TEC Coal Pty Ltd

Meandu Mine Project

Progressive Rehabilitation and Closure Plan

May 2022



Meandu Mine Project

Progressive Rehabilitation and Closure Plan

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EA Holder Name: TEC Coal Pty Ltd

Environmental Authority Number: EPML00709113

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Appendix E Meandu Mine Waste Management Plan
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Abbreviations

ACARP	Australian coal industry's research program
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AMD	Acid Mine Drainage
ANC	Acid Neutralising Capacity
ANZECC	Australian and New Zealand Environment and Conservation Council
Archaeo	Archaeo Cultural Heritage Services & Converge Heritage + Community
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ARR	Australian Rainfall and Runoff
AS	Australian Standard
ASA	Additional Surface Area
ASF	Ash Storage Facility
BoM	Bureau of Meteorology
BUA	Beneficial Use Agreement
BUTE	Base of Tertiary
BVG	Broad Vegetation Group
CEC	Cation Exchange Capacity
CHPP	Coal Handling and Preparation Plant
CM	Coaly Mudstone
CQAP	Construction Quality Assurance Plan
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAF	Department of Agriculture and Fisheries
DERM	Department of Environment and Resource Management
DES	Department of Environment and Science (Queensland)
DoR	Department of Resources
DRDMW	Department of Regional Development, Manufacturing and Water
DRP	Decommissioning and Rehabilitation Plan
dS/m	deciSiemens per metre

EA	Environmental Authority at time of PRC Plan submission (12 January 2022)
EC	Electrical Conductivity
EMS	Site Environmental Management System
EP Act	*Environmental Protection Act 1994* (Queensland)
EP Regulation	Environmental Protection Regulation 2019 (Queensland)
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999 (Commonwealth)
EPP (Water and Wetland Biodiversity)	Environmental Protection (Water and Wetland Biodiversity) Policy 2019
ERA	Environmentally Relevant Activity
ERC	Estimated Rehabilitation Cost
EV	Environmental Value
FoS	Factor of Safety
GPS	Geographic Positioning System
ha	Hectares
HQPlantations	HQPlantations Pty Ltd
HW	Highly Weathered
IPCC	Intergovernmental Panel on Climate Change
JBT	JBT Consulting Pty Ltd
k	Permeability
KLC	Kinetic Leaching Colum
kPa	kiloPascals
kV	kiloVolt
LiDAR	Laser Imaging, Detection, and Ranging
LOD	Land Outcome Document
LOM	Life of Mine
LOR	limits of reporting
MBCWAC	Meandu Barker Creek Water Advisory Committee
mBGL	Metres below ground level
MERFP Act	*Mineral and Energy Resources (Financial Provisioning) Act 2018* (Queensland)
ML	Mining Lease
MPR	Mixed Plant Rejects

Mtpa	Million tonnes per annum
MW	Megawatts
NAF	Non-acid Forming
NAG	Net Acid Generation
NC Act	*Nature Conservation Act 1992* (Queensland)
NMD	Neutral Mine Drainage
NPR	Neutralising Potential Ratio
NUMA	Non-use management area
NWBV	North-West Backfilled Void
PAF	Potentially Acid Forming
PAWC	Plant available water capacity
PMF	Probable Maximum Flood
PMLU	Post-mining land use
PSI	Preliminary Site Investigation
ppm	Parts per million
PRC Plan	Progressive Rehabilitation and Closure Plan
PRC Plan Guideline	Progressive Rehabilitation and Closure Plan (ESR/2019/4964) (Version 2.0, 2021)
PSD	Particle size distribution
QA/QC	Quality Assurance/Quality Control
RA	Rehabilitation Area
RD	Retention Dam
RE	Regional ecosystem
REMP	Receiving Environment Monitoring Program
RGS	RGS Environmental Consultants Pty Ltd
RL	Relative level
RM	Rehabilitation Milestone
RN	Registered Number
ROM	Run-of-Mine
RSA	Rejects Storage Area
SBC	solid bowl centrifuges

SILO	Scientific Information for Land Owners
SLR	SLR Consulting Australia Pty Ltd
SMD	Saline Mine Drainage
SRK	SRK Consulting (Australasia) Pty Ltd
Stanwell	Stanwell Corporation Limited
SWL	Surface Water Level
Tarong power stations	Tarong Power Station and Tarong North Power Station
TDS	Total Dissolved Solids
TEC Coal	TEC Coal Pty Ltd
TSF	Tailings Storage Facility
TSS	Total Suspended Solids
VM Act	*Vegetation Management Act 1999*
WB	Weathered Basalt
WBM	water balance model
WBNM	Watershed Bounded Network Model Version 2019
WEPP	Water Erosion Prediction Project
WQIP	Water Quality Improvement Plan
WQO	Water Quality Objective
XW	Extremely Weathered
µS/cm	Microsiemens per centimetre

1 Introduction

1.1 Introduction

A Progressive Rehabilitation and Closure Plan (PRC Plan) Transition Notice was issued to TEC Coal Pty Ltd (TEC Coal) as holder of Environmental Authority (EA) EPML00709113 for the Meandu Mine Project on 11 September 2019 under section 754 of the *Environmental Protection Act 1994* (EP Act) by the Department of Environment and Science (DES) (Appendix A). The due date for submission of the Transitional PRC Plan to the administering authority is **31 May 2022.**

This Transitional PRC Plan for the Meandu Mine addresses this requirement, having been developed in accordance with sections 126C and 126D of the EP Act to the extent relevant for transitional PRC Plans and the requirements specified in the Guideline: Progressive rehabilitation and closure plans (PRC Plan Guideline) (ESR/2019/4964) (Version 2.0, 17 March 2021).

1.1.1 Overview of the Meandu Mine

Meandu Mine is an open-cut coal mine that is operated within mining lease (ML) 6674 for the purpose of supplying black thermal coal to the adjacent Tarong and Tarong North power stations (Tarong power stations). Environmental performance at Meandu Mine is regulated by EA EPML00709113 (12 January 2022) (Appendix B).

Meandu Mine is located in Queensland's South Burnett region, approximately 150 kilometres (km) north-west of Brisbane, 14 km south-west of Nanango and 1.5 km to the south of the Tarong power stations. The nearest town to the Meandu Mine site is Yarraman, which is located approximately 6 km to the south south-east from the approved mining activities.

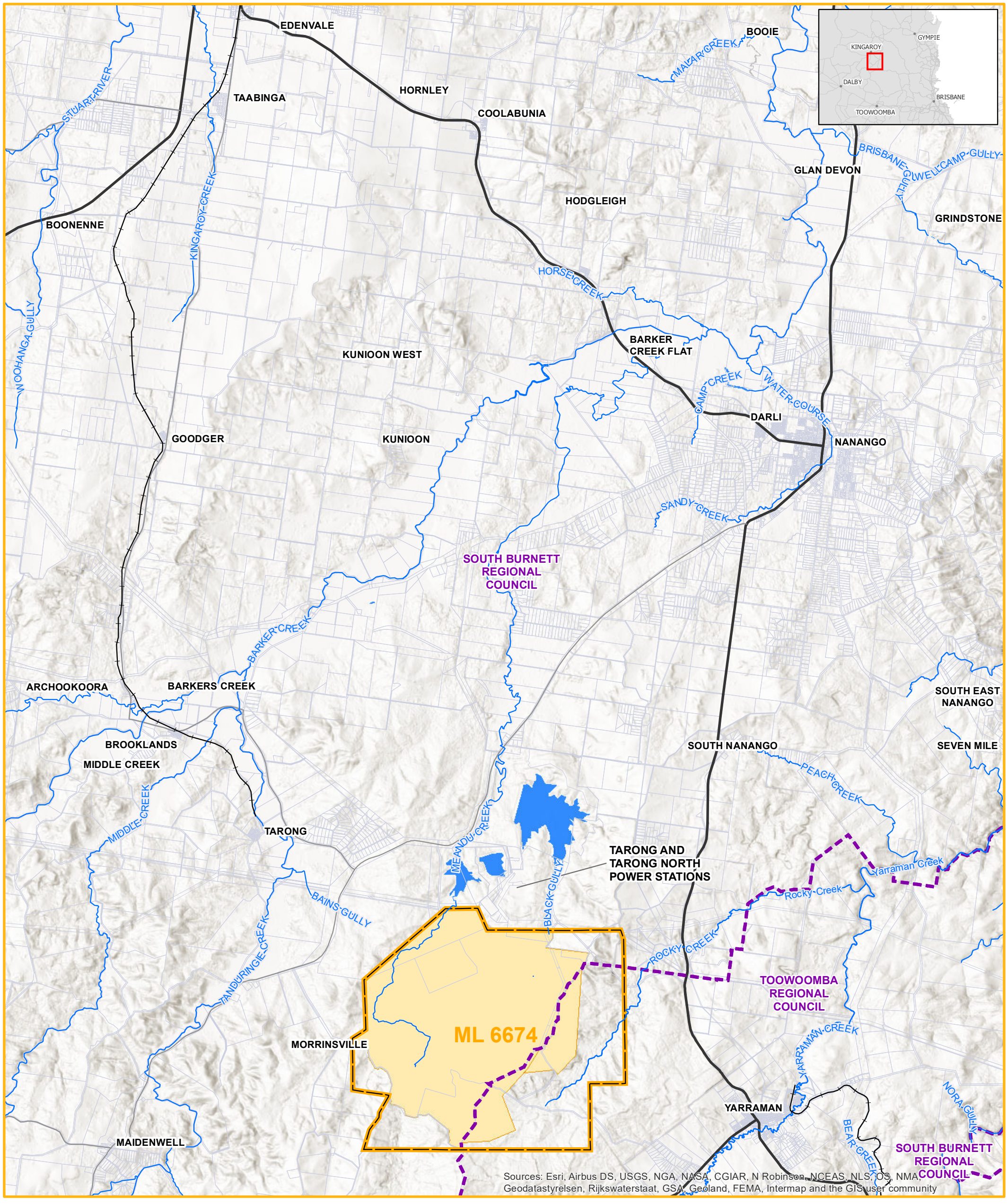
Figure 1.1 illustrates the locality of Meandu Mine within the surrounding regional area.

Meandu Mine is located wholly within coal mining lease ML6674, which was granted on 19 February 1981. ML6674 occupies a total area of 4,267 hectares (ha) partly within both the South Burnett Regional Council and Toowoomba Regional Council local government areas. TEC Coal currently holds surface rights for approximately 2,640 ha of ML6674 (refer Figure 1.2). The remaining land outside of the surface rights area is predominantly State Forrest (Yarraman State Forest) and is held under license for the production of planation timber.

At the time of compilation of this PRC Plan in May 2022, TEC Coal has received State government approval and is finalising Commonwealth approval to increase the approved surface rights area at the Meandu Mine. The King 2 East (K2E) Project involves increasing the approved surface rights area within ML6647 by an additional 186 ha which will allow progression of the existing K2E pit to the east. State approval for the K2E Project was sought via an EA amendment application for EPML00709113 under the EP Act which was approved by DES on 23 November 2021 and incorporated in the current EA. A Regional Interests Development Approval for the K2E Project was granted on 10 May 2022. Consequently, the K2E Project additional surface area (K2E ASA) is included in the PRC Plan. Commonwealth approval for the K2E Project under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is currently being assessed with further information provided via the Preliminary Documentation Assessment Report which was submitted to the Department of Agriculture, Water and the Environment on 17 May 2022.

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 1.1
Locality map of Meandu Mine



Legend

- Rail Line
- Highways
- Secondary Roads
- Watercourse
- Mining Lease (ML6674)
- Local Government Areas
- Cadastre
- Approved Surface Rights Area

Based on or contains data provided by the State of Queensland (Department of Resources) 2021. 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

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(iii) This plan may not be copied unless this note is included.

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Revision:	DRAFT
Projection:	GDA 1994 MGA Zone 56
Date:	02/03/22
Issued To:	A RUSHTON
Generated By:	N KELLEWAY
Source:	Stanwell Corporation Department of Resources

NORTH

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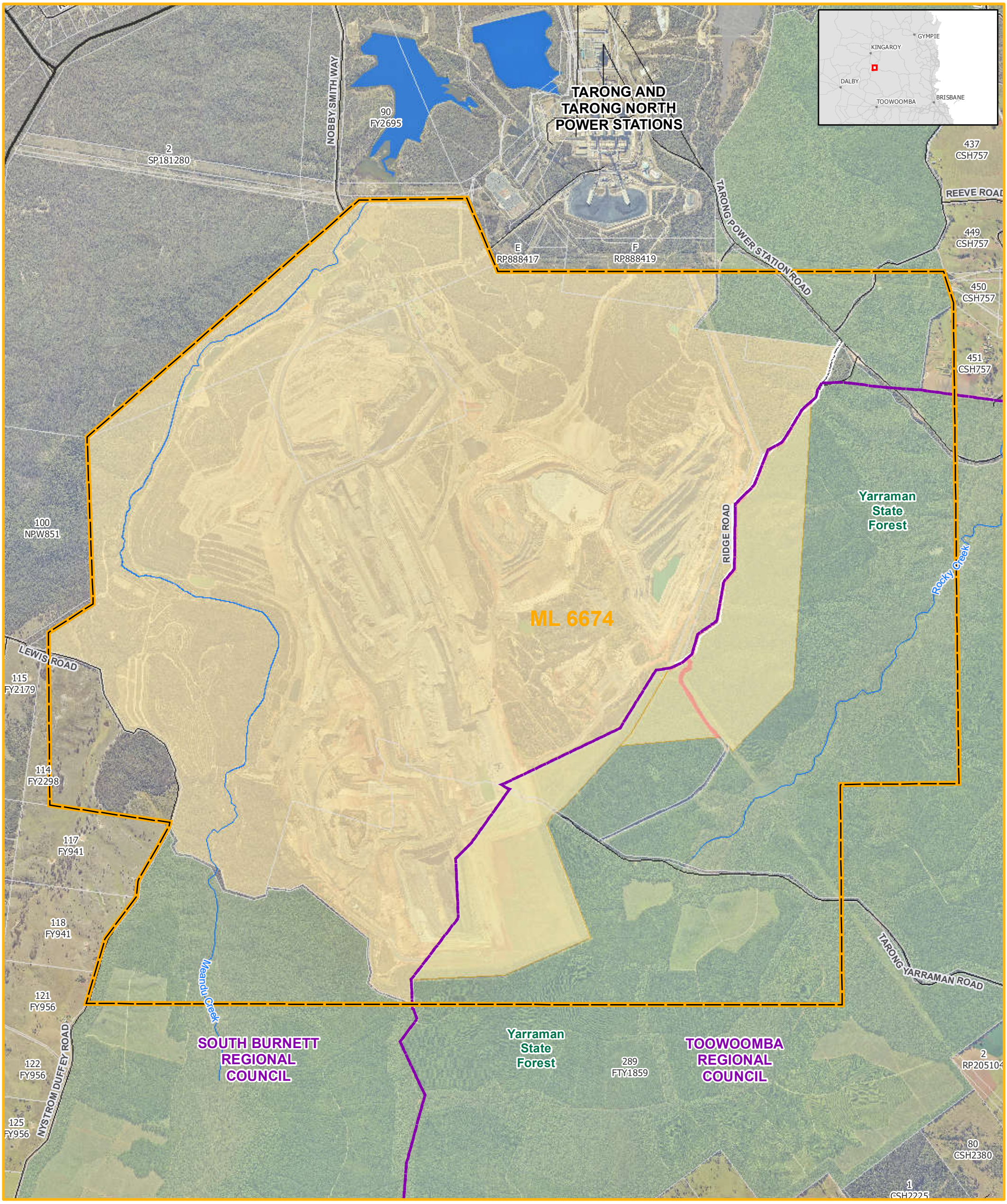
Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 1.2
Meandu Mine Lease boundary and surface right area



Legend

- Watercourse
- Ridge Road
- Mining Lease (ML6674)
- Local Government Areas
- Ridge Road Closure
- Approved Surface Rights Area
- Yarraman State Forest
- Cadastre

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Revision:	DRAFT
Projection:	GDA 1994 MGA Zone 56
Date:	11/03/22
Issued To:	A RUSHTON
Generated By:	N KELLEWAY
Source:	Stanwell Corporation Department of Resources

NORTH

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The Powerlink Queensland (Powerlink) Feeder 831 275 kilovolt (kV) transmission line between H018 Tarong and H014 Middle Ridge Substations and associated easement, currently crosses the surface rights area of the Meandu Mine in the vicinity of the K2E Pit. Relocation of a portion of this transmission line (approximately 5 km) is required to accommodate future mining progression of the K2E pit within the existing and additional surface right areas of the Meandu Mine. It is proposed that this portion of Feeder 831 is relocated further to the east and external to the additional surface rights area within ML6674 to adjoin the K2E ASA boundary. Approval for the relocation of this portion of Feeder 831 is currently being progressed by Powerlink under the Ministerial Infrastructure Designation process. The transmission line will be relocated prior to mining operations impinging on the existing alignment or commencing in the K2E ASA.

The sections of the Powerlink easement on which Feeder 831 is currently located that are not disturbed by mining, and the new easement to which it will be relocated are both excluded from the post-mining land use (PMLU) footprint for ML6674 as both easements are granted for the exclusive use of Powerlink, with coal mining activities restricted within the active use sections of the easements. Where future mining activities disturb the footprint of the existing Powerlink easement (after relocation from the current alignment), these section(s) of easement have not been excluded and a PMLU allocation has been undertaken as part of this PRC Plan.

1.1.2 Project proponent

TEC Coal Pty Ltd (TEC Coal) owns the Meandu Mine and is the holder of ML6674 and EA EPML00709113. TEC Coal is a wholly owned subsidiary of Stanwell Corporation Limited (Stanwell). Stanwell is a Queensland Government Owned Corporation under the *Government Owned Corporations Act 1993* and registered under the *Corporations Act 2001*. Stanwell is a substantial provider of electricity to the National Electricity Market and large energy users throughout Australia. It owns assets for the purposes of generating electricity, including the Meandu Mine and Tarong power stations. Through these and other assets, Stanwell has a generation capacity of more than 3,000 megawatts (MW).

The registered address for TEC Coal is:

TEC Coal Pty Ltd
Level 2, 180 Ann Street
Brisbane, Queensland, Australia, 4001.

1.1.3 Correspondence with the Department of Environment and Science

TEC Coal has engaged proactively with the DES both up to the date of receiving a transition notice, and during the period of writing this PRC Plan. A summary of the key meeting dates is included as reference in Appendix C.

1.2 Progressive rehabilitation and closure plan legislation and guideline

On 30 November 2018, the Queensland parliament passed the *Mineral and Energy Resources (Financial Provisioning) Act 2018* (MERFP Act) with the intention of improving rehabilitation and financial assurance outcomes in the resources sector. A crucial component of the MERFP Act is that it amends the EP Act through the introduction of new requirements for the progressive rehabilitation and closure of mined land.

A progressive rehabilitation and closure plan (PRC Plan) is a critical element of the Queensland Government's mined land rehabilitation policy. The main purposes of the PRC Plan are to:

- require the holder of an EA to plan how and where activities will be carried out on land in a way that maximises the progressive rehabilitation of the land to a stable condition
- provide for the condition to which the EA holder must rehabilitate the land before the EA may be surrendered.

A PRC Plan must address the requirements of sections 126C and 126D of the EP Act, pursuant to section 754 of the EP Act. Further guidance on the required content is contained in the PRC Plan Guideline which contains information to assist applicants in developing a PRC Plan. The administering authority must consider this guideline when making a decision about a PRC Plan Schedule under section 176A of the EP Act.

1.2.1 Land outcome documents

Meandu Mine is operating under an existing approved EA and commenced operations in 1983, some 36 years prior to the PRC Plan start date (1 November 2019). As a result, the transitional provisions detailed in Section 6 of the PRC Plan Guideline apply to this PRC Plan.

The consideration of transitional provisions allows for the use of existing land outcome documents, enabling the components of the existing mine and landforms with mine plans to be facilitated into the PRC Plan framework. The nomination of pre-existing documents related to rehabilitation and closure, the contents of which are already approved by the regulatory authority, gives continued approval for their implementation on the site. As such the contents and findings of a land outcome document can be relied upon as stated and adopted into the PRC Plan framework. Relevant content examples in a land outcome document include nominated PMLUs, non-use-management-areas (NUMA), rehabilitation methodologies, completion criteria and the related antecedent studies.

Land outcome documents are defined under section 750 of the EP Act as:

***land outcome document**, for land, means the following documents relating to the land—*

(a) an environmental authority for a resource activity on the land;

(b) a document made under a condition of an environmental authority mentioned in paragraph (a), if—

(i) the document relates to the management of a void within the meaning of section 126D on the land, or the rehabilitation of the land; and

(ii) the document was received by the administering authority before the assent date; and

(iii) the administering authority has not, within 20 business days after the assent date, given notice to the holder of the environmental authority that the document is insufficient in a material particular relevant to a mater mentioned in subparagraph (i); and

(iv) before the assent date, the document had not been superseded;

(c) a document made under a condition of an environmental authority mentioned in paragraph (a) if—

(i) the document relates to the management of a void within the meaning of section 126D on the land, or the rehabilitation of the land; and

(ii) the environmental authority requires the document to be given to the administering authority on a stated day that is on or after the assent date, or does not state a day when the document must be given; and

(iii) the document is received by the administering authority within 3 years after the assent date; and

(iv) the administering authority does not, within 20 business days after receiving the document, give the holder of the environmental authority notice that the document is insufficient in a material particular to a matter mentioned in subparagraph (i);

(d) a report evaluating an EIS under the State Development and Public Works Organisation Act 1971, section 34D;

(e) an EIS assessment report;

(f) a written agreement between the holder of an environmental authority mentioned in paragraph (a) and the State that is in force on the assent date.

The relevant land outcome documents for Meandu Mine are detailed in Table 1.1.

Table 1.1 Meandu Mine land outcome documents

Land outcome document	Date	Relevant area	Document reference	Comment
Environmental Authority EPML00709113	12 January 2022	Meandu Mine site		Attached (Appendix B)
Plan of Operations January 2019 – December 2020 Mining Lease ML6674	14 December 2018	Meandu Mine site	ASM-MINE-PLAN-17	Expired (Attached Appendix D)
Meandu Mine Waste Management Plan	29 July 2020	Meandu Mine site	PS119156-ENV-REP-001 Rev C, 29 July 2020, WSP, TRIM Document No. 20/90131	Requirement of Condition A13 of EA EPML00709113. Rehabilitation strategies and monitoring of rehabilitation are relevant to development of this PRC Plan. (Attached Appendix E)
Tarong Coal Project Draft Impact Assessment Study (Peter Hollingsworth & Associated Consultants)	August 1979	Proposed project and immediate surrounds		Impact assessment study undertaken for the proposed Tarong Coal Project. (Attached Appendix F)

The EP Act requires that all areas disturbed for mining activities under an EA within a relevant mining tenure be rehabilitated to either a specified PMLU or where a PMLU cannot be sustained, rehabilitated to a NUMA. There are no NUMAs proposed for the Meandu Mine, with all areas disturbed by mining allocated a PMLU.

