2.227
312.8	45.887	17.623	46.031	17.767	46.754	18.490	5.066	2.240
312.7	45.787	17.741	45.933	17.887	46.661	18.615	5.058	2.253
312.6	45.678	17.855	45.825	18.002	46.559	18.736	5.048	2.266
312.5	45.576	17.972	45.723	18.120	46.463	18.859	5.039	2.279
312.4	45.465	18.084	45.614	18.233	46.359	18.978	5.030	2.292
312.3	45.361	18.198	45.511	18.348	46.262	19.099	5.021	2.304
312.2	45.254	18.310	45.405	18.461	46.162	19.218	5.011	2.317
312.1	45.142	18.419	45.294	18.572	46.056	19.334	5.002	2.329
312	45.028	18.527	45.182	18.681	45.949	19.448	4.992	2.342
311.9	44.917	18.636	45.072	18.790	45.845	19.563	4.982	2.354
311.8	44.805	18.742	44.960	18.898	45.739	19.677	4.972	2.366
311.7	44.692	18.848	44.848	19.005	45.632	19.789	4.963	2.378
311.6	44.582	18.955	44.740	19.113	45.529	19.902	4.953	2.390

North Pit Sensitivity Analysis Results

Stage	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Mining - WBM North Pit Inflow (m³/day)	Recovery - WBM North Pit Inflow (m³/day)
311.5	44.469	19.059	44.628	19.218	45.423	20.013	4.943	2.402
311.4	44.359	19.164	44.519	19.324	45.319	20.124	4.934	2.414
311.3	44.236	19.263	44.398	19.424	45.203	20.229	4.923	2.426
311.2	44.110	19.359	44.272	19.521	45.083	20.331	4.912	2.437
311.1	43.983	19.453	44.146	19.617	44.962	20.432	4.901	2.448
311	43.843	19.542	44.008	19.706	44.828	20.527	4.889	2.459
310.9	43.676	19.617	43.841	19.782	44.666	20.607	4.874	2.468
310.8	43.429	19.655	43.595	19.821	44.423	20.649	4.853	2.475
310.7	43.078	19.644	43.244	19.810	44.073	20.639	4.822	2.479
310.6	42.526	19.538	42.692	19.703	43.519	20.531	4.774	2.475
310.5	41.960	19.422	42.125	19.587	42.950	20.412	4.724	2.470
310.4	41.632	19.412	41.798	19.578	42.624	20.404	4.696	2.474
310.3	41.307	19.402	41.472	19.568	42.300	20.396	4.667	2.477
310.2	40.862	19.333	41.027	19.499	41.854	20.326	4.628	2.475
310.1	40.269	19.191	40.434	19.355	41.258	20.179	4.576	2.468
310	39.474	18.947	39.638	19.111	40.454	19.927	4.506	2.453
309.9	38.715	18.715	38.877	18.877	39.687	19.688	4.439	2.439
309.8	38.299	18.646	38.461	18.808	39.271	19.617	4.402	2.437
309.7	37.836	18.550	37.998	18.712	38.806	19.520	4.361	2.432
309.6	37.567	18.547	37.729	18.709	38.538	19.518	4.337	2.435
309.5	37.398	18.591	37.561	18.754	38.374	19.567	4.322	2.441
309.4	37.277	18.659	37.441	18.822	38.258	19.640	4.311	2.449
309.3	37.164	18.730	37.329	18.894	38.151	19.716	4.301	2.458
309.2	37.055	18.802	37.220	18.967	38.047	19.794	4.291	2.466
309.1	36.949	18.875	37.115	19.041	37.946	19.872	4.282	2.474
309	36.835	18.942	37.002	19.109	37.837	19.945	4.272	2.482
308.9	36.727	19.012	36.895	19.180	37.735	20.020	4.262	2.491
308.8	36.615	19.080	36.784	19.249	37.628	20.093	4.252	2.499
308.7	36.499	19.145	36.669	19.314	37.518	20.163	4.242	2.506
308.6	36.391	19.213	36.562	19.383	37.415	20.237	4.232	2.514
308.5	36.284	19.280	36.455	19.452	37.313	20.310	4.222	2.522
308.4	36.173	19.346	36.346	19.518	37.208	20.380	4.213	2.530
308.3	36.059	19.408	36.232	19.581	37.099	20.448	4.202	2.537
308.2	35.943	19.468	36.117	19.642	36.987	20.513	4.192	2.545
308.1	35.816	19.522	35.991	19.697	36.865	20.572	4.181	2.551
308	35.693	19.578	35.868	19.753	36.747	20.632	4.170	2.558
307.9	35.569	19.631	35.745	19.808	36.628	20.691	4.158	2.565
307.8	35.442	19.683	35.620	19.860	36.507	20.747	4.147	2.571
307.7	35.294	19.722	35.472	19.900	36.363	20.790	4.134	2.577
307.6	35.159	19.767	35.338	19.945	36.232	20.840	4.122	2.583
307.5	35.034	19.816	35.214	19.996	36.112	20.894	4.111	2.589
307.4	34.923	19.873	35.104	20.054	36.006	20.956	4.101	2.596
307.3	34.805	19.925	34.987	20.107	35.893	21.013	4.090	2.602
307.2	34.693	19.980	34.875	20.162	35.785	21.072	4.080	2.609
307.1	34.580	20.033	34.763	20.216	35.678	21.131	4.070	2.615
307	34.464	20.084	34.647	20.267	35.566	21.186	4.059	2.621

North Pit Sensitivity Analysis Results

Stage	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Mining - WBM North Pit Inflow (m³/day)	Recovery - WBM North Pit Inflow (m³/day)
306.9	34.353	20.137	34.537	20.321	35.460	21.244	4.049	2.628
306.8	34.231	20.182	34.416	20.368	35.343	21.295	4.038	2.634
306.7	34.116	20.231	34.302	20.418	35.233	21.348	4.028	2.640
306.6	34.006	20.283	34.193	20.470	35.128	21.405	4.018	2.646
306.5	33.889	20.329	34.077	20.517	35.016	21.456	4.008	2.652
306.4	33.773	20.375	33.962	20.564	34.905	21.507	3.997	2.657
306.3	33.661	20.423	33.850	20.612	34.797	21.559	3.987	2.663
306.2	33.545	20.467	33.735	20.657	34.686	21.608	3.977	2.669
306.1	33.425	20.508	33.616	20.699	34.571	21.654	3.966	2.674
306	33.305	20.549	33.496	20.740	34.455	21.699	3.955	2.679
305.9	33.179	20.585	33.371	20.777	34.333	21.739	3.944	2.684
305.8	33.048	20.617	33.242	20.810	34.207	21.776	3.932	2.689
305.7	32.933	20.658	33.127	20.852	34.097	21.821	3.921	2.694
305.6	32.810	20.693	33.005	20.888	33.978	21.861	3.910	2.699
305.5	32.699	20.735	32.894	20.930	33.871	21.907	3.900	2.704
305.4	32.583	20.773	32.780	20.969	33.761	21.950	3.890	2.709
305.3	32.475	20.815	32.672	21.012	33.657	21.997	3.880	2.714
305.2	32.358	20.851	32.556	21.049	33.545	22.037	3.869	2.719
305.1	32.242	20.886	32.440	21.085	33.433	22.077	3.859	2.723
305	32.123	20.919	32.322	21.119	33.318	22.115	3.848	2.728
304.9	32.006	20.953	32.206	21.153	33.206	22.153	3.837	2.732
304.8	31.887	20.984	32.087	21.184	33.091	22.188	3.827	2.736
304.7	31.746	21.000	31.947	21.201	32.954	22.208	3.814	2.739
304.6	31.600	21.012	31.802	21.214	32.812	22.223	3.801	2.742
304.5	31.464	21.028	31.666	21.231	32.679	22.244	3.788	2.745
304.4	31.326	21.044	31.529	21.247	32.545	22.263	3.776	2.748
304.3	31.188	21.058	31.392	21.262	32.411	22.280	3.763	2.750
304.2	31.054	21.073	31.258	21.278	32.280	22.300	3.751	2.753
304.1	30.923	21.091	31.128	21.296	32.154	22.321	3.739	2.756
304	30.799	21.111	31.005	21.317	32.033	22.346	3.728	2.759
303.9	30.692	21.143	30.899	21.350	31.931	22.382	3.718	2.763
303.8	30.584	21.173	30.791	21.380	31.827	22.417	3.708	2.767
303.7	30.479	21.205	30.687	21.413	31.727	22.453	3.699	2.771
303.6	30.384	21.243	30.593	21.452	31.637	22.496	3.690	2.776
303.5	30.294	21.284	30.504	21.493	31.552	22.541	3.682	2.781
303.4	30.201	21.322	30.412	21.532	31.464	22.584	3.673	2.785
303.3	30.113	21.363	30.324	21.574	31.381	22.630	3.665	2.790
303.2	30.022	21.401	30.235	21.613	31.295	22.674	3.657	2.795
303.1	29.938	21.444	30.151	21.656	31.216	22.721	3.649	2.800
303	29.855	21.486	30.069	21.700	31.138	22.769	3.642	2.805
302.9	29.769	21.526	29.984	21.741	31.057	22.814	3.634	2.810
302.8	29.675	21.560	29.891	21.775	30.968	22.853	3.625	2.814
302.7	29.553	21.572	29.769	21.788	30.849	22.868	3.614	2.816
302.6	29.436	21.588	29.653	21.804	30.737	22.888	3.603	2.819
302.5	29.306	21.593	29.524	21.810	30.611	22.897	3.592	2.820
302.4	29.180	21.599	29.398	21.817	30.488	22.907	3.580	2.822

North Pit Sensitivity Analysis Results

Stage	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Mining - WBM North Pit Inflow (m³/day)	Recovery - WBM North Pit Inflow (m³/day)
302.3	29.056	21.607	29.274	21.825	30.367	22.918	3.569	2.824
302.2	28.954	21.630	29.173	21.850	30.270	22.946	3.559	2.827
302.1	28.861	21.660	29.081	21.880	30.182	22.980	3.551	2.831
302	28.764	21.685	28.984	21.906	30.089	23.010	3.542	2.834
301.9	28.679	21.719	28.901	21.941	30.010	23.050	3.534	2.838
301.8	28.582	21.743	28.804	21.966	29.917	23.078	3.525	2.841
301.7	28.480	21.763	28.704	21.988	29.828	23.112	3.516	2.844
301.6	28.379	21.784	28.607	22.011	29.744	23.149	3.507	2.847
301.5	28.265	21.793	28.496	22.023	29.648	23.175	3.496	2.849
301.4	28.155	21.804	28.388	22.038	29.555	23.204	3.486	2.851
301.3	28.051	21.820	28.287	22.056	29.468	23.237	3.476	2.853
301.2	27.941	21.830	28.180	22.069	29.375	23.264	3.466	2.855
301.1	27.809	21.822	28.052	22.065	29.263	23.276	3.454	2.855
301	27.706	21.836	27.951	22.082	29.178	23.308	3.444	2.858
300.9	27.614	21.859	27.863	22.107	29.104	23.348	3.436	2.860
300.8	27.528	21.884	27.779	22.136	29.036	23.392	3.428	2.864
300.7	27.444	21.912	27.698	22.166	28.970	23.438	3.420	2.867
300.6	27.361	21.939	27.619	22.197	28.906	23.484	3.413	2.870
300.5	27.269	21.959	27.530	22.219	28.833	23.522	3.404	2.873
300.4	27.176	21.976	27.439	22.240	28.758	23.559	3.395	2.875
300.3	27.088	21.998	27.355	22.265	28.690	23.601	3.387	2.878
300.2	26.992	22.013	27.263	22.284	28.614	23.635	3.378	2.880
300.1	26.909	22.037	27.182	22.310	28.550	23.678	3.371	2.883
300	26.819	22.055	27.096	22.332	28.480	23.717	3.362	2.886
299.9	26.733	22.076	27.013	22.356	28.413	23.756	3.354	2.889
299.8	26.637	22.088	26.920	22.371	28.337	23.788	3.345	2.890
299.7	26.554	22.110	26.841	22.397	28.274	23.830	3.338	2.893
299.6	26.456	22.119	26.746	22.409	28.196	23.859	3.328	2.895
299.5	26.362	22.131	26.655	22.424	28.122	23.890	3.320	2.897
299.4	26.276	22.148	26.573	22.445	28.055	23.928	3.312	2.899
299.3	26.195	22.170	26.495	22.470	27.994	23.969	3.304	2.902
299.2	26.108	22.185	26.411	22.489	27.927	24.004	3.296	2.904
299.1	26.020	22.200	26.327	22.506	27.858	24.038	3.288	2.906
299	25.935	22.215	26.244	22.525	27.792	24.073	3.280	2.908
298.9	25.843	22.225	26.156	22.538	27.721	24.103	3.271	2.910
298.8	25.750	22.234	26.067	22.550	27.648	24.131	3.263	2.911
298.7	25.659	22.243	25.979	22.562	27.577	24.160	3.254	2.913
298.6	25.563	22.247	25.886	22.570	27.501	24.184	3.245	2.914
298.5	25.467	22.250	25.793	22.577	27.424	24.208	3.236	2.915
298.4	25.378	22.259	25.708	22.589	27.355	24.237	3.228	2.916
298.3	25.292	22.270	25.625	22.603	27.289	24.267	3.220	2.918
298.2	25.199	22.274	25.535	22.610	27.215	24.291	3.211	2.919
298.1	25.105	22.277	25.445	22.617	27.142	24.314	3.203	2.920
298	25.000	22.270	25.343	22.612	27.057	24.327	3.193	2.920
297.9	24.908	22.273	25.254	22.619	26.985	24.350	3.184	2.921
297.8	24.801	22.262	25.150	22.611	26.898	24.359	3.174	2.920

North Pit Sensitivity Analysis Results

Stage	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Mining - WBM North Pit Inflow (m³/day)	Recovery - WBM North Pit Inflow (m³/day)
297.7	24.706	22.261	25.059	22.614	26.823	24.378	3.165	2.921
297.6	24.607	22.256	24.964	22.613	26.745	24.394	3.156	2.921
297.5	24.500	22.243	24.860	22.602	26.658	24.401	3.146	2.920
297.4	24.383	22.220	24.746	22.583	26.562	24.399	3.135	2.919
297.3	24.263	22.193	24.629	22.560	26.463	24.393	3.124	2.917
297.2	24.153	22.176	24.524	22.546	26.374	24.396	3.114	2.916
297.1	24.028	22.143	24.402	22.516	26.270	24.385	3.102	2.913
297	23.914	22.119	24.291	22.496	26.177	24.382	3.091	2.912
296.9	23.794	22.090	24.175	22.470	26.078	24.374	3.080	2.910
296.8	23.683	22.067	24.067	22.451	25.988	24.372	3.070	2.908
296.7	23.569	22.041	23.956	22.429	25.895	24.367	3.059	2.906
296.6	23.452	22.013	23.843	22.404	25.799	24.360	3.048	2.904
296.5	23.327	21.974	23.722	22.369	25.696	24.343	3.036	2.901
296.4	23.193	21.928	23.592	22.327	25.584	24.319	3.024	2.897
296.3	23.060	21.881	23.463	22.283	25.473	24.294	3.011	2.893
296.2	22.928	21.834	23.334	22.239	25.363	24.268	2.999	2.889
296.1	22.791	21.781	23.200	22.190	25.248	24.238	2.986	2.885
296	22.648	21.722	23.061	22.135	25.128	24.201	2.973	2.880
295.9	22.488	21.644	22.905	22.061	24.990	24.147	2.957	2.873
295.8	22.307	21.547	22.728	21.968	24.833	24.073	2.941	2.864
295.7	22.108	21.430	22.533	21.855	24.659	23.981	2.922	2.854
295.6	21.892	21.295	22.321	21.725	24.468	23.871	2.902	2.842
295.5	21.643	21.127	22.077	21.560	24.244	23.728	2.878	2.827
295.4	21.273	20.838	21.711	21.276	23.903	23.469	2.843	2.800
295.3	20.577	20.226	21.022	20.671	23.246	22.896	2.778	2.743
295.2	18.659	18.405	19.116	18.862	21.400	21.146	2.597	2.572
295.1	14.921	14.769	15.395	15.243	17.762	17.610	2.241	2.226
295	8.323	8.266	8.814	8.758	11.274	11.217	1.604	1.598

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
334.30	162.58	162.58	162.58	162.58	162.58	162.58	163.73	163.73	163.73	163.73	163.73	163.73	167.36	167.36	167.36	167.36	167.36	167.36	5.19	0.15	5.20	0.16	5.26	0.22	51.91	1.51	51.94	1.54	52.11	1.72
334.20	162.48	162.48	162.48	162.48	162.48	162.48	163.66	163.66	163.66	163.66	163.66	163.66	167.39	167.39	167.39	167.39	167.39	167.39	5.19	0.16	5.20	0.17	5.26	0.22	51.87	1.55	51.91	1.58	52.08	1.76
334.10	162.39	162.39	162.39	162.39	162.39	162.39	163.60	163.60	163.60	163.60	163.60	163.60	167.43	167.43	167.43	167.43	167.43	167.43	5.19	0.16	5.20	0.17	5.25	0.23	51.84	1.59	51.87	1.63	52.06	1.81
334.00	162.29	162.29	162.29	162.29	162.29	162.29	163.54	163.54	163.54	163.54	163.54	163.54	167.46	167.46	167.46	167.46	167.46	167.46	5.18	0.16	5.19	0.18	5.25	0.24	51.80	1.63	51.84	1.67	52.03	1.85
333.90	162.20	162.20	162.20	162.20	162.20	162.20	163.47	163.47	163.47	163.47	163.47	163.47	167.50	167.50	167.50	167.50	167.50	167.50	5.18	0.17	5.19	0.18	5.25	0.24	51.77	1.67	51.81	1.71	52.00	1.90
333.80	162.11	162.11	162.11	162.11	162.11	162.11	163.42	163.42	163.42	163.42	163.42	163.42	167.54	167.54	167.54	167.54	167.54	167.54	5.18	0.17	5.19	0.19	5.25	0.25	51.74	1.71	51.77	1.75	51.97	1.94
333.70	162.03	162.03	162.03	162.03	162.03	162.03	163.36	163.36	163.36	163.36	163.36	163.36	167.58	167.58	167.58	167.58	167.58	167.58	5.17	0.18	5.19	0.19	5.25	0.25	51.70	1.75	51.74	1.79	51.94	1.99
333.60	161.94	161.94	161.94	161.94	161.94	161.94	163.30	163.30	163.30	163.30	163.30	163.30	167.62	167.62	167.62	167.62	167.62	167.62	5.17	0.18	5.18	0.19	5.25	0.26	51.67	1.79	51.71	1.83	51.92	2.03
333.50	161.85	161.85	161.85	161.85	161.85	161.85	163.25	163.25	163.25	163.25	163.25	163.25	167.66	167.66	167.66	167.66	167.66	167.66	5.17	0.18	5.18	0.20	5.25	0.26	51.64	1.83	51.68	1.87	51.89	2.08
333.40	161.76	161.76	161.76	161.76	161.76	161.76	163.18	163.18	163.18	163.18	163.18	163.18	167.70	167.70	167.70	167.70	167.70	167.70	5.16	0.19	5.18	0.20	5.24	0.27	51.60	1.87	51.65	1.91	51.86	2.12
333.30	161.67	161.67	161.67	161.67	161.67	161.67	163.12	163.12	163.12	163.12	163.12	163.12	167.74	167.74	167.74	167.74	167.74	167.74	5.16	0.19	5.17	0.21	5.24	0.28	51.57	1.90	51.61	1.95	51.83	2.17
333.20	161.57	161.57	161.57	161.57	161.57	161.57	163.06	163.06	163.06	163.06	163.06	163.06	167.77	167.77	167.77	167.77	167.77	167.77	5.16	0.20	5.17	0.21	5.24	0.28	51.54	1.94	51.58	1.99	51.80	2.21
333.10	161.48	161.48	161.48	161.48	161.48	161.48	163.00	163.00	163.00	163.00	163.00	163.00	167.81	167.81	167.81	167.81	167.81	167.81	5.15	0.20	5.17	0.22	5.24	0.29	51.50	1.98	51.55	2.03	51.77	2.26
333.00	161.38	161.38	161.38	161.38	161.38	161.38	162.94	162.94	162.94	162.94	162.94	162.94	167.84	167.84	167.84	167.84	167.84	167.84	5.15	0.20	5.16	0.22	5.24	0.29	51.47	2.02	51.51	2.07	51.75	2.30
332.90	161.29	161.29	161.29	161.29	161.29	161.29	162.87	162.87	162.87	162.87	162.87	162.87	167.88	167.88	167.88	167.88	167.88	167.88	5.15	0.21	5.16	0.22	5.24	0.30	51.43	2.06	51.48	2.11	51.72	2.35
332.80	161.20	161.20	161.20	161.20	161.20	161.20	162.81	162.81	162.81	162.81	162.81	162.81	167.91	167.91	167.91	167.91	167.91	167.91	5.14	0.21	5.16	0.23	5.23	0.30	51.40	2.10	51.45	2.15	51.69	2.39
332.70	161.11	161.11	161.11	161.11	161.11	161.11	162.75	162.75	162.75	162.75	162.75	162.75	167.95	167.95	167.95	167.95	167.95	167.95	5.14	0.22	5.15	0.23	5.23	0.31	51.36	2.14	51.41	2.19	51.66	2.44
332.60	161.01	161.01	161.01	161.01	161.01	161.01	162.69	162.69	162.69	162.69	162.69	162.69	167.99	167.99	167.99	167.99	167.99	167.99	5.14	0.22	5.15	0.24	5.23	0.32	51.33	2.18	51.38	2.23	51.63	2.48
332.50	160.92	160.92	160.92	160.92	160.92	160.92	162.63	162.63	162.63	162.63	162.63	162.63	168.03	168.03	168.03	168.03	168.03	168.03	5.13	0.22	5.15	0.24	5.23	0.32	51.30	2.22	51.35	2.27	51.60	2.52
332.40	160.83	160.83	160.83	160.83	160.83	160.83	162.57	162.57	162.57	162.57	162.57	162.57	168.07	168.07	168.07	168.07	168.07	168.07	5.13	0.23	5.15	0.24	5.23	0.33	51.26	2.26	51.32	2.31	51.58	2.57
332.30	160.74	160.74	160.74	160.74	160.74	160.74	162.51	162.51	162.51	162.51	162.51	162.51	168.10	168.10	168.10	168.10	168.10	168.10	5.13	0.23	5.14	0.25	5.23	0.33	51.23	2.29	51.28	2.35	51.55	2.61
332.20	160.64	160.64	160.64	160.64	160.64	160.64	162.44	162.44	162.44	162.44	162.44	162.44	168.14	168.14	168.14	168.14	168.14	168.14	5.12	0.24	5.14	0.25	5.22	0.34	51.19	2.33	51.25	2.39	51.52	2.66
332.10	160.55	160.55	160.55	160.55	160.55	160.55	162.38	162.38	162.38	162.38	162.38	162.38	168.17	168.17	168.17	168.17	168.17	168.17	5.12	0.24	5.14	0.26	5.22	0.34	51.16	2.37	51.21	2.43	51.49	2.70
332.00	160.45	160.45	160.45	160.45	160.45	160.45	162.31	162.31	162.31	162.31	162.31	162.31	168.20	168.20	168.20	168.20	168.20	168.20	5.12	0.24	5.13	0.26	5.22	0.35	51.12	2.41	51.18	2.47	51.46	2.74
331.90	160.35	160.35	160.35	160.35	160.35	160.35	162.25	162.25	162.25	162.25	162.25	162.25	168.23	168.23	168.23	168.23	168.23	168.23	5.11	0.25	5.13	0.27	5.22	0.35	51.09	2.45	51.14	2.51	51.43	2.79
331.80	160.25	160.25	160.25	160.25	160.25	160.25	162.18	162.18	162.18	162.18	162.18	162.18	168.26	168.26	168.26	168.26	168.26	168.26	5.11	0.25	5.13	0.27	5.22	0.36	51.05	2.49	51.11	2.54	51.40	2.83
331.70	160.15	160.15	160.15	160.15	160.15	160.15	162.11	162.11	162.11	162.11	162.11	162.11	168.29	168.29	168.29	168.29	168.29	168.29	5.10	0.26	5.12	0.27	5.21	0.37	51.01	2.53	51.07	2.58	51.36	2.88
331.60	160.04	160.04	160.04	160.04	160.04	160.04	162.03	162.03	162.03	162.03	162.03	162.03	168.31	168.31	168.31	168.31	168.31	168.31	5.10	0.26	5.12	0.28	5.21	0.37	50.98	2.56	51.03	2.62	51.33	2.92
331.50	159.93	159.93	159.93	159.93	159.93	159.93	161.94	161.94	161.94	161.94	161.94	161.94	168.33	168.33	168.33	168.33	168.33	168.33	5.10	0.26	5.12	0.28	5.21	0.38	50.93	2.60	50.99	2.66	51.29	2.96
331.40	159.81	159.81	159.81	159.81	159.81	159.81	161.86	161.86	161.86	161.86	161.86	161.86	168.34	168.34	168.34	168.34	168.34	168.34	5.09	0.27	5.11	0.29	5.21	0.38	50.89	2.64	50.95	2.70	51.26	3.01
331.30	159.69	159.69	159.69	159.69	159.69	159.69	161.77	161.77	161.77	161.77	161.77	161.77	168.35	168.35	168.35	168.35	168.35	168.35	5.09	0.27	5.11	0.29	5.20	0.39	50.85	2.68	50.91	2.74	51.22	3.05
331.20	159.57	159.57	159.57	159.57	159.57	159.57	161.69	161.69	161.69	161.69	161.69	161.69	168.36	168.36	168.36	168.36	168.36	168.36	5.08	0.27	5.10	0.29	5.20	0.39	50.81	2.71	50.87	2.78	51.18	3.09
331.10	159.46	159.46	159.46	159.46	159.46	159.46	161.60	161.60	161.60	161.60	161.60	161.60	168.37	168.37	168.37	168.37	168.37	168.37	5.08	0.28	5.10	0.30	5.20	0.40	50.77	2.75	50.83	2.82	51.15	3.13
331.00	159.34	159.34	159.34	159.34	159.34	159.34	161.52	161.52	161.52	161.52	161.52	161.52	168.39	168.39	168.39	168.39	168.39	168.39	5.08	0.28	5.10	0.30	5.20	0.40	50.73	2.79	50.79	2.85	51.11	3.18
330.90	159.22	159.22	159.22	159.22	159.22	159.22	161.43	161.43	161.43	161.43	161.43	161.43	168.40	168.40	168.40	168.40	168.40	168.40	5.07	0.29	5.09	0.31	5.19	0.41	50.68	2.83	50.75	2.89	51.07	3.22
330.80	159.09	159.09	159.09	159.09	159.09	159.09	161.33	161.33	161.33	161.33	161.33	161.33	168.40	168.40	168.40	168.40	168.40	168.40	5.07	0.29	5.09	0.31	5.19	0.41	50.64	2.86	50.70	2.93	51.03	3.26
330.70	158.94	158.94	158.94	158.94	158.94	158.94	161.20	161.20	161.20	161.20	161.20	161.20	168.37	168.37	168.37	168.37	168.37	168.37	5.06	0.29	5.08	0.31	5.19	0.42	50.58	2.90	50.65	2.97	50.98	3.30
330.60	158.78	158.78	158.78	158.78	158.78	158.78	161.08	161.08	161.08	161.08	161.08	161.08	168.34	168.34	168.34	168.34	168.34	168.34	5.06	0.30	5.08	0.32	5.18	0.43	50.53	2.94	50.60	3.01	50.94	3.35
330.50	158.64	158.64	158.64	158.64	158.64	158.64	160.96	160.96	160.96	160.96	160.96	160.96	168.33	168.33	168.33	168.33	168.33	168.33	5.05	0.30	5.07	0.32	5.18	0.43	50.48	2.97	50.55	3.04	50.89	3.39
330.40	158.49	158.49	158.49	158.49	158.49	158.49	160.85	160.85	160.85	160.85	160.85	160.85	168.31	168.31	168.31	168.31	168.31	168.31	5.05	0.30	5.07	0.33	5.18	0.44	50.43	3.01	50.50	3.08	50.84	3.43
330.30	158.33	158.33	158.33	158.33	158.33	158.33	160.72	160.72	160.72	160.72	160.72	160.72	168.27	168.27	168.27	168.27	168.27	168.27	5.04	0.31	5.06	0.33	5.17	0.44	50.37	3.05	50.44	3.12	50.79	3.47
330.20	158.18	158.18	158.18	158.18	158.18	158.18	160.60	160.60	160.60	160.60	160.60	160.60	168.26	168.26	168.26	168.26	168.26	168.26	5.04	0.31	5.06	0.33	5.17	0.45	50.32	3.08	50.39	3.16	50.75	3.51
330.10	158.04	158.04	158.04	158.04	158.04	158.04	160.49	160.49	160.49	160.49	160.49	160.49	168.25	168.25	168.25	168.25	168.25	168.25	5.03	0.32	5.05	0.34	5.17	0.45	50.27	3.12	50.34	3.19	50.70	3.55
330.00	157.92	157.92	157.92	157.92	157.92	157.92	160.40	160.40	160.40	160.40	160.40	160.40	168.26	168.26	168.26	168.26	168.26	168.26	5.03	0.32	5.05	0.34	5.16	0.46	50.23	3.16	50.30	3.23	50.66	3.60
329.90	157.80	157.80	157.80	157.80	157.80	157.80	160.32	160.32	160.32	160.32	160.32	160.32	168.27	168.27	168.27	168.27	168.27	168.27	5.02	0.32	5.05	0.35	5.16	0.46	50.18	3.19	50.26	3.27	50.63	3.64
329.80	157.69	157.69	157.69	157.69	157.69	157.69	160.23	160.23	160.23	160.23	160.23	160.23	168.28	168.28	168.28	168.28	168.28	168.28	5.02	0.33	5.04	0.35	5.16	0.47	50.14	3.23	50.22	3.31	50.59	3.68
329.70	157.58	157.58	157.58	157.58	157.58	157.58	160.15	160.15	160.15	160.15	160.15	160.15	168.30	168.30	168.30	168.30	168.30	168.30	5.01	0.33	5.04	0.35	5.16	0.47	50.10	3.27	50.18	3.34	50.56	3.72
329.60	157.46	157.46	157.46	157.46	157.46	157.46	160.07	160.07	160.07	160.07	160.07	160.07	168.32	168.32	168.32	168.32	168.32	168.32	5.01	0.33	5.03	0.36	5.15	0.48	50.06	3.30	50.14	3.38	50.52	3.76
329.50	157.35	157.35	157.35	157.35	157.35	157.35	159.99	159.99	159.99	159.99	159.99	159.99	168.33	168.33	168.33	168.33	168.33	168.33	5.01	0.34	5.03	0.36	5.15	0.48	50.02	3.34	50.10	3.42	50.49	3.81
329.40	157.23	157.23	157.23	157.23	157.23	157.23	159.90	159.90	159.90	159.90	159.90	159.90	168.35	168.35	168.35	168.35	168.35	168.35	5.00	0.34	5.03	0.37	5.15	0.49	49.98	3.38	50.06	3.46	50.45	3.85
329.30	157.12	157.12	157.12	157.12	157.12	157.12	159.82	159.82	159.82	159.82	159.82	159.82	168.36	168.36	168.36	168.36	168.36	168.36	5.00	0.35	5.02	0.37	5.15	0.49	49.94	3.41	50.02	3.49	50.41	3.89
329.20	157.01	157.01	157.01	157.01	157.01	157.01	159.74	159.74	159.74	159.74	159.74	159.74	168.38	168.38	168.38	168.38	168.38	168.38	4.99	0.35	5.02	0.37	5.14	0.50	49.90	3.45	49.98	3.53	50.38	3.93
329.10	156.90	156.90	156.90	156.90	156.90	156.90	159.66	159.66	159.66	159.66	159.66	159.66	168.40	168.40	168.40	168.40	168.40	168.40	4.99	0.35	5.02	0.38	5.14	0.51	49.86	3.49	49.94	3.57	50.34	3.97
329.00	156.79	156.79	156.79	156.79	156.79	156.79	159.58	159.58	159.58	159.58	159.58	159.58	168.42	168.42	168.42	168.42	168.42	168.42	4.99	0.36	5.01	0.38	5.14	0.51	49.82	3.52	49.90	3.60	50.31	4.01
328.90	156.68	156.68	156.68	156.68	156.68	156.68	159.50	159.50	159.50	159.50	159.50	159.50	168.44	168.44	168.44	168.44	168.44	168.44	4.98	0.36	5.01	0.39	5.14	0.52	49.78	3.56	49.86	3.64	50.28	4.05
328.80	156.57	156.57	156.57	156.57	156.57	156.57	159.43	159.43	159.43	159.43	159.43	159.43	168.46	168.46	168.46	168.46	168.46	168.46	4.98	0.36	5.00	0.39	5.14	0.52	49.74	3.60	49.83	3.68	50.24	4.10
328.70	156.47	156.47	156.47	156.47	156.47	156.47	159.36	159.36	159.36	159.36	159.36	159.36	168.49	168.49	168.49	168.49	168.49	168.49	4.97	0.37	5.00	0.39	5.13	0.53	49.70	3.63	49.79	3.72	50.21	4.14
328.60	156.37	156.37	156.37	156.37	156.37	156.37	159.29	159.29	159.29	159.29	159.29	159.29	168.52	168.52	168.52	168.52	168.52	168.52	4.97	0.37	5.00	0.40	5.13	0.53	49.67	3.67	49.75	3.75	50.18	4.18
328.50	156.28	156.28	156.28	156.28	156.28	156.28	159.22	159.22	159.22	159.22	159.22	159.22	168.55	168.55	168.55	168.55	168.55	168.55	4.97	0.38	4.99	0.40	5.13	0.54	49.63	3.70	49.72	3.79	50.15	4.22
328.40	156.18	156.18	156.18	156.18	156.18	156.18	159.16	159.16	159.16	159.16	159.16	159.16	168.59	168.59	168.59	168.59	168.59	168.59	4.96	0.38	4.99	0.41	5.13	0.54	49.60	3.74	49.69	3.83	50.12	4.26
328.30	156.09	156.09	156.09	156.09	156.09	156.09	159.10	159.10	159.10	159.10	159.10	159.10	168.63	168.63	168.63	168.63	168.63	168.63	4.96	0.38	4.99	0.41	5.13	0.55	49.57	3.78	49.65	3.87	50.09	4.30
328.20	156.00	156.00	156.00	156.00	156.00	156.00	159.05	159.05	159.05	159.05	159.05	159.05	168.67	168.67	168.67	168.67	168.67	168.67	4.96	0.39	4.99	0.41	5.12	0.55	49.53	3.81	49.62	3.90	50.06	4.35
328.10	155.92	155.92	155.92	155.92	155.92	155.92	158.99	158.99	158.99	158.99	158.99	158.99	168.71	168.71	168.71	168.71	168.71	168.71	4.95	0.39	4.98	0.42	5.12	0.56	49.50	3.85	49.59	3.94	50.04	4.39
328.00	155.83	155.83	155.83	155.83	155.83	155.83	158.93	158.93	158.93	158.93	158.93	158.93	168.75	168.75	168.75	168.75	168.75	168.75	4.95	0.39	4.98	0.42	5.12	0.56	49.47	3.89	49.56	3.98	50.01	4.43
327.90	155.75	155.75	155.75	155.75	155.75	155.75	158.88	158.88	158.88	158.88	158.88	158.88	168.80	168.80	168.80	168.80	168.80	168.80	4.95	0.40	4.98	0.43	5.12	0.57	49.44	3.92	49.53	4.01	49.98	4.47
327.80	155.66	155.66	155.66	155.66	155.66	155.66	158.83	158.83	158.83	158.83	158.83	158.83	168.84	168.84	168.84	168.84	168.84	168.84	4.95	0.40	4.97	0.43	5.12	0.57	49.41	3.96	49.50	4.05	49.96	4.51
327.70	155.58	155.58	155.58	155.58	155.58	155.58	158.78	158.78	158.78	158.78	158.78	158.78	168.89	168.89	168.89	168.89	168.89	168.89	4.94	0.40	4.97	0.43	5.12	0.58	49.38	4.00	49.47	4.09	49.93	4.55
327.60	155.50	155.50	155.50	155.50	155.50	155.50	158.73	158.73	158.73	158.73	158.73	158.73	168.94	168.94	168.94	168.94	168.94	168.94	4.94	0.41	4.97	0.44	5.12	0.58	49.35	4.03	49.44	4.13	49.91	4.59
327.50	155.43	155.43	155.43	155.43	155.43	155.43	158.69	158.69	158.69	158.69	158.69	158.69	168.99	168.99	168.99	168.99	168.99	168.99	4.94	0.41	4.97	0.44	5.11	0.59	49.32	4.07	49.41	4.16	49.89	4.64
327.40	155.35	155.35	155.35	155.35	155.35	155.35	158.64	158.64	158.64	158.64	158.64	158.64	169.05	169.05	169.05	169.05	169.05	169.05	4.93	0.42	4.96	0.45	5.11	0.59	49.29	4.10	49.38	4.20	49.86	4.68
327.30	155.27	155.27	155.27	155.27	155.27	155.27	158.60	158.60	158.60	158.60	158.60	158.60	169.10	169.10	169.10	169.10	169.10	169.10	4.93	0.42	4.96	0.45	5.11	0.60	49.26	4.14	49.36	4.24	49.84	4.72
327.20	155.20	155.20	155.20	155.20	155.20	155.20	158.55	158.55	158.55	158.55	158.55	158.55	169.15	169.15	169.15	169.15	169.15	169.15	4.93	0.42	4.96	0.45	5.11	0.61	49.23	4.18	49.33	4.27	49.81	4.76
327.10	155.12	155.12	155.12	155.12	155.12	155.12	158.51	158.51	158.51	158.51	158.51	158.51	169.21	169.21	169.21	169.21	169.21	169.21	4.93	0.43	4.96	0.46	5.11	0.61	49.20	4.21	49.30	4.31	49.79	4.80
327.00	155.05	155.05	155.05	155.05	155.05	155.05	158.46	158.46	158.46	158.46	158.46	158.46	169.26	169.26	169.26	169.26	169.26	169.26	4.92	0.43	4.95	0.46	5.11	0.62	49.17	4.25	49.27	4.35	49.77	4.84
326.90	154.98	154.98	154.98	154.98	154.98	154.98	158.42	158.42	158.42	158.42	158.42	158.42	169.32	169.32	169.32	169.32	169.32	169.32	4.92	0.43	4.95	0.47	5.11	0.62	49.15	4.29	49.25	4.39	49.75	4.88
326.80	154.90	154.90	154.90	154.90	154.90	154.90	158.38	158.38	158.38	158.38	158.38	158.38	169.37	169.37	169.37	169.37	169.37	169.37	4.92	0.44	4.95	0.47	5.11	0.63	49.12	4.32	49.22	4.42	49.72	4.93
326.70	154.83	154.83	154.83	154.83	154.83	154.83	158.34	158.34	158.34	158.34	158.34	158.34	169.43	169.43	169.43	169.43	169.43	169.43	4.91	0.44	4.95	0.47	5.10	0.63	49.09	4.36	49.19	4.46	49.70	4.97
326.60	154.76	154.76	154.76	154.76	154.76	154.76	158.29	158.29	158.29	158.29	158.29	158.29	169.49	169.49	169.49	169.49	169.49	169.49	4.91	0.44	4.94	0.48	5.10	0.64	49.06	4.39	49.17	4.50	49.68	5.01
326.50	154.68	154.68	154.68	154.68	154.68	154.68	158.25	158.25	158.25	158.25	158.25	158.25	169.54	169.54	169.54	169.54	169.54	169.54	4.91	0.45	4.94	0.48	5.10	0.64	49.04	4.43	49.14	4.53	49.66	5.05
326.40	154.61	154.61	154.61	154.61	154.61	154.61	158.21	158.21	158.21	158.21	158.21	158.21	169.60	169.60	169.60	169.60	169.60	169.60	4.91	0.45	4.94	0.48	5.10	0.65	49.01	4.47	49.11	4.57	49.63	5.09
326.30	154.54	154.54	154.54	154.54	154.54	154.54	158.17	158.17	158.17	158.17	158.17	158.17	169.66	169.66	169.66	169.66	169.66	169.66	4.90	0.46	4.94	0.49	5.10	0.65	48.98	4.50	49.09	4.61	49.61	5.13

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)
324.10	152.91	152.91	152.91	152.91	152.91	152.91	157.23	157.23	157.23	157.23	157.23	157.23	170.87	170.87	170.87	170.87	170.87	170.87	4.84	0.53	4.88	0.57	5.07	0.77	48.36	5.28	48.49	5.40	49.10	6.02
324.00	152.83	152.83	152.83	152.83	152.83	152.83	157.17	157.17	157.17	157.17	157.17	157.17	170.92	170.92	170.92	170.92	170.92	170.92	4.84	0.54	4.88	0.58	5.07	0.77	48.33	5.32	48.46	5.44	49.08	6.06
323.90	152.74	152.74	152.74	152.74	152.74	152.74	157.12	157.12	157.12	157.12	157.12	157.12	170.96	170.96	170.96	170.96	170.96	170.96	4.84	0.54	4.88	0.58	5.07	0.78	48.30	5.35	48.42	5.47	49.05	6.10
323.80	152.66	152.66	152.66	152.66	152.66	152.66	157.07	157.07	157.07	157.07	157.07	157.07	171.00	171.00	171.00	171.00	171.00	171.00	4.83	0.55	4.87	0.58	5.07	0.78	48.27	5.38	48.39	5.51	49.02	6.14
323.70	152.57	152.57	152.57	152.57	152.57	152.57	157.01	157.01	157.01	157.01	157.01	157.01	171.05	171.05	171.05	171.05	171.05	171.05	4.83	0.55	4.87	0.59	5.07	0.79	48.24	5.42	48.36	5.55	49.00	6.18
323.60	152.48	152.48	152.48	152.48	152.48	152.48	156.95	156.95	156.95	156.95	156.95	156.95	171.09	171.09	171.09	171.09	171.09	171.09	4.83	0.55	4.87	0.59	5.07	0.79	48.20	5.45	48.33	5.58	48.97	6.22
323.50	152.39	152.39	152.39	152.39	152.39	152.39	156.89	156.89	156.89	156.89	156.89	156.89	171.13	171.13	171.13	171.13	171.13	171.13	4.82	0.56	4.86	0.60	5.06	0.80	48.17	5.49	48.30	5.62	48.94	6.26
323.40	152.30	152.30	152.30	152.30	152.30	152.30	156.84	156.84	156.84	156.84	156.84	156.84	171.17	171.17	171.17	171.17	171.17	171.17	4.82	0.56	4.86	0.60	5.06	0.80	48.14	5.52	48.27	5.65	48.91	6.30
323.30	152.21	152.21	152.21	152.21	152.21	152.21	156.78	156.78	156.78	156.78	156.78	156.78	171.21	171.21	171.21	171.21	171.21	171.21	4.82	0.56	4.86	0.60	5.06	0.81	48.10	5.55	48.23	5.68	48.88	6.33
323.20	152.12	152.12	152.12	152.12	152.12	152.12	156.72	156.72	156.72	156.72	156.72	156.72	171.24	171.24	171.24	171.24	171.24	171.24	4.81	0.57	4.85	0.61	5.06	0.81	48.07	5.59	48.20	5.72	48.86	6.37
323.10	152.03	152.03	152.03	152.03	152.03	152.03	156.65	156.65	156.65	156.65	156.65	156.65	171.28	171.28	171.28	171.28	171.28	171.28	4.81	0.57	4.85	0.61	5.06	0.82	48.04	5.62	48.17	5.75	48.83	6.41
323.00	151.93	151.93	151.93	151.93	151.93	151.93	156.59	156.59	156.59	156.59	156.59	156.59	171.31	171.31	171.31	171.31	171.31	171.31	4.81	0.57	4.85	0.61	5.05	0.82	48.00	5.66	48.13	5.79	48.80	6.45
322.90	151.84	151.84	151.84	151.84	151.84	151.84	156.52	156.52	156.52	156.52	156.52	156.52	171.35	171.35	171.35	171.35	171.35	171.35	4.80	0.58	4.85	0.62	5.05	0.82	47.97	5.69	48.10	5.82	48.77	6.49
322.80	151.74	151.74	151.74	151.74	151.74	151.74	156.45	156.45	156.45	156.45	156.45	156.45	171.37	171.37	171.37	171.37	171.37	171.37	4.80	0.58	4.84	0.62	5.05	0.83	47.93	5.72	48.06	5.86	48.73	6.53
322.70	151.63	151.63	151.63	151.63	151.63	151.63	156.38	156.38	156.38	156.38	156.38	156.38	171.40	171.40	171.40	171.40	171.40	171.40	4.80	0.58	4.84	0.62	5.05	0.83	47.89	5.76	48.02	5.89	48.70	6.56
322.60	151.52	151.52	151.52	151.52	151.52	151.52	156.30	156.30	156.30	156.30	156.30	156.30	171.42	171.42	171.42	171.42	171.42	171.42	4.79	0.59	4.83	0.63	5.05	0.84	47.85	5.79	47.99	5.92	48.66	6.60
322.50	151.41	151.41	151.41	151.41	151.41	151.41	156.22	156.22	156.22	156.22	156.22	156.22	171.43	171.43	171.43	171.43	171.43	171.43	4.79	0.59	4.83	0.63	5.04	0.84	47.81	5.82	47.95	5.96	48.63	6.64
322.40	151.30	151.30	151.30	151.30	151.30	151.30	156.14	156.14	156.14	156.14	156.14	156.14	171.46	171.46	171.46	171.46	171.46	171.46	4.78	0.59	4.83	0.64	5.04	0.85	47.77	5.85	47.91	5.99	48.60	6.68
322.30	151.19	151.19	151.19	151.19	151.19	151.19	156.07	156.07	156.07	156.07	156.07	156.07	171.48	171.48	171.48	171.48	171.48	171.48	4.78	0.60	4.82	0.64	5.04	0.85	47.73	5.89	47.87	6.02	48.56	6.71
322.20	151.09	151.09	151.09	151.09	151.09	151.09	155.99	155.99	155.99	155.99	155.99	155.99	171.50	171.50	171.50	171.50	171.50	171.50	4.78	0.60	4.82	0.64	5.04	0.86	47.70	5.92	47.83	6.06	48.53	6.75
322.10	150.98	150.98	150.98	150.98	150.98	150.98	155.92	155.92	155.92	155.92	155.92	155.92	171.53	171.53	171.53	171.53	171.53	171.53	4.77	0.60	4.82	0.65	5.03	0.86	47.66	5.95	47.80	6.09	48.50	6.79
322.00	150.88	150.88	150.88	150.88	150.88	150.88	155.84	155.84	155.84	155.84	155.84	155.84	171.55	171.55	171.55	171.55	171.55	171.55	4.77	0.61	4.81	0.65	5.03	0.87	47.62	5.98	47.76	6.13	48.46	6.83
321.90	150.77	150.77	150.77	150.77	150.77	150.77	155.76	155.76	155.76	155.76	155.76	155.76	171.57	171.57	171.57	171.57	171.57	171.57	4.77	0.61	4.81	0.65	5.03	0.87	47.58	6.02	47.72	6.16	48.43	6.86
321.80	150.65	150.65	150.65	150.65	150.65	150.65	155.68	155.68	155.68	155.68	155.68	155.68	171.58	171.58	171.58	171.58	171.58	171.58	4.76	0.61	4.81	0.66	5.03	0.88	47.54	6.05	47.68	6.19	48.39	6.90
321.70	150.53	150.53	150.53	150.53	150.53	150.53	155.59	155.59	155.59	155.59	155.59	155.59	171.59	171.59	171.59	171.59	171.59	171.59	4.76	0.62	4.80	0.66	5.02	0.88	47.49	6.08	47.64	6.22	48.35	6.94
321.60	150.40	150.40	150.40	150.40	150.40	150.40	155.49	155.49	155.49	155.49	155.49	155.49	171.59	171.59	171.59	171.59	171.59	171.59	4.75	0.62	4.80	0.66	5.02	0.89	47.45	6.11	47.59	6.26	48.31	6.97
321.50	150.26	150.26	150.26	150.26	150.26	150.26	155.39	155.39	155.39	155.39	155.39	155.39	171.58	171.58	171.58	171.58	171.58	171.58	4.75	0.62	4.79	0.67	5.02	0.89	47.40	6.14	47.55	6.29	48.27	7.01
321.40	150.12	150.12	150.12	150.12	150.12	150.12	155.27	155.27	155.27	155.27	155.27	155.27	171.57	171.57	171.57	171.57	171.57	171.57	4.74	0.63	4.79	0.67	5.01	0.90	47.35	6.17	47.49	6.32	48.22	7.04
321.30	149.96	149.96	149.96	149.96	149.96	149.96	155.15	155.15	155.15	155.15	155.15	155.15	171.54	171.54	171.54	171.54	171.54	171.54	4.74	0.63	4.78	0.67	5.01	0.90	47.30	6.20	47.44	6.35	48.17	7.08
321.20	149.79	149.79	149.79	149.79	149.79	149.79	155.01	155.01	155.01	155.01	155.01	155.01	171.50	171.50	171.50	171.50	171.50	171.50	4.73	0.63	4.78	0.68	5.00	0.90	47.24	6.23	47.38	6.38	48.12	7.11
321.10	149.60	149.60	149.60	149.60	149.60	149.60	154.84	154.84	154.84	154.84	154.84	154.84	171.43	171.43	171.43	171.43	171.43	171.43	4.72	0.63	4.77	0.68	5.00	0.91	47.17	6.26	47.32	6.41	48.05	7.14
321.00	149.33	149.33	149.33	149.33	149.33	149.33	154.61	154.61	154.61	154.61	154.61	154.61	171.30	171.30	171.30	171.30	171.30	171.30	4.72	0.64	4.76	0.68	4.99	0.91	47.08	6.29	47.23	6.43	47.97	7.17
320.90	148.93	148.93	148.93	148.93	148.93	148.93	154.24	154.24	154.24	154.24	154.24	154.24	171.03	171.03	171.03	171.03	171.03	171.03	4.70	0.64	4.75	0.68	4.98	0.91	46.95	6.31	47.10	6.45	47.84	7.19
320.80	148.59	148.59	148.59	148.59	148.59	148.59	153.93	153.93	153.93	153.93	153.93	153.93	170.82	170.82	170.82	170.82	170.82	170.82	4.69	0.64	4.74	0.69	4.97	0.92	46.83	6.33	46.98	6.48	47.73	7.22
320.70	148.16	148.16	148.16	148.16	148.16	148.16	153.53	153.53	153.53	153.53	153.53	153.53	170.51	170.51	170.51	170.51	170.51	170.51	4.68	0.64	4.72	0.69	4.95	0.92	46.69	6.34	46.84	6.49	47.59	7.24
320.60	147.78	147.78	147.78	147.78	147.78	147.78	153.18	153.18	153.18	153.18	153.18	153.18	170.26	170.26	170.26	170.26	170.26	170.26	4.66	0.64	4.71	0.69	4.94	0.92	46.57	6.36	46.72	6.51	47.46	7.26
320.50	147.40	147.40	147.40	147.40	147.40	147.40	152.83	152.83	152.83	152.83	152.83	152.83	170.01	170.01	170.01	170.01	170.01	170.01	4.65	0.65	4.70	0.69	4.93	0.93	46.44	6.38	46.59	6.53	47.34	7.28
320.40	146.91	146.91	146.91	146.91	146.91	146.91	152.38	152.38	152.38	152.38	152.38	152.38	169.65	169.65	169.65	169.65	169.65	169.65	4.64	0.65	4.68	0.69	4.92	0.93	46.28	6.40	46.43	6.55	47.18	7.30
320.30	146.36	146.36	146.36	146.36	146.36	146.36	151.86	151.86	151.86	151.86	151.86	151.86	169.23	169.23	169.23	169.23	169.23	169.23	4.62	0.65	4.66	0.70	4.90	0.93	46.10	6.41	46.25	6.56	47.00	7.31
320.20	145.73	145.73	145.73	145.73	145.73	145.73	151.26	151.26	151.26	151.26	151.26	151.26	168.73	168.73	168.73	168.73	168.73	168.73	4.60	0.65	4.64	0.70	4.88	0.93	45.89	6.42	46.04	6.57	46.80	7.32
320.10	145.23	145.23	145.23	145.23	145.23	145.23	150.78	150.78	150.78	150.78	150.78	150.78	168.36	168.36	168.36	168.36	168.36	168.36	4.58	0.65	4.63	0.70	4.86	0.93	45.73	6.43	45.88	6.58	46.63	7.34
320.00	144.72	144.72	144.72	144.72	144.72	144.72	150.30	150.30	150.30	150.30	150.30	150.30	167.97	167.97	167.97	167.97	167.97	167.97	4.56	0.65	4.61	0.70	4.85	0.93	45.56	6.44	45.71	6.59	46.47	7.35
319.90	144.29	144.29	144.29	144.29	144.29	144.29	149.91	149.91	149.91	149.91	149.91	149.91	167.68	167.68	167.68	167.68	167.68	167.68	4.55	0.65	4.60	0.70	4.83	0.94	45.42	6.46	45.57	6.61	46.33	7.37
319.80	143.85	143.85	143.85	143.85	143.85	143.85	149.50	149.50	149.50	149.50	149.50	149.50	167.37	167.37	167.37	167.37	167.37	167.37	4.54	0.66	4.58	0.70	4.82	0.94	45.27	6.47	45.42	6.62	46.19	7.39
319.70	143.48	143.48	143.48	143.48	143.48	143.48	149.16	149.16	149.16	149.16	149.16	149.16	167.12	167.12	167.12	167.12	167.12	167.12	4.52	0.66	4.57	0.70	4.81	0.94	45.15	6.49	45.30	6.64	46.06	7.41
319.60	143.18	143.18	143.18	143.18	143.18	143.18	148.89	148.89	148.89	148.89	148.89	148.89	166.95	166.95	166.95	166.95	166.95	166.95	4.51	0.66	4.56	0.71	4.80	0.94	45.05	6.51	45.20	6.66	45.97	7.43
319.50	142.93	142.93	142.93	142.93	142.93	142.93	148.68	148.68	148.68	148.68	148.68	148.68	166.84	166.84	166.84	166.84	166.84	166.84	4.50	0.66	4.55	0.71	4.79	0.95	44.96	6.53	45.12	6.69	45.89	7.46
319.40	142.72	142.72	142.72	142.72	142.72	142.72	148.49	148.49	148.49	148.49	148.49	148.49	166.75	166.75	166.75	166.75	166.75	166.75	4.50	0.66	4.55	0.71	4.78	0.95	44.89	6.56	45.04	6.71	45.82	7.49
319.30	142.49	142.49	142.49	142.49	142.49	142.49	148.29	148.29	148.29	148.29	148.29	148.29	166.65	166.65	166.65	166.65	166.65	166.65	4.49	0.67	4.54	0.71	4.78	0.96	44.81	6.58	44.97	6.74	45.74	7.51
319.20	142.26	142.26	142.26	142.26	142.26	142.26	148.10	148.10	148.10	148.10	148.10	148.10	166.55	166.55	166.55	166.55	166.55	166.55	4.48	0.67	4.53	0.72	4.77	0.96	44.74	6.61	44.89	6.76	45.67	7.54
319.10	142.10	142.10	142.10	142.10	142.10	142.10	147.96	147.96	147.96	147.96	147.96	147.96	166.52	166.52	166.52	166.52	166.52	166.52	4.48	0.67	4.52	0.72	4.77	0.96	44.68	6.63	44.83	6.79	45.62	7.57
319.00	141.96	141.96	141.96	141.96	141.96	141.96	147.85	147.85	147.85	147.85	147.85	147.85	166.50	166.50	166.50	166.50	166.50	166.50	4.47	0.67	4.52	0.72	4.76	0.97	44.63	6.66	44.79	6.82	45.57	7.60
318.90	141.82	141.82	141.82	141.82	141.82	141.82	147.75	147.75	147.75	147.75	147.75	147.75	166.50	166.50	166.50	166.50	166.50	166.50	4.47	0.68	4.52	0.73	4.76	0.97	44.58	6.69	44.74	6.85	45.53	7.64
318.80	141.70	141.70	141.70	141.70	141.70	141.70	147.66	147.66	147.66	147.66	147.66	147.66	166.51	166.51	166.51	166.51	166.51	166.51	4.46	0.68	4.51	0.73	4.76	0.97	44.54	6.72	44.70	6.87	45.49	7.67
318.70	141.58	141.58	141.58	141.58	141.58	141.58	147.57	147.57	147.57	147.57	147.57	147.57	166.52	166.52	166.52	166.52	166.52	166.52	4.46	0.68	4.51	0.73	4.75	0.98	44.49	6.74	44.65	6.90	45.45	7.70
318.60	141.47	141.47	141.47	141.47	141.47	141.47	147.49	147.49	147.49	147.49	147.49	147.49	166.54	166.54	166.54	166.54	166.54	166.54	4.45	0.69	4.50	0.74	4.75	0.98	44.46	6.77	44.62	6.93	45.42	7.73
318.50	141.37	141.37	141.37	141.37	141.37	141.37	147.42	147.42	147.42	147.42	147.42	147.42	166.56	166.56	166.56	166.56	166.56	166.56	4.45	0.69	4.50	0.74	4.75	0.99	44.42	6.80	44.58	6.96	45.38	7.77
318.40	141.27	141.27	141.27	141.27	141.27	141.27	147.35	147.35	147.35	147.35	147.35	147.35	166.59	166.59	166.59	166.59	166.59	166.59	4.45	0.69	4.50	0.74	4.75	0.99	44.38	6.83	44.54	6.99	45.35	7.80
318.30	141.17	141.17	141.17	141.17	141.17	141.17	147.28	147.28	147.28	147.28	147.28	147.28	166.62	166.62	166.62	166.62	166.62	166.62	4.44	0.69	4.49	0.74	4.74	1.00	44.35	6.86	44.51	7.02	45.32	7.83
318.20	141.07	141.07	141.07	141.07	141.07	141.07	147.22	147.22	147.22	147.22	147.22	147.22	166.66	166.66	166.66	166.66	166.66	166.66	4.44	0.70	4.49	0.75	4.74	1.00	44.31	6.89	44.47	7.05	45.29	7.87
318.10	140.98	140.98	140.98	140.98	140.98	140.98	147.15	147.15	147.15	147.15	147.15	147.15	166.69	166.69	166.69	166.69	166.69	166.69	4.44	0.70	4.49	0.75	4.74	1.00	44.27	6.92	44.44	7.08	45.26	7.90
318.00	140.88	140.88	140.88	140.88	140.88	140.88	147.09	147.09	147.09	147.09	147.09	147.09	166.72	166.72	166.72	166.72	166.72	166.72	4.43	0.70	4.48	0.75	4.74	1.01	44.24	6.95	44.40	7.11	45.23	7.94
317.90	140.79	140.79	140.79	140.79	140.79	140.79	147.03	147.03	147.03	147.03	147.03	147.03	166.76	166.76	166.76	166.76	166.76	166.76	4.43	0.71	4.48	0.76	4.74	1.01	44.21	6.98	44.37	7.14	45.20	7.97
317.80	140.71	140.71	140.71	140.71	140.71	140.71	146.98	146.98	146.98	146.98	146.98	146.98	166.81	166.81	166.81	166.81	166.81	166.81	4.43	0.71	4.48	0.76	4.73	1.02	44.18	7.01	44.34	7.17	45.17	8.00
317.70	140.63	140.63	140.63	140.63	140.63	140.63	146.93	146.93	146.93	146.93	146.93	146.93	166.85	166.85	166.85	166.85	166.85	166.85	4.42	0.71	4.47	0.76	4.73	1.02	44.14	7.04	44.31	7.20	45.14	8.04
317.60	140.54	140.54	140.54	140.54	140.54	140.54	146.87	146.87	146.87	146.87	146.87	146.87	166.90	166.90	166.90	166.90	166.90	166.90	4.42	0.72	4.47	0.77	4.73	1.03	44.11	7.07	44.28	7.23	45.12	8.07
317.50	140.45	140.45	140.45	140.45	140.45	140.45	146.82	146.82	146.82	146.82	146.82	146.82	166.94	166.94	166.94	166.94	166.94	166.94	4.42	0.72	4.47	0.77	4.73	1.03	44.08	7.10	44.25	7.27	45.09	8.11
317.40	140.38	140.38	140.38	140.38	140.38	140.38	146.77	146.77	146.77	146.77	146.77	146.77	166.99	166.99	166.99	166.99	166.99	166.99	4.41	0.72	4.47	0.77	4.73	1.03	44.05	7.13	44.22	7.30	45.06	8.14
317.30	140.30	140.30	140.30	140.30	140.30	140.30	146.72	146.72	146.72	146.72	146.72	146.72	167.04	167.04	167.04	167.04	167.04	167.04	4.41	0.72	4.46	0.78	4.73	1.04	44.02	7.16	44.19	7.33	45.04	8.17
317.20	140.22	140.22	140.22	140.22	140.22	140.22	146.68	146.68	146.68	146.68	146.68	146.68	167.10	167.10	167.10	167.10	167.10	167.10	4.41	0.73	4.46	0.78	4.72	1.04	43.99	7.19	44.16	7.36	45.01	8.21
317.10	140.15	140.15	140.15	140.15	140.15	140.15	146.64	146.64	146.64	146.64	146.64	146.64	167.15	167.15	167.15	167.15	167.15	167.15	4.41	0.73	4.46	0.78	4.72	1.05	43.97	7.22	44.14	7.39	44.99	8.24
317.00	140.07	140.07	140.07	140.07	140.07	140.07	146.59	146.59	146.59	146.59	146.59	146.59	167.20	167.20	167.20	167.20	167.20	167.20	4.40	0.73	4.46	0.79	4.72	1.05	43.94	7.25	44.11	7.42	44.97	8.28
316.90	140.00	140.00	140.00	140.00	140.00	140.00	146.55	146.55	146.55	146.55	146.55	146.55	167.26	167.26	167.26	167.26	167.26	167.26	4.40	0.74	4.45	0.79	4.72	1.06	43.91	7.28	44.08	7.45	44.94	8.31
316.80	139.93	139.93	139.93	139.93	139.93	139.93	146.51	146.51	146.51	146.51	146.51	146.51	167.32	167.32	167.32	167.32	167.32	167.32	4.40	0.74	4.45	0.79	4.72	1.06	43.88	7.31	44.05	7.48	44.92	8.34
316.70	139.86	139.86	139.86	139.86	139.86	139.86	146.47	146.47	146.47	146.47	146.47	146.47	167.38	167.38	167.38	167.38	167.38	167.38	4.39	0.74	4.45	0.80	4.72	1.06	43.86	7.34	44.03	7.51	44.90	8.38
316.60	139.79	139.79	139.79	139.79	139.79	139.79	146.44	146.44	146.44	146.44	146.44	146.44	167.44	167.44	167.44	167.44	167.44	167.44	4.39	0.75	4.45	0.80	4.72	1.07	43.83	7.37	44.00	7.54	44.88	8.41
316.50	139.73	139.73	139.73	139.73	139.73	139.73	146.40	146.40	146.40	146.40	146.40	146.40	167.51	167.51	167.51	167.51	167.51	167.51	4.39	0.75	4.44	0.80	4.71	1.07	43.81	7.40	43.98	7.57	44.86	8.45
316.40	139.67	139.67	139.67	139.67	139.67	139.67	146.37	146.37	146.37	146.37	146.37	146.37	167.58	167.58	167.58	167.58	167.58	167.58	4.39	0.75	4.44	0.81	4.71	1.08	43.78	7.43	43.96	7.60	44.84	8.48
316.30	139.61	139.61	139.61	139.61	139.61	139.61	146.34	146.34	146.34	146.34	146.34	146.34	167.64	167.64	167.64	167.64	167.64	167.64	4.38	0.75	4.44	0.81	4.71	1.08	43.76	7.46	43.93	7.63	44.82	8.52
316.20	139.55	139.55	139.55	139.55	139.55	139.55	146.31	146.31	146.31	146.31	146.31	146.31	167.71	167.71	167.71	167.71	167.71	167.71	4.38	0.76	4.44	0.81	4.71	1.09	43.73	7.49	43.91	7.66	44.80	8.55
316.10	139.49	139.49	139.49	139.49	139.49	139.49	146.28	146.28	146.28	146.28	146.28	146.28	167.78	167.78	167.78	167.78	167.78	167.78	4.38	0.76	4.44	0.82	4.71	1.09	43.71	7.52	43.89

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
313.90	138.01	138.01	138.01	138.01	138.01	138.01	145.49	145.49	145.49	145.49	145.49	145.49	169.14	169.14	169.14	169.14	169.14	169.14	4.32	0.83	4.38	0.89	4.68	1.19	43.14	8.16	43.33	8.36	44.31	9.33
313.80	137.94	137.94	137.94	137.94	137.94	137.94	145.45	145.45	145.45	145.45	145.45	145.45	169.21	169.21	169.21	169.21	169.21	169.21	4.32	0.83	4.38	0.89	4.68	1.19	43.11	8.19	43.31	8.39	44.28	9.36
313.70	137.88	137.88	137.88	137.88	137.88	137.88	145.42	145.42	145.42	145.42	145.42	145.42	169.28	169.28	169.28	169.28	169.28	169.28	4.32	0.83	4.38	0.89	4.68	1.19	43.09	8.22	43.28	8.42	44.26	9.40
313.60	137.82	137.82	137.82	137.82	137.82	137.82	145.39	145.39	145.39	145.39	145.39	145.39	169.34	169.34	169.34	169.34	169.34	169.34	4.32	0.84	4.38	0.90	4.68	1.20	43.06	8.25	43.26	8.45	44.25	9.43
313.50	137.76	137.76	137.76	137.76	137.76	137.76	145.36	145.36	145.36	145.36	145.36	145.36	169.41	169.41	169.41	169.41	169.41	169.41	4.31	0.84	4.38	0.90	4.68	1.20	43.04	8.28	43.24	8.48	44.23	9.46
313.40	137.70	137.70	137.70	137.70	137.70	137.70	145.33	145.33	145.33	145.33	145.33	145.33	169.48	169.48	169.48	169.48	169.48	169.48	4.31	0.84	4.37	0.90	4.68	1.21	43.02	8.31	43.21	8.51	44.21	9.50
313.30	137.64	137.64	137.64	137.64	137.64	137.64	145.30	145.30	145.30	145.30	145.30	145.30	169.55	169.55	169.55	169.55	169.55	169.55	4.31	0.84	4.37	0.91	4.68	1.21	42.99	8.34	43.19	8.54	44.19	9.53
313.20	137.58	137.58	137.58	137.58	137.58	137.58	145.28	145.28	145.28	145.28	145.28	145.28	169.62	169.62	169.62	169.62	169.62	169.62	4.31	0.85	4.37	0.91	4.68	1.22	42.97	8.37	43.17	8.57	44.17	9.57
313.10	137.52	137.52	137.52	137.52	137.52	137.52	145.25	145.25	145.25	145.25	145.25	145.25	169.69	169.69	169.69	169.69	169.69	169.69	4.31	0.85	4.37	0.91	4.67	1.22	42.95	8.40	43.15	8.60	44.15	9.60
313.00	137.46	137.46	137.46	137.46	137.46	137.46	145.22	145.22	145.22	145.22	145.22	145.22	169.76	169.76	169.76	169.76	169.76	169.76	4.30	0.85	4.36	0.91	4.67	1.22	42.92	8.43	43.12	8.63	44.13	9.63
312.90	137.39	137.39	137.39	137.39	137.39	137.39	145.18	145.18	145.18	145.18	145.18	145.18	169.82	169.82	169.82	169.82	169.82	169.82	4.30	0.86	4.36	0.92	4.67	1.23	42.90	8.45	43.10	8.66	44.11	9.67
312.80	137.33	137.33	137.33	137.33	137.33	137.33	145.15	145.15	145.15	145.15	145.15	145.15	169.89	169.89	169.89	169.89	169.89	169.89	4.30	0.86	4.36	0.92	4.67	1.23	42.87	8.48	43.07	8.69	44.09	9.70
312.70	137.26	137.26	137.26	137.26	137.26	137.26	145.11	145.11	145.11	145.11	145.11	145.11	169.95	169.95	169.95	169.95	169.95	169.95	4.30	0.86	4.36	0.92	4.67	1.24	42.85	8.51	43.05	8.72	44.07	9.73
312.60	137.20	137.20	137.20	137.20	137.20	137.20	145.08	145.08	145.08	145.08	145.08	145.08	170.02	170.02	170.02	170.02	170.02	170.02	4.29	0.86	4.36	0.93	4.67	1.24	42.82	8.54	43.03	8.74	44.05	9.76
312.50	137.13	137.13	137.13	137.13	137.13	137.13	145.05	145.05	145.05	145.05	145.05	145.05	170.08	170.08	170.08	170.08	170.08	170.08	4.29	0.87	4.35	0.93	4.67	1.24	42.80	8.57	43.00	8.77	44.03	9.80
312.40	137.07	137.07	137.07	137.07	137.07	137.07	145.02	145.02	145.02	145.02	145.02	145.02	170.15	170.15	170.15	170.15	170.15	170.15	4.29	0.87	4.35	0.93	4.67	1.25	42.77	8.60	42.98	8.80	44.00	9.83
312.30	137.00	137.00	137.00	137.00	137.00	137.00	144.98	144.98	144.98	144.98	144.98	144.98	170.21	170.21	170.21	170.21	170.21	170.21	4.29	0.87	4.35	0.94	4.67	1.25	42.75	8.63	42.95	8.83	43.98	9.86
312.20	136.93	136.93	136.93	136.93	136.93	136.93	144.94	144.94	144.94	144.94	144.94	144.94	170.26	170.26	170.26	170.26	170.26	170.26	4.28	0.88	4.35	0.94	4.66	1.26	42.72	8.65	42.92	8.86	43.96	9.89
312.10	136.86	136.86	136.86	136.86	136.86	136.86	144.90	144.90	144.90	144.90	144.90	144.90	170.32	170.32	170.32	170.32	170.32	170.32	4.28	0.88	4.34	0.94	4.66	1.26	42.69	8.68	42.90	8.89	43.94	9.93
312.00	136.78	136.78	136.78	136.78	136.78	136.78	144.85	144.85	144.85	144.85	144.85	144.85	170.38	170.38	170.38	170.38	170.38	170.38	4.28	0.88	4.34	0.95	4.66	1.27	42.66	8.71	42.87	8.92	43.91	9.96
311.90	136.71	136.71	136.71	136.71	136.71	136.71	144.81	144.81	144.81	144.81	144.81	144.81	170.44	170.44	170.44	170.44	170.44	170.44	4.27	0.88	4.34	0.95	4.66	1.27	42.64	8.74	42.84	8.95	43.89	9.99
311.80	136.64	136.64	136.64	136.64	136.64	136.64	144.77	144.77	144.77	144.77	144.77	144.77	170.49	170.49	170.49	170.49	170.49	170.49	4.27	0.89	4.34	0.95	4.66	1.27	42.61	8.77	42.82	8.97	43.86	10.02
311.70	136.56	136.56	136.56	136.56	136.56	136.56	144.72	144.72	144.72	144.72	144.72	144.72	170.54	170.54	170.54	170.54	170.54	170.54	4.27	0.89	4.33	0.95	4.66	1.28	42.58	8.79	42.79	9.00	43.84	10.05
311.60	136.48	136.48	136.48	136.48	136.48	136.48	144.67	144.67	144.67	144.67	144.67	144.67	170.59	170.59	170.59	170.59	170.59	170.59	4.27	0.89	4.33	0.96	4.65	1.28	42.55	8.82	42.76	9.03	43.81	10.09
311.50	136.40	136.40	136.40	136.40	136.40	136.40	144.63	144.63	144.63	144.63	144.63	144.63	170.64	170.64	170.64	170.64	170.64	170.64	4.26	0.90	4.33	0.96	4.65	1.29	42.52	8.85	42.73	9.06	43.79	10.12
311.40	136.32	136.32	136.32	136.32	136.32	136.32	144.57	144.57	144.57	144.57	144.57	144.57	170.68	170.68	170.68	170.68	170.68	170.68	4.26	0.90	4.32	0.96	4.65	1.29	42.49	8.87	42.70	9.09	43.76	10.15
311.30	136.23	136.23	136.23	136.23	136.23	136.23	144.52	144.52	144.52	144.52	144.52	144.52	170.73	170.73	170.73	170.73	170.73	170.73	4.26	0.90	4.32	0.97	4.65	1.29	42.46	8.90	42.67	9.11	43.73	10.18
311.20	136.14	136.14	136.14	136.14	136.14	136.14	144.45	144.45	144.45	144.45	144.45	144.45	170.76	170.76	170.76	170.76	170.76	170.76	4.25	0.90	4.32	0.97	4.65	1.30	42.42	8.93	42.63	9.14	43.70	10.21
311.10	136.02	136.02	136.02	136.02	136.02	136.02	144.37	144.37	144.37	144.37	144.37	144.37	170.77	170.77	170.77	170.77	170.77	170.77	4.25	0.91	4.31	0.97	4.64	1.30	42.38	8.95	42.59	9.16	43.66	10.24
311.00	135.89	135.89	135.89	135.89	135.89	135.89	144.28	144.28	144.28	144.28	144.28	144.28	170.78	170.78	170.78	170.78	170.78	170.78	4.24	0.91	4.31	0.97	4.64	1.30	42.33	8.97	42.55	9.19	43.62	10.26
310.90	135.78	135.78	135.78	135.78	135.78	135.78	144.19	144.19	144.19	144.19	144.19	144.19	170.79	170.79	170.79	170.79	170.79	170.79	4.24	0.91	4.31	0.98	4.64	1.31	42.29	9.00	42.51	9.21	43.59	10.29
310.80	135.63	135.63	135.63	135.63	135.63	135.63	144.08	144.08	144.08	144.08	144.08	144.08	170.78	170.78	170.78	170.78	170.78	170.78	4.24	0.91	4.30	0.98	4.63	1.31	42.24	9.02	42.46	9.24	43.54	10.32
310.70	135.47	135.47	135.47	135.47	135.47	135.47	143.95	143.95	143.95	143.95	143.95	143.95	170.75	170.75	170.75	170.75	170.75	170.75	4.23	0.92	4.30	0.98	4.63	1.31	42.19	9.04	42.40	9.26	43.49	10.34
310.60	135.31	135.31	135.31	135.31	135.31	135.31	143.81	143.81	143.81	143.81	143.81	143.81	170.71	170.71	170.71	170.71	170.71	170.71	4.22	0.92	4.29	0.98	4.62	1.32	42.13	9.06	42.34	9.28	43.43	10.37
310.50	135.09	135.09	135.09	135.09	135.09	135.09	143.63	143.63	143.63	143.63	143.63	143.63	170.63	170.63	170.63	170.63	170.63	170.63	4.22	0.92	4.28	0.99	4.62	1.32	42.06	9.08	42.27	9.30	43.36	10.39
310.40	134.75	134.75	134.75	134.75	134.75	134.75	143.32	143.32	143.32	143.32	143.32	143.32	170.41	170.41	170.41	170.41	170.41	170.41	4.21	0.92	4.27	0.99	4.61	1.32	41.94	9.09	42.16	9.31	43.25	10.40
310.30	134.34	134.34	134.34	134.34	134.34	134.34	142.94	142.94	142.94	142.94	142.94	142.94	170.13	170.13	170.13	170.13	170.13	170.13	4.19	0.92	4.26	0.99	4.59	1.32	41.80	9.09	42.02	9.31	43.11	10.40
310.20	133.80	133.80	133.80	133.80	133.80	133.80	142.43	142.43	142.43	142.43	142.43	142.43	169.72	169.72	169.72	169.72	169.72	169.72	4.17	0.92	4.24	0.99	4.57	1.32	41.63	9.09	41.85	9.30	42.94	10.39
310.10	133.12	133.12	133.12	133.12	133.12	133.12	141.78	141.78	141.78	141.78	141.78	141.78	169.17	169.17	169.17	169.17	169.17	169.17	4.15	0.92	4.22	0.98	4.55	1.32	41.40	9.07	41.62	9.29	42.71	10.38
310.00	132.60	132.60	132.60	132.60	132.60	132.60	141.29	141.29	141.29	141.29	141.29	141.29	168.78	168.78	168.78	168.78	168.78	168.78	4.13	0.92	4.20	0.98	4.53	1.32	41.23	9.06	41.45	9.28	42.54	10.37
309.90	132.08	132.08	132.08	132.08	132.08	132.08	140.81	140.81	140.81	140.81	140.81	140.81	168.39	168.39	168.39	168.39	168.39	168.39	4.12	0.92	4.18	0.98	4.52	1.32	41.06	9.06	41.28	9.28	42.37	10.37
309.80	131.69	131.69	131.69	131.69	131.69	131.69	140.44	140.44	140.44	140.44	140.44	140.44	168.12	168.12	168.12	168.12	168.12	168.12	4.10	0.92	4.17	0.98	4.50	1.32	40.93	9.06	41.15	9.28	42.24	10.37
309.70	131.27	131.27	131.27	131.27	131.27	131.27	140.06	140.06	140.06	140.06	140.06	140.06	167.84	167.84	167.84	167.84	167.84	167.84	4.09	0.92	4.16	0.98	4.49	1.32	40.79	9.06	41.01	9.28	42.10	10.37
309.60	130.64	130.64	130.64	130.64	130.64	130.64	139.45	139.45	139.45	139.45	139.45	139.45	167.33	167.33	167.33	167.33	167.33	167.33	4.07	0.92	4.14	0.98	4.47	1.32	40.59	9.05	40.80	9.27	41.89	10.36
309.50	129.71	129.71	129.71	129.71	129.71	129.71	138.56	138.56	138.56	138.56	138.56	138.56	166.53	166.53	166.53	166.53	166.53	166.53	4.04	0.91	4.11	0.98	4.44	1.31	40.28	9.01	40.50	9.23	41.59	10.32
309.40	128.85	128.85	128.85	128.85	128.85	128.85	137.73	137.73	137.73	137.73	137.73	137.73	165.80	165.80	165.80	165.80	165.80	165.80	4.01	0.91	4.08	0.98	4.41	1.31	40.00	8.98	40.22	9.20	41.30	10.28
309.30	128.55	128.55	128.55	128.55	128.55	128.55	137.45	137.45	137.45	137.45	137.45	137.45	165.63	165.63	165.63	165.63	165.63	165.63	4.00	0.91	4.07	0.98	4.40	1.31	39.90	8.99	40.12	9.21	41.20	10.29
309.20	128.30	128.30	128.30	128.30	128.30	128.30	137.24	137.24	137.24	137.24	137.24	137.24	165.51	165.51	165.51	165.51	165.51	165.51	3.99	0.91	4.06	0.98	4.39	1.31	39.82	9.00	40.04	9.22	41.12	10.31
309.10	128.14	128.14	128.14	128.14	128.14	128.14	137.12	137.12	137.12	137.12	137.12	137.12	165.48	165.48	165.48	165.48	165.48	165.48	3.99	0.91	4.05	0.98	4.39	1.31	39.76	9.02	39.98	9.24	41.07	10.33
309.00	128.03	128.03	128.03	128.03	128.03	128.03	137.03	137.03	137.03	137.03	137.03	137.03	165.50	165.50	165.50	165.50	165.50	165.50	3.98	0.92	4.05	0.98	4.38	1.32	39.72	9.04	39.94	9.26	41.03	10.35
308.90	127.92	127.92	127.92	127.92	127.92	127.92	136.95	136.95	136.95	136.95	136.95	136.95	165.52	165.52	165.52	165.52	165.52	165.52	3.98	0.92	4.05	0.98	4.38	1.32	39.68	9.07	39.90	9.29	41.00	10.38
308.80	127.82	127.82	127.82	127.82	127.82	127.82	136.88	136.88	136.88	136.88	136.88	136.88	165.54	165.54	165.54	165.54	165.54	165.54	3.98	0.92	4.04	0.99	4.38	1.32	39.65	9.09	39.87	9.31	40.96	10.40
308.70	127.71	127.71	127.71	127.71	127.71	127.71	136.81	136.81	136.81	136.81	136.81	136.81	165.57	165.57	165.57	165.57	165.57	165.57	3.97	0.92	4.04	0.99	4.37	1.32	39.61	9.11	39.83	9.33	40.93	10.43
308.60	127.61	127.61	127.61	127.61	127.61	127.61	136.74	136.74	136.74	136.74	136.74	136.74	165.60	165.60	165.60	165.60	165.60	165.60	3.97	0.92	4.04	0.99	4.37	1.33	39.57	9.13	39.79	9.35	40.89	10.46
308.50	127.52	127.52	127.52	127.52	127.52	127.52	136.68	136.68	136.68	136.68	136.68	136.68	165.63	165.63	165.63	165.63	165.63	165.63	3.97	0.93	4.03	0.99	4.37	1.33	39.54	9.16	39.76	9.38	40.86	10.48
308.40	127.43	127.43	127.43	127.43	127.43	127.43	136.62	136.62	136.62	136.62	136.62	136.62	165.68	165.68	165.68	165.68	165.68	165.68	3.96	0.93	4.03	1.00	4.37	1.34	39.51	9.18	39.73	9.40	40.84	10.51
308.30	127.35	127.35	127.35	127.35	127.35	127.35	136.57	136.57	136.57	136.57	136.57	136.57	165.72	165.72	165.72	165.72	165.72	165.72	3.96	0.93	4.03	1.00	4.37	1.34	39.47	9.20	39.70	9.43	40.81	10.54
308.20	127.26	127.26	127.26	127.26	127.26	127.26	136.51	136.51	136.51	136.51	136.51	136.51	165.77	165.77	165.77	165.77	165.77	165.77	3.96	0.93	4.02	1.00	4.36	1.34	39.44	9.23	39.67	9.45	40.78	10.57
308.10	127.18	127.18	127.18	127.18	127.18	127.18	136.46	136.46	136.46	136.46	136.46	136.46	165.81	165.81	165.81	165.81	165.81	165.81	3.95	0.94	4.02	1.00	4.36	1.35	39.41	9.25	39.64	9.48	40.75	10.59
308.00	127.10	127.10	127.10	127.10	127.10	127.10	136.41	136.41	136.41	136.41	136.41	136.41	165.86	165.86	165.86	165.86	165.86	165.86	3.95	0.94	4.02	1.01	4.36	1.35	39.38	9.28	39.61	9.50	40.73	10.62
307.90	127.02	127.02	127.02	127.02	127.02	127.02	136.36	136.36	136.36	136.36	136.36	136.36	165.91	165.91	165.91	165.91	165.91	165.91	3.95	0.94	4.02	1.01	4.36	1.35	39.35	9.30	39.57	9.52	40.70	10.65
307.80	126.93	126.93	126.93	126.93	126.93	126.93	136.30	136.30	136.30	136.30	136.30	136.30	165.95	165.95	165.95	165.95	165.95	165.95	3.94	0.94	4.01	1.01	4.36	1.36	39.32	9.32	39.54	9.55	40.67	10.67
307.70	126.84	126.84	126.84	126.84	126.84	126.84	136.25	136.25	136.25	136.25	136.25	136.25	165.99	165.99	165.99	165.99	165.99	165.99	3.94	0.95	4.01	1.01	4.35	1.36	39.29	9.35	39.51	9.57	40.64	10.70
307.60	126.76	126.76	126.76	126.76	126.76	126.76	136.20	136.20	136.20	136.20	136.20	136.20	166.04	166.04	166.04	166.04	166.04	166.04	3.94	0.95	4.01	1.02	4.35	1.36	39.25	9.37	39.48	9.60	40.61	10.73
307.50	126.68	126.68	126.68	126.68	126.68	126.68	136.15	136.15	136.15	136.15	136.15	136.15	166.09	166.09	166.09	166.09	166.09	166.09	3.93	0.95	4.00	1.02	4.35	1.37	39.22	9.39	39.45	9.62	40.59	10.76
307.40	126.60	126.60	126.60	126.60	126.60	126.60	136.10	136.10	136.10	136.10	136.10	136.10	166.14	166.14	166.14	166.14	166.14	166.14	3.93	0.95	4.00	1.02	4.35	1.37	39.20	9.42	39.42	9.64	40.56	10.78
307.30	126.53	126.53	126.53	126.53	126.53	126.53	136.06	136.06	136.06	136.06	136.06	136.06	166.20	166.20	166.20	166.20	166.20	166.20	3.93	0.96	4.00	1.03	4.35	1.37	39.17	9.44	39.40	9.67	40.54	10.81
307.20	126.45	126.45	126.45	126.45	126.45	126.45	136.01	136.01	136.01	136.01	136.01	136.01	166.25	166.25	166.25	166.25	166.25	166.25	3.93	0.96	4.00	1.03	4.34	1.38	39.14	9.46	39.37	9.69	40.51	10.84
307.10	126.38	126.38	126.38	126.38	126.38	126.38	135.97	135.97	135.97	135.97	135.97	135.97	166.30	166.30	166.30	166.30	166.30	166.30	3.92	0.96	3.99	1.03	4.34	1.38	39.11	9.49	39.34	9.72	40.49	10.87
307.00	126.30	126.30	126.30	126.30	126.30	126.30	135.92	135.92	135.92	135.92	135.92	135.92	166.35	166.35	166.35	166.35	166.35	166.35	3.92	0.96	3.99	1.03	4.34	1.38	39.08	9.51	39.31	9.74	40.46	10.89
306.90	126.21	126.21	126.21	126.21	126.21	126.21	135.87	135.87	135.87	135.87	135.87	135.87	166.40	166.40	166.40	166.40	166.40	166.40	3.92	0.97	3.99	1.04	4.34	1.39	39.05	9.53	39.28	9.76	40.43	10.92
306.80	126.14	126.14	126.14	126.14	126.14	126.14	135.82	135.82	135.82	135.82	135.82	135.82	166.45	166.45	166.45	166.45	166.45	166.45	3.91	0.97	3.98	1.04	4.34	1.39	39.02	9.56	39.25	9.79	40.41	10.95
306.70	126.06	126.06	126.06	126.06	126.06	126.06	135.78	135.78	135.78	135.78	135.78	135.78	166.50	166.50	166.50	166.50	166.50	166.50	3.91	0.97	3.98	1.04	4.33	1.39	38.99	9.58	39.22	9.81	40.38	10.97
306.60	125.99	125.99	125.99	125.99	125.99	125.99	135.73	135.73	135.73	135.73	135.73	135.73	166.56	166.56	166.56	166.56	166.56	166.56	3.91	0.97	3.98	1.04	4.33	1.40	38.96	9.60	39.20	9.84	40.36	11.00
306.50	125.91	125.91	125.91	125.91	125.91	125.91	135.69	135.69	135.69	135.69	135.69	135.69	166.61	166.61	166.61	166.61	166.61	166.61	3.91	0.97	3.98	1.05	4.33	1.40	38.93	9.63	39.17	9.86	40.34	11.03
306.40	125.84	125.84	125.84	125.84	125.84	125.84	135.65	135.65	135.65	135.65	135.65	135.65	166.67	166.67	166.67	166.67	166.67	166.67	3.90	0.98	3.97	1.05	4.33	1.40	38.91	9.65	39.14	9.89	40.31	11.06
306.30	125.77	125.77	125.77	125.77	125.77	125.77	135.61	135.61	135.61	135.61	135.61	135.61	166.73	166.73	166.73	166.73	166.73	166.73	3.90	0.98	3.97	1.05	4.33	1.41	38.88	9.68	39.11	9.91	40.29	11.08
306.20	125.70	125.70	125.70	125.70	125.70	125.70	135.57	135.57	135.57	135.57	135.57	135.57	166.78	166.78	166.78	166.78	166.78	166.78	3.90	0.98	3.97	1.05	4.33	1.41	38.85	9.70	39.09	9.93	40.26	11.11
306.10	125.62	125.62	125.62	125.62	125.62	125.62	135.52	135.52	135.52	135.52	135.52	135.52	166.84	166.84	166.84	166.84	166.84	166.84	3.89	0.98	3.97	1.06	4.32	1.41	38.82	9.72	39.06	9.96	40.24	11.14
306.00	125.55	125.55	125.55	125.55	125.55	125.55	135.48	135.48	135.48	135.48	135.48	135.48	166.89	166.89	166.89	166.89	166.89	166.89	3.89	0.99	3.96	1.06	4.32	1.42	38.80	9.75	39.03	9.98	40.22	11.17
305.90	125.48	125.48	125.48	125.48	125.48	125.48	135.44	135.44	135.44	135.44	135.44	135.44	166.95	166.95	166.95	166.95	166.95	166.95	3.89	0.99	3.96	1.06	4.32	1.42	38.77	9.77	39.01	10.01	40.19	11.19
305.80	125.41	125.

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
303.70	124.05	124.05	124.05	124.05	124.05	124.05	134.70	134.70	134.70	134.70	134.70	134.70	168.37	168.37	168.37	168.37	168.37	168.37	3.83	1.04	3.91	1.12	4.29	1.50	38.21	10.29	38.46	10.54	39.72	11.79
303.60	123.98	123.98	123.98	123.98	123.98	123.98	134.66	134.66	134.66	134.66	134.66	134.66	168.43	168.43	168.43	168.43	168.43	168.43	3.83	1.04	3.91	1.12	4.29	1.50	38.19	10.31	38.44	10.56	39.70	11.82
303.50	123.91	123.91	123.91	123.91	123.91	123.91	134.62	134.62	134.62	134.62	134.62	134.62	168.49	168.49	168.49	168.49	168.49	168.49	3.83	1.05	3.91	1.12	4.29	1.50	38.16	10.33	38.41	10.59	39.67	11.85
303.40	123.84	123.84	123.84	123.84	123.84	123.84	134.58	134.58	134.58	134.58	134.58	134.58	168.55	168.55	168.55	168.55	168.55	168.55	3.83	1.05	3.90	1.13	4.29	1.51	38.13	10.36	38.39	10.61	39.65	11.87
303.30	123.77	123.77	123.77	123.77	123.77	123.77	134.55	134.55	134.55	134.55	134.55	134.55	168.61	168.61	168.61	168.61	168.61	168.61	3.82	1.05	3.90	1.13	4.28	1.51	38.11	10.38	38.36	10.63	39.63	11.90
303.20	123.71	123.71	123.71	123.71	123.71	123.71	134.51	134.51	134.51	134.51	134.51	134.51	168.67	168.67	168.67	168.67	168.67	168.67	3.82	1.05	3.90	1.13	4.28	1.51	38.08	10.40	38.34	10.66	39.60	11.93
303.10	123.63	123.63	123.63	123.63	123.63	123.63	134.46	134.46	134.46	134.46	134.46	134.46	168.72	168.72	168.72	168.72	168.72	168.72	3.82	1.06	3.90	1.13	4.28	1.52	38.05	10.42	38.31	10.68	39.58	11.95
303.00	123.55	123.55	123.55	123.55	123.55	123.55	134.41	134.41	134.41	134.41	134.41	134.41	168.77	168.77	168.77	168.77	168.77	168.77	3.82	1.06	3.89	1.13	4.28	1.52	38.02	10.45	38.28	10.70	39.55	11.98
302.90	123.48	123.48	123.48	123.48	123.48	123.48	134.37	134.37	134.37	134.37	134.37	134.37	168.83	168.83	168.83	168.83	168.83	168.83	3.81	1.06	3.89	1.14	4.28	1.52	37.99	10.47	38.25	10.72	39.53	12.00
302.80	123.40	123.40	123.40	123.40	123.40	123.40	134.33	134.33	134.33	134.33	134.33	134.33	168.88	168.88	168.88	168.88	168.88	168.88	3.81	1.06	3.89	1.14	4.27	1.53	37.97	10.49	38.22	10.75	39.50	12.03
302.70	123.33	123.33	123.33	123.33	123.33	123.33	134.28	134.28	134.28	134.28	134.28	134.28	168.94	168.94	168.94	168.94	168.94	168.94	3.81	1.06	3.88	1.14	4.27	1.53	37.94	10.51	38.19	10.77	39.48	12.05
302.60	123.25	123.25	123.25	123.25	123.25	123.25	134.24	134.24	134.24	134.24	134.24	134.24	168.99	168.99	168.99	168.99	168.99	168.99	3.80	1.07	3.88	1.14	4.27	1.53	37.91	10.53	38.17	10.79	39.45	12.08
302.50	123.17	123.17	123.17	123.17	123.17	123.17	134.19	134.19	134.19	134.19	134.19	134.19	169.04	169.04	169.04	169.04	169.04	169.04	3.80	1.07	3.88	1.15	4.27	1.54	37.88	10.56	38.14	10.81	39.43	12.10
302.40	123.08	123.08	123.08	123.08	123.08	123.08	134.13	134.13	134.13	134.13	134.13	134.13	169.08	169.08	169.08	169.08	169.08	169.08	3.80	1.07	3.88	1.15	4.27	1.54	37.85	10.58	38.10	10.83	39.40	12.13
302.30	122.99	122.99	122.99	122.99	122.99	122.99	134.07	134.07	134.07	134.07	134.07	134.07	169.11	169.11	169.11	169.11	169.11	169.11	3.79	1.07	3.87	1.15	4.26	1.54	37.81	10.60	38.07	10.85	39.37	12.15
302.20	122.89	122.89	122.89	122.89	122.89	122.89	134.00	134.00	134.00	134.00	134.00	134.00	169.15	169.15	169.15	169.15	169.15	169.15	3.79	1.07	3.87	1.15	4.26	1.55	37.78	10.62	38.04	10.87	39.33	12.17
302.10	122.80	122.80	122.80	122.80	122.80	122.80	133.94	133.94	133.94	133.94	133.94	133.94	169.18	169.18	169.18	169.18	169.18	169.18	3.79	1.08	3.87	1.16	4.26	1.55	37.74	10.63	38.00	10.90	39.30	12.20
302.00	122.69	122.69	122.69	122.69	122.69	122.69	133.87	133.87	133.87	133.87	133.87	133.87	169.21	169.21	169.21	169.21	169.21	169.21	3.78	1.08	3.86	1.16	4.26	1.55	37.70	10.65	37.96	10.91	39.27	12.22
301.90	122.58	122.58	122.58	122.58	122.58	122.58	133.78	133.78	133.78	133.78	133.78	133.78	169.22	169.22	169.22	169.22	169.22	169.22	3.78	1.08	3.86	1.16	4.25	1.55	37.66	10.67	37.92	10.93	39.23	12.24
301.80	122.45	122.45	122.45	122.45	122.45	122.45	133.69	133.69	133.69	133.69	133.69	133.69	169.23	169.23	169.23	169.23	169.23	169.23	3.78	1.08	3.85	1.16	4.25	1.56	37.62	10.69	37.88	10.95	39.19	12.26
301.70	122.32	122.32	122.32	122.32	122.32	122.32	133.59	133.59	133.59	133.59	133.59	133.59	169.22	169.22	169.22	169.22	169.22	169.22	3.77	1.08	3.85	1.16	4.25	1.56	37.57	10.70	37.83	10.97	39.14	12.28
301.60	122.18	122.18	122.18	122.18	122.18	122.18	133.48	133.48	133.48	133.48	133.48	133.48	169.21	169.21	169.21	169.21	169.21	169.21	3.77	1.09	3.84	1.16	4.24	1.56	37.52	10.72	37.78	10.98	39.10	12.30
301.50	122.02	122.02	122.02	122.02	122.02	122.02	133.35	133.35	133.35	133.35	133.35	133.35	169.18	169.18	169.18	169.18	169.18	169.18	3.76	1.09	3.84	1.17	4.24	1.56	37.46	10.73	37.73	11.00	39.04	12.31
301.40	121.83	121.83	121.83	121.83	121.83	121.83	133.19	133.19	133.19	133.19	133.19	133.19	169.12	169.12	169.12	169.12	169.12	169.12	3.75	1.09	3.83	1.17	4.23	1.56	37.40	10.74	37.66	11.01	38.98	12.33
301.30	121.58	121.58	121.58	121.58	121.58	121.58	132.98	132.98	132.98	132.98	132.98	132.98	169.00	169.00	169.00	169.00	169.00	169.00	3.74	1.09	3.82	1.17	4.22	1.57	37.32	10.75	37.58	11.01	38.90	12.33
301.20	121.35	121.35	121.35	121.35	121.35	121.35	132.78	132.78	132.78	132.78	132.78	132.78	168.90	168.90	168.90	168.90	168.90	168.90	3.74	1.09	3.82	1.17	4.21	1.57	37.24	10.76	37.50	11.02	38.82	12.34
301.10	121.07	121.07	121.07	121.07	121.07	121.07	132.53	132.53	132.53	132.53	132.53	132.53	168.75	168.75	168.75	168.75	168.75	168.75	3.73	1.09	3.81	1.17	4.21	1.57	37.14	10.76	37.41	11.02	38.73	12.34
301.00	120.72	120.72	120.72	120.72	120.72	120.72	132.21	132.21	132.21	132.21	132.21	132.21	168.53	168.53	168.53	168.53	168.53	168.53	3.72	1.09	3.80	1.17	4.19	1.57	37.03	10.75	37.29	11.02	38.61	12.34
300.90	120.20	120.20	120.20	120.20	120.20	120.20	131.71	131.71	131.71	131.71	131.71	131.71	168.13	168.13	168.13	168.13	168.13	168.13	3.70	1.09	3.78	1.17	4.18	1.56	36.85	10.73	37.12	11.00	38.44	12.31
300.80	119.38	119.38	119.38	119.38	119.38	119.38	130.92	130.92	130.92	130.92	130.92	130.92	167.44	167.44	167.44	167.44	167.44	167.44	3.67	1.08	3.75	1.16	4.15	1.56	36.59	10.68	36.85	10.95	38.16	12.26
300.70	118.25	118.25	118.25	118.25	118.25	118.25	129.83	129.83	129.83	129.83	129.83	129.83	166.44	166.44	166.44	166.44	166.44	166.44	3.64	1.07	3.71	1.15	4.11	1.54	36.22	10.60	36.48	10.86	37.79	12.17
300.60	117.47	117.47	117.47	117.47	117.47	117.47	129.08	129.08	129.08	129.08	129.08	129.08	165.79	165.79	165.79	165.79	165.79	165.79	3.61	1.07	3.69	1.15	4.08	1.54	35.97	10.56	36.23	10.82	37.53	12.12
300.50	116.81	116.81	116.81	116.81	116.81	116.81	128.45	128.45	128.45	128.45	128.45	128.45	165.26	165.26	165.26	165.26	165.26	165.26	3.59	1.07	3.67	1.14	4.06	1.53	35.75	10.52	36.01	10.78	37.31	12.08
300.40	116.12	116.12	116.12	116.12	116.12	116.12	127.79	127.79	127.79	127.79	127.79	127.79	164.70	164.70	164.70	164.70	164.70	164.70	3.57	1.06	3.64	1.14	4.03	1.53	35.52	10.48	35.78	10.74	37.08	12.03
300.30	115.43	115.43	115.43	115.43	115.43	115.43	127.14	127.14	127.14	127.14	127.14	127.14	164.14	164.14	164.14	164.14	164.14	164.14	3.54	1.06	3.62	1.13	4.01	1.52	35.30	10.45	35.56	10.70	36.85	11.99
300.20	114.88	114.88	114.88	114.88	114.88	114.88	126.62	126.62	126.62	126.62	126.62	126.62	163.72	163.72	163.72	163.72	163.72	163.72	3.52	1.05	3.60	1.13	3.99	1.52	35.12	10.42	35.38	10.68	36.66	11.96
300.10	114.46	114.46	114.46	114.46	114.46	114.46	126.22	126.22	126.22	126.22	126.22	126.22	163.43	163.43	163.43	163.43	163.43	163.43	3.51	1.05	3.59	1.13	3.97	1.52	34.98	10.40	35.23	10.66	36.52	11.95
300.00	114.08	114.08	114.08	114.08	114.08	114.08	125.87	125.87	125.87	125.87	125.87	125.87	163.17	163.17	163.17	163.17	163.17	163.17	3.50	1.05	3.58	1.13	3.96	1.52	34.85	10.39	35.11	10.65	36.39	11.94
299.90	113.72	113.72	113.72	113.72	113.72	113.72	125.55	125.55	125.55	125.55	125.55	125.55	162.95	162.95	162.95	162.95	162.95	162.95	3.49	1.05	3.56	1.13	3.95	1.51	34.73	10.39	34.99	10.64	36.27	11.93
299.80	113.39	113.39	113.39	113.39	113.39	113.39	125.25	125.25	125.25	125.25	125.25	125.25	162.75	162.75	162.75	162.75	162.75	162.75	3.48	1.05	3.55	1.13	3.94	1.51	34.62	10.38	34.88	10.64	36.16	11.92
299.70	113.03	113.03	113.03	113.03	113.03	113.03	124.92	124.92	124.92	124.92	124.92	124.92	162.52	162.52	162.52	162.52	162.52	162.52	3.46	1.05	3.54	1.13	3.93	1.51	34.50	10.37	34.76	10.63	36.04	11.91
299.60	112.73	112.73	112.73	112.73	112.73	112.73	124.65	124.65	124.65	124.65	124.65	124.65	162.34	162.34	162.34	162.34	162.34	162.34	3.45	1.05	3.53	1.13	3.91	1.51	34.40	10.37	34.66	10.62	35.94	11.91
299.50	112.46	112.46	112.46	112.46	112.46	112.46	124.41	124.41	124.41	124.41	124.41	124.41	162.21	162.21	162.21	162.21	162.21	162.21	3.44	1.05	3.52	1.13	3.91	1.51	34.31	10.37	34.57	10.62	35.85	11.91
299.40	112.26	112.26	112.26	112.26	112.26	112.26	124.24	124.24	124.24	124.24	124.24	124.24	162.13	162.13	162.13	162.13	162.13	162.13	3.44	1.05	3.51	1.13	3.90	1.51	34.24	10.37	34.50	10.63	35.78	11.92
299.30	112.07	112.07	112.07	112.07	112.07	112.07	124.08	124.08	124.08	124.08	124.08	124.08	162.07	162.07	162.07	162.07	162.07	162.07	3.43	1.05	3.51	1.13	3.89	1.51	34.18	10.38	34.43	10.64	35.72	11.92
299.20	111.87	111.87	111.87	111.87	111.87	111.87	123.91	123.91	123.91	123.91	123.91	123.91	162.00	162.00	162.00	162.00	162.00	162.00	3.42	1.05	3.50	1.13	3.89	1.51	34.11	10.39	34.36	10.64	35.65	11.93
299.10	111.68	111.68	111.68	111.68	111.68	111.68	123.75	123.75	123.75	123.75	123.75	123.75	161.94	161.94	161.94	161.94	161.94	161.94	3.42	1.05	3.49	1.13	3.88	1.52	34.04	10.39	34.30	10.65	35.59	11.94
299.00	111.49	111.49	111.49	111.49	111.49	111.49	123.60	123.60	123.60	123.60	123.60	123.60	161.88	161.88	161.88	161.88	161.88	161.88	3.41	1.05	3.49	1.13	3.87	1.52	33.98	10.40	34.24	10.66	35.53	11.95
298.90	111.33	111.33	111.33	111.33	111.33	111.33	123.46	123.46	123.46	123.46	123.46	123.46	161.85	161.85	161.85	161.85	161.85	161.85	3.40	1.05	3.48	1.13	3.87	1.52	33.92	10.41	34.18	10.67	35.47	11.96
298.80	111.16	111.16	111.16	111.16	111.16	111.16	123.33	123.33	123.33	123.33	123.33	123.33	161.81	161.81	161.81	161.81	161.81	161.81	3.40	1.05	3.48	1.13	3.86	1.52	33.86	10.42	34.12	10.68	35.41	11.97
298.70	111.00	111.00	111.00	111.00	111.00	111.00	123.20	123.20	123.20	123.20	123.20	123.20	161.78	161.78	161.78	161.78	161.78	161.78	3.39	1.06	3.47	1.13	3.86	1.52	33.81	10.43	34.07	10.69	35.36	11.98
298.60	110.86	110.86	110.86	110.86	110.86	110.86	123.09	123.09	123.09	123.09	123.09	123.09	161.76	161.76	161.76	161.76	161.76	161.76	3.39	1.06	3.47	1.13	3.85	1.52	33.76	10.44	34.02	10.70	35.31	11.99
298.50	110.71	110.71	110.71	110.71	110.71	110.71	122.97	122.97	122.97	122.97	122.97	122.97	161.75	161.75	161.75	161.75	161.75	161.75	3.38	1.06	3.46	1.14	3.85	1.52	33.70	10.45	33.96	10.71	35.26	12.01
298.40	110.56	110.56	110.56	110.56	110.56	110.56	122.85	122.85	122.85	122.85	122.85	122.85	161.73	161.73	161.73	161.73	161.73	161.73	3.38	1.06	3.46	1.14	3.84	1.53	33.65	10.46	33.91	10.72	35.21	12.02
298.30	110.42	110.42	110.42	110.42	110.42	110.42	122.75	122.75	122.75	122.75	122.75	122.75	161.72	161.72	161.72	161.72	161.72	161.72	3.37	1.06	3.45	1.14	3.84	1.53	33.60	10.47	33.86	10.73	35.17	12.03
298.20	110.29	110.29	110.29	110.29	110.29	110.29	122.65	122.65	122.65	122.65	122.65	122.65	161.72	161.72	161.72	161.72	161.72	161.72	3.37	1.06	3.45	1.14	3.84	1.53	33.56	10.48	33.82	10.74	35.12	12.05
298.10	110.17	110.17	110.17	110.17	110.17	110.17	122.56	122.56	122.56	122.56	122.56	122.56	161.73	161.73	161.73	161.73	161.73	161.73	3.36	1.06	3.44	1.14	3.83	1.53	33.51	10.50	33.78	10.76	35.08	12.06
298.00	110.06	110.06	110.06	110.06	110.06	110.06	122.47	122.47	122.47	122.47	122.47	122.47	161.74	161.74	161.74	161.74	161.74	161.74	3.36	1.06	3.44	1.14	3.83	1.53	33.47	10.51	33.73	10.77	35.04	12.08
297.90	109.94	109.94	109.94	109.94	109.94	109.94	122.39	122.39	122.39	122.39	122.39	122.39	161.76	161.76	161.76	161.76	161.76	161.76	3.36	1.07	3.43	1.14	3.83	1.53	33.43	10.52	33.69	10.78	35.00	12.09
297.80	109.83	109.83	109.83	109.83	109.83	109.83	122.31	122.31	122.31	122.31	122.31	122.31	161.77	161.77	161.77	161.77	161.77	161.77	3.35	1.07	3.43	1.14	3.82	1.54	33.39	10.54	33.65	10.80	34.97	12.11
297.70	109.72	109.72	109.72	109.72	109.72	109.72	122.23	122.23	122.23	122.23	122.23	122.23	161.79	161.79	161.79	161.79	161.79	161.79	3.35	1.07	3.43	1.15	3.82	1.54	33.35	10.55	33.62	10.81	34.93	12.13
297.60	109.62	109.62	109.62	109.62	109.62	109.62	122.16	122.16	122.16	122.16	122.16	122.16	161.82	161.82	161.82	161.82	161.82	161.82	3.34	1.07	3.42	1.15	3.82	1.54	33.31	10.56	33.58	10.83	34.89	12.14
297.50	109.52	109.52	109.52	109.52	109.52	109.52	122.09	122.09	122.09	122.09	122.09	122.09	161.85	161.85	161.85	161.85	161.85	161.85	3.34	1.07	3.42	1.15	3.81	1.54	33.28	10.58	33.54	10.84	34.86	12.16
297.40	109.42	109.42	109.42	109.42	109.42	109.42	122.02	122.02	122.02	122.02	122.02	122.02	161.87	161.87	161.87	161.87	161.87	161.87	3.34	1.07	3.42	1.15	3.81	1.55	33.24	10.59	33.50	10.86	34.82	12.18
297.30	109.31	109.31	109.31	109.31	109.31	109.31	121.95	121.95	121.95	121.95	121.95	121.95	161.90	161.90	161.90	161.90	161.90	161.90	3.33	1.07	3.41	1.15	3.81	1.55	33.20	10.61	33.47	10.87	34.79	12.19
297.20	109.21	109.21	109.21	109.21	109.21	109.21	121.88	121.88	121.88	121.88	121.88	121.88	161.93	161.93	161.93	161.93	161.93	161.93	3.33	1.08	3.41	1.15	3.80	1.55	33.17	10.62	33.43	10.88	34.76	12.21
297.10	109.12	109.12	109.12	109.12	109.12	109.12	121.81	121.81	121.81	121.81	121.81	121.81	161.96	161.96	161.96	161.96	161.96	161.96	3.33	1.08	3.41	1.16	3.80	1.55	33.13	10.63	33.40	10.90	34.72	12.23
297.00	109.02	109.02	109.02	109.02	109.02	109.02	121.75	121.75	121.75	121.75	121.75	121.75	161.99	161.99	161.99	161.99	161.99	161.99	3.32	1.08	3.40	1.16	3.80	1.55	33.10	10.65	33.36	10.91	34.69	12.24
296.90	108.92	108.92	108.92	108.92	108.92	108.92	121.68	121.68	121.68	121.68	121.68	121.68	162.03	162.03	162.03	162.03	162.03	162.03	3.32	1.08	3.40	1.16	3.80	1.56	33.06	10.66	33.33	10.93	34.66	12.26
296.80	108.82	108.82	108.82	108.82	108.82	108.82	121.61	121.61	121.61	121.61	121.61	121.61	162.05	162.05	162.05	162.05	162.05	162.05	3.32	1.08	3.39	1.16	3.79	1.56	33.02	10.68	33.29	10.94	34.62	12.28
296.70	108.73	108.73	108.73	108.73	108.73	108.73	121.55	121.55	121.55	121.55	121.55	121.55	162.09	162.09	162.09	162.09	162.09	162.09	3.31	1.08	3.39	1.16	3.79	1.56	32.99	10.69	33.26	10.96	34.59	12.29
296.60	108.65	108.65	108.65	108.65	108.65	108.65	121.50	121.50	121.50	121.50	121.50	121.50	162.14	162.14	162.14	162.14	162.14	162.14	3.31	1.08	3.39	1.16	3.79	1.56	32.96	10.71	33.23	10.98	34.57	12.31
296.50	108.57	108.57	108.57	108.57	108.57	108.57	121.46	121.46	121.46	121.46	121.46	121.46	162.20	162.20	162.20	162.20	162.20	162.20	3.31	1.09	3.39	1.17	3.79	1.57	32.93	10.73	33.20	10.99	34.54	12.33
296.40	108.50	108.50	108.50	108.50	108.50	108.50	121.41	121.41	121.41	121.41	121.41	121.41	162.25	162.25	162.25	162.25	162.25	162.25	3.30	1.09	3.38	1.17	3.78	1.57	32.90	10.74	33.17	11.01	34.51	12.35
296.30	108.43	108.43	108.43	108.43	108.43	108.43	121.38	121.38	121.38	121.38	121.38	121.38	162.31	162.31	162.31	162.31	162.31	162.31	3.30	1.09	3.38	1.17	3.78	1.57	32.88	10.76	33.14	11.03	34.49	12.37
296.20	108.36	108.36	108.36	108.36	108.36	108.36	121.34	121.34	121.34	121.34	121.34	121.34	162.37	162.37	162.37	162.37	162.37	162.37	3.30	1.09	3.38	1.17	3.78	1.57	32.85	10.78	33.12	11.05	34.47	12.39
296.10	108.30	108.30	108.30	108.30	108.30	108.30	121.30	121.30	121.30	121.30	121.30	121.30	162.43	162.43	162.43	162.43	162.43	162.43	3.30	1.09	3.38	1.17	3.78	1.58	32.82	10.79	33.09	11.06	34.44	12.41
296.00	108.23	108.23	108.23	108.23	108.23	108.23	121.27	121.27	121.27	121.27	121.27	121.27	162.49	162.49	162.49	162.49	162.49	162.49	3.29	1.09	3.37	1.17	3.78	1.58	32.80	10.81	33.07	11.08	34.42	12.43
295.90	108.16	108.16	108.16	108.16	108.16	108.16	121.23	121.23	121.23	121.23	121.23	121.23	162.56	162.56	162.56	162.56	162.56	162.56	3.29	1.10	3.37	1.18	3.77	1.58	32.77	10.83	33.04	11.10	34.40	12.45
295.80	108.10	108.10	108.10	108.10	108.10	108.10	121.20	121.20	121.20	121.20	121.20	121.20	162.62	162.62	162.62	162.62	162.62	162.62	3.29	1.10	3.37	1.18	3.77	1.58	32.75	10.84	33.02	11.12	34.38	12.47
295.70	108.03	108.03	108.03	108.03	108.03	108.03	121.16	121.16	121.16	121.16	121.16	121.16	162.68	162.68	162.68	162.68	162.68	162.68	3.29	1.10	3.37	1.18	3.77	1.59	32.72	10.86	32.99	11.13	34.35	12.49

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
293.50	106.88	106.88	106.88	106.88	106.88	106.88	120.70	120.70	120.70	120.70	120.70	120.70	164.38	164.38	164.38	164.38	164.38	164.38	3.24	1.14	3.32	1.22	3.74	1.64	32.26	11.26	32.54	11.55	33.96	12.97
293.40	106.84	106.84	106.84	106.84	106.84	106.84	120.68	120.68	120.68	120.68	120.68	120.68	164.47	164.47	164.47	164.47	164.47	164.47	3.24	1.14	3.32	1.23	3.74	1.65	32.24	11.28	32.52	11.57	33.94	12.99
293.30	106.79	106.79	106.79	106.79	106.79	106.79	120.67	120.67	120.67	120.67	120.67	120.67	164.55	164.55	164.55	164.55	164.55	164.55	3.24	1.14	3.32	1.23	3.74	1.65	32.22	11.30	32.50	11.59	33.93	13.01
293.20	106.75	106.75	106.75	106.75	106.75	106.75	120.65	120.65	120.65	120.65	120.65	120.65	164.63	164.63	164.63	164.63	164.63	164.63	3.23	1.15	3.32	1.23	3.74	1.65	32.20	11.32	32.48	11.60	33.91	13.03
293.10	106.70	106.70	106.70	106.70	106.70	106.70	120.64	120.64	120.64	120.64	120.64	120.64	164.72	164.72	164.72	164.72	164.72	164.72	3.23	1.15	3.32	1.23	3.74	1.66	32.18	11.34	32.47	11.62	33.89	13.05
293.00	106.66	106.66	106.66	106.66	106.66	106.66	120.63	120.63	120.63	120.63	120.63	120.63	164.80	164.80	164.80	164.80	164.80	164.80	3.23	1.15	3.31	1.23	3.74	1.66	32.16	11.36	32.45	11.64	33.88	13.07
292.90	106.61	106.61	106.61	106.61	106.61	106.61	120.61	120.61	120.61	120.61	120.61	120.61	164.89	164.89	164.89	164.89	164.89	164.89	3.23	1.15	3.31	1.24	3.74	1.66	32.14	11.37	32.43	11.66	33.86	13.10
292.80	106.57	106.57	106.57	106.57	106.57	106.57	120.60	120.60	120.60	120.60	120.60	120.60	164.97	164.97	164.97	164.97	164.97	164.97	3.23	1.15	3.31	1.24	3.74	1.66	32.12	11.39	32.41	11.68	33.85	13.12
292.70	106.53	106.53	106.53	106.53	106.53	106.53	120.59	120.59	120.59	120.59	120.59	120.59	165.06	165.06	165.06	165.06	165.06	165.06	3.22	1.16	3.31	1.24	3.74	1.67	32.11	11.41	32.39	11.70	33.83	13.14
292.60	106.48	106.48	106.48	106.48	106.48	106.48	120.57	120.57	120.57	120.57	120.57	120.57	165.14	165.14	165.14	165.14	165.14	165.14	3.22	1.16	3.31	1.24	3.74	1.67	32.09	11.43	32.37	11.72	33.82	13.16
292.50	106.43	106.43	106.43	106.43	106.43	106.43	120.56	120.56	120.56	120.56	120.56	120.56	165.22	165.22	165.22	165.22	165.22	165.22	3.22	1.16	3.31	1.24	3.73	1.67	32.07	11.45	32.36	11.74	33.80	13.18
292.40	106.38	106.38	106.38	106.38	106.38	106.38	120.54	120.54	120.54	120.54	120.54	120.54	165.30	165.30	165.30	165.30	165.30	165.30	3.22	1.16	3.30	1.25	3.73	1.68	32.05	11.47	32.34	11.76	33.78	13.20
292.30	106.34	106.34	106.34	106.34	106.34	106.34	120.52	120.52	120.52	120.52	120.52	120.52	165.38	165.38	165.38	165.38	165.38	165.38	3.22	1.16	3.30	1.25	3.73	1.68	32.03	11.48	32.32	11.77	33.77	13.23
292.20	106.29	106.29	106.29	106.29	106.29	106.29	120.51	120.51	120.51	120.51	120.51	120.51	165.47	165.47	165.47	165.47	165.47	165.47	3.22	1.16	3.30	1.25	3.73	1.68	32.01	11.50	32.30	11.79	33.75	13.25
292.10	106.25	106.25	106.25	106.25	106.25	106.25	120.50	120.50	120.50	120.50	120.50	120.50	165.55	165.55	165.55	165.55	165.55	165.55	3.21	1.17	3.30	1.25	3.73	1.68	31.99	11.52	32.28	11.81	33.74	13.27
292.00	106.20	106.20	106.20	106.20	106.20	106.20	120.48	120.48	120.48	120.48	120.48	120.48	165.64	165.64	165.64	165.64	165.64	165.64	3.21	1.17	3.30	1.25	3.73	1.69	31.97	11.54	32.26	11.83	33.72	13.29
291.90	106.15	106.15	106.15	106.15	106.15	106.15	120.46	120.46	120.46	120.46	120.46	120.46	165.72	165.72	165.72	165.72	165.72	165.72	3.21	1.17	3.30	1.26	3.73	1.69	31.95	11.56	32.24	11.85	33.70	13.31
291.80	106.10	106.10	106.10	106.10	106.10	106.10	120.44	120.44	120.44	120.44	120.44	120.44	165.79	165.79	165.79	165.79	165.79	165.79	3.21	1.17	3.29	1.26	3.73	1.69	31.93	11.57	32.22	11.87	33.68	13.33
291.70	106.05	106.05	106.05	106.05	106.05	106.05	120.42	120.42	120.42	120.42	120.42	120.42	165.87	165.87	165.87	165.87	165.87	165.87	3.21	1.17	3.29	1.26	3.73	1.69	31.91	11.59	32.20	11.88	33.67	13.35
291.60	106.00	106.00	106.00	106.00	106.00	106.00	120.40	120.40	120.40	120.40	120.40	120.40	165.95	165.95	165.95	165.95	165.95	165.95	3.20	1.18	3.29	1.26	3.72	1.70	31.89	11.61	32.18	11.90	33.65	13.37
291.50	105.95	105.95	105.95	105.95	105.95	105.95	120.38	120.38	120.38	120.38	120.38	120.38	166.03	166.03	166.03	166.03	166.03	166.03	3.20	1.18	3.29	1.26	3.72	1.70	31.87	11.63	32.16	11.92	33.63	13.39
291.40	105.90	105.90	105.90	105.90	105.90	105.90	120.36	120.36	120.36	120.36	120.36	120.36	166.11	166.11	166.11	166.11	166.11	166.11	3.20	1.18	3.29	1.27	3.72	1.70	31.85	11.64	32.14	11.94	33.61	13.41
291.30	105.84	105.84	105.84	105.84	105.84	105.84	120.33	120.33	120.33	120.33	120.33	120.33	166.18	166.18	166.18	166.18	166.18	166.18	3.20	1.18	3.28	1.27	3.72	1.70	31.82	11.66	32.12	11.96	33.59	13.43
291.20	105.78	105.78	105.78	105.78	105.78	105.78	120.31	120.31	120.31	120.31	120.31	120.31	166.25	166.25	166.25	166.25	166.25	166.25	3.19	1.18	3.28	1.27	3.72	1.71	31.80	11.68	32.10	11.97	33.58	13.45
291.10	105.73	105.73	105.73	105.73	105.73	105.73	120.29	120.29	120.29	120.29	120.29	120.29	166.33	166.33	166.33	166.33	166.33	166.33	3.19	1.18	3.28	1.27	3.72	1.71	31.78	11.69	32.08	11.99	33.56	13.47
291.00	105.68	105.68	105.68	105.68	105.68	105.68	120.27	120.27	120.27	120.27	120.27	120.27	166.41	166.41	166.41	166.41	166.41	166.41	3.19	1.19	3.28	1.27	3.72	1.71	31.76	11.71	32.06	12.01	33.54	13.49
290.90	105.63	105.63	105.63	105.63	105.63	105.63	120.25	120.25	120.25	120.25	120.25	120.25	166.48	166.48	166.48	166.48	166.48	166.48	3.19	1.19	3.28	1.28	3.71	1.71	31.74	11.73	32.03	12.03	33.52	13.51
290.80	105.57	105.57	105.57	105.57	105.57	105.57	120.22	120.22	120.22	120.22	120.22	120.22	166.55	166.55	166.55	166.55	166.55	166.55	3.19	1.19	3.27	1.28	3.71	1.72	31.71	11.74	32.01	12.04	33.50	13.53
290.70	105.51	105.51	105.51	105.51	105.51	105.51	120.20	120.20	120.20	120.20	120.20	120.20	166.63	166.63	166.63	166.63	166.63	166.63	3.18	1.19	3.27	1.28	3.71	1.72	31.69	11.76	31.99	12.06	33.48	13.55
290.60	105.45	105.45	105.45	105.45	105.45	105.45	120.17	120.17	120.17	120.17	120.17	120.17	166.70	166.70	166.70	166.70	166.70	166.70	3.18	1.19	3.27	1.28	3.71	1.72	31.67	11.78	31.97	12.08	33.46	13.57
290.50	105.39	105.39	105.39	105.39	105.39	105.39	120.14	120.14	120.14	120.14	120.14	120.14	166.76	166.76	166.76	166.76	166.76	166.76	3.18	1.19	3.27	1.28	3.71	1.72	31.64	11.79	31.94	12.09	33.44	13.59
290.40	105.33	105.33	105.33	105.33	105.33	105.33	120.10	120.10	120.10	120.10	120.10	120.10	166.83	166.83	166.83	166.83	166.83	166.83	3.18	1.20	3.26	1.28	3.71	1.73	31.62	11.81	31.92	12.11	33.42	13.61
290.30	105.26	105.26	105.26	105.26	105.26	105.26	120.07	120.07	120.07	120.07	120.07	120.07	166.90	166.90	166.90	166.90	166.90	166.90	3.17	1.20	3.26	1.29	3.71	1.73	31.59	11.82	31.89	12.12	33.40	13.63
290.20	105.19	105.19	105.19	105.19	105.19	105.19	120.03	120.03	120.03	120.03	120.03	120.03	166.95	166.95	166.95	166.95	166.95	166.95	3.17	1.20	3.26	1.29	3.70	1.73	31.57	11.84	31.87	12.14	33.37	13.64
290.10	105.13	105.13	105.13	105.13	105.13	105.13	120.00	120.00	120.00	120.00	120.00	120.00	167.02	167.02	167.02	167.02	167.02	167.02	3.17	1.20	3.26	1.29	3.70	1.73	31.54	11.85	31.84	12.15	33.35	13.66
290.00	105.06	105.06	105.06	105.06	105.06	105.06	119.96	119.96	119.96	119.96	119.96	119.96	167.08	167.08	167.08	167.08	167.08	167.08	3.17	1.20	3.26	1.29	3.70	1.74	31.52	11.87	31.82	12.17	33.33	13.68
289.90	105.00	105.00	105.00	105.00	105.00	105.00	119.93	119.93	119.93	119.93	119.93	119.93	167.14	167.14	167.14	167.14	167.14	167.14	3.16	1.20	3.25	1.29	3.70	1.74	31.49	11.88	31.79	12.19	33.30	13.70
289.80	104.93	104.93	104.93	104.93	104.93	104.93	119.89	119.89	119.89	119.89	119.89	119.89	167.20	167.20	167.20	167.20	167.20	167.20	3.16	1.20	3.25	1.29	3.70	1.74	31.46	11.90	31.77	12.20	33.28	13.71
289.70	104.86	104.86	104.86	104.86	104.86	104.86	119.85	119.85	119.85	119.85	119.85	119.85	167.27	167.27	167.27	167.27	167.27	167.27	3.16	1.21	3.25	1.30	3.69	1.74	31.44	11.91	31.74	12.22	33.26	13.73
289.60	104.80	104.80	104.80	104.80	104.80	104.80	119.82	119.82	119.82	119.82	119.82	119.82	167.33	167.33	167.33	167.33	167.33	167.33	3.16	1.21	3.25	1.30	3.69	1.74	31.41	11.93	31.72	12.23	33.23	13.75
289.50	104.73	104.73	104.73	104.73	104.73	104.73	119.79	119.79	119.79	119.79	119.79	119.79	167.40	167.40	167.40	167.40	167.40	167.40	3.15	1.21	3.24	1.30	3.69	1.75	31.39	11.94	31.69	12.25	33.21	13.77
289.40	104.67	104.67	104.67	104.67	104.67	104.67	119.75	119.75	119.75	119.75	119.75	119.75	167.46	167.46	167.46	167.46	167.46	167.46	3.15	1.21	3.24	1.30	3.69	1.75	31.36	11.96	31.67	12.26	33.19	13.79
289.30	104.60	104.60	104.60	104.60	104.60	104.60	119.72	119.72	119.72	119.72	119.72	119.72	167.53	167.53	167.53	167.53	167.53	167.53	3.15	1.21	3.24	1.30	3.69	1.75	31.34	11.97	31.64	12.28	33.17	13.80
289.20	104.55	104.55	104.55	104.55	104.55	104.55	119.69	119.69	119.69	119.69	119.69	119.69	167.60	167.60	167.60	167.60	167.60	167.60	3.15	1.21	3.24	1.30	3.69	1.75	31.31	11.99	31.62	12.29	33.15	13.82
289.10	104.49	104.49	104.49	104.49	104.49	104.49	119.67	119.67	119.67	119.67	119.67	119.67	167.67	167.67	167.67	167.67	167.67	167.67	3.14	1.22	3.23	1.31	3.68	1.76	31.29	12.00	31.60	12.31	33.13	13.84
289.00	104.43	104.43	104.43	104.43	104.43	104.43	119.64	119.64	119.64	119.64	119.64	119.64	167.74	167.74	167.74	167.74	167.74	167.74	3.14	1.22	3.23	1.31	3.68	1.76	31.27	12.02	31.57	12.33	33.11	13.86
288.90	104.37	104.37	104.37	104.37	104.37	104.37	119.61	119.61	119.61	119.61	119.61	119.61	167.81	167.81	167.81	167.81	167.81	167.81	3.14	1.22	3.23	1.31	3.68	1.76	31.24	12.04	31.55	12.34	33.09	13.88
288.80	104.31	104.31	104.31	104.31	104.31	104.31	119.58	119.58	119.58	119.58	119.58	119.58	167.88	167.88	167.88	167.88	167.88	167.88	3.14	1.22	3.23	1.31	3.68	1.76	31.22	12.05	31.53	12.36	33.07	13.90
288.70	104.25	104.25	104.25	104.25	104.25	104.25	119.56	119.56	119.56	119.56	119.56	119.56	167.95	167.95	167.95	167.95	167.95	167.95	3.13	1.22	3.23	1.31	3.68	1.76	31.20	12.07	31.51	12.37	33.05	13.91
288.60	104.20	104.20	104.20	104.20	104.20	104.20	119.53	119.53	119.53	119.53	119.53	119.53	168.02	168.02	168.02	168.02	168.02	168.02	3.13	1.22	3.22	1.31	3.68	1.77	31.18	12.08	31.48	12.39	33.03	13.93
288.50	104.14	104.14	104.14	104.14	104.14	104.14	119.51	119.51	119.51	119.51	119.51	119.51	168.10	168.10	168.10	168.10	168.10	168.10	3.13	1.22	3.22	1.32	3.67	1.77	31.15	12.10	31.46	12.41	33.01	13.95
288.40	104.09	104.09	104.09	104.09	104.09	104.09	119.49	119.49	119.49	119.49	119.49	119.49	168.18	168.18	168.18	168.18	168.18	168.18	3.13	1.23	3.22	1.32	3.67	1.77	31.13	12.11	31.44	12.42	32.99	13.97
288.30	104.04	104.04	104.04	104.04	104.04	104.04	119.47	119.47	119.47	119.47	119.47	119.47	168.26	168.26	168.26	168.26	168.26	168.26	3.13	1.23	3.22	1.32	3.67	1.77	31.11	12.13	31.42	12.44	32.97	13.99
288.20	103.99	103.99	103.99	103.99	103.99	103.99	119.45	119.45	119.45	119.45	119.45	119.45	168.33	168.33	168.33	168.33	168.33	168.33	3.12	1.23	3.22	1.32	3.67	1.78	31.09	12.15	31.40	12.46	32.95	14.01
288.10	103.94	103.94	103.94	103.94	103.94	103.94	119.43	119.43	119.43	119.43	119.43	119.43	168.41	168.41	168.41	168.41	168.41	168.41	3.12	1.23	3.21	1.32	3.67	1.78	31.07	12.16	31.38	12.47	32.94	14.03
288.00	103.89	103.89	103.89	103.89	103.89	103.89	119.41	119.41	119.41	119.41	119.41	119.41	168.49	168.49	168.49	168.49	168.49	168.49	3.12	1.23	3.21	1.32	3.67	1.78	31.05	12.18	31.36	12.49	32.92	14.05
287.90	103.84	103.84	103.84	103.84	103.84	103.84	119.39	119.39	119.39	119.39	119.39	119.39	168.57	168.57	168.57	168.57	168.57	168.57	3.12	1.23	3.21	1.33	3.67	1.78	31.03	12.20	31.34	12.51	32.90	14.07
287.80	103.79	103.79	103.79	103.79	103.79	103.79	119.37	119.37	119.37	119.37	119.37	119.37	168.65	168.65	168.65	168.65	168.65	168.65	3.12	1.24	3.21	1.33	3.67	1.79	31.01	12.21	31.32	12.52	32.88	14.09
287.70	103.74	103.74	103.74	103.74	103.74	103.74	119.35	119.35	119.35	119.35	119.35	119.35	168.73	168.73	168.73	168.73	168.73	168.73	3.11	1.24	3.21	1.33	3.66	1.79	30.99	12.23	31.30	12.54	32.87	14.11
287.60	103.69	103.69	103.69	103.69	103.69	103.69	119.34	119.34	119.34	119.34	119.34	119.34	168.81	168.81	168.81	168.81	168.81	168.81	3.11	1.24	3.20	1.33	3.66	1.79	30.97	12.25	31.28	12.56	32.85	14.13
287.50	103.64	103.64	103.64	103.64	103.64	103.64	119.32	119.32	119.32	119.32	119.32	119.32	168.89	168.89	168.89	168.89	168.89	168.89	3.11	1.24	3.20	1.33	3.66	1.79	30.95	12.26	31.26	12.58	32.83	14.15
287.40	103.59	103.59	103.59	103.59	103.59	103.59	119.30	119.30	119.30	119.30	119.30	119.30	168.97	168.97	168.97	168.97	168.97	168.97	3.11	1.24	3.20	1.34	3.66	1.80	30.93	12.28	31.24	12.59	32.82	14.16
287.30	103.54	103.54	103.54	103.54	103.54	103.54	119.28	119.28	119.28	119.28	119.28	119.28	169.05	169.05	169.05	169.05	169.05	169.05	3.11	1.24	3.20	1.34	3.66	1.80	30.91	12.29	31.22	12.61	32.80	14.18
287.20	103.49	103.49	103.49	103.49	103.49	103.49	119.25	119.25	119.25	119.25	119.25	119.25	169.12	169.12	169.12	169.12	169.12	169.12	3.10	1.25	3.20	1.34	3.66	1.80	30.89	12.31	31.20	12.62	32.78	14.20
287.10	103.43	103.43	103.43	103.43	103.43	103.43	119.23	119.23	119.23	119.23	119.23	119.23	169.20	169.20	169.20	169.20	169.20	169.20	3.10	1.25	3.19	1.34	3.66	1.80	30.86	12.32	31.18	12.64	32.76	14.22
287.00	103.38	103.38	103.38	103.38	103.38	103.38	119.22	119.22	119.22	119.22	119.22	119.22	169.28	169.28	169.28	169.28	169.28	169.28	3.10	1.25	3.19	1.34	3.66	1.81	30.84	12.34	31.16	12.66	32.74	14.24
286.90	103.34	103.34	103.34	103.34	103.34	103.34	119.20	119.20	119.20	119.20	119.20	119.20	169.36	169.36	169.36	169.36	169.36	169.36	3.10	1.25	3.19	1.34	3.65	1.81	30.82	12.36	31.14	12.67	32.73	14.26
286.80	103.29	103.29	103.29	103.29	103.29	103.29	119.18	119.18	119.18	119.18	119.18	119.18	169.44	169.44	169.44	169.44	169.44	169.44	3.10	1.25	3.19	1.35	3.65	1.81	30.80	12.37	31.12	12.69	32.71	14.28
286.70	103.24	103.24	103.24	103.24	103.24	103.24	119.17	119.17	119.17	119.17	119.17	119.17	169.53	169.53	169.53	169.53	169.53	169.53	3.09	1.25	3.19	1.35	3.65	1.81	30.79	12.39	31.10	12.71	32.69	14.30
286.60	103.20	103.20	103.20	103.20	103.20	103.20	119.15	119.15	119.15	119.15	119.15	119.15	169.61	169.61	169.61	169.61	169.61	169.61	3.09	1.26	3.19	1.35	3.65	1.82	30.77	12.41	31.08	12.72	32.68	14.32
286.50	103.15	103.15	103.15	103.15	103.15	103.15	119.14	119.14	119.14	119.14	119.14	119.14	169.69	169.69	169.69	169.69	169.69	169.69	3.09	1.26	3.18	1.35	3.65	1.82	30.75	12.42	31.07	12.74	32.66	14.34
286.40	103.10	103.10	103.10	103.10	103.10	103.10	119.12	119.12	119.12	119.12	119.12	119.12	169.77	169.77	169.77	169.77	169.77	169.77	3.09	1.26	3.18	1.35	3.65	1.82	30.73	12.44	31.05	12.76	32.64	14.35
286.30	103.05	103.05	103.05	103.05	103.05	103.05	119.10	119.10	119.10	119.10	119.10	119.10	169.85	169.85	169.85	169.85	169.85	169.85	3.09	1.26	3.18	1.35	3.65	1.82	30.71	12.45	31.03	12.77	32.63	14.37
286.20	103.00	103.00	103.00	103.00	103.00	103.00	119.08	119.08	119.08	119.08	119.08	119.08	169.93	169.93	169.93	169.93	169.93	169.93	3.08	1.26	3.18	1.36	3.65	1.82	30.69	12.47	31.01	12.79	32.61	14.39
286.10	102.95	102.95	102.95	102.95	102.95	102.95	119.06	119.06	119.06	119.06	119.06	119.06	170.01	170.01	170.01	170.01	170.01	170.01	3.08	1.26	3.18	1.36	3.65	1.83	30.67	12.48	30.99	12.81	32.59	14.41
286.00	102.90	102.90	102.90	102.90	102.90	102.90	119.04	119.04	119.04	119.04	119.04	119.04	170.09	170.09	170.09	170.09	170.09	170.09	3.08	1.27	3.17	1.36	3.64	1.83	30.64	12.50	30.97	12.82	32.57	14.43
285.90	102.85	102.85	102.85	102.85	102.85	102.85	119.02	119.02	119.02	119.02	119.02	119.02	170.16	170.16	170.16	170.16	170.16	170.16	3.08	1.27	3.17	1.36	3.64	1.83	30.62	12.52	30.94	12.84	32.55	14.45
285.80	102.80	102.80	102.80	102.80	102.80	102.80	119.00	119.00	119.00	119.00	119.00	119.00	170.24	170.24	170.24	170.24	170.24	170.24	3.08	1.27	3.17	1.36	3.64	1.83	30.60	12.53	30.92	12.85	32.54	14.47
285.70	102.74	102.74	102.74	102.74	102.74	102.74	118.98	118.98	118.98	118.98	118.98	118.98	170.32	170.32	170.32	170.32	170.32	170.32	3.07	1.27	3.17	1.36	3.64	1.84	30.58	12.55	30.90	12.87	32.52	14.48
285.60	102.69	102.69	102.69	102.69	102.69	102.69	118.96	118.96	118.96	118.96	118.96	118.96	170.39	170.39	170.39	170.39	170.39	170.39	3.07	1.27	3.17	1.37	3.64	1.84	30.56	12.56	30.88	12.88	32.50	14.50
285.50	102.64	102.64	102.64	102.64	102.64	102.64	118.93	118.93	118.93	118.93	118.93	118.93	170.47	170.47	170.47	170.47	170.47	170.47	3.07	1.27	3.16	1.37	3.64	1.84	30.54	12.58	30.86	12.90	32.48	14.52

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
283.30	101.39	101.39	101.39	101.39	101.39	101.39	118.37	118.37	118.37	118.37	118.37	118.37	172.07	172.07	172.07	172.07	172.07	172.07	3.02	1.30	3.12	1.40	3.60	1.89	30.04	12.89	30.37	13.22	32.04	14.89
283.20	101.33	101.33	101.33	101.33	101.33	101.33	118.34	118.34	118.34	118.34	118.34	118.34	172.13	172.13	172.13	172.13	172.13	172.13	3.02	1.31	3.11	1.40	3.60	1.89	30.01	12.90	30.35	13.24	32.02	14.91
283.10	101.25	101.25	101.25	101.25	101.25	101.25	118.30	118.30	118.30	118.30	118.30	118.30	172.19	172.19	172.19	172.19	172.19	172.19	3.01	1.31	3.11	1.40	3.60	1.89	29.99	12.91	30.32	13.25	32.00	14.92
283.00	101.18	101.18	101.18	101.18	101.18	101.18	118.25	118.25	118.25	118.25	118.25	118.25	172.24	172.24	172.24	172.24	172.24	172.24	3.01	1.31	3.11	1.41	3.60	1.89	29.96	12.92	30.29	13.26	31.97	14.94
282.90	101.11	101.11	101.11	101.11	101.11	101.11	118.22	118.22	118.22	118.22	118.22	118.22	172.30	172.30	172.30	172.30	172.30	172.30	3.01	1.31	3.11	1.41	3.59	1.90	29.93	12.94	30.27	13.27	31.95	14.95
282.80	101.04	101.04	101.04	101.04	101.04	101.04	118.18	118.18	118.18	118.18	118.18	118.18	172.36	172.36	172.36	172.36	172.36	172.36	3.01	1.31	3.10	1.41	3.59	1.90	29.91	12.95	30.24	13.28	31.92	14.96
282.70	100.97	100.97	100.97	100.97	100.97	100.97	118.13	118.13	118.13	118.13	118.13	118.13	172.42	172.42	172.42	172.42	172.42	172.42	3.00	1.31	3.10	1.41	3.59	1.90	29.88	12.96	30.21	13.30	31.90	14.98
282.60	100.89	100.89	100.89	100.89	100.89	100.89	118.09	118.09	118.09	118.09	118.09	118.09	172.47	172.47	172.47	172.47	172.47	172.47	3.00	1.31	3.10	1.41	3.59	1.90	29.85	12.97	30.19	13.31	31.87	14.99
282.50	100.82	100.82	100.82	100.82	100.82	100.82	118.05	118.05	118.05	118.05	118.05	118.05	172.53	172.53	172.53	172.53	172.53	172.53	3.00	1.31	3.10	1.41	3.59	1.90	29.82	12.98	30.16	13.32	31.84	15.01
282.40	100.74	100.74	100.74	100.74	100.74	100.74	118.00	118.00	118.00	118.00	118.00	118.00	172.58	172.58	172.58	172.58	172.58	172.58	3.00	1.32	3.09	1.41	3.58	1.90	29.79	12.99	30.13	13.33	31.82	15.02
282.30	100.67	100.67	100.67	100.67	100.67	100.67	117.96	117.96	117.96	117.96	117.96	117.96	172.64	172.64	172.64	172.64	172.64	172.64	2.99	1.32	3.09	1.41	3.58	1.91	29.76	13.00	30.10	13.34	31.79	15.03
282.20	100.59	100.59	100.59	100.59	100.59	100.59	117.91	117.91	117.91	117.91	117.91	117.91	172.69	172.69	172.69	172.69	172.69	172.69	2.99	1.32	3.09	1.42	3.58	1.91	29.73	13.01	30.07	13.35	31.77	15.05
282.10	100.51	100.51	100.51	100.51	100.51	100.51	117.86	117.86	117.86	117.86	117.86	117.86	172.73	172.73	172.73	172.73	172.73	172.73	2.99	1.32	3.08	1.42	3.58	1.91	29.70	13.02	30.04	13.36	31.74	15.06
282.00	100.42	100.42	100.42	100.42	100.42	100.42	117.80	117.80	117.80	117.80	117.80	117.80	172.77	172.77	172.77	172.77	172.77	172.77	2.98	1.32	3.08	1.42	3.57	1.91	29.67	13.03	30.01	13.37	31.70	15.07
281.90	100.32	100.32	100.32	100.32	100.32	100.32	117.73	117.73	117.73	117.73	117.73	117.73	172.80	172.80	172.80	172.80	172.80	172.80	2.98	1.32	3.08	1.42	3.57	1.91	29.63	13.04	29.97	13.38	31.67	15.08
281.80	100.21	100.21	100.21	100.21	100.21	100.21	117.65	117.65	117.65	117.65	117.65	117.65	172.82	172.82	172.82	172.82	172.82	172.82	2.98	1.32	3.07	1.42	3.57	1.91	29.59	13.04	29.93	13.38	31.63	15.08
281.70	100.09	100.09	100.09	100.09	100.09	100.09	117.57	117.57	117.57	117.57	117.57	117.57	172.83	172.83	172.83	172.83	172.83	172.83	2.97	1.32	3.07	1.42	3.56	1.91	29.55	13.05	29.89	13.39	31.59	15.09
281.60	99.97	99.97	99.97	99.97	99.97	99.97	117.47	117.47	117.47	117.47	117.47	117.47	172.84	172.84	172.84	172.84	172.84	172.84	2.97	1.32	3.07	1.42	3.56	1.91	29.51	13.05	29.85	13.39	31.55	15.09
281.50	99.82	99.82	99.82	99.82	99.82	99.82	117.35	117.35	117.35	117.35	117.35	117.35	172.82	172.82	172.82	172.82	172.82	172.82	2.96	1.32	3.06	1.42	3.55	1.91	29.45	13.05	29.79	13.39	31.50	15.10
281.40	99.66	99.66	99.66	99.66	99.66	99.66	117.23	117.23	117.23	117.23	117.23	117.23	172.79	172.79	172.79	172.79	172.79	172.79	2.96	1.32	3.05	1.42	3.55	1.91	29.40	13.05	29.74	13.39	31.44	15.09
281.30	99.43	99.43	99.43	99.43	99.43	99.43	117.03	117.03	117.03	117.03	117.03	117.03	172.69	172.69	172.69	172.69	172.69	172.69	2.95	1.32	3.05	1.42	3.54	1.91	29.32	13.04	29.66	13.38	31.36	15.08
281.20	99.11	99.11	99.11	99.11	99.11	99.11	116.74	116.74	116.74	116.74	116.74	116.74	172.50	172.50	172.50	172.50	172.50	172.50	2.94	1.32	3.04	1.42	3.53	1.91	29.21	13.01	29.55	13.35	31.25	15.05
281.10	98.79	98.79	98.79	98.79	98.79	98.79	116.46	116.46	116.46	116.46	116.46	116.46	172.31	172.31	172.31	172.31	172.31	172.31	2.93	1.32	3.03	1.41	3.52	1.90	29.11	12.99	29.45	13.33	31.15	15.03
281.00	98.42	98.42	98.42	98.42	98.42	98.42	116.11	116.11	116.11	116.11	116.11	116.11	172.06	172.06	172.06	172.06	172.06	172.06	2.91	1.31	3.01	1.41	3.50	1.90	28.98	12.96	29.32	13.30	31.02	14.99
280.90	97.97	97.97	97.97	97.97	97.97	97.97	115.69	115.69	115.69	115.69	115.69	115.69	171.74	171.74	171.74	171.74	171.74	171.74	2.90	1.31	3.00	1.40	3.49	1.89	28.83	12.91	29.17	13.25	30.86	14.94
280.80	97.47	97.47	97.47	97.47	97.47	97.47	115.22	115.22	115.22	115.22	115.22	115.22	171.37	171.37	171.37	171.37	171.37	171.37	2.88	1.30	2.98	1.40	3.47	1.89	28.67	12.86	29.01	13.20	30.69	14.88
280.70	96.90	96.90	96.90	96.90	96.90	96.90	114.69	114.69	114.69	114.69	114.69	114.69	170.94	170.94	170.94	170.94	170.94	170.94	2.86	1.30	2.96	1.39	3.45	1.88	28.48	12.80	28.82	13.14	30.50	14.82
280.60	96.41	96.41	96.41	96.41	96.41	96.41	114.23	114.23	114.23	114.23	114.23	114.23	170.57	170.57	170.57	170.57	170.57	170.57	2.85	1.29	2.94	1.39	3.43	1.87	28.32	12.75	28.65	13.08	30.33	14.76
280.50	95.76	95.76	95.76	95.76	95.76	95.76	113.60	113.60	113.60	113.60	113.60	113.60	170.05	170.05	170.05	170.05	170.05	170.05	2.83	1.28	2.92	1.38	3.40	1.86	28.11	12.68	28.44	13.01	30.11	14.67
280.40	95.01	95.01	95.01	95.01	95.01	95.01	112.89	112.89	112.89	112.89	112.89	112.89	169.44	169.44	169.44	169.44	169.44	169.44	2.80	1.27	2.90	1.37	3.37	1.85	27.86	12.59	28.19	12.92	29.85	14.58
280.30	94.24	94.24	94.24	94.24	94.24	94.24	112.15	112.15	112.15	112.15	112.15	112.15	168.79	168.79	168.79	168.79	168.79	168.79	2.78	1.26	2.87	1.36	3.34	1.83	27.61	12.49	27.94	12.82	29.59	14.47
280.20	93.57	93.57	93.57	93.57	93.57	93.57	111.52	111.52	111.52	111.52	111.52	111.52	168.26	168.26	168.26	168.26	168.26	168.26	2.75	1.26	2.85	1.35	3.32	1.82	27.39	12.42	27.72	12.75	29.36	14.38
280.10	92.95	92.95	92.95	92.95	92.95	92.95	110.93	110.93	110.93	110.93	110.93	110.93	167.76	167.76	167.76	167.76	167.76	167.76	2.73	1.25	2.83	1.34	3.30	1.81	27.19	12.35	27.52	12.67	29.15	14.30
280.00	92.34	92.34	92.34	92.34	92.34	92.34	110.34	110.34	110.34	110.34	110.34	110.34	167.28	167.28	167.28	167.28	167.28	167.28	2.71	1.24	2.81	1.34	3.27	1.80	26.99	12.28	27.31	12.60	28.94	14.23
279.90	91.82	91.82	91.82	91.82	91.82	91.82	109.86	109.86	109.86	109.86	109.86	109.86	166.89	166.89	166.89	166.89	166.89	166.89	2.70	1.24	2.79	1.33	3.25	1.79	26.82	12.22	27.14	12.54	28.76	14.16
279.80	91.28	91.28	91.28	91.28	91.28	91.28	109.35	109.35	109.35	109.35	109.35	109.35	166.48	166.48	166.48	166.48	166.48	166.48	2.68	1.23	2.77	1.32	3.23	1.79	26.64	12.16	26.96	12.48	28.57	14.09
279.70	90.70	90.70	90.70	90.70	90.70	90.70	108.80	108.80	108.80	108.80	108.80	108.80	166.03	166.03	166.03	166.03	166.03	166.03	2.66	1.22	2.75	1.32	3.21	1.78	26.45	12.09	26.77	12.41	28.38	14.02
279.60	90.36	90.36	90.36	90.36	90.36	90.36	108.49	108.49	108.49	108.49	108.49	108.49	165.81	165.81	165.81	165.81	165.81	165.81	2.65	1.22	2.74	1.31	3.20	1.77	26.33	12.06	26.65	12.38	28.26	13.98
279.50	90.02	90.02	90.02	90.02	90.02	90.02	108.18	108.18	108.18	108.18	108.18	108.18	165.61	165.61	165.61	165.61	165.61	165.61	2.64	1.22	2.73	1.31	3.19	1.77	26.22	12.03	26.54	12.35	28.14	13.95
279.40	89.79	89.79	89.79	89.79	89.79	89.79	107.98	107.98	107.98	107.98	107.98	107.98	165.50	165.50	165.50	165.50	165.50	165.50	2.63	1.22	2.72	1.31	3.18	1.76	26.14	12.01	26.46	12.33	28.06	13.93
279.30	89.57	89.57	89.57	89.57	89.57	89.57	107.80	107.80	107.80	107.80	107.80	107.80	165.42	165.42	165.42	165.42	165.42	165.42	2.62	1.21	2.71	1.31	3.17	1.76	26.07	12.00	26.39	12.32	27.99	13.92
279.20	89.38	89.38	89.38	89.38	89.38	89.38	107.63	107.63	107.63	107.63	107.63	107.63	165.35	165.35	165.35	165.35	165.35	165.35	2.61	1.21	2.71	1.31	3.16	1.76	26.00	11.99	26.32	12.31	27.92	13.91
279.10	89.19	89.19	89.19	89.19	89.19	89.19	107.47	107.47	107.47	107.47	107.47	107.47	165.29	165.29	165.29	165.29	165.29	165.29	2.61	1.21	2.70	1.30	3.16	1.76	25.94	11.98	26.26	12.30	27.85	13.90
279.00	89.00	89.00	89.00	89.00	89.00	89.00	107.32	107.32	107.32	107.32	107.32	107.32	165.24	165.24	165.24	165.24	165.24	165.24	2.60	1.21	2.69	1.30	3.15	1.76	25.87	11.97	26.19	12.29	27.79	13.89
278.90	88.83	88.83	88.83	88.83	88.83	88.83	107.18	107.18	107.18	107.18	107.18	107.18	165.19	165.19	165.19	165.19	165.19	165.19	2.60	1.21	2.69	1.30	3.14	1.76	25.81	11.96	26.13	12.28	27.73	13.88
278.80	88.66	88.66	88.66	88.66	88.66	88.66	107.03	107.03	107.03	107.03	107.03	107.03	165.15	165.15	165.15	165.15	165.15	165.15	2.59	1.21	2.68	1.30	3.14	1.76	25.75	11.96	26.07	12.28	27.67	13.87
278.70	88.51	88.51	88.51	88.51	88.51	88.51	106.91	106.91	106.91	106.91	106.91	106.91	165.13	165.13	165.13	165.13	165.13	165.13	2.58	1.21	2.68	1.30	3.13	1.76	25.70	11.95	26.02	12.27	27.62	13.87
278.60	88.36	88.36	88.36	88.36	88.36	88.36	106.80	106.80	106.80	106.80	106.80	106.80	165.11	165.11	165.11	165.11	165.11	165.11	2.58	1.21	2.67	1.30	3.13	1.76	25.65	11.95	25.97	12.27	27.57	13.87
278.50	88.24	88.24	88.24	88.24	88.24	88.24	106.71	106.71	106.71	106.71	106.71	106.71	165.11	165.11	165.11	165.11	165.11	165.11	2.58	1.21	2.67	1.30	3.12	1.76	25.60	11.95	25.92	12.27	27.52	13.86
278.40	88.11	88.11	88.11	88.11	88.11	88.11	106.61	106.61	106.61	106.61	106.61	106.61	165.12	165.12	165.12	165.12	165.12	165.12	2.57	1.21	2.66	1.30	3.12	1.76	25.56	11.95	25.88	12.27	27.48	13.87
278.30	87.99	87.99	87.99	87.99	87.99	87.99	106.52	106.52	106.52	106.52	106.52	106.52	165.13	165.13	165.13	165.13	165.13	165.13	2.57	1.21	2.66	1.30	3.11	1.76	25.51	11.95	25.83	12.27	27.43	13.87
278.20	87.88	87.88	87.88	87.88	87.88	87.88	106.44	106.44	106.44	106.44	106.44	106.44	165.14	165.14	165.14	165.14	165.14	165.14	2.56	1.21	2.65	1.30	3.11	1.76	25.47	11.95	25.79	12.27	27.39	13.87
278.10	87.76	87.76	87.76	87.76	87.76	87.76	106.35	106.35	106.35	106.35	106.35	106.35	165.15	165.15	165.15	165.15	165.15	165.15	2.56	1.21	2.65	1.30	3.10	1.76	25.43	11.95	25.75	12.27	27.35	13.87
278.00	87.64	87.64	87.64	87.64	87.64	87.64	106.27	106.27	106.27	106.27	106.27	106.27	165.17	165.17	165.17	165.17	165.17	165.17	2.55	1.21	2.64	1.30	3.10	1.76	25.39	11.95	25.71	12.27	27.31	13.87
277.90	87.54	87.54	87.54	87.54	87.54	87.54	106.20	106.20	106.20	106.20	106.20	106.20	165.19	165.19	165.19	165.19	165.19	165.19	2.55	1.21	2.64	1.30	3.10	1.76	25.35	11.95	25.67	12.27	27.28	13.87
277.80	87.43	87.43	87.43	87.43	87.43	87.43	106.12	106.12	106.12	106.12	106.12	106.12	165.22	165.22	165.22	165.22	165.22	165.22	2.55	1.21	2.64	1.30	3.09	1.76	25.31	11.95	25.63	12.27	27.24	13.88
277.70	87.33	87.33	87.33	87.33	87.33	87.33	106.05	106.05	106.05	106.05	106.05	106.05	165.24	165.24	165.24	165.24	165.24	165.24	2.54	1.21	2.63	1.30	3.09	1.76	25.28	11.95	25.60	12.27	27.20	13.88
277.60	87.24	87.24	87.24	87.24	87.24	87.24	105.99	105.99	105.99	105.99	105.99	105.99	165.28	165.28	165.28	165.28	165.28	165.28	2.54	1.21	2.63	1.30	3.09	1.76	25.24	11.96	25.56	12.28	27.17	13.88
277.50	87.16	87.16	87.16	87.16	87.16	87.16	105.94	105.94	105.94	105.94	105.94	105.94	165.33	165.33	165.33	165.33	165.33	165.33	2.54	1.21	2.63	1.30	3.08	1.76	25.21	11.96	25.53	12.28	27.14	13.89
277.40	87.08	87.08	87.08	87.08	87.08	87.08	105.89	105.89	105.89	105.89	105.89	105.89	165.38	165.38	165.38	165.38	165.38	165.38	2.53	1.21	2.62	1.30	3.08	1.76	25.18	11.97	25.50	12.29	27.11	13.90
277.30	86.99	86.99	86.99	86.99	86.99	86.99	105.84	105.84	105.84	105.84	105.84	105.84	165.42	165.42	165.42	165.42	165.42	165.42	2.53	1.21	2.62	1.30	3.08	1.76	25.15	11.97	25.47	12.29	27.08	13.91
277.20	86.92	86.92	86.92	86.92	86.92	86.92	105.79	105.79	105.79	105.79	105.79	105.79	165.47	165.47	165.47	165.47	165.47	165.47	2.53	1.21	2.62	1.30	3.08	1.76	25.12	11.98	25.44	12.30	27.06	13.91
277.10	86.84	86.84	86.84	86.84	86.84	86.84	105.75	105.75	105.75	105.75	105.75	105.75	165.53	165.53	165.53	165.53	165.53	165.53	2.52	1.21	2.62	1.30	3.07	1.76	25.09	11.98	25.42	12.31	27.03	13.92
277.00	86.78	86.78	86.78	86.78	86.78	86.78	105.71	105.71	105.71	105.71	105.71	105.71	165.59	165.59	165.59	165.59	165.59	165.59	2.52	1.21	2.61	1.31	3.07	1.76	25.07	11.99	25.39	12.31	27.00	13.93
276.90	86.71	86.71	86.71	86.71	86.71	86.71	105.68	105.68	105.68	105.68	105.68	105.68	165.65	165.65	165.65	165.65	165.65	165.65	2.52	1.21	2.61	1.31	3.07	1.76	25.04	12.00	25.36	12.32	26.98	13.94
276.80	86.63	86.63	86.63	86.63	86.63	86.63	105.63	105.63	105.63	105.63	105.63	105.63	165.71	165.71	165.71	165.71	165.71	165.71	2.52	1.22	2.61	1.31	3.07	1.77	25.01	12.00	25.34	12.33	26.95	13.95
276.70	86.57	86.57	86.57	86.57	86.57	86.57	105.60	105.60	105.60	105.60	105.60	105.60	165.77	165.77	165.77	165.77	165.77	165.77	2.51	1.22	2.61	1.31	3.06	1.77	24.99	12.01	25.31	12.34	26.93	13.96
276.60	86.51	86.51	86.51	86.51	86.51	86.51	105.57	105.57	105.57	105.57	105.57	105.57	165.84	165.84	165.84	165.84	165.84	165.84	2.51	1.22	2.60	1.31	3.06	1.77	24.96	12.02	25.29	12.34	26.91	13.97
276.50	86.45	86.45	86.45	86.45	86.45	86.45	105.54	105.54	105.54	105.54	105.54	105.54	165.91	165.91	165.91	165.91	165.91	165.91	2.51	1.22	2.60	1.31	3.06	1.77	24.94	12.03	25.26	12.35	26.89	13.98
276.40	86.39	86.39	86.39	86.39	86.39	86.39	105.51	105.51	105.51	105.51	105.51	105.51	165.98	165.98	165.98	165.98	165.98	165.98	2.51	1.22	2.60	1.31	3.06	1.77	24.92	12.04	25.24	12.36	26.87	13.99
276.30	86.33	86.33	86.33	86.33	86.33	86.33	105.49	105.49	105.49	105.49	105.49	105.49	166.05	166.05	166.05	166.05	166.05	166.05	2.50	1.22	2.60	1.31	3.06	1.77	24.89	12.04	25.22	12.37	26.85	14.00
276.20	86.28	86.28	86.28	86.28	86.28	86.28	105.46	105.46	105.46	105.46	105.46	105.46	166.13	166.13	166.13	166.13	166.13	166.13	2.50	1.22	2.59	1.31	3.06	1.77	24.87	12.05	25.20	12.38	26.83	14.01
276.10	86.22	86.22	86.22	86.22	86.22	86.22	105.44	105.44	105.44	105.44	105.44	105.44	166.20	166.20	166.20	166.20	166.20	166.20	2.50	1.22	2.59	1.31	3.05	1.77	24.85	12.06	25.18	12.39	26.81	14.02
276.00	86.17	86.17	86.17	86.17	86.17	86.17	105.41	105.41	105.41	105.41	105.41	105.41	166.28	166.28	166.28	166.28	166.28	166.28	2.50	1.22	2.59	1.31	3.05	1.78	24.83	12.07	25.15	12.40	26.79	14.03
275.90	86.11	86.11	86.11	86.11	86.11	86.11	105.39	105.39	105.39	105.39	105.39	105.39	166.35	166.35	166.35	166.35	166.35	166.35	2.50	1.22	2.59	1.32	3.05	1.78	24.81	12.08	25.13	12.41	26.77	14.04
275.80	86.06	86.06	86.06	86.06	86.06	86.06	105.37	105.37	105.37	105.37	105.37	105.37	166.42	166.42	166.42	166.42	166.42	166.42	2.49	1.22	2.59	1.32	3.05	1.78	24.78	12.09	25.11	12.42	26.75	14.05
275.70	86.00	86.00	86.00	86.00	86.00	86.00	105.34	105.34	105.34	105.34	105.34	105.34	166.50	166.50	166.50	166.50	166.50	166.50	2.49	1.22	2.58	1.32	3.05	1.78	24.76	12.10	25.09	12.42	26.73	14.06
275.60	85.95	85.95	85.95	85.95	85.95	85.95	105.32	105.32	105.32	105.32	105.32	105.32	166.57	166.57	166.57	166.57	166.57	166.57	2.49	1.23	2.58	1.32	3.04	1.78	24.74	12.11	25.07	12.43	26.71	14.07
275.50	85.89	85.89	85.89	85.89	85.89	85.89	105.30	105.30	105.30	105.30	105.30	105.30	166.65	166.65	166.65	166.65	166.65	166.65	2.49	1.23	2.58	1.32	3.04	1.78	24.72	12.11	25.05	12.44	26.69	14.08
275.40	85.84	85.84	85.84	85.84	85.84	85.84	105.28	105.28	105.28	105.28	105.28	105.28	166.73	166.73	166.73	166.73	166.73	166.73	2.48	1.23	2.58	1.32	3.04	1.78	24.70	12.12	25.02	12.45	26.67	14.09
275.30	85.79	85.79	85.79	85.79	85.79	85.79	105.25	105.25	105.25	105.25	105.25	105.25	166.80	166.80	166.80	166.80	166.80	166.80	2.48	1.23	2.58	1.32	3.04	1.79	24.67	12.13	25.00	12.46	26.65	14.11
275.20	85.74	85.