Under Condition G3 of EA EPML00709113, all areas significantly disturbed by mining activities must be rehabilitated to achieve:

a a landform for final uses that are:

i safe to humans and wildlife
ii non-polluting
iii stable; and
iv able to sustain the final land use.

The final land use and rehabilitation success criteria for PMLUs at the Meandu Mine are outlined in Appendix 7 – Final land use and rehabilitation success criteria for landforms of EA EMPL00709113 (refer Appendix B).

1.3 Structure of the PRC Plan

In accordance with the PRC Plan Guideline requirements and as required by the EP Act, this PRC Plan is comprised of two components:

- Part A: Rehabilitation Planning Part, which provides information about the Meandu Mine site, the rehabilitation plans, and evidence and justification to support the development of the proposed PRC Plan Schedule including:
    - site characteristics
    - pre-mining conditions
    - post-mining land-uses (PMLUs)
    - community consultation
    - rehabilitation methodology and criteria
    - a risk assessment; and
    - a monitoring program.
- Part B: The PRC Plan – Schedule, which includes maps of rehabilitation and closure outcomes for the Meandu Mine site and tables of time-based milestones and:
    - allocates all mine disturbance to a designated rehabilitation area which has a specific PMLU
    - nominates rehabilitation milestones (which when all achieved represents completed rehabilitation); and
    - provides a detailed schedule for the progressive rehabilitation of all rehabilitation areas to achieve the rehabilitation milestones.

This PRC Plan also includes Part C: Appendices, which provides key information and specialist studies used to support development of this PRC Plan.

1.3.1 Site history and existing approvals

The history of discovery of the Meandu coal deposit extends back to 1967, when Rio Tinto Coal took out an authority to prospect in the Tarong area near the town of Yarraman. Drilling in subsequent years showed steaming coal occurring at substantial thicknesses, indicating the likelihood of a sufficient coal resource to support power generation.

An application for a mining lease was made on 24 July 1979, with ML6674 granted on 19 February 1981. Meandu Mine was developed in conjunction with the adjacent Tarong Power Station, with mining operations commencing in 1983. Tarong North Power Station commenced operation in 2003, increasing the coal supply requirement from Meandu Mine.

Ownership of Meandu Mine was assumed by Tarong Energy in early 2008. Following a restructure of Queensland Government owned generators, ownership of Meandu Mine was transferred to Stanwell from Tarong Energy in July 2011. TEC Coal Pty Ltd contracts all mining services at the Meandu Mine to a mining contractor. Between 2008 this was Thiess Mining Services Pty Ltd. From 2013 mining services have been contracted to Downer EDI Mining Pty Ltd (now BUMA Australia).

All mining operations at Meandu Mine occur within the surface rights area of ML6674 and under EA EPML00709113. Mining operations currently advance the existing Central, Ramp 5, King 4 East (K4E), and King 4 South (K4S) pits. The historically mined K2E pit is in care and maintenance pending future mining progress in line with the life of mine (LOM) plan. Waste rock material is moved by dragline and excavator/haul truck fleets to in-pit or ex-pit overburden dumps, appropriate to the LOM Plan and mining location. Coarse rejects are stockpiled at the coal handling and preparation plant (CHPP) and solid bowl centrifuge rejects in the rejects trench before being comingled and trucked to the mixed plant rejects (MPR) cell dump locations for co-disposal. Since late 2015, all rejects material (other than a minor volume of tailings) is dumped into cells located in the spoil dumps that are dumped over and track compacted at least 6 m beneath the final landform profile to ensure adequate capping can be constructed in accordance with cover requirements to achieve the final landform surface.

1.3.1.1 Environmentally relevant activities

The Meandu Mine EA EPML00709113 authorises black coal mining (Schedule 3 – ERA 13) on ML6674. Table 1.2 outlines prescribed ERAs, as identified in Schedule 2 of the Environmental Protection Regulation 2019 (EP Regulation) along with associated thresholds which are also undertaken at the Meandu Mine site as ancillary activities.

Table 1.2 Prescribed ERAs authorised under EA EPML00709113

Prescribe ERA	Threshold
ERA 7 Chemical manufacturing	Threshold 3: manufacturing, in a year, a total of 200 t or more of any of the following: (d) explosives.
ERA 8 Chemical storage	Threshold 3: storing more than 500 m^3 of chemicals of class C1 or C2 combustible liquids under Australian Standard (AS) 1940 or dangerous goods class 3 under subsection (1)(c).
ERA 31 Mineral processing	Threshold 2: processing, in a year, the following quantities of mineral products, other than coke – (b) more than 100,000 t.

Prescribe ERA	Threshold
ERA 60 Waste disposal	Threshold 1: operating a facility for disposing of, in a year, the following quantity of waste mentioned in subsection (1)(a) – (a) less than 50,000 t.
ERA 62 Resource recovery and transfer facility operation	Threshold 1: operating a facility or receiving and sorting, dismantling, baling or temporarily storing (c) regulated waste.
ERA 63 Sewage treatment	Threshold 1: operating sewage treatment works, other than no-release works, with a total daily peak design capacity of: (b-i) more than 100 but not more than 1500 EP if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme.

1.3.1.2 Notifiable activities

TEC Coal has a duty to notify for activities that have the potential to cause land contamination under section 320 of the EP Act. Notification to the administering authority is required where any of the following occur:

- Notify within 24 hours of becoming aware of an event that is not authorised or a change in condition involving contaminants:
  - that is causing or could involve serious or material environmental harm; or
  - on land that has previously been listed on the Environmental Management Register on the basis of a notifiable activity.
- Notify within 20 business days of becoming aware of a notifiable activity that either has or is being conducted.

The notifiable activities (as listed under Schedule 3 of the EP Act), which will be carried out at Meandu Mine during the life of the mine, are shown in Table 1.3.

Table 1.3 Notifiable activities (under the EP Act) of relevance to the Meandu Mine operations

Notifiable activity	Description
1	**Abrasive blasting** – carrying out abrasive blast cleaning (other than cleaning carried out in fully enclosed booths) or disposing of abrasive blast material.
6	**Chemical manufacture or formulation** – manufacturing, blending, mixing or formulating chemicals if: **a** the chemicals are designated dangerous goods under the dangerous goods code; and **b** the facility used to manufacture, blend, mix or formulate the chemicals has a design production capacity of more than 1 tonne per week.
7	**Chemical storage** – (other than petroleum products or oil under item 29)—storing more than 10 tonnes of chemicals (other than compressed or liquefied gases) that are dangerous goods under the dangerous goods code.

Notifiable activity	Description
14	**Engine reconditioning works** – carrying out engine reconditioning work at a place where more than 500 L of any of the following are stored: **a** halogenated and non-halogenated hydrocarbon solvents **b** dangerous goods in class 6.1 under the dangerous goods code **c** industrial degreasing solutions.
15	**Explosives production or storage** – operating an explosives factory under the *Explosives Act 1999.*
20	**Landfill** – disposing of waste (excluding inert construction and demolition waste).
23	**Metal treatment or coating** – treating or coating metal, including, for example, anodising, galvanising, pickling, electroplating, heat treatment using cyanide compounds and spray painting using more than 5 L of paint per week (other than spray painting within a fully enclosed booth).
24	**Mine wastes** – **a** storing hazardous mine or exploration wastes, including, for example, tailings dams, overburden or waste rock dumps containing hazardous contaminants; or **b** exploring for, or mining or processing, minerals in a way that exposes faces, or releases groundwater, containing hazardous contaminants.
29	**Petroleum product or soil storage** – storing petroleum products or oil— **a** in underground tanks with more than 200 L capacity; or **b** in above ground tanks with— **i** for petroleum products or oil in class 3 in packaging groups 1 and 2 of the dangerous goods code—more than 2,500 L capacity; or **ii** for petroleum products or oil in class 3 in packaging groups 3 of the dangerous goods code—more than 5,000 L capacity; or **iii** for petroleum products that are combustible liquids in class C1 or C2 in Australian Standard AS 1940, 'The storage and handling of flammable and combustible liquids' published by Standards Australia—more than 25,000 L capacity.
33	**Scrap yards** – operating a scrap yard including automotive dismantling or wrecking yard or scrap metal yard.

Part A: Rehabilitation planning

2 Project planning

2.1 Baseline information

PRC Plan Guideline (Section 3.1):

In addition to the legislative requirements, the following information about the site, where relevant, is considered necessary by the administering authority (as per section 126C(1)(j) of the EP Act to decide whether to approve the PRC plan schedule:

- site topography (locally and regionally)
- climate (general and specific (rain, evaporation, temperatures)) including long-term projections
- geological setting
- site hydrology and fluvial networks
- groundwater levels and properties
- soil types, properties and productivity
- land stability (pre-existing land degradation/erosion and predisposition to ongoing stability issues)
- vegetation communities and ecological data (including existing regional ecosystem mapping)
- fauna presence and populations
- pre-mining land use
- identification of underlying landholders.

NOTE: Transitional PRC plans must include any baseline information collected as part of an EIS process or original EA application. If this information is unavailable, the reasons should be explained in this section of the rehabilitation planning part. Transitional PRC plans are not required to demonstrate how aspects of the mine site have been designed for closure for existing or approved disturbance. However, any expansion to an existing site must demonstrate how it has been designed for closure. The rehabilitation/improvement planning must include data from when mining first commenced up until planned surrender. The transitional provisions of the EP Act include an exceptional circumstance for when land is unavailable for rehabilitation.

Meandu Mine has been operating for almost 40 years and baseline information prior to the commencement of coal mining operations is not available in a spatial format. Consequently, data in this section has been obtained from either the Tarong Coal Project Draft Impact Assessment Study (Hollingsworth, 1979) (refer Appendix F), Land Resources of the Burnett Region, Part 1: South Burnett (Vandersee and Kent, 1982), Cooyar Grazing Lands Study for Cooyar Shire in 1977 (Vandersee, 1977) and the King 2 East (K2E) Project EA Amendment Supporting Information Report (WSP, 2021a) for the K2E ASA or collected after mining has commenced.

2.1.1 Site topography

ML6674 is located on part of the remnants of a once extensive plateau which has undergone minor structural movement, erosion, and weathering to produce a series of land surfaces of varying altitudes and elevations (Hollingsworth, 1979).

The average altitude of the area surrounding the Meandu Mine is approximately 480 metres (m) with the topography reducing in elevation from south to north. The region is predominantly undulating hills of low relief, characterised by steep upper slopes and gentle summits and ridges. These hills are spurs of the Cooyar Range (altitude 600 m above sea level), which lies to the south-east of ML6674. Flat-lying basalt flows and associated sedimentary geological units form the generally subdued scarp of the Cooyar Range. Remnants of sandstones and conglomerates of the coal measures form isolated knobs and subdued hill scarps.

The topography of the Meandu Mine itself has been altered significantly by mining operations. Within the K2E ASA, the topography is heavily undulating and well drained. Ridge Road, separating the east side of the Meandu Mine and the Hoop Pine plantation (Yarraman State Forest), has been formed along the crest of a deeply weathered basalt ridge. The ridge is reasonably level, with upper slopes typically between 5% and 10%, mid slopes between 15% and 20% and more gentle gradients at the toe of the slope towards the ephemeral drainage line known as Rocky Creek.

The topography of the Meandu Mine prior to mining operations is illustrated in Figure 2.1.

2.1.2 Climate

2.1.2.1 Regional climate

Meandu Mine lies within the subtropical climate zone. The Australian subtropical climate is seasonal with the highest temperature, rainfall and evaporation occurring during the summer months of November to February. General regional climate conditions have been described below based on climate data obtained from the closest Bureau of Meteorology (BoM) weather stations to the Meandu Mine, including:

- temperature from Nanango Wills Street (#040158) and Kingaroy Airport (#040922) weather stations; and
- rainfall records from Yarraman Post Office (#040258) and Tarong weather stations (#040199).

Temperature

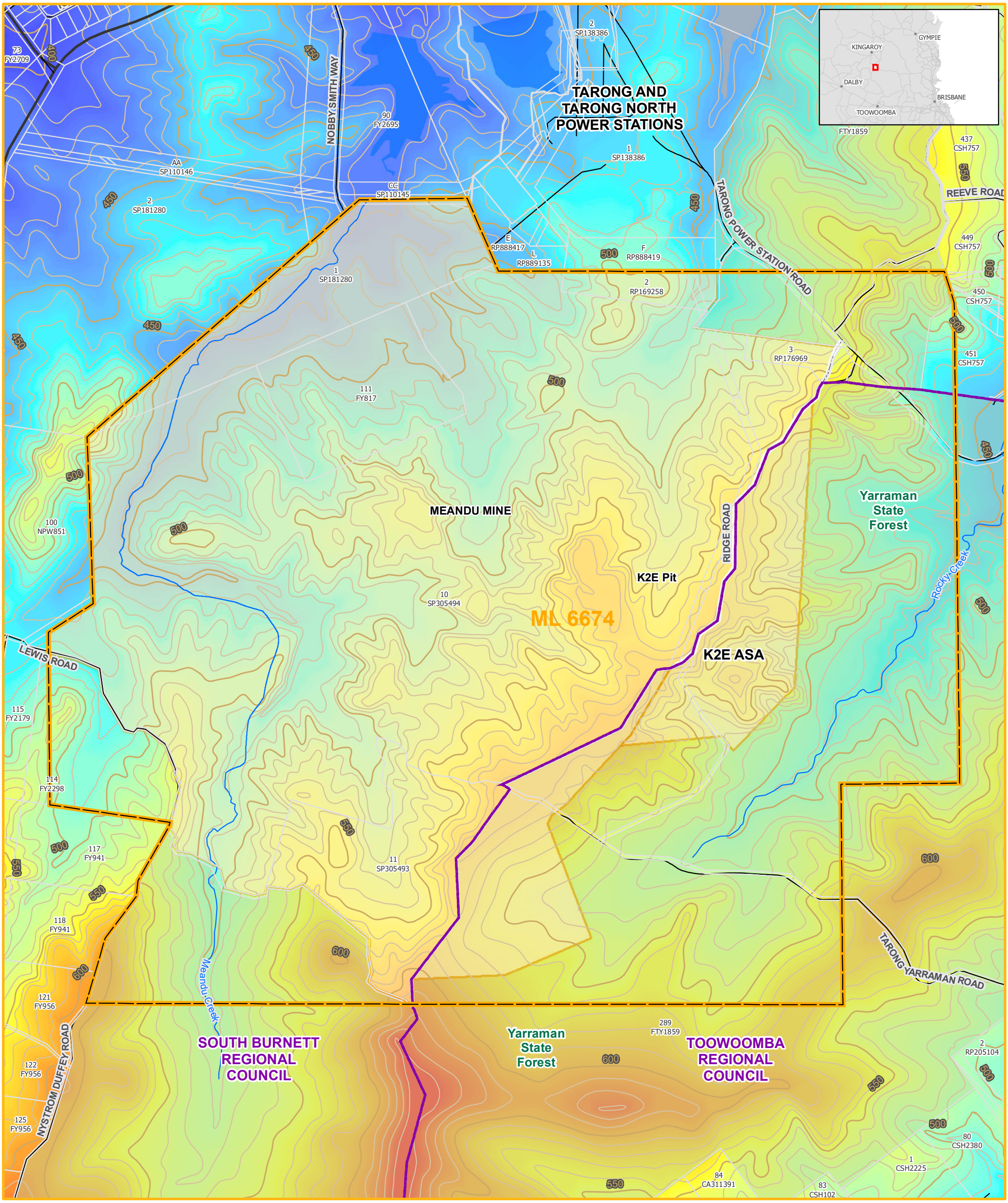
Annual average maximum temperatures for the region range from 24.8°C to 25.9°C. January is the hottest month of the year with a mean maximum temperature of between 30.4°C to 31.1°C and a mean minimum temperature of between 17.3°C and 18.0°C. July is the coolest month of the year with a mean maximum temperature between 19.3°C and 19.8°C and a mean minimum temperature of between 2.7°C to 3.7°C.

Rainfall and evaporation

Rainfall in the region is seasonal and highly variable. Annual rainfall is more than 800 millimetres (mm) at Yarraman Post Office station (#040258) and approximately 700 mm at the Tarong station (#040199). Most rainfall generally falls between October and March (i.e., the wet season) when approximately 560 mm of rainfall is typically recorded at Yarraman Post Office station (#040258) and 500 mm at the Tarong station (#040199). The wet season is characterised by short-lived intense rainfall events (i.e., high daily totals) while drier conditions are experienced throughout the rest of the year (when average monthly rainfall is less than 50 mm). Recharge and stream run-off potential is highest during the wet season months when most rainfall occurs. Similarly, evaporation is higher between October and March (i.e. in the warmer months).

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.1
Topography of the Meandu Mine and surrounds (Pre-mining)



Legend

- Watercourse
- Ridge Road
- Mining Lease (ML6674)
- Local Government Areas
- Cadastre
- Approved Surface Rights Area
- Yarraman State Forest

Contours

- 50 m Contour
- 10 m Contour

Elevation

High : 640

Low : 390

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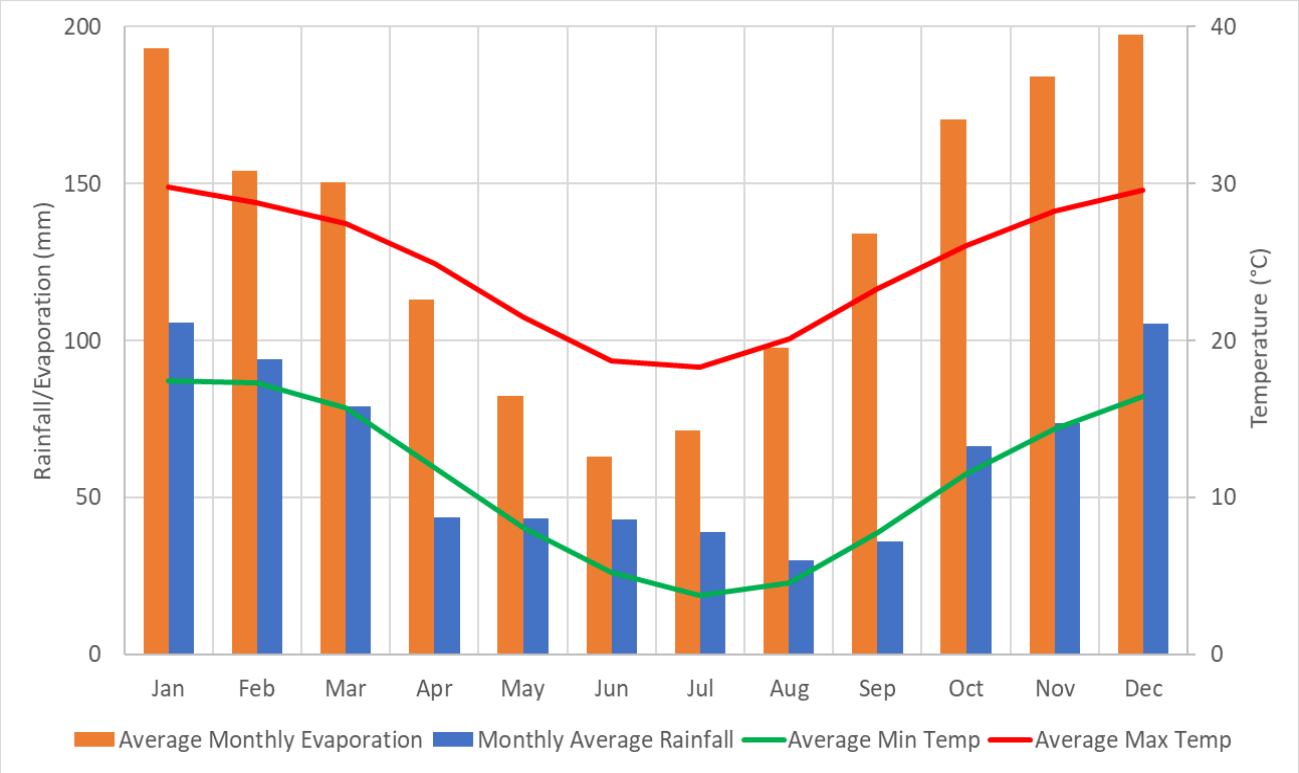
Given the inconsistency of locally available data, long-term average rainfall and evaporation patterns were derived from the DES's Scientific Information for Land Owners (SILO) database for the Meandu Mine site. The SILO database uses mathematical interpolation to fill temporal and spatial data gaps from BoM's weather stations. Based on data generated for the SILO grid point -26.80, 151.90, for the period January 1900 to June 2021, the total average annual evaporation (1,612 mm/year) is more than double the total annual rainfall (759 mm/year). As shown in Figure 2.2, the evaporation rates are strongly linked to temperature variations.



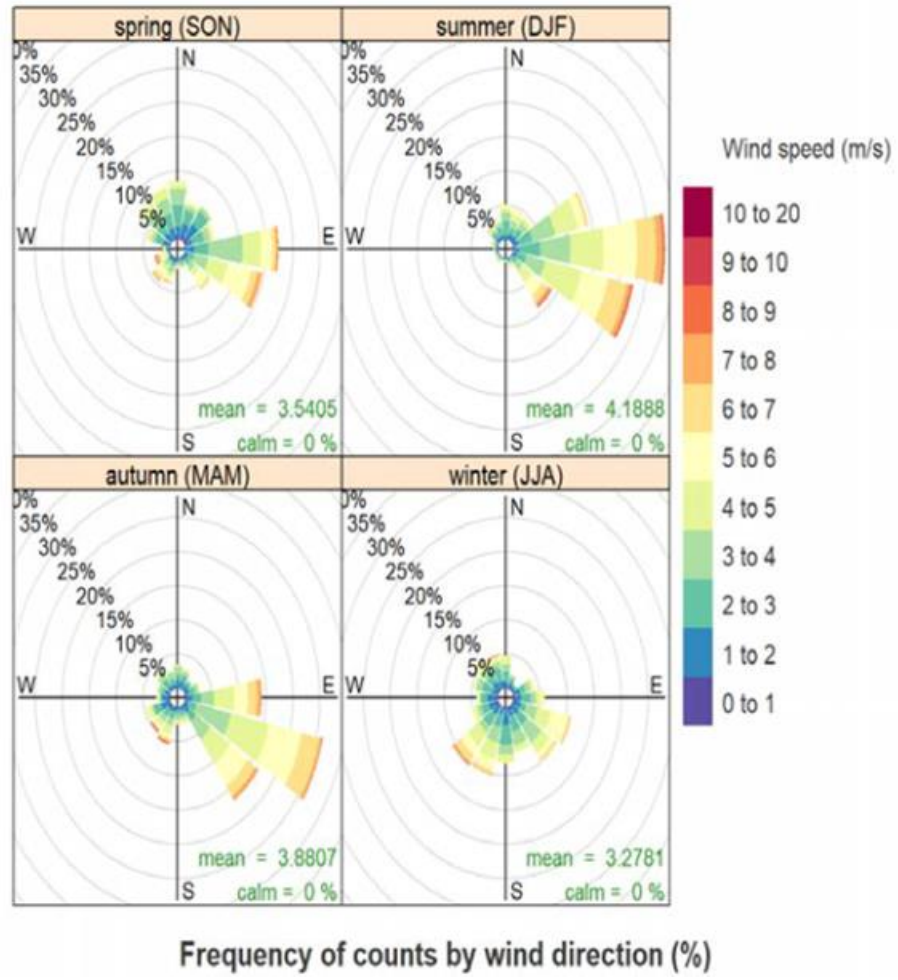
Source: SLR, 2022a

Figure 2.2 Meandu Mine average monthly evaporation, rainfall and temperature (BoM data: January 1900 – June 2021)

Prevailing wind directions

Seasonal wind direction shows that east/south-easterly winds occur throughout the year at the Meandu Mine, with very few westerly winds occurring at the Meandu Mine site. Winds are moderately strong, with an average speed of 3.7 metres per second (m/s). During summer and autumn, wind direction tends to be east to south-easterly. In winter, southerly winds are dominant, and in spring the wind is characterised by more frequent easterly winds.

Seasonal wind direction and speed at the Meandu Mine site is illustrated in Figure 2.3.



Source: Katestone, 2021 in WSP (2021a)

Figure 2.3 Meandu Mine prevailing winds

2.1.2.2 Future regional climate projections

Increasingly reliable regional climate change projections are now available for many regions of the world due to advances in modelling and understanding of the physical processes of the climate system. An assessment of projected climate change for Australia and New Zealand has been undertaken by the Intergovernmental Panel on Climate Change (IPCC) and the results are summarised in Chapter 11 of the IPCC special report entitled “Global Warming of 1.5°C” (IPCC, 2018).

Based on the Global Circulation Model climate modelling findings of the IPCC, the projected median warming, to the year 2100, averaged over the region where the Meandu Mine is located (north of 30°S) is approximately 3°C (range of 2.8°C to 3.5°C). Changes in rainfall in this region are uncertain, however, extremes of daily precipitation are very likely to increase. An increase in potential evaporation is also likely. Overall, hotter and drier conditions, with increased frequency of extreme rainfall events is expected at the Meandu Mine site and surrounding regions for the near future.

Downscaled model predictions are also available, one of which reviewed is the Climate Future tool developed by CSIRO and BoM (2021). The Climate Futures tool predicts the percentage change in rainfall and the maximum daily temperature increase for a predicted year and allows the user to explore projections in 5 yearly increments up until 2090. The prediction uses emissions scenarios called representative concentration pathways (RCPs) which describe a lower emissions future, where greenhouse gas emissions are substantially reduced, and a high emissions future, where high levels of greenhouse gas emissions are set to continue. For the East Coast area of Australia, most scenarios showed that rainfall was likely to vary from 5% to -15% indicating little change to drier climate. Maximum daily temperature is likely to increase from 0.5 to 1.5°C by 2040 and from 1.5 to 3.0°C by 2090, indicating a warmer to hotter climate. These predictions are generally consistent with the IPCC's (2018) projection for the region.

The State of Queensland (2019) has produced publications on the impact of climate change on the Wide Bay-Burnett region which summarises the climate predictions of the region. Based on different emission scenarios (CSRIO and BoM, 2021), the future climate of the Wide Bay-Burnett region can generally expect (amongst other things):

- higher temperatures:
    - maximum, minimum and average temperatures are projected to continue to rise
    - for the near future (2030), the annually averaged warming is projected to be between 0.6 and 1.3°C above the climate of 1986–2005
    - by 2070, the projected range of warming is 1.1 to 3.4°C, depending on future emissions; and
    - a rise in the summer average temperature from 25°C (current) to over 26°C by 2030 and over 28°C by 2070
- hotter and more frequent hot days
- fewer frosts
- harsher fire weather; and
- reduced rainfall:
    - rainfall projections for 2070 show little change or a decrease, particularly in winter and spring; however, the projections show high variability; and
    - the intensity of heavy rainfall events is expected to increase.

The climate change projection data from the region have been considered in the development of the Meandu Mine PRC Plan with respect to the following aspects:

- inclusion of two Water Storage PMLU areas to support adjacent Native Ecosystem and Beef Cattle Grazing PMLUs (Section 4.1)
- climate change scenarios considered in the final void assessment (Section 6.3)
- risk assessment included the risk of climate change and the potential impacts on seed mix and establishment of rehabilitation/bushfire risk/erosion (Section 7)
- time contingency allowed in PRC Plan Schedule for weather delays/climatic delays to the rehabilitation sequence (Section 9); and
- erosion modelling of the landform using evolution modelling and Watershed Erosion Prediction Project (WEPP) models (Section 6.1.5).

2.1.3 Geological setting

The Meandu Mine is located in an area where the Late Triassic Tarong beds (the host unit for the coal seams mined at Meandu Mine) occur at the surface. ML6674 overlies part of the Triassic-aged Tarong Basin, a north north-west/south south-east trending elongate pull-apart basin, the maximum dimensions of which are approximately 80 km long and 30 km wide (Pegrem, 1986). In the area of the Meandu Mine the maximum width of the Tarong Basin is in the order of 9 to 10 km. The approximate western and eastern limits of the Tarong Basin are shown on Figure 2.4. These limits are based on interpretation of the boundary between the Boondooma Igneous Complex (Permo-Triassic intrusives) to the west, the Maronghi Creek beds to the east, and sediment of the Tarong beds in ML6674.

Meandu Mine is located near the centre of the Tarong Basin, which has been interpreted by Flood and Garces (1986) to be formed by a dextral, strike-slip, pull-apart mechanism. In the vicinity of Meandu Mine, areas of the Triassic sediments have been overlain by Tertiary Main Range Volcanics and thin layers of Quaternary sediments restricted to the existing drainage lines.

2.1.3.1 Geology

Geology at Meandu Mine comprises (from the surface downwards): Quaternary alluvium, Tertiary basalt, and regolith and upper Triassic coal measures (the Tarong beds) with sandstone/siltstone between the coal seams. A summary of the geological units is presented in Table 2.1. Figure 2.4 shows the surface geology of the Meandu Mine and the surrounding area.

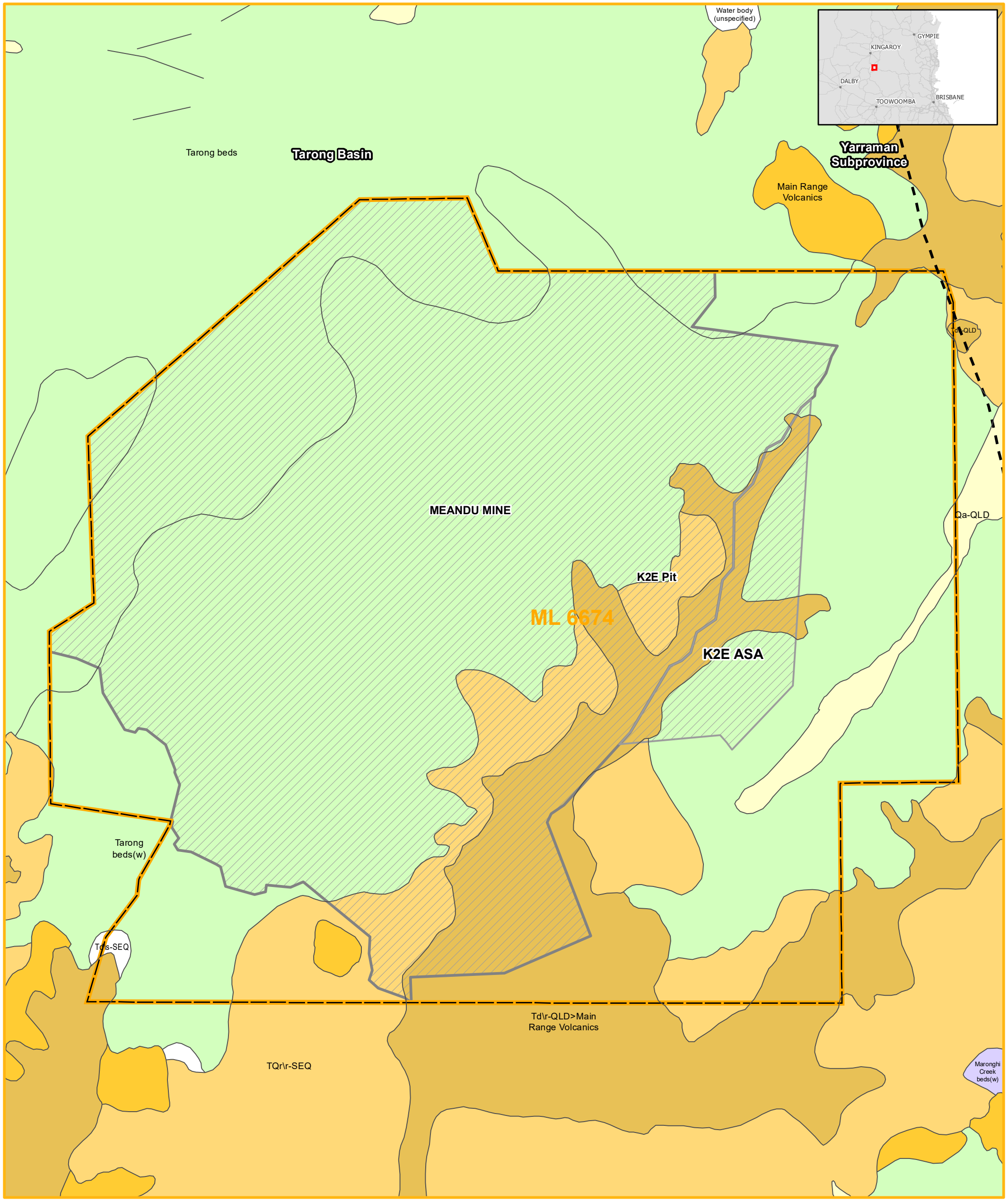
Table 2.1 Geological units at the Meandu Mine

Age	Geological unit	Description
Quaternary	Alluvium	The Quaternary alluvium at the Meandu Mine site is present as current valley filled deposits of unconsolidated gravels, sands and silts. The alluvium is present as a thin veneer confined to the beds of watercourse and associated floodplain (JB Mining Services, 2016). Within ML6674 the alluvium is relatively thin and unsaturated. Quaternary alluvial deposits are associated with ephemeral creeks including Barker and Meandu creeks (which are part of the Burnett River catchment) and Rocky and Yarraman creeks (part of the Brisbane River catchment). The divide between the two catchments is defined by the line of ridge top basalt that can be seen extending from south-west to north-east through the central-east area of Meandu Mine.
Tertiary	Basalt (Main Range Volcanics)	Parts of the deposit are unconformably overlain by the Tertiary-aged Main Range Volcanics which are dominated by thick basalt flows intercalated with poorly consolidated lithic sediments, including claystone, sandstone and lignite. The unconformity at Meandu Mine is very undulose. It is not always readily identifiable in cuttings and boreholes, especially as the weathered Triassic strata appears very similar to the Tertiary lithic sediments. The Main Range Volcanics are generally found in the topographically high areas but can also be found in deeply incised valleys resulting in the deep basalt occurrences such as that dividing the K4E and K4S pits. The basalts are frequently deeply lateritised and weathered.

Age	Geological unit	Description
		In the southern area and central-eastern area of ML6674, deposits of Tertiary basalt occur at surface. In the central-eastern area of ML6674, the basalt occurs as remnant ridge-top deposits.
	Regolith, laterite, residual soils and slope wash deposits	This unit is used to broadly categorise Tertiary-age colluvial deposits, alluvial fans, pediment slope wash, clay, silt, scree, pebbles and cobbles, and regolith. At Meandu Mine the Tertiary unit comprises a unit that is known locally as the regolith; the regolith comprises the upper 20–30 m of Tarong beds that have been weathered during the Tertiary period and consists of weathered sandstone, shale and conglomerate.
Triassic	Tarong beds	The Tarong Basin has been in-filled by the Tarong beds which comprise clastic sedimentary rocks ranging in grainsize and bedding characteristics from laminated mudstone to massive cobble-boulder polymictic conglomerate and includes thick coal accumulations (Cranfield et al., 2001). The Tarong beds have a preserved thickness of approximately 450 m (Pegrem, 1995). The coarse-grained sediments of the Tarong Basin represent high-energy fan and braided stream deposits. The sediments are composed of massive, to thinly bedded, clast supported sheet-flow gravel fan conglomerates, sandy matrix-supported distal-flow conglomerates and horizontally stratified cross-bedded to massive distal fan braid-plain sandstones (Flood and Garces, 1986). Thick deposits of laminated mudstones are also present within the Basin, most notably stratigraphically near to the coal seams. These are interpreted as representing waning flood sedimentation in a lacustrine environment (Cranfield et al., 2001). The geology of the Meandu Mine is predominately labile, poorly sorted fine-grained sandstones associated with polymictic conglomerates, minor siltstones and mudstone. The coal seams are inter-bedded with fine grained sedimentary bands that are often highly variable in both thickness and composition. The Ace, King and Queens seams are the actively mined units at Meandu Mine. The coal within the basin has been classified by Pegrem (1995) as high ash, high volatile, bituminous, low sulphur steaming coal with weak coking properties. In the vicinity of Meandu Mine, the Tarong beds have been affected by strike-slip faults that are generally oriented north north-west/south south-east. The strike of the faults is generally north-west/south-east, consistent with the margins of the Tarong Basin. The faults significantly disrupt the west-east continuity of the coal seams at Meandu Mine. The Boulevard Fault (the eastern-most fault) is the most significant fault in ML6674 with a recorded throw of up to 80 m.

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.4
Surface Geology



Legend

- Geology Structure
- Tarong Basin
- Yarraman Subprovince
- Mining Lease (ML6674)
- Approved Surface Rights Area

Detailed Surface Geology

- Main Range Volcanics
- Main Range Volcanics?
- Maronghi Creek beds(w)
- Qa-QLD
- TQr\r-SEQ
- Tarong beds
- Tarong beds(w)
- Td\r-QLD
- Td\r-QLD>Main Range Volcanics
- Water body (unspecified)

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2.1.3.2 Coal seams

The coal seams at the Meandu Mine generally dip gently to the south and south-east at less than five degrees from horizontal. The seam sequence (top down) in the Meandu Mine deposit is:

- Ace Seam
- King Seam, commencing at a depth of 20 to 60 m below the Ace Seam
- Queen Group (A to J Seams) subdivided as Queen Upper and Queen Lower Seam packages with Queen Upper commencing from a further 30 to 50 m below the King Seam; and
- coal seams below the Queen Seams, which are not mined at site (including Prince, Baron, Duke and Duchess (followed by a set of inconsistent low-quality plies at greater depth).

The stratigraphy of the Meandu Mine is shown in Figure 2.5.

Geology Unit	Group	Seam / Strat	Name, description	Model Code	Coal Resources
SOIL			0.5m thick soil interval	SOIL	
TERTIARY			Red clay interval	RED	
			Tertiary 1	TE1	
			Basalt 1	BA1	
			Tertiary 2	TE2	
			Basalt 2	BA2	
			Tertiary 3	TE3	
			Basalt 3	BA3	
			Tertiary 4	TE4	
			Basalt 4	BA4	
			Tertiary 5	TE5	
			Basalt 5	BA5	
			Tertiary 6	TE6	
UNIT BOUNDARY ONLY			Base of Tertiary	BUTE	
TRIASSIC			Upper Triassic	UT	
			Conglomerate / sandstone	CG	
			Shale unit	SH	
TARONG COAL MEASURES	ACE	ACE	Ace 1	ACE1	Yes
			Ace 2	ACE2	Yes
			Ace 3	ACE3	Yes
	KING	KING	King 2	KNG2	Yes
			King 3	KNG3	Yes
			King 4	KNG4	Yes
			King 5	KNG5	Yes
	UPPER QUEEN	A	A1	A1	Yes
			A2	A2	Yes
			A3	A3	Yes
		B	B1	B1	Yes
			B2	B2	Yes
			B3	B3	Yes
		C	C1	C1	Yes
			C2	C2	Yes
			C3	C3	Yes
		D	D1	D1	Yes
			D2	D2	Yes
			D3	D3	Yes
	LOWER QUEEN	E	E1	E1	Yes
			E2	E2	Yes
			E3	E3	Yes
		F	F1	F1	Yes
			F2	F2	Yes
			F3	F3	Yes
		G	G1	G1	Yes
			G2	G2	Yes
			G3	G3	Yes
		H	H1	H1	Yes
			H2	H2	Yes
			H3	H3	Yes
		J	J1	J1	No
			J2	J2	No
			J3	J3	No
	Prince	PNC	Prince 1, 2, 3		
	Baron	BRN	Baron 1, 2, 3		
	Duke	DUK	Duke 1, 2, 3		
	Duchess	DUCH	Duchess 1, 2		

Figure 2.5 Meandu Mine stratigraphy and geological model inputs

Major faults, typically trending parallel to the Tarong Basin axis, occur along the eastern margin of the basin disrupting the continuity of coal seams within ML6674 (refer further to Section 2.1.5.1 and Figure 2.9). Vertical throws have been interpreted up to 80 m in height. The Tertiary sequence also includes poorly consolidated sediments.

2.1.4 Site hydrology and fluvial networks

2.1.4.1 Catchment overview

Most of the surface rights area of ML6674 at the Meandu Mine is located within the headwaters of the Barker and Barambah Creeks sub-basin of the Burnett drainage basin, with a small portion along the eastern edge of the surface rights area located within the headwaters of the Brisbane River sub-basin of the Brisbane drainage basin. A description of both catchment areas and associated watercourses is provided in the following sections.

2.1.4.2 Barker and Barambah creeks sub-basin

The Barker and Barambah Creeks sub-basin covers an area of approximately 5,930 km^2. Barker Creek originates below the Stuart Range and flows in a north-easterly direction eventually flowing into the Bjelke-Petersen Dam approximately 100 km downstream. Downstream of Bjelke-Petersen Dam, Barker Creek becomes Barambah Creek, which eventually flows into the Burnett River, which discharges into the Coral Sea at Bundaberg.

Waterways within the Barker and Barambah Creeks sub-basin relevant to Meandu Mine are Meandu Creek and Black Creek.

Meandu Creek

Meandu Mine and the Tarong power stations are located near the headwaters of Meandu Creek, a tributary of Barker Creek (Figure 2.6). Meandu Creek runs along the western side of Meandu Mine, flowing from south to north, and entering Meandu Creek Dam, immediately downstream of Meandu Mine.

Prior to construction of the Meandu Mine and Tarong power stations, Meandu Creek was an ephemeral system, only flowing for limited periods during the wet season. For the remainder of the year, Meandu Creek comprised a series of wet areas and isolated waterholes (Hollingsworth, 1979). With the construction of the Meandu Creek Dam (an artificial dam located on Meandu Creek that forms part of the overall water management system for the Meandu Mine and the Tarong power stations) Meandu Creek downstream of Meandu Creek Dam now has a perennial flow regime due to regular releases from the dam (except during extreme drought conditions when releases may cease).

Based on the differing nature of and influences on the Meandu Creek system, Meandu Creek has been divided into the following four reaches (refer Figure 2.7):

- Meandu Creek upstream of the Meandu Mine
- Meandu Creek adjacent to Meandu Mine and upstream of Meandu Creek Dam
- Meandu Creek Dam; and
- Meandu Creek downstream of Meandu Creek Dam.

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.6
Mapped watercourses and wetlands in the vicinity of the Meandu Mine

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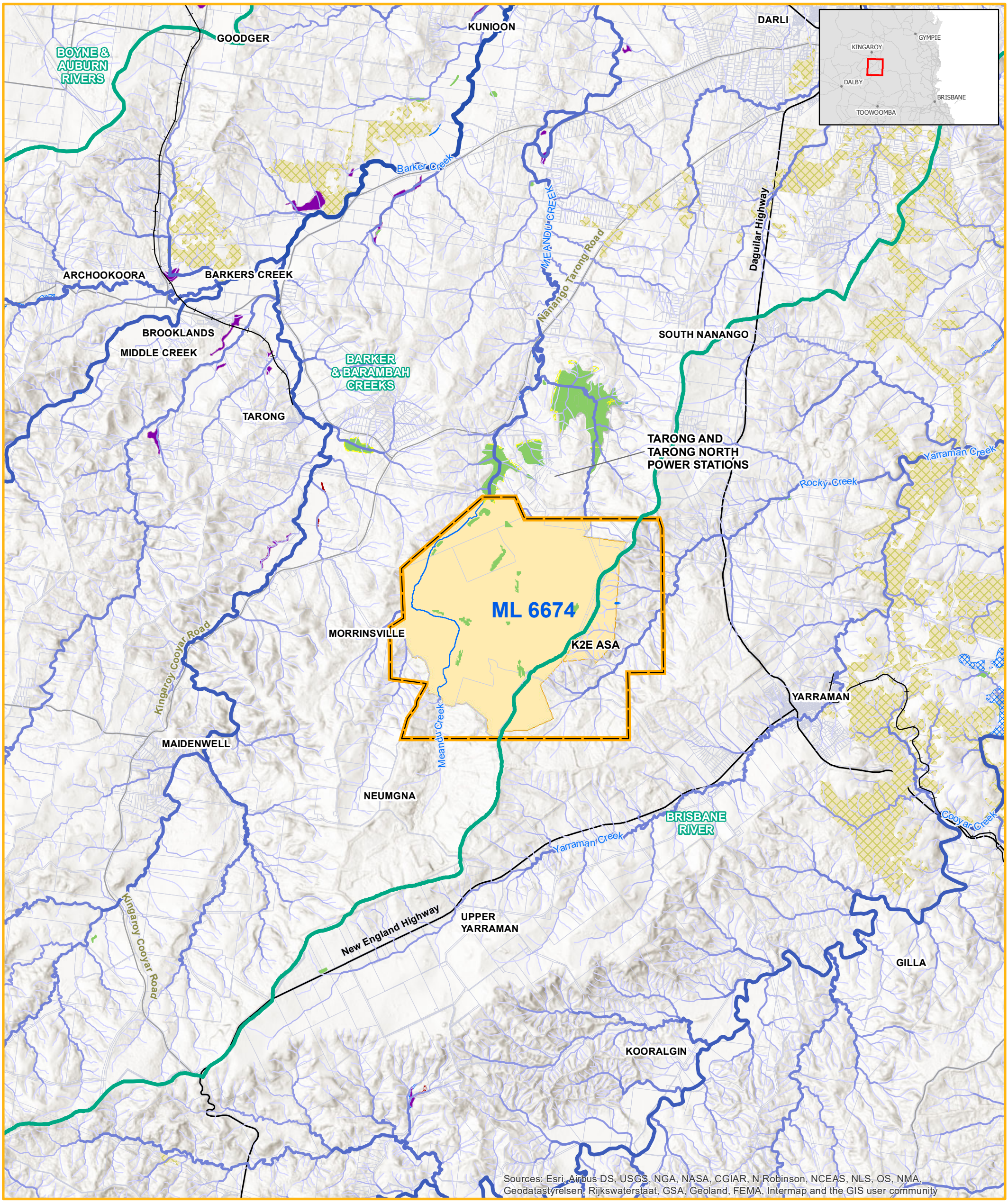

Legend

- Rail Line
- Freeways/Motorways
- Highway
- Secondary Roads and Local Connector Roads
- Drainage Basin Sub-area
- Mining Lease (ML6674)
- Cadastre
- Approved Surface Rights Area

Ordered Drainage: 1, 2, 3, 4, 5, 6, 7, 8, 9

Wetland: M_WB, E_WB, R_WB, L_WB, P_WB, M_RE, E_RE, R_RE, L_RE, P_RE, 51-80_RE, 01-50_RE

- MSES High Ecological Significance Wetlands

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Meandu Creek upstream of Meandu Mine

The upper reaches of Meandu Creek are a stream order 2, with poorly defined channels that are naturally ephemeral (i.e., they convey runoff after rainfall, but water rarely pools) and are dry for the majority of the year (Figure 2.6). Upstream of the Meandu Mine, there are three tributaries of Meandu Creek; the eastern tributary has a catchment area of 1,535 ha and enters ML6674 at the now de-commissioned retention dam RD19. Land use in this catchment is dominated by forestry/pine plantations, with remnant vegetation along the creek corridor. The two small western tributaries have a combined catchment area of 1,241 ha and enter ML6674 adjacent to retention dams RD14 (RD14C, RD14A, RD14B). Most of this catchment comprises land cleared for farming and grazing with the remaining third comprising remnant forest/bushland. External impacts are likely to be low given the surrounding area is dominated by intact native forest; the most apparent impact is humans accessing the State Forest for recreational activities and agricultural activities. Given this reach is typically dry, instream habitat is limited.