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
273.10	84.64	84.64	84.64	84.64	84.64	84.64	104.79	104.79	104.79	104.79	104.79	104.79	168.49	168.49	168.49	168.49	168.49	168.49	2.44	1.25	2.53	1.34	3.00	1.81	24.21	12.32	24.54	12.66	26.23	14.34
273.00	84.58	84.58	84.58	84.58	84.58	84.58	104.76	104.76	104.76	104.76	104.76	104.76	168.56	168.56	168.56	168.56	168.56	168.56	2.43	1.25	2.53	1.34	3.00	1.82	24.18	12.33	24.52	12.66	26.21	14.35
272.90	84.52	84.52	84.52	84.52	84.52	84.52	104.73	104.73	104.73	104.73	104.73	104.73	168.63	168.63	168.63	168.63	168.63	168.63	2.43	1.25	2.53	1.34	3.00	1.82	24.16	12.33	24.50	12.67	26.18	14.36
272.80	84.46	84.46	84.46	84.46	84.46	84.46	104.70	104.70	104.70	104.70	104.70	104.70	168.70	168.70	168.70	168.70	168.70	168.70	2.43	1.25	2.52	1.34	3.00	1.82	24.14	12.34	24.47	12.68	26.16	14.37
272.70	84.40	84.40	84.40	84.40	84.40	84.40	104.67	104.67	104.67	104.67	104.67	104.67	168.77	168.77	168.77	168.77	168.77	168.77	2.43	1.25	2.52	1.34	3.00	1.82	24.11	12.35	24.45	12.68	26.14	14.38
272.60	84.35	84.35	84.35	84.35	84.35	84.35	104.65	104.65	104.65	104.65	104.65	104.65	168.85	168.85	168.85	168.85	168.85	168.85	2.42	1.25	2.52	1.35	2.99	1.82	24.09	12.35	24.43	12.69	26.12	14.38
272.50	84.29	84.29	84.29	84.29	84.29	84.29	104.62	104.62	104.62	104.62	104.62	104.62	168.92	168.92	168.92	168.92	168.92	168.92	2.42	1.25	2.52	1.35	2.99	1.82	24.07	12.36	24.41	12.70	26.10	14.39
272.40	84.23	84.23	84.23	84.23	84.23	84.23	104.60	104.60	104.60	104.60	104.60	104.60	168.99	168.99	168.99	168.99	168.99	168.99	2.42	1.25	2.51	1.35	2.99	1.82	24.04	12.37	24.38	12.71	26.08	14.40
272.30	84.18	84.18	84.18	84.18	84.18	84.18	104.57	104.57	104.57	104.57	104.57	104.57	169.06	169.06	169.06	169.06	169.06	169.06	2.42	1.25	2.51	1.35	2.99	1.82	24.02	12.37	24.36	12.71	26.06	14.41
272.20	84.12	84.12	84.12	84.12	84.12	84.12	104.54	104.54	104.54	104.54	104.54	104.54	169.14	169.14	169.14	169.14	169.14	169.14	2.42	1.25	2.51	1.35	2.99	1.82	24.00	12.38	24.34	12.72	26.04	14.42
272.10	84.06	84.06	84.06	84.06	84.06	84.06	104.52	104.52	104.52	104.52	104.52	104.52	169.21	169.21	169.21	169.21	169.21	169.21	2.41	1.25	2.51	1.35	2.98	1.83	23.98	12.39	24.32	12.73	26.02	14.43
272.00	84.00	84.00	84.00	84.00	84.00	84.00	104.49	104.49	104.49	104.49	104.49	104.49	169.28	169.28	169.28	169.28	169.28	169.28	2.41	1.25	2.51	1.35	2.98	1.83	23.95	12.40	24.29	12.74	26.00	14.44
271.90	83.95	83.95	83.95	83.95	83.95	83.95	104.47	104.47	104.47	104.47	104.47	104.47	169.35	169.35	169.35	169.35	169.35	169.35	2.41	1.26	2.50	1.35	2.98	1.83	23.93	12.40	24.27	12.74	25.98	14.45
271.80	83.89	83.89	83.89	83.89	83.89	83.89	104.44	104.44	104.44	104.44	104.44	104.44	169.42	169.42	169.42	169.42	169.42	169.42	2.41	1.26	2.50	1.35	2.98	1.83	23.91	12.41	24.25	12.75	25.96	14.46
271.70	83.83	83.83	83.83	83.83	83.83	83.83	104.42	104.42	104.42	104.42	104.42	104.42	169.50	169.50	169.50	169.50	169.50	169.50	2.40	1.26	2.50	1.35	2.98	1.83	23.89	12.42	24.23	12.76	25.94	14.47
271.60	83.78	83.78	83.78	83.78	83.78	83.78	104.39	104.39	104.39	104.39	104.39	104.39	169.57	169.57	169.57	169.57	169.57	169.57	2.40	1.26	2.50	1.35	2.98	1.83	23.86	12.42	24.21	12.77	25.91	14.47
271.50	83.72	83.72	83.72	83.72	83.72	83.72	104.36	104.36	104.36	104.36	104.36	104.36	169.64	169.64	169.64	169.64	169.64	169.64	2.40	1.26	2.50	1.35	2.97	1.83	23.84	12.43	24.18	12.77	25.89	14.48
271.40	83.66	83.66	83.66	83.66	83.66	83.66	104.33	104.33	104.33	104.33	104.33	104.33	169.71	169.71	169.71	169.71	169.71	169.71	2.40	1.26	2.49	1.35	2.97	1.83	23.82	12.44	24.16	12.78	25.87	14.49
271.30	83.60	83.60	83.60	83.60	83.60	83.60	104.30	104.30	104.30	104.30	104.30	104.30	169.78	169.78	169.78	169.78	169.78	169.78	2.39	1.26	2.49	1.36	2.97	1.83	23.79	12.44	24.13	12.78	25.85	14.50
271.20	83.53	83.53	83.53	83.53	83.53	83.53	104.27	104.27	104.27	104.27	104.27	104.27	169.84	169.84	169.84	169.84	169.84	169.84	2.39	1.26	2.49	1.36	2.97	1.84	23.77	12.45	24.11	12.79	25.83	14.51
271.10	83.47	83.47	83.47	83.47	83.47	83.47	104.24	104.24	104.24	104.24	104.24	104.24	169.91	169.91	169.91	169.91	169.91	169.91	2.39	1.26	2.49	1.36	2.97	1.84	23.74	12.45	24.08	12.80	25.80	14.51
271.00	83.40	83.40	83.40	83.40	83.40	83.40	104.20	104.20	104.20	104.20	104.20	104.20	169.97	169.97	169.97	169.97	169.97	169.97	2.39	1.26	2.48	1.36	2.96	1.84	23.71	12.46	24.06	12.80	25.78	14.52
270.90	83.33	83.33	83.33	83.33	83.33	83.33	104.16	104.16	104.16	104.16	104.16	104.16	170.03	170.03	170.03	170.03	170.03	170.03	2.38	1.26	2.48	1.36	2.96	1.84	23.69	12.46	24.03	12.81	25.75	14.53
270.80	83.27	83.27	83.27	83.27	83.27	83.27	104.13	104.13	104.13	104.13	104.13	104.13	170.10	170.10	170.10	170.10	170.10	170.10	2.38	1.26	2.48	1.36	2.96	1.84	23.66	12.47	24.01	12.81	25.73	14.53
270.70	83.21	83.21	83.21	83.21	83.21	83.21	104.10	104.10	104.10	104.10	104.10	104.10	170.16	170.16	170.16	170.16	170.16	170.16	2.38	1.26	2.48	1.36	2.96	1.84	23.64	12.47	23.98	12.82	25.71	14.54
270.60	83.14	83.14	83.14	83.14	83.14	83.14	104.06	104.06	104.06	104.06	104.06	104.06	170.22	170.22	170.22	170.22	170.22	170.22	2.38	1.26	2.47	1.36	2.95	1.84	23.61	12.48	23.96	12.82	25.68	14.55
270.50	83.07	83.07	83.07	83.07	83.07	83.07	104.02	104.02	104.02	104.02	104.02	104.02	170.28	170.28	170.28	170.28	170.28	170.28	2.37	1.26	2.47	1.36	2.95	1.84	23.59	12.48	23.93	12.83	25.66	14.55
270.40	83.00	83.00	83.00	83.00	83.00	83.00	103.99	103.99	103.99	103.99	103.99	103.99	170.35	170.35	170.35	170.35	170.35	170.35	2.37	1.26	2.47	1.36	2.95	1.84	23.56	12.49	23.91	12.83	25.63	14.56
270.30	82.93	82.93	82.93	82.93	82.93	82.93	103.95	103.95	103.95	103.95	103.95	103.95	170.40	170.40	170.40	170.40	170.40	170.40	2.37	1.26	2.47	1.36	2.95	1.84	23.53	12.49	23.88	12.84	25.61	14.57
270.20	82.86	82.86	82.86	82.86	82.86	82.86	103.91	103.91	103.91	103.91	103.91	103.91	170.46	170.46	170.46	170.46	170.46	170.46	2.37	1.26	2.46	1.36	2.94	1.84	23.51	12.49	23.85	12.84	25.58	14.57
270.10	82.78	82.78	82.78	82.78	82.78	82.78	103.85	103.85	103.85	103.85	103.85	103.85	170.51	170.51	170.51	170.51	170.51	170.51	2.36	1.27	2.46	1.36	2.94	1.84	23.47	12.50	23.82	12.84	25.55	14.57
270.00	82.70	82.70	82.70	82.70	82.70	82.70	103.81	103.81	103.81	103.81	103.81	103.81	170.56	170.56	170.56	170.56	170.56	170.56	2.36	1.27	2.46	1.36	2.94	1.84	23.45	12.50	23.79	12.85	25.53	14.58
269.90	82.63	82.63	82.63	82.63	82.63	82.63	103.77	103.77	103.77	103.77	103.77	103.77	170.62	170.62	170.62	170.62	170.62	170.62	2.36	1.27	2.45	1.36	2.94	1.84	23.42	12.50	23.76	12.85	25.50	14.58
269.80	82.55	82.55	82.55	82.55	82.55	82.55	103.72	103.72	103.72	103.72	103.72	103.72	170.67	170.67	170.67	170.67	170.67	170.67	2.35	1.27	2.45	1.36	2.93	1.85	23.39	12.51	23.74	12.85	25.47	14.59
269.70	82.48	82.48	82.48	82.48	82.48	82.48	103.68	103.68	103.68	103.68	103.68	103.68	170.72	170.72	170.72	170.72	170.72	170.72	2.35	1.27	2.45	1.36	2.93	1.85	23.36	12.51	23.71	12.86	25.44	14.59
269.60	82.40	82.40	82.40	82.40	82.40	82.40	103.64	103.64	103.64	103.64	103.64	103.64	170.78	170.78	170.78	170.78	170.78	170.78	2.35	1.27	2.45	1.36	2.93	1.85	23.33	12.51	23.68	12.86	25.42	14.60
269.50	82.33	82.33	82.33	82.33	82.33	82.33	103.59	103.59	103.59	103.59	103.59	103.59	170.83	170.83	170.83	170.83	170.83	170.83	2.35	1.27	2.44	1.36	2.93	1.85	23.30	12.52	23.65	12.86	25.39	14.60
269.40	82.25	82.25	82.25	82.25	82.25	82.25	103.55	103.55	103.55	103.55	103.55	103.55	170.89	170.89	170.89	170.89	170.89	170.89	2.34	1.27	2.44	1.36	2.92	1.85	23.28	12.52	23.62	12.87	25.36	14.61
269.30	82.18	82.18	82.18	82.18	82.18	82.18	103.51	103.51	103.51	103.51	103.51	103.51	170.94	170.94	170.94	170.94	170.94	170.94	2.34	1.27	2.44	1.36	2.92	1.85	23.25	12.52	23.60	12.87	25.34	14.61
269.20	82.11	82.11	82.11	82.11	82.11	82.11	103.47	103.47	103.47	103.47	103.47	103.47	171.00	171.00	171.00	171.00	171.00	171.00	2.34	1.27	2.43	1.36	2.92	1.85	23.22	12.52	23.57	12.87	25.31	14.61
269.10	82.04	82.04	82.04	82.04	82.04	82.04	103.42	103.42	103.42	103.42	103.42	103.42	171.06	171.06	171.06	171.06	171.06	171.06	2.33	1.27	2.43	1.37	2.92	1.85	23.19	12.53	23.54	12.88	25.28	14.62
269.00	81.97	81.97	81.97	81.97	81.97	81.97	103.39	103.39	103.39	103.39	103.39	103.39	171.12	171.12	171.12	171.12	171.12	171.12	2.33	1.27	2.43	1.37	2.91	1.85	23.17	12.53	23.51	12.88	25.26	14.62
268.90	81.90	81.90	81.90	81.90	81.90	81.90	103.35	103.35	103.35	103.35	103.35	103.35	171.18	171.18	171.18	171.18	171.18	171.18	2.33	1.27	2.43	1.37	2.91	1.85	23.14	12.53	23.49	12.88	25.23	14.63
268.80	81.82	81.82	81.82	81.82	81.82	81.82	103.31	103.31	103.31	103.31	103.31	103.31	171.24	171.24	171.24	171.24	171.24	171.24	2.33	1.27	2.42	1.37	2.91	1.85	23.11	12.54	23.46	12.89	25.21	14.63
268.70	81.76	81.76	81.76	81.76	81.76	81.76	103.27	103.27	103.27	103.27	103.27	103.27	171.30	171.30	171.30	171.30	171.30	171.30	2.32	1.27	2.42	1.37	2.91	1.85	23.08	12.54	23.43	12.89	25.18	14.64
268.60	81.69	81.69	81.69	81.69	81.69	81.69	103.23	103.23	103.23	103.23	103.23	103.23	171.36	171.36	171.36	171.36	171.36	171.36	2.32	1.27	2.42	1.37	2.90	1.85	23.06	12.55	23.41	12.90	25.16	14.65
268.50	81.63	81.63	81.63	81.63	81.63	81.63	103.20	103.20	103.20	103.20	103.20	103.20	171.42	171.42	171.42	171.42	171.42	171.42	2.32	1.27	2.42	1.37	2.90	1.85	23.03	12.55	23.38	12.90	25.13	14.65
268.40	81.56	81.56	81.56	81.56	81.56	81.56	103.17	103.17	103.17	103.17	103.17	103.17	171.49	171.49	171.49	171.49	171.49	171.49	2.32	1.27	2.41	1.37	2.90	1.85	23.01	12.55	23.36	12.90	25.11	14.66
268.30	81.50	81.50	81.50	81.50	81.50	81.50	103.13	103.13	103.13	103.13	103.13	103.13	171.55	171.55	171.55	171.55	171.55	171.55	2.31	1.27	2.41	1.37	2.90	1.85	22.98	12.56	23.33	12.91	25.09	14.66
268.20	81.43	81.43	81.43	81.43	81.43	81.43	103.10	103.10	103.10	103.10	103.10	103.10	171.62	171.62	171.62	171.62	171.62	171.62	2.31	1.27	2.41	1.37	2.89	1.86	22.96	12.56	23.31	12.91	25.06	14.67
268.10	81.37	81.37	81.37	81.37	81.37	81.37	103.07	103.07	103.07	103.07	103.07	103.07	171.68	171.68	171.68	171.68	171.68	171.68	2.31	1.27	2.41	1.37	2.89	1.86	22.93	12.57	23.28	12.92	25.04	14.67
268.00	81.30	81.30	81.30	81.30	81.30	81.30	103.03	103.03	103.03	103.03	103.03	103.03	171.75	171.75	171.75	171.75	171.75	171.75	2.31	1.27	2.40	1.37	2.89	1.86	22.91	12.57	23.26	12.92	25.02	14.68
267.90	81.24	81.24	81.24	81.24	81.24	81.24	103.00	103.00	103.00	103.00	103.00	103.00	171.82	171.82	171.82	171.82	171.82	171.82	2.30	1.27	2.40	1.37	2.89	1.86	22.88	12.58	23.24	12.93	25.00	14.69
267.80	81.18	81.18	81.18	81.18	81.18	81.18	102.97	102.97	102.97	102.97	102.97	102.97	171.88	171.88	171.88	171.88	171.88	171.88	2.30	1.27	2.40	1.37	2.89	1.86	22.86	12.58	23.21	12.93	24.97	14.69
267.70	81.12	81.12	81.12	81.12	81.12	81.12	102.94	102.94	102.94	102.94	102.94	102.94	171.95	171.95	171.95	171.95	171.95	171.95	2.30	1.27	2.40	1.37	2.88	1.86	22.83	12.58	23.19	12.94	24.95	14.70
267.60	81.06	81.06	81.06	81.06	81.06	81.06	102.91	102.91	102.91	102.91	102.91	102.91	172.02	172.02	172.02	172.02	172.02	172.02	2.30	1.27	2.39	1.37	2.88	1.86	22.81	12.59	23.16	12.94	24.93	14.71
267.50	81.00	81.00	81.00	81.00	81.00	81.00	102.88	102.88	102.88	102.88	102.88	102.88	172.09	172.09	172.09	172.09	172.09	172.09	2.29	1.27	2.39	1.37	2.88	1.86	22.79	12.59	23.14	12.95	24.90	14.71
267.40	80.94	80.94	80.94	80.94	80.94	80.94	102.85	102.85	102.85	102.85	102.85	102.85	172.16	172.16	172.16	172.16	172.16	172.16	2.29	1.28	2.39	1.37	2.88	1.86	22.76	12.60	23.12	12.95	24.88	14.72
267.30	80.88	80.88	80.88	80.88	80.88	80.88	102.82	102.82	102.82	102.82	102.82	102.82	172.22	172.22	172.22	172.22	172.22	172.22	2.29	1.28	2.39	1.37	2.88	1.86	22.74	12.60	23.09	12.96	24.86	14.72
267.20	80.81	80.81	80.81	80.81	80.81	80.81	102.79	102.79	102.79	102.79	102.79	102.79	172.29	172.29	172.29	172.29	172.29	172.29	2.29	1.28	2.38	1.37	2.87	1.86	22.71	12.61	23.07	12.96	24.84	14.73
267.10	80.74	80.74	80.74	80.74	80.74	80.74	102.75	102.75	102.75	102.75	102.75	102.75	172.35	172.35	172.35	172.35	172.35	172.35	2.28	1.28	2.38	1.37	2.87	1.86	22.69	12.61	23.04	12.96	24.81	14.73
267.00	80.67	80.67	80.67	80.67	80.67	80.67	102.71	102.71	102.71	102.71	102.71	102.71	172.41	172.41	172.41	172.41	172.41	172.41	2.28	1.28	2.38	1.37	2.87	1.86	22.66	12.61	23.02	12.97	24.79	14.74
266.90	80.61	80.61	80.61	80.61	80.61	80.61	102.68	102.68	102.68	102.68	102.68	102.68	172.48	172.48	172.48	172.48	172.48	172.48	2.28	1.28	2.38	1.38	2.87	1.86	22.64	12.62	22.99	12.97	24.76	14.74
266.80	80.55	80.55	80.55	80.55	80.55	80.55	102.65	102.65	102.65	102.65	102.65	102.65	172.54	172.54	172.54	172.54	172.54	172.54	2.28	1.28	2.37	1.38	2.86	1.87	22.61	12.62	22.97	12.98	24.74	14.75
266.70	80.49	80.49	80.49	80.49	80.49	80.49	102.62	102.62	102.62	102.62	102.62	102.62	172.61	172.61	172.61	172.61	172.61	172.61	2.27	1.28	2.37	1.38	2.86	1.87	22.59	12.63	22.94	12.98	24.72	14.76
266.60	80.43	80.43	80.43	80.43	80.43	80.43	102.60	102.60	102.60	102.60	102.60	102.60	172.69	172.69	172.69	172.69	172.69	172.69	2.27	1.28	2.37	1.38	2.86	1.87	22.57	12.63	22.92	12.99	24.70	14.76
266.50	80.38	80.38	80.38	80.38	80.38	80.38	102.57	102.57	102.57	102.57	102.57	102.57	172.76	172.76	172.76	172.76	172.76	172.76	2.27	1.28	2.37	1.38	2.86	1.87	22.54	12.64	22.90	12.99	24.68	14.77
266.40	80.32	80.32	80.32	80.32	80.32	80.32	102.55	102.55	102.55	102.55	102.55	102.55	172.83	172.83	172.83	172.83	172.83	172.83	2.27	1.28	2.37	1.38	2.86	1.87	22.52	12.64	22.88	13.00	24.66	14.78
266.30	80.27	80.27	80.27	80.27	80.27	80.27	102.52	102.52	102.52	102.52	102.52	102.52	172.91	172.91	172.91	172.91	172.91	172.91	2.27	1.28	2.36	1.38	2.85	1.87	22.50	12.65	22.85	13.00	24.64	14.78
266.20	80.21	80.21	80.21	80.21	80.21	80.21	102.50	102.50	102.50	102.50	102.50	102.50	172.98	172.98	172.98	172.98	172.98	172.98	2.26	1.28	2.36	1.38	2.85	1.87	22.48	12.65	22.83	13.01	24.62	14.79
266.10	80.15	80.15	80.15	80.15	80.15	80.15	102.47	102.47	102.47	102.47	102.47	102.47	173.05	173.05	173.05	173.05	173.05	173.05	2.26	1.28	2.36	1.38	2.85	1.87	22.45	12.65	22.81	13.01	24.59	14.80
266.00	80.08	80.08	80.08	80.08	80.08	80.08	102.43	102.43	102.43	102.43	102.43	102.43	173.11	173.11	173.11	173.11	173.11	173.11	2.26	1.28	2.36	1.38	2.85	1.87	22.42	12.66	22.78	13.01	24.57	14.80
265.90	80.01	80.01	80.01	80.01	80.01	80.01	102.39	102.39	102.39	102.39	102.39	102.39	173.17	173.17	173.17	173.17	173.17	173.17	2.26	1.28	2.35	1.38	2.85	1.87	22.40	12.66	22.76	13.02	24.54	14.80
265.80	79.95	79.95	79.95	79.95	79.95	79.95	102.36	102.36	102.36	102.36	102.36	102.36	173.23	173.23	173.23	173.23	173.23	173.23	2.25	1.28	2.35	1.38	2.84	1.87	22.37	12.66	22.73	13.02	24.52	14.81
265.70	79.89	79.89	79.89	79.89	79.89	79.89	102.33	102.33	102.33	102.33	102.33	102.33	173.30	173.30	173.30	173.30	173.30	173.30	2.25	1.28	2.35	1.38	2.84	1.87	22.35	12.67	22.71	13.02	24.50	14.81
265.60	79.83	79.83	79.83	79.83	79.83	79.83	102.30	102.30	102.30	102.30	102.30	102.30	173.37	173.37	173.37	173.37	173.37	173.37	2.25	1.28	2.35	1.38	2.84	1.87	22.33	12.67	22.69	13.03	24.48	14.82
265.50	79.77	79.77	79.77	79.77	79.77	79.77	102.28	102.28	102.28	102.28	102.28	102.28	173.45	173.45	173.45	173.45	173.45	173.45	2.25	1.28	2.34	1.38	2.84	1.87	22.30	12.68	22.66	13.03	24.46	14.83
265.40	79.71	79.71	79.71	79.71	79.71	79.71	102.25	102.25	102.25	102.25	102.25	102.25	173.52	173.52	173.52	173.52	173.52	173.52	2.24	1.28	2.34	1.38	2.84	1.88	22.28	12.68	22.64	13.04	24.43	14.83
265.30	79.65	79.65	79.65	79.65	79.65	79.65	102.22	102.22	102.22	102.22	102.22	102.22	173.59	173.59	173.59	173.59	173.59	173.59	2.24	1.28	2.34	1.38	2.83	1.88	22.26	12.68	22.62	13.04	24.41	14.84
265.20	79.59	79.59	79.59	79.59	79.59	79.59	102.19	102.19	102.19	102.19	102.19	102.19	173.65	173.65	173.65	173.65	173.65	173.65	2.24	1.28	2.34	1.38	2.83	1.88	22.23	12.69	22.59	13.05	24.39	14.84
265.10	79.52	79.52	79.52	79.52	79.52	79.52	102.15	102.15	102.15	102.15	102.15	102.15	173.71	173.71	173.71	173.71	173.71	173.71	2.24	1.28	2.33	1.38	2.83	1.88	22.20	12.69	22.56	13.05	24.36	14.85
265.00	79.44	79.

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
262.90	77.99	77.99	77.99	77.99	77.99	77.99	101.30	101.30	101.30	101.30	101.30	101.30	175.02	175.02	175.02	175.02	175.02	175.02	2.18	1.29	2.28	1.39	2.77	1.88	21.61	12.72	21.98	13.09	23.80	14.91
262.80	77.93	77.93	77.93	77.93	77.93	77.93	101.27	101.27	101.27	101.27	101.27	101.27	175.09	175.09	175.09	175.09	175.09	175.09	2.17	1.29	2.27	1.39	2.77	1.88	21.59	12.73	21.96	13.09	23.78	14.92
262.70	77.87	77.87	77.87	77.87	77.87	77.87	101.24	101.24	101.24	101.24	101.24	101.24	175.16	175.16	175.16	175.16	175.16	175.16	2.17	1.29	2.27	1.39	2.77	1.89	21.57	12.73	21.93	13.09	23.76	14.92
262.60	77.80	77.80	77.80	77.80	77.80	77.80	101.21	101.21	101.21	101.21	101.21	101.21	175.22	175.22	175.22	175.22	175.22	175.22	2.17	1.29	2.27	1.39	2.77	1.89	21.54	12.73	21.91	13.10	23.73	14.92
262.50	77.74	77.74	77.74	77.74	77.74	77.74	101.18	101.18	101.18	101.18	101.18	101.18	175.29	175.29	175.29	175.29	175.29	175.29	2.17	1.29	2.27	1.39	2.76	1.89	21.52	12.73	21.88	13.10	23.71	14.93
262.40	77.68	77.68	77.68	77.68	77.68	77.68	101.14	101.14	101.14	101.14	101.14	101.14	175.36	175.36	175.36	175.36	175.36	175.36	2.16	1.29	2.26	1.39	2.76	1.89	21.49	12.73	21.86	13.10	23.69	14.93
262.30	77.60	77.60	77.60	77.60	77.60	77.60	101.10	101.10	101.10	101.10	101.10	101.10	175.41	175.41	175.41	175.41	175.41	175.41	2.16	1.29	2.26	1.39	2.76	1.89	21.46	12.74	21.83	13.10	23.66	14.93
262.20	77.53	77.53	77.53	77.53	77.53	77.53	101.06	101.06	101.06	101.06	101.06	101.06	175.47	175.47	175.47	175.47	175.47	175.47	2.16	1.29	2.26	1.39	2.76	1.89	21.44	12.74	21.80	13.10	23.64	14.93
262.10	77.46	77.46	77.46	77.46	77.46	77.46	101.02	101.02	101.02	101.02	101.02	101.02	175.53	175.53	175.53	175.53	175.53	175.53	2.16	1.29	2.26	1.39	2.75	1.89	21.41	12.74	21.78	13.10	23.61	14.94
262.00	77.39	77.39	77.39	77.39	77.39	77.39	100.98	100.98	100.98	100.98	100.98	100.98	175.58	175.58	175.58	175.58	175.58	175.58	2.15	1.29	2.25	1.39	2.75	1.89	21.38	12.74	21.75	13.10	23.58	14.94
261.90	77.31	77.31	77.31	77.31	77.31	77.31	100.94	100.94	100.94	100.94	100.94	100.94	175.64	175.64	175.64	175.64	175.64	175.64	2.15	1.29	2.25	1.39	2.75	1.89	21.35	12.74	21.72	13.10	23.56	14.94
261.80	77.24	77.24	77.24	77.24	77.24	77.24	100.89	100.89	100.89	100.89	100.89	100.89	175.69	175.69	175.69	175.69	175.69	175.69	2.15	1.29	2.25	1.39	2.75	1.89	21.32	12.74	21.69	13.10	23.53	14.94
261.70	77.16	77.16	77.16	77.16	77.16	77.16	100.85	100.85	100.85	100.85	100.85	100.85	175.75	175.75	175.75	175.75	175.75	175.75	2.15	1.29	2.25	1.39	2.74	1.89	21.30	12.73	21.66	13.10	23.50	14.94
261.60	77.08	77.08	77.08	77.08	77.08	77.08	100.80	100.80	100.80	100.80	100.80	100.80	175.80	175.80	175.80	175.80	175.80	175.80	2.14	1.29	2.24	1.39	2.74	1.89	21.27	12.73	21.63	13.10	23.47	14.94
261.50	77.00	77.00	77.00	77.00	77.00	77.00	100.75	100.75	100.75	100.75	100.75	100.75	175.85	175.85	175.85	175.85	175.85	175.85	2.14	1.29	2.24	1.39	2.74	1.89	21.24	12.73	21.60	13.10	23.44	14.94
261.40	76.91	76.91	76.91	76.91	76.91	76.91	100.69	100.69	100.69	100.69	100.69	100.69	175.88	175.88	175.88	175.88	175.88	175.88	2.14	1.29	2.24	1.39	2.73	1.89	21.20	12.73	21.57	13.10	23.41	14.94
261.30	76.81	76.81	76.81	76.81	76.81	76.81	100.62	100.62	100.62	100.62	100.62	100.62	175.91	175.91	175.91	175.91	175.91	175.91	2.13	1.29	2.23	1.39	2.73	1.89	21.17	12.72	21.53	13.09	23.37	14.93
261.20	76.70	76.70	76.70	76.70	76.70	76.70	100.54	100.54	100.54	100.54	100.54	100.54	175.93	175.93	175.93	175.93	175.93	175.93	2.13	1.29	2.23	1.39	2.73	1.89	21.12	12.72	21.49	13.08	23.33	14.92
261.10	76.58	76.58	76.58	76.58	76.58	76.58	100.45	100.45	100.45	100.45	100.45	100.45	175.94	175.94	175.94	175.94	175.94	175.94	2.12	1.29	2.22	1.39	2.72	1.88	21.08	12.71	21.45	13.07	23.29	14.91
261.00	76.45	76.45	76.45	76.45	76.45	76.45	100.36	100.36	100.36	100.36	100.36	100.36	175.94	175.94	175.94	175.94	175.94	175.94	2.12	1.29	2.22	1.38	2.72	1.88	21.04	12.70	21.40	13.06	23.24	14.90
260.90	76.31	76.31	76.31	76.31	76.31	76.31	100.24	100.24	100.24	100.24	100.24	100.24	175.93	175.93	175.93	175.93	175.93	175.93	2.11	1.28	2.21	1.38	2.71	1.88	20.99	12.68	21.35	13.05	23.19	14.89
260.80	76.15	76.15	76.15	76.15	76.15	76.15	100.12	100.12	100.12	100.12	100.12	100.12	175.90	175.90	175.90	175.90	175.90	175.90	2.11	1.28	2.21	1.38	2.71	1.88	20.93	12.66	21.30	13.03	23.14	14.87
260.70	75.99	75.99	75.99	75.99	75.99	75.99	99.98	99.98	99.98	99.98	99.98	99.98	175.86	175.86	175.86	175.86	175.86	175.86	2.10	1.28	2.20	1.38	2.70	1.88	20.87	12.65	21.24	13.01	23.08	14.85
260.60	75.81	75.81	75.81	75.81	75.81	75.81	99.83	99.83	99.83	99.83	99.83	99.83	175.81	175.81	175.81	175.81	175.81	175.81	2.10	1.28	2.20	1.38	2.69	1.87	20.81	12.62	21.18	12.99	23.01	14.83
260.50	75.61	75.61	75.61	75.61	75.61	75.61	99.67	99.67	99.67	99.67	99.67	99.67	175.74	175.74	175.74	175.74	175.74	175.74	2.09	1.28	2.19	1.37	2.68	1.87	20.74	12.60	21.11	12.97	22.94	14.80
260.40	75.41	75.41	75.41	75.41	75.41	75.41	99.50	99.50	99.50	99.50	99.50	99.50	175.67	175.67	175.67	175.67	175.67	175.67	2.08	1.27	2.18	1.37	2.68	1.87	20.67	12.57	21.04	12.94	22.87	14.77
260.30	75.20	75.20	75.20	75.20	75.20	75.20	99.32	99.32	99.32	99.32	99.32	99.32	175.60	175.60	175.60	175.60	175.60	175.60	2.08	1.27	2.17	1.37	2.67	1.86	20.60	12.55	20.97	12.91	22.80	14.74
260.20	74.97	74.97	74.97	74.97	74.97	74.97	99.12	99.12	99.12	99.12	99.12	99.12	175.49	175.49	175.49	175.49	175.49	175.49	2.07	1.27	2.17	1.37	2.66	1.86	20.52	12.51	20.89	12.88	22.71	14.71
260.10	74.72	74.72	74.72	74.72	74.72	74.72	98.90	98.90	98.90	98.90	98.90	98.90	175.37	175.37	175.37	175.37	175.37	175.37	2.06	1.26	2.16	1.36	2.65	1.85	20.44	12.48	20.80	12.84	22.63	14.67
260.00	74.46	74.46	74.46	74.46	74.46	74.46	98.67	98.67	98.67	98.67	98.67	98.67	175.24	175.24	175.24	175.24	175.24	175.24	2.05	1.26	2.15	1.36	2.64	1.85	20.35	12.44	20.72	12.80	22.54	14.63
259.90	74.20	74.20	74.20	74.20	74.20	74.20	98.45	98.45	98.45	98.45	98.45	98.45	175.11	175.11	175.11	175.11	175.11	175.11	2.04	1.26	2.14	1.35	2.63	1.84	20.26	12.40	20.63	12.77	22.44	14.58
259.80	73.97	73.97	73.97	73.97	73.97	73.97	98.25	98.25	98.25	98.25	98.25	98.25	175.01	175.01	175.01	175.01	175.01	175.01	2.03	1.25	2.13	1.35	2.62	1.84	20.19	12.37	20.55	12.73	22.36	14.55
259.70	73.74	73.74	73.74	73.74	73.74	73.74	98.04	98.04	98.04	98.04	98.04	98.04	174.91	174.91	174.91	174.91	174.91	174.91	2.03	1.25	2.12	1.35	2.61	1.83	20.11	12.34	20.47	12.70	22.28	14.51
259.60	73.54	73.54	73.54	73.54	73.54	73.54	97.88	97.88	97.88	97.88	97.88	97.88	174.84	174.84	174.84	174.84	174.84	174.84	2.02	1.25	2.12	1.34	2.60	1.83	20.04	12.31	20.40	12.67	22.21	14.48
259.50	73.38	73.38	73.38	73.38	73.38	73.38	97.75	97.75	97.75	97.75	97.75	97.75	174.81	174.81	174.81	174.81	174.81	174.81	2.01	1.24	2.11	1.34	2.60	1.83	19.98	12.29	20.34	12.65	22.15	14.46
259.40	73.24	73.24	73.24	73.24	73.24	73.24	97.63	97.63	97.63	97.63	97.63	97.63	174.79	174.79	174.79	174.79	174.79	174.79	2.01	1.24	2.11	1.34	2.59	1.82	19.93	12.28	20.29	12.64	22.10	14.45
259.30	73.10	73.10	73.10	73.10	73.10	73.10	97.53	97.53	97.53	97.53	97.53	97.53	174.78	174.78	174.78	174.78	174.78	174.78	2.00	1.24	2.10	1.34	2.58	1.82	19.88	12.26	20.24	12.62	22.05	14.43
259.20	72.96	72.96	72.96	72.96	72.96	72.96	97.42	97.42	97.42	97.42	97.42	97.42	174.78	174.78	174.78	174.78	174.78	174.78	2.00	1.24	2.10	1.34	2.58	1.82	19.83	12.25	20.20	12.61	22.00	14.42
259.10	72.83	72.83	72.83	72.83	72.83	72.83	97.33	97.33	97.33	97.33	97.33	97.33	174.78	174.78	174.78	174.78	174.78	174.78	1.99	1.24	2.09	1.34	2.57	1.82	19.79	12.24	20.15	12.60	21.96	14.40
259.00	72.71	72.71	72.71	72.71	72.71	72.71	97.24	97.24	97.24	97.24	97.24	97.24	174.79	174.79	174.79	174.79	174.79	174.79	1.99	1.24	2.09	1.33	2.57	1.82	19.75	12.22	20.11	12.59	21.91	14.39
258.90	72.60	72.60	72.60	72.60	72.60	72.60	97.15	97.15	97.15	97.15	97.15	97.15	174.80	174.80	174.80	174.80	174.80	174.80	1.99	1.24	2.08	1.33	2.56	1.82	19.70	12.21	20.06	12.57	21.87	14.38
258.80	72.48	72.48	72.48	72.48	72.48	72.48	97.07	97.07	97.07	97.07	97.07	97.07	174.81	174.81	174.81	174.81	174.81	174.81	1.98	1.24	2.08	1.33	2.56	1.81	19.66	12.20	20.02	12.56	21.83	14.37
258.70	72.37	72.37	72.37	72.37	72.37	72.37	96.99	96.99	96.99	96.99	96.99	96.99	174.83	174.83	174.83	174.83	174.83	174.83	1.98	1.23	2.07	1.33	2.56	1.81	19.62	12.19	19.98	12.56	21.79	14.36
258.60	72.26	72.26	72.26	72.26	72.26	72.26	96.91	96.91	96.91	96.91	96.91	96.91	174.85	174.85	174.85	174.85	174.85	174.85	1.97	1.23	2.07	1.33	2.55	1.81	19.58	12.19	19.94	12.55	21.75	14.35
258.50	72.16	72.16	72.16	72.16	72.16	72.16	96.83	96.83	96.83	96.83	96.83	96.83	174.88	174.88	174.88	174.88	174.88	174.88	1.97	1.23	2.07	1.33	2.55	1.81	19.54	12.18	19.90	12.54	21.71	14.34
258.40	72.06	72.06	72.06	72.06	72.06	72.06	96.77	96.77	96.77	96.77	96.77	96.77	174.90	174.90	174.90	174.90	174.90	174.90	1.97	1.23	2.06	1.33	2.54	1.81	19.51	12.17	19.87	12.53	21.67	14.34
258.30	71.96	71.96	71.96	71.96	71.96	71.96	96.70	96.70	96.70	96.70	96.70	96.70	174.94	174.94	174.94	174.94	174.94	174.94	1.96	1.23	2.06	1.33	2.54	1.81	19.47	12.16	19.83	12.52	21.64	14.33
258.20	71.87	71.87	71.87	71.87	71.87	71.87	96.64	96.64	96.64	96.64	96.64	96.64	174.98	174.98	174.98	174.98	174.98	174.98	1.96	1.23	2.06	1.33	2.54	1.81	19.44	12.16	19.80	12.52	21.61	14.32
258.10	71.78	71.78	71.78	71.78	71.78	71.78	96.58	96.58	96.58	96.58	96.58	96.58	175.01	175.01	175.01	175.01	175.01	175.01	1.96	1.23	2.05	1.33	2.53	1.81	19.40	12.15	19.77	12.51	21.57	14.32
258.00	71.69	71.69	71.69	71.69	71.69	71.69	96.52	96.52	96.52	96.52	96.52	96.52	175.05	175.05	175.05	175.05	175.05	175.05	1.95	1.23	2.05	1.33	2.53	1.81	19.37	12.14	19.73	12.51	21.54	14.31
257.90	71.59	71.59	71.59	71.59	71.59	71.59	96.46	96.46	96.46	96.46	96.46	96.46	175.09	175.09	175.09	175.09	175.09	175.09	1.95	1.23	2.04	1.32	2.53	1.81	19.34	12.14	19.70	12.50	21.50	14.31
257.80	71.50	71.50	71.50	71.50	71.50	71.50	96.40	96.40	96.40	96.40	96.40	96.40	175.12	175.12	175.12	175.12	175.12	175.12	1.95	1.23	2.04	1.32	2.52	1.80	19.30	12.13	19.66	12.49	21.47	14.30
257.70	71.41	71.41	71.41	71.41	71.41	71.41	96.34	96.34	96.34	96.34	96.34	96.34	175.16	175.16	175.16	175.16	175.16	175.16	1.94	1.23	2.04	1.32	2.52	1.80	19.27	12.12	19.63	12.49	21.44	14.29
257.60	71.33	71.33	71.33	71.33	71.33	71.33	96.28	96.28	96.28	96.28	96.28	96.28	175.21	175.21	175.21	175.21	175.21	175.21	1.94	1.23	2.03	1.32	2.52	1.80	19.24	12.12	19.60	12.48	21.41	14.29
257.50	71.24	71.24	71.24	71.24	71.24	71.24	96.23	96.23	96.23	96.23	96.23	96.23	175.25	175.25	175.25	175.25	175.25	175.25	1.94	1.23	2.03	1.32	2.51	1.80	19.20	12.11	19.57	12.48	21.38	14.29
257.40	71.15	71.15	71.15	71.15	71.15	71.15	96.17	96.17	96.17	96.17	96.17	96.17	175.29	175.29	175.29	175.29	175.29	175.29	1.93	1.23	2.03	1.32	2.51	1.80	19.17	12.11	19.53	12.47	21.34	14.28
257.30	71.05	71.05	71.05	71.05	71.05	71.05	96.10	96.10	96.10	96.10	96.10	96.10	175.32	175.32	175.32	175.32	175.32	175.32	1.93	1.22	2.02	1.32	2.50	1.80	19.13	12.10	19.50	12.46	21.30	14.27
257.20	70.95	70.95	70.95	70.95	70.95	70.95	96.03	96.03	96.03	96.03	96.03	96.03	175.35	175.35	175.35	175.35	175.35	175.35	1.92	1.22	2.02	1.32	2.50	1.80	19.10	12.09	19.46	12.45	21.27	14.26
257.10	70.86	70.86	70.86	70.86	70.86	70.86	95.98	95.98	95.98	95.98	95.98	95.98	175.39	175.39	175.39	175.39	175.39	175.39	1.92	1.22	2.02	1.32	2.50	1.80	19.07	12.09	19.43	12.45	21.24	14.26
257.00	70.78	70.78	70.78	70.78	70.78	70.78	95.93	95.93	95.93	95.93	95.93	95.93	175.44	175.44	175.44	175.44	175.44	175.44	1.92	1.22	2.01	1.32	2.49	1.80	19.03	12.08	19.40	12.44	21.21	14.25
256.90	70.70	70.70	70.70	70.70	70.70	70.70	95.87	95.87	95.87	95.87	95.87	95.87	175.49	175.49	175.49	175.49	175.49	175.49	1.92	1.22	2.01	1.32	2.49	1.80	19.00	12.08	19.37	12.44	21.18	14.25
256.80	70.61	70.61	70.61	70.61	70.61	70.61	95.82	95.82	95.82	95.82	95.82	95.82	175.53	175.53	175.53	175.53	175.53	175.53	1.91	1.22	2.01	1.32	2.49	1.80	18.97	12.07	19.33	12.43	21.15	14.25
256.70	70.53	70.53	70.53	70.53	70.53	70.53	95.76	95.76	95.76	95.76	95.76	95.76	175.57	175.57	175.57	175.57	175.57	175.57	1.91	1.22	2.00	1.32	2.48	1.80	18.94	12.07	19.30	12.43	21.11	14.24
256.60	70.43	70.43	70.43	70.43	70.43	70.43	95.70	95.70	95.70	95.70	95.70	95.70	175.61	175.61	175.61	175.61	175.61	175.61	1.91	1.22	2.00	1.32	2.48	1.80	18.90	12.06	19.27	12.42	21.08	14.23
256.50	70.34	70.34	70.34	70.34	70.34	70.34	95.64	95.64	95.64	95.64	95.64	95.64	175.65	175.65	175.65	175.65	175.65	175.65	1.90	1.22	2.00	1.32	2.48	1.79	18.87	12.05	19.23	12.41	21.05	14.23
256.40	70.26	70.26	70.26	70.26	70.26	70.26	95.59	95.59	95.59	95.59	95.59	95.59	175.69	175.69	175.69	175.69	175.69	175.69	1.90	1.22	1.99	1.32	2.47	1.79	18.84	12.05	19.20	12.41	21.01	14.22
256.30	70.17	70.17	70.17	70.17	70.17	70.17	95.53	95.53	95.53	95.53	95.53	95.53	175.73	175.73	175.73	175.73	175.73	175.73	1.90	1.22	1.99	1.31	2.47	1.79	18.81	12.04	19.17	12.40	20.98	14.21
256.20	70.21	70.21	70.21	70.21	70.21	70.21	95.60	95.60	95.60	95.60	95.60	95.60	175.90	175.90	175.90	175.90	175.90	175.90	1.89	1.22	1.99	1.32	2.47	1.80	18.78	12.04	19.14	12.40	20.96	14.22
256.10	70.29	70.29	70.29	70.29	70.29	70.29	95.72	95.72	95.72	95.72	95.72	95.72	176.11	176.11	176.11	176.11	176.11	176.11	1.89	1.22	1.99	1.32	2.48	1.81	18.75	12.03	19.11	12.40	20.95	14.23
256.00	70.37	70.37	70.37	70.37	70.37	70.37	95.83	95.83	95.83	95.83	95.83	95.83	176.32	176.32	176.32	176.32	176.32	176.32	1.89	1.22	1.99	1.32	2.49	1.82	18.72	12.03	19.09	12.40	20.93	14.24
255.90	70.45	70.45	70.45	70.45	70.45	70.45	95.94	95.94	95.94	95.94	95.94	95.94	176.53	176.53	176.53	176.53	176.53	176.53	1.89	1.22	1.99	1.32	2.49	1.82	18.69	12.03	19.06	12.40	20.91	14.25
255.80	70.53	70.53	70.53	70.53	70.53	70.53	96.05	96.05	96.05	96.05	96.05	96.05	176.74	176.74	176.74	176.74	176.74	176.74	1.88	1.22	1.99	1.32	2.50	1.83	18.67	12.02	19.04	12.40	20.90	14.26
255.70	70.61	70.61	70.61	70.61	70.61	70.61	96.16	96.16	96.16	96.16	96.16	96.16	176.95	176.95	176.95	176.95	176.95	176.95	1.88	1.22	1.98	1.32	2.50	1.84	18.64	12.02	19.01	12.39	20.88	14.27
255.60	70.69	70.69	70.69	70.69	70.69	70.69	96.27	96.27	96.27	96.27	96.27	96.27	177.16	177.16	177.16	177.16	177.16	177.16	1.88	1.22	1.98	1.32	2.51	1.85	18.61	12.02	18.99	12.39	20.87	14.27
255.50	70.77	70.77	70.77	70.77	70.77	70.77	96.38	96.38	96.38	96.38	96.38	96.38	177.37	177.37	177.37	177.37	177.37	177.37	1.88	1.22	1.98	1.32	2.51	1.86	18.58	12.01	18.96	12.39	20.85	14.28
255.40	70.85	70.85	70.85	70.85	70.85	70.85	96.49	96.49	96.49	96.49	96.49	96.49	177.58	177.58	177.58	177.58	177.58	177.58	1.87	1.22	1.98	1.33	2.52	1.87	18.55	12.01	18.93	12.39	20.83	14.29
255.30	70.93	70.93	70.93	70.93	70.93	70.93	96.60	96.60	96.60	96.60	96.60	96.60	177.78	177.78	177.78	177.78	177.78	177.78	1.87	1.22	1.98	1.33	2.53	1.87	18.52	12.00	18.90	12.39	20.82	14.30
255.20	71.01	71.01	71.01	71.01	71.01	71.01	96.71	96.71	96.71	96.71	96.71	96.71	177.99	177.99	177.99	177.99	177.99	177.99	1.87	1.22	1.98	1.33	2.53	1.88	18.49	12.00	18.88	12.38	20.80	14.31
255.10	71.09	71.09	71.09	71.09	71.09	71.09	96.82	96.82	96.82	96.82	96.82	96.82	178.20	178.20	178.20	178.20	178.20	178.20	1.86	1.22	1.98	1.33	2.54	1.89	18.46	11.99	18.85	12.38	20.78	14.31
255.00	71.17	71.17	71.17	71.17	71.17	71.17	96.93	96.93	96.93	96.93	96.93	96.93	178.41	178.41	178.41	178.41	178.41	178.41	1.86	1.22	1.98	1.33	2.54	1.90	18.43	11.99	18.82	12.38	20.76	14.32
254.90	71.25	71.25	71.25	71.25	71.25	71.25	97.04	97.04	97.04	97.04	97.04	97.04	178.62	178.62	178.62	178.62	178.62	178.62	1.86	1.22	1.97	1.33	2.55	1.91	18.40	11.99	18.79	12.38	20.75	14.33

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
252.70	72.97	72.97	72.97	72.97	72.97	72.97	99.45	99.45	99.45	99.45	99.45	99.45	183.18	183.18	183.18	183.18	183.18	183.18	1.81	1.22	1.95	1.36	2.67	2.08	17.82	11.92	18.26	12.35	20.43	14.52
252.60	73.05	73.05	73.05	73.05	73.05	73.05	99.56	99.56	99.56	99.56	99.56	99.56	183.39	183.39	183.39	183.39	183.39	183.39	1.80	1.22	1.95	1.36	2.68	2.09	17.80	11.91	18.23	12.35	20.41	14.53
252.50	73.13	73.13	73.13	73.13	73.13	73.13	99.67	99.67	99.67	99.67	99.67	99.67	183.60	183.60	183.60	183.60	183.60	183.60	1.80	1.22	1.95	1.36	2.68	2.10	17.76	11.91	18.20	12.34	20.39	14.53
252.40	73.20	73.20	73.20	73.20	73.20	73.20	99.78	99.78	99.78	99.78	99.78	99.78	183.80	183.80	183.80	183.80	183.80	183.80	1.80	1.22	1.95	1.36	2.69	2.10	17.74	11.90	18.17	12.34	20.37	14.54
252.30	73.28	73.28	73.28	73.28	73.28	73.28	99.88	99.88	99.88	99.88	99.88	99.88	184.01	184.01	184.01	184.01	184.01	184.01	1.80	1.22	1.95	1.36	2.69	2.11	17.71	11.89	18.15	12.34	20.36	14.54
252.20	73.36	73.36	73.36	73.36	73.36	73.36	99.99	99.99	99.99	99.99	99.99	99.99	184.22	184.22	184.22	184.22	184.22	184.22	1.79	1.22	1.95	1.37	2.70	2.12	17.68	11.89	18.12	12.33	20.34	14.55
252.10	73.43	73.43	73.43	73.43	73.43	73.43	100.10	100.10	100.10	100.10	100.10	100.10	184.42	184.42	184.42	184.42	184.42	184.42	1.79	1.22	1.94	1.37	2.70	2.13	17.65	11.89	18.10	12.33	20.33	14.56
252.00	73.51	73.51	73.51	73.51	73.51	73.51	100.21	100.21	100.21	100.21	100.21	100.21	184.63	184.63	184.63	184.63	184.63	184.63	1.79	1.22	1.94	1.37	2.71	2.13	17.63	11.88	18.08	12.33	20.31	14.57
251.90	73.59	73.59	73.59	73.59	73.59	73.59	100.31	100.31	100.31	100.31	100.31	100.31	184.83	184.83	184.83	184.83	184.83	184.83	1.79	1.22	1.94	1.37	2.71	2.14	17.60	11.88	18.05	12.33	20.30	14.58
251.80	73.66	73.66	73.66	73.66	73.66	73.66	100.42	100.42	100.42	100.42	100.42	100.42	185.04	185.04	185.04	185.04	185.04	185.04	1.78	1.22	1.94	1.37	2.72	2.15	17.57	11.87	18.02	12.33	20.28	14.58
251.70	73.74	73.74	73.74	73.74	73.74	73.74	100.53	100.53	100.53	100.53	100.53	100.53	185.24	185.24	185.24	185.24	185.24	185.24	1.78	1.21	1.94	1.37	2.73	2.16	17.54	11.87	18.00	12.32	20.26	14.59
251.60	73.82	73.82	73.82	73.82	73.82	73.82	100.64	100.64	100.64	100.64	100.64	100.64	185.45	185.45	185.45	185.45	185.45	185.45	1.78	1.21	1.94	1.37	2.73	2.17	17.51	11.86	17.97	12.32	20.24	14.59
251.50	73.89	73.89	73.89	73.89	73.89	73.89	100.74	100.74	100.74	100.74	100.74	100.74	185.66	185.66	185.66	185.66	185.66	185.66	1.78	1.21	1.94	1.37	2.74	2.17	17.48	11.85	17.94	12.31	20.23	14.60
251.40	73.97	73.97	73.97	73.97	73.97	73.97	100.85	100.85	100.85	100.85	100.85	100.85	185.86	185.86	185.86	185.86	185.86	185.86	1.77	1.21	1.94	1.37	2.74	2.18	17.45	11.85	17.91	12.31	20.21	14.61
251.30	74.04	74.04	74.04	74.04	74.04	74.04	100.96	100.96	100.96	100.96	100.96	100.96	186.07	186.07	186.07	186.07	186.07	186.07	1.77	1.21	1.93	1.38	2.75	2.19	17.42	11.84	17.89	12.30	20.19	14.61
251.20	74.12	74.12	74.12	74.12	74.12	74.12	101.06	101.06	101.06	101.06	101.06	101.06	186.27	186.27	186.27	186.27	186.27	186.27	1.77	1.21	1.93	1.38	2.75	2.20	17.39	11.84	17.86	12.30	20.18	14.62
251.10	74.20	74.20	74.20	74.20	74.20	74.20	101.17	101.17	101.17	101.17	101.17	101.17	186.48	186.48	186.48	186.48	186.48	186.48	1.77	1.21	1.93	1.38	2.76	2.20	17.36	11.83	17.83	12.29	20.16	14.62
251.00	74.27	74.27	74.27	74.27	74.27	74.27	101.28	101.28	101.28	101.28	101.28	101.28	186.68	186.68	186.68	186.68	186.68	186.68	1.76	1.21	1.93	1.38	2.76	2.21	17.33	11.82	17.80	12.29	20.14	14.63
250.90	74.35	74.35	74.35	74.35	74.35	74.35	101.39	101.39	101.39	101.39	101.39	101.39	186.89	186.89	186.89	186.89	186.89	186.89	1.76	1.21	1.93	1.38	2.77	2.22	17.30	11.81	17.77	12.28	20.12	14.63
250.80	74.42	74.42	74.42	74.42	74.42	74.42	101.49	101.49	101.49	101.49	101.49	101.49	187.09	187.09	187.09	187.09	187.09	187.09	1.76	1.21	1.93	1.38	2.77	2.23	17.27	11.81	17.74	12.28	20.10	14.64
250.70	74.50	74.50	74.50	74.50	74.50	74.50	101.60	101.60	101.60	101.60	101.60	101.60	187.30	187.30	187.30	187.30	187.30	187.30	1.76	1.21	1.93	1.38	2.78	2.24	17.24	11.80	17.72	12.28	20.09	14.64
250.60	74.57	74.57	74.57	74.57	74.57	74.57	101.70	101.70	101.70	101.70	101.70	101.70	187.50	187.50	187.50	187.50	187.50	187.50	1.75	1.21	1.92	1.38	2.79	2.24	17.22	11.80	17.69	12.27	20.07	14.65
250.50	74.65	74.65	74.65	74.65	74.65	74.65	101.81	101.81	101.81	101.81	101.81	101.81	187.70	187.70	187.70	187.70	187.70	187.70	1.75	1.21	1.92	1.38	2.79	2.25	17.19	11.79	17.67	12.27	20.05	14.66
250.40	74.72	74.72	74.72	74.72	74.72	74.72	101.92	101.92	101.92	101.92	101.92	101.92	187.91	187.91	187.91	187.91	187.91	187.91	1.75	1.21	1.92	1.39	2.80	2.26	17.16	11.79	17.64	12.27	20.04	14.66
250.30	74.80	74.80	74.80	74.80	74.80	74.80	102.02	102.02	102.02	102.02	102.02	102.02	188.11	188.11	188.11	188.11	188.11	188.11	1.75	1.21	1.92	1.39	2.80	2.27	17.14	11.78	17.62	12.26	20.03	14.67
250.20	74.87	74.87	74.87	74.87	74.87	74.87	102.13	102.13	102.13	102.13	102.13	102.13	188.32	188.32	188.32	188.32	188.32	188.32	1.74	1.21	1.92	1.39	2.81	2.27	17.11	11.78	17.59	12.26	20.01	14.68
250.10	74.95	74.95	74.95	74.95	74.95	74.95	102.24	102.24	102.24	102.24	102.24	102.24	188.52	188.52	188.52	188.52	188.52	188.52	1.74	1.21	1.92	1.39	2.81	2.28	17.09	11.77	17.57	12.26	20.00	14.69
250.00	75.02	75.02	75.02	75.02	75.02	75.02	102.34	102.34	102.34	102.34	102.34	102.34	188.73	188.73	188.73	188.73	188.73	188.73	1.74	1.21	1.92	1.39	2.82	2.29	17.06	11.77	17.55	12.26	19.98	14.69
249.90	75.10	75.10	75.10	75.10	75.10	75.10	102.45	102.45	102.45	102.45	102.45	102.45	188.93	188.93	188.93	188.93	188.93	188.93	1.74	1.21	1.92	1.39	2.82	2.30	17.04	11.77	17.52	12.26	19.97	14.70
249.80	75.17	75.17	75.17	75.17	75.17	75.17	102.55	102.55	102.55	102.55	102.55	102.55	189.13	189.13	189.13	189.13	189.13	189.13	1.73	1.21	1.92	1.39	2.83	2.30	17.01	11.76	17.50	12.25	19.96	14.71
249.70	75.25	75.25	75.25	75.25	75.25	75.25	102.66	102.66	102.66	102.66	102.66	102.66	189.34	189.34	189.34	189.34	189.34	189.34	1.73	1.21	1.92	1.39	2.83	2.31	16.99	11.76	17.48	12.25	19.94	14.72
249.60	75.32	75.32	75.32	75.32	75.32	75.32	102.77	102.77	102.77	102.77	102.77	102.77	189.54	189.54	189.54	189.54	189.54	189.54	1.73	1.21	1.91	1.39	2.84	2.32	16.96	11.76	17.46	12.25	19.93	14.73
249.50	75.40	75.40	75.40	75.40	75.40	75.40	102.87	102.87	102.87	102.87	102.87	102.87	189.75	189.75	189.75	189.75	189.75	189.75	1.73	1.21	1.91	1.40	2.84	2.32	16.94	11.75	17.44	12.25	19.92	14.73
249.40	75.47	75.47	75.47	75.47	75.47	75.47	102.98	102.98	102.98	102.98	102.98	102.98	189.95	189.95	189.95	189.95	189.95	189.95	1.73	1.21	1.91	1.40	2.85	2.33	16.92	11.75	17.42	12.25	19.91	14.74
249.30	75.55	75.55	75.55	75.55	75.55	75.55	103.08	103.08	103.08	103.08	103.08	103.08	190.15	190.15	190.15	190.15	190.15	190.15	1.72	1.21	1.91	1.40	2.85	2.34	16.90	11.75	17.40	12.25	19.90	14.75
249.20	75.62	75.62	75.62	75.62	75.62	75.62	103.19	103.19	103.19	103.19	103.19	103.19	190.36	190.36	190.36	190.36	190.36	190.36	1.72	1.21	1.91	1.40	2.86	2.35	16.87	11.75	17.37	12.25	19.89	14.76
249.10	75.70	75.70	75.70	75.70	75.70	75.70	103.29	103.29	103.29	103.29	103.29	103.29	190.56	190.56	190.56	190.56	190.56	190.56	1.72	1.21	1.91	1.40	2.86	2.35	16.85	11.74	17.35	12.25	19.87	14.77
249.00	75.77	75.77	75.77	75.77	75.77	75.77	103.40	103.40	103.40	103.40	103.40	103.40	190.76	190.76	190.76	190.76	190.76	190.76	1.72	1.21	1.91	1.40	2.87	2.36	16.82	11.74	17.33	12.25	19.86	14.78
248.90	75.85	75.85	75.85	75.85	75.85	75.85	103.50	103.50	103.50	103.50	103.50	103.50	190.97	190.97	190.97	190.97	190.97	190.97	1.72	1.21	1.91	1.40	2.87	2.37	16.80	11.74	17.31	12.24	19.85	14.78
248.80	75.92	75.92	75.92	75.92	75.92	75.92	103.61	103.61	103.61	103.61	103.61	103.61	191.17	191.17	191.17	191.17	191.17	191.17	1.71	1.21	1.91	1.40	2.88	2.38	16.78	11.73	17.29	12.24	19.84	14.79
248.70	75.99	75.99	75.99	75.99	75.99	75.99	103.72	103.72	103.72	103.72	103.72	103.72	191.38	191.38	191.38	191.38	191.38	191.38	1.71	1.21	1.91	1.40	2.88	2.38	16.75	11.73	17.27	12.24	19.83	14.80
248.60	76.07	76.07	76.07	76.07	76.07	76.07	103.82	103.82	103.82	103.82	103.82	103.82	191.58	191.58	191.58	191.58	191.58	191.58	1.71	1.21	1.91	1.41	2.89	2.39	16.73	11.73	17.25	12.24	19.81	14.81
248.50	76.14	76.14	76.14	76.14	76.14	76.14	103.93	103.93	103.93	103.93	103.93	103.93	191.78	191.78	191.78	191.78	191.78	191.78	1.71	1.21	1.91	1.41	2.89	2.40	16.71	11.73	17.23	12.24	19.81	14.82
248.40	76.22	76.22	76.22	76.22	76.22	76.22	104.03	104.03	104.03	104.03	104.03	104.03	191.99	191.99	191.99	191.99	191.99	191.99	1.71	1.21	1.90	1.41	2.90	2.40	16.69	11.73	17.21	12.24	19.80	14.83
248.30	76.29	76.29	76.29	76.29	76.29	76.29	104.14	104.14	104.14	104.14	104.14	104.14	192.19	192.19	192.19	192.19	192.19	192.19	1.70	1.21	1.90	1.41	2.91	2.41	16.67	11.72	17.19	12.24	19.78	14.84
248.20	76.37	76.37	76.37	76.37	76.37	76.37	104.24	104.24	104.24	104.24	104.24	104.24	192.39	192.39	192.39	192.39	192.39	192.39	1.70	1.21	1.90	1.41	2.91	2.42	16.65	11.72	17.17	12.24	19.77	14.85
248.10	76.44	76.44	76.44	76.44	76.44	76.44	104.35	104.35	104.35	104.35	104.35	104.35	192.60	192.60	192.60	192.60	192.60	192.60	1.70	1.21	1.90	1.41	2.92	2.42	16.62	11.72	17.14	12.24	19.76	14.85
248.00	76.51	76.51	76.51	76.51	76.51	76.51	104.45	104.45	104.45	104.45	104.45	104.45	192.80	192.80	192.80	192.80	192.80	192.80	1.70	1.21	1.90	1.41	2.92	2.43	16.60	11.71	17.12	12.24	19.75	14.86
247.90	76.59	76.59	76.59	76.59	76.59	76.59	104.56	104.56	104.56	104.56	104.56	104.56	193.00	193.00	193.00	193.00	193.00	193.00	1.70	1.21	1.90	1.41	2.93	2.44	16.58	11.71	17.10	12.24	19.74	14.87
247.80	76.66	76.66	76.66	76.66	76.66	76.66	104.66	104.66	104.66	104.66	104.66	104.66	193.21	193.21	193.21	193.21	193.21	193.21	1.69	1.21	1.90	1.42	2.93	2.45	16.56	11.71	17.08	12.24	19.73	14.88
247.70	76.74	76.74	76.74	76.74	76.74	76.74	104.77	104.77	104.77	104.77	104.77	104.77	193.41	193.41	193.41	193.41	193.41	193.41	1.69	1.21	1.90	1.42	2.94	2.45	16.53	11.71	17.06	12.24	19.72	14.89
247.60	76.81	76.81	76.81	76.81	76.81	76.81	104.87	104.87	104.87	104.87	104.87	104.87	193.61	193.61	193.61	193.61	193.61	193.61	1.69	1.21	1.90	1.42	2.94	2.46	16.51	11.70	17.04	12.23	19.70	14.90
247.50	76.89	76.89	76.89	76.89	76.89	76.89	104.98	104.98	104.98	104.98	104.98	104.98	193.82	193.82	193.82	193.82	193.82	193.82	1.69	1.21	1.90	1.42	2.95	2.47	16.49	11.70	17.02	12.23	19.69	14.90
247.40	76.96	76.96	76.96	76.96	76.96	76.96	105.09	105.09	105.09	105.09	105.09	105.09	194.02	194.02	194.02	194.02	194.02	194.02	1.69	1.21	1.90	1.42	2.95	2.47	16.46	11.69	17.00	12.23	19.68	14.91
247.30	77.04	77.04	77.04	77.04	77.04	77.04	105.19	105.19	105.19	105.19	105.19	105.19	194.23	194.23	194.23	194.23	194.23	194.23	1.68	1.21	1.90	1.42	2.96	2.48	16.44	11.69	16.98	12.23	19.67	14.92
247.20	77.11	77.11	77.11	77.11	77.11	77.11	105.30	105.30	105.30	105.30	105.30	105.30	194.43	194.43	194.43	194.43	194.43	194.43	1.68	1.21	1.89	1.42	2.96	2.49	16.42	11.69	16.96	12.23	19.65	14.93
247.10	77.18	77.18	77.18	77.18	77.18	77.18	105.40	105.40	105.40	105.40	105.40	105.40	194.63	194.63	194.63	194.63	194.63	194.63	1.68	1.21	1.89	1.42	2.97	2.50	16.39	11.68	16.94	12.23	19.64	14.93
247.00	77.26	77.26	77.26	77.26	77.26	77.26	105.51	105.51	105.51	105.51	105.51	105.51	194.84	194.84	194.84	194.84	194.84	194.84	1.68	1.21	1.89	1.42	2.97	2.50	16.37	11.68	16.92	12.23	19.63	14.94
246.90	77.33	77.33	77.33	77.33	77.33	77.33	105.61	105.61	105.61	105.61	105.61	105.61	195.04	195.04	195.04	195.04	195.04	195.04	1.68	1.21	1.89	1.43	2.98	2.51	16.35	11.68	16.89	12.22	19.62	14.95
246.80	77.41	77.41	77.41	77.41	77.41	77.41	105.72	105.72	105.72	105.72	105.72	105.72	195.24	195.24	195.24	195.24	195.24	195.24	1.67	1.21	1.89	1.43	2.98	2.52	16.33	11.68	16.88	12.22	19.61	14.96
246.70	77.48	77.48	77.48	77.48	77.48	77.48	105.83	105.83	105.83	105.83	105.83	105.83	195.45	195.45	195.45	195.45	195.45	195.45	1.67	1.21	1.89	1.43	2.99	2.52	16.31	11.67	16.86	12.22	19.60	14.97
246.60	77.56	77.56	77.56	77.56	77.56	77.56	105.93	105.93	105.93	105.93	105.93	105.93	195.65	195.65	195.65	195.65	195.65	195.65	1.67	1.21	1.89	1.43	2.99	2.53	16.28	11.67	16.83	12.22	19.59	14.98
246.50	77.63	77.63	77.63	77.63	77.63	77.63	106.04	106.04	106.04	106.04	106.04	106.04	195.86	195.86	195.86	195.86	195.86	195.86	1.67	1.21	1.89	1.43	3.00	2.54	16.26	11.67	16.81	12.22	19.58	14.98
246.40	77.71	77.71	77.71	77.71	77.71	77.71	106.14	106.14	106.14	106.14	106.14	106.14	196.06	196.06	196.06	196.06	196.06	196.06	1.67	1.21	1.89	1.43	3.00	2.55	16.23	11.66	16.79	12.22	19.56	14.99
246.30	77.78	77.78	77.78	77.78	77.78	77.78	106.25	106.25	106.25	106.25	106.25	106.25	196.27	196.27	196.27	196.27	196.27	196.27	1.66	1.21	1.89	1.43	3.01	2.55	16.21	11.65	16.77	12.21	19.55	15.00
246.20	77.86	77.86	77.86	77.86	77.86	77.86	106.36	106.36	106.36	106.36	106.36	106.36	196.47	196.47	196.47	196.47	196.47	196.47	1.66	1.21	1.89	1.43	3.01	2.56	16.18	11.65	16.74	12.21	19.54	15.00
246.10	77.94	77.94	77.94	77.94	77.94	77.94	106.46	106.46	106.46	106.46	106.46	106.46	196.68	196.68	196.68	196.68	196.68	196.68	1.66	1.21	1.89	1.43	3.02	2.57	16.16	11.65	16.72	12.21	19.52	15.01
246.00	78.01	78.01	78.01	78.01	78.01	78.01	106.57	106.57	106.57	106.57	106.57	106.57	196.88	196.88	196.88	196.88	196.88	196.88	1.66	1.21	1.88	1.44	3.02	2.57	16.14	11.64	16.70	12.20	19.51	15.02
245.90	78.09	78.09	78.09	78.09	78.09	78.09	106.68	106.68	106.68	106.68	106.68	106.68	197.09	197.09	197.09	197.09	197.09	197.09	1.65	1.21	1.88	1.44	3.03	2.58	16.12	11.64	16.68	12.20	19.50	15.03
245.80	78.16	78.16	78.16	78.16	78.16	78.16	106.78	106.78	106.78	106.78	106.78	106.78	197.29	197.29	197.29	197.29	197.29	197.29	1.65	1.21	1.88	1.44	3.03	2.59	16.09	11.63	16.66	12.20	19.49	15.03
245.70	78.24	78.24	78.24	78.24	78.24	78.24	106.89	106.89	106.89	106.89	106.89	106.89	197.50	197.50	197.50	197.50	197.50	197.50	1.65	1.21	1.88	1.44	3.04	2.60	16.07	11.63	16.64	12.20	19.48	15.04
245.60	78.32	78.32	78.32	78.32	78.32	78.32	107.00	107.00	107.00	107.00	107.00	107.00	197.70	197.70	197.70	197.70	197.70	197.70	1.65	1.21	1.88	1.44	3.05	2.60	16.05	11.63	16.62	12.20	19.47	15.05
245.50	78.39	78.39	78.39	78.39	78.39	78.39	107.11	107.11	107.11	107.11	107.11	107.11	197.91	197.91	197.91	197.91	197.91	197.91	1.65	1.21	1.88	1.44	3.05	2.61	16.02	11.62	16.59	12.19	19.45	15.05
245.40	78.47	78.47	78.47	78.47	78.47	78.47	107.22	107.22	107.22	107.22	107.22	107.22	198.12	198.12	198.12	198.12	198.12	198.12	1.64	1.21	1.88	1.44	3.06	2.62	15.99	11.61	16.56	12.19	19.44	15.06
245.30	78.55	78.55	78.55	78.55	78.55	78.55	107.33	107.33	107.33	107.33	107.33	107.33	198.32	198.32	198.32	198.32	198.32	198.32	1.64	1.20	1.88	1.44	3.06	2.63	15.96	11.60	16.54	12.18	19.42	15.06
245.20	78.63	78.63	78.63	78.63	78.63	78.63	107.43	107.43	107.43	107.43	107.43	107.43	198.53	198.53	198.53	198.53	198.53	198.53	1.64	1.20	1.88	1.44	3.07	2.63	15.94	11.60	16.51	12.18	19.41	15.07
245.10	78.71	78.71	78.71	78.71	78.71	78.71	107.54	107.54	107.54	107.54	107.54	107.54	198.74	198.74	198.74	198.74	198.74	198.74	1.64	1.20	1.88	1.44	3.07	2.64	15.91	11.59	16.49	12.17	19.39	15.07
245.00	78.79	78.79	78.79	78.79	78.79	78.79	107.65	107.65	107.65	107.65	107.65	107.65	198.95	198.95	198.95	198.95	198.95	198.95	1.63	1.20	1.87	1.44	3.08	2.65	15.89	11.58	16.47	12.17	19.38	15.08
244.90	78.87	78.87	78.87	78.87	78.87	78.87	107.77	107.77	107.77	107.77	107.77	107.77	199.16	199.16	199.16	199.16	199.16	199.16	1.63	1.20	1.87	1.45	3.08	2.66	15.86	11.58	16.45	12.16	19.37	15.09
244.80	78.95	78.95	78.95	78.95	78.95	78.95	107.88	107.88	107.88	107.88	107.88	107.88	199.37	199.37	199.37	199.37	199.37	199.37	1.63	1.20	1.87	1.45	3.09	2.66	15.84	11.58	16.43	12.16	19.36	15.09
244.70	79.03	79.03	79.03	79.03	79.03	79.03	107.99	107.99	107.99	107.99	107.99	107.99	199.58	199.58	199.58	199.58	199.58	199.58	1.63	1.20	1.87	1.45	3.10	2.67	15.82	11.57	16.41	12.16	19.35	15.10