Meandu Creek adjacent to Meandu Mine

Meandu Creek adjacent to Meandu Mine between retention dam RD15 and compliance point CP3 has a total catchment area of 4,893 ha (i.e., an additional 2,117 ha from Meandu Creek upstream of the Meandu Mine). Since the commencement of mining activities this reach of Meandu Creek has been diverted in three areas, which has changed the natural flow and function of the waterway (refer to Section 4.1.1.2).

This section of the creek forms part of the overall water management systems for Meandu Mine. The much larger eastern catchment of this reach is affected by mining activities (including active pits, un-rehabilitated waste dumps, rehabilitated landforms and Meandu Mine industrial/administration areas), whereas the western catchment is comprised of remnant forest/bush land, unaffected by mining.

This section of the creek is more characteristic of a typical intermittent waterway with several disjointed, non-flowing pools along the channel (Figure 2.6). The riparian vegetation is cleared in some areas. There are limited in-stream habitat features, but features include dense stands of cumbungi (*Typha* sp.) growing within the channel in places.

Meandu Creek Dam

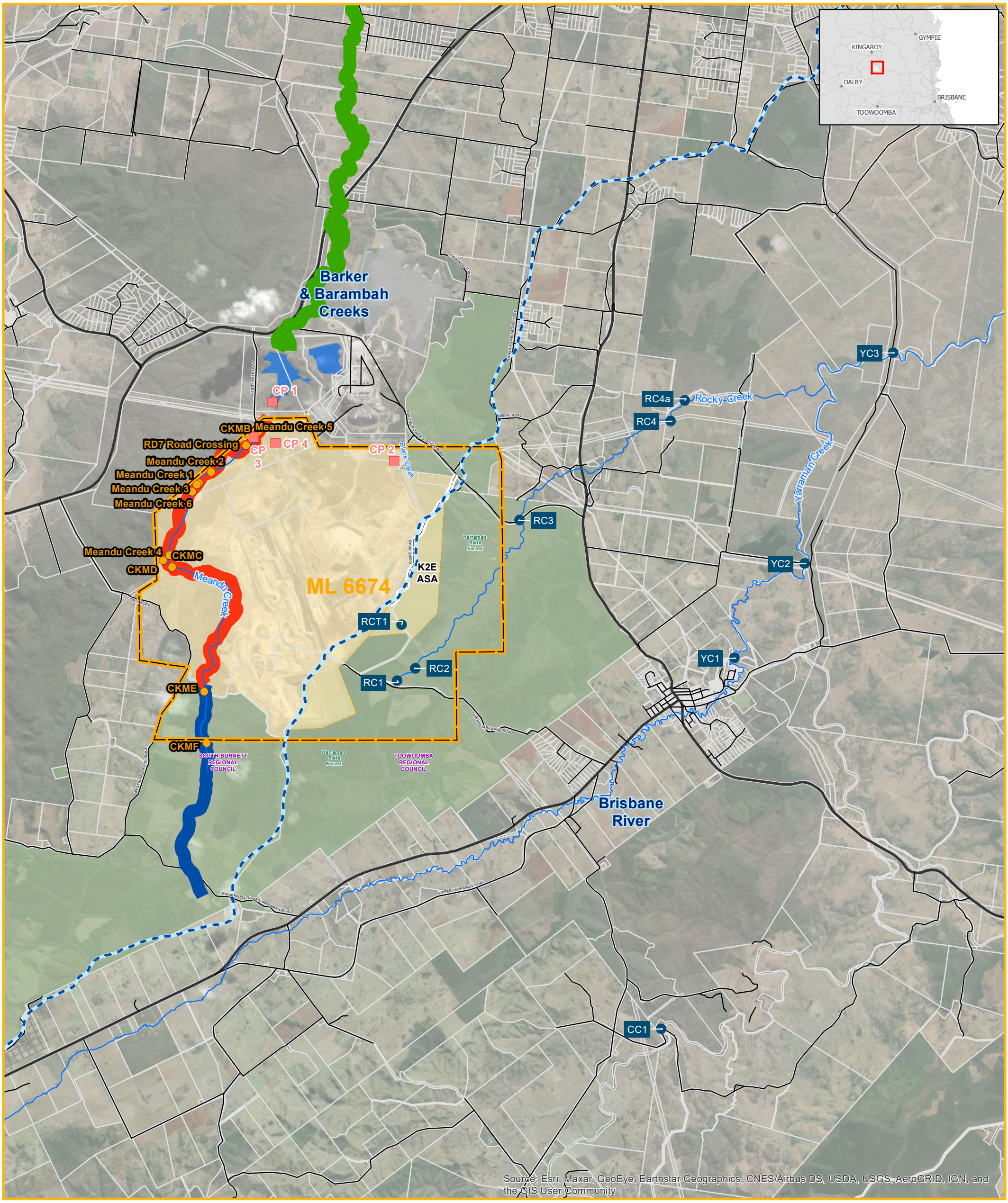
Immediately downstream of the Meandu Mine, Meandu Creek drains into the Meandu Creek Dam, which is a large earth filled constructed water storage dam with a release point and spillway. The dam is operated under the EA of Tarong power stations.

With the exception of some drought situations, Meandu Creek Dam receives continual blow-down water from the Tarong power stations, overflow water from the Cooling Water Dam, stormwater runoff from Meandu Creek and the Tarong power stations site as well as stormwater runoff and licensed discharges from Meandu Mine. The overall catchment area draining to the Meandu Creek Dam is 5,473 ha. At full supply level, Meandu Creek Dam holds 3,150 ML of water and has a surface area of 49.7 ha.

Water from Meandu Creek Dam is subsequently released to the receiving environment of Meandu Creek via a release valve at the dam wall (monitoring site W3). Under normal operating conditions, there is a continual release of water; in the absence of rainfall and catchment inflows, these releases are the main source of water for Meandu Creek downstream of Meandu Creek Dam. An average of 15 to 20 ML/day is currently released from Meandu Creek Dam under the Tarong power stations' EA, which enters Meandu Creek approximately 150 m downstream of the release point. Following cessation of mining and power station operations, the ability to release (frequency and quantity) remains to be confirmed as part of the power station closure plan.

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.7
Surface water quality monitoring sites at Meandu Mine



Legend

- Ridge Road
- Watercourse
- Cadastre
- Mining Lease (ML6674)
- Sub-basin Catchment Area
- Approved Surface Rights Area
- Yarraman State Forest
- Meandu Creek downstream of Meandu Creek Dam
- Meandu Creek upstream of Meandu Creek Dam
- Meandu Creek upstream of Meandu Mine

Surface Water Quality Monitoring Sites

- K2E Project
- Historical Meandu Creek

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Meandu Creek downstream of Meandu Creek Dam

Meandu Creek downstream of Meandu Creek Dam is a stream order 5 waterway and is mapped as a watercourse under the *Water Act 2000*. The surface water receiving environment of Meandu Mine and the Tarong power stations is Meandu Creek approximately 5 km downstream of Meandu Creek Dam to site W3 (Figure 2.7). Water flow in the receiving environment of Meandu Creek downstream of Meandu Creek Dam has been substantially modified due to the construction of the Meandu Creek Dam and subsequent licensed water releases. Meandu Creek was an ephemeral system up until 1985 when a licence was issued to allow releases of cooling water from the Tarong Power Station. After the commencement of cooling water releases, Meandu Creek downstream of the Meandu Creek Dam became a perennial system. Water releases from Meandu Creek Dam to the downstream Meandu Creek receiving environment are controlled and managed by the adjacent Tarong power stations and the associated EA.

Black Creek including Black Creek Dam

Black Creek originally flowed into Meandu Creek, approximately 2 km downstream of Meandu Creek Dam. Black Creek has been substantially modified from its natural state through the construction of the Tarong Ash Dam, Black Creek Dam and the Black Creek Dam overflow diversion channel. Black Creek was de-gazetted as a watercourse in 2000 under the *Water Act 2000*. Upstream of monitoring point CP2, the Black Creek catchment (361 ha) is wholly contained within ML6674. Water is released downstream via the CP2 spillway or release valve and flows into Black Creek Dam, which is a large water storage dam located just north of ML6674, on the eastern side of the Tarong power stations (Figure 2.6 and Figure 2.7).

The additional catchment draining to Black Creek Dam through this reach is 817 ha (i.e., total catchment area of Black Creek Dam is 1,178 ha), with land use predominantly remnant forest/bush land and forestry/pine plantation, with a small industrial area (Tarong power stations). Water in Black Creek Dam can be used at the Tarong power stations; pumped to Meandu Creek Dam; or overflow to the Black Creek Diversion Channel. Black Creek Dam only overflows during extreme rain events, with water from the Black Creek Diversion Channel entering Meandu Creek approximately 2 km downstream of Meandu Creek Dam (Figure 2.6 and Figure 2.7).

Environmental values

The quality of natural waters in Queensland is protected under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (Water and Wetland Biodiversity). Section 6 of the EPP (Water and Wetland Biodiversity) lists the categories into which waters can be classified and their associated environmental values (EVs). The EVs and the WQOs assigned to maintain the identified EVs, are progressively being determined for each water basin in Queensland. Queensland waters with defined EVs and WQOs are listed in Schedule 1 of the EPP (Water and Wetland Biodiversity).

Meandu Creek and other waterways in the vicinity of Meandu Mine (part of the Burnett River Basin) are not yet listed in Schedule 1 of the EPP (Water and Wetland Biodiversity). As such, the relevant EVs must be assigned from those outlined in section 6 (2) of the policy, and by reference to other relevant sources for the area such as the Burnett Mary Water Quality Improvement Plan (WQIP) (Burnett Mary Regional Group, 2015). The EVs for waterways surrounding the Meandu Mine have recently been reviewed in the Meandu Mine Receiving Environment Monitoring Program (REMP) (Stanwell, 2020). A summary of these EVs is provided in the following sections.

Proposed post-closure environmental values for PMLUs are discussed in Section 8.2.6.

Meandu Creek upstream of Meandu Mine

The following draft Environmental Values (EVs) have been attributed to Meandu Creek above Meandu Creek Dam by the Burnett Mary WQIP and the Meandu Mine REMP:

- aquatic ecosystems; and
- industrial use.

This section of Meandu Creek is upstream of (and unimpacted by) mining operations and located within the Yarraman State Forest. As such, the aquatic ecosystem EV is considered most appropriate for this section of Meandu Creek. It is unknown if other EVs apply to this reach. Although Hoop Pine plantations are present throughout the wider area, Meandu Creek upstream of Meandu Mine has relatively good coverage of riparian vegetation and is relatively undisturbed. Therefore, the aquatic ecosystem is currently considered to meet the definition of 'slightly disturbed' (i.e., slightly modified physical or chemical indicators but effectively unmodified biological indicators).

Meandu Creek adjacent to Meandu Mine

The following draft EVs have been attributed to Meandu Creek above Meandu Creek Dam by the Burnett Mary WQIP and Meandu Mine REMP:

- aquatic ecosystems; and
- industrial use.

Meandu Creek upstream of the Meandu Creek Dam and adjacent to Meandu Mine has been significantly modified through the creation of the dam downstream and diversions to facilitate mining operations. Public access to Meandu Creek within the Meandu Mine lease is prohibited. The aquatic ecosystems and industrial use EVs are listed in the Burnett Mary WQIP as applying to waters of Meandu Creek upstream of Meandu Creek Dam. These waters are degraded aquatic ecosystems of low ecological value that are heavily influenced by mining activities. Therefore, the highly disturbed aquatic ecosystems EV is considered applicable to this reach.

Meandu Creek Dam

The following draft EVs have been attributed to Meandu Creek Dam by the Burnett Mary WQIP:

- aquatic ecosystems; and
- stock watering.

Meandu Creek Dam forms part of the overall site water management systems for Meandu Mine and the Tarong power stations. Public access to Meandu Creek Dam, including stock access and watering is prohibited. As such, the stock watering EV is currently not considered relevant. Meandu Creek Dam supports aquatic species and communities and forms part of the water management system for Meandu Mine and Tarong power stations. As such the highly disturbed ecosystem value is considered to be applicable to the dam. Meandu Creek Dam is directly connected to Meandu Creek downstream of Meandu Creek Dam (via the release valve). The quantity and quality of water released from Meandu Creek Dam is managed by the Tarong power stations (operated by Stanwell) under EA EPPR00971913 and accompanying monitoring programs, including the Meandu Creek Impact Monitoring Program.

Meandu Creek downstream of Meandu Creek Dam

The following draft EVs have been attributed to Meandu Creek downstream of Meandu Creek Dam by the Burnett Mary WQIP, findings from available literature, previous technical reports or the results of monitoring completed to date:

- aquatic ecosystems
- irrigation
- farm supply
- stock watering
- human consumption of shellfish
- primary recreation
- secondary recreation; and
- potentially industrial use.

There have been several previous assessments of EVs relevant to the receiving environment downstream of Meandu Creek Dam; most of these assessments classify the aquatic ecosystems of Meandu Creek as “highly disturbed”. However, the aquatic ecosystems of Meandu Creek downstream of Meandu Creek Dam are not significantly degraded or of a lower ecological value than surrounding waters (as would be the case for highly disturbed waters). Therefore, the system is currently considered to meet the definition of ‘moderately disturbed’ (i.e., the biological integrity of the water is adversely affected by human activity to a relatively small but measurable degree).

Black Creek including Black Creek Dam

The upper reaches of the Black Creek catchment are within Meandu Mine, draining to RD17B/CP2. Downstream of CP2/RD17B Black Creek flows offsite onto the Tarong power stations complex area and into Black Creek Dam. Black Creek Dam forms part of the overall site water management system for the Tarong power stations. Black Creek has been substantially modified from its natural state through construction of the Tarong Ash Dam, Black Creek Dam and the Black Creek Dam overflow diversion channel. Public access to Black Creek and Black Creek Dam is prohibited. Based on this, ‘industrial use’ is the only EV currently applicable to Black Creek and Black Creek Dam.

Table 2.2 summarises the EVs assigned to the waterways surrounding the Meandu Mine with the Barker and Barambah creeks sub-basin.

Table 2.2 Environmental values assigned for waterways surrounding the Meandu Mine with the Barker and Barambah creeks sub-basin

Environmental value	Barker and Barambah Creeks sub-basin			
	Meandu Creek upstream of Meandu Mine	Meandu Creek adjacent to Meandu Mine, Meandu Creek Dam	Black Creek and Black Creek Dam	Meandu Creek downstream of Meandu Creek Dam (receiving environment)
Aquatic ecosystems	**Y (moderately disturbed)**	**Y (highly disturbed)**	N/A	**Y (moderately disturbed)**
Irrigation	–	N/A	N/A	**Y^**
Farm supply/use	–	N/A	N/A	**Y**
Stock watering	–	N/A	N/A	**Y**
Aquaculture	–	N/A	N/A	N/A
Human consumer	–	N/A	N/A	**Y**
Primary recreation	–	N/A	N/A	**Y**
Secondary recreation	–	N/A	N/A	**Y**
Visual appreciation	–	N/A	N/A	N/A
Drinking water	–	N/A	N/A	N/A
Industrial use	N/A	**Y**	**Y**	**Y**
Cultural and spiritual values	–	N/A	N/A	N/A

a Source: Burnett Mary Regional Group 2015 and Stanwell Corporation Limited 2020

Y Indicates applicable EV

N/A EV not applicable.

– Currently not determined for this area. EV assumed to apply as a conservative approach.

^ The irrigation EV for Meandu Creek downstream of Meandu Creek Dam is managed through communication of water quality with downstream users.

2.1.4.3 Brisbane River sub-basin

The Brisbane River sub-basin is separated into three separate management districts (upper, mid and lower), with the K2E ASA of the Meandu Mine within the Upper Brisbane River catchment. The Upper Brisbane River catchment within the Brisbane River sub-basin covers an area of approximately 5,483 km^2 and is located at the base of the Great Dividing Range and the Cooyar, Brisbane and Jimna Ranges (DES, 2019). The Brisbane River is 309 km in length. From its origin, it flows in a southerly direction, through Wivenhoe Dam (approximately 140 km downstream of the Meandu Mine), and then flows east until it eventually discharges into Moreton Bay, which is a marine park and RAMSAR wetland (approximately 310 km downstream of the Meandu Mine).

Waterways within the Brisbane River sub-basin of relevance to the Meandu Mine comprise Rocky Creek, Yarraman Creek, Cooyar Creek and the Upper Brisbane River.

Rocky Creek

The K2E ASA of the Meandu Mine is located near the headwaters of Rocky Creek, a tributary of Cooyar Creek, which flows into the Brisbane River approximately 45 km downstream of the K2E ASA. Rocky Creek originates approximately 2.5 km upstream of the K2E ASA. The main Rocky Creek watercourse flows in a north-east direction to the south of the K2E ASA, however several of its tributaries are located within and in close proximity to the K2E ASA and flow to the main Rocky Creek watercourse. The headwaters of Rocky Creek and its tributaries flow within the Yarraman State Forest, which is largely licensed for forestry use and principally utilised for Hoop Pine plantations. Land use downstream of the Yarraman State Forest is dominated by agriculture.

Rocky Creek comprises stream order 1, 2, 3 and 4 waterways all of which are ephemeral (refer Figure 2.6). The headwaters and tributaries of Rocky Creek (including those that occur in the K2E ASA) are not mapped as watercourses under the *Water Act 2000* and, based on email advice from the former Department of Natural Resources, Mines and Energy (now Department of Regional Development, Manufacturing and Water) (email correspondence 10 September 2020) would be considered unnamed drainage lines. Rocky Creek downstream from ML6674 is mapped as a watercourse.

Yarraman Creek

Yarraman Creek originates upstream of the township of Upper Yarraman. It flows in a north-east direction parallel to Rocky Creek to the south and through the town of Yarraman before its confluence with Rocky Creek (approximately 9 km downstream of the Meandu Mine). The waterway is ephemeral and has been impounded downstream of the town of Yarraman to create Yarraman Weir. Outside of the urban areas, land use is dominated by agriculture (grazing and some cropping). Yarraman Creek from (and including) Yarraman Weir to its confluence with Cooyar Creek, is a stream order 4 waterway, and is mapped as a watercourse under the *Water Act 2000*.

Cooyar Creek

Cooyar Creek originates near the Bunya Mountains and flows in a north-east direction parallel to Yarraman Creek to the south before its confluence with Yarraman Creek (approximately 15.5 km downstream of the Meandu Mine). The waterway is intermittent with some long-lasting pools. Land use is dominated by agriculture (grazing and cropping). Cooyar Creek is a stream order 6 waterway from 30 km upstream of its confluence with Yarraman Creek to its confluence with the Brisbane River. It is mapped as a watercourse under the *Water Act 2000*, and it is partially mapped as a riverine wetland with one lacustrine wetland mapped immediately downstream of its confluence with Yarraman Creek.

Upper Brisbane River

The Brisbane River originates near the Brisbane Range, 25 km north-east of Nanango, and flows in a southerly direction, joining Cooyar Creek approximately 45 km downstream of the Meandu Mine. The waterway is perennial and land use is dominated by agriculture (grazing). The Brisbane River from its confluence with Cooyar Creek is a stream order 7 waterway. It is mapped as a watercourse under the *Water Act 2000* and is partially mapped as a riverine wetland (Queensland Globe, 2020).

Environmental values

The EPP (Water and Wetland Biodiversity) for the Upper Brisbane River assigns EVs to freshwaters within the Cooyar Creek sub-catchment (which comprises the waterways of Rocky, Yarraman and Cooyar creeks) and the upper Brisbane River sub-catchment (which comprises the upper Brisbane River) (DERM, 2010).

The following EVs have been attributed to Cooyar Creek including Yarraman Creek by the Upper Brisbane River Environmental Values and Water Quality Objectives (2010): – aquatic ecosystems, irrigation, farm use/ supply, stock water, aquaculture, human consumer, primary recreation, secondary recreation, visual recreation, drinking water, industrial use, cultural and spiritual values.

A review of the current water licences issued for surface water users of the waterways within the area of the Meandu Mine indicates that the EV of aquaculture is not relevant to waters of the Upper Brisbane River within the area; all other EVs are considered relevant.

The aquatic ecosystems of waterways in the area surrounding the Meandu Mine within the Brisbane River sub-basin are considered “moderately disturbed” as per the EPP South-east Queensland Map Series Plan WQ1438 (DERM, 2010). However, the revised draft Map Series Plan indicates proposed changes to the management intent for certain waterways, including Rocky Creek.

Since the headwaters of Rocky Creek and its tributaries flow within the Yarraman State Forest, these waterways are mapped as “slightly disturbed”. However, much of the State Forest has been licensed as forestry plantation, and activities associated with the plantations may have influenced the surrounding waterways. Waterways have been disturbed through clearing native riparian vegetation, introducing invasive pest species of plants and modifying flow pathways. Therefore, the tributaries of Rocky Creek within the forestry plantation (including those relevant to the Meandu Mine – K2E ASA) have been adversely affected to a relatively small but measurable degree by human activity and are considered “moderately disturbed”. The headwaters of Rocky Creek (upstream of the main watercourse) are outside the forestry plantation areas and are located within the remaining natural area of the Yarraman State Forest, with relatively good coverage of riparian vegetation with natural flow pathways. These waterways are considered “slightly disturbed”.

All other reaches of Rocky Creek downstream of Yarraman State Forest as well as the waterways of Yarraman Creek, Cooyar Creek and the Upper Brisbane River are mapped as, and considered to be, “moderately disturbed”.

Table 2.3 summarises the EVs assigned to waterways surrounding the Meandu Mine within the Brisbane River sub-basin.

Table 2.3 Environmental values assigned for waterways surrounding the Meandu Mine within the Brisbane River sub-basin

Environmental value	Brisbane River Sub-Basin
	Cooyar Creek sub-catchment and Upper Brisbane River sub-catchment a
Aquatic ecosystems	Y (moderately disturbed)
Irrigation	Y
Farm supply/use	Y
Stock watering	Y
Aquaculture	Y*
Human consumer	Y
Primary recreation	Y
Secondary recreation	Y
Visual appreciation	Y
Drinking water	Y
Industrial use	Y
Cultural and spiritual values	Y

a Source: DERM, 2010

Y Indicates applicable EV

* Not relevant to the waters surrounding the Meandu Mine.

2.1.4.4 Baseline water quality

Barker and Barambah Creeks sub-basin

Prior to mining operations occurring at Meandu Mine, Meandu Creek and its tributaries were sampled for water quality criteria on a number of occasions since 1976, as well as on a weekly basis at five sample points on Meandu Creek during periods when stream flow rates were sufficient from October 1978 to May 1983.

The baseline water quality data for this latter survey sampling is summarised in Table 2.4. These results indicate that the most representative data is from two monitoring sites – the site below RD2 and the site opposite RD14 (locations are shown in Figure 2.23, Section 2.2.2). The water quality from these two locations showed relatively high concentration of total dissolved solids (TDS), with the 80th percentile being 2,730 mg/L and 2,840 mg/L respectively. These values are within the recommended concentrations of TDS in drinking water for most of livestock, apart from dairy cattle (below 2,400 mg/L) and poultry (below 2,000 mg/L) in accordance with the ANZECC & ARMCANZ (2000) guideline. The samples analysed from these sites also had a noticeable elevated concentration of chlorine, which is potentially harmful to a range of fish species. The water quality from the other three sites showed significantly lower concentrations of TDS and other measured parameters, although the data were only obtained from a limited number of samples.

Ongoing surface water quality monitoring of physical-chemical parameters and contaminants has been undertaken by Stanwell as part of compliance monitoring for the Meandu Mine and Tarong power stations since 1978. Throughout this period, the following sites have been monitored on Meandu Creek (Figure 2.7):

- two Meandu Creek sites upstream of Meandu Mine (CKMF/MCUS1, CKME/MCUS2), although these are often dry during sampling
- nine Meandu Creek sites upstream of Meandu Creek Dam and adjacent to Meandu Mine (CKMB, CKMD, CKMC, RD7 Road Crossing, Meandu Creek 1, Meandu Creek 2, Meandu Creek 3, Meandu Creek 4, Meandu Creek 5, Meandu Creek 6)
- three compliance sites within the water management system (CP1, CP3, CP4); and
- three receiving environment sites in Meandu Creek downstream of the Meandu Creek Dam (W3, W2, SW16).

Based on the past 43 years of monitoring data, the following trends were identified:

- Median pH was higher at the Meandu Mine compliance points CP3 and historically CP1 (which are located near the inflow and within Meandu Creek Dam, respectively) than in Meandu Creek adjacent to Meandu Mine. While there have been occasions where the pH at the compliance points and Meandu Creek sites has been low (e.g. approximately 4 pH units), there has been little change in the median pH in recent years compared to the long-term median.
- Electrical conductivity levels were higher in Meandu Creek adjacent to Meandu Mine than at CP3 and CP1. There has been an increase in median electrical conductivity levels at both compliance points in the past 4 years compared with the long-term median. However, median electrical conductivity at the compliance points was below the water contaminant limit of 2500 µS/cm listed in the current EA.
- Similarly, concentrations of sodium and chloride were higher in Meandu Creek adjacent to Meandu Mine than at the compliance points. Median concentrations in the past 4 years were generally similar to the long-term median.
- Concentrations of sulfate, oxides of nitrogen and most metals (including cobalt, iron, manganese, molybdenum, nickel and zinc) were higher at the compliance points than in Meandu Creek adjacent to Meandu Mine.

Table 2.4 Summary statistics of available surface water baseline data (prior to the commencement of mining)

During Oct 1978 to May 1983		Parameters measured (mg/L)							
Monitoring sites	**Statistic**	**TDS**	**Calcium**	**Sodium**	**Potassium**	**Chloride**	**Sulfate**	**Hardness**	**Total Iron**
Meandu Creek – below RD2 (based on 42 samples)	Minimum	1200	5.9	66	8	115	17.1	62	0.005
	Median	2570	55	620	13	1276	73	600	0.05
	80th percentile	**2730**	**70**	**688**	**16**	**1360**	**90**	**670**	**0.4**
Meandu Creek draining forestry catchment – just below (100–200 m) southern lease boundary (based on 10 samples)	Minimum	37	2.2	9.4	0.5	10	0.5	12	0.3
	Median	111	4.9	17.5	2.9	25	4.5	33.5	2.8
	80th percentile	**148**	**7.2**	**22.7**	**4.9**	**37.6**	**6.2**	**46.8**	**7.0**
Meandu Creek – opposite RD14 (based on 101 samples)	Minimum	1170	18	250	9	530	15	0.5	0.05
	Median	2600	46	654	16	1260	80	595	0.1
	80th percentile	**2840**	**58**	**720**	**19.5**	**1410**	**97**	**650**	**0.2**
Meandu Creek Dam – spillway (only one sample)	–	504	11	91	7.68	161	22.2	119	6.58
Small gully draining into Meandu Creek, just below RD14 (based on four samples)	Minimum	105	7.5	12	0.5	28	7	43	0.3
	Median	180	11.1	19.1	7	32.5	9	52.5	5.1
	80th percentile	**235**	**13.9**	**20**	**8.3**	**47**	**9.4**	**67.6**	**5.9**

Brisbane River sub-basin

Baseline surface water quality data for the Brisbane River sub-basin (Rocky Creek, Yarraman Creek, Cooyar Creek and the upper Brisbane River) is available from a comprehensive baseline surface water quality condition assessment monitoring program designed in accordance with the Queensland Water Quality Guidelines (DEHP, 2013) for State approval of the K2E Project. Twelve sites were surveyed between the period of April 2018 to March 2019 (refer Figure 2.7), including:

- one site on an unnamed tributary of Rocky Creek, located within the K2E ASA
- five sites on Rocky Creek, located downstream of the K2E ASA
- three sites on Yarraman Creek, two located upstream and one located downstream of the K2E ASA (i.e., downstream of the confluence with Rocky Creek)
- one site on Cooyar Creek, located upstream of the K2E ASA (i.e., upstream of its confluence with Yarraman Creek); and
- two sites on the Brisbane River, located downstream of the K2E ASA (i.e., downstream of its confluence with Cooyar Creek).

This assessment found that surface water quality in the vicinity and downstream of the K2E ASA was typical of a moderately disturbed ecosystem (ESP, 2021). Waterways are influenced primarily by surrounding land uses (e.g. Hoop Pine plantations surrounding the headwaters of Rocky Creek and agriculture surrounding the other waterways), however they are considered suitable for supporting the EVs of the waterways and were of low toxicity risk to flora and fauna.

Overall, water quality was poor in areas high in the catchment in the vicinity of the K2E ASA and improved with distance downstream (ESP, 2021). Many water quality parameters were within or below available regional Water Quality Objectives (WQOs) or default WQOs for the protection of the relevant EVs, or occasionally exceed the WQOs. However, some parameters were frequently outside of the WQOs, including levels of dissolved oxygen (which are often low), electrical conductivity (except in the Brisbane River, where it is low), total dissolved solids, sodium, nutrients (primarily ammonia, organic nitrogen and total nitrogen; and to a lesser extent total phosphorus), total petroleum hydrocarbons, and concentrations of some metals and metalloids (primarily manganese and iron). These parameters varied across the area with differences likely based on a combination of local factors that would influence conditions of each waterway in addition to the surrounding land uses (i.e., water type (dam verse waterway), location within the catchment (upper catchment verse lower catchment) and surrounding geology).

Water quality of Rocky Creek in the immediate vicinity of the K2E ASA was found to be the most degraded compared to other sites, with high pH, high concentrations of nutrients (inorganic and organic), high concentrations of certain metals (manganese, aluminium and iron) and hydrocarbons. Water quality of waterways of Rocky Creek (downstream of the lacustrine wetland) and Yarraman and Cooyar creeks was characterised by very high electrical conductivity, total dissolved solids and concentrations of sodium, which are likely a result of the local geology of these waterways (ESP, 2021). Water quality of the upper Brisbane River was in the best condition, with lower electrical conductivity and concentrations of ions as well as lower concentrations of nitrogen, metals and hydrocarbons, however water quality was still influenced by surrounding activities to a measurable degree (ESP, 2021).

2.1.5 Groundwater

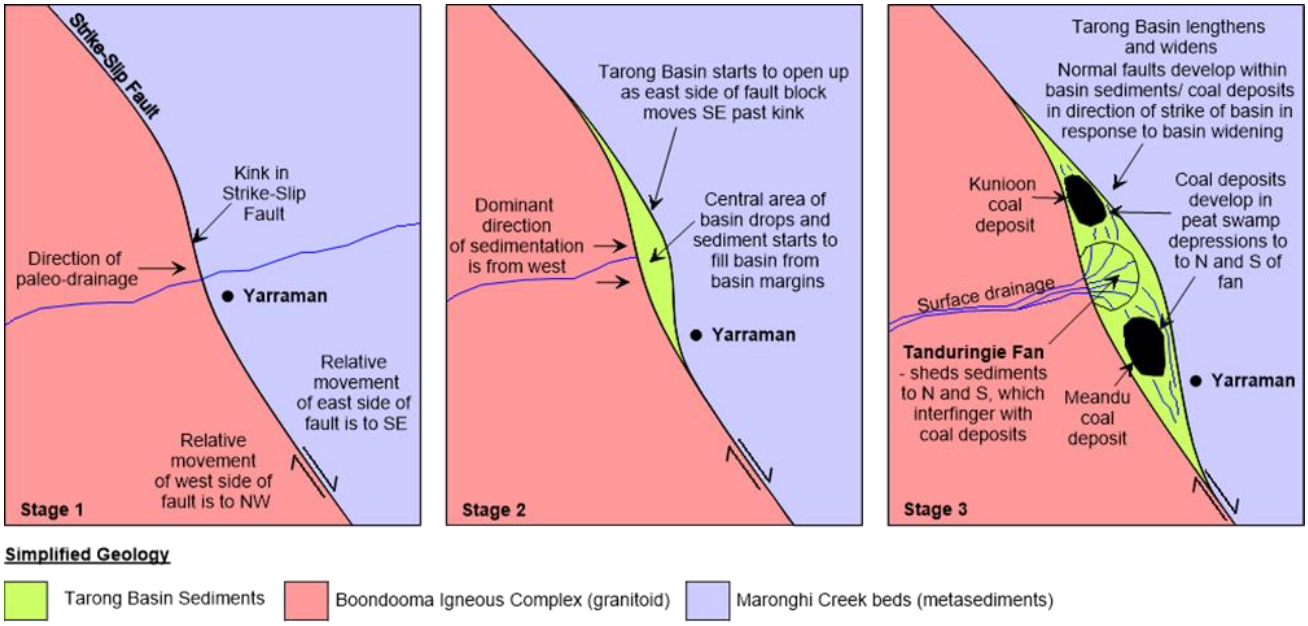
2.1.5.1 Hydrogeological setting

Tarong Basin

The Meandu Mine is located within the Tarong Basin, a Triassic-age pull-apart basin. To appreciate groundwater flow dynamics within the basin an understanding of the basin margins, especially in the west and east, is deemed important. This also has implications for understanding regional groundwater flow(s).

Three main stages in the development/formation of the Tarong Basin are described in Flood and Garces (1986). These are summarised below and shown on Figure 2.8:

- Stage 1 – a strike-slip fault developed in a north-west/south-east orientation. The fault has a regional kink shown in the area where the Tarong Basin later developed. To the west of the fault are the granitic rocks of the Boondooma Igneous Complex, while to the east are the meta-sedimentary rocks of the Maronghi Creek beds. The direction of paleo-drainage is from west to east.
- Stage 2 – The Tarong Basin started to “open-up” due to movement along the strike-slip fault. On the western side of the fault, rocks of the Boondooma Igneous Complex moved in a relative north-west direction, while to the east, the metasediments of the Maronghi Creek beds moved in a relative south-east direction. As the basin started to form (i.e., open up), the central area of the basin began to subside and the deposition of sediments (i.e., through a process of sedimentation) sourcing from the basin margins commenced. The dominant direction of sedimentation was from the west.
- Stage 3 – Increasing sedimentation from the west resulted in the formation of an alluvial fan complex, known as the Tanduringie Fan (Flood and Garces, 1986). Peat swamp depressions formed to the north and the south of the Tanduringie Fan. Coal deposits started to form within the area of the swamp environments as the basin opened up and subsided further and as sedimentation continued. The coal deposits to the south of the Tanduringie Fan represent the units that are currently being mined at Meandu Mine (i.e., the Tarong beds, which are up to 450 m thick at Meandu Mine (Pegrem, 1986)), while the coal deposits to the north of the Tanduringie Fan are located within the area of the Kunioon deposit. There are no known coal deposits within the Tanduringie Fan between Meandu Mine and the Kunioon coal deposit. Sediments of the Tanduringie Fan can be seen at the surface in road cuttings along the Tarong-Nanango Road (Pegrem, 1986).



Source: After Flood & Garces (1986)

Figure 2.8 Formation of the Tarong Basin

2.1.5.2 Groundwater occurrence

Prior to mining activities at Meandu Mine, a regional groundwater assessment was undertaken by Hollingsworth (1979). Findings from that study showed that only limited supplies of groundwater were available as it was contained within porous sedimentary rocks (i.e., primary porosity) and fractures in igneous rocks (i.e., secondary porosity).

This study also found that within the Meandu mining lease (i.e., ML6674) there was a tendency for the water table to follow the general dip of the coal seams, rather than mimic surface topography gradients as would normally be expected. In some locations the water table was found to be present (within) or just (below) the coal seam. In other locations the groundwater table followed the top of the coal seam; where the coal seam formed the aquifer. There was some evidence that the groundwater table was perched where it occurred close to the surface (e.g., under creeks, at the break of slopes and on flat hilltop areas such as above the basalt of the Cooyar Range). Some of the perched groundwater tables were also found to be related to the coarse sandstone infilling palaeo-stream channels within the coal measures. Seasonal groundwater level fluctuations appeared to be less than 5 m over most of the area with some recharge from soil water (Hollingsworth, 1979).

Since the commencement of mining, a substantial body of work has been undertaken to conceptualise and model groundwater movement and interactions at the Meandu Mine.

As shown on Figure 2.9, the Meandu Mine groundwater system is bound by the Permo-Triassic Boondooma Igneous Complex to the West and the Carboniferous Maronghi Creek beds to the east. To the north, the Meandu Mine groundwater system is bounded by the Tanduringie Fan which has been assessed to be in hydraulic isolation from Meandu Mine (JBT, 2021a). To the south, the basin approaches its margin, with the subcrop of the coal seams located outside of the ML6674 southern boundary and thought to constitute the main conduit/s for groundwater recharge. The Queen A and B ply modelled subcrop limits underlie Yarraman Creek (refer Figure 2.11).

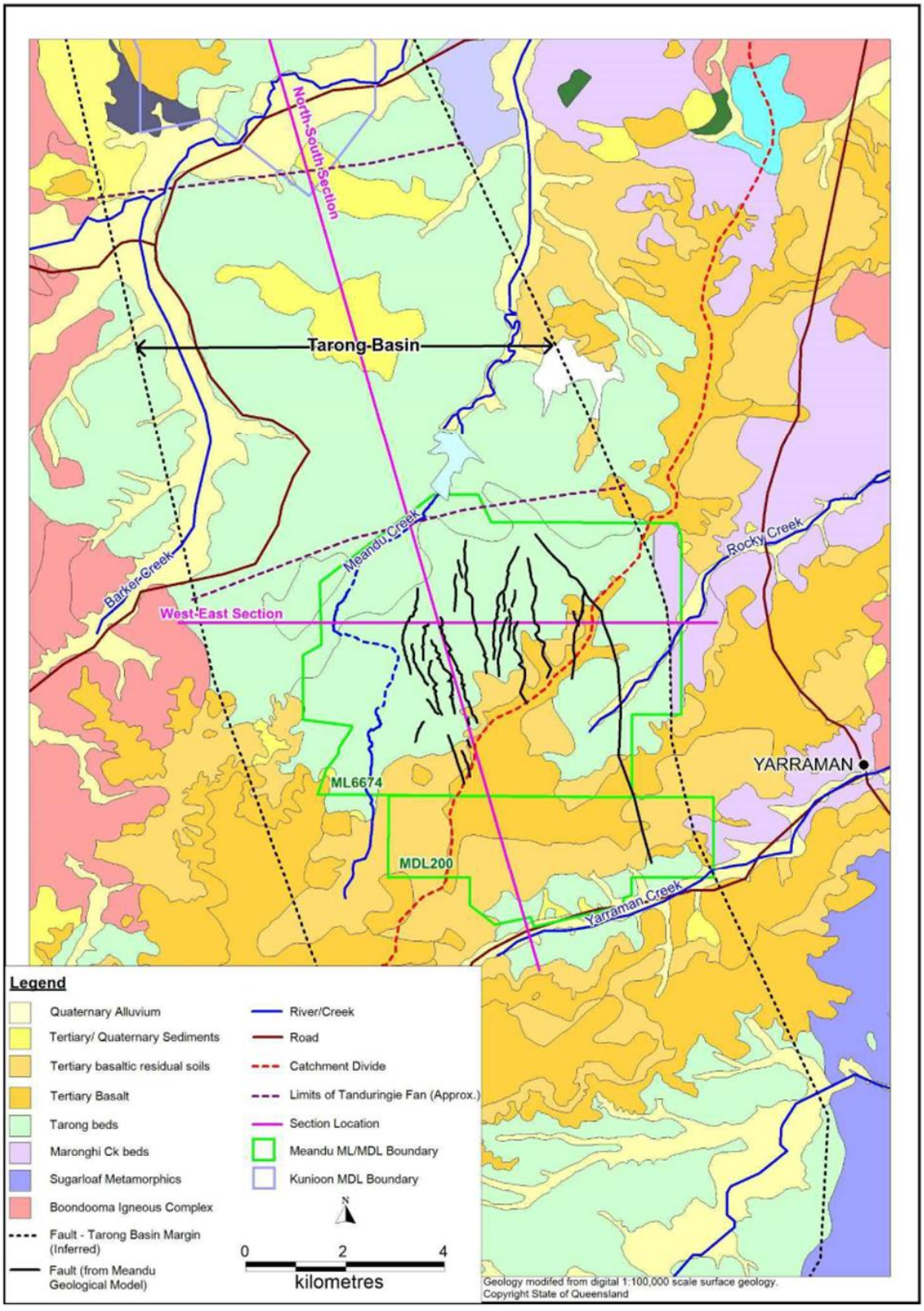
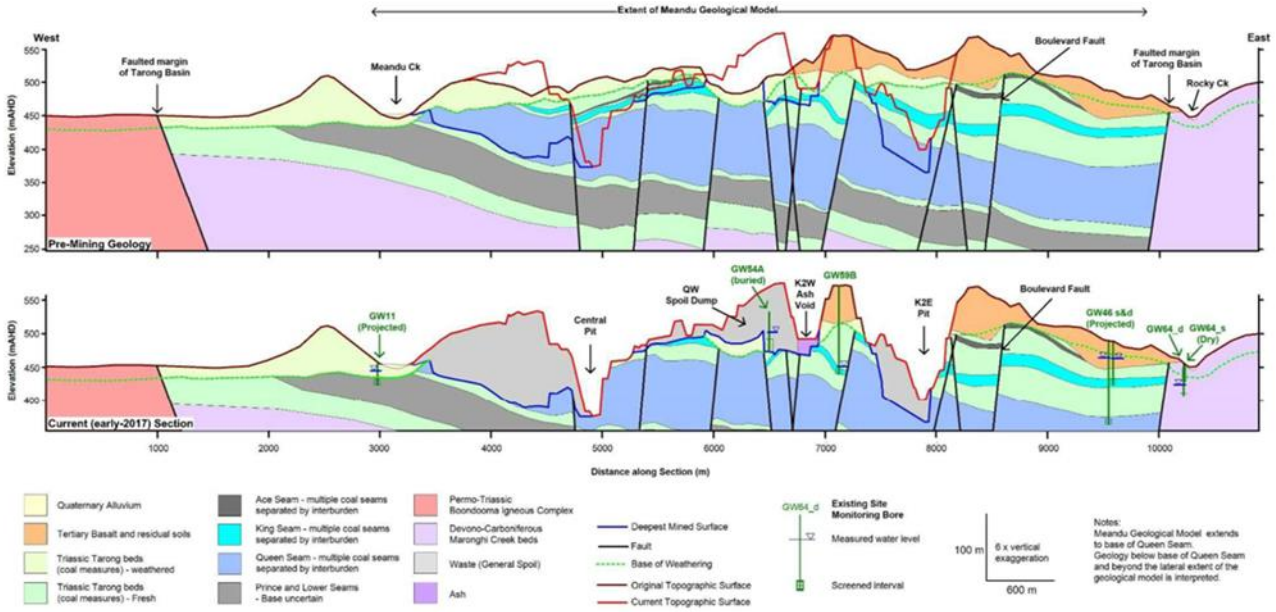


Figure 2.9 Surface and structural geology (source: JBT, 2021a)

Geological east-west (Figure 2.10) and north-south (Figure 2.11) cross sections show the relationship between features of the Tarong Basin, such as basin margins, the Tanduringie Fan and the impact of geological structures on the strata within the area of Meandu Mine.

These cross sections have been generated for the pre-mining geology (upper section) and the early 2017 as mined topography including excavation and dumps. Key summaries for each cross-section, with emphasis on geological controls impacting groundwater flow, are described in the following sub-section.