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
242.50	81.00	81.00	81.00	81.00	81.00	81.00	110.64	110.64	110.64	110.64	110.64	110.64	204.39	204.39	204.39	204.39	204.39	204.39	1.58	1.20	1.86	1.47	3.23	2.85	15.30	11.46	15.93	12.09	19.11	15.27
242.40	81.09	81.09	81.09	81.09	81.09	81.09	110.76	110.76	110.76	110.76	110.76	110.76	204.61	204.61	204.61	204.61	204.61	204.61	1.58	1.20	1.86	1.47	3.24	2.85	15.27	11.45	15.91	12.08	19.09	15.27
242.30	81.18	81.18	81.18	81.18	81.18	81.18	110.88	110.88	110.88	110.88	110.88	110.88	204.83	204.83	204.83	204.83	204.83	204.83	1.58	1.20	1.86	1.47	3.24	2.86	15.24	11.44	15.88	12.08	19.08	15.28
242.20	81.27	81.27	81.27	81.27	81.27	81.27	111.01	111.01	111.01	111.01	111.01	111.01	205.05	205.05	205.05	205.05	205.05	205.05	1.58	1.20	1.85	1.48	3.25	2.87	15.22	11.44	15.86	12.08	19.07	15.29
242.10	81.36	81.36	81.36	81.36	81.36	81.36	111.13	111.13	111.13	111.13	111.13	111.13	205.27	205.27	205.27	205.27	205.27	205.27	1.57	1.20	1.85	1.48	3.26	2.88	15.20	11.43	15.84	12.07	19.06	15.29
242.00	81.45	81.45	81.45	81.45	81.45	81.45	111.25	111.25	111.25	111.25	111.25	111.25	205.48	205.48	205.48	205.48	205.48	205.48	1.57	1.20	1.85	1.48	3.26	2.89	15.17	11.42	15.82	12.07	19.05	15.30
241.90	81.54	81.54	81.54	81.54	81.54	81.54	111.37	111.37	111.37	111.37	111.37	111.37	205.70	205.70	205.70	205.70	205.70	205.70	1.57	1.20	1.85	1.48	3.27	2.89	15.14	11.41	15.79	12.06	19.03	15.30
241.80	81.63	81.63	81.63	81.63	81.63	81.63	111.49	111.49	111.49	111.49	111.49	111.49	205.92	205.92	205.92	205.92	205.92	205.92	1.57	1.19	1.85	1.48	3.27	2.90	15.11	11.40	15.76	12.05	19.02	15.30
241.70	81.72	81.72	81.72	81.72	81.72	81.72	111.61	111.61	111.61	111.61	111.61	111.61	206.14	206.14	206.14	206.14	206.14	206.14	1.56	1.19	1.85	1.48	3.28	2.91	15.08	11.39	15.73	12.04	18.99	15.30
241.60	81.81	81.81	81.81	81.81	81.81	81.81	111.73	111.73	111.73	111.73	111.73	111.73	206.36	206.36	206.36	206.36	206.36	206.36	1.56	1.19	1.85	1.48	3.29	2.92	15.04	11.37	15.70	12.03	18.98	15.31
241.50	81.90	81.90	81.90	81.90	81.90	81.90	111.85	111.85	111.85	111.85	111.85	111.85	206.58	206.58	206.58	206.58	206.58	206.58	1.56	1.19	1.85	1.48	3.29	2.93	15.01	11.36	15.67	12.02	18.96	15.31
241.40	81.99	81.99	81.99	81.99	81.99	81.99	111.97	111.97	111.97	111.97	111.97	111.97	206.80	206.80	206.80	206.80	206.80	206.80	1.55	1.19	1.84	1.48	3.30	2.94	14.98	11.35	15.64	12.01	18.94	15.31
241.30	82.07	82.07	82.07	82.07	82.07	82.07	112.09	112.09	112.09	112.09	112.09	112.09	207.02	207.02	207.02	207.02	207.02	207.02	1.55	1.19	1.84	1.48	3.31	2.94	14.94	11.33	15.61	12.00	18.92	15.31
241.20	82.16	82.16	82.16	82.16	82.16	82.16	112.21	112.21	112.21	112.21	112.21	112.21	207.23	207.23	207.23	207.23	207.23	207.23	1.55	1.19	1.84	1.48	3.31	2.95	14.90	11.31	15.57	11.98	18.89	15.30
241.10	82.25	82.25	82.25	82.25	82.25	82.25	112.33	112.33	112.33	112.33	112.33	112.33	207.45	207.45	207.45	207.45	207.45	207.45	1.54	1.19	1.84	1.48	3.32	2.96	14.86	11.29	15.52	11.96	18.86	15.30
241.00	82.34	82.34	82.34	82.34	82.34	82.34	112.45	112.45	112.45	112.45	112.45	112.45	207.67	207.67	207.67	207.67	207.67	207.67	1.54	1.18	1.84	1.48	3.33	2.97	14.81	11.27	15.48	11.94	18.83	15.29
240.90	82.43	82.43	82.43	82.43	82.43	82.43	112.57	112.57	112.57	112.57	112.57	112.57	207.89	207.89	207.89	207.89	207.89	207.89	1.53	1.18	1.83	1.48	3.33	2.98	14.76	11.24	15.43	11.91	18.80	15.28
240.80	82.52	82.52	82.52	82.52	82.52	82.52	112.69	112.69	112.69	112.69	112.69	112.69	208.11	208.11	208.11	208.11	208.11	208.11	1.53	1.18	1.83	1.48	3.34	2.99	14.70	11.21	15.38	11.88	18.76	15.26
240.70	82.61	82.61	82.61	82.61	82.61	82.61	112.81	112.81	112.81	112.81	112.81	112.81	208.33	208.33	208.33	208.33	208.33	208.33	1.52	1.18	1.83	1.48	3.34	3.00	14.64	11.18	15.32	11.85	18.71	15.25
240.60	82.70	82.70	82.70	82.70	82.70	82.70	112.93	112.93	112.93	112.93	112.93	112.93	208.54	208.54	208.54	208.54	208.54	208.54	1.52	1.17	1.82	1.48	3.35	3.01	14.57	11.13	15.25	11.81	18.66	15.22
240.50	82.79	82.79	82.79	82.79	82.79	82.79	113.05	113.05	113.05	113.05	113.05	113.05	208.76	208.76	208.76	208.76	208.76	208.76	1.51	1.17	1.82	1.48	3.36	3.02	14.50	11.09	15.19	11.78	18.61	15.20
240.40	82.87	82.87	82.87	82.87	82.87	82.87	113.17	113.17	113.17	113.17	113.17	113.17	208.98	208.98	208.98	208.98	208.98	208.98	1.50	1.17	1.81	1.48	3.36	3.03	14.44	11.06	15.13	11.74	18.57	15.18
240.30	82.96	82.96	82.96	82.96	82.96	82.96	113.29	113.29	113.29	113.29	113.29	113.29	209.20	209.20	209.20	209.20	209.20	209.20	1.50	1.16	1.81	1.47	3.37	3.03	14.38	11.02	15.07	11.71	18.52	15.16
240.20	83.05	83.05	83.05	83.05	83.05	83.05	113.41	113.41	113.41	113.41	113.41	113.41	209.41	209.41	209.41	209.41	209.41	209.41	1.49	1.16	1.81	1.47	3.38	3.04	14.33	10.99	15.02	11.68	18.48	15.15
240.10	83.14	83.14	83.14	83.14	83.14	83.14	113.53	113.53	113.53	113.53	113.53	113.53	209.63	209.63	209.63	209.63	209.63	209.63	1.49	1.16	1.80	1.47	3.38	3.05	14.28	10.96	14.97	11.66	18.45	15.13
240.00	83.23	83.23	83.23	83.23	83.23	83.23	113.65	113.65	113.65	113.65	113.65	113.65	209.85	209.85	209.85	209.85	209.85	209.85	1.48	1.16	1.80	1.47	3.39	3.06	14.23	10.94	14.93	11.64	18.42	15.12
239.90	83.32	83.32	83.32	83.32	83.32	83.32	113.77	113.77	113.77	113.77	113.77	113.77	210.07	210.07	210.07	210.07	210.07	210.07	1.48	1.15	1.80	1.47	3.40	3.07	14.19	10.92	14.89	11.62	18.39	15.12
239.80	83.40	83.40	83.40	83.40	83.40	83.40	113.89	113.89	113.89	113.89	113.89	113.89	210.28	210.28	210.28	210.28	210.28	210.28	1.48	1.15	1.80	1.47	3.40	3.08	14.14	10.89	14.85	11.60	18.36	15.11
239.70	83.49	83.49	83.49	83.49	83.49	83.49	114.01	114.01	114.01	114.01	114.01	114.01	210.50	210.50	210.50	210.50	210.50	210.50	1.47	1.15	1.80	1.47	3.41	3.09	14.10	10.87	14.81	11.58	18.33	15.11
239.60	83.58	83.58	83.58	83.58	83.58	83.58	114.12	114.12	114.12	114.12	114.12	114.12	210.72	210.72	210.72	210.72	210.72	210.72	1.47	1.15	1.79	1.47	3.41	3.09	14.06	10.86	14.77	11.56	18.31	15.10
239.50	83.67	83.67	83.67	83.67	83.67	83.67	114.24	114.24	114.24	114.24	114.24	114.24	210.93	210.93	210.93	210.93	210.93	210.93	1.47	1.15	1.79	1.47	3.42	3.10	14.03	10.84	14.74	11.55	18.29	15.10
239.40	83.75	83.75	83.75	83.75	83.75	83.75	114.36	114.36	114.36	114.36	114.36	114.36	211.15	211.15	211.15	211.15	211.15	211.15	1.46	1.15	1.79	1.47	3.43	3.11	13.99	10.82	14.70	11.53	18.26	15.09
239.30	83.84	83.84	83.84	83.84	83.84	83.84	114.48	114.48	114.48	114.48	114.48	114.48	211.37	211.37	211.37	211.37	211.37	211.37	1.46	1.14	1.79	1.47	3.43	3.12	13.95	10.80	14.67	11.52	18.24	15.09
239.20	83.93	83.93	83.93	83.93	83.93	83.93	114.60	114.60	114.60	114.60	114.60	114.60	211.58	211.58	211.58	211.58	211.58	211.58	1.46	1.14	1.79	1.47	3.44	3.13	13.92	10.79	14.63	11.50	18.22	15.09
239.10	84.02	84.02	84.02	84.02	84.02	84.02	114.72	114.72	114.72	114.72	114.72	114.72	211.80	211.80	211.80	211.80	211.80	211.80	1.45	1.14	1.78	1.47	3.44	3.13	13.88	10.77	14.60	11.49	18.20	15.08
239.00	84.10	84.10	84.10	84.10	84.10	84.10	114.84	114.84	114.84	114.84	114.84	114.84	212.02	212.02	212.02	212.02	212.02	212.02	1.45	1.14	1.78	1.47	3.45	3.14	13.84	10.75	14.57	11.47	18.17	15.08
238.90	84.19	84.19	84.19	84.19	84.19	84.19	114.95	114.95	114.95	114.95	114.95	114.95	212.23	212.23	212.23	212.23	212.23	212.23	1.45	1.14	1.78	1.47	3.46	3.15	13.81	10.74	14.54	11.46	18.15	15.08
238.80	84.28	84.28	84.28	84.28	84.28	84.28	115.07	115.07	115.07	115.07	115.07	115.07	212.45	212.45	212.45	212.45	212.45	212.45	1.44	1.14	1.78	1.47	3.46	3.16	13.78	10.72	14.50	11.45	18.14	15.08
238.70	84.37	84.37	84.37	84.37	84.37	84.37	115.19	115.19	115.19	115.19	115.19	115.19	212.67	212.67	212.67	212.67	212.67	212.67	1.44	1.14	1.78	1.47	3.47	3.17	13.74	10.71	14.47	11.44	18.12	15.08
238.60	84.45	84.45	84.45	84.45	84.45	84.45	115.31	115.31	115.31	115.31	115.31	115.31	212.88	212.88	212.88	212.88	212.88	212.88	1.44	1.14	1.78	1.48	3.47	3.17	13.71	10.69	14.44	11.42	18.10	15.08
238.50	84.54	84.54	84.54	84.54	84.54	84.54	115.43	115.43	115.43	115.43	115.43	115.43	213.10	213.10	213.10	213.10	213.10	213.10	1.44	1.13	1.78	1.48	3.48	3.18	13.68	10.68	14.42	11.41	18.08	15.08
238.40	84.63	84.63	84.63	84.63	84.63	84.63	115.54	115.54	115.54	115.54	115.54	115.54	213.32	213.32	213.32	213.32	213.32	213.32	1.43	1.13	1.77	1.48	3.49	3.19	13.65	10.67	14.39	11.40	18.06	15.08
238.30	84.71	84.71	84.71	84.71	84.71	84.71	115.66	115.66	115.66	115.66	115.66	115.66	213.53	213.53	213.53	213.53	213.53	213.53	1.43	1.13	1.77	1.48	3.49	3.20	13.62	10.66	14.36	11.39	18.05	15.08
238.20	84.80	84.80	84.80	84.80	84.80	84.80	115.78	115.78	115.78	115.78	115.78	115.78	213.75	213.75	213.75	213.75	213.75	213.75	1.43	1.13	1.77	1.48	3.50	3.20	13.60	10.64	14.34	11.38	18.03	15.08
238.10	84.89	84.89	84.89	84.89	84.89	84.89	115.90	115.90	115.90	115.90	115.90	115.90	213.96	213.96	213.96	213.96	213.96	213.96	1.42	1.13	1.77	1.48	3.50	3.21	13.56	10.63	14.30	11.37	18.01	15.08
238.00	84.97	84.97	84.97	84.97	84.97	84.97	116.02	116.02	116.02	116.02	116.02	116.02	214.18	214.18	214.18	214.18	214.18	214.18	1.42	1.13	1.77	1.48	3.51	3.22	13.53	10.62	14.28	11.36	18.00	15.08
237.90	85.06	85.06	85.06	85.06	85.06	85.06	116.13	116.13	116.13	116.13	116.13	116.13	214.40	214.40	214.40	214.40	214.40	214.40	1.42	1.13	1.77	1.48	3.52	3.23	13.50	10.60	14.25	11.35	17.98	15.08
237.80	85.15	85.15	85.15	85.15	85.15	85.15	116.25	116.25	116.25	116.25	116.25	116.25	214.61	214.61	214.61	214.61	214.61	214.61	1.42	1.13	1.77	1.48	3.52	3.23	13.47	10.59	14.22	11.34	17.97	15.08
237.70	85.23	85.23	85.23	85.23	85.23	85.23	116.37	116.37	116.37	116.37	116.37	116.37	214.83	214.83	214.83	214.83	214.83	214.83	1.41	1.13	1.77	1.48	3.53	3.24	13.45	10.58	14.20	11.33	17.95	15.08
237.60	85.32	85.32	85.32	85.32	85.32	85.32	116.49	116.49	116.49	116.49	116.49	116.49	215.04	215.04	215.04	215.04	215.04	215.04	1.41	1.13	1.76	1.48	3.53	3.25	13.41	10.57	14.17	11.32	17.93	15.08
237.50	85.41	85.41	85.41	85.41	85.41	85.41	116.60	116.60	116.60	116.60	116.60	116.60	215.26	215.26	215.26	215.26	215.26	215.26	1.41	1.12	1.76	1.48	3.54	3.26	13.37	10.54	14.13	11.30	17.91	15.08
237.40	85.49	85.49	85.49	85.49	85.49	85.49	116.72	116.72	116.72	116.72	116.72	116.72	215.47	215.47	215.47	215.47	215.47	215.47	1.40	1.12	1.76	1.48	3.55	3.26	13.34	10.53	14.10	11.28	17.89	15.07
237.30	85.58	85.58	85.58	85.58	85.58	85.58	116.84	116.84	116.84	116.84	116.84	116.84	215.69	215.69	215.69	215.69	215.69	215.69	1.40	1.12	1.76	1.48	3.55	3.27	13.31	10.51	14.07	11.27	17.87	15.07
237.20	85.67	85.67	85.67	85.67	85.67	85.67	116.96	116.96	116.96	116.96	116.96	116.96	215.90	215.90	215.90	215.90	215.90	215.90	1.40	1.12	1.76	1.48	3.56	3.28	13.27	10.49	14.03	11.26	17.85	15.07
237.10	85.75	85.75	85.75	85.75	85.75	85.75	117.07	117.07	117.07	117.07	117.07	117.07	216.12	216.12	216.12	216.12	216.12	216.12	1.39	1.12	1.76	1.48	3.56	3.29	13.24	10.48	14.00	11.24	17.82	15.07
237.00	85.84	85.84	85.84	85.84	85.84	85.84	117.19	117.19	117.19	117.19	117.19	117.19	216.34	216.34	216.34	216.34	216.34	216.34	1.39	1.12	1.75	1.48	3.57	3.30	13.20	10.46	13.97	11.23	17.80	15.06
236.90	85.92	85.92	85.92	85.92	85.92	85.92	117.31	117.31	117.31	117.31	117.31	117.31	216.55	216.55	216.55	216.55	216.55	216.55	1.39	1.12	1.75	1.48	3.58	3.30	13.16	10.44	13.93	11.21	17.78	15.06
236.80	86.01	86.01	86.01	86.01	86.01	86.01	117.42	117.42	117.42	117.42	117.42	117.42	216.77	216.77	216.77	216.77	216.77	216.77	1.38	1.11	1.75	1.48	3.58	3.31	13.12	10.42	13.89	11.19	17.75	15.05
236.70	86.10	86.10	86.10	86.10	86.10	86.10	117.54	117.54	117.54	117.54	117.54	117.54	216.98	216.98	216.98	216.98	216.98	216.98	1.38	1.11	1.75	1.48	3.59	3.32	13.09	10.40	13.86	11.17	17.73	15.05
236.60	86.18	86.18	86.18	86.18	86.18	86.18	117.66	117.66	117.66	117.66	117.66	117.66	217.20	217.20	217.20	217.20	217.20	217.20	1.38	1.11	1.75	1.48	3.59	3.33	13.05	10.38	13.83	11.16	17.71	15.04
236.50	86.27	86.27	86.27	86.27	86.27	86.27	117.78	117.78	117.78	117.78	117.78	117.78	217.41	217.41	217.41	217.41	217.41	217.41	1.37	1.11	1.75	1.48	3.60	3.33	13.02	10.36	13.79	11.14	17.69	15.04
236.40	86.35	86.35	86.35	86.35	86.35	86.35	117.89	117.89	117.89	117.89	117.89	117.89	217.63	217.63	217.63	217.63	217.63	217.63	1.37	1.11	1.74	1.48	3.60	3.34	12.98	10.34	13.76	11.12	17.66	15.03
236.30	86.44	86.44	86.44	86.44	86.44	86.44	118.01	118.01	118.01	118.01	118.01	118.01	217.84	217.84	217.84	217.84	217.84	217.84	1.37	1.11	1.74	1.48	3.61	3.35	12.94	10.32	13.72	11.11	17.64	15.02
236.20	86.53	86.53	86.53	86.53	86.53	86.53	118.13	118.13	118.13	118.13	118.13	118.13	218.06	218.06	218.06	218.06	218.06	218.06	1.36	1.10	1.74	1.48	3.62	3.36	12.90	10.30	13.69	11.09	17.62	15.02
236.10	86.61	86.61	86.61	86.61	86.61	86.61	118.24	118.24	118.24	118.24	118.24	118.24	218.27	218.27	218.27	218.27	218.27	218.27	1.36	1.10	1.74	1.48	3.62	3.36	12.87	10.29	13.66	11.07	17.60	15.02
236.00	86.70	86.70	86.70	86.70	86.70	86.70	118.36	118.36	118.36	118.36	118.36	118.36	218.49	218.49	218.49	218.49	218.49	218.49	1.36	1.10	1.74	1.48	3.63	3.37	12.83	10.27	13.62	11.06	17.58	15.01
235.90	86.78	86.78	86.78	86.78	86.78	86.78	118.48	118.48	118.48	118.48	118.48	118.48	218.70	218.70	218.70	218.70	218.70	218.70	1.36	1.10	1.74	1.48	3.63	3.38	12.80	10.25	13.59	11.05	17.56	15.01
235.80	86.87	86.87	86.87	86.87	86.87	86.87	118.60	118.60	118.60	118.60	118.60	118.60	218.92	218.92	218.92	218.92	218.92	218.92	1.35	1.10	1.73	1.48	3.64	3.39	12.77	10.24	13.57	11.04	17.54	15.01
235.70	86.96	86.96	86.96	86.96	86.96	86.96	118.71	118.71	118.71	118.71	118.71	118.71	219.13	219.13	219.13	219.13	219.13	219.13	1.35	1.10	1.73	1.48	3.65	3.39	12.74	10.23	13.54	11.03	17.53	15.01
235.60	87.05	87.05	87.05	87.05	87.05	87.05	118.83	118.83	118.83	118.83	118.83	118.83	219.35	219.35	219.35	219.35	219.35	219.35	1.35	1.10	1.73	1.48	3.65	3.40	12.72	10.22	13.52	11.02	17.52	15.01
235.50	87.14	87.14	87.14	87.14	87.14	87.14	118.95	118.95	118.95	118.95	118.95	118.95	219.57	219.57	219.57	219.57	219.57	219.57	1.35	1.10	1.73	1.48	3.66	3.41	12.69	10.21	13.50	11.01	17.50	15.02
235.40	87.23	87.23	87.23	87.23	87.23	87.23	119.08	119.08	119.08	119.08	119.08	119.08	219.79	219.79	219.79	219.79	219.79	219.79	1.34	1.10	1.73	1.48	3.66	3.42	12.67	10.20	13.47	11.00	17.49	15.02
235.30	87.32	87.32	87.32	87.32	87.32	87.32	119.20	119.20	119.20	119.20	119.20	119.20	220.01	220.01	220.01	220.01	220.01	220.01	1.34	1.10	1.73	1.48	3.67	3.42	12.64	10.19	13.45	10.99	17.48	15.02
235.20	87.41	87.41	87.41	87.41	87.41	87.41	119.32	119.32	119.32	119.32	119.32	119.32	220.23	220.23	220.23	220.23	220.23	220.23	1.34	1.09	1.73	1.48	3.68	3.43	12.62	10.18	13.43	10.99	17.47	15.03
235.10	87.50	87.50	87.50	87.50	87.50	87.50	119.44	119.44	119.44	119.44	119.44	119.44	220.45	220.45	220.45	220.45	220.45	220.45	1.34	1.09	1.73	1.49	3.68	3.44	12.60	10.17	13.41	10.98	17.46	15.03
235.00	87.59	87.59	87.59	87.59	87.59	87.59	119.57	119.57	119.57	119.57	119.57	119.57	220.68	220.68	220.68	220.68	220.68	220.68	1.33	1.09	1.73	1.49	3.69	3.45	12.57	10.16	13.38	10.97	17.45	15.03
234.90	87.69	87.69	87.69	87.69	87.69	87.69	119.69	119.69	119.69	119.69	119.69	119.69	220.90	220.90	220.90	220.90	220.90	220.90	1.33	1.09	1.73	1.49	3.70	3.46	12.54	10.14	13.36	10.96	17.43	15.04
234.80	87.78	87.78	87.78	87.78	87.78	87.78	119.82	119.82	119.82	119.82	119.82	119.82	221.12	221.12	221.12	221.12	221.12	221.12	1.33	1.09	1.73	1.49	3.70	3.46	12.51	10.13	13.33	10.95	17.42	15.04
234.70	87.88	87.88	87.88	87.88	87.88	87.88	119.94	119.94	119.94	119.94	119.94	119.94	221.35	221.35	221.35	221.35	221.35	221.35	1.33	1.09	1.72	1.49	3.71	3.47	12.48	10.12	13.30	10.94	17.40	15.04
234.60	87.97	87.97	87.97	87.97	87.97	87.97	120.07	120.07	120.07	120.07	120.07	120.07	221.57	221.57	221.57	221.57	221.57	221.57	1.32	1.09	1.72	1.49	3.72	3.48	12.45	10.10	13.28	10.93	17.39	15.04
234.50	88.07	88.07	88.07	88.07	88.07	88.07	120.20	120.20	120.20	120.20	120.20	120.20	221.80	221.80	221.80	221.80	221.80	221.80	1.32	1.09	1.72	1.49	3.72	3.49	12.43	10.09	13.25	10.91	17.38	15.04

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
232.30	90.16	90.16	90.16	90.16	90.16	90.16	122.97	122.97	122.97	122.97	122.97	122.97	226.73	226.73	226.73	226.73	226.73	226.73	1.27	1.07	1.70	1.50	3.87	3.66	11.83	9.81	12.71	10.69	17.09	15.07
232.20	90.25	90.25	90.25	90.25	90.25	90.25	123.10	123.10	123.10	123.10	123.10	123.10	226.95	226.95	226.95	226.95	226.95	226.95	1.27	1.07	1.70	1.50	3.87	3.67	11.80	9.80	12.68	10.67	17.08	15.07
232.10	90.35	90.35	90.35	90.35	90.35	90.35	123.22	123.22	123.22	123.22	123.22	123.22	227.18	227.18	227.18	227.18	227.18	227.18	1.26	1.07	1.70	1.50	3.88	3.68	11.77	9.78	12.66	10.66	17.06	15.07
232.00	90.44	90.44	90.44	90.44	90.44	90.44	123.35	123.35	123.35	123.35	123.35	123.35	227.40	227.40	227.40	227.40	227.40	227.40	1.26	1.06	1.70	1.50	3.88	3.69	11.75	9.77	12.63	10.66	17.05	15.07
231.90	90.54	90.54	90.54	90.54	90.54	90.54	123.47	123.47	123.47	123.47	123.47	123.47	227.62	227.62	227.62	227.62	227.62	227.62	1.26	1.06	1.70	1.50	3.89	3.69	11.73	9.76	12.62	10.65	17.05	15.08
231.80	90.63	90.63	90.63	90.63	90.63	90.63	123.60	123.60	123.60	123.60	123.60	123.60	227.85	227.85	227.85	227.85	227.85	227.85	1.26	1.06	1.70	1.50	3.90	3.70	11.71	9.76	12.60	10.64	17.04	15.08
231.70	90.72	90.72	90.72	90.72	90.72	90.72	123.72	123.72	123.72	123.72	123.72	123.72	228.07	228.07	228.07	228.07	228.07	228.07	1.26	1.06	1.70	1.50	3.90	3.71	11.69	9.75	12.58	10.64	17.03	15.09
231.60	90.82	90.82	90.82	90.82	90.82	90.82	123.85	123.85	123.85	123.85	123.85	123.85	228.29	228.29	228.29	228.29	228.29	228.29	1.25	1.06	1.70	1.50	3.91	3.72	11.66	9.73	12.56	10.63	17.02	15.09
231.50	90.91	90.91	90.91	90.91	90.91	90.91	123.97	123.97	123.97	123.97	123.97	123.97	228.51	228.51	228.51	228.51	228.51	228.51	1.25	1.06	1.70	1.51	3.92	3.73	11.64	9.72	12.53	10.62	17.01	15.09
231.40	91.00	91.00	91.00	91.00	91.00	91.00	124.09	124.09	124.09	124.09	124.09	124.09	228.74	228.74	228.74	228.74	228.74	228.74	1.25	1.06	1.70	1.51	3.92	3.73	11.62	9.71	12.51	10.61	17.00	15.10
231.30	91.10	91.10	91.10	91.10	91.10	91.10	124.22	124.22	124.22	124.22	124.22	124.22	228.96	228.96	228.96	228.96	228.96	228.96	1.25	1.06	1.70	1.51	3.93	3.74	11.59	9.70	12.49	10.60	16.99	15.10
231.20	91.19	91.19	91.19	91.19	91.19	91.19	124.34	124.34	124.34	124.34	124.34	124.34	229.18	229.18	229.18	229.18	229.18	229.18	1.25	1.06	1.69	1.51	3.94	3.75	11.57	9.70	12.47	10.60	16.98	15.11
231.10	91.28	91.28	91.28	91.28	91.28	91.28	124.47	124.47	124.47	124.47	124.47	124.47	229.40	229.40	229.40	229.40	229.40	229.40	1.24	1.06	1.69	1.51	3.94	3.76	11.55	9.69	12.45	10.59	16.98	15.11
231.00	91.37	91.37	91.37	91.37	91.37	91.37	124.59	124.59	124.59	124.59	124.59	124.59	229.62	229.62	229.62	229.62	229.62	229.62	1.24	1.06	1.69	1.51	3.95	3.76	11.53	9.68	12.44	10.58	16.97	15.12
230.90	91.47	91.47	91.47	91.47	91.47	91.47	124.71	124.71	124.71	124.71	124.71	124.71	229.85	229.85	229.85	229.85	229.85	229.85	1.24	1.06	1.69	1.51	3.96	3.77	11.51	9.67	12.42	10.58	16.96	15.12
230.80	91.56	91.56	91.56	91.56	91.56	91.56	124.84	124.84	124.84	124.84	124.84	124.84	230.07	230.07	230.07	230.07	230.07	230.07	1.24	1.06	1.69	1.51	3.96	3.78	11.49	9.66	12.40	10.57	16.95	15.12
230.70	91.65	91.65	91.65	91.65	91.65	91.65	124.96	124.96	124.96	124.96	124.96	124.96	230.29	230.29	230.29	230.29	230.29	230.29	1.24	1.06	1.69	1.51	3.97	3.79	11.46	9.65	12.38	10.56	16.94	15.13
230.60	91.74	91.74	91.74	91.74	91.74	91.74	125.08	125.08	125.08	125.08	125.08	125.08	230.51	230.51	230.51	230.51	230.51	230.51	1.24	1.06	1.69	1.51	3.97	3.79	11.44	9.64	12.36	10.55	16.93	15.13
230.50	91.84	91.84	91.84	91.84	91.84	91.84	125.21	125.21	125.21	125.21	125.21	125.21	230.73	230.73	230.73	230.73	230.73	230.73	1.23	1.05	1.69	1.51	3.98	3.80	11.42	9.63	12.34	10.55	16.93	15.14
230.40	91.93	91.93	91.93	91.93	91.93	91.93	125.33	125.33	125.33	125.33	125.33	125.33	230.95	230.95	230.95	230.95	230.95	230.95	1.23	1.05	1.69	1.51	3.99	3.81	11.40	9.62	12.32	10.54	16.92	15.14
230.30	92.02	92.02	92.02	92.02	92.02	92.02	125.45	125.45	125.45	125.45	125.45	125.45	231.18	231.18	231.18	231.18	231.18	231.18	1.23	1.05	1.69	1.51	3.99	3.82	11.38	9.61	12.30	10.53	16.91	15.14
230.20	92.11	92.11	92.11	92.11	92.11	92.11	125.58	125.58	125.58	125.58	125.58	125.58	231.40	231.40	231.40	231.40	231.40	231.40	1.23	1.05	1.69	1.51	4.00	3.83	11.35	9.60	12.28	10.53	16.90	15.15
230.10	92.21	92.21	92.21	92.21	92.21	92.21	125.70	125.70	125.70	125.70	125.70	125.70	231.62	231.62	231.62	231.62	231.62	231.62	1.23	1.05	1.69	1.52	4.01	3.83	11.33	9.59	12.26	10.52	16.89	15.15
230.00	92.30	92.30	92.30	92.30	92.30	92.30	125.82	125.82	125.82	125.82	125.82	125.82	231.84	231.84	231.84	231.84	231.84	231.84	1.22	1.05	1.69	1.52	4.01	3.84	11.31	9.58	12.24	10.51	16.89	15.16
229.90	92.39	92.39	92.39	92.39	92.39	92.39	125.95	125.95	125.95	125.95	125.95	125.95	232.06	232.06	232.06	232.06	232.06	232.06	1.22	1.05	1.69	1.52	4.02	3.85	11.29	9.57	12.22	10.51	16.88	15.16
229.80	92.48	92.48	92.48	92.48	92.48	92.48	126.07	126.07	126.07	126.07	126.07	126.07	232.28	232.28	232.28	232.28	232.28	232.28	1.22	1.05	1.69	1.52	4.03	3.86	11.27	9.57	12.20	10.50	16.87	15.17
229.70	92.57	92.57	92.57	92.57	92.57	92.57	126.19	126.19	126.19	126.19	126.19	126.19	232.50	232.50	232.50	232.50	232.50	232.50	1.22	1.05	1.69	1.52	4.03	3.86	11.25	9.56	12.18	10.49	16.86	15.17
229.60	92.66	92.66	92.66	92.66	92.66	92.66	126.31	126.31	126.31	126.31	126.31	126.31	232.72	232.72	232.72	232.72	232.72	232.72	1.22	1.05	1.69	1.52	4.04	3.87	11.23	9.55	12.17	10.48	16.86	15.18
229.50	92.76	92.76	92.76	92.76	92.76	92.76	126.44	126.44	126.44	126.44	126.44	126.44	232.94	232.94	232.94	232.94	232.94	232.94	1.22	1.05	1.69	1.52	4.05	3.88	11.21	9.54	12.15	10.48	16.85	15.18
229.40	92.85	92.85	92.85	92.85	92.85	92.85	126.56	126.56	126.56	126.56	126.56	126.56	233.16	233.16	233.16	233.16	233.16	233.16	1.21	1.05	1.69	1.52	4.05	3.89	11.18	9.53	12.12	10.47	16.84	15.18
229.30	92.94	92.94	92.94	92.94	92.94	92.94	126.68	126.68	126.68	126.68	126.68	126.68	233.38	233.38	233.38	233.38	233.38	233.38	1.21	1.05	1.69	1.52	4.06	3.89	11.16	9.51	12.10	10.46	16.83	15.18
229.20	93.03	93.03	93.03	93.03	93.03	93.03	126.80	126.80	126.80	126.80	126.80	126.80	233.60	233.60	233.60	233.60	233.60	233.60	1.21	1.05	1.68	1.52	4.06	3.90	11.13	9.50	12.08	10.45	16.82	15.18
229.10	93.12	93.12	93.12	93.12	93.12	93.12	126.93	126.93	126.93	126.93	126.93	126.93	233.83	233.83	233.83	233.83	233.83	233.83	1.21	1.04	1.68	1.52	4.07	3.91	11.11	9.49	12.06	10.44	16.81	15.19
229.00	93.21	93.21	93.21	93.21	93.21	93.21	127.05	127.05	127.05	127.05	127.05	127.05	234.05	234.05	234.05	234.05	234.05	234.05	1.20	1.04	1.68	1.52	4.08	3.92	11.09	9.48	12.04	10.43	16.80	15.19
228.90	93.30	93.30	93.30	93.30	93.30	93.30	127.17	127.17	127.17	127.17	127.17	127.17	234.27	234.27	234.27	234.27	234.27	234.27	1.20	1.04	1.68	1.52	4.08	3.92	11.06	9.47	12.02	10.42	16.79	15.19
228.80	93.39	93.39	93.39	93.39	93.39	93.39	127.29	127.29	127.29	127.29	127.29	127.29	234.49	234.49	234.49	234.49	234.49	234.49	1.20	1.04	1.68	1.52	4.09	3.93	11.04	9.46	12.00	10.41	16.78	15.19
228.70	93.48	93.48	93.48	93.48	93.48	93.48	127.41	127.41	127.41	127.41	127.41	127.41	234.71	234.71	234.71	234.71	234.71	234.71	1.20	1.04	1.68	1.52	4.10	3.94	11.02	9.44	11.97	10.40	16.77	15.20
228.60	93.57	93.57	93.57	93.57	93.57	93.57	127.53	127.53	127.53	127.53	127.53	127.53	234.93	234.93	234.93	234.93	234.93	234.93	1.20	1.04	1.68	1.52	4.10	3.95	10.99	9.43	11.95	10.39	16.76	15.20
228.50	93.66	93.66	93.66	93.66	93.66	93.66	127.66	127.66	127.66	127.66	127.66	127.66	235.15	235.15	235.15	235.15	235.15	235.15	1.19	1.04	1.68	1.53	4.11	3.95	10.97	9.42	11.93	10.38	16.75	15.20
228.40	93.76	93.76	93.76	93.76	93.76	93.76	127.78	127.78	127.78	127.78	127.78	127.78	235.36	235.36	235.36	235.36	235.36	235.36	1.19	1.04	1.68	1.53	4.11	3.96	10.95	9.41	11.91	10.37	16.74	15.20
228.30	93.85	93.85	93.85	93.85	93.85	93.85	127.90	127.90	127.90	127.90	127.90	127.90	235.58	235.58	235.58	235.58	235.58	235.58	1.19	1.04	1.68	1.53	4.12	3.97	10.92	9.40	11.89	10.36	16.73	15.20
228.20	93.94	93.94	93.94	93.94	93.94	93.94	128.02	128.02	128.02	128.02	128.02	128.02	235.80	235.80	235.80	235.80	235.80	235.80	1.19	1.04	1.68	1.53	4.13	3.98	10.90	9.38	11.87	10.35	16.72	15.21
228.10	94.03	94.03	94.03	94.03	94.03	94.03	128.14	128.14	128.14	128.14	128.14	128.14	236.02	236.02	236.02	236.02	236.02	236.02	1.19	1.04	1.68	1.53	4.13	3.98	10.87	9.37	11.84	10.34	16.71	15.21
228.00	94.12	94.12	94.12	94.12	94.12	94.12	128.26	128.26	128.26	128.26	128.26	128.26	236.24	236.24	236.24	236.24	236.24	236.24	1.18	1.03	1.68	1.53	4.14	3.99	10.85	9.36	11.82	10.33	16.70	15.21
227.90	94.21	94.21	94.21	94.21	94.21	94.21	128.38	128.38	128.38	128.38	128.38	128.38	236.46	236.46	236.46	236.46	236.46	236.46	1.18	1.03	1.68	1.53	4.15	4.00	10.82	9.35	11.80	10.32	16.69	15.21
227.80	94.30	94.30	94.30	94.30	94.30	94.30	128.50	128.50	128.50	128.50	128.50	128.50	236.68	236.68	236.68	236.68	236.68	236.68	1.18	1.03	1.67	1.53	4.15	4.01	10.80	9.33	11.78	10.31	16.68	15.21
227.70	94.39	94.39	94.39	94.39	94.39	94.39	128.63	128.63	128.63	128.63	128.63	128.63	236.90	236.90	236.90	236.90	236.90	236.90	1.18	1.03	1.67	1.53	4.16	4.01	10.78	9.32	11.76	10.30	16.67	15.21
227.60	94.48	94.48	94.48	94.48	94.48	94.48	128.75	128.75	128.75	128.75	128.75	128.75	237.12	237.12	237.12	237.12	237.12	237.12	1.17	1.03	1.67	1.53	4.17	4.02	10.75	9.31	11.73	10.29	16.65	15.21
227.50	94.57	94.57	94.57	94.57	94.57	94.57	128.87	128.87	128.87	128.87	128.87	128.87	237.34	237.34	237.34	237.34	237.34	237.34	1.17	1.03	1.67	1.53	4.17	4.03	10.71	9.28	11.70	10.27	16.63	15.20
227.40	94.66	94.66	94.66	94.66	94.66	94.66	128.99	128.99	128.99	128.99	128.99	128.99	237.56	237.56	237.56	237.56	237.56	237.56	1.17	1.03	1.67	1.53	4.18	4.04	10.68	9.26	11.67	10.25	16.61	15.20
227.30	94.75	94.75	94.75	94.75	94.75	94.75	129.11	129.11	129.11	129.11	129.11	129.11	237.78	237.78	237.78	237.78	237.78	237.78	1.17	1.03	1.67	1.53	4.18	4.04	10.65	9.25	11.64	10.24	16.60	15.19
227.20	94.84	94.84	94.84	94.84	94.84	94.84	129.23	129.23	129.23	129.23	129.23	129.23	238.00	238.00	238.00	238.00	238.00	238.00	1.16	1.02	1.67	1.53	4.19	4.05	10.62	9.23	11.61	10.22	16.58	15.19
227.10	94.93	94.93	94.93	94.93	94.93	94.93	129.35	129.35	129.35	129.35	129.35	129.35	238.21	238.21	238.21	238.21	238.21	238.21	1.16	1.02	1.67	1.53	4.20	4.06	10.59	9.21	11.59	10.21	16.57	15.19
227.00	95.01	95.01	95.01	95.01	95.01	95.01	129.47	129.47	129.47	129.47	129.47	129.47	238.43	238.43	238.43	238.43	238.43	238.43	1.16	1.02	1.67	1.53	4.20	4.07	10.56	9.19	11.56	10.19	16.55	15.18
226.90	95.10	95.10	95.10	95.10	95.10	95.10	129.59	129.59	129.59	129.59	129.59	129.59	238.65	238.65	238.65	238.65	238.65	238.65	1.16	1.02	1.66	1.53	4.21	4.07	10.53	9.18	11.53	10.18	16.54	15.18
226.80	95.19	95.19	95.19	95.19	95.19	95.19	129.71	129.71	129.71	129.71	129.71	129.71	238.87	238.87	238.87	238.87	238.87	238.87	1.15	1.02	1.66	1.53	4.21	4.08	10.51	9.16	11.51	10.17	16.52	15.18
226.70	95.28	95.28	95.28	95.28	95.28	95.28	129.83	129.83	129.83	129.83	129.83	129.83	239.09	239.09	239.09	239.09	239.09	239.09	1.15	1.02	1.66	1.53	4.22	4.09	10.48	9.15	11.48	10.15	16.51	15.18
226.60	95.37	95.37	95.37	95.37	95.37	95.37	129.95	129.95	129.95	129.95	129.95	129.95	239.31	239.31	239.31	239.31	239.31	239.31	1.15	1.02	1.66	1.53	4.23	4.09	10.45	9.13	11.46	10.14	16.50	15.18
226.50	95.46	95.46	95.46	95.46	95.46	95.46	130.07	130.07	130.07	130.07	130.07	130.07	239.53	239.53	239.53	239.53	239.53	239.53	1.15	1.01	1.66	1.53	4.23	4.10	10.42	9.11	11.43	10.12	16.48	15.17
226.40	95.55	95.55	95.55	95.55	95.55	95.55	130.19	130.19	130.19	130.19	130.19	130.19	239.75	239.75	239.75	239.75	239.75	239.75	1.14	1.01	1.66	1.53	4.24	4.11	10.39	9.10	11.41	10.11	16.47	15.17
226.30	95.64	95.64	95.64	95.64	95.64	95.64	130.32	130.32	130.32	130.32	130.32	130.32	239.96	239.96	239.96	239.96	239.96	239.96	1.14	1.01	1.66	1.53	4.25	4.12	10.37	9.08	11.38	10.10	16.45	15.17
226.20	95.73	95.73	95.73	95.73	95.73	95.73	130.44	130.44	130.44	130.44	130.44	130.44	240.18	240.18	240.18	240.18	240.18	240.18	1.14	1.01	1.66	1.53	4.25	4.12	10.34	9.06	11.35	10.08	16.44	15.17
226.10	95.82	95.82	95.82	95.82	95.82	95.82	130.56	130.56	130.56	130.56	130.56	130.56	240.40	240.40	240.40	240.40	240.40	240.40	1.14	1.01	1.66	1.53	4.26	4.13	10.31	9.04	11.33	10.06	16.42	15.16
226.00	95.91	95.91	95.91	95.91	95.91	95.91	130.68	130.68	130.68	130.68	130.68	130.68	240.62	240.62	240.62	240.62	240.62	240.62	1.13	1.01	1.65	1.53	4.26	4.14	10.28	9.03	11.30	10.05	16.41	15.16
225.90	96.00	96.00	96.00	96.00	96.00	96.00	130.80	130.80	130.80	130.80	130.80	130.80	240.84	240.84	240.84	240.84	240.84	240.84	1.13	1.01	1.65	1.53	4.27	4.15	10.26	9.02	11.28	10.04	16.40	15.16
225.80	96.09	96.09	96.09	96.09	96.09	96.09	130.92	130.92	130.92	130.92	130.92	130.92	241.06	241.06	241.06	241.06	241.06	241.06	1.13	1.01	1.65	1.53	4.28	4.15	10.23	9.00	11.26	10.03	16.39	15.16
225.70	96.18	96.18	96.18	96.18	96.18	96.18	131.04	131.04	131.04	131.04	131.04	131.04	241.28	241.28	241.28	241.28	241.28	241.28	1.13	1.00	1.65	1.53	4.28	4.16	10.21	8.99	11.24	10.02	16.38	15.16
225.60	96.27	96.27	96.27	96.27	96.27	96.27	131.16	131.16	131.16	131.16	131.16	131.16	241.50	241.50	241.50	241.50	241.50	241.50	1.12	1.00	1.65	1.53	4.29	4.17	10.18	8.98	11.21	10.01	16.37	15.16
225.50	96.36	96.36	96.36	96.36	96.36	96.36	131.28	131.28	131.28	131.28	131.28	131.28	241.72	241.72	241.72	241.72	241.72	241.72	1.12	1.00	1.65	1.53	4.30	4.18	10.16	8.96	11.19	9.99	16.36	15.16
225.40	96.45	96.45	96.45	96.45	96.45	96.45	131.40	131.40	131.40	131.40	131.40	131.40	241.94	241.94	241.94	241.94	241.94	241.94	1.12	1.00	1.65	1.53	4.30	4.18	10.13	8.94	11.16	9.98	16.34	15.16
225.30	96.54	96.54	96.54	96.54	96.54	96.54	131.53	131.53	131.53	131.53	131.53	131.53	242.16	242.16	242.16	242.16	242.16	242.16	1.12	1.00	1.65	1.53	4.31	4.19	10.10	8.93	11.14	9.97	16.33	15.16
225.20	96.63	96.63	96.63	96.63	96.63	96.63	131.65	131.65	131.65	131.65	131.65	131.65	242.38	242.38	242.38	242.38	242.38	242.38	1.11	1.00	1.65	1.53	4.31	4.20	10.07	8.91	11.12	9.95	16.32	15.16
225.10	96.73	96.73	96.73	96.73	96.73	96.73	131.77	131.77	131.77	131.77	131.77	131.77	242.60	242.60	242.60	242.60	242.60	242.60	1.11	1.00	1.65	1.53	4.32	4.21	10.05	8.90	11.09	9.94	16.31	15.15
225.00	96.82	96.82	96.82	96.82	96.82	96.82	131.90	131.90	131.90	131.90	131.90	131.90	242.82	242.82	242.82	242.82	242.82	242.82	1.11	1.00	1.65	1.53	4.33	4.21	10.02	8.88	11.07	9.92	16.29	15.15
224.90	96.91	96.91	96.91	96.91	96.91	96.91	132.02	132.02	132.02	132.02	132.02	132.02	243.05	243.05	243.05	243.05	243.05	243.05	1.11	0.99	1.65	1.53	4.33	4.22	9.99	8.86	11.04	9.91	16.28	15.15
224.80	97.01	97.01	97.01	97.01	97.01	97.01	132.15	132.15	132.15	132.15	132.15	132.15	243.27	243.27	243.27	243.27	243.27	243.27	1.11	0.99	1.64	1.53	4.34	4.23	9.97	8.85	11.02	9.90	16.27	15.15
224.70	97.10	97.10	97.10	97.10	97.10	97.10	132.27	132.27	132.27	132.27	132.27	132.27	243.49	243.49	243.49	243.49	243.49	243.49	1.10	0.99	1.64	1.53	4.35	4.24	9.94	8.83	11.00	9.89	16.26	15.15
224.60	97.20	97.20	97.20	97.20	97.20	97.20	132.40	132.40	132.40	132.40	132.40	132.40	243.72	243.72	243.72	243.72	243.72	243.72	1.10	0.99	1.64	1.53	4.35	4.24	9.92	8.82	10.97	9.87	16.25	15.15
224.50	97.30	97.30	97.30	97.30	97.30	97.30	132.53	132.53	132.53	132.53	132.53	132.53	243.94	243.94	243.94	243.94	243.94	243.94	1.10	0.99	1.64	1.53	4.36	4.25	9.89	8.80	10.95	9.86	16.24	15.15
224.40	97.39	97.39	97.39	97.39	97.39	97.39	132.66	132.66	132.66	132.66	132.66	132.66	244.17	244.17	244.17	244.17	244.17	244.17	1.10	0.99	1.64	1.53	4.37	4.26	9.87	8.79	10.93	9.85	16.23	15.15
224.30	97.49	97.49	97.49	97.49	97.49	97.49	132.78	132.78	132.78	132.78	132.78	132.78	244.40	244.40	244.40	244.40	244.40	244.40	1.09	0.99	1.64	1.53	4.37	4.27	9.84	8.77	10.90	9.83	16.21	15.15

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
222.10	99.64	99.64	99.64	99.64	99.64	99.64	135.62	135.62	135.62	135.62	135.62	135.62	249.39	249.39	249.39	249.39	249.39	249.39	1.04	0.95	1.62	1.53	4.52	4.44	9.20	8.36	10.32	9.48	15.91	15.07
222.00	99.74	99.74	99.74	99.74	99.74	99.74	135.75	135.75	135.75	135.75	135.75	135.75	249.62	249.62	249.62	249.62	249.62	249.62	1.03	0.95	1.62	1.53	4.53	4.45	9.17	8.34	10.29	9.46	15.89	15.06
221.90	99.83	99.83	99.83	99.83	99.83	99.83	135.87	135.87	135.87	135.87	135.87	135.87	249.84	249.84	249.84	249.84	249.84	249.84	1.03	0.95	1.62	1.53	4.54	4.45	9.14	8.32	10.26	9.44	15.88	15.06
221.80	99.93	99.93	99.93	99.93	99.93	99.93	136.00	136.00	136.00	136.00	136.00	136.00	250.07	250.07	250.07	250.07	250.07	250.07	1.03	0.95	1.61	1.53	4.54	4.46	9.11	8.30	10.23	9.42	15.86	15.05
221.70	100.03	100.03	100.03	100.03	100.03	100.03	136.13	136.13	136.13	136.13	136.13	136.13	250.30	250.30	250.30	250.30	250.30	250.30	1.03	0.95	1.61	1.53	4.55	4.47	9.08	8.27	10.20	9.40	15.85	15.05
221.60	100.13	100.13	100.13	100.13	100.13	100.13	136.26	136.26	136.26	136.26	136.26	136.26	250.52	250.52	250.52	250.52	250.52	250.52	1.02	0.94	1.61	1.53	4.56	4.48	9.03	8.24	10.16	9.37	15.82	15.03
221.50	100.22	100.22	100.22	100.22	100.22	100.22	136.39	136.39	136.39	136.39	136.39	136.39	250.75	250.75	250.75	250.75	250.75	250.75	1.02	0.94	1.61	1.53	4.56	4.49	8.99	8.21	10.13	9.35	15.80	15.02
221.40	100.32	100.32	100.32	100.32	100.32	100.32	136.52	136.52	136.52	136.52	136.52	136.52	250.97	250.97	250.97	250.97	250.97	250.97	1.02	0.94	1.61	1.53	4.57	4.49	8.96	8.19	10.09	9.32	15.78	15.01
221.30	100.42	100.42	100.42	100.42	100.42	100.42	136.64	136.64	136.64	136.64	136.64	136.64	251.20	251.20	251.20	251.20	251.20	251.20	1.01	0.94	1.61	1.53	4.58	4.50	8.92	8.16	10.06	9.30	15.76	15.00
221.20	100.51	100.51	100.51	100.51	100.51	100.51	136.77	136.77	136.77	136.77	136.77	136.77	251.43	251.43	251.43	251.43	251.43	251.43	1.01	0.93	1.60	1.53	4.58	4.51	8.89	8.14	10.03	9.28	15.74	14.99
221.10	100.61	100.61	100.61	100.61	100.61	100.61	136.90	136.90	136.90	136.90	136.90	136.90	251.65	251.65	251.65	251.65	251.65	251.65	1.01	0.93	1.60	1.53	4.59	4.52	8.85	8.11	10.00	9.25	15.72	14.98
221.00	100.71	100.71	100.71	100.71	100.71	100.71	137.03	137.03	137.03	137.03	137.03	137.03	251.88	251.88	251.88	251.88	251.88	251.88	1.00	0.93	1.60	1.53	4.60	4.52	8.82	8.08	9.96	9.23	15.70	14.97
220.90	100.81	100.81	100.81	100.81	100.81	100.81	137.16	137.16	137.16	137.16	137.16	137.16	252.10	252.10	252.10	252.10	252.10	252.10	1.00	0.93	1.60	1.53	4.60	4.53	8.78	8.06	9.93	9.21	15.68	14.96
220.80	100.90	100.90	100.90	100.90	100.90	100.90	137.28	137.28	137.28	137.28	137.28	137.28	252.33	252.33	252.33	252.33	252.33	252.33	1.00	0.92	1.60	1.53	4.61	4.54	8.74	8.03	9.89	9.18	15.65	14.94
220.70	101.00	101.00	101.00	101.00	101.00	101.00	137.41	137.41	137.41	137.41	137.41	137.41	252.56	252.56	252.56	252.56	252.56	252.56	0.99	0.92	1.60	1.53	4.61	4.54	8.70	8.00	9.85	9.15	15.63	14.93
220.60	101.09	101.09	101.09	101.09	101.09	101.09	137.54	137.54	137.54	137.54	137.54	137.54	252.78	252.78	252.78	252.78	252.78	252.78	0.99	0.92	1.59	1.53	4.62	4.55	8.66	7.97	9.82	9.13	15.61	14.92
220.50	101.19	101.19	101.19	101.19	101.19	101.19	137.67	137.67	137.67	137.67	137.67	137.67	253.01	253.01	253.01	253.01	253.01	253.01	0.99	0.92	1.59	1.52	4.63	4.56	8.63	7.95	9.79	9.11	15.59	14.91
220.40	101.29	101.29	101.29	101.29	101.29	101.29	137.79	137.79	137.79	137.79	137.79	137.79	253.23	253.23	253.23	253.23	253.23	253.23	0.98	0.91	1.59	1.52	4.63	4.57	8.59	7.92	9.75	9.08	15.57	14.89
220.30	101.38	101.38	101.38	101.38	101.38	101.38	137.92	137.92	137.92	137.92	137.92	137.92	253.46	253.46	253.46	253.46	253.46	253.46	0.98	0.91	1.59	1.52	4.64	4.57	8.55	7.89	9.71	9.05	15.54	14.88
220.20	101.48	101.48	101.48	101.48	101.48	101.48	138.05	138.05	138.05	138.05	138.05	138.05	253.68	253.68	253.68	253.68	253.68	253.68	0.97	0.91	1.59	1.52	4.65	4.58	8.51	7.85	9.67	9.02	15.51	14.86
220.10	101.58	101.58	101.58	101.58	101.58	101.58	138.17	138.17	138.17	138.17	138.17	138.17	253.91	253.91	253.91	253.91	253.91	253.91	0.97	0.91	1.58	1.52	4.65	4.59	8.46	7.81	9.63	8.99	15.48	14.84
220.00	101.67	101.67	101.67	101.67	101.67	101.67	138.30	138.30	138.30	138.30	138.30	138.30	254.13	254.13	254.13	254.13	254.13	254.13	0.96	0.90	1.58	1.52	4.66	4.60	8.40	7.77	9.58	8.95	15.45	14.81
219.90	101.77	101.77	101.77	101.77	101.77	101.77	138.43	138.43	138.43	138.43	138.43	138.43	254.36	254.36	254.36	254.36	254.36	254.36	0.96	0.90	1.58	1.52	4.66	4.60	8.35	7.73	9.53	8.91	15.41	14.79
219.80	101.86	101.86	101.86	101.86	101.86	101.86	138.56	138.56	138.56	138.56	138.56	138.56	254.58	254.58	254.58	254.58	254.58	254.58	0.95	0.89	1.57	1.51	4.67	4.61	8.30	7.69	9.48	8.87	15.37	14.76
219.70	101.96	101.96	101.96	101.96	101.96	101.96	138.68	138.68	138.68	138.68	138.68	138.68	254.81	254.81	254.81	254.81	254.81	254.81	0.95	0.89	1.57	1.51	4.67	4.61	8.23	7.63	9.41	8.81	15.32	14.72
219.60	102.06	102.06	102.06	102.06	102.06	102.06	138.81	138.81	138.81	138.81	138.81	138.81	255.03	255.03	255.03	255.03	255.03	255.03	0.94	0.88	1.56	1.51	4.68	4.62	8.15	7.56	9.33	8.75	15.26	14.67
219.50	102.15	102.15	102.15	102.15	102.15	102.15	138.94	138.94	138.94	138.94	138.94	138.94	255.26	255.26	255.26	255.26	255.26	255.26	0.93	0.88	1.56	1.50	4.68	4.63	8.07	7.50	9.26	8.69	15.20	14.63
219.40	102.25	102.25	102.25	102.25	102.25	102.25	139.06	139.06	139.06	139.06	139.06	139.06	255.48	255.48	255.48	255.48	255.48	255.48	0.92	0.87	1.55	1.50	4.69	4.63	7.97	7.41	9.16	8.60	15.12	14.56
219.30	102.34	102.34	102.34	102.34	102.34	102.34	139.19	139.19	139.19	139.19	139.19	139.19	255.71	255.71	255.71	255.71	255.71	255.71	0.91	0.85	1.54	1.48	4.69	4.63	7.81	7.27	9.01	8.46	14.98	14.44
219.20	102.44	102.44	102.44	102.44	102.44	102.44	139.31	139.31	139.31	139.31	139.31	139.31	255.93	255.93	255.93	255.93	255.93	255.93	0.88	0.83	1.51	1.46	4.68	4.63	7.53	7.01	8.73	8.21	14.72	14.21
219.10	102.53	102.53	102.53	102.53	102.53	102.53	139.44	139.44	139.44	139.44	139.44	139.44	256.16	256.16	256.16	256.16	256.16	256.16	0.86	0.81	1.50	1.45	4.68	4.63	7.34	6.84	8.54	8.05	14.56	14.06
219.00	102.63	102.63	102.63	102.63	102.63	102.63	139.57	139.57	139.57	139.57	139.57	139.57	256.38	256.38	256.38	256.38	256.38	256.38	0.86	0.81	1.49	1.45	4.69	4.64	7.26	6.77	8.47	7.98	14.50	14.01
218.90	102.72	102.72	102.72	102.72	102.72	102.72	139.69	139.69	139.69	139.69	139.69	139.69	256.61	256.61	256.61	256.61	256.61	256.61	0.85	0.80	1.49	1.44	4.69	4.65	7.21	6.73	8.42	7.94	14.46	13.99
218.80	102.82	102.82	102.82	102.82	102.82	102.82	139.82	139.82	139.82	139.82	139.82	139.82	256.83	256.83	256.83	256.83	256.83	256.83	0.85	0.80	1.49	1.44	4.70	4.65	7.16	6.69	8.37	7.90	14.43	13.96
218.70	102.91	102.91	102.91	102.91	102.91	102.91	139.95	139.95	139.95	139.95	139.95	139.95	257.05	257.05	257.05	257.05	257.05	257.05	0.84	0.80	1.49	1.44	4.70	4.66	7.12	6.66	8.33	7.87	14.41	13.94
218.60	103.01	103.01	103.01	103.01	103.01	103.01	140.07	140.07	140.07	140.07	140.07	140.07	257.28	257.28	257.28	257.28	257.28	257.28	0.84	0.79	1.48	1.44	4.71	4.66	7.07	6.62	8.29	7.83	14.37	13.92
218.50	103.10	103.10	103.10	103.10	103.10	103.10	140.20	140.20	140.20	140.20	140.20	140.20	257.50	257.50	257.50	257.50	257.50	257.50	0.83	0.79	1.48	1.44	4.71	4.67	7.02	6.57	8.24	7.79	14.34	13.89
218.40	103.20	103.20	103.20	103.20	103.20	103.20	140.32	140.32	140.32	140.32	140.32	140.32	257.73	257.73	257.73	257.73	257.73	257.73	0.83	0.78	1.48	1.43	4.72	4.68	6.97	6.53	8.19	7.75	14.30	13.87
218.30	103.29	103.29	103.29	103.29	103.29	103.29	140.45	140.45	140.45	140.45	140.45	140.45	257.95	257.95	257.95	257.95	257.95	257.95	0.82	0.78	1.47	1.43	4.73	4.68	6.91	6.49	8.14	7.71	14.27	13.84
218.20	103.39	103.39	103.39	103.39	103.39	103.39	140.57	140.57	140.57	140.57	140.57	140.57	258.17	258.17	258.17	258.17	258.17	258.17	0.82	0.78	1.47	1.43	4.73	4.69	6.87	6.45	8.10	7.68	14.24	13.82
218.10	103.48	103.48	103.48	103.48	103.48	103.48	140.70	140.70	140.70	140.70	140.70	140.70	258.40	258.40	258.40	258.40	258.40	258.40	0.82	0.77	1.47	1.43	4.74	4.70	6.83	6.42	8.06	7.65	14.21	13.80
218.00	103.57	103.57	103.57	103.57	103.57	103.57	140.82	140.82	140.82	140.82	140.82	140.82	258.62	258.62	258.62	258.62	258.62	258.62	0.81	0.77	1.47	1.43	4.74	4.70	6.78	6.38	8.02	7.61	14.18	13.78
217.90	103.67	103.67	103.67	103.67	103.67	103.67	140.95	140.95	140.95	140.95	140.95	140.95	258.84	258.84	258.84	258.84	258.84	258.84	0.81	0.77	1.46	1.42	4.75	4.71	6.74	6.34	7.97	7.58	14.15	13.76
217.80	103.76	103.76	103.76	103.76	103.76	103.76	141.07	141.07	141.07	141.07	141.07	141.07	259.07	259.07	259.07	259.07	259.07	259.07	0.80	0.76	1.46	1.42	4.75	4.71	6.69	6.31	7.93	7.54	14.12	13.73
217.70	103.86	103.86	103.86	103.86	103.86	103.86	141.20	141.20	141.20	141.20	141.20	141.20	259.29	259.29	259.29	259.29	259.29	259.29	0.80	0.76	1.46	1.42	4.76	4.72	6.65	6.27	7.89	7.51	14.09	13.71
217.60	103.95	103.95	103.95	103.95	103.95	103.95	141.33	141.33	141.33	141.33	141.33	141.33	259.51	259.51	259.51	259.51	259.51	259.51	0.79	0.76	1.46	1.42	4.76	4.73	6.60	6.23	7.85	7.47	14.06	13.69
217.50	104.04	104.04	104.04	104.04	104.04	104.04	141.45	141.45	141.45	141.45	141.45	141.45	259.74	259.74	259.74	259.74	259.74	259.74	0.79	0.75	1.45	1.42	4.77	4.73	6.56	6.19	7.80	7.44	14.03	13.67
217.40	104.14	104.14	104.14	104.14	104.14	104.14	141.58	141.58	141.58	141.58	141.58	141.58	259.96	259.96	259.96	259.96	259.96	259.96	0.79	0.75	1.45	1.41	4.77	4.74	6.50	6.15	7.75	7.40	14.00	13.64
217.30	104.23	104.23	104.23	104.23	104.23	104.23	141.70	141.70	141.70	141.70	141.70	141.70	260.18	260.18	260.18	260.18	260.18	260.18	0.78	0.75	1.45	1.41	4.78	4.74	6.45	6.10	7.70	7.35	13.96	13.61
217.20	104.33	104.33	104.33	104.33	104.33	104.33	141.82	141.82	141.82	141.82	141.82	141.82	260.41	260.41	260.41	260.41	260.41	260.41	0.77	0.74	1.44	1.41	4.78	4.75	6.38	6.04	7.63	7.29	13.90	13.57
217.10	104.42	104.42	104.42	104.42	104.42	104.42	141.95	141.95	141.95	141.95	141.95	141.95	260.63	260.63	260.63	260.63	260.63	260.63	0.77	0.73	1.44	1.40	4.79	4.75	6.29	5.96	7.55	7.22	13.84	13.50
217.00	104.51	104.51	104.51	104.51	104.51	104.51	142.07	142.07	142.07	142.07	142.07	142.07	260.85	260.85	260.85	260.85	260.85	260.85	0.75	0.72	1.42	1.39	4.79	4.75	6.15	5.83	7.41	7.10	13.71	13.40
216.90	104.61	104.61	104.61	104.61	104.61	104.61	142.20	142.20	142.20	142.20	142.20	142.20	261.08	261.08	261.08	261.08	261.08	261.08	0.74	0.71	1.41	1.38	4.79	4.76	6.03	5.72	7.29	6.99	13.61	13.30
216.80	104.70	104.70	104.70	104.70	104.70	104.70	142.32	142.32	142.32	142.32	142.32	142.32	261.30	261.30	261.30	261.30	261.30	261.30	0.73	0.70	1.41	1.38	4.79	4.76	5.94	5.64	7.21	6.91	13.54	13.24
216.70	104.79	104.79	104.79	104.79	104.79	104.79	142.45	142.45	142.45	142.45	142.45	142.45	261.52	261.52	261.52	261.52	261.52	261.52	0.72	0.69	1.40	1.37	4.79	4.76	5.85	5.57	7.12	6.84	13.47	13.18
216.60	104.89	104.89	104.89	104.89	104.89	104.89	142.57	142.57	142.57	142.57	142.57	142.57	261.74	261.74	261.74	261.74	261.74	261.74	0.72	0.69	1.40	1.37	4.80	4.77	5.77	5.49	7.04	6.76	13.41	13.13
216.50	104.98	104.98	104.98	104.98	104.98	104.98	142.70	142.70	142.70	142.70	142.70	142.70	261.97	261.97	261.97	261.97	261.97	261.97	0.71	0.68	1.39	1.36	4.80	4.77	5.70	5.43	6.98	6.70	13.35	13.08
216.40	105.07	105.07	105.07	105.07	105.07	105.07	142.82	142.82	142.82	142.82	142.82	142.82	262.19	262.19	262.19	262.19	262.19	262.19	0.70	0.67	1.38	1.36	4.80	4.78	5.62	5.36	6.90	6.64	13.29	13.02
216.30	105.17	105.17	105.17	105.17	105.17	105.17	142.95	142.95	142.95	142.95	142.95	142.95	262.41	262.41	262.41	262.41	262.41	262.41	0.69	0.67	1.38	1.35	4.81	4.78	5.54	5.28	6.82	6.56	13.22	12.97
216.20	105.26	105.26	105.26	105.26	105.26	105.26	143.07	143.07	143.07	143.07	143.07	143.07	262.63	262.63	262.63	262.63	262.63	262.63	0.69	0.66	1.37	1.35	4.81	4.78	5.45	5.21	6.74	6.49	13.15	12.91
216.10	105.35	105.35	105.35	105.35	105.35	105.35	143.19	143.19	143.19	143.19	143.19	143.19	262.86	262.86	262.86	262.86	262.86	262.86	0.68	0.65	1.37	1.34	4.81	4.79	5.36	5.12	6.65	6.41	13.08	12.84
216.00	105.45	105.45	105.45	105.45	105.45	105.45	143.32	143.32	143.32	143.32	143.32	143.32	263.08	263.08	263.08	263.08	263.08	263.08	0.67	0.64	1.36	1.33	4.81	4.79	5.25	5.02	6.54	6.31	12.99	12.76
215.90	105.54	105.54	105.54	105.54	105.54	105.54	143.44	143.44	143.44	143.44	143.44	143.44	263.30	263.30	263.30	263.30	263.30	263.30	0.65	0.63	1.35	1.32	4.81	4.79	5.12	4.90	6.41	6.19	12.87	12.65
215.80	105.63	105.63	105.63	105.63	105.63	105.63	143.57	143.57	143.57	143.57	143.57	143.57	263.52	263.52	263.52	263.52	263.52	263.52	0.64	0.62	1.33	1.31	4.81	4.79	4.97	4.76	6.27	6.06	12.74	12.53
215.70	105.73	105.73	105.73	105.73	105.73	105.73	143.69	143.69	143.69	143.69	143.69	143.69	263.75	263.75	263.75	263.75	263.75	263.75	0.62	0.60	1.32	1.30	4.81	4.79	4.81	4.61	6.10	5.91	12.60	12.40
215.60	105.82	105.82	105.82	105.82	105.82	105.82	143.82	143.82	143.82	143.82	143.82	143.82	263.97	263.97	263.97	263.97	263.97	263.97	0.60	0.58	1.30	1.28	4.80	4.78	4.58	4.40	5.88	5.70	12.39	12.21
215.50	105.91	105.91	105.91	105.91	105.91	105.91	143.94	143.94	143.94	143.94	143.94	143.94	264.19	264.19	264.19	264.19	264.19	264.19	0.58	0.56	1.28	1.26	4.79	4.77	4.33	4.15	5.63	5.46	12.16	11.99
215.40	106.01	106.01	106.01	106.01	106.01	106.01	144.07	144.07	144.07	144.07	144.07	144.07	264.41	264.41	264.41	264.41	264.41	264.41	0.55	0.54	1.26	1.24	4.78	4.77	4.11	3.95	5.42	5.26	11.96	11.80
215.30	106.10	106.10	106.10	106.10	106.10	106.10	144.19	144.19	144.19	144.19	144.19	144.19	264.64	264.64	264.64	264.64	264.64	264.64	0.53	0.52	1.24	1.23	4.77	4.76	3.90	3.76	5.21	5.07	11.77	11.63
215.20	106.19	106.19	106.19	106.19	106.19	106.19	144.31	144.31	144.31	144.31	144.31	144.31	264.86	264.86	264.86	264.86	264.86	264.86	0.51	0.50	1.22	1.21	4.77	4.75	3.68	3.54	4.99	4.86	11.57	11.43
215.10	106.29	106.29	106.29	106.29	106.29	106.29	144.44	144.44	144.44	144.44	144.44	144.44	265.08	265.08	265.08	265.08	265.08	265.08	0.50	0.48	1.21	1.19	4.76	4.75	3.51	3.38	4.82	4.70	11.41	11.29
215.00	106.38	106.38	106.38	106.38	106.38	106.38	144.56	144.56	144.56	144.56	144.56	144.56	265.30	265.30	265.30	265.30	265.30	265.30	0.48	0.47	1.20	1.18	4.76	4.75	3.39	3.27	4.71	4.59	11.31	11.19
214.90	106.47	106.47	106.47	106.47	106.47	106.47	144.69	144.69	144.69	144.69	144.69	144.69	265.53	265.53	265.53	265.53	265.53	265.53	0.47	0.46	1.19	1.18	4.76	4.75	3.29	3.18	4.62	4.50	11.23	11.12
214.80	106.57	106.57	106.57	106.57	106.57	106.57	144.81	144.81	144.81	144.81	144.81	144.81	265.75	265.75	265.75	265.75	265.75	265.75	0.46	0.45	1.18	1.17	4.76	4.75	3.19	3.08	4.52	4.41	11.15	11.04
214.70	106.66	106.66	106.66	106.66	106.66	106.66	144.94	144.94	144.94	144.94	144.94	144.94	265.97	265.97	265.97	265.97	265.97	265.97	0.45	0.44	1.17	1.16	4.76	4.75	3.07	2.97	4.40	4.30	11.05	10.95
214.60	106.75	106.75	106.75	106.75	106.75	106.75	145.06	145.06	145.06	145.06	145.06	145.06	266.19	266.19	266.19	266.19	266.19	266.19	0.44	0.43	1.16	1.15	4.76	4.75	2.96	2.86	4.29	4.19	10.95	10.85
214.50	106.85	106.85	106.85	106.85	106.85	106.85	145.18	145.18	145.18	145.18	145.18	145.18	266.42	266.42	266.42	266.42	266.42	266.42	0.43	0.43	1.16	1.15	4.76	4.75	2.88	2.79	4.21	4.12	10.88	10.79
214.40	106.94	106.94	106.94	106.94	106.94	106.94	145.31	145.31	145.31	145.31	145.31	145.31	266.64	266.64	266.64	266.64	266.64	266.64	0.43	0.42	1.15	1.14	4.76	4.75	2.80	2.71	4.13	4.05	10.82	10.73
214.30	107.03	107.03	107.03	107.03	107.03	107.03	145.43	145.43	145.43	145.43	145.43	145.43	266.86	266.86	266.86	266.86	266.86	266.86	0.42	0.41	1.14	1.13	4.76	4.75	2.69	2.61	4.03	3.95	10.73	10.65
214.20	107.13	107.13	107.13	107.13	107.13	107.13	145.56	145.56	145.56	145.56	145.56	145.56	267.08	267.08	267.08	267.08	267.08	267.08	0.40	0.40	1.13	1.12	4.76	4.75	2.57	2.50	3.91	3.84	10.62	10.55
214.10	107.22	107.22	107.22	107.22	107.22	107.22	145.68	145.68	145.68	145.68	145.68	145.68	267.31	267.31	267.31	267.31	267.31	267.31	0.40	0.39	1.13	1.12	4.76	4.75	2.51	2.44	3.86	3.79	10.58	10.51