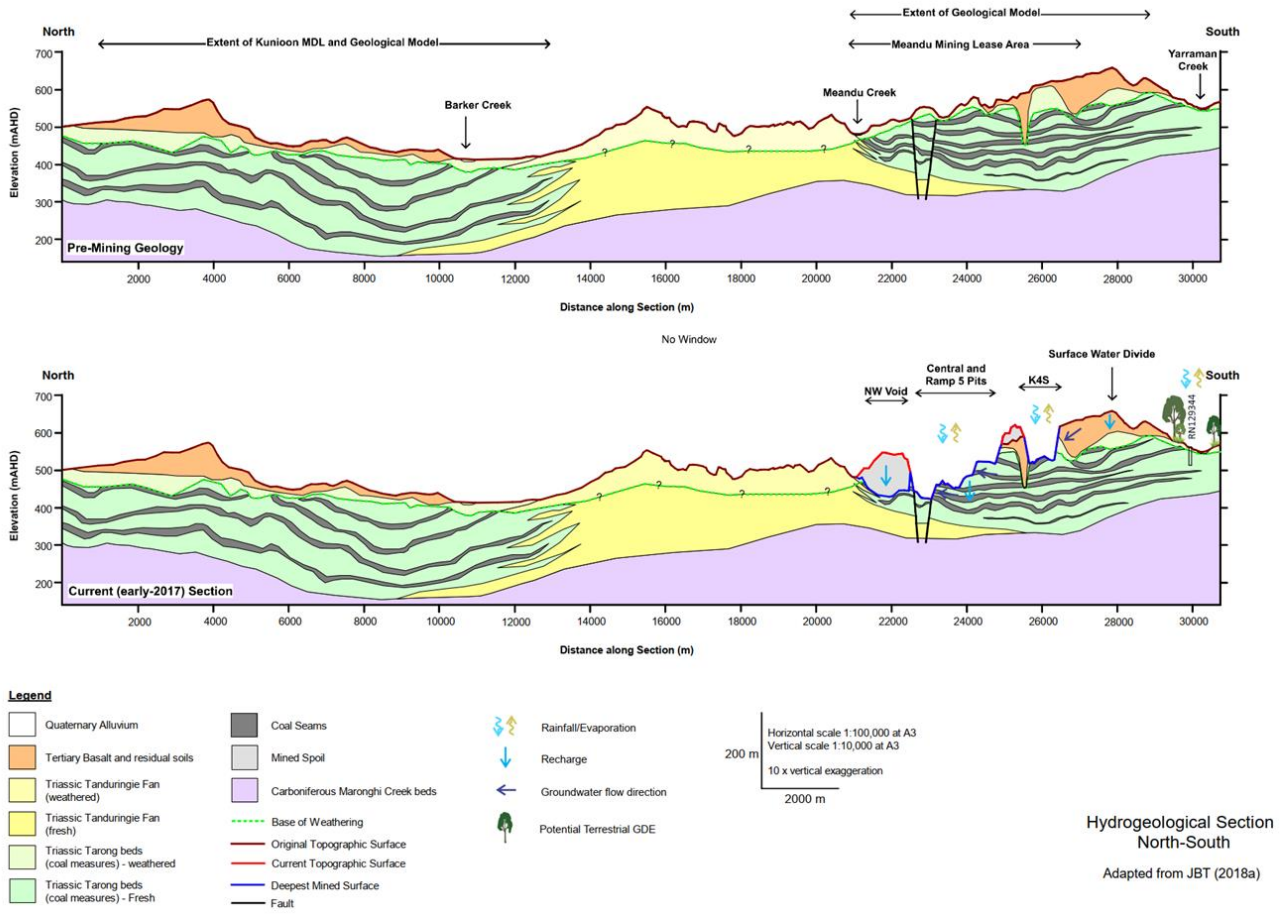


Source: Adapted from JBT (2021a) in SLR (2022a)

Figure 2.10 West-east hydrogeological section

The following summarises key observations from the west-east cross section (Figure 2.10). These are:

- A series of north north-west/south south-east trending faults significantly disrupt the lateral continuity of the coal measures in this section orientation. These faults have the potential to disrupt groundwater flow, particularly in cases where the throw of the fault is greater than the thickness of the coal seam – this results in the abrupt termination of a transmissive coal seam against lower permeability interburden.
- The apparent dip of the coal seams is towards the east (away from the central area of the Tanduringie Fan, as noted in Pegrem (1986)). However, the faulting has, in many cases, resulted in the western side of the fault dropping relative to the eastern side of the fault and resulted in localised folding, so that the dip direction of the coal seams is not constant.



Source: Adapted from JBT (2018) in SLR (2022a)

Figure 2.11 North-south hydrogeological section

The following summarises key observations from the north-south cross section (Figure 2.11). These are:

- Within ML6674, the Tarong beds extend to the south beneath Yarraman Creek. It is interpreted that recharge to the deeper coal seams (water bearing units of the Triassic Tarong beds) occurs primarily where the unit underlies the regolith and alluvium. It is conceptualised that the main area where recharge occurs to the coal seams is in particular where the Queen A and B plies subcrop beneath Yarraman Creek to the south of Meandu Mine outside of ML6674.
- The topography generally shows a trend of reducing elevation from south to north. The bedrock elevation also decreases from south to north (based on the base of coal measures modelled at both the Meandu Mine and Kunioon deposit). Pegrem (1986) noted that at a basin scale the coal seams dip at shallow angles towards the south and south-east, away from the central area of the alluvial fan (Tanduringie Fan). Nonetheless, due to local and regional-scale faulting and folding, the apparent dip of the coal measures within the area of the mining lease in this orientation is to the north (refer Figure 2.11).
- The Tanduringie Fan occurs as a non-coal bearing unit that separates the coal deposits at Meandu Mine from those at Kunioon. The southern margin of the Tanduringie Fan occurs to the south of the Meandu Creek Dam, which limits the potential for drawdown via the coal seams to the north of the Meandu Mine as the coal seams do not extend into the Tanduringie Fan.

2.1.5.3 Aquifer properties of hydrogeological units

The occurrence of groundwater at Meandu Mine has been assessed as limited to occurring in the Quaternary alluvium, the Tertiary basalt (in discreet and disjointed fractures), the Tertiary Regolith, and the coal measures of the Triassic Tarong beds.

The hydrogeological stratigraphy at Meandu Mine is summarised in Table 2.5.

Table 2.5 Hydrogeological units

Geological period	Geologic unit		Aquifer/aquitard
Quaternary	Alluvium		Aquifer (in coarser grained areas)
Tertiary	Basalt		Aquifer (fractured rock). Unconfined in upper units and semi-confined to confined in lower units where the interbedded sediments are confined by basalt flows (JBT, 2021b)
Tertiary	Regolith		Aquifer (variable saturation)
Triassic	Tarong Beds	Coal Measures	Aquifer (coal seams)
		Interburden	Aquitard
Permian-Triassic	Boondooma Igneous Complex		Aquitard (groundwater isolated to hydraulically disconnected fractures)
Devonian-Carboniferous	Maronghi Creek beds		Aquifer (where fractured, hydraulically isolated)

Source: SLR (2022a)

Further information on each of the hydrogeological units, from Table 2.5 is provided in the following sub-sections.

Quaternary alluvium

The Quaternary alluvium is primarily associated with surface drainage systems such as Meandu, Rocky and Yarraman creeks (Figure 2.9). Quaternary alluvium is comprised of clay, silt, sand and gravel. The thickness and extent of the alluvium is variable, with the average observed thickness near Meandu Creek generally being less than 5 m, although thicknesses up to 35 m have been observed from drilling along Barkers Creek (Pegrem, 1986). The Rocky Creek alluvium is relatively thin. Black Creek is located at the top of the drainage system and does not contain significant occurrences of alluvium to host groundwater (JBT, 2018).

Tertiary basalt

The Tertiary basalt is present as ridge-top deposits in the central-eastern area of the Meandu Mine (JBT, 2018). The unit is comprised of olivine basalt flows and some pyroclastics, interbedded with minor siltstone, shale, sandstone and silcrete. No information on the thickness of this unit is available, however site groundwater monitoring bores that are screened in the basalt are installed to depths of approximately 40 to 66 metres below ground level (mBGL). Groundwater typically occurs in fractures within the basalt and within the interbedded sediments. Due to the nature of the fractured rock aquifer, some areas are unsaturated and historically most groundwater bores at Meandu Mine have been dry. The aquifer is unconfined in upper units and semi-confined to confined in lower units where the interbedded sediments are confined by basalt flows (JBT, 2021b).

Tertiary regolith

The Tertiary Regolith occurs across the entire Meandu Mine area and is present below the alluvium, basalt, spoil and exposed at surface in some areas. The unit is primarily the upper 20 to 30 m of weathered Tarong beds. The unit is comprised of sandstone, siltstone, shale and conglomerate. Regionally, the regolith is generally unsaturated, although may become saturated in some areas following rainfall recharge. The aquifer is unconfined to semi-confined (JBT, 2021b). Within Meandu Mine, the regolith is mostly saturated where present below the spoil which act as a recharge area. It is conceptualised that prior to mining the unit was primarily dry with groundwater occurring only around creek beds which were the dominant recharge mechanism (JBT, 2018).

Tarong beds

In the area of the Meandu Mine site, the Tarong beds contain the Ace, King and Queen coal seams. These are the primary coal seams that are being mined. The coal seams are the dominant aquifers within the unit, with groundwater occurring primarily within fractures and cleats. The Ace seam is the top seam and is generally dry. The King seam occurs approximately 60 m below the Ace seam and contains groundwater in most areas. The Queen seam occurs approximately 30 to 40 m below the King seam and typically contains groundwater. The interburden between the coal seams has low permeability and can be classified as aquitards in comparison to the coal seams (JBT, 2021b). Due to the faulting, the coal seams are cut off by the less permeable interburden and form hydraulically isolated areas from each other. The aquifer types of the Tarong beds unit include fracture rock aquifer, unconfined in upper units and semi-confined to confined in lower flows.

Boondooma Igneous Complex (Aquitards)

The Permian-Triassic Boondooma Igneous Complex is present at the surface to the west of the Meandu Mine and defines the faulted western margin of the Tarong Basin. Publicly available information on the construction of registered groundwater bores shows that there are very few screened in this unit, suggesting it is not a significant regional groundwater source (JBT, 2021b). The unit is a fractured rock aquifer with groundwater occurrence typically limited to fractures (JBT, 2018) and semi-confined to confined in lower part of unit.

Maronghi Creek beds

The Devonian-Carboniferous Maronghi Creek beds occur to the east of the Meandu Mine and occur at the surface due to the faulted eastern margin of the Tarong Basin (JBT, 2018). Groundwater occurs in fractures that are typically discontinuous and hydraulically isolated; however, some fractured areas are dry. In areas where groundwater bearing fractures are more dominant, the aquifer has the potential to provide water supplies of low yield (JBT, 2018). There are a number of groundwater bores developed in this unit that are likely only used for stock watering (as suggested by the salinity of the unit) (JBT, 2021a). Apart from fractured rock, the unit also consists of unconfined in upper units and semi-confined to confined in lower part of unit.

Spoil

In addition to the above-described groundwater units, an anthropogenic groundwater-bearing unit at Meandu Mine of spoil has been created as a result of mining activities.

The spoil aquifer comprises both dragline and truck and shovel waste material that has been relocated from source to within mined-out voids or to out-of-pit storage dumps. The spoil progressively replaces the voids as mining progresses.

Truck and shovel spoil comprises successive track rolled layers (lifts) of reworked material (waste rock) from coal mining, as well as mixed plant reject cells. Dragline spoil comprises reworked material (waste rock) dug and relocated in loose dumped piles from source to within mined out voids. As a result, hydraulic conductivity can be highly variable both laterally and vertically within a mass of spoil, however, is generally higher than in unmined ground.

Groundwater within the unit generally occurs within the lower portion of the spoil pile as a result of infiltration from the surface of the spoil and deep drainage over time to the base of spoil. The aquifer is unconfined and there is no evidence of significant groundwater mounds or perched water tables (JBT, 2018).

2.1.5.4 Groundwater levels

Regional groundwater levels

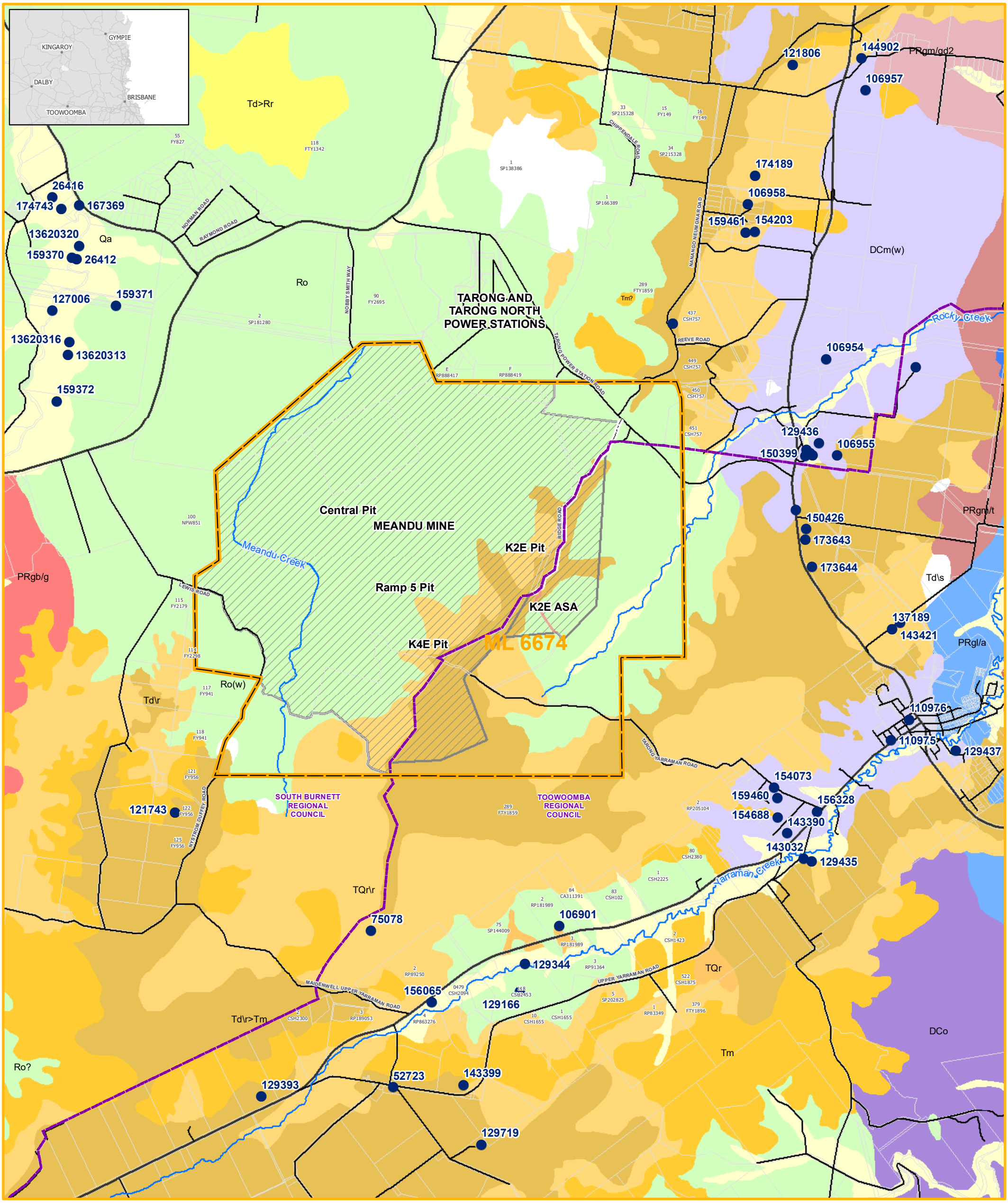
Available regional groundwater level data for private groundwater bores within the Tarong beds and Maronghi Creek beds, is summarised in Table 2.6; with bore locations shown in Figure 2.12. This data is sourced from either baseline bore surveys, ongoing groundwater monitoring or the Queensland Government Groundwater Database.

Table 2.6 Available water level data for regional landholder bores

Groundwater units	Number of records	Elevation range (mAHD)	Water level year record	Water level range (mAHD)
Maronghi Creek beds	17	425.0–555.5	1994, 2006–2010, 2012–2013, 2015, 2018	400.4–466.1
Tarong beds	2	489.3–506.4	2004, 2006	475.2–494.2
Tertiary Basalt	8	455.2–570.6	2003, 2006, 2007, 2008, 2009, 2013, 2014, 2016	438.0–562.6

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.12
Location of known private groundwater bores



Legend

- Private Groundwater Bores
- Watercourse
- Ridge Road
- Mining Lease (ML6674)
- Local Government Areas
- Ridge Road Closure
- Cadastre
- Approved Surface Rights Area
- Yarraman State Forest

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Groundwater monitoring network

A total of 121 monitoring bores have been installed at the Meandu Mine, with 60 of these in active use (with reference to the Meandu Mine site groundwater monitoring bore register). Bores are decommissioned and rehabilitated as areas are mined through or bores become of limited usefulness due to nearby mining activities and aquifer connectivity changes.

A summary of active monitoring bores and standing water level (SWL) in metres below ground level (mBGL) for each aquifer is provided in Table 2.7 with the location of these bores shown on Figure 2.13. The bores assessed as not impacted by mining (i.e. control and background bores) are highlighted in grey shading.

Table 2.7 Groundwater monitoring bore network (active bores) and standing water level (SWL)

Bore name	Coordinates AGD84		Top of casing mRL	Total depth mBGL	Screened interval mBGL		Screened geology	SWL May 2021 (mBGL)
	Easting	Northing			Upper	Lower		
GW05	391056	7035094	463.0	29.0	–	–	Queen Seam	7.0
GW09	390653	7034308	480.1	44.9	33.3	44.3	Sandstone below Queen Seam	36.1
GW22	387834	7032483	470.1	54.6	37.3	54.2	Coal Measures below Queen Seam	12.9
GW25	388980	7035226	431.4	13.9	5.3	13.9	Regolith	2.9
GW30	388747	7035093	433.5	9.9	5.5	9.5	Regolith	4.0
GW34	389484	7035322	442.3	42.0	35.0	42.0	Queen Seam	10.2
GW36	388740	7034925	441.5	30.0	17.0	30.0	Regolith	9.0
GW37	390580	7035904	432.0	36.0	29.0	36.0	Regolith	6.2
GW38	389370	7035573	426.7	24.0	17.0	24.0	Regolith	3.8
GW39*	389931	7036197	421.1	12.0	5.0	12.0	Meandu Creek alluvium	3.3
GW40	389797	7036057	421.7	12.0	5.0	12.0	Meandu Creek alluvium	3.6
GW41	390598	7035084	447.9	13.0	7.0	13.0	Interface between spoil/ underlying regolith	13.6
GW43_d*	391373	7030177	555.1	145.5	–	–	Queen Seam	80.8
GW43_s	391367	7030176	555.4	66.3	–	–	Basalt	55.8
GW44_d*	393995	7031154	514.8	146.0	–	–	Queen Seam	31.5
GW44_s*	393998	7031154	514.7	97.5	–	–	Queen Seam	30.8
GW45_d*	393709	7031395	500.0	149.5	–	–	Queen Seam	21.8
GW45_s*	393707	7031395	499.5	78.5	–	–	King Seam	22.2
GW46_d*	394328	7033544	484.6	124.5	–	–	Queen Seam	26.7
GW46_s*	394330	7033546	484.5	67.0	–	–	King Seam	25.6
GW48	389007	7034417	488.7	103.7	82.0	94.0	Spoil	55.4

Bore name	Coordinates AGD84		Top of casing mRL	Total depth mBGL	Screened interval mBGL		Screened geology	SWL May 2021 (mBGL)
	Easting	Northing			Upper	Lower		
GW49	389210	7034794	484.4	100.6	76.7	88.7	Spoil (Production/ Dewatering Bore)	51.2
GW56B_d	391947	7032150	587.3	145.0	140.5	145.0	–	127.2
GW58_d*	392595	7032686	570.1	170.0	149.0	161.0	King Seam	110.7
GW59B	391863	7033509	583.8	144.0	129.0	141.0	–	102.4
GW60	393207	7034409	540.4	109.0	97.0	109.0	Queen Seam	82.3
GW61_d	392708	7035417	467.0	53.5	41.5	53.5	Regolith	7.1
GW61_s	392708	7035407	467.0	18.2	12.2	18.2	Regolith	9.3
GW63_d*	393974	7032350	482.7	374.7	–	–	Queen Seam	22.8
GW64_d	394858	7033643	472.3	422.3	–	–	Maronghi Creek beds	19
GW65	394670	7034730	494.9	422.9	–	–	Maronghi Creek beds	30.1
GW68	390900	7034903	452.6	17.6	14.5	17.5	Regolith	4.2
GW69	390512	7035357	441.3	24.5	18.5	24.5	Regolith	6.0
GW70	392450	7035246	494.2	26.0	20.0	26.0	Interface between spoil/ underlying regolith	25.2
GW71	392559	7034977	509.4	35.0	29.0	35.0	Interface between spoil/ underlying regolith	31.3
GW72	391926	7035103	518.2	41.0	35.0	41.0	Interface between K2 tailings and regolith	35.3
GW73	392860	7035712	460.5	20.0	17.0	20.0	Regolith	7.0
GW74	392772	7036159	456.8	20.0	17.0	20.0	Regolith	8.2
GW75	389146	7035090	456.9	36.0	30.0	36.0	Spoil	23.2
GW80	391024	7034681	465.5	16.0	13.0	16.0	Regolith	10.0
GW81	390826	7034603	467.7	16.0	13.0	16.0	Regolith	9.9
GW82	390802	7034409	473.8	15.0	12.0	15.0	Regolith	12.1
GW84	390866	7034819	454.4	11.8	8.8	11.8	Coal	1
GW85_d	391114	7034387	491.3	36.1	33.1	36.1	Coal	22.8
GW86	389366	7035561	426.8	24.0	15.0	24.0	Replace GW01, Coal Measures below Queen Seam	3.3
GW87_d	388025	7034138	448.8	38.0	26.0	38.0	Replace GW11, Coal Measures – below Queen Seam	15.4

Bore name	Coordinates AGD84		Top of casing mRL	Total depth mBGL	Screened interval mBGL		Screened geology	SWL May 2021 (mBGL)
	Easting	Northing			Upper	Lower		
GW87_s	388022	7034131	448.8	20.0	17.0	20.0	Regolith	15.8
GW88_d	388365	7034749	439.0	30.0	24.0	30.0	Regolith and coal measures below Queen Seam	9.5
GW88_s	388368	7034753	438.9	12.0	9.0	12.0	Regolith and coal measures below Queen Seam	8.2
GW89_s	388469	7035142	432.7	12.0	9.0	12.0	Regolith claystone and Regolith sandstone respectively	5.3
GW89_d	388471	7035145	432.6	30.0	24.0	30.0	Regolith claystone and Regolith sandstone respectively	5.0
GW90	388623	7035270	432.2	29.7	23.7	29.7	Regolith siltstone	4.6
GW91	389001	7035506	437.5	24.0	18.0	24.0	Regolith	12.3
GW92	389272	7035677	432.7	24.0	18.0	24.0	Coal measures below Queen Seam	10.2
GW93	389620	7035921	427.0	35.0	29.0	35.0	Coal measures below Queen Seam	5.5
GW94	390711	7035231	446.5	25.0	14.0	25.0	Coal measures below Queen Seam	2.7
GW95	390452	7035353	439.7	36.0	30.0	36.0	Coal measures below Queen Seam	6.8
GW96	390572	7035683	450.2	51.0	45.0	51.0	Coal measures below Queen Seam	20.9
GW97	390055	7035922	439.7	36.0	30.0	36.0	Coal measures below Queen Seam	6.8
GW98	39088	7034507	n/a	90.5	78.5	90.5		Constructed June 2021

2.1.5.5 Current and potential future use of groundwater

Groundwater in the region is used for the purposes of irrigation, stock watering and domestic use (JBT, 2021 in SLR, 2022a). A search of the Queensland Government groundwater database identified 72 bores (refer Figure 2.12) within a 5 km radius of the Meandu Mine mining lease. Of these, the use of 1 bore is listed as stock, 43 as water supply and 28 are unknown. Future groundwater uses are anticipated to be similar to current uses.