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Pit Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)	GW Inflow (m^3/day)
211.90	109.27	109.27	109.27	109.27	109.27	109.27	148.42	148.42	148.42	148.42	148.42	148.42	272.20	272.20	272.20	272.20	272.20	272.20	0.26	0.26	1.02	1.02	4.81	4.80	1.05	1.04	2.45	2.44	9.44	9.43
211.80	109.36	109.36	109.36	109.36	109.36	109.36	148.54	148.54	148.54	148.54	148.54	148.54	272.42	272.42	272.42	272.42	272.42	272.42	0.25	0.25	1.01	1.01	4.81	4.81	0.97	0.96	2.37	2.36	9.37	9.36
211.70	109.46	109.46	109.46	109.46	109.46	109.46	148.66	148.66	148.66	148.66	148.66	148.66	272.64	272.64	272.64	272.64	272.64	272.64	0.24	0.24	1.00	1.00	4.81	4.81	0.89	0.89	2.30	2.29	9.31	9.30
211.60	109.55	109.55	109.55	109.55	109.55	109.55	148.79	148.79	148.79	148.79	148.79	148.79	272.87	272.87	272.87	272.87	272.87	272.87	0.24	0.24	1.00	1.00	4.81	4.81	0.81	0.81	2.22	2.21	9.25	9.24
211.50	109.64	109.64	109.64	109.64	109.64	109.64	148.91	148.91	148.91	148.91	148.91	148.91	273.09	273.09	273.09	273.09	273.09	273.09	0.23	0.23	0.99	0.99	4.81	4.81	0.74	0.73	2.14	2.14	9.18	9.18
211.40	109.74	109.74	109.74	109.74	109.74	109.74	149.03	149.03	149.03	149.03	149.03	149.03	273.31	273.31	273.31	273.31	273.31	273.31	0.22	0.22	0.99	0.99	4.81	4.81	0.66	0.65	2.07	2.06	9.12	9.11
211.30	109.83	109.83	109.83	109.83	109.83	109.83	149.16	149.16	149.16	149.16	149.16	149.16	273.53	273.53	273.53	273.53	273.53	273.53	0.21	0.21	0.98	0.98	4.81	4.81	0.58	0.58	1.99	1.99	9.05	9.05
211.20	109.92	109.92	109.92	109.92	109.92	109.92	149.28	149.28	149.28	149.28	149.28	149.28	273.75	273.75	273.75	273.75	273.75	273.75	0.21	0.21	0.97	0.97	4.81	4.81	0.50	0.50	1.91	1.91	8.99	8.98
211.10	110.01	110.01	110.01	110.01	110.01	110.01	149.41	149.41	149.41	149.41	149.41	149.41	273.97	273.97	273.97	273.97	273.97	273.97	0.20	0.20	0.97	0.97	4.81	4.81	0.41	0.41	1.83	1.83	8.91	8.91
211.04	110.11	110.11	110.11	110.11	110.11	110.11	149.53	149.53	149.53	149.53	149.53	149.53	274.16	274.16	274.16	274.16	274.16	274.16	0.19	0.19	0.96	0.96	4.81	4.81	0.35	0.35	1.77	1.77	8.87	8.87
210.04	110.00	110.00	110.00	110.00	110.00	110.00	149.73	149.73	149.73	149.73	149.73	149.73	275.34	275.34	275.34	275.34	275.34	275.34	0.19	0.19	0.96	0.96	4.80	4.80	0.36	0.36	1.78	1.78	8.90	8.90

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Dewatering WBM South Pit Inflow (m³/day)	Recovery WBM South Pit Inflow (m³/day)
334.30	518.99	15.03	519.11	15.14	519.66	15.70	52.99	2.59
334.20	518.65	15.43	518.76	15.54	519.33	16.11	52.96	2.63
334.10	518.31	15.82	518.43	15.94	519.01	16.53	52.92	2.68
334.00	517.95	16.22	518.07	16.34	518.67	16.94	52.89	2.72
333.90	517.61	16.61	517.73	16.74	518.35	17.35	52.86	2.76
333.80	517.29	17.01	517.41	17.13	518.04	17.76	52.83	2.80
333.70	516.96	17.40	517.09	17.53	517.73	18.18	52.80	2.84
333.60	516.63	17.80	516.76	17.93	517.42	18.59	52.77	2.89
333.50	516.30	18.19	516.44	18.32	517.11	19.00	52.74	2.93
333.40	515.96	18.58	516.10	18.72	516.79	19.41	52.71	2.97
333.30	515.62	18.97	515.76	19.11	516.46	19.82	52.68	3.01
333.20	515.28	19.36	515.42	19.51	516.14	20.23	52.64	3.05
333.10	514.93	19.75	515.07	19.90	515.81	20.63	52.61	3.09
333.00	514.58	20.14	514.73	20.29	515.48	21.04	52.58	3.14
332.90	514.23	20.53	514.38	20.68	515.14	21.45	52.55	3.18
332.80	513.89	20.92	514.05	21.08	514.82	21.85	52.52	3.22
332.70	513.56	21.31	513.72	21.47	514.51	22.26	52.49	3.26
332.60	513.22	21.70	513.38	21.86	514.19	22.67	52.45	3.30
332.50	512.88	22.08	513.04	22.25	513.86	23.07	52.42	3.34
332.40	512.54	22.47	512.71	22.64	513.55	23.47	52.39	3.38
332.30	512.20	22.86	512.37	23.03	513.22	23.88	52.36	3.43
332.20	511.85	23.24	512.03	23.41	512.89	24.28	52.33	3.47
332.10	511.50	23.63	511.68	23.80	512.56	24.68	52.30	3.51
332.00	511.14	24.01	511.32	24.19	512.21	25.08	52.26	3.55
331.90	510.78	24.39	510.96	24.57	511.87	25.49	52.23	3.59
331.80	510.42	24.77	510.60	24.96	511.53	25.88	52.20	3.63
331.70	510.04	25.16	510.23	25.34	511.17	26.28	52.16	3.67
331.60	509.65	25.54	509.84	25.73	510.80	26.68	52.13	3.71
331.50	509.24	25.91	509.43	26.11	510.40	27.08	52.09	3.75
331.40	508.82	26.29	509.01	26.49	510.00	27.47	52.05	3.80
331.30	508.39	26.67	508.59	26.87	509.59	27.86	52.01	3.84
331.20	507.98	27.04	508.18	27.24	509.19	28.26	51.97	3.88
331.10	507.55	27.42	507.76	27.62	508.79	28.65	51.93	3.92
331.00	507.14	27.79	507.35	28.00	508.39	29.04	51.89	3.96
330.90	506.71	28.16	506.93	28.38	507.98	29.43	51.85	4.00
330.80	506.25	28.53	506.46	28.75	507.54	29.82	51.81	4.04
330.70	505.70	28.90	505.92	29.12	507.00	30.20	51.76	4.08
330.60	505.16	29.26	505.38	29.48	506.48	30.58	51.71	4.12
330.50	504.65	29.63	504.88	29.85	505.99	30.97	51.66	4.16
330.40	504.15	29.99	504.37	30.22	505.50	31.35	51.62	4.20
330.30	503.57	30.35	503.80	30.58	504.94	31.73	51.56	4.24
330.20	503.05	30.72	503.28	30.95	504.44	32.10	51.52	4.28
330.10	502.57	31.08	502.80	31.32	503.97	32.49	51.47	4.32
330.00	502.14	31.45	502.37	31.68	503.56	32.87	51.43	4.36
329.90	501.71	31.81	501.95	32.05	503.15	33.25	51.39	4.40
329.80	501.30	32.18	501.54	32.42	502.76	33.64	51.35	4.44
329.70	500.90	32.55	501.14	32.79	502.37	34.02	51.32	4.48
329.60	500.49	32.91	500.74	33.16	501.98	34.40	51.28	4.52
329.50	500.08	33.28	500.33	33.53	501.59	34.78	51.24	4.56
329.40	499.67	33.64	499.92	33.89	501.19	35.17	51.20	4.60
329.30	499.26	34.00	499.51	34.26	500.80	35.55	51.17	4.64
329.20	498.86	34.37	499.12	34.63	500.42	35.93	51.13	4.68
329.10	498.46	34.73	498.72	34.99	500.04	36.31	51.09	4.72
329.00	498.06	35.09	498.33	35.36	499.66	36.69	51.05	4.76
328.90	497.66	35.45	497.93	35.72	499.27	37.06	51.02	4.80
328.80	497.27	35.81	497.55	36.09	498.90	37.44	50.98	4.84
328.70	496.90	36.18	497.17	36.45	498.55	37.82	50.95	4.88
328.60	496.54	36.54	496.81	36.82	498.20	38.20	50.91	4.91
328.50	496.19	36.90	496.47	37.18	497.87	38.58	50.88	4.95
328.40	495.85	37.26	496.13	37.55	497.54	38.96	50.85	4.99
328.30	495.51	37.63	495.80	37.91	497.23	39.34	50.82	5.03
328.20	495.18	37.99	495.47	38.28	496.91	39.72	50.79	5.07
328.10	494.85	38.35	495.15	38.64	496.60	40.10	50.76	5.11
328.00	494.53	38.71	494.83	39.01	496.30	40.48	50.73	5.15
327.90	494.22	39.08	494.52	39.37	496.00	40.86	50.70	5.19
327.80	493.91	39.44	494.21	39.74	495.71	41.24	50.67	5.22
327.70	493.61	39.80	493.91	40.10	495.43	41.62	50.64	5.26
327.60	493.31	40.16	493.62	40.47	495.15	42.00	50.62	5.30
327.50	493.02	40.52	493.33	40.83	494.87	42.38	50.59	5.34
327.40	492.72	40.89	493.04	41.20	494.60	42.76	50.56	5.38
327.30	492.44	41.25	492.75	41.56	494.33	43.14	50.53	5.42
327.20	492.15	41.61	492.47	41.93	494.06	43.52	50.51	5.45
327.10	491.87	41.97	492.19	42.29	493.79	43.89	50.48	5.49
327.00	491.58	42.33	491.91	42.65	493.52	44.27	50.46	5.53
326.90	491.30	42.69	491.63	43.02	493.26	44.65	50.43	5.57
326.80	491.02	43.05	491.35	43.38	492.99	45.03	50.40	5.61
326.70	490.74	43.41	491.07	43.74	492.73	45.40	50.38	5.64
326.60	490.46	43.77	490.80	44.11	492.47	45.78	50.35	5.68
326.50	490.19	44.13	490.53	44.47	492.22	46.16	50.33	5.72
326.40	489.91	44.49	490.25	44.83	491.96	46.53	50.30	5.76
326.30	489.64	44.85	489.99	45.19	491.70	46.91	50.28	5.80
326.20	489.37	45.21	489.72	45.55	491.46	47.29	50.25	5.83
326.10	489.10	45.56	489.45	45.91	491.20	47.66	50.23	5.87
326.00	488.83	45.92	489.18	46.27	490.94	48.04	50.20	5.91
325.90	488.56	46.28	488.92	46.63	490.69	48.41	50.18	5.95
325.80	488.29	46.63	488.65	46.99	490.44	48.78	50.15	5.98
325.70	488.01	46.99	488.37	47.35	490.18	49.16	50.12	6.02
325.60	487.74	47.34	488.10	47.71	489.92	49.53	50.10	6.06
325.50	487.47	47.70	487.83	48.07	489.67	49.90	50.07	6.10
325.40	487.19	48.05	487.56	48.42	489.41	50.27	50.05	6.13
325.30	486.91	48.41	487.28	48.78	489.15	50.65	50.02	6.17
325.20	486.63	48.76	487.01	49.14	488.89	51.02	50.00	6.21
325.10	486.35	49.11	486.73	49.49	488.63	51.39	49.97	6.25
325.00	486.07	49.47	486.45	49.85	488.36	51.76	49.94	6.28
324.90	485.79	49.82	486.18	50.20	488.10	52.13	49.92	6.32
324.80	485.51	50.17	485.90	50.56	487.83	52.49	49.89	6.36
324.70	485.22	50.52	485.61	50.91	487.57	52.86	49.87	6.40
324.60	484.94	50.87	485.33	51.26	487.30	53.23	49.84	6.43
324.50	484.65	51.22	485.04	51.61	487.02	53.59	49.81	6.47
324.40	484.35	51.57	484.75	51.96	486.74	53.96	49.79	6.51
324.30	484.05	51.91	484.45	52.31	486.46	54.32	49.76	6.54
324.20	483.74	52.26	484.14	52.66	486.16	54.69	49.73	6.58

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Dewatering WBM South Pit Inflow (m³/day)	Recovery WBM South Pit Inflow (m³/day)
324.10	483.42	52.60	483.83	53.01	485.87	55.05	49.70	6.62
324.00	483.11	52.95	483.52	53.36	485.57	55.41	49.67	6.65
323.90	482.79	53.29	483.20	53.70	485.27	55.77	49.64	6.69
323.80	482.47	53.63	482.89	54.05	484.97	56.13	49.61	6.73
323.70	482.15	53.97	482.57	54.39	484.67	56.49	49.58	6.76
323.60	481.82	54.31	482.24	54.74	484.35	56.85	49.55	6.80
323.50	481.49	54.65	481.92	55.08	484.04	57.20	49.52	6.84
323.40	481.16	54.99	481.59	55.42	483.72	57.56	49.49	6.87
323.30	480.82	55.33	481.26	55.76	483.41	57.91	49.46	6.91
323.20	480.49	55.67	480.92	56.10	483.09	58.27	49.43	6.94
323.10	480.14	56.00	480.57	56.44	482.76	58.62	49.39	6.98
323.00	479.79	56.34	480.23	56.78	482.42	58.97	49.36	7.02
322.90	479.44	56.67	479.88	57.11	482.09	59.32	49.33	7.05
322.80	479.07	57.00	479.51	57.45	481.73	59.67	49.29	7.09
322.70	478.68	57.33	479.12	57.78	481.36	60.02	49.26	7.12
322.60	478.28	57.66	478.73	58.11	480.98	60.36	49.22	7.16
322.50	477.88	57.98	478.33	58.44	480.60	60.70	49.18	7.20
322.40	477.49	58.31	477.95	58.77	480.23	61.04	49.15	7.23
322.30	477.10	58.64	477.56	59.09	479.86	61.39	49.11	7.27
322.20	476.72	58.96	477.19	59.42	479.49	61.73	49.08	7.30
322.10	476.34	59.29	476.81	59.75	479.13	62.07	49.04	7.34
322.00	475.96	59.61	476.42	60.08	478.76	62.41	49.01	7.37
321.90	475.56	59.94	476.03	60.40	478.37	62.75	48.97	7.41
321.80	475.14	60.25	475.61	60.73	477.97	63.09	48.93	7.44
321.70	474.71	60.57	475.18	61.05	477.56	63.42	48.89	7.48
321.60	474.25	60.88	474.73	61.36	477.12	63.75	48.85	7.51
321.50	473.77	61.19	474.25	61.67	476.65	64.08	48.80	7.55
321.40	473.26	61.50	473.74	61.98	476.16	64.40	48.76	7.58
321.30	472.71	61.80	473.20	62.28	475.63	64.71	48.71	7.61
321.20	472.12	62.09	472.61	62.58	475.05	65.02	48.65	7.65
321.10	471.45	62.37	471.94	62.86	474.39	65.31	48.59	7.68
321.00	470.56	62.62	471.05	63.11	473.51	65.58	48.51	7.71
320.90	469.23	62.81	469.72	63.30	472.19	65.78	48.38	7.74
320.80	468.09	63.02	468.59	63.52	471.08	66.01	48.28	7.77
320.70	466.66	63.20	467.16	63.70	469.65	66.19	48.14	7.80
320.60	465.41	63.39	465.91	63.89	468.41	66.39	48.03	7.83
320.50	464.14	63.58	464.64	64.08	467.15	66.60	47.91	7.85
320.40	462.54	63.73	463.04	64.23	465.56	66.75	47.76	7.88
320.30	460.73	63.84	461.23	64.34	463.76	66.87	47.59	7.90
320.20	458.67	63.91	459.18	64.42	461.71	66.95	47.40	7.93
320.10	457.00	64.04	457.51	64.54	460.04	67.08	47.25	7.95
320.00	455.32	64.16	455.82	64.66	458.37	67.21	47.09	7.97
319.90	453.91	64.31	454.42	64.82	456.97	67.37	46.96	8.00
319.80	452.46	64.46	452.97	64.97	455.53	67.53	46.82	8.02
319.70	451.21	64.64	451.73	65.15	454.30	67.72	46.71	8.05
319.60	450.21	64.85	450.73	65.36	453.30	67.94	46.62	8.08
319.50	449.38	65.08	449.90	65.60	452.49	68.19	46.54	8.11
319.40	448.64	65.32	449.16	65.84	451.76	68.44	46.47	8.14
319.30	447.87	65.56	448.39	66.08	451.00	68.69	46.40	8.17
319.20	447.10	65.80	447.62	66.32	450.24	68.94	46.33	8.20
319.10	446.51	66.06	447.04	66.59	449.68	69.22	46.27	8.23
319.00	446.02	66.34	446.55	66.87	449.20	69.51	46.22	8.26
318.90	445.56	66.62	446.09	67.15	448.75	69.81	46.18	8.29
318.80	445.11	66.90	445.64	67.43	448.32	70.11	46.14	8.32
318.70	444.69	67.18	445.22	67.72	447.91	70.41	46.10	8.35
318.60	444.29	67.47	444.83	68.01	447.53	70.71	46.06	8.38
318.50	443.91	67.76	444.46	68.30	447.17	71.01	46.03	8.41
318.40	443.54	68.05	444.09	68.60	446.81	71.32	45.99	8.44
318.30	443.19	68.34	443.73	68.89	446.47	71.63	45.96	8.48
318.20	442.83	68.64	443.38	69.19	446.13	71.94	45.93	8.51
318.10	442.48	68.93	443.03	69.48	445.79	72.24	45.89	8.54
318.00	442.13	69.22	442.69	69.77	445.47	72.55	45.86	8.57
317.90	441.80	69.51	442.36	70.07	445.15	72.86	45.83	8.60
317.80	441.48	69.81	442.05	70.37	444.85	73.17	45.80	8.63
317.70	441.17	70.10	441.73	70.67	444.55	73.49	45.77	8.67
317.60	440.85	70.40	441.42	70.97	444.25	73.80	45.74	8.70
317.50	440.53	70.69	441.10	71.26	443.95	74.11	45.71	8.73
317.40	440.24	70.99	440.81	71.56	443.67	74.42	45.69	8.76
317.30	439.94	71.29	440.52	71.86	443.39	74.73	45.66	8.79
317.20	439.66	71.58	440.23	72.16	443.12	75.05	45.63	8.82
317.10	439.37	71.88	439.95	72.46	442.85	75.36	45.60	8.86
317.00	439.08	72.18	439.66	72.76	442.57	75.67	45.58	8.89
316.90	438.79	72.47	439.38	73.06	442.30	75.98	45.55	8.92
316.80	438.53	72.77	439.12	73.36	442.06	76.30	45.53	8.95
316.70	438.27	73.07	438.86	73.66	441.81	76.62	45.50	8.98
316.60	438.01	73.37	438.60	73.97	441.57	76.93	45.48	9.01
316.50	437.76	73.67	438.36	74.27	441.34	77.25	45.45	9.05
316.40	437.52	73.98	438.12	74.57	441.11	77.57	45.43	9.08
316.30	437.28	74.28	437.88	74.88	440.88	77.89	45.41	9.11
316.20	437.04	74.58	437.64	75.18	440.66	78.20	45.39	9.14
316.10	436.80	74.88	437.41	75.49	440.44	78.52	45.36	9.17
316.00	436.55	75.18	437.16	75.79	440.21	78.84	45.34	9.20
315.90	436.30	75.48	436.92	76.09	439.98	79.15	45.32	9.23
315.80	436.06	75.78	436.68	76.39	439.75	79.47	45.29	9.27
315.70	435.82	76.08	436.43	76.69	439.52	79.78	45.27	9.30
315.60	435.56	76.37	436.18	76.99	439.29	80.10	45.25	9.33
315.50	435.30	76.67	435.93	77.29	439.04	80.41	45.22	9.36
315.40	435.04	76.96	435.66	77.59	438.80	80.72	45.20	9.39
315.30	434.78	77.26	435.41	77.89	438.56	81.03	45.18	9.42
315.20	434.54	77.55	435.17	78.19	438.33	81.34	45.15	9.45
315.10	434.29	77.85	434.93	78.48	438.10	81.66	45.13	9.49
315.00	434.04	78.14	434.67	78.78	437.86	81.97	45.11	9.52
314.90	433.76	78.43	434.40	79.07	437.60	82.27	45.08	9.55
314.80	433.47	78.72	434.12	79.36	437.33	82.58	45.05	9.58
314.70	433.20	79.01	433.85	79.65	437.07	82.88	45.03	9.61
314.60	432.92	79.30	433.57	79.94	436.81	83.19	45.00	9.64
314.50	432.62	79.58	433.27	80.23	436.53	83.49	44.97	9.67
314.40	432.36	79.87	433.01	80.52	436.28	83.79	44.95	9.70
314.30	432.09	80.16	432.75	80.82	436.03	84.10	44.92	9.73
314.20	431.82	80.45	432.48	81.11	435.78	84.40	44.90	9.76
314.10	431.57	80.74	432.23	81.40	435.54	84.71	44.87	9.79
314.00	431.31	81.03	431.97	81.69	435.30	85.01	44.85	9.82

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Dewatering WBM South Pit Inflow (m³/day)	Recovery WBM South Pit Inflow (m³/day)
313.90	431.06	81.32	431.73	81.99	435.06	85.32	44.83	9.85
313.80	430.81	81.61	431.48	82.28	434.83	85.63	44.80	9.88
313.70	430.57	81.90	431.24	82.57	434.60	85.93	44.78	9.91
313.60	430.33	82.19	431.00	82.87	434.38	86.24	44.76	9.94
313.50	430.08	82.48	430.76	83.16	434.15	86.55	44.74	9.98
313.40	429.84	82.77	430.52	83.45	433.93	86.85	44.71	10.01
313.30	429.61	83.06	430.29	83.74	433.71	87.16	44.69	10.04
313.20	429.38	83.35	430.07	84.04	433.50	87.47	44.67	10.07
313.10	429.14	83.64	429.83	84.33	433.28	87.78	44.65	10.10
313.00	428.89	83.93	429.59	84.62	433.04	88.08	44.62	10.13
312.90	428.64	84.22	429.33	84.91	432.81	88.38	44.60	10.16
312.80	428.39	84.50	429.09	85.20	432.57	88.69	44.58	10.19
312.70	428.13	84.79	428.83	85.49	432.33	88.99	44.55	10.22
312.60	427.89	85.07	428.59	85.78	432.10	89.29	44.53	10.25
312.50	427.64	85.36	428.34	86.06	431.87	89.59	44.51	10.28
312.40	427.39	85.64	428.10	86.35	431.64	89.89	44.48	10.31
312.30	427.11	85.92	427.83	86.63	431.38	90.19	44.46	10.34
312.20	426.84	86.20	427.55	86.91	431.12	90.48	44.43	10.37
312.10	426.57	86.48	427.29	87.20	430.87	90.78	44.41	10.40
312.00	426.29	86.76	427.01	87.48	430.60	91.07	44.38	10.43
311.90	426.01	87.03	426.73	87.76	430.34	91.36	44.35	10.46
311.80	425.73	87.31	426.45	88.03	430.07	91.66	44.33	10.49
311.70	425.42	87.58	426.15	88.31	429.78	91.94	44.30	10.51
311.60	425.13	87.85	425.86	88.58	429.51	92.23	44.27	10.54
311.50	424.83	88.12	425.56	88.85	429.22	92.52	44.24	10.57
311.40	424.52	88.39	425.25	89.12	428.93	92.80	44.21	10.60
311.30	424.20	88.66	424.94	89.39	428.63	93.08	44.19	10.63
311.20	423.85	88.91	424.59	89.65	428.29	93.35	44.15	10.66
311.10	423.42	89.15	424.16	89.90	427.87	93.61	44.11	10.69
311.00	422.99	89.39	423.73	90.14	427.46	93.87	44.07	10.71
310.90	422.57	89.64	423.31	90.38	427.05	94.12	44.03	10.74
310.80	422.05	89.86	422.80	90.61	426.55	94.36	43.98	10.76
310.70	421.50	90.07	422.25	90.82	426.01	94.58	43.93	10.79
310.60	420.92	90.28	421.68	91.03	425.45	94.80	43.88	10.81
310.50	420.20	90.45	420.95	91.21	424.73	94.99	43.81	10.84
310.40	419.05	90.53	419.80	91.29	423.59	95.08	43.70	10.85
310.30	417.69	90.56	418.45	91.32	422.25	95.12	43.58	10.86
310.20	415.92	90.51	416.68	91.27	420.48	95.06	43.41	10.87
310.10	413.69	90.35	414.45	91.10	418.25	94.90	43.20	10.87
310.00	411.98	90.29	412.74	91.05	416.53	94.85	43.04	10.87
309.90	410.28	90.24	411.04	91.00	414.83	94.80	42.88	10.88
309.80	408.96	90.27	409.72	91.03	413.52	94.83	42.76	10.89
309.70	407.58	90.29	408.34	91.05	412.15	94.85	42.63	10.90
309.60	405.51	90.14	406.27	90.91	410.07	94.71	42.44	10.90
309.50	402.49	89.79	403.25	90.55	407.05	94.34	42.15	10.88
309.40	399.70	89.48	400.45	90.24	404.24	94.02	41.89	10.87
309.30	398.67	89.56	399.43	90.32	403.22	94.11	41.79	10.88
309.20	397.85	89.69	398.61	90.45	402.41	94.25	41.72	10.90
309.10	397.29	89.87	398.06	90.64	401.87	94.45	41.66	10.92
309.00	396.87	90.09	397.64	90.85	401.46	94.68	41.62	10.95
308.90	396.48	90.31	397.25	91.08	401.09	94.91	41.59	10.97
308.80	396.11	90.53	396.87	91.30	400.72	95.15	41.55	11.00
308.70	395.74	90.76	396.51	91.53	400.37	95.39	41.52	11.02
308.60	395.37	90.98	396.14	91.76	400.01	95.63	41.48	11.05
308.50	395.02	91.21	395.80	91.99	399.68	95.87	41.45	11.07
308.40	394.69	91.45	395.47	92.23	399.37	96.12	41.42	11.10
308.30	394.38	91.68	395.16	92.47	399.07	96.37	41.39	11.12
308.20	394.07	91.92	394.85	92.70	398.77	96.62	41.36	11.15
308.10	393.76	92.15	394.54	92.94	398.48	96.88	41.33	11.17
308.00	393.45	92.39	394.24	93.18	398.19	97.13	41.30	11.20
307.90	393.14	92.63	393.93	93.42	397.89	97.38	41.27	11.22
307.80	392.81	92.86	393.61	93.65	397.58	97.62	41.24	11.25
307.70	392.49	93.09	393.29	93.88	397.27	97.87	41.21	11.27
307.60	392.18	93.32	392.98	94.12	396.97	98.11	41.18	11.30
307.50	391.88	93.56	392.68	94.36	396.69	98.37	41.16	11.32
307.40	391.60	93.79	392.40	94.60	396.42	98.62	41.13	11.35
307.30	391.31	94.03	392.11	94.84	396.15	98.87	41.10	11.37
307.20	391.02	94.27	391.83	95.08	395.88	99.12	41.07	11.40
307.10	390.73	94.50	391.54	95.32	395.60	99.37	41.05	11.42
307.00	390.43	94.74	391.24	95.55	395.31	99.62	41.02	11.45
306.90	390.11	94.97	390.93	95.78	395.01	99.87	40.99	11.47
306.80	389.82	95.20	390.64	96.02	394.74	100.12	40.96	11.50
306.70	389.54	95.43	390.36	96.26	394.47	100.37	40.93	11.52
306.60	389.25	95.67	390.07	96.49	394.19	100.61	40.91	11.55
306.50	388.97	95.91	389.80	96.73	393.93	100.87	40.88	11.57
306.40	388.70	96.14	389.53	96.97	393.68	101.12	40.86	11.60
306.30	388.42	96.38	389.25	97.21	393.41	101.37	40.83	11.63
306.20	388.14	96.61	388.97	97.45	393.14	101.62	40.80	11.65
306.10	387.85	96.84	388.69	97.68	392.88	101.87	40.78	11.68
306.00	387.58	97.08	388.42	97.92	392.62	102.12	40.75	11.70
305.90	387.30	97.31	388.14	98.15	392.35	102.36	40.72	11.73
305.80	387.03	97.55	387.87	98.39	392.09	102.61	40.70	11.75
305.70	386.75	97.78	387.60	98.63	391.84	102.86	40.67	11.78
305.60	386.49	98.01	387.34	98.86	391.59	103.11	40.65	11.80
305.50	386.23	98.25	387.08	99.10	391.34	103.36	40.62	11.83
305.40	385.97	98.49	386.82	99.34	391.10	103.62	40.60	11.85
305.30	385.72	98.73	386.58	99.58	390.87	103.87	40.58	11.88
305.20	385.48	98.97	386.34	99.83	390.64	104.13	40.55	11.90
305.10	385.24	99.20	386.10	100.07	390.41	104.38	40.53	11.93
305.00	384.99	99.44	385.86	100.31	390.19	104.64	40.51	11.95
304.90	384.75	99.68	385.62	100.55	389.96	104.89	40.48	11.98
304.80	384.50	99.92	385.37	100.79	389.72	105.14	40.46	12.00
304.70	384.25	100.15	385.13	101.03	389.49	105.39	40.44	12.03
304.60	384.00	100.39	384.88	101.27	389.26	105.64	40.41	12.05
304.50	383.75	100.62	384.63	101.50	389.02	105.89	40.39	12.08
304.40	383.50	100.86	384.38	101.74	388.78	106.14	40.37	12.10
304.30	383.25	101.09	384.13	101.98	388.55	106.39	40.34	12.13
304.20	383.00	101.33	383.89	102.21	388.32	106.64	40.32	12.15
304.10	382.76	101.56	383.65	102.45	388.09	106.89	40.30	12.18
304.00	382.51	101.80	383.40	102.69	387.86	107.14	40.27	12.20
303.90	382.24	102.02	383.14	102.92	387.60	107.39	40.25	12.23
303.80	381.99	102.25	382.88	103.15	387.36	107.63	40.22	12.25

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Dewatering WBM South Pit Inflow (m³/day)	Recovery WBM South Pit Inflow (m³/day)
303.70	381.73	102.48	382.63	103.38	387.12	107.88	40.20	12.27
303.60	381.46	102.71	382.36	103.61	386.87	108.12	40.17	12.30
303.50	381.19	102.94	382.10	103.84	386.62	108.36	40.15	12.32
303.40	380.94	103.17	381.84	104.07	386.37	108.60	40.12	12.35
303.30	380.67	103.39	381.58	104.30	386.12	108.84	40.10	12.37
303.20	380.40	103.62	381.32	104.53	385.87	109.09	40.07	12.39
303.10	380.11	103.84	381.03	104.75	385.60	109.32	40.05	12.42
303.00	379.81	104.05	380.73	104.97	385.31	109.55	40.02	12.44
302.90	379.53	104.27	380.45	105.19	385.05	109.78	39.99	12.47
302.80	379.25	104.49	380.17	105.41	384.78	110.02	39.96	12.49
302.70	378.97	104.71	379.89	105.63	384.51	110.25	39.94	12.51
302.60	378.68	104.92	379.60	105.85	384.24	110.48	39.91	12.54
302.50	378.38	105.14	379.31	106.07	383.95	110.71	39.88	12.56
302.40	378.04	105.34	378.97	106.27	383.63	110.93	39.85	12.58
302.30	377.69	105.54	378.63	106.47	383.29	111.14	39.82	12.60
302.20	377.35	105.74	378.28	106.67	382.96	111.35	39.79	12.62
302.10	376.99	105.93	377.93	106.87	382.62	111.56	39.75	12.65
302.00	376.62	106.12	377.56	107.06	382.26	111.77	39.72	12.67
301.90	376.20	106.30	377.15	107.24	381.86	111.96	39.68	12.69
301.80	375.76	106.47	376.71	107.41	381.43	112.14	39.64	12.71
301.70	375.29	106.63	376.23	107.58	380.97	112.31	39.59	12.73
301.60	374.78	106.78	375.73	107.73	380.48	112.47	39.54	12.74
301.50	374.22	106.91	375.18	107.86	379.93	112.62	39.49	12.76
301.40	373.59	107.02	374.55	107.98	379.31	112.74	39.43	12.77
301.30	372.75	107.07	373.70	108.03	378.47	112.80	39.35	12.78
301.20	371.96	107.14	372.91	108.09	377.69	112.87	39.28	12.80
301.10	371.02	107.16	371.97	108.11	376.76	112.90	39.19	12.80
301.00	369.86	107.11	370.82	108.07	375.60	112.86	39.08	12.80
300.90	368.13	106.90	369.08	107.85	373.87	112.64	38.92	12.79
300.80	365.45	106.41	366.40	107.36	371.17	112.13	38.66	12.76
300.70	361.79	105.62	362.73	106.57	367.48	111.32	38.32	12.70
300.60	359.24	105.16	360.19	106.11	364.92	110.85	38.08	12.67
300.50	357.09	104.81	358.03	105.76	362.76	110.49	37.87	12.65
300.40	354.84	104.43	355.78	105.37	360.50	110.09	37.66	12.62
300.30	352.59	104.04	353.53	104.98	358.24	109.70	37.45	12.59
300.20	350.78	103.78	351.72	104.73	356.43	109.43	37.28	12.58
300.10	349.37	103.64	350.31	104.58	355.02	109.29	37.14	12.57
300.00	348.10	103.54	349.04	104.48	353.75	109.18	37.02	12.57
299.90	346.92	103.46	347.86	104.40	352.57	109.11	36.91	12.57
299.80	345.81	103.40	346.76	104.34	351.47	109.05	36.81	12.57
299.70	344.62	103.31	345.56	104.25	350.28	108.97	36.70	12.56
299.60	343.60	103.27	344.54	104.22	349.26	108.93	36.60	12.57
299.50	342.71	103.27	343.65	104.22	348.37	108.94	36.51	12.57
299.40	342.01	103.33	342.95	104.28	347.68	109.00	36.45	12.58
299.30	341.35	103.40	342.30	104.35	347.03	109.08	36.39	12.59
299.20	340.66	103.46	341.61	104.40	346.35	109.15	36.32	12.60
299.10	340.01	103.53	340.97	104.48	345.72	109.23	36.26	12.61
299.00	339.38	103.60	340.33	104.55	345.09	109.31	36.20	12.62
298.90	338.79	103.69	339.75	104.64	344.52	109.41	36.14	12.63
298.80	338.21	103.77	339.17	104.73	343.94	109.50	36.09	12.64
298.70	337.67	103.87	338.63	104.83	343.41	109.61	36.04	12.66
298.60	337.15	103.97	338.11	104.93	342.91	109.73	35.99	12.67
298.50	336.64	104.08	337.60	105.04	342.40	109.84	35.94	12.68
298.40	336.11	104.18	337.08	105.14	341.89	109.95	35.89	12.70
298.30	335.63	104.29	336.59	105.26	341.41	110.08	35.84	12.71
298.20	335.17	104.41	336.13	105.38	340.96	110.21	35.80	12.72
298.10	334.74	104.54	335.71	105.51	340.55	110.35	35.76	12.74
298.00	334.32	104.67	335.29	105.64	340.14	110.49	35.72	12.75
297.90	333.91	104.80	334.88	105.78	339.74	110.64	35.68	12.77
297.80	333.51	104.94	334.48	105.91	339.35	110.78	35.64	12.78
297.70	333.12	105.08	334.09	106.05	338.97	110.93	35.60	12.80
297.60	332.73	105.22	333.71	106.19	338.60	111.08	35.57	12.82
297.50	332.36	105.36	333.34	106.34	338.24	111.24	35.53	12.83
297.40	331.99	105.50	332.97	106.48	337.88	111.39	35.50	12.85
297.30	331.62	105.64	332.60	106.63	337.53	111.55	35.46	12.86
297.20	331.25	105.78	332.24	106.77	337.17	111.70	35.43	12.88
297.10	330.89	105.93	331.88	106.92	336.83	111.86	35.39	12.90
297.00	330.54	106.07	331.53	107.06	336.49	112.02	35.36	12.91
296.90	330.19	106.22	331.18	107.21	336.14	112.18	35.33	12.93
296.80	329.81	106.35	330.80	107.35	335.78	112.32	35.29	12.94
296.70	329.48	106.51	330.48	107.50	335.47	112.49	35.26	12.96
296.60	329.18	106.67	330.18	107.67	335.18	112.66	35.23	12.98
296.50	328.89	106.83	329.89	107.83	334.90	112.84	35.20	13.00
296.40	328.61	107.00	329.61	108.00	334.63	113.02	35.18	13.01
296.30	328.34	107.17	329.34	108.17	334.37	113.20	35.15	13.03
296.20	328.08	107.34	329.09	108.35	334.13	113.39	35.13	13.05
296.10	327.82	107.51	328.83	108.52	333.88	113.57	35.10	13.07
296.00	327.55	107.68	328.56	108.69	333.63	113.76	35.08	13.09
295.90	327.29	107.85	328.31	108.86	333.38	113.94	35.05	13.11
295.80	327.04	108.02	328.06	109.04	333.15	114.13	35.03	13.12
295.70	326.78	108.19	327.80	109.21	332.91	114.31	35.00	13.14
295.60	326.53	108.36	327.55	109.39	332.67	114.50	34.98	13.16
295.50	326.28	108.54	327.30	109.56	332.43	114.69	34.95	13.18
295.40	326.03	108.71	327.06	109.74	332.20	114.87	34.93	13.20
295.30	325.78	108.88	326.81	109.91	331.96	115.06	34.91	13.22
295.20	325.55	109.06	326.58	110.09	331.74	115.25	34.88	13.24
295.10	325.32	109.23	326.35	110.27	331.52	115.44	34.86	13.25
295.00	325.08	109.41	326.12	110.45	331.30	115.63	34.84	13.27
294.90	324.86	109.59	325.90	110.63	331.10	115.82	34.82	13.29
294.80	324.65	109.77	325.69	110.81	330.90	116.02	34.80	13.31
294.70	324.44	109.95	325.48	111.00	330.70	116.22	34.78	13.33
294.60	324.23	110.14	325.28	111.18	330.51	116.42	34.76	13.35
294.50	324.03	110.32	325.08	111.37	330.32	116.62	34.74	13.37
294.40	323.83	110.51	324.88	111.56	330.14	116.82	34.72	13.39
294.30	323.63	110.69	324.69	111.75	329.96	117.02	34.70	13.41
294.20	323.43	110.88	324.49	111.93	329.77	117.22	34.68	13.43
294.10	323.23	111.06	324.29	112.12	329.58	117.42	34.66	13.45
294.00	323.03	111.25	324.09	112.31	329.40	117.62	34.64	13.47
293.90	322.85	111.44	323.91	112.50	329.23	117.82	34.63	13.49
293.80	322.67	111.63	323.73	112.69	329.07	118.03	34.61	13.51
293.70	322.49	111.82	323.56	112.88	328.90	118.23	34.59	13.53
293.60	322.31	112.01	323.38	113.08	328.74	118.44	34.58	13.55

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Dewatering WBM South Pit Inflow (m³/day)	Recovery WBM South Pit Inflow (m³/day)
293.50	322.11	112.19	323.19	113.26	328.56	118.64	34.56	13.57
293.40	321.93	112.38	323.00	113.45	328.39	118.84	34.54	13.58
293.30	321.73	112.56	322.81	113.64	328.21	119.04	34.52	13.60
293.20	321.54	112.75	322.62	113.83	328.03	119.24	34.50	13.62
293.10	321.35	112.93	322.44	114.02	327.86	119.44	34.48	13.64
293.00	321.17	113.12	322.25	114.20	327.69	119.64	34.47	13.66
292.90	320.98	113.30	322.06	114.39	327.51	119.84	34.45	13.68
292.80	320.79	113.49	321.88	114.58	327.34	120.04	34.43	13.70
292.70	320.60	113.67	321.70	114.77	327.17	120.24	34.41	13.72
292.60	320.41	113.85	321.51	114.95	326.99	120.44	34.40	13.74
292.50	320.22	114.04	321.32	115.13	326.81	120.63	34.38	13.76
292.40	320.02	114.21	321.12	115.32	326.63	120.83	34.36	13.78
292.30	319.82	114.39	320.93	115.50	326.45	121.02	34.34	13.80
292.20	319.63	114.58	320.74	115.68	326.27	121.22	34.32	13.82
292.10	319.44	114.76	320.55	115.87	326.10	121.41	34.30	13.83
292.00	319.25	114.94	320.36	116.05	325.92	121.61	34.28	13.85
291.90	319.04	115.12	320.16	116.23	325.73	121.80	34.26	13.87
291.80	318.83	115.29	319.94	116.40	325.53	121.99	34.24	13.89
291.70	318.62	115.46	319.74	116.58	325.33	122.18	34.22	13.91
291.60	318.41	115.63	319.53	116.76	325.14	122.36	34.20	13.93
291.50	318.20	115.81	319.33	116.93	324.95	122.55	34.18	13.94
291.40	318.00	115.98	319.13	117.11	324.76	122.74	34.17	13.96
291.30	317.76	116.15	318.89	117.27	324.54	122.92	34.14	13.98
291.20	317.55	116.31	318.68	117.45	324.34	123.10	34.12	14.00
291.10	317.34	116.49	318.47	117.62	324.14	123.29	34.10	14.02
291.00	317.13	116.66	318.26	117.79	323.95	123.48	34.08	14.03
290.90	316.91	116.82	318.04	117.96	323.74	123.66	34.06	14.05
290.80	316.68	116.99	317.82	118.13	323.53	123.84	34.04	14.07
290.70	316.45	117.15	317.60	118.30	323.32	124.02	34.02	14.09
290.60	316.22	117.31	317.36	118.46	323.10	124.19	34.00	14.10
290.50	315.97	117.47	317.12	118.62	322.87	124.36	33.97	14.12
290.40	315.73	117.62	316.88	118.77	322.63	124.53	33.95	14.14
290.30	315.47	117.78	316.63	118.93	322.40	124.70	33.92	14.15
290.20	315.20	117.92	316.36	119.08	322.14	124.86	33.90	14.17
290.10	314.95	118.07	316.10	119.23	321.89	125.02	33.87	14.19
290.00	314.70	118.23	315.86	119.39	321.66	125.19	33.85	14.20
289.90	314.43	118.37	315.60	119.53	321.41	125.35	33.83	14.22
289.80	314.16	118.52	315.33	119.68	321.15	125.51	33.80	14.23
289.70	313.91	118.66	315.07	119.83	320.91	125.67	33.77	14.25
289.60	313.66	118.82	314.83	119.99	320.68	125.84	33.75	14.27
289.50	313.42	118.97	314.59	120.14	320.45	126.00	33.73	14.28
289.40	313.15	119.11	314.33	120.29	320.20	126.16	33.70	14.30
289.30	312.91	119.27	314.08	120.44	319.97	126.33	33.68	14.32
289.20	312.67	119.42	313.85	120.60	319.75	126.50	33.66	14.33
289.10	312.44	119.58	313.62	120.76	319.53	126.67	33.63	14.35
289.00	312.20	119.73	313.39	120.91	319.31	126.83	33.61	14.36
288.90	311.97	119.89	313.16	121.07	319.09	127.01	33.59	14.38
288.80	311.75	120.04	312.93	121.23	318.88	127.18	33.57	14.40
288.70	311.51	120.20	312.70	121.39	318.66	127.34	33.55	14.41
288.60	311.29	120.35	312.48	121.55	318.45	127.52	33.52	14.43
288.50	311.07	120.51	312.27	121.71	318.25	127.69	33.50	14.45
288.40	310.86	120.67	312.06	121.87	318.05	127.87	33.48	14.47
288.30	310.65	120.84	311.85	122.04	317.85	128.04	33.46	14.48
288.20	310.44	121.00	311.64	122.20	317.66	128.22	33.44	14.50
288.10	310.23	121.16	311.43	122.36	317.46	128.39	33.42	14.52
288.00	310.02	121.32	311.23	122.53	317.27	128.57	33.40	14.53
287.90	309.81	121.48	311.02	122.69	317.08	128.75	33.38	14.55
287.80	309.61	121.64	310.83	122.86	316.90	128.93	33.37	14.57
287.70	309.42	121.81	310.63	123.02	316.71	129.10	33.35	14.59
287.60	309.22	121.97	310.43	123.19	316.53	129.28	33.33	14.60
287.50	309.02	122.13	310.24	123.36	316.34	129.46	33.31	14.62
287.40	308.81	122.29	310.03	123.52	316.15	129.63	33.29	14.64
287.30	308.59	122.45	309.81	123.67	315.94	129.80	33.27	14.65
287.20	308.37	122.60	309.60	123.83	315.74	129.97	33.25	14.67
287.10	308.16	122.76	309.39	123.99	315.54	130.15	33.23	14.69
287.00	307.96	122.92	309.19	124.15	315.36	130.32	33.21	14.70
286.90	307.76	123.08	309.00	124.32	315.18	130.50	33.19	14.72
286.80	307.56	123.25	308.80	124.48	314.99	130.68	33.17	14.74
286.70	307.37	123.41	308.61	124.65	314.81	130.85	33.15	14.75
286.60	307.17	123.57	308.42	124.81	314.63	131.03	33.13	14.77
286.50	306.98	123.73	308.22	124.98	314.45	131.21	33.11	14.79
286.40	306.78	123.89	308.03	125.14	314.27	131.38	33.09	14.81
286.30	306.58	124.05	307.83	125.30	314.08	131.55	33.08	14.82
286.20	306.37	124.21	307.63	125.46	313.89	131.73	33.06	14.84
286.10	306.16	124.36	307.42	125.62	313.70	131.90	33.04	14.86
286.00	305.95	124.51	307.21	125.77	313.50	132.06	33.02	14.87
285.90	305.74	124.67	307.00	125.93	313.30	132.23	32.99	14.89
285.80	305.53	124.82	306.79	126.08	313.11	132.40	32.97	14.90
285.70	305.31	124.97	306.58	126.24	312.91	132.57	32.95	14.92
285.60	305.10	125.12	306.37	126.39	312.71	132.73	32.93	14.94
285.50	304.89	125.27	306.16	126.54	312.51	132.90	32.91	14.95
285.40	304.68	125.42	305.95	126.70	312.32	133.06	32.89	14.97
285.30	304.46	125.57	305.73	126.85	312.11	133.23	32.87	14.98
285.20	304.22	125.71	305.50	126.99	311.89	133.38	32.85	15.00
285.10	303.99	125.86	305.28	127.14	311.68	133.54	32.83	15.01
285.00	303.78	126.01	305.07	127.29	311.48	133.71	32.81	15.03
284.90	303.58	126.16	304.86	127.44	311.29	133.87	32.79	15.05
284.80	303.37	126.31	304.65	127.60	311.09	134.04	32.77	15.06
284.70	303.15	126.45	304.44	127.74	310.89	134.20	32.75	15.08
284.60	302.92	126.60	304.22	127.89	310.68	134.36	32.73	15.09
284.50	302.70	126.74	303.99	128.04	310.47	134.51	32.70	15.11
284.40	302.47	126.88	303.77	128.18	310.26	134.67	32.68	15.12
284.30	302.25	127.03	303.55	128.33	310.05	134.83	32.66	15.14
284.20	302.02	127.17	303.32	128.47	309.83	134.98	32.64	15.15
284.10	301.79	127.31	303.09	128.61	309.62	135.14	32.62	15.17
284.00	301.56	127.44	302.87	128.75	309.40	135.29	32.60	15.18
283.90	301.33	127.58	302.64	128.89	309.19	135.44	32.57	15.20
283.80	301.09	127.72	302.41	129.03	308.97	135.59	32.55	15.21
283.70	300.86	127.86	302.18	129.17	308.75	135.74	32.53	15.23
283.60	300.63	127.99	301.95	129.31	308.53	135.89	32.51	15.24
283.50	300.39	128.13	301.71	129.44	308.31	136.04	32.48	15.26
283.40	300.14	128.25	301.46	129.58	308.07	136.18	32.46	15.27

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Dewatering WBM South Pit Inflow (m³/day)	Recovery WBM South Pit Inflow (m³/day)
283.30	299.89	128.38	301.22	129.71	307.84	136.33	32.44	15.29
283.20	299.64	128.51	300.97	129.84	307.60	136.47	32.41	15.30
283.10	299.37	128.63	300.70	129.95	307.34	136.60	32.39	15.31
283.00	299.09	128.74	300.42	130.07	307.08	136.73	32.36	15.32
282.90	298.82	128.86	300.15	130.19	306.82	136.86	32.33	15.34
282.80	298.54	128.97	299.88	130.31	306.56	136.99	32.31	15.35
282.70	298.27	129.09	299.61	130.42	306.29	137.11	32.28	15.36
282.60	297.98	129.20	299.32	130.54	306.03	137.24	32.25	15.37
282.50	297.70	129.31	299.04	130.65	305.75	137.36	32.23	15.39
282.40	297.42	129.42	298.76	130.76	305.48	137.48	32.20	15.40
282.30	297.13	129.52	298.48	130.87	305.21	137.60	32.17	15.41
282.20	296.84	129.63	298.19	130.98	304.94	137.72	32.14	15.42
282.10	296.52	129.72	297.88	131.07	304.63	137.83	32.11	15.43
282.00	296.18	129.81	297.54	131.16	304.30	137.93	32.08	15.44
281.90	295.81	129.88	297.17	131.23	303.95	138.01	32.05	15.45
281.80	295.42	129.93	296.78	131.29	303.56	138.08	32.01	15.46
281.70	295.01	129.98	296.36	131.34	303.16	138.14	31.97	15.47
281.60	294.56	130.02	295.92	131.38	302.73	138.18	31.93	15.47
281.50	294.03	130.01	295.40	131.38	302.21	138.19	31.88	15.47
281.40	293.47	130.00	294.84	131.36	301.65	138.18	31.82	15.47
281.30	292.70	129.88	294.06	131.25	300.88	138.07	31.75	15.47
281.20	291.63	129.64	293.00	131.00	299.82	137.82	31.65	15.45
281.10	290.58	129.40	291.94	130.76	298.76	137.58	31.55	15.43
281.00	289.32	129.06	290.68	130.42	297.49	137.24	31.43	15.40
280.90	287.84	128.63	289.20	129.99	296.00	136.79	31.28	15.36
280.80	286.18	128.11	287.54	129.47	294.34	136.26	31.13	15.32
280.70	284.34	127.51	285.69	128.86	292.47	135.64	30.95	15.27
280.60	282.70	127.00	284.06	128.35	290.82	135.12	30.79	15.22
280.50	280.57	126.26	281.91	127.61	288.66	134.35	30.59	15.16
280.40	278.14	125.38	279.48	126.73	286.21	133.45	30.36	15.08
280.30	275.61	124.46	276.95	125.80	283.64	132.49	30.12	15.00
280.20	273.44	123.69	274.78	125.03	281.45	131.71	29.91	14.93
280.10	271.41	122.98	272.74	124.32	279.40	130.98	29.71	14.87
280.00	269.39	122.28	270.72	123.61	277.36	130.25	29.52	14.81
279.90	267.70	121.72	269.02	123.05	275.65	129.68	29.36	14.76
279.80	265.91	121.12	267.24	122.44	273.85	129.06	29.19	14.71
279.70	264.02	120.46	265.33	121.78	271.93	128.38	29.00	14.65
279.60	262.86	120.14	264.18	121.46	270.77	128.06	28.89	14.62
279.50	261.74	119.83	263.06	121.15	269.65	127.74	28.79	14.60
279.40	260.94	119.67	262.26	120.99	268.85	127.58	28.71	14.58
279.30	260.21	119.54	261.53	120.86	268.12	127.46	28.64	14.57
279.20	259.54	119.44	260.86	120.76	267.46	127.35	28.58	14.56
279.10	258.89	119.34	260.21	120.66	266.82	127.27	28.51	14.56
279.00	258.25	119.25	259.57	120.57	266.18	127.18	28.45	14.55
278.90	257.64	119.17	258.96	120.49	265.58	127.10	28.39	14.55
278.80	257.05	119.09	258.37	120.42	264.99	127.04	28.34	14.54
278.70	256.52	119.05	257.84	120.37	264.46	127.00	28.28	14.54
278.60	256.01	119.02	257.34	120.34	263.97	126.97	28.24	14.54
278.50	255.56	119.00	256.88	120.33	263.52	126.97	28.19	14.54
278.40	255.11	119.00	256.44	120.33	263.09	126.97	28.15	14.54
278.30	254.68	118.99	256.01	120.33	262.66	126.98	28.11	14.54
278.20	254.27	119.00	255.60	120.33	262.26	126.99	28.07	14.54
278.10	253.84	119.00	255.17	120.33	261.84	127.00	28.03	14.54
278.00	253.43	119.01	254.77	120.34	261.44	127.02	27.99	14.55
277.90	253.05	119.03	254.39	120.36	261.08	127.05	27.95	14.55
277.80	252.67	119.05	254.01	120.38	260.71	127.08	27.92	14.55
277.70	252.30	119.06	253.64	120.41	260.34	127.11	27.88	14.56
277.60	251.96	119.10	253.30	120.45	260.01	127.16	27.85	14.56
277.50	251.65	119.15	253.00	120.50	259.72	127.22	27.82	14.57
277.40	251.35	119.21	252.69	120.55	259.42	127.28	27.79	14.57
277.30	251.04	119.26	252.38	120.60	259.13	127.35	27.76	14.58
277.20	250.74	119.31	252.09	120.66	258.84	127.41	27.73	14.59
277.10	250.46	119.37	251.81	120.73	258.58	127.49	27.70	14.59
277.00	250.20	119.45	251.55	120.80	258.33	127.57	27.68	14.60
276.90	249.94	119.52	251.30	120.87	258.08	127.66	27.65	14.61
276.80	249.66	119.58	251.02	120.94	257.81	127.73	27.63	14.62
276.70	249.40	119.65	250.77	121.01	257.57	127.82	27.60	14.63
276.60	249.16	119.73	250.53	121.09	257.34	127.91	27.58	14.63
276.50	248.93	119.81	250.30	121.18	257.12	128.00	27.56	14.64
276.40	248.70	119.90	250.07	121.26	256.90	128.10	27.53	14.65
276.30	248.47	119.98	249.84	121.35	256.68	128.20	27.51	14.66
276.20	248.24	120.06	249.61	121.44	256.47	128.29	27.49	14.67
276.10	248.02	120.15	249.40	121.53	256.27	128.40	27.47	14.68
276.00	247.80	120.24	249.18	121.61	256.06	128.50	27.45	14.69
275.90	247.58	120.32	248.96	121.70	255.85	128.59	27.42	14.70
275.80	247.35	120.41	248.73	121.79	255.64	128.69	27.40	14.71
275.70	247.13	120.49	248.51	121.88	255.43	128.79	27.38	14.72
275.60	246.91	120.58	248.30	121.96	255.22	128.89	27.36	14.73
275.50	246.70	120.67	248.08	122.06	255.02	128.99	27.34	14.74
275.40	246.48	120.76	247.87	122.15	254.82	129.10	27.32	14.75
275.30	246.27	120.85	247.67	122.24	254.63	129.20	27.30	14.76
275.20	246.07	120.94	247.46	122.33	254.43	129.30	27.28	14.77
275.10	245.86	121.03	247.26	122.42	254.24	129.41	27.26	14.78
275.00	245.66	121.12	247.06	122.52	254.05	129.51	27.24	14.79
274.90	245.45	121.21	246.85	122.61	253.86	129.62	27.22	14.80
274.80	245.24	121.30	246.65	122.70	253.67	129.72	27.20	14.81
274.70	245.03	121.39	246.43	122.79	253.46	129.82	27.18	14.81
274.60	244.82	121.47	246.23	122.88	253.27	129.92	27.16	14.82
274.50	244.61	121.56	246.02	122.97	253.07	130.02	27.14	14.83
274.40	244.40	121.65	245.81	123.06	252.88	130.12	27.12	14.84
274.30	244.20	121.74	245.61	123.15	252.69	130.23	27.10	14.85
274.20	244.00	121.83	245.42	123.25	252.50	130.33	27.08	14.86
274.10	243.78	121.91	245.20	123.33	252.30	130.43	27.06	14.87
274.00	243.56	121.99	244.98	123.41	252.09	130.52	27.04	14.88
273.90	243.34	122.07	244.77	123.50	251.89	130.62	27.02	14.89
273.80	243.13	122.16	244.56	123.58	251.69	130.71	27.00	14.90
273.70	242.92	122.24	244.35	123.67	251.49	130.81	26.98	14.91
273.60	242.71	122.32	244.14	123.75	251.29	130.91	26.95	14.92
273.50	242.49	122.40	243.93	123.84	251.09	131.00	26.93	14.93
273.40	242.28	122.49	243.71	123.92	250.89	131.10	26.91	14.93
273.30	242.06	122.56	243.50	124.00	250.68	131.19	26.89	14.94
273.20	241.83	122.64	243.27	124.08	250.47	131.28	26.87	14.95

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Dewatering WBM South Pit Inflow (m³/day)	Recovery WBM South Pit Inflow (m³/day)
273.10	241.59	122.70	243.03	124.15	250.24	131.36	26.85	14.96
273.00	241.35	122.77	242.79	124.22	250.02	131.44	26.82	14.97
272.90	241.11	122.84	242.56	124.29	249.79	131.52	26.80	14.97
272.80	240.88	122.91	242.32	124.36	249.57	131.60	26.78	14.98
272.70	240.65	122.98	242.10	124.43	249.35	131.68	26.76	14.99
272.60	240.42	123.05	241.87	124.50	249.14	131.77	26.73	15.00
272.50	240.19	123.12	241.65	124.58	248.92	131.85	26.71	15.00
272.40	239.96	123.19	241.42	124.65	248.71	131.94	26.69	15.01
272.30	239.74	123.26	241.20	124.72	248.50	132.02	26.67	15.02
272.20	239.51	123.33	240.97	124.80	248.28	132.11	26.65	15.03
272.10	239.28	123.40	240.74	124.87	248.07	132.19	26.62	15.04
272.00	239.05	123.47	240.52	124.94	247.85	132.27	26.60	15.04
271.90	238.83	123.54	240.30	125.01	247.64	132.36	26.58	15.05
271.80	238.60	123.61	240.07	125.08	247.42	132.44	26.56	15.06
271.70	238.37	123.68	239.85	125.15	247.21	132.52	26.54	15.07
271.60	238.15	123.75	239.63	125.23	247.00	132.61	26.52	15.08
271.50	237.92	123.82	239.40	125.30	246.79	132.68	26.49	15.08
271.40	237.67	123.88	239.15	125.36	246.55	132.76	26.47	15.09
271.30	237.43	123.93	238.91	125.42	246.32	132.83	26.45	15.10
271.20	237.19	123.99	238.67	125.48	246.09	132.90	26.42	15.10
271.10	236.93	124.04	238.41	125.53	245.85	132.96	26.40	15.11
271.00	236.65	124.09	238.14	125.57	245.59	133.02	26.37	15.11
270.90	236.41	124.14	237.90	125.63	245.35	133.08	26.35	15.12
270.80	236.16	124.19	237.65	125.69	245.11	133.15	26.32	15.13
270.70	235.91	124.25	237.40	125.74	244.88	133.22	26.30	15.13
270.60	235.65	124.29	237.14	125.79	244.63	133.27	26.27	15.14
270.50	235.38	124.34	236.88	125.84	244.38	133.33	26.25	15.14
270.40	235.12	124.38	236.62	125.88	244.12	133.39	26.22	15.15
270.30	234.85	124.42	236.35	125.93	243.87	133.44	26.20	15.15
270.20	234.57	124.46	236.07	125.96	243.60	133.49	26.17	15.16
270.10	234.26	124.48	235.77	125.99	243.30	133.52	26.14	15.16
270.00	233.98	124.51	235.49	126.02	243.03	133.57	26.11	15.17
269.90	233.68	124.54	235.20	126.05	242.75	133.60	26.08	15.17
269.80	233.40	124.57	234.91	126.08	242.48	133.65	26.06	15.17
269.70	233.11	124.60	234.63	126.11	242.20	133.69	26.03	15.18
269.60	232.83	124.63	234.35	126.15	241.94	133.73	26.00	15.18
269.50	232.55	124.66	234.07	126.18	241.67	133.78	25.97	15.19
269.40	232.27	124.69	233.79	126.21	241.39	133.82	25.95	15.19
269.30	231.98	124.72	233.51	126.24	241.12	133.86	25.92	15.19
269.20	231.71	124.76	233.24	126.28	240.86	133.91	25.89	15.20
269.10	231.43	124.79	232.96	126.31	240.60	133.95	25.87	15.20
269.00	231.16	124.82	232.69	126.35	240.34	134.00	25.84	15.21
268.90	230.89	124.85	232.42	126.39	240.08	134.04	25.81	15.21
268.80	230.62	124.89	232.15	126.42	239.82	134.09	25.79	15.21
268.70	230.35	124.92	231.89	126.46	239.56	134.14	25.76	15.22
268.60	230.09	124.96	231.63	126.50	239.32	134.19	25.74	15.22
268.50	229.84	125.01	231.38	126.55	239.08	134.25	25.71	15.23
268.40	229.59	125.05	231.13	126.59	238.84	134.30	25.69	15.23
268.30	229.34	125.09	230.88	126.64	238.60	134.36	25.66	15.24
268.20	229.09	125.13	230.63	126.68	238.36	134.41	25.64	15.24
268.10	228.84	125.18	230.39	126.73	238.13	134.47	25.62	15.25
268.00	228.59	125.22	230.14	126.77	237.89	134.52	25.59	15.25
267.90	228.34	125.26	229.90	126.82	237.66	134.58	25.57	15.26
267.80	228.10	125.31	229.66	126.86	237.43	134.64	25.54	15.27
267.70	227.86	125.35	229.41	126.91	237.20	134.69	25.52	15.27
267.60	227.61	125.40	229.17	126.96	236.97	134.75	25.50	15.28
267.50	227.37	125.44	228.93	127.00	236.74	134.81	25.47	15.28
267.40	227.14	125.49	228.70	127.05	236.52	134.87	25.45	15.29
267.30	226.90	125.54	228.46	127.10	236.29	134.93	25.43	15.29
267.20	226.64	125.57	228.21	127.14	236.05	134.97	25.40	15.30
267.10	226.37	125.60	227.94	127.17	235.79	135.02	25.38	15.30
267.00	226.12	125.63	227.69	127.21	235.55	135.06	25.35	15.30
266.90	225.87	125.67	227.44	127.25	235.31	135.12	25.33	15.31
266.80	225.63	125.71	227.20	127.29	235.08	135.17	25.31	15.31
266.70	225.39	125.76	226.97	127.34	234.86	135.23	25.28	15.32
266.60	225.16	125.81	226.74	127.39	234.65	135.29	25.26	15.32
266.50	224.94	125.86	226.52	127.44	234.43	135.35	25.24	15.33
266.40	224.72	125.91	226.30	127.49	234.22	135.42	25.22	15.34
266.30	224.49	125.96	226.08	127.55	234.01	135.48	25.20	15.34
266.20	224.26	126.01	225.85	127.59	233.80	135.54	25.17	15.35
266.10	224.02	126.04	225.61	127.63	233.57	135.59	25.15	15.35
266.00	223.75	126.07	225.34	127.66	233.31	135.63	25.12	15.36
265.90	223.48	126.09	225.08	127.69	233.06	135.67	25.10	15.36
265.80	223.24	126.13	224.84	127.73	232.82	135.72	25.07	15.36
265.70	223.00	126.17	224.60	127.77	232.60	135.77	25.05	15.37
265.60	222.78	126.22	224.38	127.82	232.39	135.83	25.03	15.37
265.50	222.55	126.26	224.15	127.86	232.17	135.89	25.01	15.38
265.40	222.31	126.30	223.92	127.91	231.95	135.94	24.98	15.38
265.30	222.07	126.34	223.68	127.95	231.72	135.99	24.96	15.39
265.20	221.82	126.37	223.43	127.98	231.49	136.03	24.94	15.39
265.10	221.55	126.39	223.16	128.00	231.23	136.07	24.91	15.39
265.00	221.26	126.39	222.87	128.01	230.95	136.08	24.88	15.40
264.90	220.94	126.39	222.56	128.00	230.64	136.09	24.85	15.40
264.80	220.66	126.39	222.27	128.01	230.37	136.11	24.82	15.40
264.70	220.39	126.41	222.01	128.03	230.11	136.14	24.80	15.40
264.60	220.12	126.43	221.74	128.05	229.86	136.17	24.77	15.40
264.50	219.85	126.45	221.48	128.07	229.60	136.20	24.75	15.41
264.40	219.57	126.46	221.20	128.09	229.33	136.22	24.72	15.41
264.30	219.30	126.48	220.93	128.11	229.07	136.25	24.69	15.41
264.20	219.03	126.49	220.66	128.12	228.82	136.28	24.67	15.41
264.10	218.74	126.50	220.37	128.13	228.54	136.29	24.64	15.41
264.00	218.43	126.49	220.07	128.12	228.24	136.30	24.61	15.41
263.90	218.14	126.49	219.78	128.13	227.96	136.31	24.58	15.42
263.80	217.87	126.50	219.51	128.14	227.70	136.34	24.55	15.42
263.70	217.61	126.52	219.25	128.16	227.45	136.37	24.53	15.42
263.60	217.34	126.54	218.98	128.18	227.20	136.39	24.50	15.42
263.50	217.08	126.55	218.72	128.20	226.95	136.42	24.48	15.43
263.40	216.83	126.58	218.48	128.22	226.71	136.46	24.45	15.43
263.30	216.59	126.61	218.24	128.26	226.48	136.50	24.43	15.43
263.20	216.34	126.63	217.99	128.28	226.25	136.54	24.41	15.44
263.10	216.11	126.66	217.76	128.32	226.03	136.58	24.38	15.44
263.00	215.88	126.70	217.54	128.35	225.82	136.63	24.36	15.44

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Dewatering WBM South Pit Inflow (m³/day)	Recovery WBM South Pit Inflow (m³/day)
262.90	215.65	126.73	217.31	128.39	225.60	136.68	24.34	15.45
262.80	215.41	126.76	217.07	128.42	225.37	136.72	24.32	15.45
262.70	215.16	126.78	216.83	128.45	225.14	136.76	24.29	15.45
262.60	214.92	126.81	216.58	128.47	224.91	136.79	24.27	15.46
262.50	214.68	126.83	216.34	128.50	224.68	136.83	24.25	15.46
262.40	214.42	126.85	216.09	128.52	224.44	136.86	24.22	15.46
262.30	214.15	126.85	215.82	128.52	224.17	136.88	24.19	15.46
262.20	213.88	126.86	215.55	128.53	223.91	136.90	24.17	15.47
262.10	213.59	126.86	215.27	128.53	223.64	136.91	24.14	15.47
262.00	213.32	126.86	214.99	128.54	223.38	136.92	24.11	15.47
261.90	213.04	126.86	214.72	128.54	223.11	136.94	24.09	15.47
261.80	212.75	126.86	214.43	128.54	222.83	136.94	24.06	15.47
261.70	212.46	126.85	214.14	128.53	222.56	136.95	24.03	15.47
261.60	212.17	126.84	213.85	128.53	222.27	136.95	24.00	15.47
261.50	211.86	126.82	213.55	128.51	221.98	136.94	23.97	15.47
261.40	211.52	126.79	213.21	128.48	221.65	136.92	23.94	15.47
261.30	211.15	126.73	212.84	128.42	221.29	136.87	23.90	15.46
261.20	210.75	126.65	212.44	128.34	220.90	136.80	23.86	15.46
261.10	210.33	126.56	212.02	128.26	220.48	136.72	23.82	15.45
261.00	209.87	126.46	211.57	128.15	220.04	136.62	23.78	15.44
260.90	209.37	126.31	211.06	128.01	219.54	136.48	23.73	15.43
260.80	208.82	126.15	210.52	127.84	218.99	136.32	23.68	15.41
260.70	208.24	125.96	209.94	127.66	218.42	136.14	23.62	15.39
260.60	207.61	125.74	209.31	127.44	217.79	135.92	23.56	15.37
260.50	206.94	125.50	208.63	127.19	217.12	135.68	23.50	15.35
260.40	206.25	125.24	207.94	126.93	216.43	135.42	23.43	15.33
260.30	205.54	124.97	207.24	126.67	215.73	135.15	23.36	15.30
260.20	204.74	124.64	206.44	126.34	214.92	134.82	23.28	15.27
260.10	203.89	124.29	205.59	125.98	214.07	134.46	23.20	15.24
260.00	203.03	123.92	204.73	125.62	213.21	134.10	23.12	15.21
259.90	202.16	123.55	203.86	125.24	212.33	133.72	23.03	15.17
259.80	201.37	123.22	203.06	124.92	211.53	133.39	22.96	15.14
259.70	200.58	122.90	202.27	124.59	210.74	133.06	22.88	15.11
259.60	199.90	122.64	201.60	124.33	210.07	132.81	22.81	15.09
259.50	199.34	122.45	201.04	124.15	209.52	132.62	22.76	15.07
259.40	198.83	122.29	200.53	123.99	209.00	132.47	22.71	15.06
259.30	198.34	122.15	200.04	123.84	208.53	132.33	22.66	15.04
259.20	197.86	122.00	199.56	123.70	208.05	132.19	22.62	15.03
259.10	197.41	121.88	199.11	123.58	207.60	132.07	22.57	15.02
259.00	196.97	121.77	198.67	123.47	207.18	131.97	22.53	15.01
258.90	196.55	121.66	198.26	123.36	206.76	131.87	22.49	15.00
258.80	196.14	121.56	197.84	123.26	206.36	131.78	22.45	14.99
258.70	195.75	121.47	197.45	123.17	205.97	131.69	22.41	14.98
258.60	195.35	121.38	197.06	123.08	205.59	131.61	22.37	14.98
258.50	194.96	121.28	196.67	122.99	205.21	131.53	22.34	14.97
258.40	194.60	121.21	196.31	122.92	204.85	131.46	22.30	14.96
258.30	194.25	121.15	195.96	122.86	204.51	131.41	22.27	14.96
258.20	193.91	121.08	195.62	122.80	204.18	131.36	22.23	14.95
258.10	193.57	121.02	195.28	122.74	203.85	131.31	22.20	14.95
258.00	193.23	120.96	194.94	122.68	203.52	131.25	22.17	14.94
257.90	192.89	120.90	194.61	122.62	203.19	131.20	22.13	14.93
257.80	192.55	120.84	194.27	122.55	202.86	131.15	22.10	14.93
257.70	192.21	120.78	193.93	122.50	202.53	131.10	22.07	14.92
257.60	191.90	120.73	193.62	122.45	202.23	131.06	22.04	14.92
257.50	191.58	120.68	193.30	122.40	201.92	131.02	22.01	14.92
257.40	191.23	120.61	192.95	122.33	201.58	130.96	21.97	14.91
257.30	190.86	120.52	192.59	122.25	201.22	130.89	21.94	14.90
257.20	190.51	120.45	192.24	122.18	200.88	130.82	21.90	14.90
257.10	190.19	120.40	191.92	122.13	200.57	130.78	21.87	14.89
257.00	189.88	120.35	191.61	122.08	200.27	130.74	21.84	14.89
256.90	189.57	120.30	191.30	122.03	199.97	130.70	21.81	14.88
256.80	189.25	120.25	190.99	121.98	199.66	130.66	21.78	14.88
256.70	188.92	120.18	190.65	121.92	199.34	130.61	21.75	14.87
256.60	188.57	120.11	190.31	121.85	199.01	130.54	21.71	14.87
256.50	188.25	120.05	189.99	121.79	198.69	130.49	21.68	14.86
256.40	187.92	119.99	189.66	121.73	198.37	130.44	21.65	14.86
256.30	187.59	119.92	189.33	121.67	198.05	130.38	21.62	14.85
256.20	187.29	119.88	189.03	121.63	197.78	130.37	21.59	14.85
256.10	187.00	119.84	188.76	121.60	197.53	130.37	21.56	14.85
256.00	186.73	119.82	188.49	121.57	197.28	130.37	21.53	14.84
255.90	186.45	119.78	188.21	121.54	197.03	130.36	21.51	14.84
255.80	186.16	119.74	187.93	121.51	196.78	130.36	21.48	14.84
255.70	185.88	119.71	187.66	121.48	196.53	130.36	21.45	14.83
255.60	185.61	119.68	187.39	121.46	196.29	130.36	21.43	14.83
255.50	185.32	119.64	187.11	121.42	196.03	130.35	21.40	14.83
255.40	185.01	119.58	186.80	121.37	195.76	130.33	21.37	14.82
255.30	184.71	119.53	186.51	121.33	195.49	130.31	21.34	14.82
255.20	184.41	119.48	186.21	121.28	195.22	130.29	21.31	14.82
255.10	184.11	119.43	185.92	121.24	194.95	130.27	21.28	14.81
255.00	183.82	119.39	185.63	121.20	194.69	130.26	21.25	14.81
254.90	183.52	119.33	185.33	121.15	194.42	130.24	21.22	14.80
254.80	183.24	119.30	185.07	121.12	194.18	130.24	21.19	14.80
254.70	182.97	119.26	184.80	121.09	193.94	130.24	21.17	14.80
254.60	182.70	119.23	184.54	121.07	193.71	130.24	21.14	14.79
254.50	182.44	119.21	184.28	121.05	193.48	130.24	21.12	14.79
254.40	182.18	119.18	184.02	121.02	193.25	130.25	21.09	14.79
254.30	181.90	119.14	183.75	120.99	193.00	130.24	21.06	14.79
254.20	181.62	119.10	183.48	120.95	192.76	130.23	21.04	14.78
254.10	181.36	119.07	183.23	120.93	192.53	130.24	21.01	14.78
254.00	181.10	119.04	182.96	120.90	192.29	130.23	20.98	14.78
253.90	180.81	118.99	182.68	120.86	192.04	130.22	20.96	14.77
253.80	180.54	118.95	182.41	120.83	191.80	130.21	20.93	14.77
253.70	180.27	118.92	182.15	120.80	191.56	130.21	20.90	14.77
253.60	180.01	118.89	181.89	120.77	191.33	130.21	20.88	14.77
253.50	179.75	118.86	181.64	120.75	191.11	130.21	20.85	14.76
253.40	179.48	118.82	181.38	120.72	190.88	130.21	20.83	14.76
253.30	179.22	118.79	181.12	120.69	190.64	130.21	20.80	14.76
253.20	178.96	118.75	180.87	120.66	190.41	130.21	20.78	14.76
253.10	178.70	118.72	180.62	120.64	190.19	130.21	20.75	14.75
253.00	178.44	118.69	180.36	120.61	189.96	130.21	20.73	14.75
252.90	178.16	118.64	180.09	120.57	189.71	130.20	20.70	14.75
252.80	177.90	118.61	179.83	120.54	189.49	130.20	20.67	14.74

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Dewatering WBM South Pit Inflow (m³/day)	Recovery WBM South Pit Inflow (m³/day)
252.70	177.64	118.58	179.58	120.51	189.26	130.19	20.65	14.74
252.60	177.35	118.52	179.29	120.46	189.00	130.17	20.62	14.74
252.50	177.03	118.44	178.98	120.39	188.71	130.13	20.59	14.73
252.40	176.74	118.39	178.69	120.34	188.46	130.10	20.56	14.72
252.30	176.44	118.33	178.40	120.28	188.19	130.07	20.53	14.72
252.20	176.18	118.29	178.14	120.25	187.96	130.07	20.50	14.72
252.10	175.91	118.25	177.88	120.22	187.73	130.06	20.48	14.71
252.00	175.66	118.21	177.63	120.19	187.50	130.06	20.45	14.71
251.90	175.38	118.17	177.36	120.15	187.26	130.04	20.43	14.70
251.80	175.09	118.11	177.07	120.09	187.00	130.02	20.40	14.70
251.70	174.79	118.04	176.78	120.03	186.73	129.98	20.37	14.69
251.60	174.47	117.96	176.46	119.96	186.44	129.94	20.34	14.69
251.50	174.15	117.88	176.15	119.89	186.16	129.89	20.31	14.68
251.40	173.87	117.82	175.87	119.83	185.91	129.87	20.28	14.67
251.30	173.59	117.78	175.60	119.79	185.67	129.85	20.25	14.67
251.20	173.29	117.71	175.31	119.72	185.40	129.81	20.22	14.66
251.10	172.95	117.61	174.98	119.64	185.09	129.75	20.19	14.65
251.00	172.64	117.54	174.67	119.57	184.82	129.71	20.16	14.65
250.90	172.34	117.47	174.38	119.50	184.55	129.68	20.13	14.64
250.80	172.05	117.40	174.09	119.44	184.29	129.64	20.10	14.64
250.70	171.76	117.34	173.80	119.39	184.03	129.61	20.07	14.63
250.60	171.48	117.28	173.53	119.33	183.79	129.59	20.04	14.63
250.50	171.21	117.23	173.26	119.29	183.54	129.57	20.02	14.62
250.40	170.95	117.19	173.01	119.25	183.32	129.56	19.99	14.62
250.30	170.67	117.13	172.74	119.20	183.07	129.53	19.97	14.61
250.20	170.40	117.08	172.47	119.15	182.84	129.52	19.94	14.61
250.10	170.16	117.05	172.24	119.12	182.63	129.51	19.92	14.60
250.00	169.91	117.01	171.99	119.09	182.41	129.51	19.89	14.60
249.90	169.65	116.96	171.74	119.05	182.19	129.50	19.87	14.60
249.80	169.39	116.92	171.49	119.01	181.96	129.48	19.84	14.59
249.70	169.16	116.89	171.25	118.99	181.75	129.48	19.82	14.59
249.60	168.91	116.85	171.02	118.96	181.54	129.48	19.79	14.59
249.50	168.68	116.82	170.79	118.93	181.34	129.48	19.77	14.58
249.40	168.45	116.80	170.57	118.91	181.15	129.49	19.75	14.58
249.30	168.23	116.77	170.35	118.89	180.96	129.50	19.73	14.58
249.20	167.99	116.74	170.11	118.86	180.75	129.50	19.70	14.58
249.10	167.74	116.70	169.88	118.83	180.54	129.49	19.68	14.57
249.00	167.50	116.66	169.64	118.80	180.33	129.49	19.66	14.57
248.90	167.26	116.63	169.41	118.77	180.12	129.48	19.63	14.57
248.80	167.04	116.60	169.18	118.75	179.93	129.49	19.61	14.57
248.70	166.80	116.57	168.96	118.72	179.73	129.49	19.59	14.56
248.60	166.59	116.55	168.75	118.70	179.54	129.50	19.57	14.56
248.50	166.38	116.53	168.54	118.69	179.37	129.52	19.55	14.56
248.40	166.16	116.51	168.33	118.68	179.18	129.53	19.52	14.56
248.30	165.93	116.48	168.11	118.65	178.99	129.53	19.50	14.56
248.20	165.70	116.44	167.88	118.62	178.78	129.53	19.48	14.55
248.10	165.45	116.40	167.64	118.59	178.57	129.52	19.45	14.55
248.00	165.23	116.37	167.42	118.56	178.38	129.52	19.43	14.55
247.90	165.01	116.34	167.21	118.54	178.19	129.53	19.41	14.54
247.80	164.79	116.32	166.99	118.52	178.01	129.54	19.39	14.54
247.70	164.57	116.29	166.78	118.50	177.82	129.54	19.37	14.54
247.60	164.32	116.24	166.53	118.46	177.60	129.53	19.34	14.54
247.50	164.08	116.20	166.30	118.42	177.39	129.52	19.32	14.53
247.40	163.83	116.16	166.06	118.38	177.18	129.51	19.30	14.53
247.30	163.61	116.13	165.84	118.36	176.99	129.51	19.27	14.53
247.20	163.37	116.08	165.60	118.32	176.78	129.50	19.25	14.52
247.10	163.14	116.05	165.39	118.29	176.59	129.50	19.23	14.52
247.00	162.92	116.02	165.17	118.27	176.40	129.50	19.21	14.52
246.90	162.69	115.98	164.94	118.24	176.20	129.50	19.18	14.51
246.80	162.48	115.96	164.74	118.22	176.03	129.51	19.16	14.51
246.70	162.26	115.93	164.52	118.19	175.84	129.51	19.14	14.51
246.60	162.02	115.89	164.29	118.16	175.64	129.50	19.12	14.50
246.50	161.79	115.85	164.06	118.12	175.43	129.49	19.09	14.50
246.40	161.53	115.79	163.81	118.07	175.21	129.47	19.07	14.50
246.30	161.26	115.72	163.55	118.01	174.98	129.44	19.04	14.49
246.20	161.01	115.67	163.30	117.96	174.76	129.42	19.02	14.48
246.10	160.78	115.63	163.08	117.92	174.56	129.41	19.00	14.48
246.00	160.55	115.59	162.85	117.89	174.37	129.40	18.97	14.48
245.90	160.32	115.55	162.63	117.86	174.17	129.40	18.95	14.47
245.80	160.09	115.51	162.40	117.82	173.97	129.39	18.93	14.47
245.70	159.85	115.46	162.17	117.78	173.76	129.37	18.90	14.47
245.60	159.61	115.41	161.93	117.74	173.56	129.36	18.88	14.46
245.50	159.36	115.35	161.69	117.68	173.34	129.34	18.86	14.46
245.40	159.05	115.26	161.39	117.59	173.07	129.27	18.83	14.45
245.30	158.75	115.16	161.09	117.51	172.80	129.22	18.80	14.44
245.20	158.50	115.11	160.85	117.45	172.59	129.19	18.77	14.43
245.10	158.24	115.04	160.60	117.40	172.37	129.17	18.75	14.43
245.00	157.99	114.98	160.35	117.34	172.15	129.14	18.72	14.42
244.90	157.75	114.93	160.11	117.29	171.94	129.12	18.70	14.42
244.80	157.52	114.89	159.89	117.26	171.75	129.11	18.68	14.41
244.70	157.32	114.86	159.70	117.24	171.58	129.12	18.66	14.41
244.60	157.12	114.84	159.50	117.22	171.41	129.13	18.64	14.41
244.50	156.92	114.82	159.31	117.20	171.25	129.15	18.62	14.41
244.40	156.72	114.79	159.11	117.18	171.08	129.16	18.60	14.40
244.30	156.50	114.75	158.90	117.15	170.90	129.15	18.58	14.40
244.20	156.27	114.71	158.67	117.11	170.70	129.14	18.55	14.40
244.10	156.03	114.65	158.44	117.07	170.50	129.13	18.53	14.39
244.00	155.80	114.61	158.22	117.02	170.31	129.11	18.51	14.39
243.90	155.57	114.56	157.99	116.98	170.11	129.10	18.48	14.38
243.80	155.34	114.51	157.77	116.94	169.92	129.09	18.46	14.38
243.70	155.10	114.45	157.53	116.89	169.71	129.07	18.44	14.37
243.60	154.83	114.38	157.28	116.82	169.49	129.04	18.41	14.37
243.50	154.60	114.33	157.05	116.78	169.29	129.02	18.39	14.36
243.40	154.38	114.29	156.84	116.74	169.11	129.02	18.37	14.36
243.30	154.16	114.24	156.62	116.70	168.92	129.01	18.35	14.35
243.20	153.92	114.19	156.39	116.66	168.72	128.99	18.32	14.35
243.10	153.67	114.13	156.15	116.60	168.51	128.96	18.30	14.34
243.00	153.41	114.05	155.89	116.53	168.29	128.92	18.27	14.34
242.90	153.17	113.99	155.65	116.47	168.08	128.90	18.25	14.33
242.80	152.92	113.92	155.41	116.42	167.87	128.87	18.22	14.32
242.70	152.65	113.84	155.14	116.34	167.63	128.83	18.20	14.32
242.60	152.37	113.75	154.87	116.25	167.39	128.77	18.17	14.31

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Dewatering WBM South Pit Inflow (m³/day)	Recovery WBM South Pit Inflow (m³/day)
242.50	152.00	113.60	154.51	116.11	167.06	128.66	18.13	14.29
242.40	151.71	113.50	154.23	116.02	166.81	128.60	18.11	14.28
242.30	151.47	113.44	153.99	115.96	166.61	128.57	18.08	14.28
242.20	151.24	113.38	153.77	115.91	166.41	128.55	18.06	14.27
242.10	150.99	113.32	153.53	115.85	166.20	128.53	18.04	14.27
242.00	150.71	113.22	153.25	115.76	165.95	128.47	18.01	14.26
241.90	150.43	113.13	152.98	115.68	165.72	128.41	17.98	14.25
241.80	150.12	113.01	152.67	115.56	165.44	128.33	17.95	14.24
241.70	149.77	112.86	152.33	115.42	165.13	128.23	17.91	14.22
241.60	149.44	112.74	152.01	115.30	164.84	128.14	17.88	14.21
241.50	149.11	112.61	151.69	115.18	164.55	128.04	17.85	14.20
241.40	148.78	112.47	151.36	115.05	164.25	127.95	17.82	14.19
241.30	148.42	112.32	151.01	114.90	163.94	127.83	17.78	14.17
241.20	148.01	112.12	150.60	114.71	163.56	127.67	17.74	14.15
241.10	147.54	111.88	150.14	114.48	163.14	127.48	17.70	14.13
241.00	147.09	111.66	149.70	114.26	162.72	127.29	17.65	14.11
240.90	146.57	111.37	149.18	113.98	162.24	127.04	17.60	14.08
240.80	145.99	111.05	148.61	113.67	161.71	126.76	17.54	14.05
240.70	145.41	110.72	148.03	113.34	161.16	126.47	17.49	14.02
240.60	144.66	110.27	147.30	112.90	160.46	126.06	17.41	13.97
240.50	143.98	109.86	146.62	112.50	159.82	125.70	17.35	13.94
240.40	143.39	109.52	146.04	112.17	159.27	125.40	17.29	13.90
240.30	142.78	109.17	145.43	111.82	158.70	125.09	17.23	13.87
240.20	142.20	108.84	144.86	111.50	158.16	124.80	17.17	13.84
240.10	141.68	108.55	144.35	111.22	157.69	124.55	17.12	13.81
240.00	141.22	108.31	143.90	110.98	157.27	124.35	17.08	13.79
239.90	140.78	108.08	143.46	110.76	156.86	124.16	17.03	13.76
239.80	140.35	107.86	143.04	110.55	156.47	123.98	16.99	13.74
239.70	139.94	107.66	142.64	110.35	156.10	123.82	16.95	13.72
239.60	139.55	107.47	142.25	110.16	155.75	123.66	16.91	13.70
239.50	139.17	107.28	141.87	109.99	155.40	123.52	16.88	13.69
239.40	138.80	107.10	141.51	109.82	155.07	123.38	16.84	13.67
239.30	138.43	106.93	141.15	109.65	154.74	123.24	16.80	13.65
239.20	138.06	106.75	140.79	109.48	154.41	123.10	16.77	13.64
239.10	137.68	106.56	140.41	109.30	154.07	122.95	16.73	13.62
239.00	137.33	106.40	140.07	109.14	153.76	122.83	16.69	13.60
238.90	136.99	106.24	139.73	108.99	153.46	122.71	16.66	13.59
238.80	136.66	106.09	139.41	108.84	153.16	122.60	16.63	13.57
238.70	136.31	105.93	139.07	108.69	152.86	122.48	16.59	13.56
238.60	136.00	105.79	138.76	108.56	152.58	122.37	16.56	13.54
238.50	135.69	105.66	138.46	108.43	152.31	122.28	16.53	13.53
238.40	135.39	105.53	138.16	108.31	152.05	122.19	16.50	13.52
238.30	135.10	105.41	137.88	108.19	151.79	122.11	16.47	13.51
238.20	134.80	105.29	137.59	108.07	151.54	122.02	16.45	13.49
238.10	134.47	105.13	137.27	107.93	151.25	121.91	16.41	13.48
238.00	134.16	105.00	136.96	107.80	150.97	121.81	16.38	13.47
237.90	133.87	104.87	136.68	107.68	150.72	121.72	16.35	13.45
237.80	133.58	104.75	136.39	107.56	150.46	121.63	16.32	13.44
237.70	133.28	104.62	136.10	107.44	150.21	121.55	16.30	13.43
237.60	132.97	104.48	135.80	107.31	149.94	121.44	16.27	13.42
237.50	132.55	104.26	135.39	107.09	149.56	121.26	16.22	13.39
237.40	132.20	104.08	135.04	106.92	149.24	121.12	16.19	13.38
237.30	131.86	103.92	134.71	106.77	148.95	121.00	16.16	13.36
237.20	131.53	103.76	134.38	106.61	148.65	120.88	16.12	13.35
237.10	131.16	103.57	134.02	106.43	148.32	120.73	16.09	13.33
237.00	130.81	103.40	133.68	106.26	148.01	120.60	16.05	13.31
236.90	130.43	103.20	133.31	106.07	147.67	120.44	16.02	13.29
236.80	130.00	102.96	132.88	105.84	147.28	120.24	15.97	13.27
236.70	129.65	102.79	132.54	105.67	146.97	120.10	15.94	13.25
236.60	129.31	102.62	132.21	105.51	146.67	119.98	15.91	13.24
236.50	128.93	102.42	131.83	105.31	146.32	119.81	15.87	13.22
236.40	128.53	102.20	131.43	105.10	145.96	119.63	15.83	13.19
236.30	128.16	102.00	131.07	104.91	145.63	119.47	15.79	13.18
236.20	127.79	101.81	130.71	104.73	145.30	119.32	15.76	13.16
236.10	127.43	101.62	130.35	104.55	144.98	119.17	15.72	13.14
236.00	127.08	101.44	130.01	104.37	144.67	119.03	15.69	13.12
235.90	126.76	101.29	129.70	104.22	144.39	118.92	15.65	13.11
235.80	126.46	101.15	129.41	104.09	144.13	118.82	15.62	13.09
235.70	126.19	101.03	129.14	103.98	143.89	118.73	15.60	13.08
235.60	125.92	100.91	128.88	103.87	143.67	118.66	15.57	13.07
235.50	125.67	100.81	128.64	103.77	143.46	118.60	15.55	13.06
235.40	125.42	100.70	128.39	103.68	143.24	118.53	15.52	13.05
235.30	125.17	100.60	128.15	103.58	143.03	118.47	15.50	13.04
235.20	124.92	100.50	127.91	103.49	142.83	118.41	15.47	13.03
235.10	124.67	100.40	127.66	103.39	142.62	118.34	15.45	13.02
235.00	124.41	100.28	127.41	103.28	142.39	118.27	15.42	13.01
234.90	124.12	100.14	127.12	103.15	142.14	118.17	15.39	13.00
234.80	123.82	100.01	126.83	103.02	141.89	118.07	15.36	12.98
234.70	123.53	99.87	126.55	102.88	141.63	117.97	15.34	12.97
234.60	123.24	99.73	126.27	102.75	141.39	117.87	15.31	12.96
234.50	122.96	99.60	125.99	102.63	141.14	117.78	15.28	12.94
234.40	122.63	99.42	125.67	102.46	140.85	117.65	15.25	12.93
234.30	122.32	99.27	125.37	102.32	140.59	117.54	15.22	12.91
234.20	122.01	99.12	125.06	102.17	140.32	117.42	15.19	12.90
234.10	121.71	98.97	124.77	102.02	140.06	117.31	15.16	12.88
234.00	121.38	98.79	124.45	101.86	139.77	117.18	15.12	12.86
233.90	121.03	98.60	124.10	101.67	139.46	117.03	15.09	12.85
233.80	120.73	98.45	123.81	101.53	139.20	116.92	15.06	12.83
233.70	120.45	98.32	123.54	101.40	138.96	116.83	15.03	12.82
233.60	120.17	98.18	123.26	101.27	138.72	116.73	15.00	12.80
233.50	119.91	98.06	123.01	101.16	138.50	116.66	14.98	12.79
233.40	119.65	97.94	122.75	101.05	138.28	116.58	14.95	12.78
233.30	119.38	97.81	122.49	100.93	138.05	116.49	14.93	12.77
233.20	119.12	97.69	122.23	100.81	137.83	116.41	14.90	12.76
233.10	118.84	97.56	121.97	100.69	137.60	116.32	14.87	12.74
233.00	118.58	97.44	121.71	100.57	137.37	116.23	14.85	12.73
232.90	118.32	97.32	121.46	100.46	137.16	116.16	14.82	12.72
232.80	118.07	97.21	121.22	100.35	136.95	116.08	14.80	12.71
232.70	117.84	97.11	120.99	100.26	136.76	116.02	14.77	12.70
232.60	117.61	97.01	120.77	100.17	136.57	115.97	14.75	12.69
232.50	117.38	96.91	120.55	100.08	136.38	115.91	14.73	12.68
232.40	117.15	96.82	120.32	99.99	136.19	115.86	14.71	12.67

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Dewatering WBM South Pit Inflow (m³/day)	Recovery WBM South Pit Inflow (m³/day)
232.30	116.92	96.71	120.10	99.89	136.00	115.79	14.68	12.66
232.20	116.62	96.56	119.81	99.74	135.74	115.68	14.65	12.65
232.10	116.34	96.42	119.54	99.61	135.51	115.58	14.63	12.63
232.00	116.10	96.31	119.30	99.51	135.31	115.52	14.60	12.62
231.90	115.89	96.23	119.10	99.43	135.14	115.47	14.58	12.61
231.80	115.67	96.14	118.89	99.35	134.96	115.42	14.56	12.61
231.70	115.44	96.03	118.66	99.25	134.76	115.36	14.54	12.60
231.60	115.20	95.92	118.43	99.15	134.57	115.29	14.51	12.58
231.50	114.97	95.82	118.20	99.05	134.37	115.22	14.49	12.57
231.40	114.73	95.71	117.97	98.95	134.17	115.16	14.47	12.56
231.30	114.49	95.60	117.74	98.85	133.98	115.09	14.44	12.55
231.20	114.28	95.51	117.53	98.76	133.80	115.04	14.42	12.54
231.10	114.06	95.42	117.32	98.68	133.63	114.99	14.40	12.54
231.00	113.84	95.33	117.11	98.59	133.45	114.94	14.38	12.53
230.90	113.63	95.23	116.90	98.51	133.28	114.89	14.36	12.52
230.80	113.40	95.14	116.69	98.42	133.10	114.83	14.33	12.51
230.70	113.17	95.03	116.46	98.32	132.90	114.76	14.31	12.50
230.60	112.94	94.92	116.24	98.22	132.71	114.70	14.29	12.49
230.50	112.72	94.83	116.02	98.13	132.53	114.64	14.27	12.48
230.40	112.50	94.73	115.81	98.04	132.35	114.58	14.24	12.47
230.30	112.28	94.63	115.60	97.95	132.18	114.53	14.22	12.46
230.20	112.07	94.54	115.39	97.86	132.00	114.48	14.20	12.45
230.10	111.85	94.44	115.18	97.77	131.83	114.42	14.18	12.44
230.00	111.63	94.34	114.97	97.68	131.65	114.36	14.16	12.43
229.90	111.42	94.25	114.76	97.59	131.47	114.31	14.14	12.42
229.80	111.20	94.16	114.55	97.51	131.30	114.26	14.12	12.41
229.70	110.99	94.06	114.35	97.42	131.13	114.20	14.10	12.40
229.60	110.77	93.96	114.13	97.33	130.95	114.14	14.07	12.39
229.50	110.55	93.86	113.92	97.24	130.78	114.09	14.05	12.38
229.40	110.31	93.74	113.68	97.12	130.57	114.01	14.03	12.37
229.30	110.05	93.61	113.43	96.99	130.35	113.91	14.00	12.36
229.20	109.80	93.48	113.19	96.87	130.14	113.83	13.98	12.35
229.10	109.57	93.37	112.97	96.77	129.96	113.76	13.96	12.34
229.00	109.34	93.26	112.75	96.67	129.77	113.69	13.93	12.32
228.90	109.10	93.14	112.51	96.55	129.57	113.61	13.91	12.31
228.80	108.86	93.02	112.28	96.44	129.37	113.53	13.88	12.30
228.70	108.62	92.90	112.04	96.32	129.17	113.45	13.86	12.29
228.60	108.38	92.78	111.81	96.21	128.97	113.37	13.84	12.28
228.50	108.14	92.66	111.58	96.10	128.77	113.29	13.81	12.27
228.40	107.90	92.54	111.35	95.98	128.58	113.21	13.79	12.25
228.30	107.66	92.41	111.11	95.87	128.37	113.13	13.77	12.24
228.20	107.40	92.28	110.86	95.74	128.16	113.04	13.74	12.23
228.10	107.15	92.15	110.62	95.61	127.95	112.95	13.72	12.21
228.00	106.90	92.01	110.37	95.49	127.74	112.86	13.69	12.20
227.90	106.65	91.88	110.13	95.36	127.53	112.77	13.67	12.19
227.80	106.42	91.76	109.90	95.25	127.34	112.69	13.64	12.18
227.70	106.18	91.64	109.67	95.13	127.14	112.61	13.62	12.17
227.60	105.91	91.49	109.41	95.00	126.92	112.50	13.59	12.15
227.50	105.53	91.25	109.04	94.76	126.58	112.30	13.55	12.13
227.40	105.20	91.04	108.72	94.56	126.29	112.14	13.52	12.11
227.30	104.90	90.87	108.42	94.39	126.03	112.00	13.49	12.09
227.20	104.58	90.67	108.11	94.20	125.76	111.85	13.46	12.07
227.10	104.30	90.51	107.84	94.04	125.52	111.73	13.43	12.05
227.00	104.00	90.33	107.55	93.87	125.26	111.59	13.40	12.04
226.90	103.71	90.16	107.26	93.71	125.01	111.46	13.37	12.02
226.80	103.44	90.00	106.99	93.56	124.78	111.35	13.35	12.00
226.70	103.15	89.83	106.71	93.40	124.54	111.22	13.32	11.99
226.60	102.87	89.67	106.44	93.24	124.30	111.10	13.29	11.97
226.50	102.58	89.50	106.16	93.08	124.05	110.97	13.26	11.95
226.40	102.29	89.33	105.88	92.91	123.81	110.84	13.23	11.94
226.30	102.02	89.16	105.61	92.76	123.57	110.72	13.21	11.92
226.20	101.72	88.99	105.32	92.59	123.32	110.58	13.18	11.90
226.10	101.41	88.80	105.02	92.40	123.05	110.43	13.15	11.89
226.00	101.15	88.64	104.76	92.26	122.83	110.32	13.12	11.87
225.90	100.91	88.51	104.53	92.13	122.63	110.23	13.10	11.86
225.80	100.68	88.39	104.31	92.02	122.45	110.15	13.07	11.85
225.70	100.43	88.25	104.07	91.88	122.24	110.06	13.05	11.83
225.60	100.17	88.10	103.81	91.74	122.02	109.94	13.02	11.82
225.50	99.90	87.93	103.54	91.58	121.79	109.83	13.00	11.80
225.40	99.61	87.76	103.27	91.42	121.54	109.69	12.97	11.78
225.30	99.33	87.59	103.00	91.26	121.31	109.57	12.94	11.77
225.20	99.07	87.43	102.74	91.10	121.09	109.45	12.91	11.75
225.10	98.79	87.27	102.47	90.95	120.85	109.33	12.89	11.74
225.00	98.50	87.09	102.19	90.78	120.61	109.20	12.86	11.72
224.90	98.23	86.93	101.93	90.62	120.38	109.08	12.83	11.70
224.80	97.99	86.79	101.68	90.48	120.18	108.98	12.81	11.69
224.70	97.73	86.64	101.44	90.34	119.97	108.87	12.78	11.67
224.60	97.47	86.48	101.19	90.20	119.75	108.76	12.76	11.66
224.50	97.21	86.33	100.93	90.05	119.53	108.65	12.73	11.64
224.40	96.95	86.17	100.68	89.90	119.31	108.54	12.70	11.63
224.30	96.67	85.99	100.40	89.73	119.08	108.41	12.68	11.61
224.20	96.34	85.78	100.09	89.52	118.80	108.24	12.64	11.59
224.10	96.00	85.55	99.75	89.30	118.50	108.05	12.61	11.57
224.00	95.68	85.34	99.43	89.09	118.22	107.88	12.58	11.54
223.90	95.44	85.20	99.21	88.97	118.03	107.79	12.56	11.53
223.80	95.21	85.07	98.98	88.84	117.84	107.70	12.53	11.52
223.70	94.96	84.92	98.74	88.70	117.64	107.60	12.51	11.50
223.60	94.72	84.78	98.51	88.57	117.44	107.50	12.48	11.49
223.50	94.48	84.64	98.27	88.43	117.25	107.40	12.46	11.48
223.40	94.23	84.48	98.03	88.29	117.04	107.29	12.43	11.46
223.30	93.93	84.29	97.74	88.10	116.78	107.15	12.41	11.44
223.20	93.59	84.06	97.41	87.88	116.49	106.96	12.37	11.42
223.10	93.28	83.85	97.10	87.68	116.22	106.80	12.34	11.40
223.00	92.95	83.63	96.79	87.47	115.95	106.62	12.31	11.38
222.90	92.63	83.41	96.47	87.25	115.66	106.45	12.28	11.35
222.80	92.29	83.18	96.14	87.03	115.38	106.26	12.24	11.33
222.70	91.98	82.98	95.84	86.83	115.11	106.10	12.21	11.31
222.60	91.67	82.76	95.53	86.62	114.84	105.93	12.18	11.29
222.50	91.35	82.55	95.22	86.41	114.57	105.76	12.15	11.27
222.40	91.05	82.34	94.92	86.22	114.31	105.60	12.12	11.25
222.30	90.76	82.15	94.64	86.04	114.06	105.46	12.09	11.23
222.20	90.46	81.96	94.36	85.85	113.81	105.31	12.06	11.21

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Dewatering WBM South Pit Inflow (m³/day)	Recovery WBM South Pit Inflow (m³/day)
222.10	90.17	81.76	94.07	85.66	113.57	105.16	12.03	11.19
222.00	89.86	81.55	93.77	85.46	113.31	104.99	12.00	11.17
221.90	89.55	81.33	93.46	85.25	113.03	104.82	11.97	11.15
221.80	89.25	81.13	93.17	85.05	112.78	104.66	11.94	11.13
221.70	88.92	80.91	92.85	84.84	112.50	104.48	11.91	11.11
221.60	88.48	80.57	92.42	84.51	112.10	104.19	11.86	11.07
221.50	88.08	80.28	92.02	84.22	111.75	103.94	11.82	11.04
221.40	87.70	80.00	91.65	83.95	111.42	103.71	11.79	11.02
221.30	87.34	79.74	91.30	83.70	111.10	103.50	11.75	10.99
221.20	86.99	79.49	90.96	83.46	110.80	103.30	11.72	10.97
221.10	86.64	79.23	90.61	83.21	110.49	103.08	11.68	10.94
221.00	86.28	78.98	90.27	82.96	110.18	102.87	11.65	10.92
220.90	85.92	78.71	89.91	82.70	109.86	102.65	11.61	10.89
220.80	85.50	78.39	89.50	82.39	109.49	102.38	11.57	10.86
220.70	85.11	78.10	89.11	82.10	109.14	102.13	11.53	10.83
220.60	84.75	77.83	88.76	81.85	108.83	101.91	11.49	10.80
220.50	84.37	77.56	88.40	81.58	108.50	101.68	11.46	10.78
220.40	83.99	77.27	88.02	81.30	108.16	101.44	11.42	10.75
220.30	83.57	76.95	87.61	80.99	107.79	101.17	11.38	10.72
220.20	83.15	76.62	87.19	80.66	107.41	100.88	11.34	10.68
220.10	82.65	76.23	86.70	80.28	106.96	100.54	11.29	10.64
220.00	82.11	75.80	86.17	79.86	106.47	100.16	11.23	10.60
219.90	81.60	75.39	85.67	79.46	106.01	99.79	11.18	10.56
219.80	81.04	74.93	85.12	79.01	105.49	99.38	11.13	10.52
219.70	80.33	74.34	84.41	78.42	104.83	98.84	11.06	10.46
219.60	79.56	73.69	83.65	77.78	104.10	98.23	10.98	10.39
219.50	78.79	73.04	82.89	77.14	103.39	97.64	10.90	10.33
219.40	77.74	72.12	81.85	76.23	102.38	96.77	10.80	10.24
219.30	76.18	70.74	80.30	74.86	100.88	95.44	10.65	10.10
219.20	73.28	68.11	77.41	72.23	98.04	92.87	10.36	9.84
219.10	71.43	66.44	75.57	70.58	96.24	91.25	10.18	9.68
219.00	70.61	65.73	74.75	69.88	95.47	90.59	10.09	9.61
218.90	70.09	65.31	74.24	69.46	95.00	90.21	10.04	9.56
218.80	69.63	64.93	73.78	69.09	94.58	89.88	10.00	9.53
218.70	69.19	64.57	73.35	68.74	94.18	89.57	9.95	9.49
218.60	68.70	64.17	72.87	68.34	93.74	89.21	9.90	9.45
218.50	68.16	63.72	72.34	67.90	93.25	88.81	9.85	9.41
218.40	67.64	63.29	71.83	67.48	92.78	88.43	9.80	9.36
218.30	67.13	62.87	71.33	67.06	92.32	88.05	9.75	9.32
218.20	66.68	62.49	70.89	66.70	91.91	87.72	9.70	9.29
218.10	66.24	62.13	70.45	66.35	91.52	87.41	9.66	9.25
218.00	65.80	61.77	70.02	65.99	91.13	87.09	9.62	9.21
217.90	65.34	61.39	69.57	65.62	90.71	86.76	9.57	9.18
217.80	64.89	61.01	69.12	65.25	90.30	86.43	9.53	9.14
217.70	64.44	60.64	68.68	64.88	89.90	86.10	9.48	9.10
217.60	63.98	60.26	68.23	64.51	89.49	85.77	9.44	9.06
217.50	63.50	59.86	67.76	64.12	89.06	85.41	9.39	9.02
217.40	62.97	59.41	67.24	63.68	88.57	85.01	9.34	8.98
217.30	62.41	58.92	66.68	63.20	88.05	84.57	9.28	8.93
217.20	61.73	58.34	66.01	62.62	87.43	84.03	9.21	8.87
217.10	60.85	57.55	65.14	61.84	86.60	83.30	9.12	8.79
217.00	59.45	56.27	63.75	60.57	85.24	82.07	8.99	8.67
216.90	58.22	55.16	62.53	59.46	84.06	81.00	8.86	8.56
216.80	57.32	54.35	61.64	58.66	83.21	80.24	8.77	8.48
216.70	56.45	53.57	60.78	57.89	82.39	79.51	8.69	8.40
216.60	55.63	52.83	59.96	57.16	81.62	78.82	8.61	8.33
216.50	54.91	52.19	59.24	56.53	80.94	78.22	8.53	8.26
216.40	54.11	51.47	58.45	55.82	80.19	77.55	8.45	8.19
216.30	53.29	50.73	57.64	55.09	79.42	76.86	8.37	8.12
216.20	52.43	49.96	56.79	54.32	78.61	76.13	8.29	8.04
216.10	51.49	49.10	55.86	53.48	77.72	75.33	8.19	7.96
216.00	50.38	48.09	54.76	52.47	76.66	74.36	8.08	7.85
215.90	49.02	46.82	53.40	51.21	75.34	73.14	7.95	7.73
215.80	47.57	45.48	51.97	49.87	73.95	71.85	7.81	7.60
215.70	45.92	43.93	50.32	48.34	72.34	70.36	7.64	7.44
215.60	43.66	41.81	48.07	46.22	70.13	68.28	7.42	7.23
215.50	41.10	39.39	45.52	43.81	67.63	65.92	7.16	6.99
215.40	38.93	37.35	43.36	41.78	65.51	63.93	6.95	6.79
215.30	36.86	35.39	41.30	39.82	63.49	62.02	6.74	6.59
215.20	34.60	33.24	39.04	37.69	61.28	59.92	6.51	6.38
215.10	32.87	31.61	37.33	36.07	59.60	58.34	6.34	6.22
215.00	31.68	30.50	36.15	34.96	58.46	57.27	6.22	6.11
214.90	30.72	29.60	35.19	34.07	57.55	56.42	6.13	6.02
214.80	29.71	28.65	34.19	33.13	56.59	55.52	6.03	5.92
214.70	28.51	27.51	33.00	32.00	55.43	54.43	5.91	5.81
214.60	27.35	26.42	31.85	30.91	54.32	53.38	5.79	5.70
214.50	26.56	25.67	31.06	30.17	53.57	52.68	5.71	5.62
214.40	25.74	24.90	30.25	29.41	52.80	51.96	5.63	5.55
214.30	24.70	23.91	29.22	28.43	51.80	51.02	5.53	5.45
214.20	23.47	22.74	27.99	27.27	50.62	49.89	5.40	5.33
214.10	22.91	22.22	27.45	26.75	50.11	49.42	5.35	5.28
214.00	22.43	21.77	26.97	26.31	49.68	49.02	5.30	5.23
213.90	21.91	21.29	26.46	25.84	49.21	48.58	5.25	5.19
213.80	21.32	20.72	25.87	25.28	48.65	48.06	5.19	5.13
213.70	20.55	20.00	25.12	24.56	47.94	47.38	5.11	5.06
213.60	19.91	19.39	24.48	23.96	47.34	46.82	5.05	5.00
213.50	19.33	18.84	23.91	23.42	46.81	46.32	4.99	4.94
213.40	18.76	18.30	23.35	22.89	46.29	45.83	4.93	4.89
213.30	18.22	17.78	22.81	22.38	45.79	45.35	4.88	4.84
213.20	17.67	17.26	22.27	21.86	45.29	44.88	4.82	4.78
213.10	17.06	16.68	21.67	21.29	44.72	44.34	4.76	4.72
213.00	16.35	16.00	20.97	20.62	44.06	43.71	4.69	4.66
212.90	15.57	15.25	20.20	19.88	43.33	43.01	4.61	4.58
212.80	14.89	14.59	19.53	19.23	42.69	42.40	4.55	4.52
212.70	14.25	13.98	18.89	18.62	42.10	41.83	4.48	4.45
212.60	13.61	13.36	18.25	18.01	41.50	41.25	4.42	4.39
212.50	12.94	12.72	17.60	17.37	40.89	40.66	4.35	4.33
212.40	12.24	12.04	16.90	16.70	40.23	40.02	4.28	4.26
212.30	11.48	11.30	16.16	15.97	39.52	39.34	4.20	4.19
212.20	10.66	10.50	15.34	15.18	38.75	38.59	4.12	4.11
212.10	9.83	9.69	14.52	14.38	37.96	37.82	4.04	4.03
212.00	9.00	8.88	13.70	13.58	37.18	37.06	3.96	3.94

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Pit Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Dewatering WBM South Pit Inflow (m³/day)	Recovery WBM South Pit Inflow (m³/day)
211.90	8.18	8.08	12.89	12.79	36.41	36.30	3.87	3.86
211.80	7.38	7.29	12.09	12.01	35.65	35.56	3.79	3.79
211.70	6.60	6.53	11.32	11.25	34.91	34.84	3.72	3.71
211.60	5.82	5.76	10.54	10.49	34.18	34.12	3.64	3.63
211.50	5.02	4.98	9.76	9.71	33.43	33.38	3.56	3.55
211.40	4.23	4.20	8.97	8.94	32.69	32.65	3.48	3.48
211.30	3.44	3.42	8.19	8.17	31.94	31.92	3.40	3.40
211.20	2.63	2.61	7.38	7.37	31.17	31.16	3.32	3.32
211.10	1.76	1.75	6.52	6.52	30.35	30.34	3.23	3.23
211.04	1.19	1.19	5.96	5.96	29.82	29.82	3.17	3.17
210.04	1.20	1.20	6.02	6.02	30.08	30.08	3.17	3.17

Underground Voids Sensitivity Analysis Results

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8
Open Void Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)
306	8.96279889	8.96279889	8.96279889	8.96279889	8.96279889	8.96279889	14.5503687	14.5503687	14.5503687	14.5503687	14.5503687	14.5503687	32.2198159	32.2198159	32.2198159
291	12.616097	12.616097	12.616097	12.616097	12.616097	12.616097	22.859975	22.859975	22.859975	22.859975	22.859975	22.859975	55.2539615	55.2539615	55.2539615
265	17.3599173	17.3599173	17.3599173	17.3599173	17.3599173	17.3599173	35.6747295	35.6747295	35.6747295	35.6747295	35.6747295	35.6747295	93.5912509	93.5912509	93.5912509
241	21.3313724	21.3313724	21.3313724	21.3313724	21.3313724	21.3313724	47.0962777	47.0962777	47.0962777	47.0962777	47.0962777	47.0962777	128.572062	128.572062	128.572062
221	24.5247077	24.5247077	24.5247077	24.5247077	24.5247077	24.5247077	56.4980238	56.4980238	56.4980238	56.4980238	56.4980238	56.4980238	157.606527	157.606527	157.606527
200	27.681465	27.681465	27.681465	27.681465	27.681465	27.681465	66.1736126	66.1736126	66.1736126	66.1736126	66.1736126	66.1736126	187.896471	187.896471	187.896471
200	28.3471009	28.3471009	28.3471009	28.3471009	28.3471009	28.3471009	66.8392484	66.8392484	66.8392484	66.8392484	66.8392484	66.8392484	188.562107	188.562107	188.562107
200	28.8653524	28.8653524	28.8653524	28.8653524	28.8653524	28.8653524	67.3575	67.3575	67.3575	67.3575	67.3575	67.3575	189.080358	189.080358	189.080358
193	30.2280646	30.2280646	30.2280646	30.2280646	30.2280646	30.2280646	70.8931561	70.8931561	70.8931561	70.8931561	70.8931561	70.8931561	199.487466	199.487466	199.487466
171	33.0947154	33.0947154	33.0947154	33.0947154	33.0947154	33.0947154	80.5890588	80.5890588	80.5890588	80.5890588	80.5890588	80.5890588	230.77936	230.77936	230.77936
153	36.1425165	36.1425165	36.1425165	36.1425165	36.1425165	36.1425165	89.2244297	89.2244297	89.2244297	89.2244297	89.2244297	89.2244297	257.084178	257.084178	257.084178
146	38.0620934	38.0620934	38.0620934	38.0620934	38.0620934	38.0620934	93.3169504	93.3169504	93.3169504	93.3169504	93.3169504	93.3169504	268.04815	268.04815	268.04815
146	38.544988	38.544988	38.544988	38.544988	38.544988	38.544988	93.799845	93.799845	93.799845	93.799845	93.799845	93.799845	268.531045	268.531045	268.531045
130	40.6402323	40.6402323	40.6402323	40.6402323	40.6402323	40.6402323	100.861818	100.861818	100.861818	100.861818	100.861818	100.861818	291.299193	291.299193	291.299193
125	41.50548	41.50548	41.50548	41.50548	41.50548	41.50548	103.279168	103.279168	103.279168	103.279168	103.279168	103.279168	298.624724	298.624724	298.624724
125	41.8504858	41.8504858	41.8504858	41.8504858	41.8504858	41.8504858	103.624174	103.624174	103.624174	103.624174	103.624174	103.624174	298.969729	298.969729	298.969729
125	42.0898482	42.0898482	42.0898482	42.0898482	42.0898482	42.0898482	103.863537	103.863537	103.863537	103.863537	103.863537	103.863537	299.209092	299.209092	299.209092
125	42.452985	42.452985	42.452985	42.452985	42.452985	42.452985	104.226674	104.226674	104.226674	104.226674	104.226674	104.226674	299.572229	299.572229	299.572229
125	42.6583964	42.6583964	42.6583964	42.6583964	42.6583964	42.6583964	104.432085	104.432085	104.432085	104.432085	104.432085	104.432085	299.77764	299.77764	299.77764
112	44.6850264	44.6850264	44.6850264	44.6850264	44.6850264	44.6850264	110.494182	110.494182	110.494182	110.494182	110.494182	110.494182	318.601004	318.601004	318.601004
101	46.355155	46.355155	46.355155	46.355155	46.355155	46.355155	115.578937	115.578937	115.578937	115.578937	115.578937	115.578937	334.483755	334.483755	334.483755
93	47.6379336	47.6379336	47.6379336	47.6379336	47.6379336	47.6379336	119.34508	119.34508	119.34508	119.34508	119.34508	119.34508	346.102985	346.102985	346.102985
85	48.9247838	48.9247838	48.9247838	48.9247838	48.9247838	48.9247838	123.115294	123.115294	123.115294	123.115294	123.115294	123.115294	357.726287	357.726287	357.726287
64	51.8150958	51.8150958	51.8150958	51.8150958	51.8150958	51.8150958	132.524437	132.524437	132.524437	132.524437	132.524437	132.524437	387.749786	387.749786	387.749786
55	53.1551046	53.1551046	53.1551046	53.1551046	53.1551046	53.1551046	136.658231	136.658231	136.658231	136.658231	136.658231	136.658231	400.718303	400.718303	400.718303
34	55.9880063	55.9880063	55.9880063	55.9880063	55.9880063	55.9880063	146.009964	146.009964	146.009964	146.009964	146.009964	146.009964	430.684391	430.684391	430.684391
26	57.1659695	57.1659695	57.1659695	57.1659695	57.1659695	57.1659695	149.671292	149.671292	149.671292	149.671292	149.671292	149.671292	442.198807	442.198807	442.198807
26	57.476853	57.476853	57.476853	57.476853	57.476853	57.476853	149.982175	149.982175	149.982175	149.982175	149.982175	149.982175	442.50969	442.50969	442.50969
21	58.4340867	58.4340867	58.4340867	58.4340867	58.4340867	58.4340867	152.491512	152.491512	152.491512	152.491512	152.491512	152.491512	449.927206	449.927206	449.927206
2	61.0603929	61.0603929	61.0603929	61.0603929	61.0603929	61.0603929	161.015808	161.015808	161.015808	161.015808	161.015808	161.015808	477.102586	477.102586	477.102586
2	61.5661559	61.5661559	61.5661559	61.5661559	61.5661559	61.5661559	161.521571	161.521571	161.521571	161.521571	161.521571	161.521571	477.608349	477.608349	477.608349
2	62.0351398	62.0351398	62.0351398	62.0351398	62.0351398	62.0351398	161.990555	161.990555	161.990555	161.990555	161.990555	161.990555	478.077333	478.077333	478.077333
2	62.4264352	62.4264352	62.4264352	62.4264352	62.4264352	62.4264352	162.381851	162.381851	162.381851	162.381851	162.381851	162.381851	478.468628	478.468628	478.468628
2	62.795871	62.795871	62.795871	62.795871	62.795871	62.795871	162.751287	162.751287	162.751287	162.751287	162.751287	162.751287	478.838064	478.838064	478.838064
2	63.1162996	63.1162996	63.1162996	63.1162996	63.1162996	63.1162996	163.071715	163.071715	163.071715	163.071715	163.071715	163.071715	479.158493	479.158493	479.158493
2	63.2572878	63.2572878	63.2572878	63.2572878	63.2572878	63.2572878	163.212703	163.212703	163.212703	163.212703	163.212703	163.212703	479.299481	479.299481	479.299481
2	63.372808	63.372808	63.372808	63.372808	63.372808	63.372808	163.328224	163.328224	163.328224	163.328224	163.328224	163.328224	479.415001	479.415001	479.415001
2	63.6387232	63.6387232	63.6387232	63.6387232	63.6387232	63.6387232	163.594139	163.594139	163.594139	163.594139	163.594139	163.594139	479.680916	479.680916	479.680916
2	63.9925312	63.9925312	63.9925312	63.9925312	63.9925312	63.9925312	163.947947	163.947947	163.947947	163.947947	163.947947	163.947947	480.034724	480.034724	480.034724
2	64.3810974	64.3810974	64.3810974	64.3810974	64.3810974	64.3810974	164.336513	164.336513	164.336513	164.336513	164.336513	164.336513	480.423291	480.423291	480.423291
2	64.8093193	64.8093193	64.8093193	64.8093193	64.8093193	64.8093193	164.764735	164.764735	164.764735	164.764735	164.764735	164.764735	480.851512	480.851512	480.851512
2	65.2754207	65.2754207	65.2754207	65.2754207	65.2754207	65.2754207	165.230836	165.230836	165.230836	165.230836	165.230836	165.230836	481.317614	481.317614	481.317614
2	65.5002237	65.5002237	65.5002237	65.5002237	65.5002237	65.5002237	165.455639	165.455639	165.455639	165.455639	165.455639	165.455639	481.542417	481.542417	481.542417
2	65.5348032	65.5348032	65.5348032	65.5348032	65.5348032	65.5348032	165.490219	165.490219	165.490219	165.490219	165.490219	165.490219	481.576996	481.576996	481.576996

Underground Voids Sensitivity Analysis Results

Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering
Scenario	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8
Open Void Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)
2	65.5747114	65.5747114	65.5747114	65.5747114	65.5747114	65.5747114	165.530127	165.530127	165.530127	165.530127	165.530127	165.530127	481.616905	481.616905	481.616905
2	65.59637	65.59637	65.59637	65.59637	65.59637	65.59637	165.551786	165.551786	165.551786	165.551786	165.551786	165.551786	481.638563	481.638563	481.638563
2	65.6570098	65.6570098	65.6570098	65.6570098	65.6570098	65.6570098	165.612425	165.612425	165.612425	165.612425	165.612425	165.612425	481.699203	481.699203	481.699203
2	65.7175056	65.7175056	65.7175056	65.7175056	65.7175056	65.7175056	165.672921	165.672921	165.672921	165.672921	165.672921	165.672921	481.759699	481.759699	481.759699
2	65.7414083	65.7414083	65.7414083	65.7414083	65.7414083	65.7414083	165.696824	165.696824	165.696824	165.696824	165.696824	165.696824	481.783601	481.783601	481.783601
2	65.7887374	65.7887374	65.7887374	65.7887374	65.7887374	65.7887374	165.744153	165.744153	165.744153	165.744153	165.744153	165.744153	481.830931	481.830931	481.830931
2	65.8512682	65.8512682	65.8512682	65.8512682	65.8512682	65.8512682	165.806684	165.806684	165.806684	165.806684	165.806684	165.806684	481.893461	481.893461	481.893461
2	65.8852996	65.8852996	65.8852996	65.8852996	65.8852996	65.8852996	165.840715	165.840715	165.840715	165.840715	165.840715	165.840715	481.927493	481.927493	481.927493
2	66.0414147	66.0414147	66.0414147	66.0414147	66.0414147	66.0414147	165.99683	165.99683	165.99683	165.99683	165.99683	165.99683	482.083608	482.083608	482.083608
2	66.2093234	66.2093234	66.2093234	66.2093234	66.2093234	66.2093234	166.164739	166.164739	166.164739	166.164739	166.164739	166.164739	482.251516	482.251516	482.251516
2	66.4114612	66.4114612	66.4114612	66.4114612	66.4114612	66.4114612	166.366877	166.366877	166.366877	166.366877	166.366877	166.366877	482.453654	482.453654	482.453654
2	66.6352781	66.6352781	66.6352781	66.6352781	66.6352781	66.6352781	166.590694	166.590694	166.590694	166.590694	166.590694	166.590694	482.677471	482.677471	482.677471
2	66.8072354	66.8072354	66.8072354	66.8072354	66.8072354	66.8072354	166.762651	166.762651	166.762651	166.762651	166.762651	166.762651	482.849428	482.849428	482.849428
2	66.8546334	66.8546334	66.8546334	66.8546334	66.8546334	66.8546334	166.810049	166.810049	166.810049	166.810049	166.810049	166.810049	482.896827	482.896827	482.896827

Type	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Void Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
306	32.2198159	32.2198159	32.2198159	0.02276526	0.04098538	0.02636973	0.04458985	0.04439206	0.06261218	0.22162778	0.40382898	0.23357313	0.41577433	0.29329987	0.47550107
291	55.2539615	55.2539615	55.2539615	0.05867346	0.10350425	0.0657648	0.1105956	0.10122152	0.14605232	0.57654697	1.02485491	0.60670992	1.05501786	0.75752467	1.20583261
265	93.5912509	93.5912509	93.5912509	0.12589793	0.17560716	0.14068228	0.19039151	0.21460404	0.26431326	1.24113082	1.73822307	1.31758036	1.81467261	1.69982807	2.19692031
241	128.572062	128.572062	128.572062	0.19198999	0.23681917	0.21578547	0.26061465	0.3347629	0.37959208	1.89434197	2.34263381	2.03006528	2.47835713	2.70868187	3.15697371
221	157.606527	157.606527	157.606527	0.24932944	0.29850056	0.2819568	0.33112792	0.4450936	0.49426471	2.46099903	2.95271016	2.658091	3.14980214	3.64355089	4.13526202
200	187.896471	187.896471	187.896471	0.30734291	0.30734291	0.35018962	0.35018962	0.56442315	0.56442315	3.0343627	3.0343627	3.30656421	3.30656421	4.66757174	4.66757174
200	188.562107	188.562107	188.562107	0.32771792	0.32771792	0.37212441	0.37212441	0.59415688	0.59415688	3.23541659	3.23541659	3.51243113	3.51243113	4.89750382	4.89750382
200	189.080358	189.080358	189.080358	0.34358214	0.36233403	0.38920555	0.40795744	0.61732259	0.63607447	3.391954	3.57947288	3.67271837	3.86023725	5.0765402	5.26405908
193	199.487466	199.487466	199.487466	0.37549017	0.43644071	0.42571979	0.48667033	0.67686787	0.73781841	3.70715034	4.31665575	4.01844094	4.62794635	5.57489394	6.18439936
171	230.77936	230.77936	230.77936	0.43047578	0.47929416	0.49255388	0.54137226	0.8029444	0.85176278	4.2507776	4.73896143	4.65563793	5.14382175	6.67993955	7.16812337
153	257.084178	257.084178	257.084178	0.50317817	0.52301066	0.57797261	0.59780511	0.95194482	0.97177732	4.96911452	5.16743948	5.4663903	5.66471526	7.95276921	8.15109417
146	268.04815	268.04815	268.04815	0.56523883	0.56523883	0.64772383	0.64772383	1.06014883	1.06014883	5.58201347	5.58201347	6.12536426	6.12536426	8.84211822	8.84211822
146	268.531045	268.531045	268.531045	0.58666509	0.63750944	0.67075185	0.7215962	1.09118565	1.14203	5.79351915	6.30196266	6.3418596	6.85030311	9.08356186	9.59200537
130	291.299193	291.299193	291.299193	0.63180199	0.6474741	0.72669922	0.74237133	1.20118536	1.21685747	6.23974981	6.39647086	6.87564152	7.03236257	10.0551001	10.2118211
125	298.624724	298.624724	298.624724	0.65606984	0.65606984	0.7552376	0.7552376	1.25107641	1.25107641	6.4795237	6.4795237	7.14650268	7.14650268	10.4813976	10.4813976
125	298.969729	298.969729	298.969729	0.67322388	0.67322388	0.7736661	0.7736661	1.2758772	1.2758772	6.64887315	6.64887315	7.31983265	7.31983265	10.6746301	10.6746301
125	299.209092	299.209092	299.209092	0.68512532	0.68512532	0.7864521	0.7864521	1.29308602	1.29308602	6.7663666	6.7663666	7.44008811	7.44008811	10.8086956	10.8086956
125	299.572229	299.572229	299.572229	0.70318114	0.70318114	0.80585045	0.80585045	1.31919701	1.31919701	6.94461616	6.94461616	7.62252847	7.62252847	11.01209	11.01209
125	299.77764	299.77764	299.77764	0.71339463	0.75830913	0.81682365	0.86173815	1.33396876	1.37888326	7.04544454	7.49458956	7.72572771	8.17487273	11.1271436	11.5762886
112	318.601004	318.601004	318.601004	0.77031743	0.80880331	0.8846759	0.92316177	1.45646824	1.49495412	7.60795085	7.99280962	8.37064178	8.75550055	12.1840964	12.5689552
101	334.483755	334.483755	334.483755	0.81690243	0.84509778	0.94073091	0.96892626	1.55987328	1.58806863	8.06832484	8.35027831	8.90381162	9.1857651	13.0812456	13.363199
93	346.102985	346.102985	346.102985	0.8550961	0.88357363	0.98632596	1.01480349	1.64247526	1.67095278	8.44573716	8.73051245	9.33714039	9.62191567	13.7941565	14.0789318
85	357.726287	357.726287	357.726287	0.89412312	0.96963604	1.03297958	1.10849251	1.72726189	1.80277482	8.83138385	9.5865131	9.78055909	10.5356883	14.5264353	15.2815646
64	387.749786	387.749786	387.749786	0.96762479	0.99975627	1.12515304	1.15728452	1.91279428	1.94492576	9.55794425	9.87925905	10.6600122	10.981327	16.1703518	16.4916666
55	400.718303	400.718303	400.718303	1.00565001	1.08091123	1.1720089	1.24727012	2.00380335	2.07906456	9.933756	10.6863681	11.1063683	11.8589804	16.9694299	17.7220421
34	430.684391	430.684391	430.684391	1.07401792	1.10236128	1.26030194	1.2886453	2.19172201	2.22006538	10.6096515	10.8930851	11.9503809	12.2338145	18.6540277	18.9374613
26	442.198807	442.198807	442.198807	1.1070287	1.1070287	1.30171289	1.30171289	2.27513383	2.27513383	10.9359256	10.9359256	12.3453221	12.3453221	19.3923043	19.3923043
26	442.50969	442.50969	442.50969	1.13032829	1.14846976	1.32671657	1.34485804	2.30865796	2.32679942	11.1660003	11.3474149	12.5807523	12.7621669	19.6545126	19.8359272
21	449.927206	449.927206	449.927206	1.16828367	1.23836023	1.3712714	1.44134796	2.38621004	2.4562866	11.5409908	12.2417564	13.0034847	13.7042503	20.3159541	21.0167197
2	477.102586	477.102586	477.102586	1.23625887	1.23625887	1.45933526	1.45933526	2.57471721	2.57471721	12.2129779	12.2129779	13.8452985	13.8452985	22.0069016	22.0069016
2	477.608349	477.608349	477.608349	1.27725704	1.27725704	1.50332601	1.50332601	2.63367087	2.63367087	12.617831	12.617831	14.2595631	14.2595631	22.4682237	22.4682237
2	478.077333	478.077333	478.077333	1.315274	1.315274	1.54411866	1.54411866	2.68834192	2.68834192	12.9932434	12.9932434	14.6437033	14.6437033	22.8960029	22.8960029
2	478.468628	478.468628	478.468628	1.34699348	1.34699348	1.57815454	1.57815454	2.73395986	2.73395986	13.3064678	13.3064678	14.9642102	14.9642102	23.2529226	23.2529226
2	478.838064	478.838064	478.838064	1.37694107	1.37694107	1.61028958	1.61028958	2.77703213	2.77703213	13.6021941	13.6021941	15.2668127	15.2668127	23.5899058	23.5899058
2	479.158493	479.158493	479.158493	1.40291608	1.40291608	1.63816221	1.63816221	2.81439287	2.81439287	13.8586912	13.8586912	15.5292742	15.5292742	23.8821891	23.8821891
2	479.299481	479.299481	479.299481	1.41434507	1.41434507	1.65042625	1.65042625	2.83083218	2.83083218	13.9715496	13.9715496	15.644757	15.644757	24.0107939	24.0107939
2	479.415001	479.415001	479.415001	1.42370956	1.42370956	1.660475	1.660475	2.8443022	2.8443022	14.0640214	14.0640214	15.7393792	15.7393792	24.1161681	24.1161681
2	479.680916	479.680916	479.680916	1.44526564	1.44526564	1.68360632	1.68360632	2.87530975	2.87530975	14.2768816	14.2768816	15.9571895	15.9571895	24.358729	24.358729
2	480.034724	480.034724	480.034724	1.47394673	1.47394673	1.71438367	1.71438367	2.91656837	2.91656837	14.5600986	14.5600986	16.2469931	16.2469931	24.6814656	24.6814656
2	480.423291	480.423291	480.423291	1.50544556	1.50544556	1.74818515	1.74818515	2.96188307	2.96188307	14.8711389	14.8711389	16.5652675	16.5652675	25.0359108	25.0359108
2	480.851512	480.851512	480.851512	1.5401592	1.5401592	1.78543698	1.78543698	3.01182587	3.01182587	15.213923	15.213923	16.9160246	16.9160246	25.4265329	25.4265329
2	481.317614	481.317614	481.317614	1.57794369	1.57794369	1.82598484	1.82598484	3.0661906	3.0661906	15.5870292	15.5870292	17.2978097	17.2978097	25.8517125	25.8517125
2	481.542417	481.542417	481.542417	1.59616739	1.59616739	1.84554158	1.84554158	3.09241249	3.09241249	15.7669801	15.7669801	17.4819468	17.4819468	26.0567803	26.0567803
2	481.576996	481.576996	481.576996	1.59897059	1.59897059	1.84854984	1.84854984	3.09644608	3.09644608	15.7946605	15.7946605	17.5102711	17.5102711	26.0883242	26.0883242

Underground Voids Sensitivity Analysis Results

Type	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery
Scenario	8	9	9	1	1	2	2	3	3	4	4	5	5	6	6
Open Void Level (mAHD)	Radius of Influence (m)	Radius of Influence (m)	Radius of Influence (m)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)
2	481.616905	481.616905	481.616905	1.60220577	1.60220577	1.85202168	1.85202168	3.10110126	3.10110126	15.8266063	15.8266063	17.5429601	17.5429601	26.1247291	26.1247291
2	481.638563	481.638563	481.638563	1.60396153	1.60396153	1.85390589	1.85390589	3.10362769	3.10362769	15.8439437	15.8439437	17.5607008	17.5607008	26.1444864	26.1444864
2	481.699203	481.699203	481.699203	1.60887732	1.60887732	1.8591813	1.8591813	3.11070123	3.11070123	15.8924848	15.8924848	17.6103711	17.6103711	26.1998029	26.1998029
2	481.759699	481.759699	481.759699	1.61378144	1.61378144	1.86444421	1.86444421	3.11775805	3.11775805	15.9409107	15.9409107	17.6599236	17.6599236	26.2549882	26.2549882
2	481.783601	481.783601	481.783601	1.61571912	1.61571912	1.86652365	1.86652365	3.12054631	3.12054631	15.9600444	15.9600444	17.6795024	17.6795024	26.2767927	26.2767927
2	481.830931	481.830931	481.830931	1.61955588	1.61955588	1.87064112	1.87064112	3.12606732	3.12606732	15.9979306	15.9979306	17.71827	17.71827	26.3199672	26.3199672
2	481.893461	481.893461	481.893461	1.62462498	1.62462498	1.87608109	1.87608109	3.13336169	3.13336169	16.0479854	16.0479854	17.7694894	17.7694894	26.377009	26.377009
2	481.927493	481.927493	481.927493	1.62738375	1.62738375	1.87904172	1.87904172	3.13733156	3.13733156	16.075227	16.075227	17.7973647	17.7973647	26.4080531	26.4080531
2	482.083608	482.083608	482.083608	1.64003932	1.64003932	1.8926233	1.8926233	3.1555432	3.1555432	16.2001945	16.2001945	17.9252396	17.9252396	26.5504647	26.5504647
2	482.251516	482.251516	482.251516	1.65365098	1.65365098	1.90723101	1.90723101	3.17513116	3.17513116	16.3346027	16.3346027	18.0627748	18.0627748	26.7036354	26.7036354
2	482.453654	482.453654	482.453654	1.67003747	1.67003747	1.92481672	1.92481672	3.19871297	3.19871297	16.4964108	16.4964108	18.2283475	18.2283475	26.8880314	26.8880314
2	482.677471	482.677471	482.677471	1.68818144	1.68818144	1.94428868	1.94428868	3.22482485	3.22482485	16.6755727	16.6755727	18.411678	18.411678	27.0922046	27.0922046
2	482.849428	482.849428	482.849428	1.70212138	1.70212138	1.959249	1.959249	3.24488712	3.24488712	16.8132218	16.8132218	18.5525299	18.5525299	27.2490705	27.2490705
2	482.896827	482.896827	482.896827	1.70596376	1.70596376	1.96337266	1.96337266	3.25041716	3.25041716	16.8511631	16.8511631	18.5913541	18.5913541	27.2923088	27.2923088

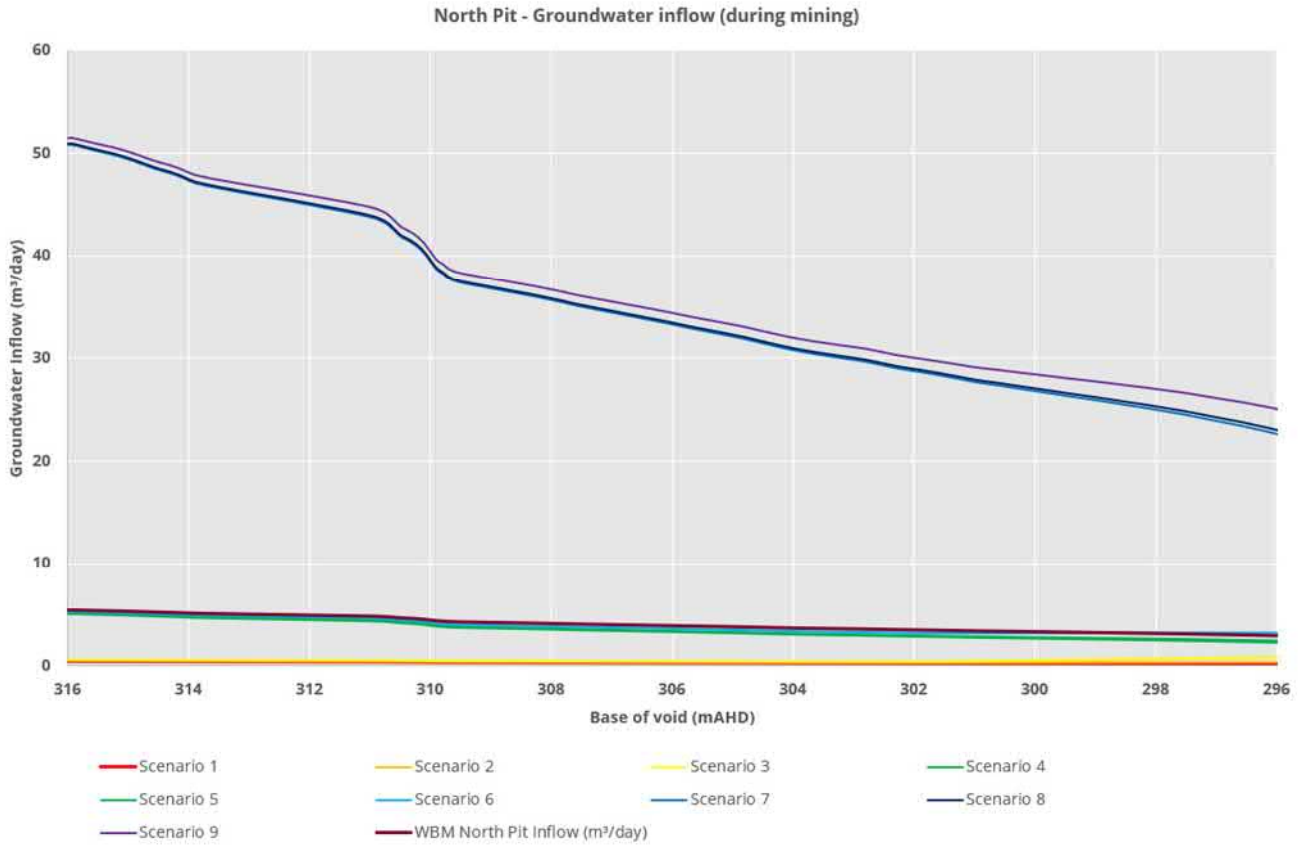
Underground Voids Sensitivity Analysis Results