It is noted that a number of the private bores are screened in the alluvium of Tanduringie Creek (a tributary of Barker Creek to the west of ML6674). These bores are within a surface-water sub catchment isolated from the Meandu Mine mining lease.

Groundwater within the Meandu mining lease surface area expresses into the current open cut voids, continuing as their depth increases and the extent of drawdown expands. Groundwater and rain water collected in the open cut voids is pumped into the mine water management system, and if/when of suitable quality released to Meandu Creek in accordance with conditions of the EA.

Current extraction of groundwater from the lower levels of spoil in the North-West Backfilled Void (NWBV) through use of up to three submersible pumps (refer to Section 6.1.7.4) will be discontinued prior to cessation of mining or earlier as contaminant target levels are achieved.

Post-mining, groundwater will continue to express into the final void water storages for utilisation to support PMLUs of Native Ecosystem and provide a source of water for Beef Cattle Grazing (see Section 6.3.5).

2.1.5.6 Recharge and discharge

Local recharge to the groundwater system primarily occurs from rainfall and seepage/infiltration between groundwater units. Natural recharge pathways (i.e., pre-mining and current) have been identified as:

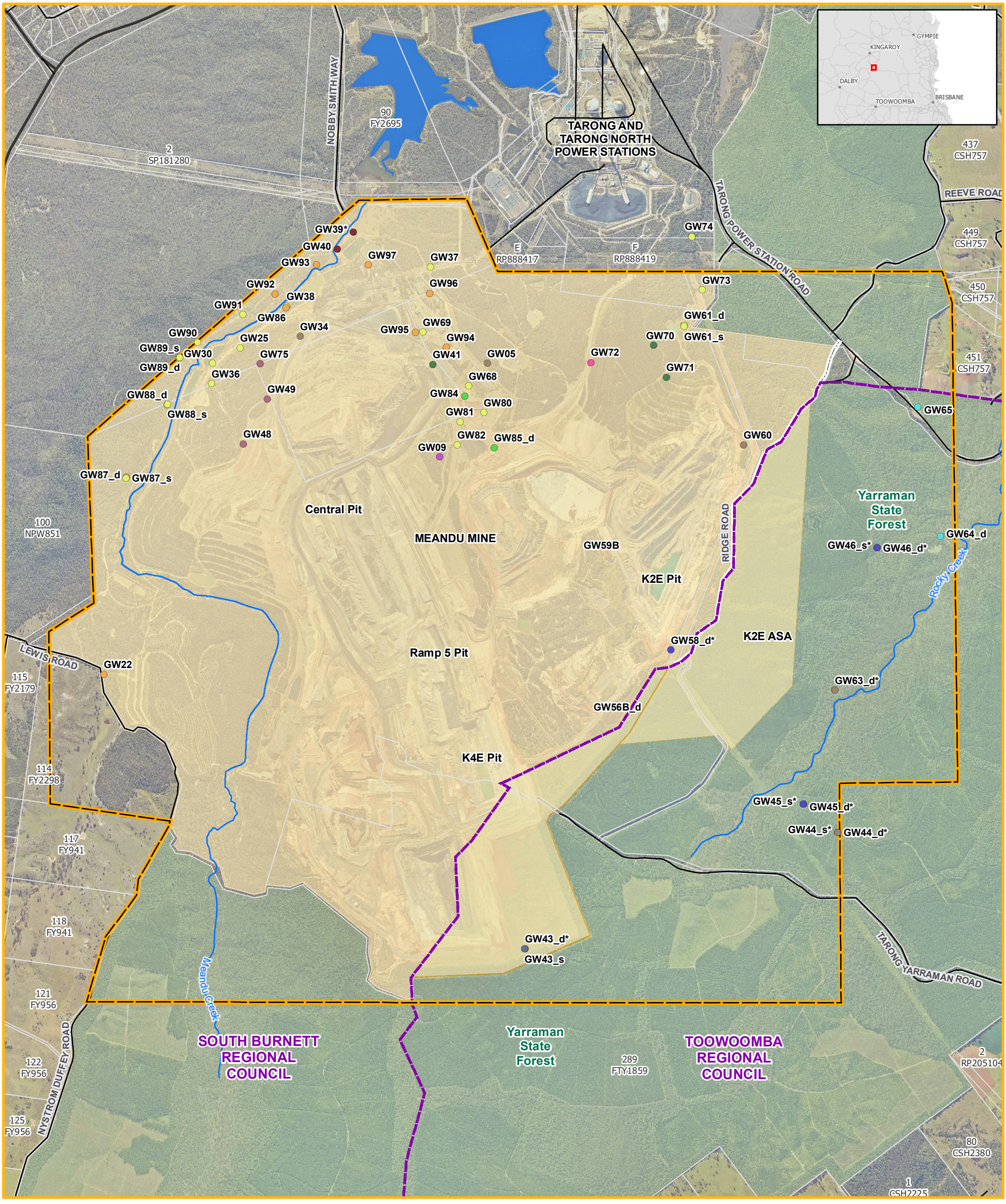
- Quaternary alluvium – Recharge occurs directly from rainfall and seepage from creek beds following rainfall event (i.e., when creeks are flowing).
- Tertiary regolith - Recharge occurs directly from rainfall. Recharge also occurs through the alluvium where present in creek beds (e.g., Meandu Creek and Black Creek drainage channel) or where the regolith is directly exposed (e.g., Rocky Creek). It is conceptualised that this was the predominant recharge mechanism before mining, with groundwater primarily occurring around the creek beds and the rest of the unit being dry.
- Tertiary basalt – Recharge is directly via rainfall, with recharge occurring more easily through fractures. The units that underlie the basalt will receive some component of recharge via downward seepage.
- Coal seams – Recharge to the water bearing units of the Triassic Tarong beds occurs primarily where the unit underlies the regolith and alluvium. It is conceptualised that the main area where recharge occurs to the coal seams is where the Queen A and B plies; in particular, the subcrop beneath Yarraman Creek to the south of Meandu Mine outside of ML6674.

Locally, natural discharge to the groundwater system (i.e., pre-mining and current) occurs through:

- Evapotranspiration – mostly along drainage lines where groundwater levels are shallow (i.e., <5 m).
- Baseflow – Some creeks may receive some degree of baseflow from the alluvium. For example, ponded water which occurs in some of the Rocky Creek waterholes (e.g., downstream of Meandu Mine) may receive some discharge from groundwater for at least some of the year.

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.13
Meandu Mine groundwater monitoring bore network



Legend

- Ridge Road
- Mining Lease (ML6674)
- Local Government Areas
- Cadastre
- Approved Surface Rights Area
- Yarraman State Forest

Groundwater Monitoring Bores

Screened geology

- Basalt
- Coal
- Coal measures below Queen Seam
- Interface between K2 tailings and regolith
- Interface between spoil/ underlying regolith
- King Seam
- Maronghi Creek beds
- Meandu Creek alluvium
- Queen Seam
- Regolith
- Sandstone below Queen Seam
- Spoil

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Anthropogenic influences have modified the natural groundwater recharge and discharge processes as follows:

- Recharge:
  - Recharge to the Quaternary alluvium downstream of Meandu Creek Dam (outside of ML6674) would occur as a result of water releases from Meandu Creek Dam.
  - Spoil material at Meandu Mine is recharged directly from rainfall. The reworked spoil material is permeable and porous relative to in-situ material/s. Modelling of deep drainage (i.e., recharge) through spoil conducted by Landloch (2021a) indicates that spoil recharge occurs primarily after heavy rainfall (i.e., greater than average rainfall); with recharge rates estimated from 0.3 to 5% of rainfall depending on the level/type of vegetation and soil compaction.
  - Recharge to the Tertiary regolith occurs through the spoil where present. The Tertiary regolith plays an important role in seepage transport where topography is the main driver for movement and shallow seepage is preferentially transported within the shallow regolith.
  - Tailings and other less permeable mine rejects may form hydraulic barriers and reduce recharge and seepage. Areas that are capped (i.e., low permeability capping) also significantly reduce potential recharge to underlying units.
- Discharge:
  - Groundwater extraction from landholder bores. The closest bores from the mining lease are RN 189817 and Hilltop bore (approximately 800 m from ML6674). However, these bores are upgradient from the mine groundwater flow. It is noted that no private bores downgradient of Meandu Mine have been identified within 3 km from ML6674.
  - Minor rates of (combined) pit seepage that are generally less than 5 L/s that are directed via surface drains to pit sumps and removed from the pits with surface water runoff and handled through the Meandu Mine site water management system.
  - Groundwater extraction via dewatering in the NWBV area. Current extraction rates are approximately ~7 L/s for the combined bores GW48 and GW49. A third dewatering bore (i.e., GW98) was commissioned and tested in September 2021 but has been put into stand-by mode until all dewatering data can be analysed to determine if it is required. Based on pump curve data, each of the groundwater extraction bores have the capacity to dewater at a rate of ~3.0 to 3.5 L/s.

2.1.5.7 Groundwater quality (baseline)

During the Hollingsworth (1979) (pre-mining) survey, groundwater analysed from existing boreholes had a pH range of 3.5–6.8. Local knowledge indicated that the salt content of the water had increased over recent years. Estimates of total dissolved solid concentrations undertaken at the time gave values ranging from 450 to 5,260 ppm. Concentrations of some heavy metals in some water samples exceeded levels recommended for irrigation, livestock and domestic supplies. Suspended solids ranged from 0 to 27 mg/L and consisted mainly of slowly settling iron-stained particles, possible of organic origin. Overall, the water quality was adequate to meet requirements for supply for stock watering purposes.

A summary of statistical baseline data, obtained from bores assessed as not impacted by mining (refer to Section 2.1.5.4 – Regional groundwater levels) for pH, electrical conductivity (EC) and major ions, is shown in Table 2.8. However, overall, the data shows neutral (coal measures) to slightly acidic pH (alluvium) (median pH of 6.16) and slightly (coal measures) to mildly brackish (alluvium) (median EC of 2,473 µS/cm) waters. Sulfate concentration is below 100 mg/L in the coal measures and below 200 mg/L in the alluvium. It is noted that the baseline data is based on a limited number of locations (especially for the alluvium and coal measures below Queen Seam) and cannot be interpreted as being wholly representative of the pre-mining water quality in all water bearing zones of the same geological unit, but it may be regarded as being indicative of the general pre-mining water quality.

Table 2.8 Summary of statistics of groundwater baseline data for pH, EC and major ions

Sites	Statistic	pH field	EC field (µS/cm)	SO_4^{2+} (mg/L)	Cl^- (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^+ (mg/L)	K^- (mg/L)	F^- (mg/L)
Alluvium (GW39)	Total Number	17	17	38	38	38	2	38	38	25
	Min	6.0	2320	134	0.5	27	33	391	0.5	0.2
	Median	6.2	2473	188.5	667	32	39.5	433.5	8	0.2
	Max	7.3	2710	214	775	46	46	534	11	0.3
Queen Seam (GW43D, GW44D, GW44S, GW45D, GW46D, GW63D)	Total Number	97	98	149	149	149	8	149	149	149
	Min	5.7	713	0.5	165	8	11	98	5	0.05
	Median	7.2	2112	69	508	62	24.5	317	16	0.05
	Max	8.0	13360	740	4670	785	516	1580	81	0.4
King Seam (GW45S, GW46S, GW58D)	Total Number	73	64	97	97	97	5	97	97	97
	Min	5.7	956	30	254	5	26	129	4	0.05
	Median	6.4	1712	52	421	35	32	261	18	0.1
	Max	7.0	5750	376	1950	321	153	608	56	1.6
Coal Measures Below Queen Seam (GW11)	Total Number	36	36	21	21	21	1	21	21	19
	Min	6.0	1763	31	337	20	23	206	11	0.05
	Median	6.7	1841.5	34	488	88	23	248	20	0.1
	Max	7.1	3260	291	919	98	23	449	31	0.1

A statistical summary of (baseline) data for dissolved metals/metalloids is shown in Table 2.9. Baseline data is defined here as non-impacted by mining (refer to Section 2.1.5.4 – Regional groundwater levels). Therefore, the bores assessed as not impacted by mining (control and background bores) have been selected as being representative of baseline data.

Overall, the data shows that the median dissolved metal/metalloid concentrations are generally below the laboratory limits of reporting (LOR) in the coal measures and alluvium. Exceptions are barium, manganese, boron and iron. It is noted that the baseline data is based on a limited number of locations (especially for the alluvium and coal measures below Queen Seam) and cannot be interpreted as representative of the pre-mining water quality in all water bearing zones of the same geological unit, but may be regarded as being, indicative.

Table 2.9 Summary statistics of baseline data for dissolved metals

Sites	Alluvium (GW39)		King Seam (GW45S, GW46S, GW58D)		Queen Seam (GW43D, GW44D, GW44S, GW45D, GW46D, GW63D)		Coal measures below Queen Seam (GW87d)	
Statistic	Median	Max	Median	Max	Median	Max	Median	Max
Al (mg/L)	<LOR	0.03	<LOR	0.04	<LOR	10	0.02	2.17
Sb (mg/L)	<LOR	0.001	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
As (mg/L)	<LOR	0.001	<LOR	0.002	<LOR	0.004	<LOR	<LOR
Be (mg/L)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Ba (mg/L)	0.063	0.2	0.137	0.673	0.1325	1.4	0.182	0.228
Cd (mg/L)	<LOR	<LOR	<LOR	0.0001	<LOR	0.0003	<LOR	0.0027
Cr (mg/L)	<LOR	<LOR	<LOR	0.005	<LOR	0.002	<LOR	0.0010
Co (mg/L)	0.002	0.003	<LOR	0.012	<LOR	0.008	<LOR	0.0450
Cu (mg/L)	<LOR	0.012	<LOR	0.003	<LOR	0.074	0.004	0.349
Pb (mg/L)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Mn (mg/L)	0.268	0.381	0.1445	0.649	0.09	1.32	0.9630	5.8500
Mo (mg/L)	<LOR	0.002	<LOR	0.006	<LOR	0.004	<LOR	<LOR
Ni (mg/L)	0.003	0.012	0.001	0.034	<LOR	0.01	0.006	0.048
Se (mg/L)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Ag (mg/L)	<LOR	<LOR	<LOR	0.001	<LOR	<LOR	<LOR	<LOR
Tl (mg/L)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
U (mg/L)	<LOR	<LOR	<LOR	<LOR	<LOR	0.002	<LOR	<LOR
V (mg/L)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Zn (mg/L)	0.045	0.128	0.0095	0.132	<LOR	0.194	0.088	0.635
B (mg/L)	0.06	0.11	0.14	0.34	0.06	0.15	0.12	0.13
Fe (mg/L)	0.22	1	6.455	33.1	0.885	6.84	26.3	30.3
Hg (mg/L)	<LOR	0.0001	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR

2.1.6 Soil types, properties and productivity

2.1.6.1 Pre-mining soil mapping for the Meandu Mine and surrounding areas

Prior to mining, soils varied in depth, texture and profile in accordance with topography. As a general rule soils became shallower and exhibited less pedological development with increasing degree of slope (Hollingsworth, 1979).

Soils on steep slopes formed on the finer sediments of the Tarong beds were mostly shallow, medium to coarse textured, sandy and silty gravelly soils with rock outcrop occurring locally. Medium to fine textured sandy and silty clay soils occurred on gentle slopes or level areas. In all areas except alluvial surfaces, soil horizons having pedological development were mainly very thin and overlie weathered rock materials of the Tarong beds at shallow depth (Hollingsworth, 1979).

Soils developed on the coal measure conglomerates in areas of higher relief were generally medium to coarse textured grey or light brown sandy gravel or gravelly clay soils on footslopes, drainage floors and flatter areas. Rock outcrop with associated skeletal soils may have occurred on crests, steep slopes or locally elevated areas. On flat or gently concave inclined valley surfaces of low internal relief, soils were mostly transported medium to fine textured grey-brown sandy and gravelly clay soils. However, in some areas of low relief very shallow medium to coarse textured grey or light brown silty or clayey gravelly soils occurred particularly where depth to bedrock is shallow. These soils are of low fertility being deficient in nitrogen and phosphorous (Hollingsworth, 1979).

Soils derived from the tertiary basalt were primarily red earths. They were acid, friable, moderately fertile, relatively deep soils and on the slopes little differentiation into horizons is evident. On the hilltops, a less fertile, light textured, red soil overlies a moderately acidic and more fertile shallow B horizon (Hollingsworth, 1979).

Areas of Quaternary-Recent Alluvium although containing a variety of transported soils consisted predominantly of deep, medium to fine textured brown or dark grey sandy and silty clay soils. These soils of alluvial origin were deep and fertile although of limited extent (Hollingsworth, 1979).

Earth resources in the area of ML6674 were restricted to deposits of sand and gravel in Meandu Creek. No minerals or earth resources apart from coal are known to occur in the area (Hollingsworth, 1979).

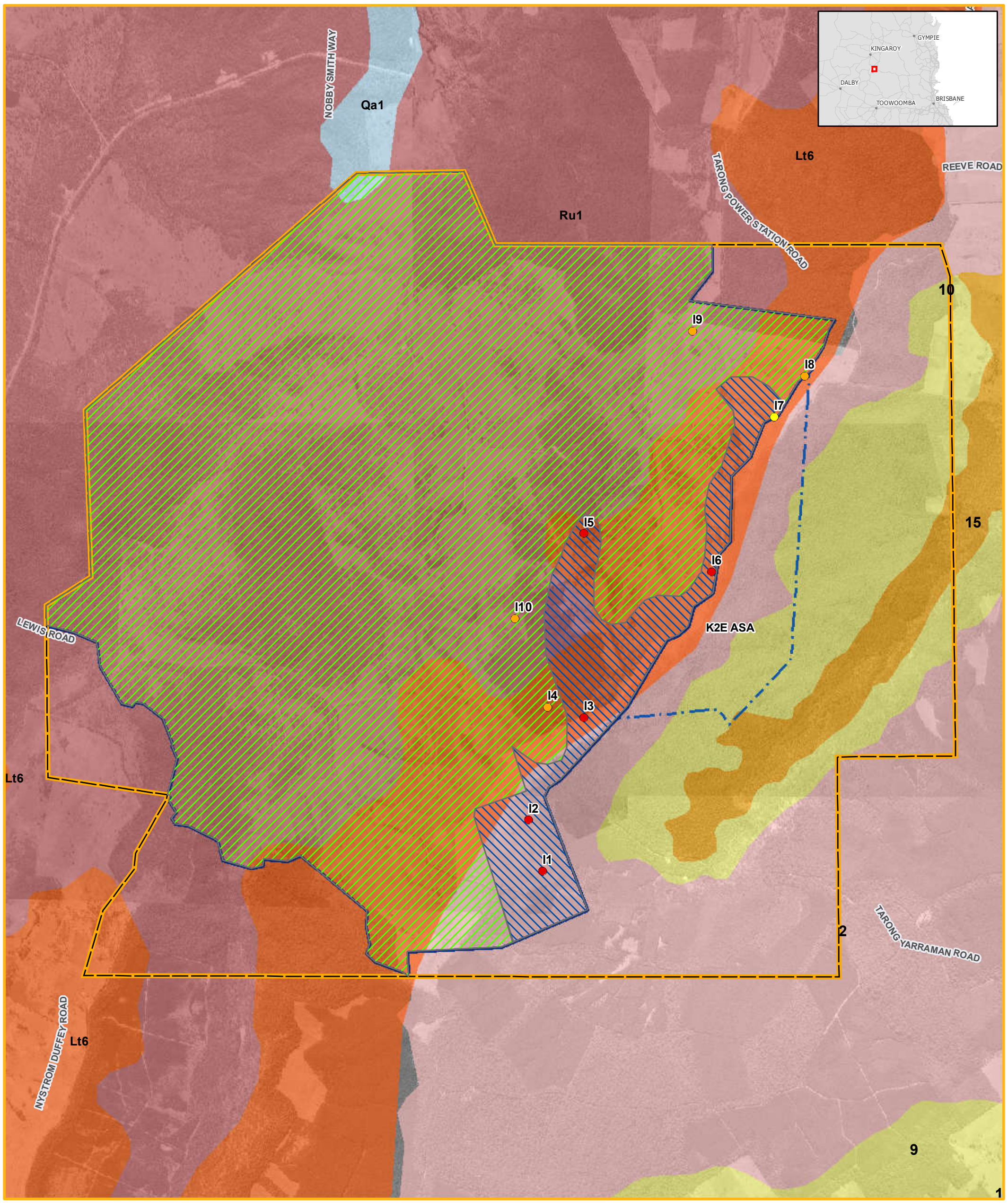
Figure 2.14 illustrates the land systems mapping released by the Queensland Department of Primary Industries for the South Burnett region in 1983 (Vandersee and Kent, 1982) and for Cooyar Shire in 1977 (Vandersee, 1977). This mapping reflects the pre-mining soil conditions of Meandu Mine area. A description of these land system units and the soils located in the corresponding system is provided in Table 2.10.

Table 2.10 Meandu Mine associated soil units and description – pre-mining condition

Land system unit	Soil description
Alluvials (Qa1)	Flat to slightly undulating plains of recent alluvia with associated terraces and swales of rivers and creeks; deep, dark cracking clays (black earths and alluvial soils), minor areas of texture contrast soils with brown or yellowish-brown clay subsoils clay subsoils (solodic and solodized solonetz).
Sandstone, siltstones, shales and conglomerates (Ru1)	Undulating to steep hilly terrain on sandstones of the Tarong beds; shallow sandy, stony lithosols with some rock outcrops with areas of texture contrast soils with yellow clay subsoils, often motted (soldics and solodized solonetz).
Laterite (Lt6)	Steep hilly terrain and scarps on lateritised Main Range Volcanics; shallow, loamy lithosols with variable amounts of laterite to shallow, uniform and gradational, red loams and clay loams (Krasnozems and euchrozems).
Upper Yarraman (UY)	Predominantly moderately deep to deep, red, structured earths with minor areas of yellow earths.
Rocky Creek (RC)	Complex area with shallow, stony, lithosols, texture-contrast soils with bright reddish-brown and yellowish-brown clay subsoils and areas of red and brown clays.
Palms (PL)	Vary from shallow, stony, brown-black lithosols to moderately deep, brown or yellowish-brown clays or texture-contrast soils with yellowish-brown clay subsoils.