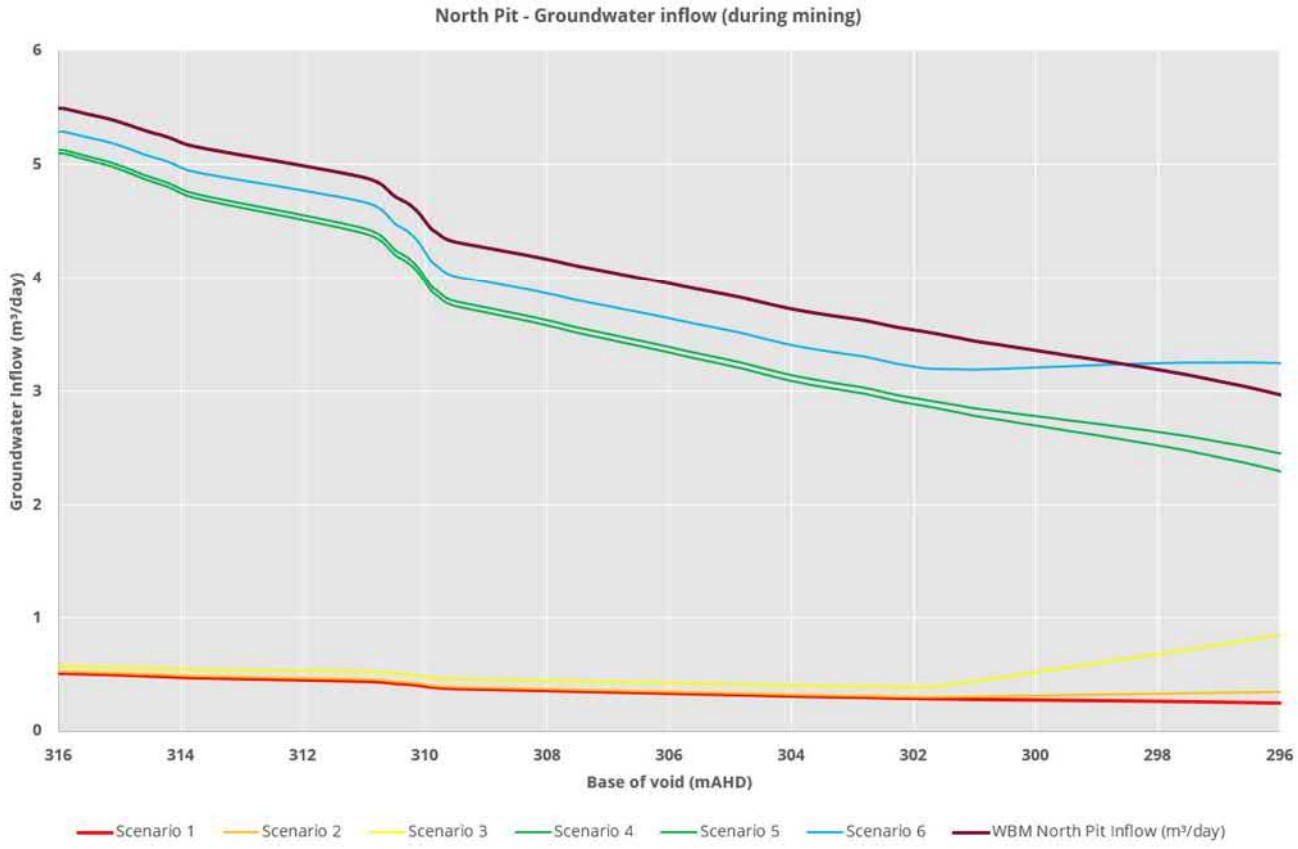
Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Void Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Mining - WBM GW Inflow (m³/day)	Recovery - WBM GW Inflow (m³/day)
306	2.202517	4.024529	2.26692738	4.08893939	2.5889793	4.4109913	1.0	1.19
291	5.73776464	10.220844	5.92857394	10.4116533	6.88262039	11.3656998	1.4	1.81
265	12.3581209	17.3290434	12.909867	17.8807894	15.6685972	20.6395197	2.0	2.51
241	18.8652065	23.3481249	19.9095867	24.3925051	25.1314882	29.6144066	2.6	3.10
221	24.5101162	29.4272275	26.0815397	30.998651	33.938657	38.8557683	3.2	3.69
200	30.2220178	30.2220178	32.4575958	32.4575958	43.6354858	43.6354858	3.8	3.75
200	32.2242993	32.2242993	34.474978	34.474978	45.7283715	45.7283715	4.0	3.95
200	33.7832387	35.6584275	36.045677	37.9208658	47.3578686	49.2330573	4.1	4.29
193	36.9229422	43.0179963	39.4416032	45.5366574	52.0349087	58.1299628	4.4	5.02
171	42.3390633	47.2209015	45.7128154	50.5946536	62.5815758	67.4634141	4.9	5.42
153	49.4949051	51.4781548	53.6827027	55.6659523	74.6216904	76.60494	5.6	5.83
146	55.5997497	55.5997497	60.1517176	60.1517176	82.9115575	82.9115575	6.2	6.23
146	57.7062582	62.7906933	62.2739293	67.3583644	85.1122849	90.19672	6.4	6.95
130	62.1520587	63.7192693	67.5292186	69.0964291	94.4150179	95.9822284	6.9	7.02
125	64.5406078	64.5406078	70.1918809	70.1918809	98.4482464	98.4482464	7.1	7.09
125	66.2272855	66.2272855	71.8910965	71.8910965	100.210151	100.210151	7.3	7.26
125	67.3974897	67.3974897	73.0699997	73.0699997	101.432549	101.432549	7.4	7.38
125	69.1728077	69.1728077	74.8585155	74.8585155	103.287054	103.287054	7.6	7.55
125	70.1770309	74.6684811	75.8702045	80.3616546	104.336072	108.827522	7.7	8.10
112	75.7807412	79.6293289	82.2125812	86.0611689	114.371781	118.220369	8.2	8.58
101	80.3670773	83.186612	87.4572607	90.2767954	122.908178	125.727712	8.6	8.92
93	84.1268563	86.9746091	91.7188269	94.5665798	129.67868	132.526433	9.0	9.29
85	87.9686693	95.5199618	96.0797452	103.631038	136.635125	144.186417	9.4	10.13
64	95.2073211	98.420469	104.739514	107.952662	152.400481	155.613628	10.1	10.38
55	98.9513429	106.477464	109.132598	116.658719	160.038872	167.564993	10.4	11.17
34	105.6855	108.519836	117.448733	120.28307	176.2649	179.099237	11.1	11.34
26	108.936078	108.936078	121.337331	121.337331	183.343594	183.343594	11.4	11.36
26	111.227661	113.041808	123.645817	125.459963	185.736593	187.55074	11.6	11.77
21	114.963165	121.970821	127.801132	134.808788	191.990966	198.998622	12.0	12.65
2	121.658351	121.658351	136.095846	136.095846	208.283323	208.283323	12.6	12.58
2	125.690781	125.690781	140.157986	140.157986	212.494012	212.494012	13.0	12.98
2	129.429973	129.429973	143.924728	143.924728	216.398505	216.398505	13.4	13.35
2	132.549757	132.549757	147.067499	147.067499	219.65621	219.65621	13.7	13.67
2	135.495255	135.495255	150.034701	150.034701	222.731927	222.731927	14.0	13.96
2	138.050022	138.050022	152.608292	152.608292	225.399641	225.399641	14.2	14.21
2	139.174116	139.174116	153.740668	153.740668	226.573432	226.573432	14.3	14.32
2	140.095155	140.095155	154.668494	154.668494	227.535191	227.535191	14.4	14.42
2	142.215287	142.215287	156.804249	156.804249	229.749058	229.749058	14.6	14.63
2	145.036186	145.036186	159.645934	159.645934	232.694675	232.694675	14.9	14.91
2	148.134211	148.134211	162.766788	162.766788	235.929674	235.929674	15.2	15.22
2	151.54841	151.54841	166.206146	166.206146	239.494828	239.494828	15.6	15.56
2	155.264621	155.264621	169.949742	169.949742	243.375352	243.375352	15.9	15.92
2	157.056967	157.056967	171.755298	171.755298	245.246949	245.246949	16.1	16.10
2	157.332669	157.332669	172.033031	172.033031	245.534841	245.534841	16.1	16.13

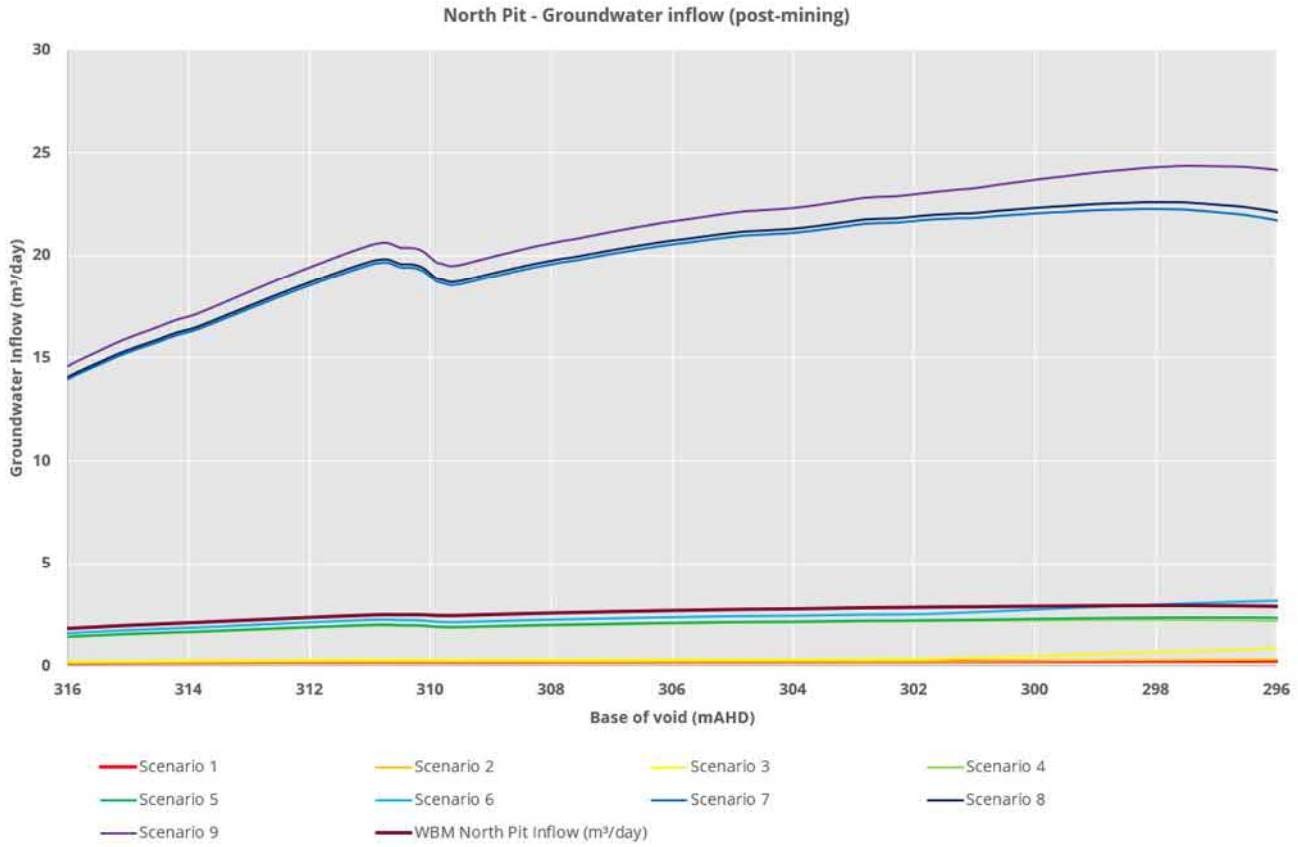
Underground Voids Sensitivity Analysis Results

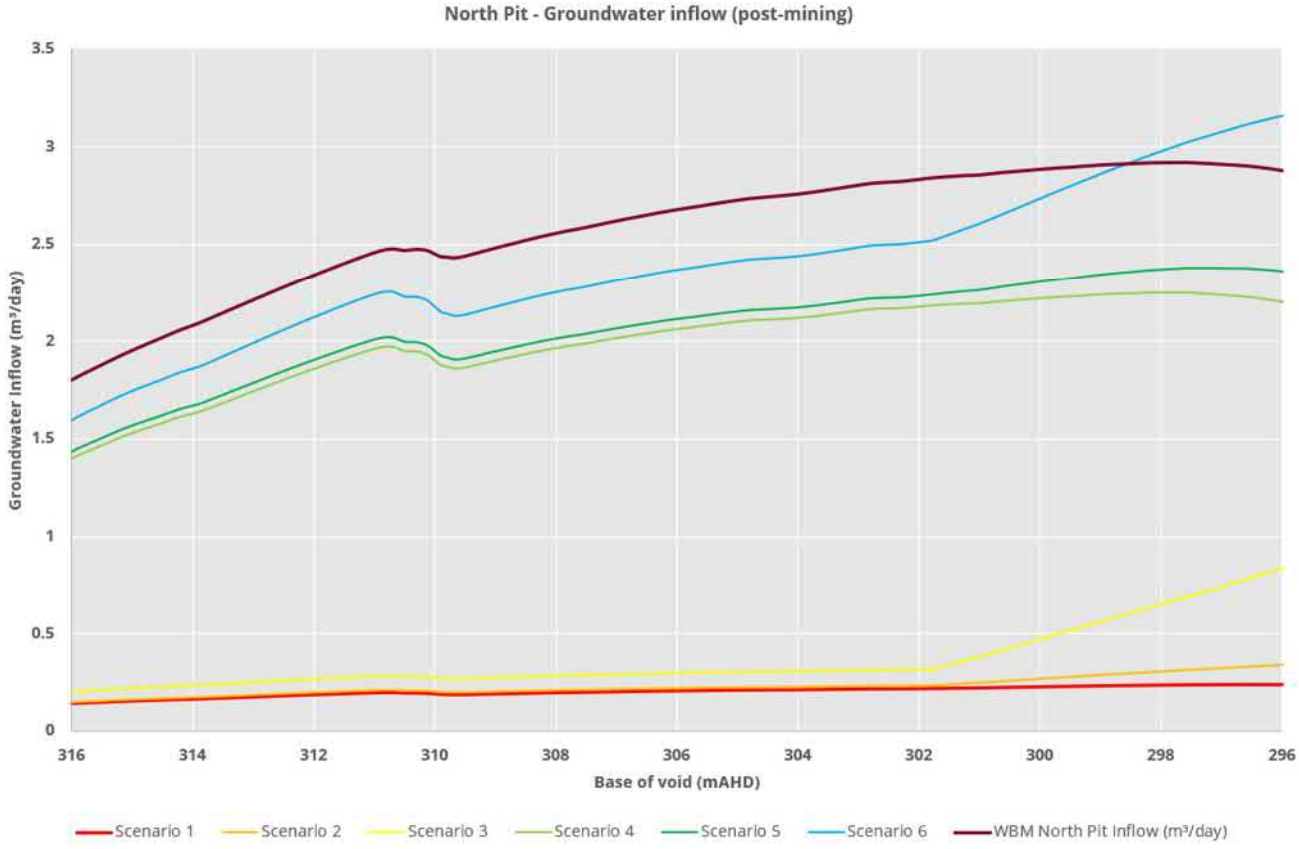
Type	Dewatering	Recovery	Dewatering	Recovery	Dewatering	Recovery		
Scenario	7	7	8	8	9	9		
Open Void Level (mAHD)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	GW Inflow (m³/day)	Mining - WBM GW Inflow (m³/day)	Recovery - WBM GW Inflow (m³/day)
2	157.650856	157.650856	172.353562	172.353562	245.867097	245.867097	16.2	16.16
2	157.823539	157.823539	172.527519	172.527519	246.047416	246.047416	16.2	16.18
2	158.307018	158.307018	173.01456	173.01456	246.552273	246.552273	16.2	16.23
2	158.789349	158.789349	173.500446	173.500446	247.055931	247.055931	16.3	16.28
2	158.979924	158.979924	173.692426	173.692426	247.254933	247.254933	16.3	16.29
2	159.357278	159.357278	174.07256	174.07256	247.648972	247.648972	16.3	16.33
2	159.855834	159.855834	174.57479	174.57479	248.169572	248.169572	16.4	16.38
2	160.127165	160.127165	174.848121	174.848121	248.452901	248.452901	16.4	16.41
2	161.371865	161.371865	176.101994	176.101994	249.752639	249.752639	16.5	16.53
2	162.710596	162.710596	177.450591	177.450591	251.150565	251.150565	16.7	16.67
2	164.322234	164.322234	179.074106	179.074106	252.833467	252.833467	16.8	16.83
2	166.106719	166.106719	180.871743	180.871743	254.69686	254.69686	17.0	17.00
2	167.477729	167.477729	182.252857	182.252857	256.128495	256.128495	17.1	17.14
2	167.855632	167.855632	182.633545	182.633545	256.523108	256.523108	17.2	17.18

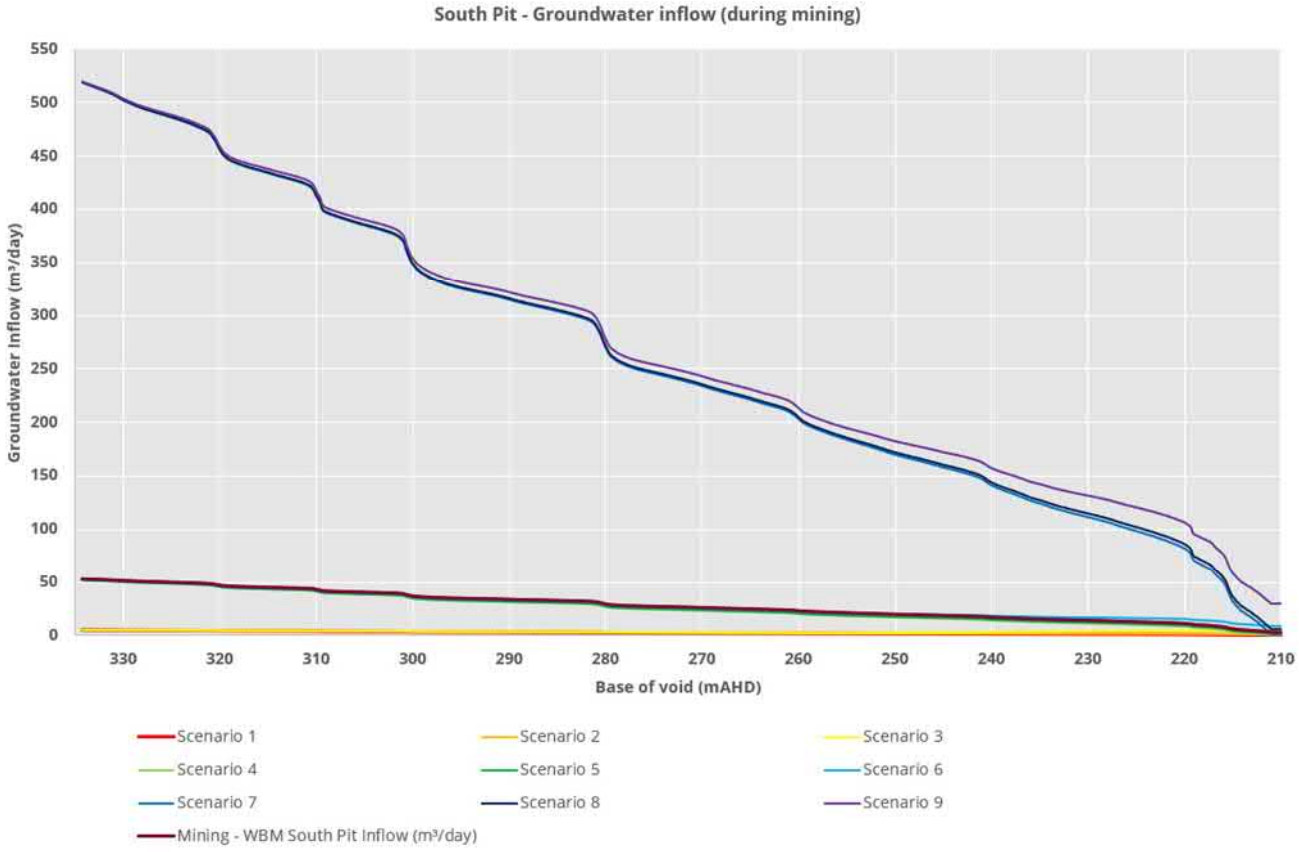
B.3 Graphs of groundwater inflow calculations

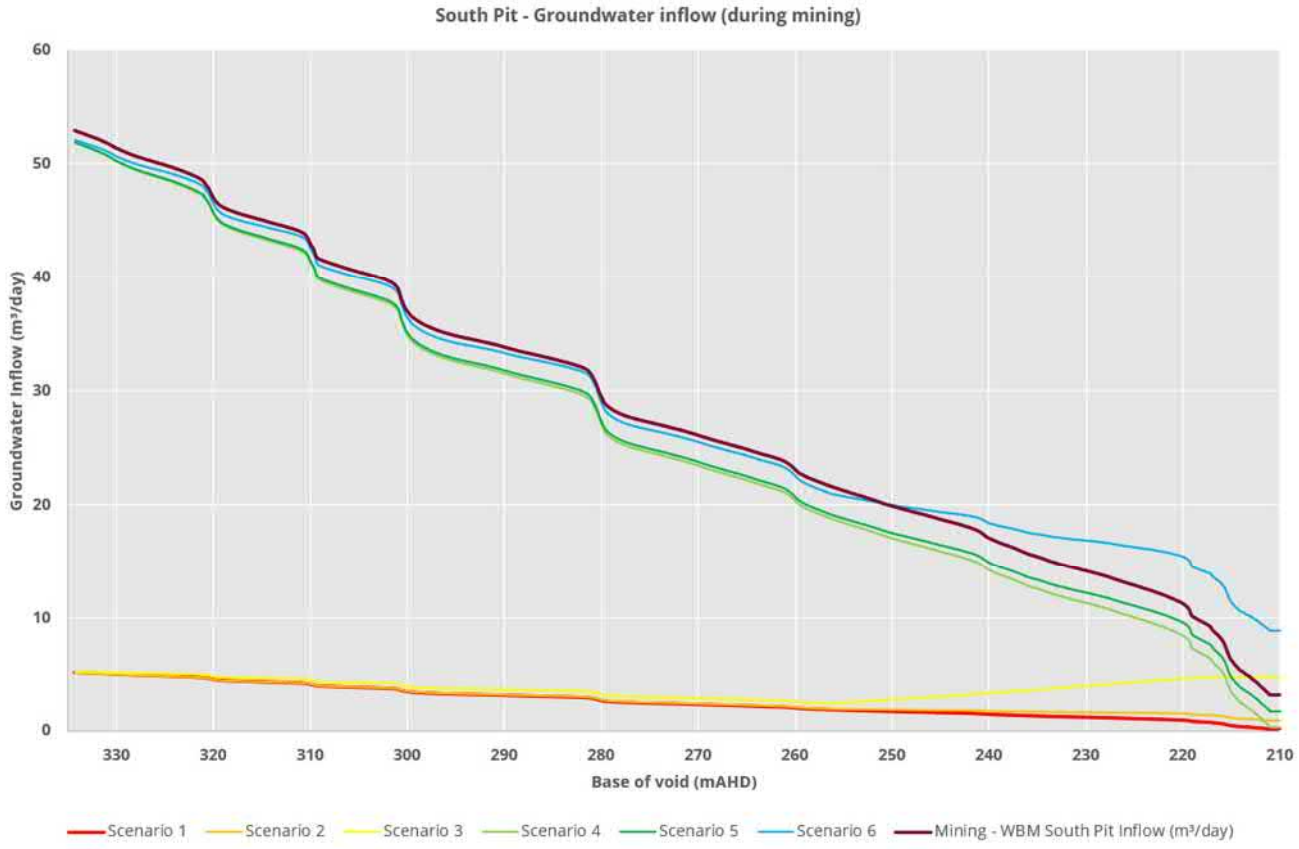


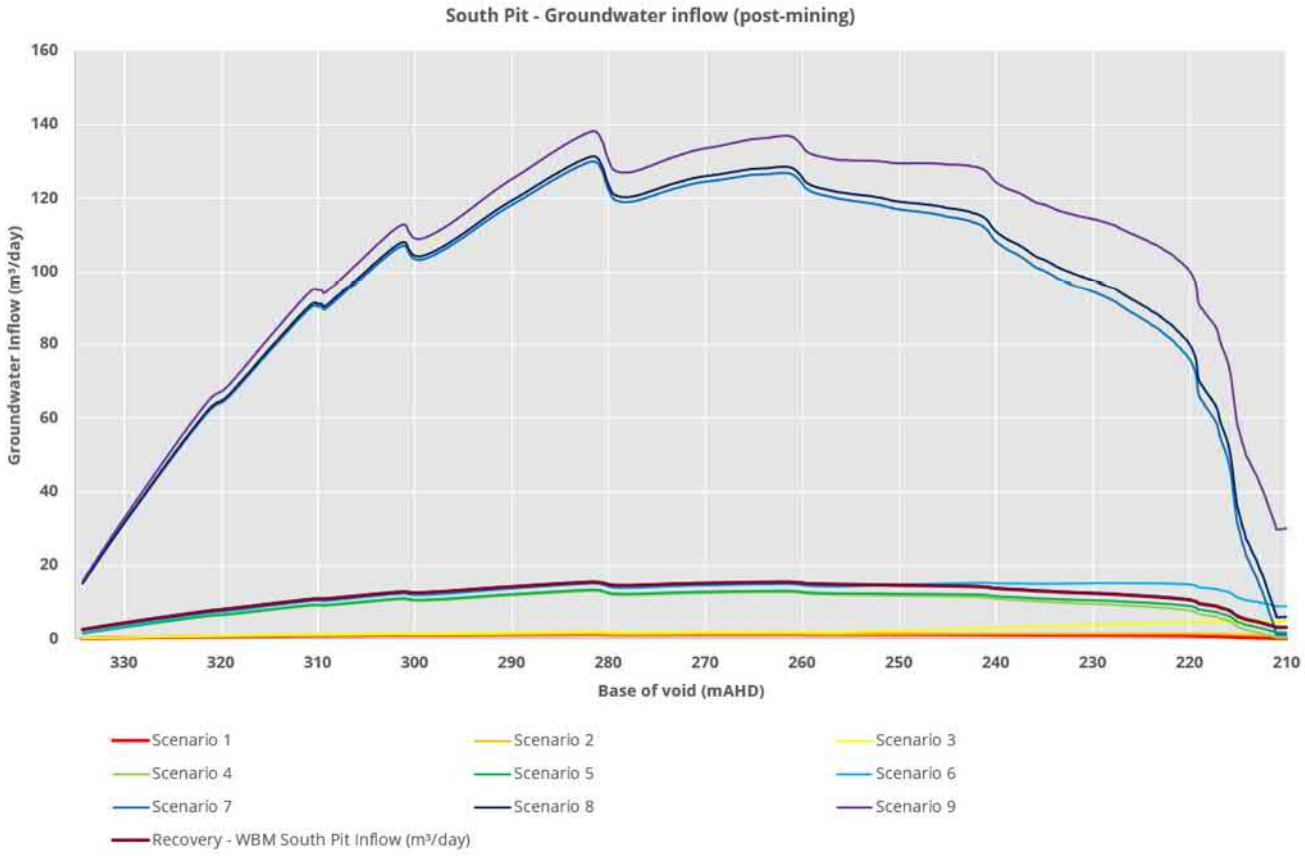


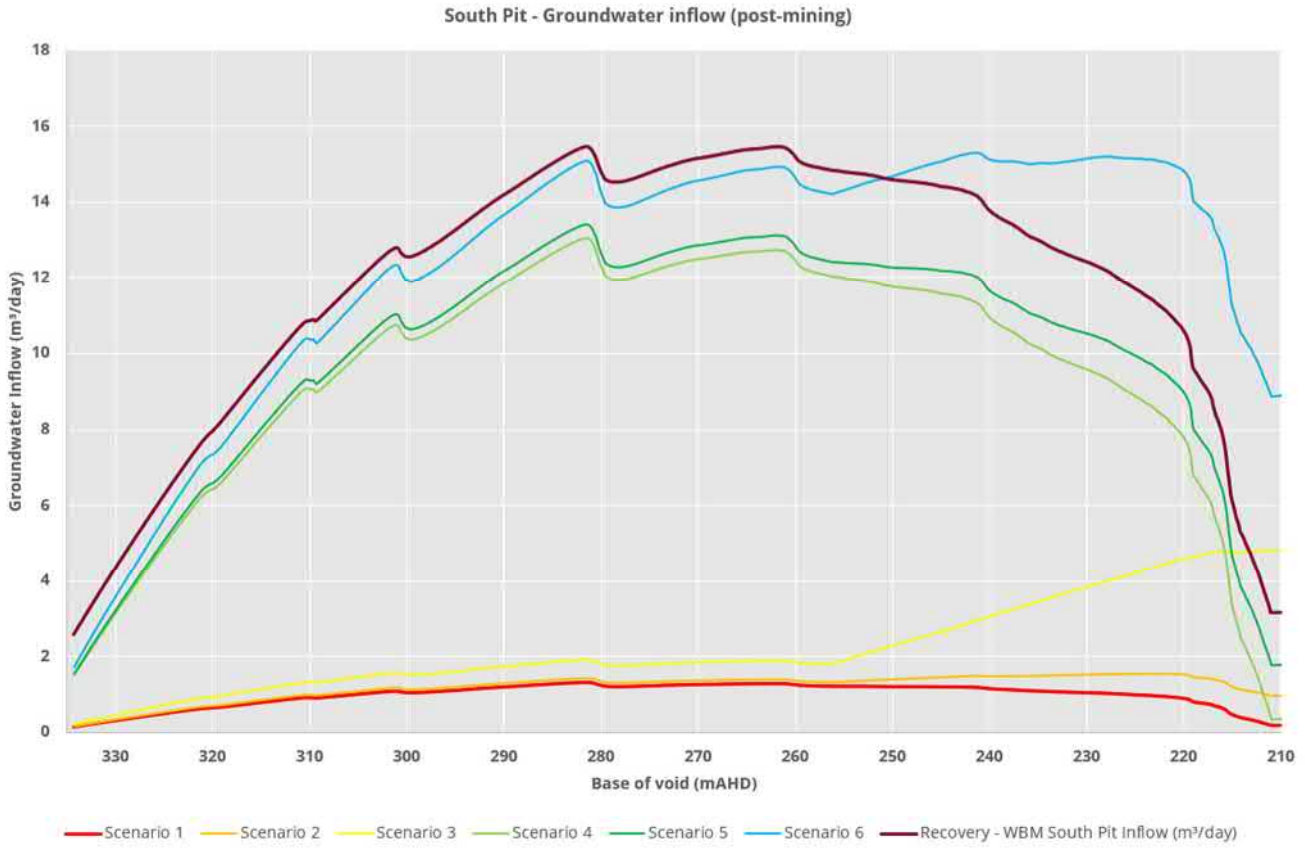

North Pit - Groundwater inflow (post-mining)
Groundwater inflow (m³/day)
30
25
20
15
10
5
0
316
314
312
310
308
306
304
302
300
298
296
Base of void (mAHD)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Scenario 7
Scenario 8
Scenario 9
WBM North Pit Inflow (m³/day)

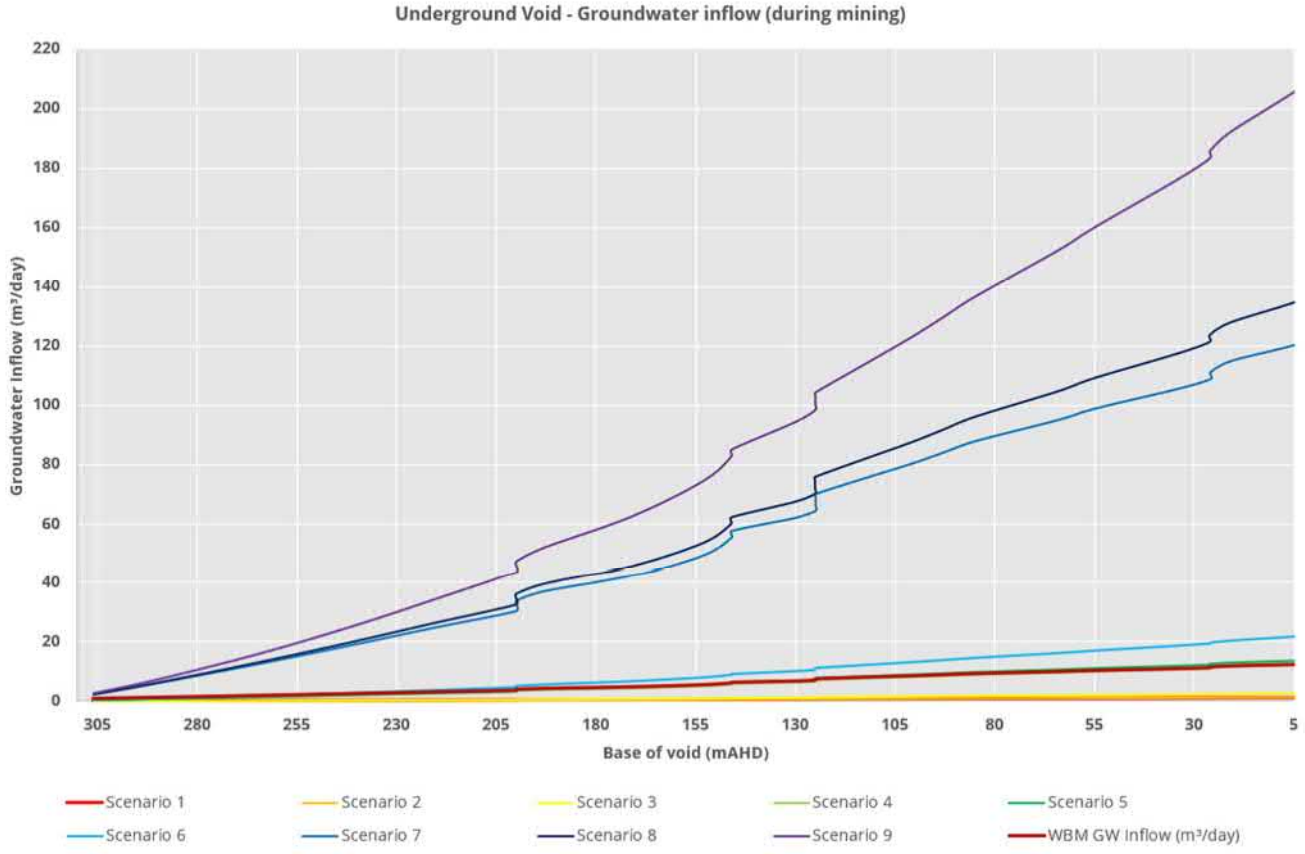

North Pit - Groundwater inflow (post-mining)
Groundwater inflow (m³/day)
3.5
3
2.5
2
1.5
1
0.5
0
316
314
312
310
308
306
304
302
300
298
296
Base of void (mAHD)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
WBM North Pit Inflow (m³/day)

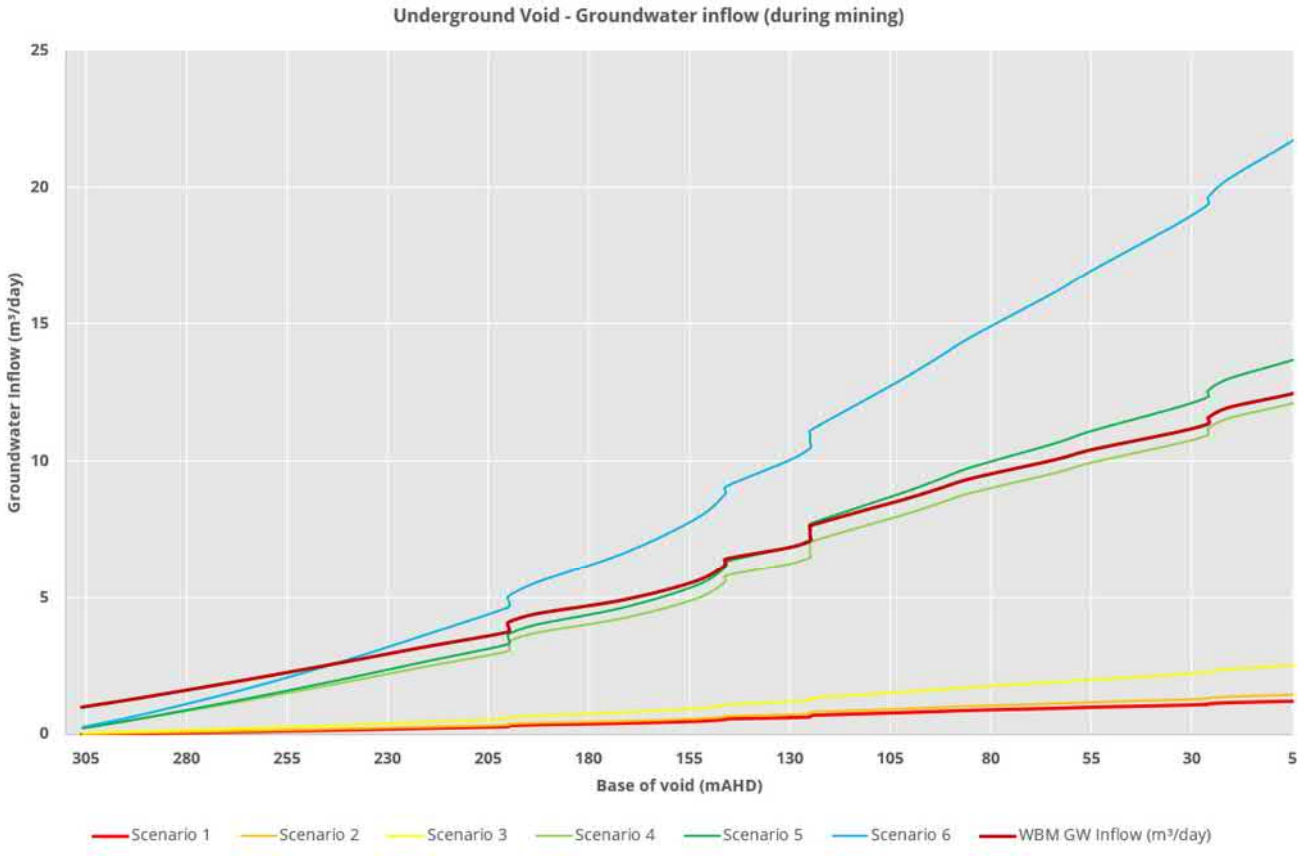

South Pit - Groundwater inflow (during mining)
Groundwater Inflow (m³/day)
550
500
450
400
350
300
250
200
150
100
50
0
330
320
310
300
290
280
270
260
250
240
230
220
210
Base of void (mAHD)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Scenario 7
Scenario 8
Scenario 9
Mining - WBM South Pit Inflow (m³/day)

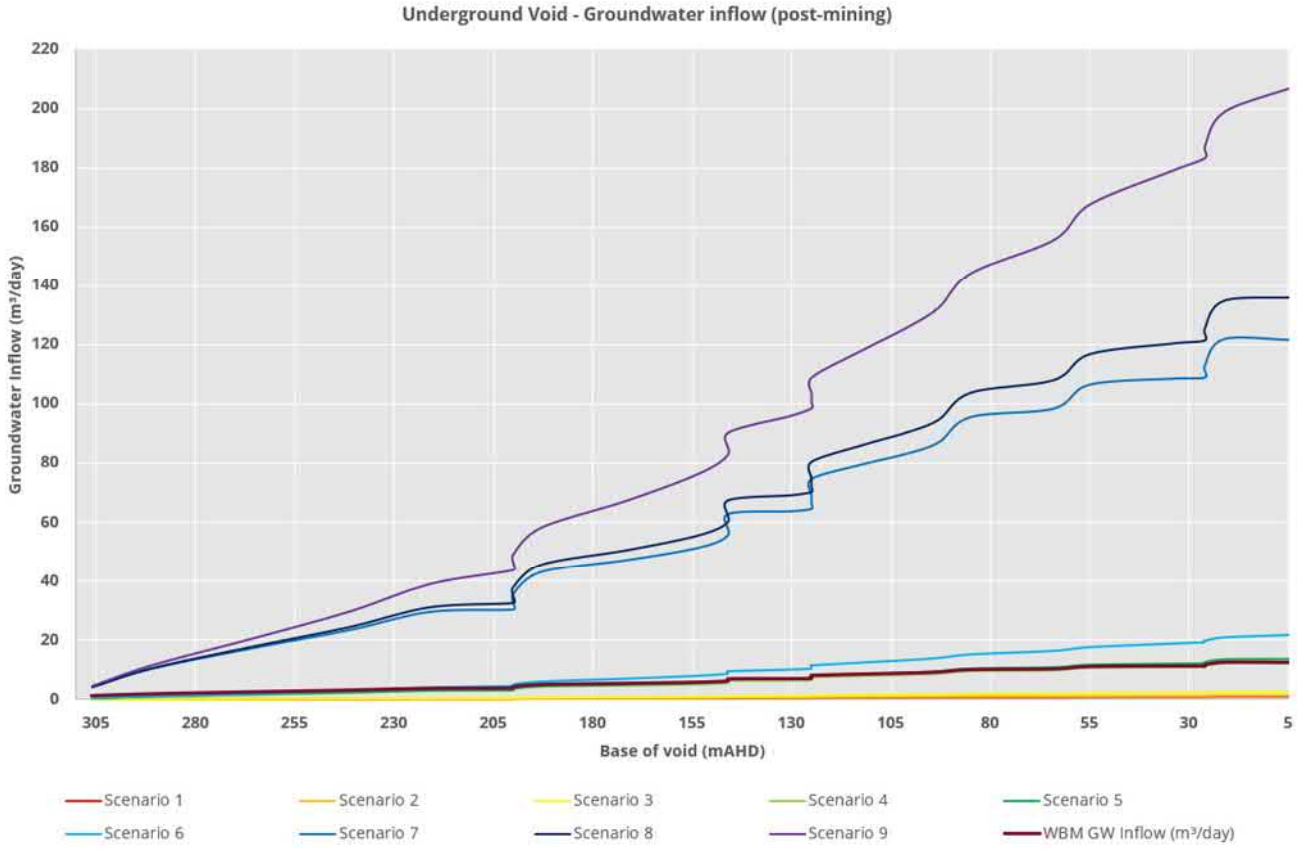

South Pit - Groundwater inflow (during mining)
Groundwater Inflow (m³/day)
60
50
40
30
20
10
0
330
320
310
300
290
280
270
260
250
240
230
220
210
Base of void (mAHD)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Mining - WBM South Pit Inflow (m³/day)

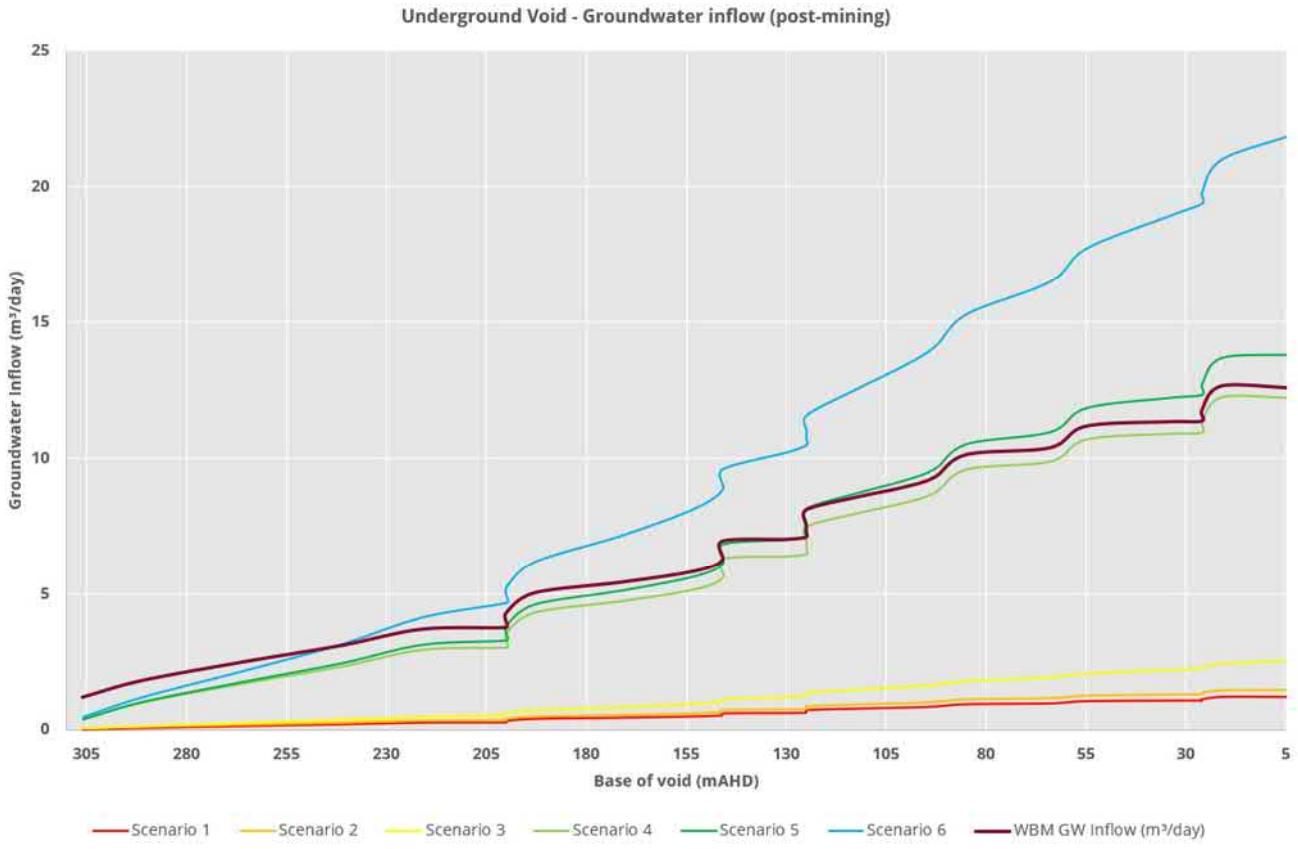

South Pit - Groundwater inflow (post-mining)
Groundwater Inflow (m³/day)
160
140
120
100
80
60
40
20
0
330
320
310
300
290
280
270
260
250
240
230
220
210
Base of void (mAHD)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Scenario 7
Scenario 8
Scenario 9
Recovery - WBM South Pit Inflow (m³/day)


South Pit - Groundwater inflow (post-mining)
Groundwater Inflow (m³/day)
18
16
14
12
10
8
6
4
2
0
330
320
310
300
290
280
270
260
250
240
230
220
210
Base of void (mAHD)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Recovery - WBM South Pit Inflow (m³/day)


Underground Void - Groundwater inflow (during mining)
Groundwater Inflow (m³/day)
220
200
180
160
140
120
100
80
60
40
20
0
305
280
255
230
205
180
155
130
105
80
55
30
5
Base of void (mAHD)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Scenario 7
Scenario 8
Scenario 9
WBM GW Inflow (m³/day)


Underground Void - Groundwater inflow (during mining)
Groundwater Inflow (m³/day)
25
20
15
10
5
0
305
280
255
230
205
180
155
130
105
80
55
30
5
Base of void (mAHD)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
WBM GW Inflow (m³/day)


Underground Void - Groundwater inflow (post-mining)
Groundwater Inflow (m³/day)
220
200
180
160
140
120
100
80
60
40
20
0
305
280
255
230
205
180
155
130
105
80
55
30
5
Base of void (mAHD)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
Scenario 7
Scenario 8
Scenario 9
WBM GW Inflow (m³/day)


Underground Void - Groundwater inflow (post-mining)
Groundwater Inflow (m³/day)
25
20
15
10
5
0
305
280
255
230
205
180
155
130
105
80
55
30
5
Base of void (mAHD)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5
Scenario 6
WBM GW Inflow (m³/day)

B.4 Examples of sensitivity analysis calculations

Example of sensitivity analysis calculations

Scenario 9

Open pit Geometry							Radius of Influence					Marinelli and Nicoli (2000)		
UG Void Level (mAHD)	Height (m) (Portal @ 325mAHD)	Volume (m^3)	Cumulative Volume of Void (m^3)	Cumulative Depth of void (m)	Radius of void (m)	Equivalent Volume Radius (m)	Hydraulic Conductivity Depth Factor	Horizontal Hydraulic Conductivity	Regional GW Level	Drawdown	Radius of Influence	Total GW Inflow	Total GW Inflow	Total GW Inflow
OP_L (h)	Height (m) (Portal @ 325mAHD)	OP_V	OP_V_Cum	OP_D_Cum	Rv	r_0	F_{Kdepth}	K_{h2}	H	s	R	Q_{tot}	Q_{tot}	Q_{tot}
mAHD	m	m^3	m^3	m	m	sqrt((OP_V_Cum/OP_D_Cum)/pi())	-	m/s	mAHD	m	R=3000 (H-h) √(K_sat)+ r_0	m^3/day	m^3/day	ML/day
From Void Geometry	From Void Geometry	From Void Geometry	Calculated	Calculated	Calculated	Calculated	Assumed	Assumed	Regional GW Level (assumed level before mining - BAWBR01-BAWB02 June 2018)	Calculated (H - h)	Calculated	Factor allowing for boundary conditions	Calculated	Calculated
	325.00						1	0.000000229	324			100%	-	
306	19.00	421,078	1,406	11	4.85	6.38	1.00	2.29E-07	324.00	18.00	32.22	100%	2.589	0.00259
291	34.00	419,146	5,070	26	6.89	7.88	1.00	2.29E-07	324.00	33.00	55.25	100%	6.883	0.00688
265	60.00	412,171	12,910	52	8.28	8.89	1.00	2.29E-07	324.00	59.00	93.59	100%	15.669	0.01567
241	84.00	403,180	21,168	76	8.96	9.42	1.00	2.29E-07	324.00	83.00	128.57	100%	25.131	0.02513
221	104.00	395,145	28,599	96	9.36	9.74	1.00	2.29E-07	324.00	103.00	157.61	100%	33.939	0.03394
200	125.00	388,532	35,878	117	9.56	9.88	1.00	2.29E-07	324.00	124.00	187.90	100%	43.635	0.04364
200	125.00	382,434	40,876	117	10.20	10.55	1.00	2.29E-07	324.00	124.00	188.56	100%	45.728	0.04573
200	125.00	381,111	44,992	117	10.70	11.06	1.00	2.29E-07	324.00	124.00	189.08	100%	47.358	0.04736
193	132.00	378,686	50,818	124	11.07	11.42	1.00	2.29E-07	324.00	131.00	199.49	100%	52.035	0.05203
171	154.00	376,856	56,816	146	10.84	11.13	1.00	2.29E-07	324.00	153.00	230.78	100%	62.582	0.06258
153	172.00	375,933	69,250	164	11.32	11.59	1.00	2.29E-07	324.00	171.00	257.08	100%	74.622	0.07462
146	179.00	373,603	84,048	171	12.23	12.51	1.00	2.29E-07	324.00	178.00	268.05	100%	82.912	0.08291
146	179.00	371,275	90,663	171	12.70	12.99	1.00	2.29E-07	324.00	178.00	268.53	100%	85.112	0.08511
130	195.00	370,445	96,091	187	12.52	12.79	1.00	2.29E-07	324.00	194.00	291.30	100%	94.415	0.09442
125	200.00	368,918	100,948	192	12.68	12.94	1.00	2.29E-07	324.00	199.00	298.62	100%	98.448	0.09845
125	200.00	367,598	106,404	192	13.01	13.28	1.00	2.29E-07	324.00	199.00	298.97	100%	100.210	0.10021
125	200.00	359,073	110,274	192	13.25	13.52	1.00	2.29E-07	324.00	199.00	299.21	100%	101.433	0.10143
125	200.00	341,715	116,276	192	13.60	13.88	1.00	2.29E-07	324.00	199.00	299.57	100%	103.287	0.10329
125	200.00	326,147	119,742	192	13.80	14.09	1.00	2.29E-07	324.00	199.00	299.78	100%	104.336	0.10434
112	213.00	312,335	130,776	205	13.98	14.25	1.00	2.29E-07	324.00	212.00	318.60	100%	114.372	0.11437
101	224.00	300,019	139,558	216	14.08	14.34	1.00	2.29E-07	324.00	223.00	334.48	100%	122.908	0.12291
93	232.00	290,925	147,450	224	14.22	14.48	1.00	2.29E-07	324.00	231.00	346.10	100%	129.679	0.12968
85	240.00	287,018	155,649	232	14.37	14.61	1.00	2.29E-07	324.00	239.00	357.73	100%	136.635	0.13664
64	261.00	282,285	166,859	253	14.27	14.49	1.00	2.29E-07	324.00	260.00	387.75	100%	152.400	0.15240
55	270.00	271,676	173,940	262	14.32	14.54	1.00	2.29E-07	324.00	269.00	400.72	100%	160.039	0.16004
34	291.00	259,696	183,209	283	14.16	14.36	1.00	2.29E-07	324.00	290.00	430.68	100%	176.265	0.17626
26	299.00	247,302	189,162	291	14.19	14.38	1.00	2.29E-07	324.00	298.00	442.20	100%	183.344	0.18334
26	299.00	232,846	197,427	291	14.50	14.70	1.00	2.29E-07	324.00	298.00	442.51	100%	185.737	0.18574
21	304.00	217,744	207,417	296	14.74	14.93	1.00	2.29E-07	324.00	303.00	449.93	100%	191.991	0.19199
2	323.00	207,417	217,744	315	14.65	14.83	1.00	2.29E-07	324.00	322.00	477.10	100%	208.283	0.20828
2	323.00	197,427	232,846	315	15.15	15.34	1.00	2.29E-07	324.00	322.00	477.61	100%	212.494	0.21249
2	323.00	189,162	247,302	315	15.61	15.81	1.00	2.29E-07	324.00	322.00	478.08	100%	216.399	0.21640
2	323.00	183,209	259,696	315	16.00	16.20	1.00	2.29E-07	324.00	322.00	478.47	100%	219.656	0.21966
2	323.00	173,940	271,676	315	16.36	16.57	1.00	2.29E-07	324.00	322.00	478.84	100%	222.732	0.22273
2	323.00	166,859	282,285	315	16.68	16.89	1.00	2.29E-07	324.00	322.00	479.16	100%	225.400	0.22540
2	323.00	155,649	287,018	315	16.82	17.03	1.00	2.29E-07	324.00	322.00	479.30	100%	226.573	0.22657
2	323.00	147,450	290,925	315	16.93	17.15	1.00	2.29E-07	324.00	322.00	479.42	100%	227.535	0.22754
2	323.00	139,558	300,019	315	17.19	17.41	1.00	2.29E-07	324.00	322.00	479.68	100%	229.749	0.22975
2	323.00	130,776	312,335	315	17.54	17.77	1.00	2.29E-07	324.00	322.00	480.03	100%	232.695	0.23269
2	323.00	119,742	326,147	315	17.93	18.15	1.00	2.29E-07	324.00	322.00	480.42	100%	235.930	0.23593

Example of sensitivity analysis calculations

UG Void Level (mAHD)	Height (m) (Portal @ 325mAHD)	Volume (m^3)	Cumulative Volume of Void (m^3)	Cumulative Depth of void (m)	Radius of void (m)	Equivalent Volume Radius (m)	Hydraulic Conductivity Depth Factor	Horizontal Hydraulic Conductivity	Regional GW Level	Drawdown	Radius of Influence	Total GW Inflow	Total GW Inflow	Total GW Inflow
OP_L (h)	Height (m) (Portal @ 325mAHD)	OP_V	OP_V_Cum	OP_D_Cum	Rv	r_0	F_{Kdepth}	K_{h2}	H	s	R	Q_{tot}	Q_{tot}	Q_{tot}
mAHD	m	m^3	m^3	m	m	sqrt((OP_V_Cum/OP_D_Cum)/pi())	-	m/s	mAHD	m	R=3000 (H-h) √(K_sat)+ r_0	m^3/day	m^3/day	ML/day
From Void Geometry	From Void Geometry	From Void Geometry	Calculated	Calculated	Calculated	Calculated	Assumed	Assumed	Regional GW Level (assumed level before mining - BAWBR01-BAWB02 June 2018)	Calculated (H - h)	Calculated	Factor allowing for boundary conditions	Calculated	Calculated
	325.00						1	0.000000229	324			100%	-	
2	323.00	116,276	341,715	315	18.35	18.58	1.00	2.29E-07	324.00	322.00	480.85	100%	239.495	0.23949
2	323.00	110,274	359,073	315	18.81	19.05	1.00	2.29E-07	324.00	322.00	481.32	100%	243.375	0.24338
2	323.00	106,404	367,598	315	19.03	19.27	1.00	2.29E-07	324.00	322.00	481.54	100%	245.247	0.24525
2	323.00	100,948	368,918	315	19.07	19.31	1.00	2.29E-07	324.00	322.00	481.58	100%	245.535	0.24553
2	323.00	96,091	370,445	315	19.11	19.35	1.00	2.29E-07	324.00	322.00	481.62	100%	245.867	0.24587
2	323.00	90,663	371,275	315	19.13	19.37	1.00	2.29E-07	324.00	322.00	481.64	100%	246.047	0.24605
2	323.00	84,048	373,603	315	19.19	19.43	1.00	2.29E-07	324.00	322.00	481.70	100%	246.552	0.24655
2	323.00	69,250	375,933	315	19.25	19.49	1.00	2.29E-07	324.00	322.00	481.76	100%	247.056	0.24706
2	323.00	56,816	376,856	315	19.27	19.51	1.00	2.29E-07	324.00	322.00	481.78	100%	247.255	0.24725
2	323.00	50,818	378,686	315	19.32	19.56	1.00	2.29E-07	324.00	322.00	481.83	100%	247.649	0.24765
2	323.00	44,992	381,111	315	19.38	19.62	1.00	2.29E-07	324.00	322.00	481.89	100%	248.170	0.24817
2	323.00	40,876	382,434	315	19.41	19.66	1.00	2.29E-07	324.00	322.00	481.93	100%	248.453	0.24845
2	323.00	35,878	388,532	315	19.57	19.81	1.00	2.29E-07	324.00	322.00	482.08	100%	249.753	0.24975
2	323.00	28,599	395,145	315	19.73	19.98	1.00	2.29E-07	324.00	322.00	482.25	100%	251.151	0.25115
2	323.00	21,168	403,180	315	19.93	20.18	1.00	2.29E-07	324.00	322.00	482.45	100%	252.833	0.25283
2	323.00	12,910	412,171	315	20.15	20.41	1.00	2.29E-07	324.00	322.00	482.68	100%	254.697	0.25470
2	323.00	5,070	419,146	315	20.32	20.58	1.00	2.29E-07	324.00	322.00	482.85	100%	256.128	0.25613
2	323.00	1,406	421,078	315	20.37	20.63	1.00	2.29E-07	324.00	322.00	482.90	100%	256.523	0.25652

Example of sensitivity analysis calculations

Scenario 9

		Assumptions					Marinelli and Nicoli (2000)							
UG Void Level (mAHD)	Height (m) (Portal @ 325mAHD)	Average annual rainfall	Average Annual Recharge	Base of Aquifer	Radius of Influence	Regional GW Level	Radius of Influence	Radius of Void	Zone 1 Inflows	Radius of Influence	Radius of Void	Hydraulic Conductivity Factor	Horizontal Hydraulic Conductivity	Vertical Hydraulic Conductivity
OP_L (h)	Height (m) (Portal @ 325mAHD)	P	W	B_{aq}	r_o	GW	r_o	r_p	Q1	r_o	r_p		K_{h2}	K_{v2}
mAHD	m	m/year	m/d	mAHD	m	mAHD	m	m	m^3/day	m	m		m/day	m/day
From Void Geometry	From Void Geometry	Assume average in Mt Isa (461 mm/year)	Assume 2% of rainfall	Assume base of open pit	Calculated	Assume level before mining - BAWBR01-BAWB02 June 2018	Calculated	From void geometry	Calculated	Calculated	From void calculations	Linear from top to bottom	Assumed	Assume % of K_h
	325.00	461	10%	2		324		-	-		-	Calculated	Calculated	10%
306	19.00	0.001263014	0.000126301	2	32.22	324	32.22	4.85	0.403	32.22	4.85	1.00	1.98E-02	1.98E-03
291	34.00	0.001263014	0.000126301	2	55.25	324	55.25	6.89	1.193	55.25	6.89	1.00	1.98E-02	1.98E-03
265	60.00	0.001263014	0.000126301	2	93.59	324	93.59	8.28	3.448	93.59	8.28	1.00	1.98E-02	1.98E-03
241	84.00	0.001263014	0.000126301	2	128.57	324	128.57	8.96	6.527	128.57	8.96	1.00	1.98E-02	1.98E-03
221	104.00	0.001263014	0.000126301	2	157.61	324	157.61	9.36	9.821	157.61	9.36	1.00	1.98E-02	1.98E-03
200	125.00	0.001263014	0.000126301	2	187.90	324	187.90	9.56	13.972	187.90	9.56	1.00	1.98E-02	1.98E-03
200	125.00	0.001263014	0.000126301	2	188.56	324	188.56	10.20	14.067	188.56	10.20	1.00	1.98E-02	1.98E-03
200	125.00	0.001263014	0.000126301	2	189.08	324	189.08	10.70	14.140	189.08	10.70	1.00	1.98E-02	1.98E-03
193	132.00	0.001263014	0.000126301	2	199.49	324	199.49	11.07	15.742	199.49	11.07	1.00	1.98E-02	1.98E-03
171	154.00	0.001263014	0.000126301	2	230.78	324	230.78	10.84	21.086	230.78	10.84	1.00	1.98E-02	1.98E-03
153	172.00	0.001263014	0.000126301	2	257.08	324	257.08	11.32	26.174	257.08	11.32	1.00	1.98E-02	1.98E-03
146	179.00	0.001263014	0.000126301	2	268.05	324	268.05	12.23	28.450	268.05	12.23	1.00	1.98E-02	1.98E-03
146	179.00	0.001263014	0.000126301	2	268.53	324	268.53	12.70	28.548	268.53	12.70	1.00	1.98E-02	1.98E-03
130	195.00	0.001263014	0.000126301	2	291.30	324	291.30	12.52	33.607	291.30	12.52	1.00	1.98E-02	1.98E-03
125	200.00	0.001263014	0.000126301	2	298.62	324	298.62	12.68	35.320	298.62	12.68	1.00	1.98E-02	1.98E-03
125	200.00	0.001263014	0.000126301	2	298.97	324	298.97	13.01	35.399	298.97	13.01	1.00	1.98E-02	1.98E-03
125	200.00	0.001263014	0.000126301	2	299.21	324	299.21	13.25	35.453	299.21	13.25	1.00	1.98E-02	1.98E-03
125	200.00	0.001263014	0.000126301	2	299.57	324	299.57	13.60	35.536	299.57	13.60	1.00	1.98E-02	1.98E-03
125	200.00	0.001263014	0.000126301	2	299.78	324	299.78	13.80	35.582	299.78	13.80	1.00	1.98E-02	1.98E-03
112	213.00	0.001263014	0.000126301	2	318.60	324	318.60	13.98	40.199	318.60	13.98	1.00	1.98E-02	1.98E-03
101	224.00	0.001263014	0.000126301	2	334.48	324	334.48	14.08	44.314	334.48	14.08	1.00	1.98E-02	1.98E-03
93	232.00	0.001263014	0.000126301	2	346.10	324	346.10	14.22	47.450	346.10	14.22	1.00	1.98E-02	1.98E-03
85	240.00	0.001263014	0.000126301	2	357.73	324	357.73	14.37	50.694	357.73	14.37	1.00	1.98E-02	1.98E-03
64	261.00	0.001263014	0.000126301	2	387.75	324	387.75	14.27	59.576	387.75	14.27	1.00	1.98E-02	1.98E-03
55	270.00	0.001263014	0.000126301	2	400.72	324	400.72	14.32	63.633	400.72	14.32	1.00	1.98E-02	1.98E-03
34	291.00	0.001263014	0.000126301	2	430.68	324	430.68	14.16	73.520	430.68	14.16	1.00	1.98E-02	1.98E-03
26	299.00	0.001263014	0.000126301	2	442.20	324	442.20	14.19	77.508	442.20	14.19	1.00	1.98E-02	1.98E-03
26	299.00	0.001263014	0.000126301	2	442.51	324	442.51	14.50	77.613	442.51	14.50	1.00	1.98E-02	1.98E-03
21	304.00	0.001263014	0.000126301	2	449.93	324	449.93	14.74	80.237	449.93	14.74	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	477.10	324	477.10	14.65	90.234	477.10	14.65	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	477.61	324	477.61	15.15	90.420	477.61	15.15	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	478.08	324	478.08	15.61	90.592	478.08	15.61	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	478.47	324	478.47	16.00	90.736	478.47	16.00	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	478.84	324	478.84	16.36	90.872	478.84	16.36	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	479.16	324	479.16	16.68	90.989	479.16	16.68	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	479.30	324	479.30	16.82	91.041	479.30	16.82	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	479.42	324	479.42	16.93	91.083	479.42	16.93	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	479.68	324	479.68	17.19	91.181	479.68	17.19	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	480.03	324	480.03	17.54	91.311	480.03	17.54	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	480.42	324	480.42	17.93	91.454	480.42	17.93	1.00	1.98E-02	1.98E-03

Example of sensitivity analysis calculations

UG Void Level (mAHD)	Height (m) (Portal @ 325mAHD)	Average annual rainfall	Average Annual Recharge	Base of Aquifer	Radius of Influence	Regional GW Level	Radius of Influence	Radius of Void	Zone 1 Inflows	Radius of Influence	Radius of Void	Hydraulic Conductivity Factor	Horizontal Hydraulic Conductivity	Vertical Hydraulic Conductivity
OP_L (h)	Height (m) (Portal @ 325mAHD)	P	W	B_{aq}	r_o	GW	r_o	r_p	Q1	r_o	r_p		K_{h2}	K_{v2}
mAHD	m	m/year	m/d	mAHD	m	mAHD	m	m	m³/day	m	m		m/day	m/day
From Void Geometry	From Void Geometry	Assume average in Mt Isa (461 mm/year)	Assume 2% of rainfall	Assume base of open pit	Calculated	Assume level before mining - BAWBR01-BAWB02 June 2018	Calculated	From void geometry	Calculated	Calculated	From void calculations	Linear from top to bottom	Assumed	Assume % of K_h
	325.00	461	10%	2		324		-	-		-	Calculated	Calculated	10%
2	323.00	0.001263014	0.000126301	2	480.85	324	480.85	18.35	91.611	480.85	18.35	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	481.32	324	481.32	18.81	91.782	481.32	18.81	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	481.54	324	481.54	19.03	91.865	481.54	19.03	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	481.58	324	481.58	19.07	91.877	481.58	19.07	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	481.62	324	481.62	19.11	91.892	481.62	19.11	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	481.64	324	481.64	19.13	91.900	481.64	19.13	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	481.70	324	481.70	19.19	91.922	481.70	19.19	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	481.76	324	481.76	19.25	91.944	481.76	19.25	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	481.78	324	481.78	19.27	91.953	481.78	19.27	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	481.83	324	481.83	19.32	91.971	481.83	19.32	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	481.89	324	481.89	19.38	91.993	481.89	19.38	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	481.93	324	481.93	19.41	92.006	481.93	19.41	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	482.08	324	482.08	19.57	92.063	482.08	19.57	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	482.25	324	482.25	19.73	92.125	482.25	19.73	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	482.45	324	482.45	19.93	92.199	482.45	19.93	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	482.68	324	482.68	20.15	92.281	482.68	20.15	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	482.85	324	482.85	20.32	92.345	482.85	20.32	1.00	1.98E-02	1.98E-03
2	323.00	0.001263014	0.000126301	2	482.90	324	482.90	20.37	92.362	482.90	20.37	1.00	1.98E-02	1.98E-03

Example of sensitivity analysis calculations

Scenario 9

UG Void Level (mAHD)	Height (m) (Portal @ 325mAHD)	Degree of anisotropy	Saturated Thickness of Aquifer	Depth of water level in void	Zone 2 Inflows
OP_L (h)	Height (m) (Portal @ 325mAHD)	m_2	h_0	d	Q2
mAHD	m	-	m	m	m³/day
From Void Geometry	From Void Geometry	srqt(K_h/K_v)	Calculate from regional GWL	Set at 0 during dewatering	
	325.00				
306	19.00	3.16228	18	0	2.186
291	34.00	3.16228	33	0	5.690
265	60.00	3.16228	59	0	12.220
241	84.00	3.16228	83	0	18.604
221	104.00	3.16228	103	0	24.117
200	125.00	3.16228	124	0	29.663
200	125.00	3.16228	124	0	31.662
200	125.00	3.16228	124	0	33.218
193	132.00	3.16228	131	0	36.293
171	154.00	3.16228	153	0	41.496
153	172.00	3.16228	171	0	48.448
146	179.00	3.16228	178	0	54.462
146	179.00	3.16228	178	0	56.564
130	195.00	3.16228	194	0	60.808
125	200.00	3.16228	199	0	63.128
125	200.00	3.16228	199	0	64.811
125	200.00	3.16228	199	0	65.979
125	200.00	3.16228	199	0	67.751
125	200.00	3.16228	199	0	68.754
112	213.00	3.16228	212	0	74.173
101	224.00	3.16228	223	0	78.595
93	232.00	3.16228	231	0	82.229
85	240.00	3.16228	239	0	85.941
64	261.00	3.16228	260	0	92.824
55	270.00	3.16228	269	0	96.406
34	291.00	3.16228	290	0	102.745
26	299.00	3.16228	298	0	105.836
26	299.00	3.16228	298	0	108.123
21	304.00	3.16228	303	0	111.754
2	323.00	3.16228	322	0	118.049
2	323.00	3.16228	322	0	122.074
2	323.00	3.16228	322	0	125.806
2	323.00	3.16228	322	0	128.920
2	323.00	3.16228	322	0	131.860
2	323.00	3.16228	322	0	134.410
2	323.00	3.16228	322	0	135.532
2	323.00	3.16228	322	0	136.452
2	323.00	3.16228	322	0	138.568
2	323.00	3.16228	322	0	141.384
2	323.00	3.16228	322	0	144.476

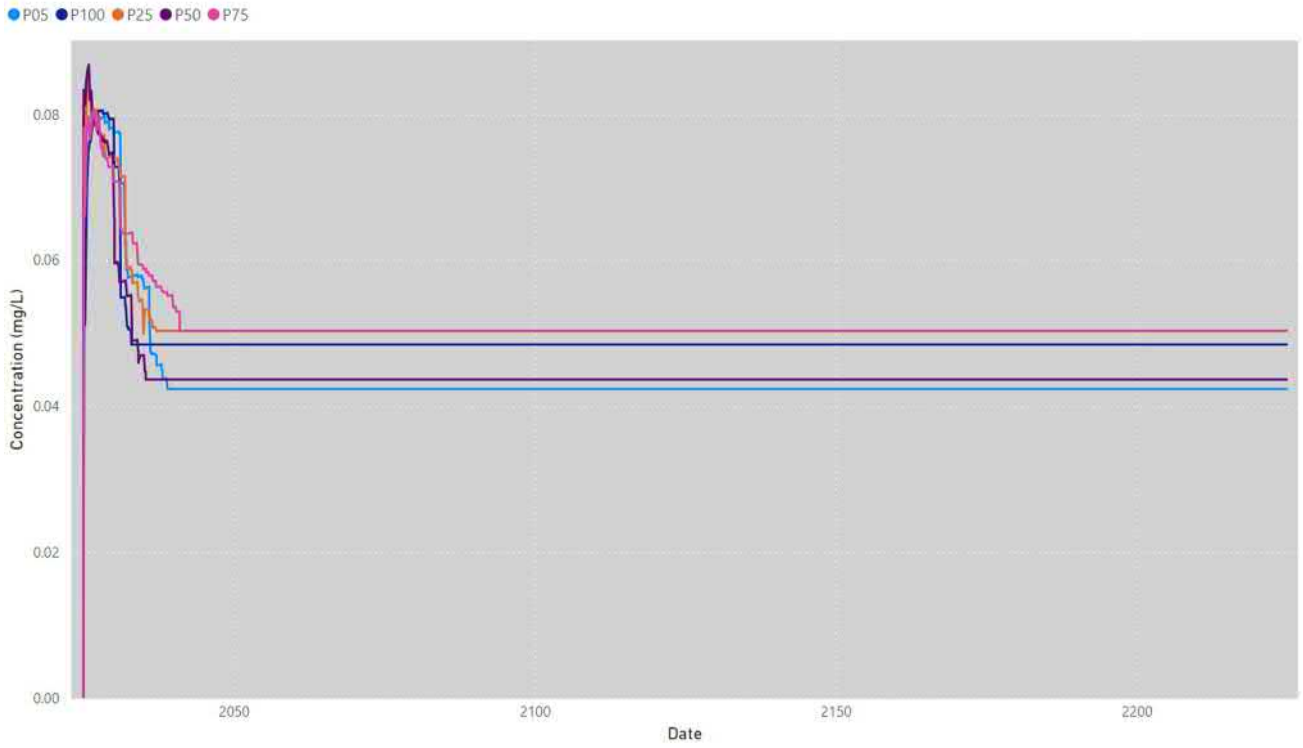
Example of sensitivity analysis calculations

UG Void Level (mAHD)	Height (m) (Portal @ 325mAHD)	Degree of anisotropy	Saturated Thickness of Aquifer	Depth of water level in void	Zone 2 Inflows
OP_L (h)	Height (m) (Portal @ 325mAHD)	m_2	h_0	d	Q2
mAHD	m	-	m	m	m^3/day
From Void Geometry	From Void Geometry	srqt(K_h/K_v)	Calculate from regional GWL	Set at 0 during dewatering	
	325.00				
2	323.00	3.16228	322	0	147.884
2	323.00	3.16228	322	0	151.593
2	323.00	3.16228	322	0	153.382
2	323.00	3.16228	322	0	153.658
2	323.00	3.16228	322	0	153.975
2	323.00	3.16228	322	0	154.148
2	323.00	3.16228	322	0	154.630
2	323.00	3.16228	322	0	155.112
2	323.00	3.16228	322	0	155.302
2	323.00	3.16228	322	0	155.678
2	323.00	3.16228	322	0	156.176
2	323.00	3.16228	322	0	156.447
2	323.00	3.16228	322	0	157.689
2	323.00	3.16228	322	0	159.026
2	323.00	3.16228	322	0	160.634
2	323.00	3.16228	322	0	162.415
2	323.00	3.16228	322	0	163.784
2	323.00	3.16228	322	0	164.161

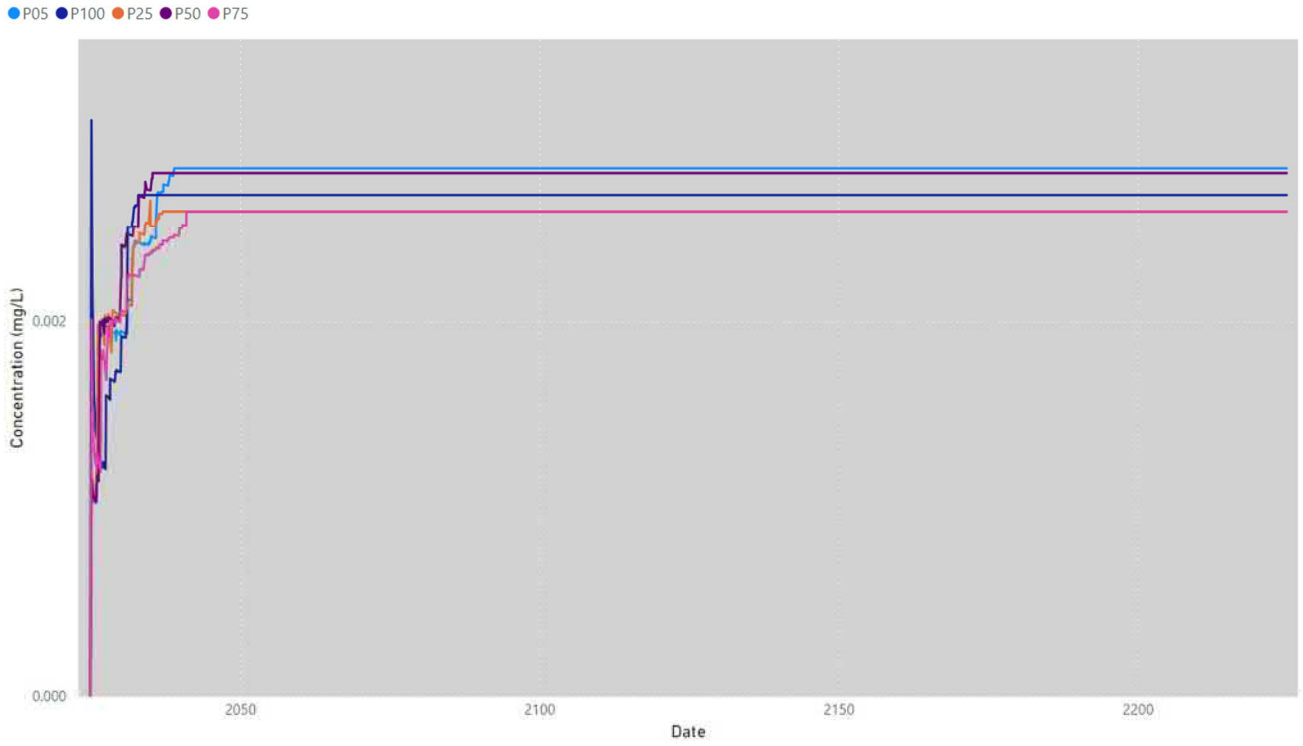
Appendix C Long-term (200 yrs) underground void water quality

C.1 Underground void modelled water quality time series

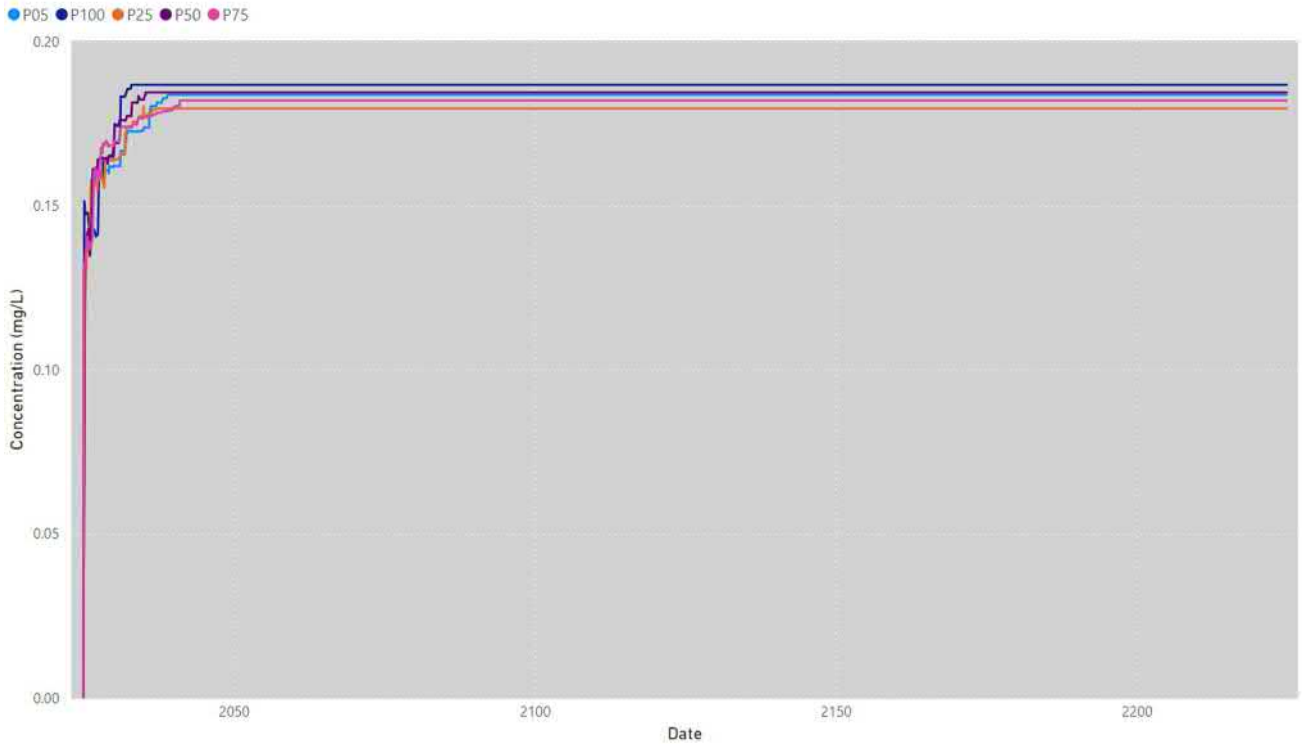
Aluminium



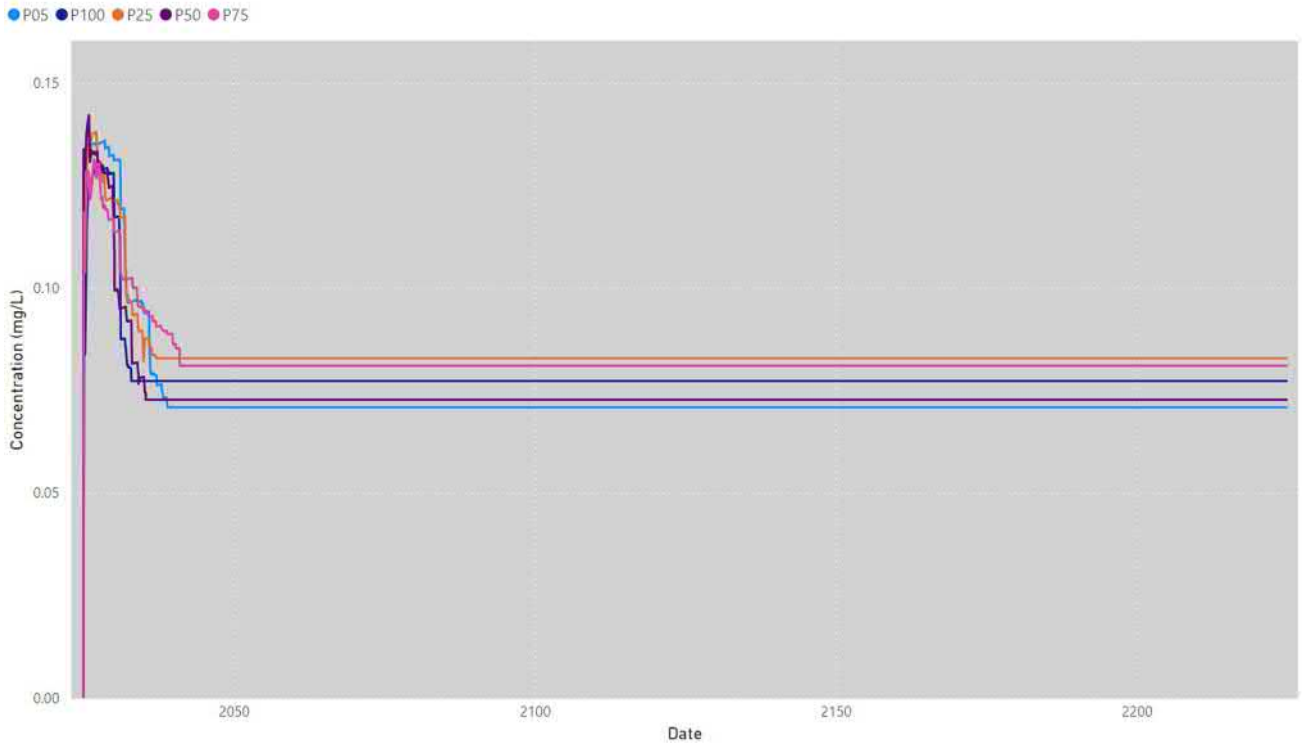
Arsenic



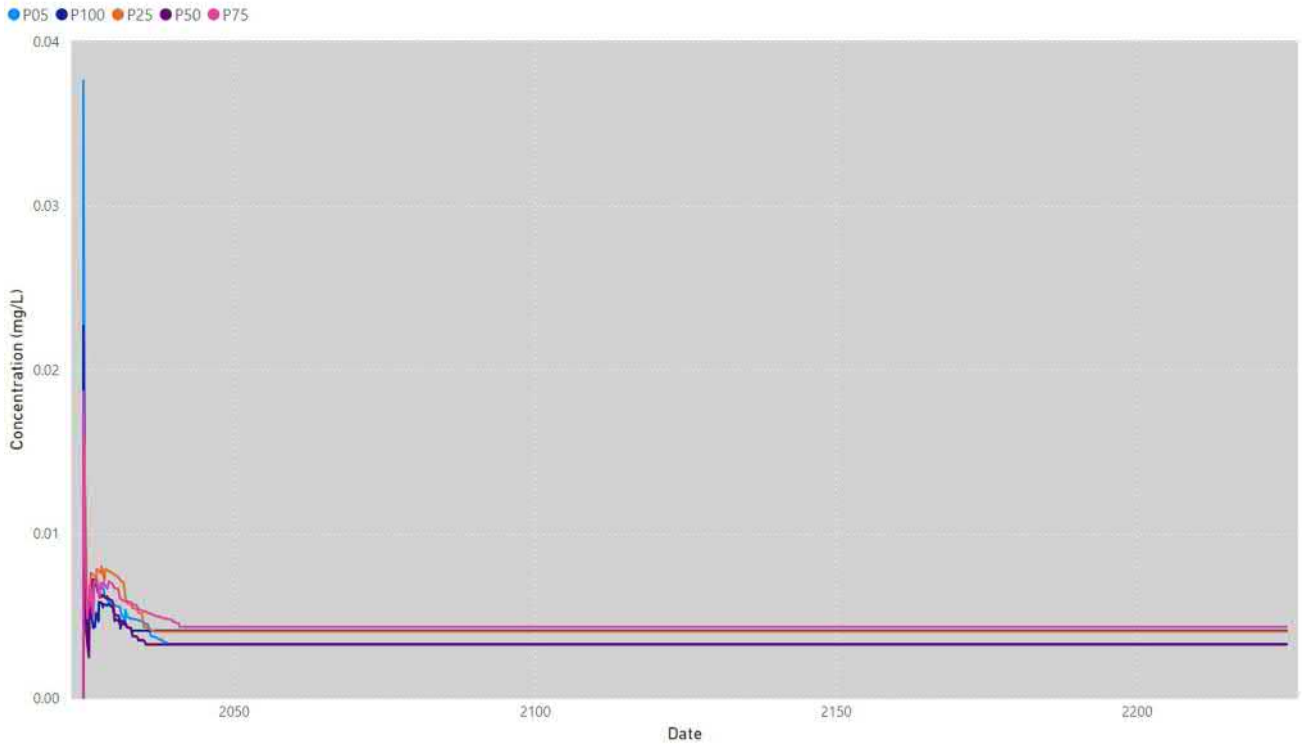
Barium



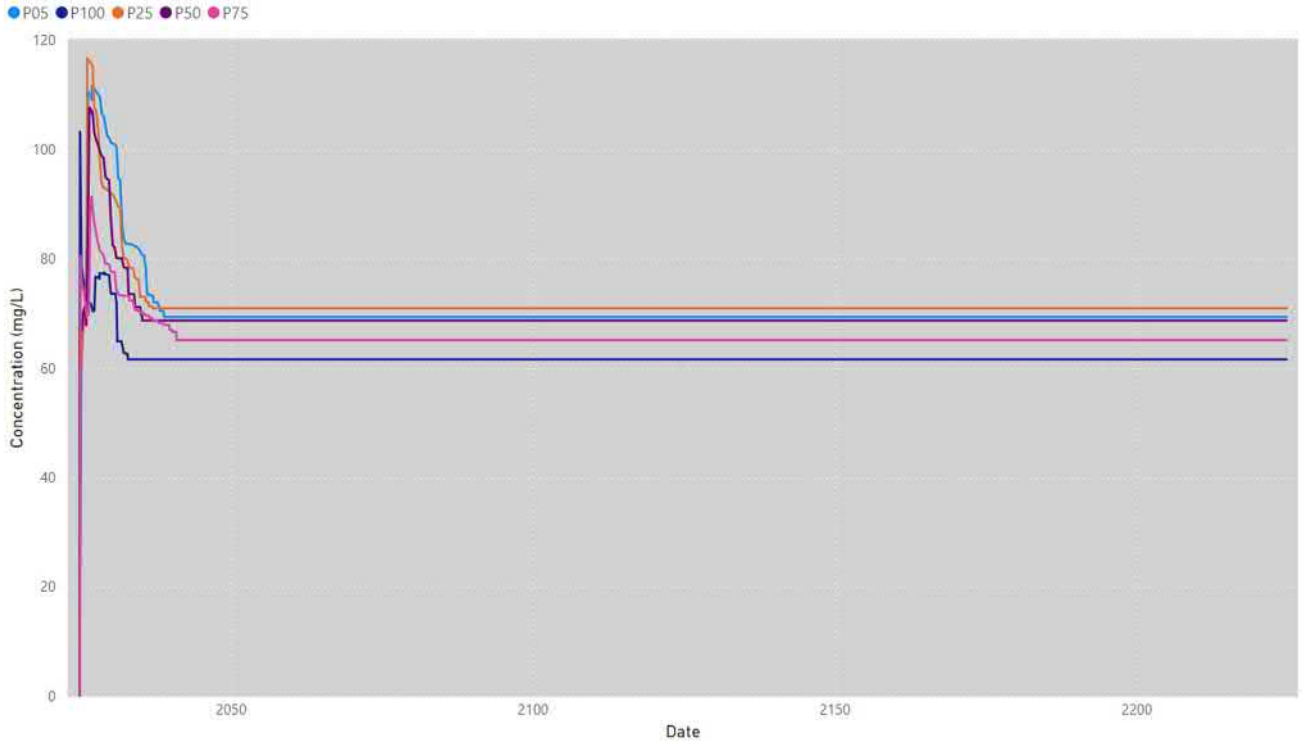
Boron



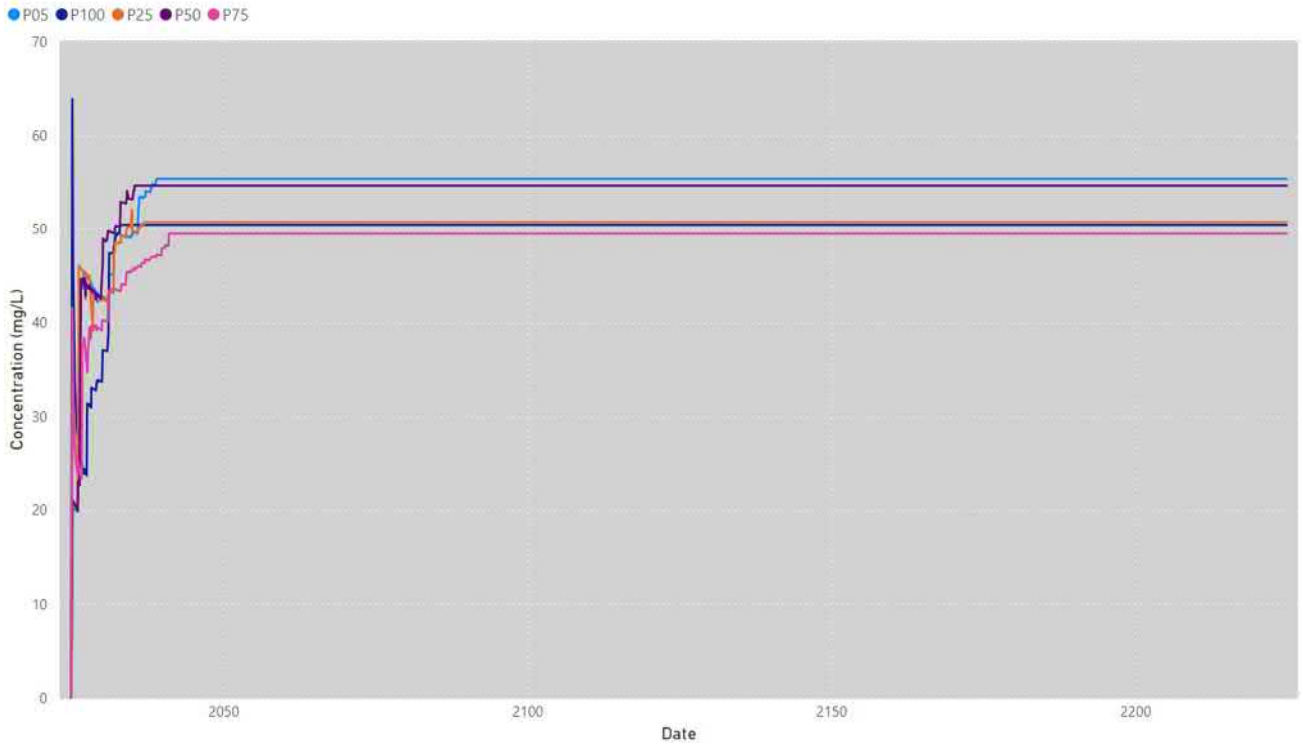
Cadmium



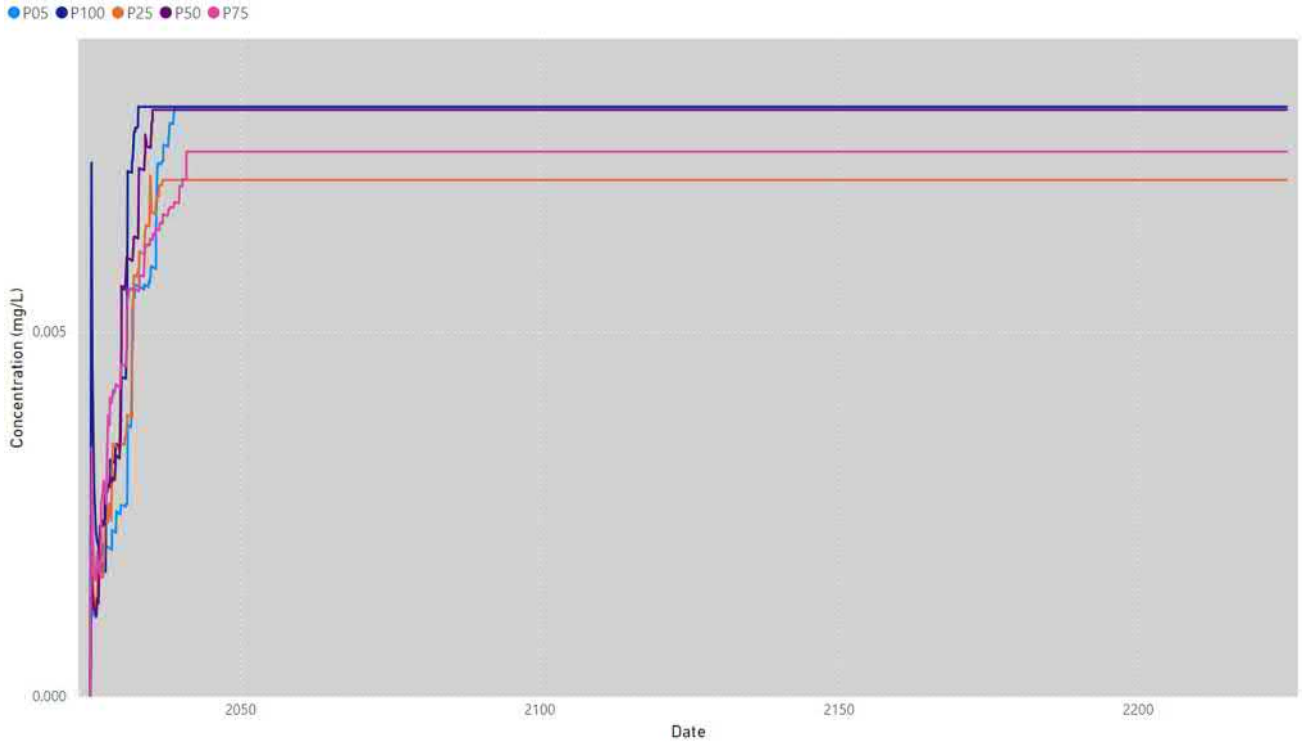
Calcium



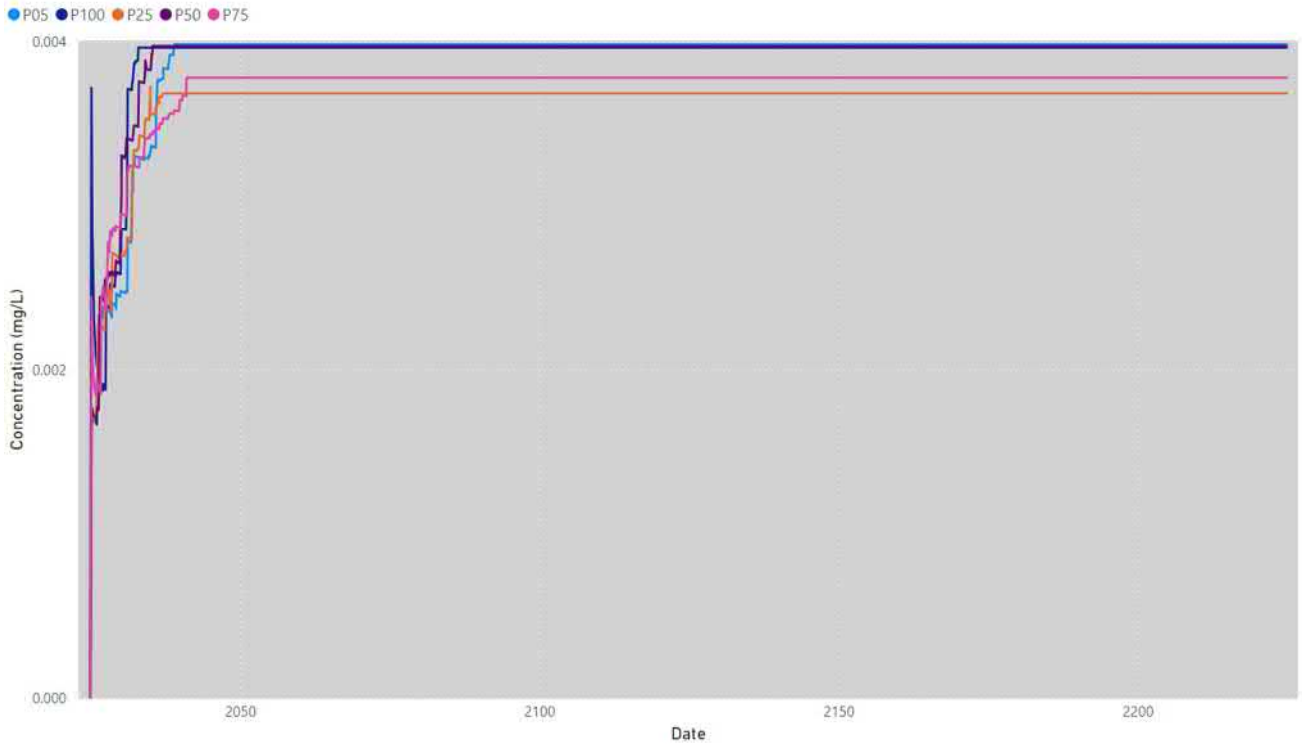
Chloride



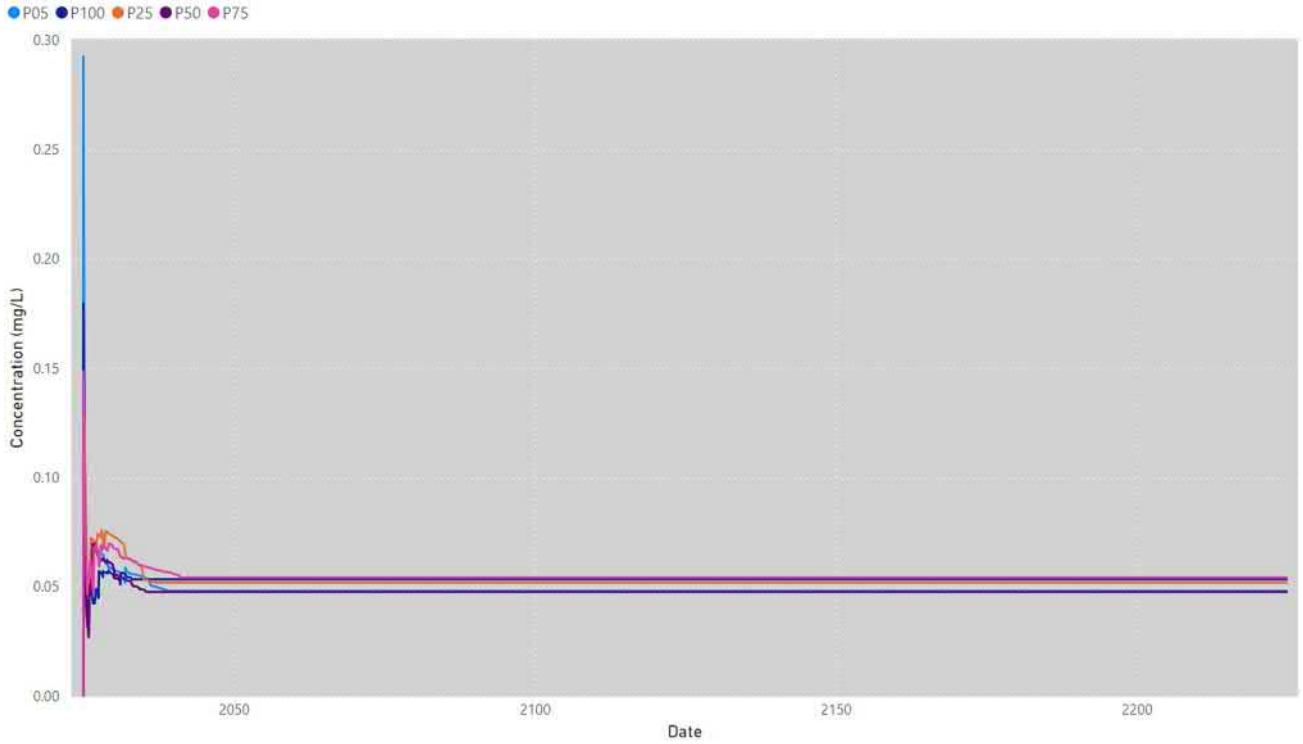
Chromium



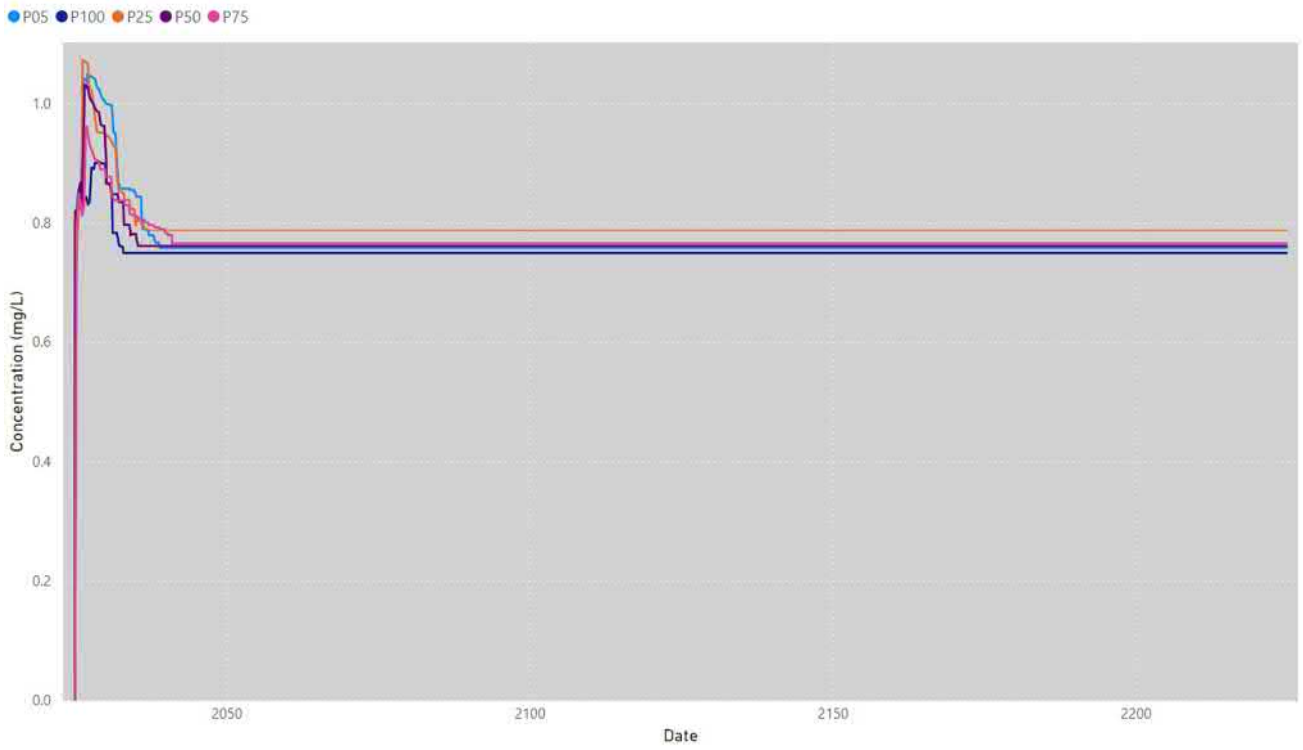
Cobalt



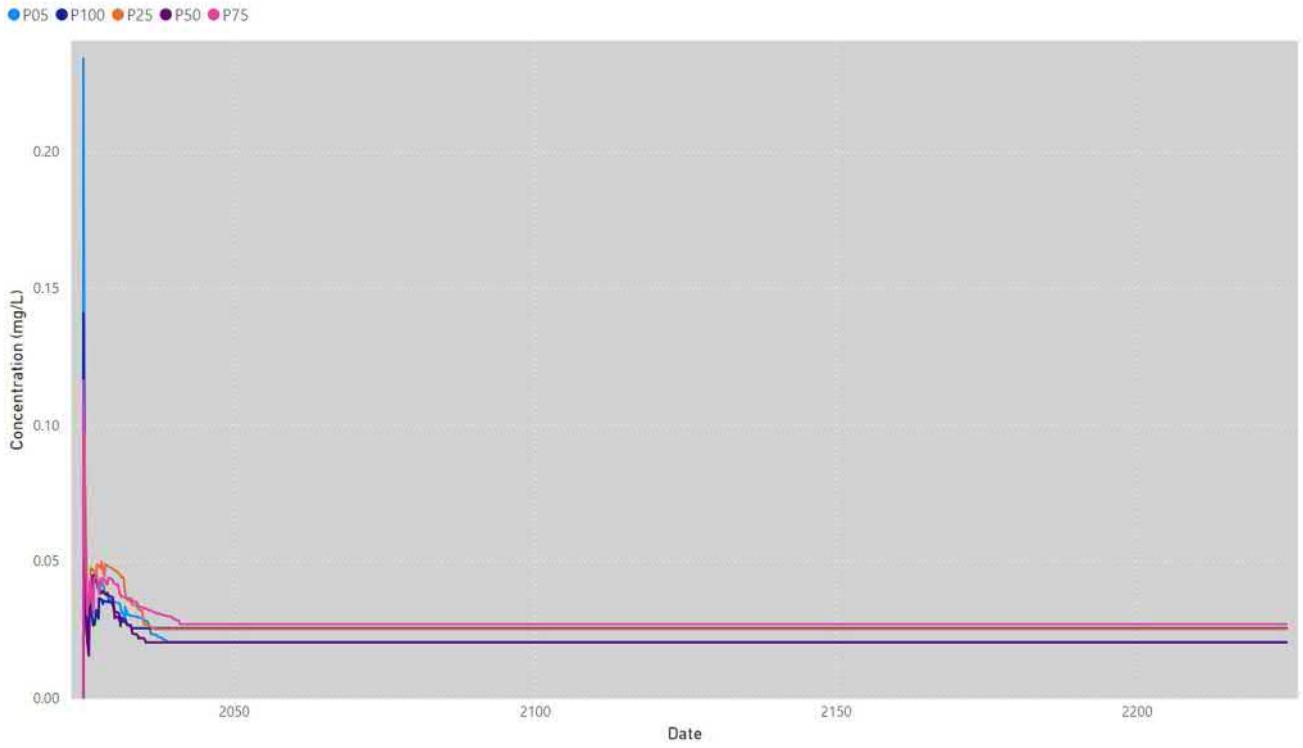
Copper



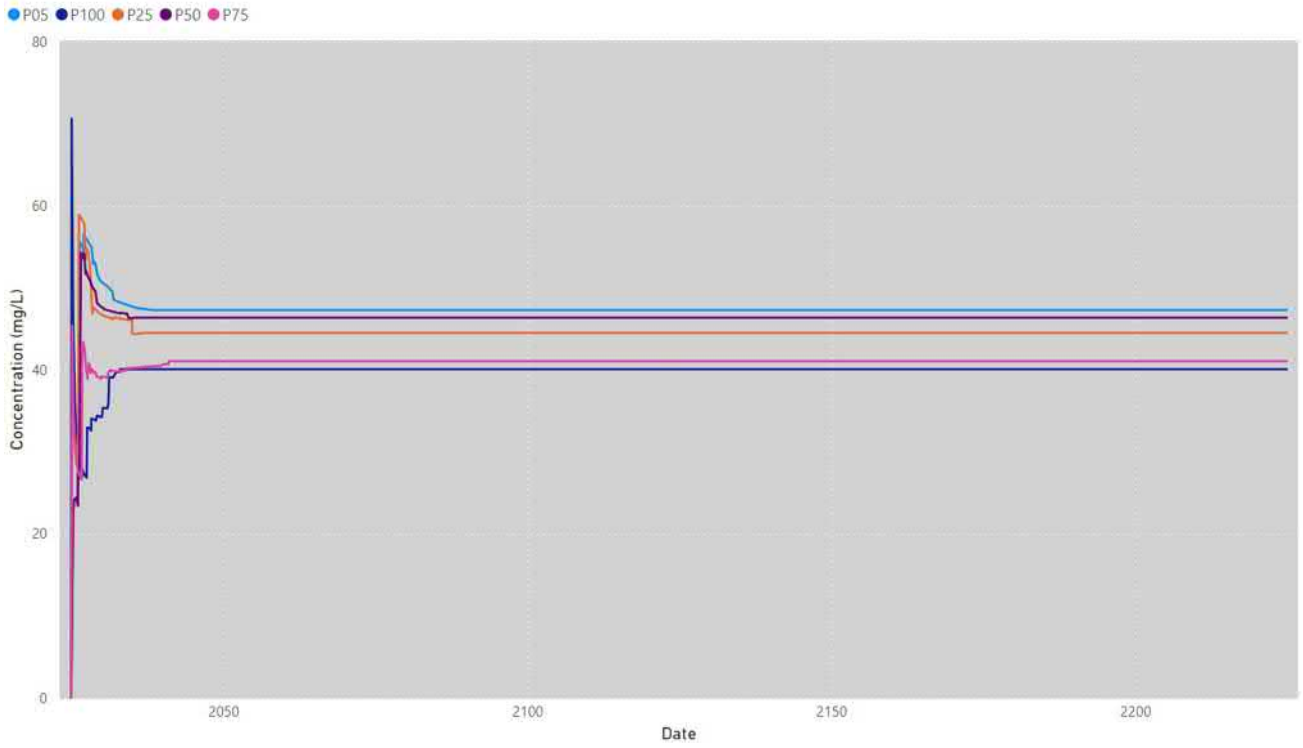
Fluoride



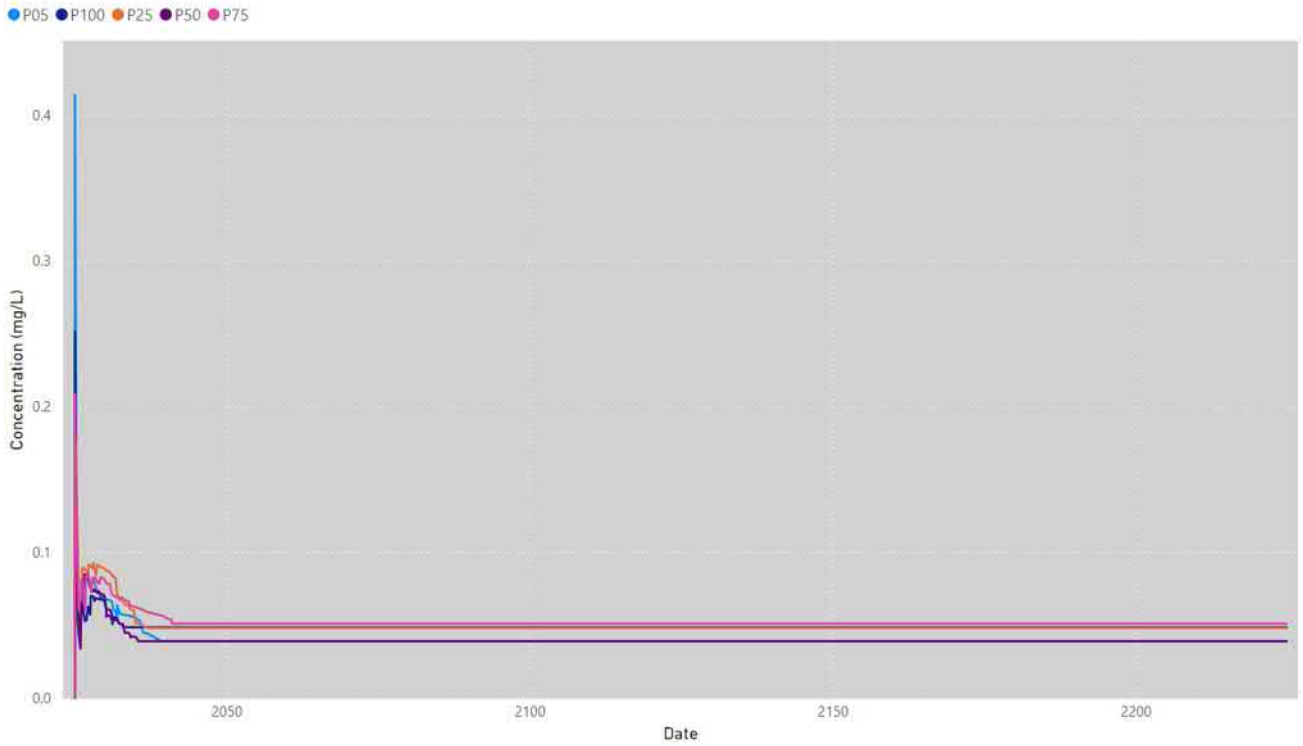
Lead



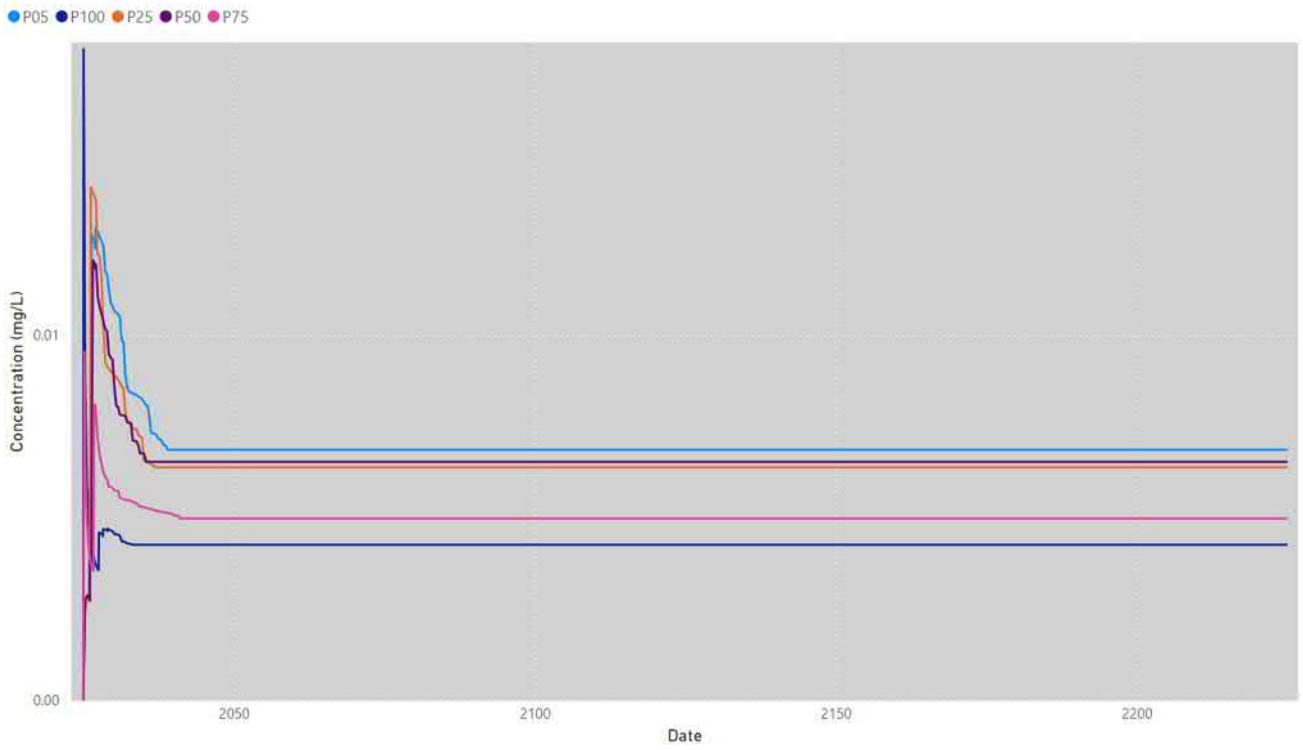
Magnesium



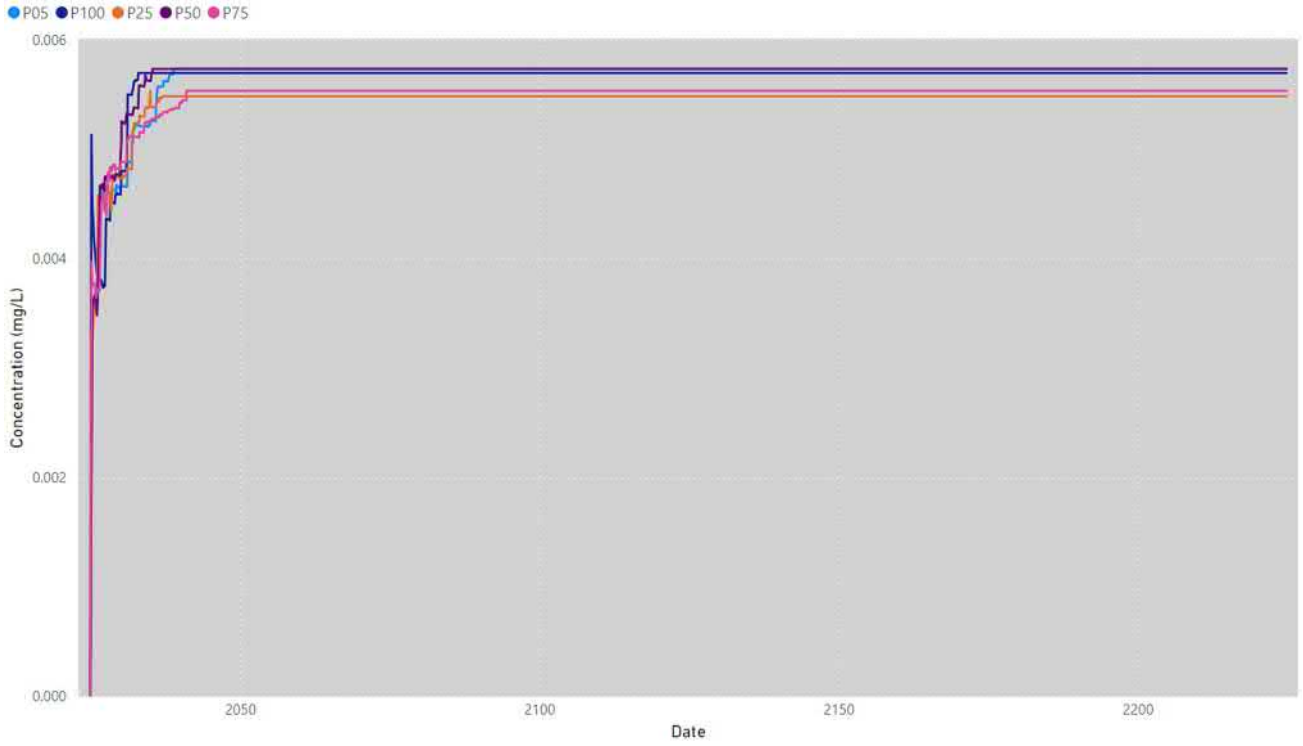
Manganese



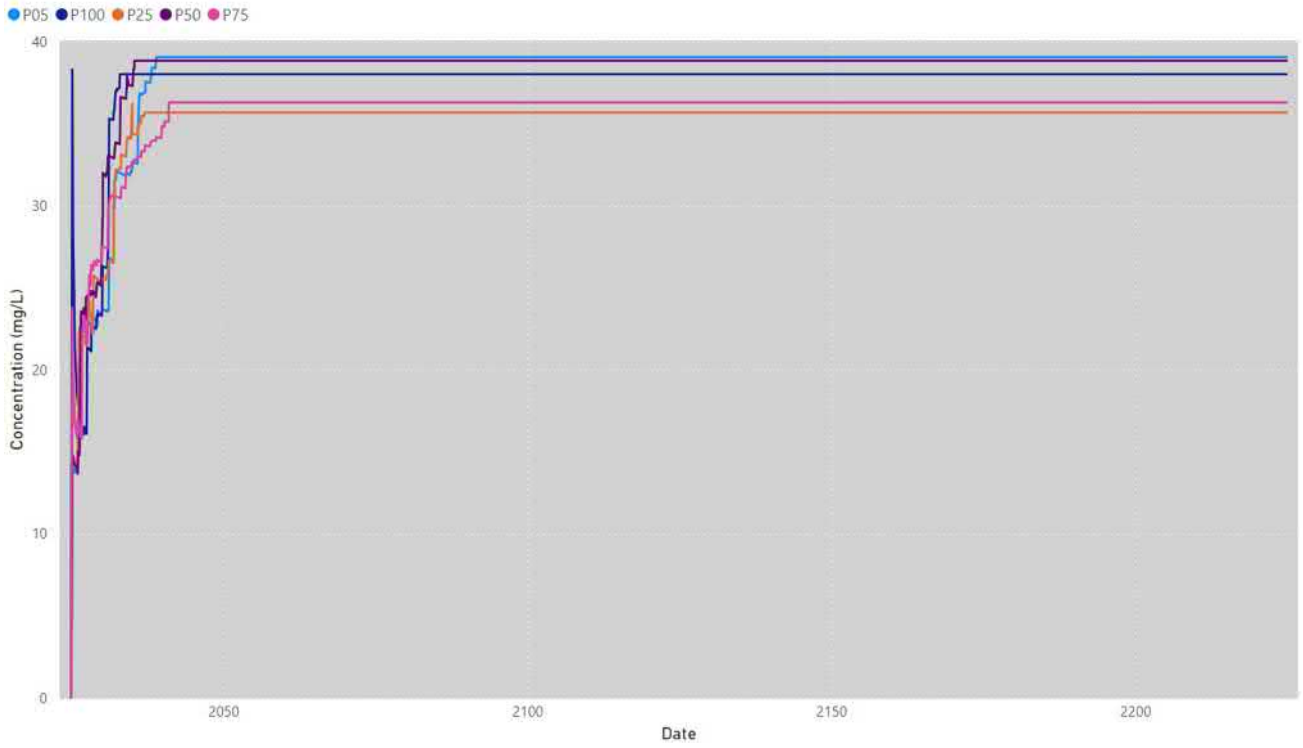
Molybdenum



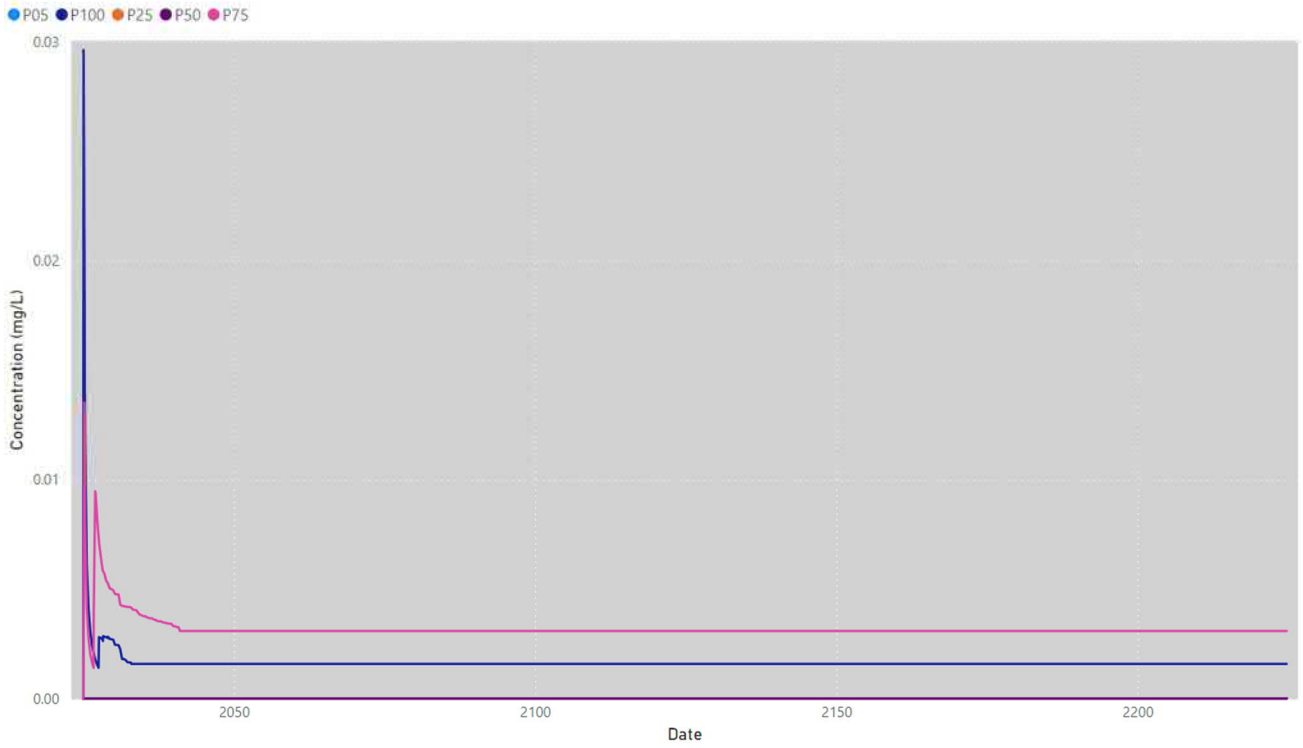
Nickel



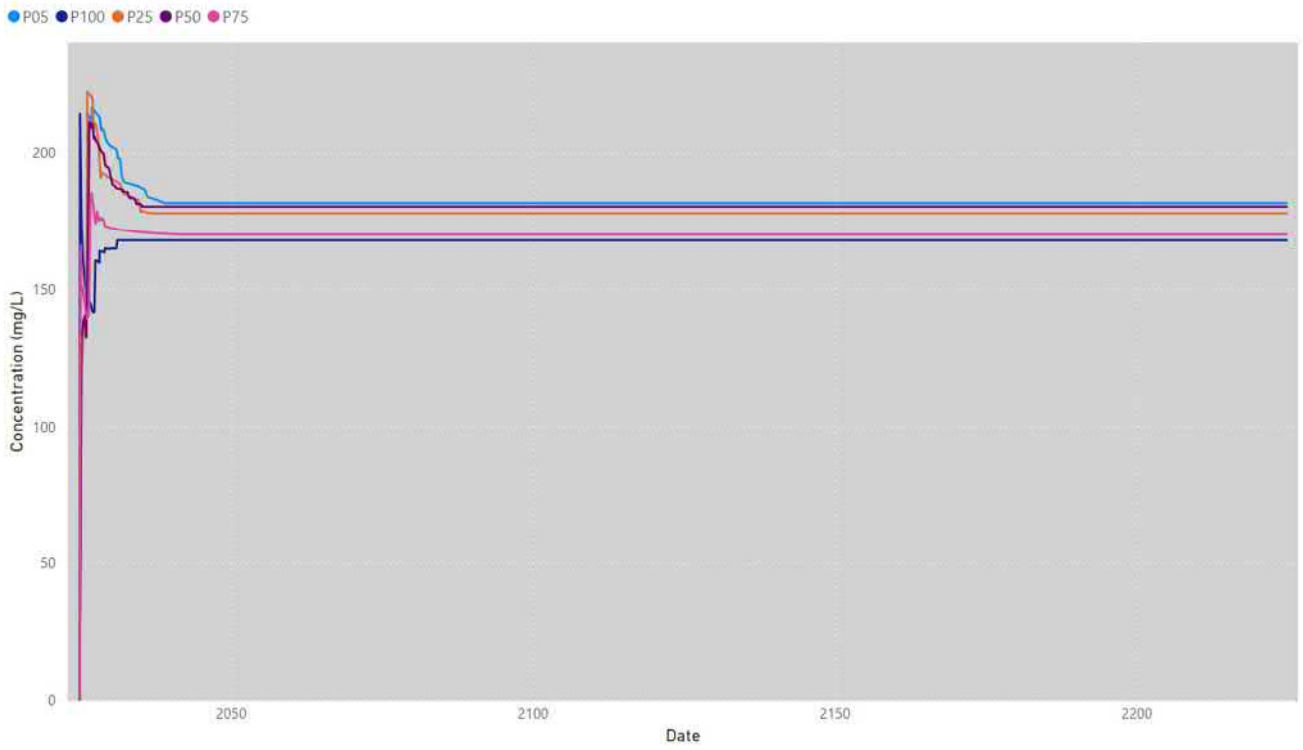
Potassium



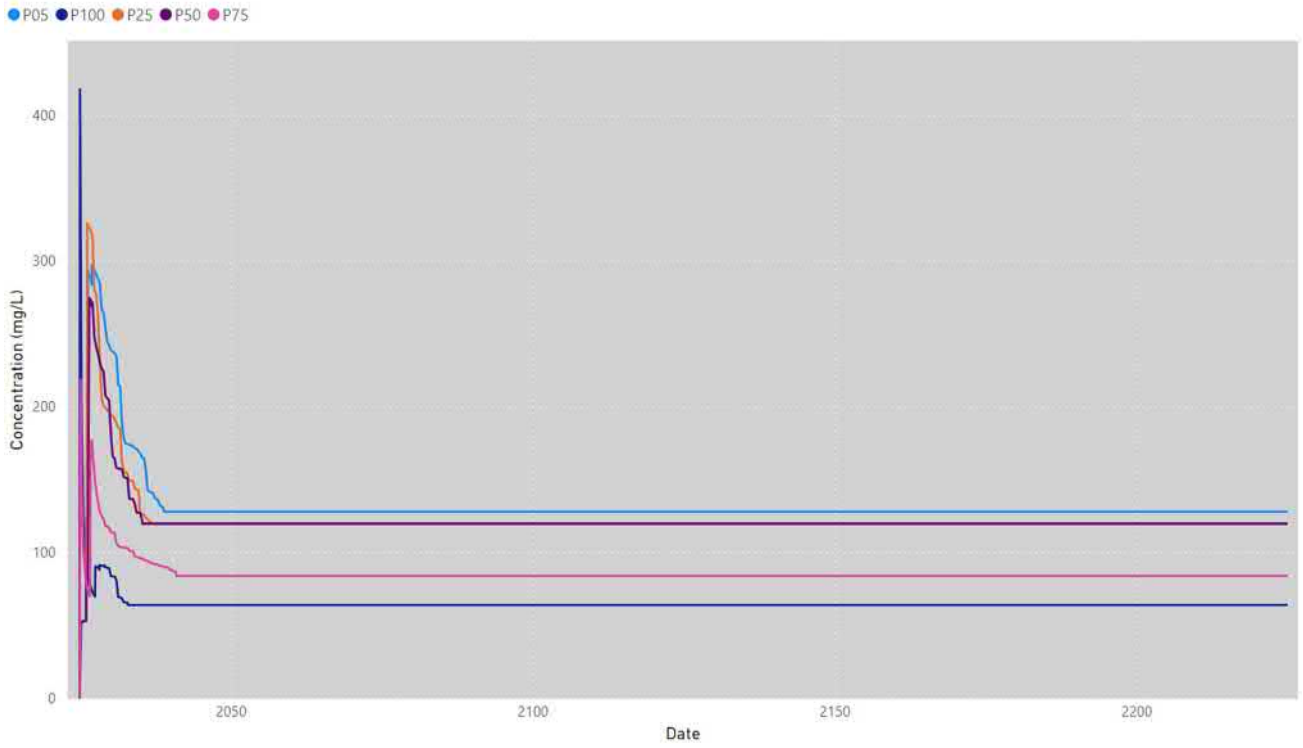
Selenium



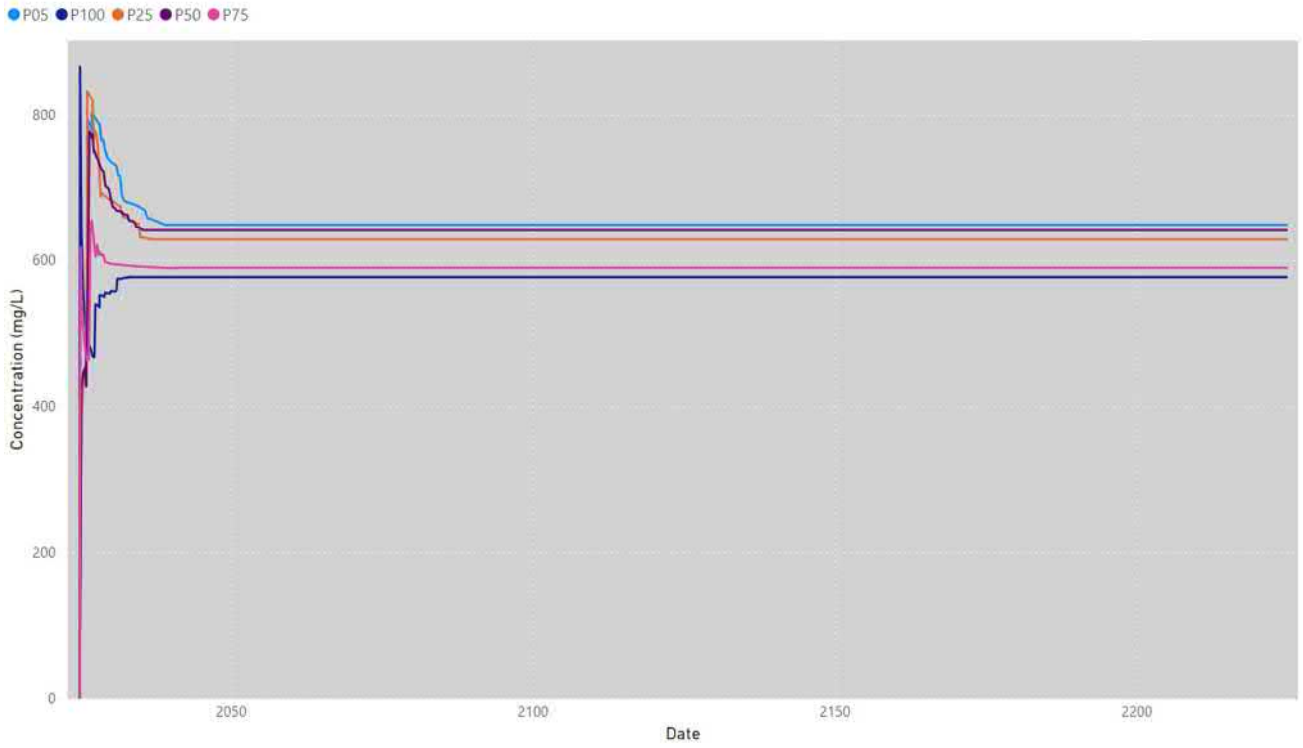
Sodium



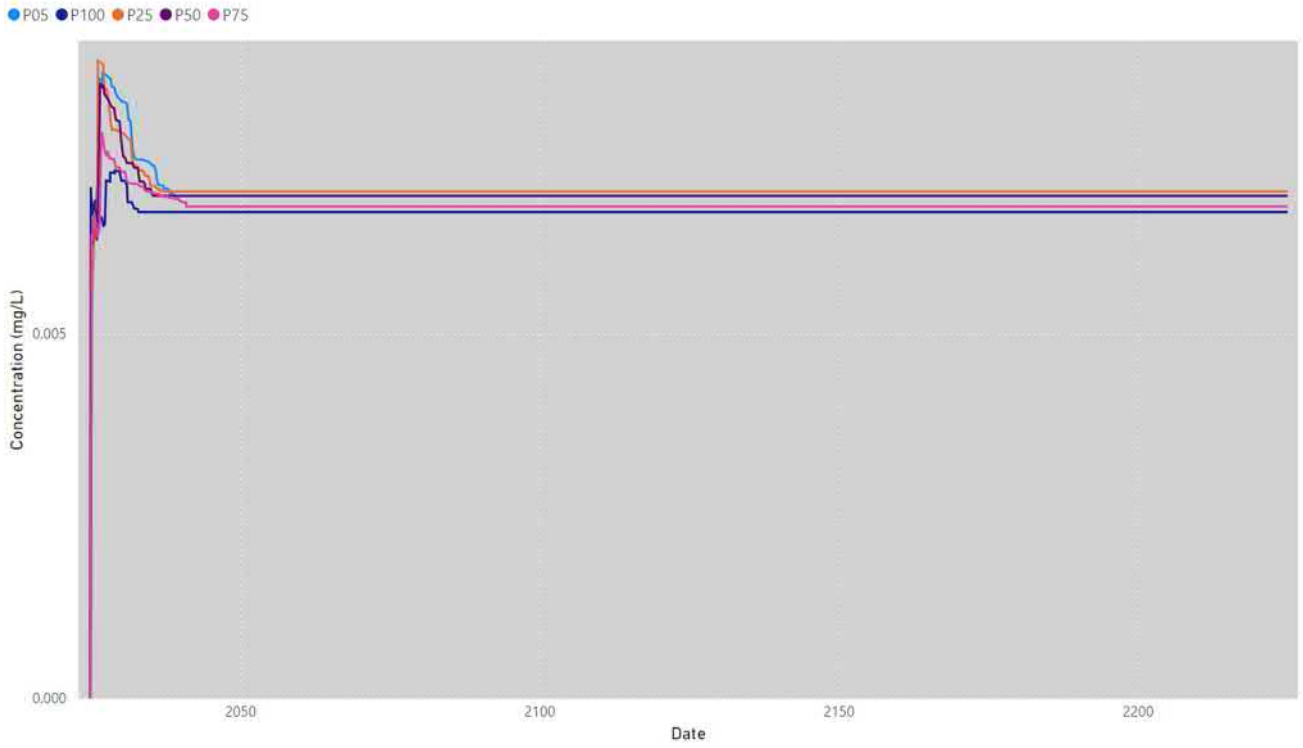
Sulfate



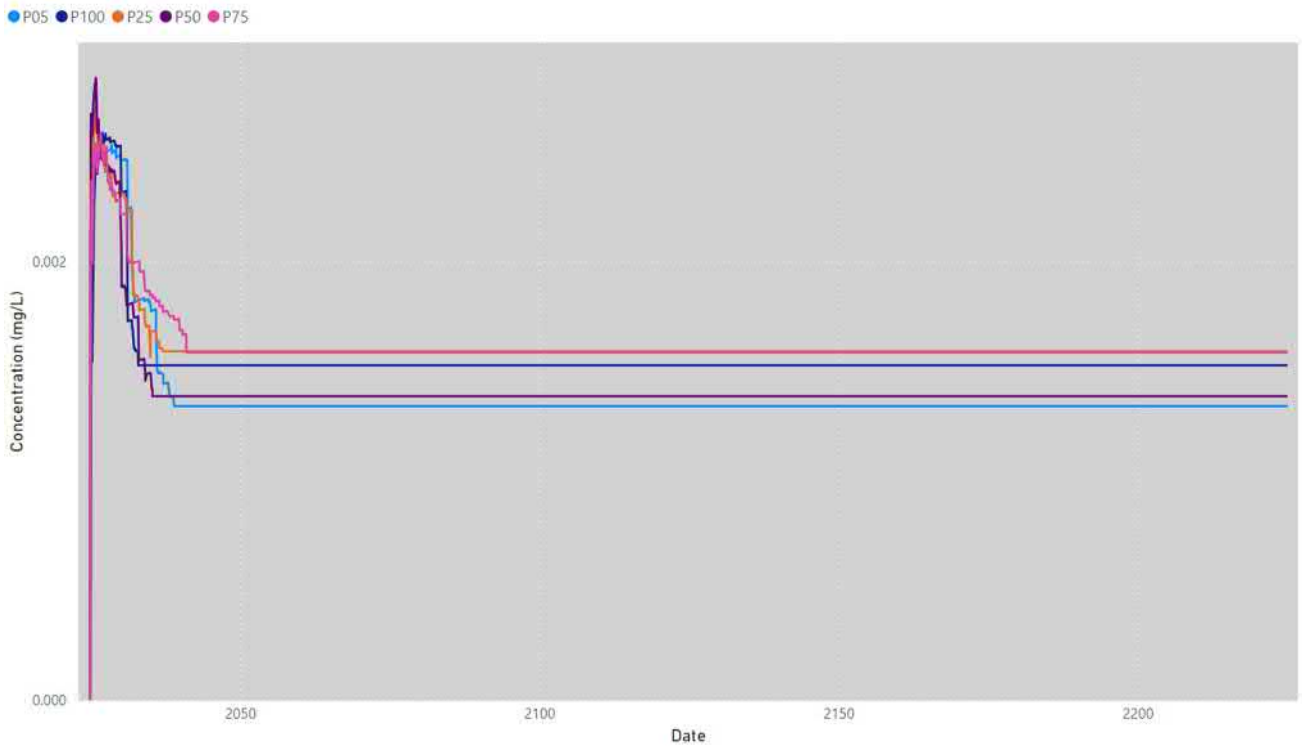
Total Dissolved Solids



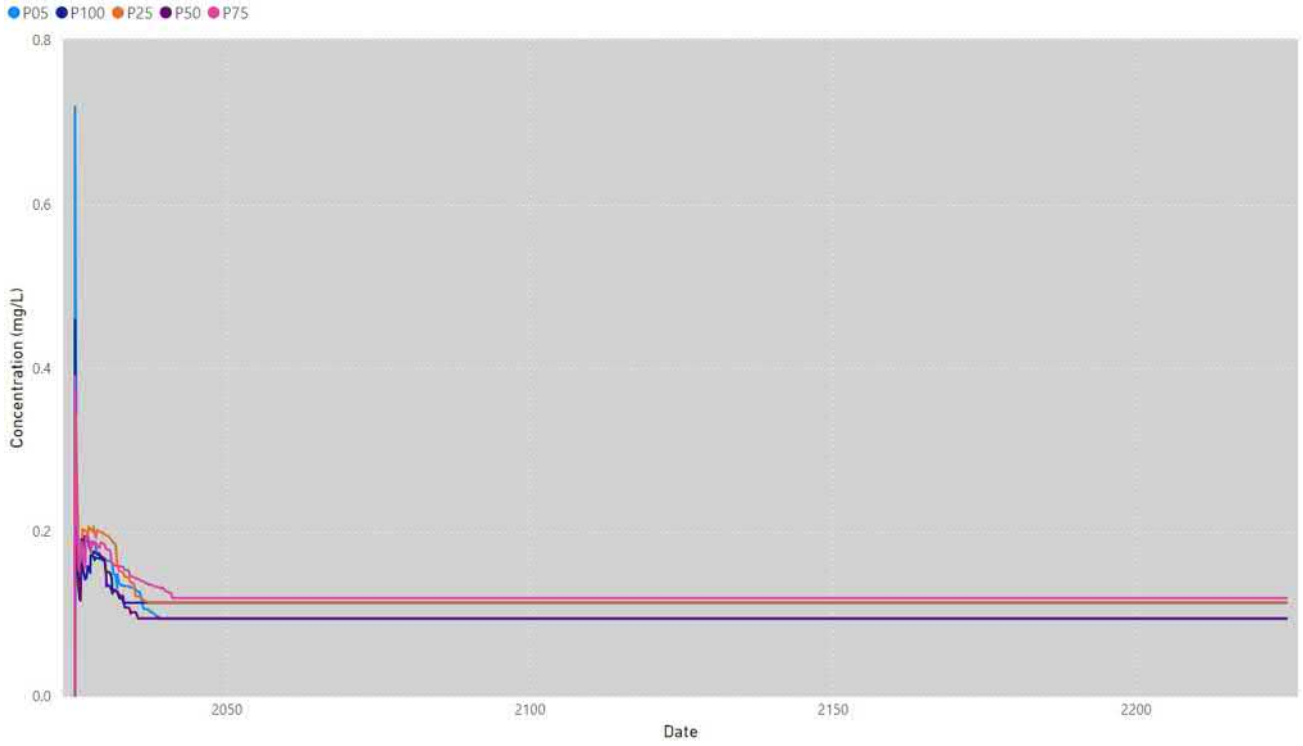
Uranium



Vanadium



Zinc



Appendix D 2023 water quality modelling results for open pits and WRD sediment dam

D.1 Summary of results

D.1.1 WRD Sediment Dam final void water quality

Final void water quality can be summarised as follows:

- The solute concentrations at all times and for both models (i.e. mixing and equilibrium models) remain below the applicable ANZECC 2000 Water Quality Guideline values for livestock watering.
- The main processes that impact solute levels in the sediment dam are dilution due to rainfall runoff into the pit and concentration due to evaporation from the open pit. Due to the presence of the HDPE liner, groundwater inflow or outflow does not occur. The short-term or seasonal variations in solute concentrations can be correlated with the net balance between rainfall and evaporation.
- Under the 75th percentile climatic conditions, the WRD sediment Dam runs dry between early-2040 and end-2045. This affects the water quality in the WRD Sediment Dam.

D.1.2 North Pit water quality

Final void water quality can be summarised as follows:

- The solute concentrations at all times and for both models (i.e. mixing and equilibrium models) remain below the applicable ANZECC 2000 Water Quality Guideline values for livestock watering.
- The main physical processes that impact solute levels in the open pit are dilution due to rainfall runoff, groundwater inflow into the pit, and concentration due to evaporation from the open pit. Groundwater inflow only plays a minor role, with long-term groundwater inflows comprising only ±10% of total inflows into the open pit. Short-term variations in solute concentrations are related to the net flow balance between inflows and evaporation. Whilst groundwater inflow is only a minor component of pit inflows, it does buffer the effect of evaporation on solute concentrations.

D.1.3 South Pit water quality

Final void water quality can be summarised as follows:

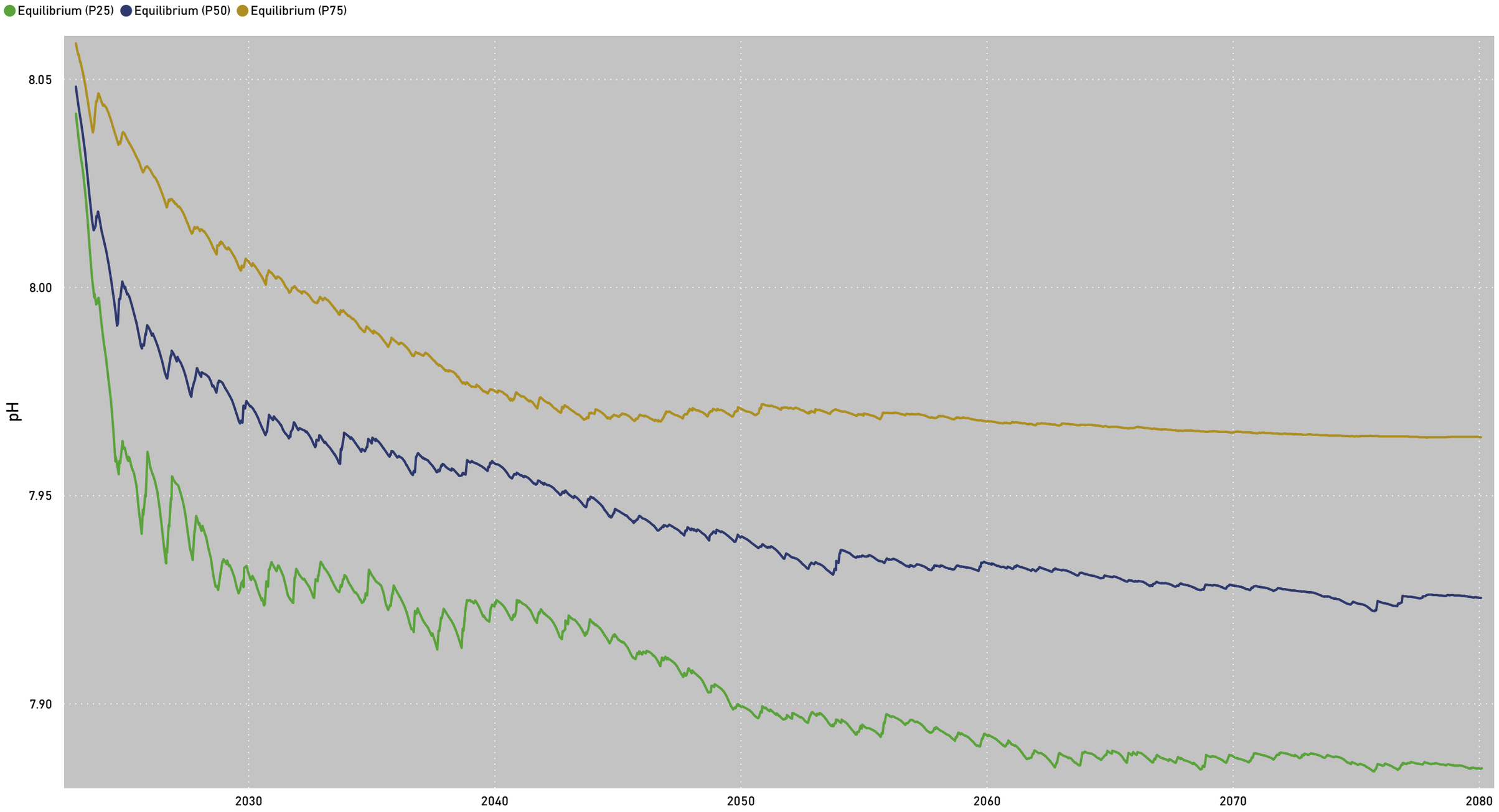
- • The solute concentrations at all times and for both models (i.e. mixing and equilibrium models) and scenarios remain below the applicable ANZECC 2000 Water Quality Guideline values for livestock watering.
- • The main physical processes that impact solute levels in the open pit are dilution due to rainfall runoff, groundwater inflow into the pit, and concentration due to evaporation from the open pit. Groundwater inflow plays a moderate role, with long-term groundwater inflows (a combination of regional inflow and seepage from the North Pit) comprising ±20% of total inflows into the open pit. Short-term variations in solute concentrations are related to the net flow balance between inflows and evaporation. Groundwater inflow buffers the effect of evaporation on solute concentrations.

D.1.4 Summary

The water quality modelling indicates that the modelled solute concentrations at all times and for both models (i.e. mixing and equilibrium models) remain below the applicable ANZECC 2000 Water Quality Guideline values for livestock watering. Long-term water quality in the pits and voids is determined by climatic conditions and geochemical reactions and tends to stabilise. The net flow balance between rainfall runoff plus groundwater inflow and evaporation determines short-term variations. Based on the WQM results, the North Pit, South Pit and WRD Sediment Dam are considered suitable as PMLUs for livestock watering.

D.2 Water quality time series

D.2.1 North Pit water quality


Equilibrium (P25)
Equilibrium (P50)
Equilibrium (P75)
8.05
8.00
7.95
7.90
pH
2030
2040
2050
2060
2070
2080