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.14
Pre-mining land systems of Meandu Mine and surrounds



Legend

Insitu Soils - Probable Origin
- Sedimentary
- Volcanic
- Volcanic/Disturbed
- Mining Lease (ML6674)
- Approved Surface Rights Area
- K2E ASA

Soil Parent Material
- Sedimetary
- Volcanic

Land Systems Cooyar Grazing Lands Study ACR
- 1 - Kooralgin
- 10 - Palms
- 15 - Rocky Creek
- 2 - Upper Yarraman
- 9 - Tarong

Land systems - land resources of the Burnett region part 1 - South Burnett - ABS
- Lt6 - Land systems on laterite, Type 6
- Qa1 - Land systems on alluvials, Type 1
- Ru1 - Land systems on sandstone, siltstones, shales and conglomerates, Type 8

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2.1.6.2 Recent pre-mining soil survey of K2E ASA

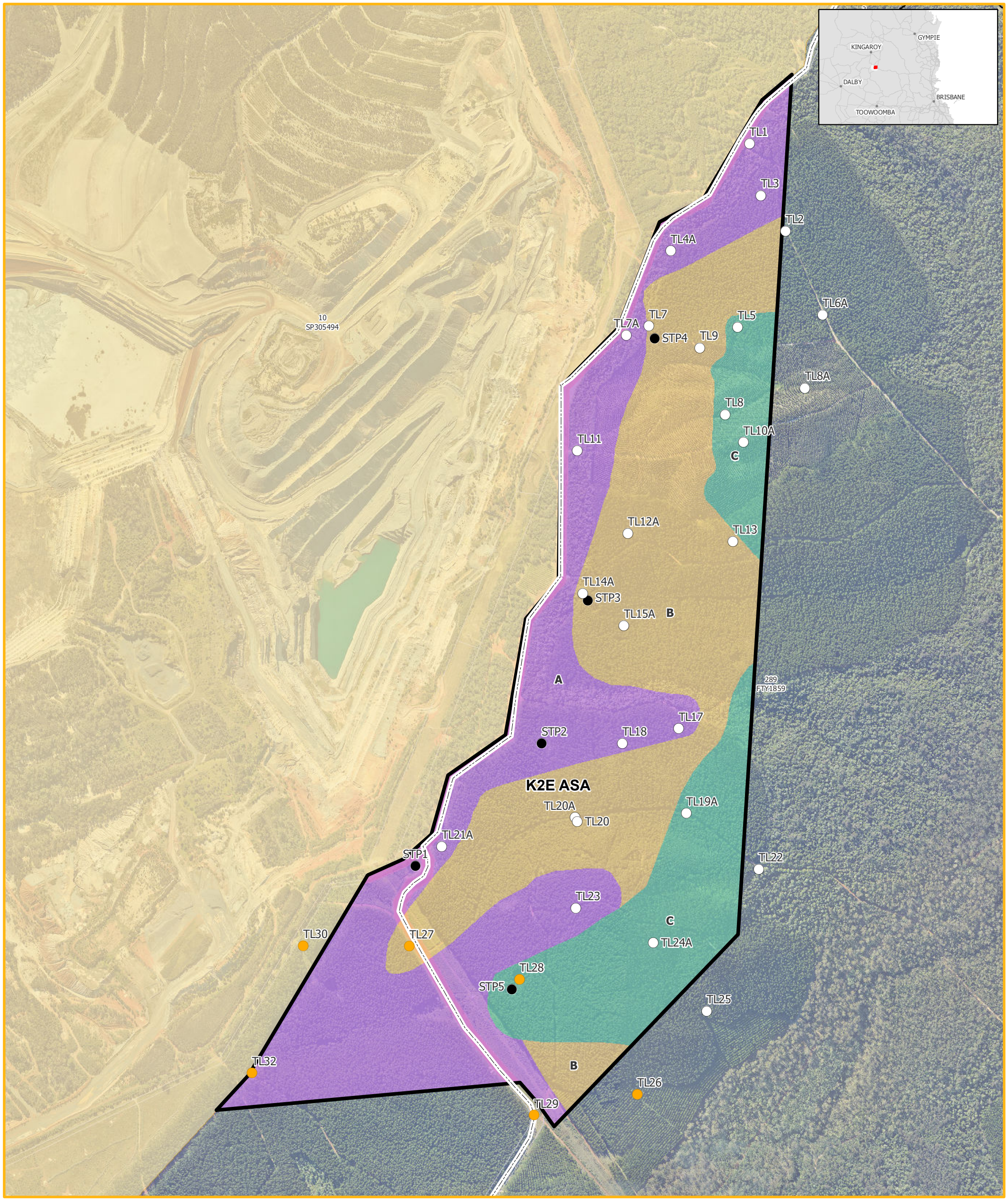
A pre-mining soils assessment of the K2E ASA was undertaken more recently to inform mine planning for the proposed extension of the K2E pit (Jamstone, 2020 in WSP, 2021a). Soil types encountered within the K2E ASA during the soil tests are described in Table 2.11. The spatial distribution of the identified soil types across the K2E ASA is illustrated in Figure 2.15, based on the subsurface conditions encountered in the boreholes and the laboratory data, together with geological and topographic data.

Table 2.11 Soil types within the K2E ASA (Jamstone, 2020 in WSP, 2021a)

Soil type	Description
Soil A – Red Ferrosol	Basalt soils or shallow variant was encountered in the upper-most, western part of the K2E ASA, underlain by weathered and lateritised basaltic rocks. This soil type appears to have acidic A and B horizons with varying nutrient levels and low potential for dispersive behaviour. It typically occurs above RL 550 m.
Soil B – Red Ferrosol	A deeper variant of the Red Ferrosol and was encountered in the upper to lower mid slopes within the K2E ASA. This soil type appears to have acidic A and B horizons with varying nutrient levels and low potential for dispersive behaviour.
Soil C – Grey Dermosol	Encountered on the lower slopes of the K2E ASA, below approximately 520 m in the area underlain by the sedimentary rocks of the Tarong beds. Both acidic and alkali soils were encountered within this soil group and a potential for dispersive behaviour was also indicated.

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.15
Meandu Mine soil types – K2E ASA



Legend

- Ridge Road
- Cadastre
- K2E ASA
- Mining Lease (ML6674)
- Approved Surface Rights Area
- Yarraman State Forest

Soil Sampling Locations

- Sample Site Feb 2018
- Sample Site Nov 2016
- Sample Site Sept 2019

Soil Type

- A - RB; Red Ferrosal-Basalt
- B - R; Red Ferrosal
- C - G; Grey Dermosal

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In-situ soil mapping units

A soil survey was undertaken by Landloch in September 2021 (Landloch, 2021d), investigating materials sampled from 10 in-situ sites at the Meandu Mine site towards the south-eastern boundary of the existing surface rights area adjoining K2E ASA (refer Figure 2.14). The in-situ sites selected were considered to represent the natural soil present on Meandu Mine and have had minimal disturbance from mining activities. Sampling was undertaken in areas previously disturbed by geotechnical and other drilling. Some in-situ sampling occurred in areas that Meandu Mine had not yet cleared for activities but will expand to in future.

The two in-situ soil mapping units identified on site are a Red Ferrosol, derived from volcanic parent material, and a brown complex of Kurosols, Chromosols and Sodosols derived from sedimentary parent material:

- Volcanic derived soils: the Red Ferrosols which were found on the eastern side of Meandu Mine. This soil unit is defined by its moderate to strong structure, polyhedral peds and bright red colours throughout the profile. Table 2.12 summarises the key soil characteristics. For mapping purposes, soils that are basalt derived have been mapped as volcanic soils (Figure 2.14).
- Sedimentary derived soils were found on slopes of the basalt plateaus. These soils are a mix of Kurosols, Chromosols and Sodosols, and all are brown. Table 2.12 summarises the key soil characteristics of the sedimentary derived soils.

The pre-mining survey results from Jamstone (2020 in WSP, 2021a) for the K2E ASA are relatively consistent with the in-situ soil survey results from Landloch (2021d). Geographically, Grey Dermosol is the sedimentary derived soil located within the eastern side of the K2E ASA and a mix of Kurosols, Chromosols and Sodosols are the dominant sedimentary derived soils across the rest of the Meandu Mine site.

Table 2.12 In-situ soil profile characteristics

Feature	Volcanic derived (Red Ferrosol) soil	Sedimentary derived soil
Brief description	Uniformly textured soil with bright, even reddish tones throughout	Texture contrast and gradationally textured soils with even brown tones throughout
Landform	Undulating plateaus	Side slopes of basal plateaus
Geology	Basalt	Sedimentary
Australian Soils Classification	Red Ferrosol	Brown Kurosols, Brown Chromosols, Brown Sodosols
Structure	Moderate to strong throughout profile, polyhedral peds	Massive to moderate
Surface texture (0–10 cm)	Clay loam to light clay	Sandy clay loam to clay loam
Subsoil texture (>10 cm)	Light clay to medium clay	Sandy clay loam to medium clay
Observations	Site I1, I2, I3, I5, I6, I7 shown in Figure 2.14	Site I4, I8, I9, I10 shown in Figure 2.14

2.1.7 Land suitability and stability (pre-existing land)

2.1.7.1 Land suitability

A desktop assessment was undertaken to identify the pre-mining land capability class of the Meandu Mine site based on the available land system mapping from Cooyar Grazing Lands Study (Vandersee, 1977) and Land Resources of the Burnett Region (Vandersee and Kent, 1982).

Table 2.13 provides a summary of the pre-mining land capability classification for the Meandu Mine based on GIS calculations. The land capability classifications used were based on Rosser et al. (1974). The pre-mining land at the Meandu Mine comprised mainly land suitable for grazing of native and improved pasture (Class VI) which represents approximately 69% of the total surface rights area (existing plus K2E ASA). This is followed by Class VI-VII, which is suitable for grazing of native and minor areas of improved pastures and represents 629 ha (22% of the total surface rights area). Only a small percent of land suitable for cropping (Class II-III) (approximately 9% of the total surface rights area) was present, all of which is within the K2E ASA.

Table 2.13 Meandu Mine pre-mining land capability class calculations

Land capability class	Surface Rights Area (including the K2E ASA) (ha)	Land use limitations and land capability sub-class	Production suitability and management needs
	Total		
I (water)	0	–	–
II – III	250 (9%)	Slight to moderate water erosion limitation (e2-3). Minor areas of slight gilgai microrelief (g2). Slight workability restrictions (k2).	Suitable for summer and winter cropping of grain and forage crops with some bean and oil seed crops. Annual fertilizer applications as determined by soil analysis are desirable for continuous cropping. Requires soil conservation practices when cultivated. Suitable for grazing of native and improved pastures.
VI	1,947 (69%)	Moderate to severe moisture, effective soil depth, and water erosion limitations (m_{4-6}, d_4, e_{4-6}) and minor topography limitation (t_{4-6}). Small areas of moderate rockiness and stoniness limitation (r_{4-5}). Occasional small outbreaks of moderate to severe soil salinity (s_{4-7}).	Suitable for grazing of native and improved pasture. Some areas have excessive slope gradients, rock outcrops and/or highly erodible soils.

Land capability class	Surface Rights Area (including the K2E ASA) (ha)	Land use limitations and land capability sub-class	Production suitability and management needs
	Total		
VI – VII	629 (22%)	Moderate to severe moisture, effective soil depth, water erosion, topography, rockiness and stoniness limitations (m6, d4-6, e6-7, t4-6, r4-5).	Suitable for grazing of native and minor areas of improved pastures. Clearing should be restricted, and overgrazing avoided for catchment protection, particularly on erosion susceptible soils. Minor areas are suitable for tree crops (medicinal and horticultural). Erosion susceptible soils and steeper slope gradient are more suited to both native and/or planted forests.
Total	2,826		

2.1.7.2 Land erodibility and stability

Land erodibility and stability at Meandu Mine is interpreted based on the available study report and associated land system mapping from the South Burnett Region (Vandersee and Kent, 1982) for most of the mine and Cooyar Grazing Lands Study (Vandersee, 1977) for the eastern side of Meandu Mine which comprises mainly the K2E ASA.

For the South Burnett region, the entire area has been mapped into sixty-five mapping units on the basis of topography, vegetation soils and geology. Three of these mapping units were present at Meandu Mine and the surrounds namely:

- laterite (Lt6)
- alluvials (Qa1); and
- sandstone, siltstones, shale and conglomerates (Ru1).

Various types of land degradation occurred to varying degrees throughout the area before the mining operations. The most common forms of degradation are erosion, salinity, tree and shrub regrowth and pasture degradation while landslips are also of concern. The majority of the mining activities are located on the sandstone, siltstones, shale and conglomerates (Ru1) mapping unit, where the landform is characterised by undulating to steep hilly terrain with frequent rock outcrops and scarps and the soils associated with this area are yellow clay subsoils, often mottled. These materials can be sodic and dispersive which means high potential of erosion and instability can be expected if not appropriately managed.

The red soils of laterite mapping unit (Lt6) which present to the eastern side of the Meandu Mine site are prone to sheet erosion even though they consist largely of highly permeable, well-structured krasnozems. Gully erosion is associated with badly maintained waterways or poorly situated access tracks in this land system.

Landslips recorded were associated with the Tertiary volcanic or lateritic mapping units (e.g., also Lt6 on the eastern side of the Meandu Mine) and all recorded landslips were associated with slopes of greater than 20% which have been completely cleared of trees and shrubs. Areas of weakness develop during very wet periods resulting in landslips developing.

2.1.8 Vegetation communities and ecological data

2.1.8.1 Pre-mining vegetation

Prior to mining, vegetation within ML6674 consisted of a mix of native vegetation, forestry plantation and areas of pasture/cropping. The native vegetation comprised predominantly Eucalypt forest and semi-evergreen vine thicket communities.

The pre-clearing regional ecosystems (REs) outlined in Table 2.14 and shown on Figure 2.16 are mapped as having occurred within ML6674 (Department of Resources, 2021). The pre-clearing regional ecosystems shown represent the distribution before the development of the forestry plantation, cropping and other farming practices (prior to mining).

Table 2.14 Pre-clearing regional ecosystems within ML6674 (Department of Resources, 2021)

RE code	RE description	Biodiversity status	Broad vegetation group (BVG)
BVG: Eucalypt open forests to woodlands on floodplains (16-16d):			
RE 12.3.3./12.3.7	RE:12.3.3 – *Eucalyptus tereticornis* woodland on Quaternary alluvium.	Endangered	16c
	RE: 12.3.7 – *Eucalyptus tereticornis*, *Casuarina cunninghamiana* subsp. *cunninghamiana* +/- *Melaleuca* spp. fringing woodland.	Of Concern	16c
BVG: Eucalyptus woodlands to open forests (mainly eastern Queensland) (9-15):			
RE 12.9-10.18/ 12.9-10.21	RE: 12.9-10.18 – *Angophora leiocarpa*, *Eucalyptus crebra* woodland on sedimentary rocks.	Of Concern	9h
	RE: 12.9-10.21 – *Eucalyptus acmenoides* or *E. portuensis* woodland usually with *Corymbia trachyphloia* subsp. *trachyphloia* on Cainozoic to Proterozoic sediments.	No Concern at Present	9h
RE12.9-10.7	*Eucalyptus crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, *Angophora* spp. and *E. melanophloia* woodland on sedimentary rocks.	Of Concern	13c
RE12.5.1a	*Eucalyptus decorticans* open forest +/- *Corymbia citriodora* subsp. *variegata*, *C. trachyphloia* and *Acacia blakei*. Occurs on remnant Tertiary surfaces often around margins of plateaus.	No Concern at Present	12a

RE code	RE description	Biodiversity status	Broad vegetation group (BVG)
RE12.8.13	Araucarian complex microphyll vine forest on Cainozoic igneous rocks.	Of Concern	5a
RE 12.9-10.3	*Eucalyptus moluccana* open forest on sedimentary rocks.	Of Concern	13d
BVG: Rainforests and shrubs (1-7b):			
RE12.5.13a/12.5.1	RE12.5.13a – Microphyll to notophyll vine forest +/- *Araucaria cunninghamii*. Characteristic species include *Araucaria cunninghamii*, *Cupaniopsis parvifolia*, *Dendrocnide photiniphylla*, *Rhodosphaera rhodanthema*, *Flindersia australis*, *F. schottiana*, *F. xanthoxyla*, *Drypetes deplanchei*, *Olea paniculata*, *Diospyros geminata*, *Gossia bidwillii*, *Excoecaria dallachyana* and *Vitex lignum-vitae*. *Argyrodendron trifoliolatum* sometimes present especially in subregion 6. Occurs on remnant Tertiary surfaces especially lateritised basalt.	Endangered	5a
	RE12.5.1 – Open forest complex with *Corymbia citriodora* subsp. *variegata* on subcoastal remnant Tertiary surfaces. Usually deep red soils.	No Concern at Present	5a

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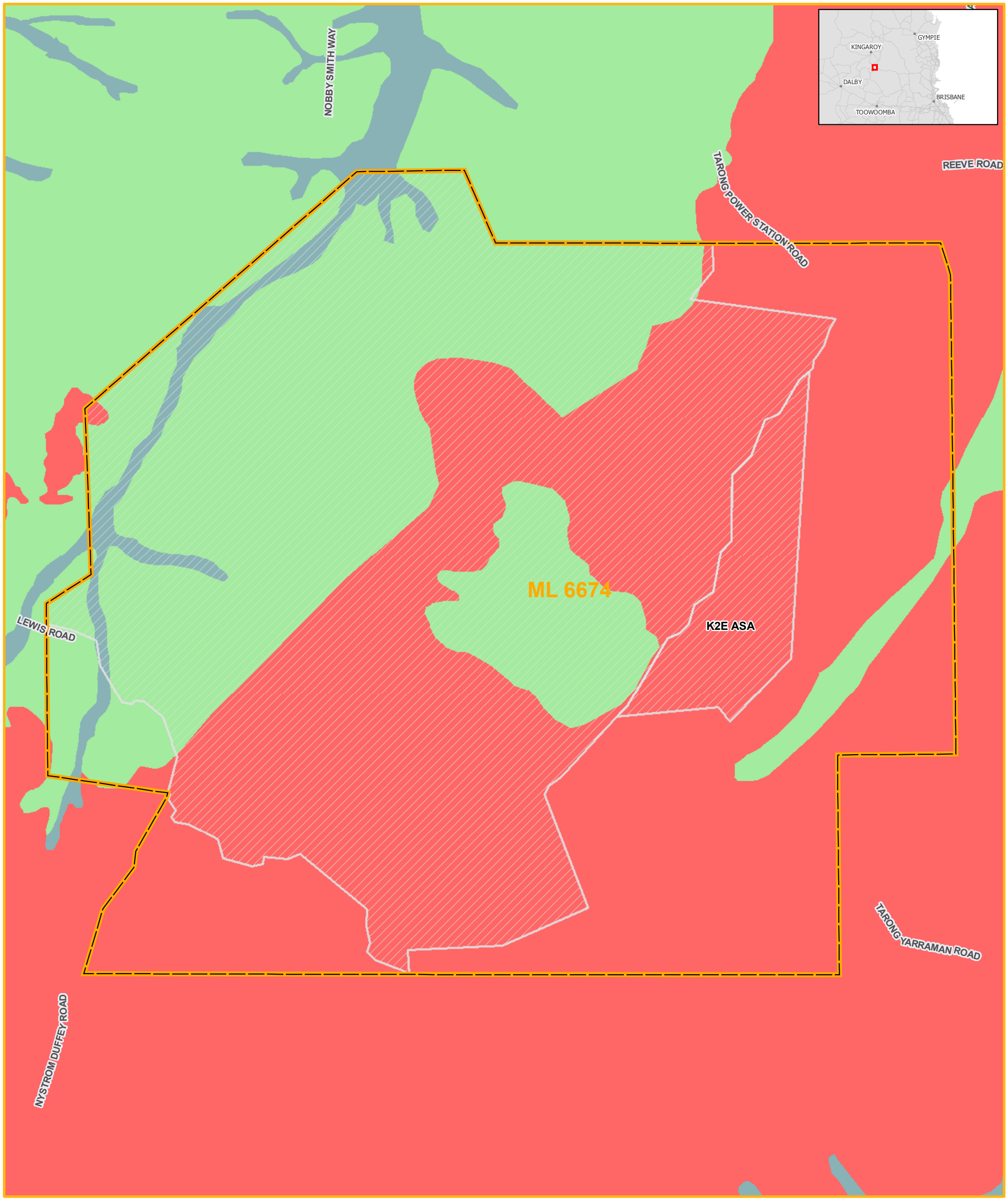
Figure 2.16
Pre-clearing regional ecosystem map



Legend

- Mining Lease (ML6674)
- Approved Surface Rights Area

Pre_clearing_Broad_Vegetation_Groups

Representation: QLD_BVG_PRECLEAR_V5_1_Rep

- 1. Rainforests and scrubs
- 3. Eucalypt woodlands to open forests (mainly Eastern)
- 4. Eucalypt open forests to woodlands on floodplains

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A pre-mining vegetation survey of ML6674 concluded that grazing, clearing and burning had severely modified much of the original vegetation which occurred on the land used for agricultural purposes prior to mining activities. Land under the former Department of Forestry control was found to have been largely cleared and planted with hoop pine plantation, although there were fire breaks and some unplanted areas which still supported the original closed forests (Hollingsworth, 1979).

Vegetation types identified on ML6674 during this survey included eucalyptus open forest, closed vine forest, plantation forest and grassland. A summary of these vegetation types is provided in Table 2.15.

Table 2.15 Vegetation types within ML6674 (Hollingsworth, 1979)

Vegetation type	Description
Eucalyptus open forest	The Eucalyptus open forest vegetation community was dominated by Narrow-leaved Ironbark (*E. crebra*) on shallow ridge topsoils. This species graded into a mixed community of Narrow-leaved Ironbark and Spotted Gum (*E. maculata*) and Sugar Gum (*Angophora costata*) on the ridge slopes. Gum-topped Box (*E. moluccana*) also occurred on the slopes in some areas. In the north of the area Popular Box (*E. populnea*) grew on slopes often in association with Gum-topped Box. A number of associations occurred on lower slopes. Mixed Blue Gum (*E. tereticornis*), Broad-leaved Apple (*Angophora subvelutina*) and bloodwood (*E. intermedia*) associated on some sites whilst on better soils the Broad-leaved Ironbark (*E. siderophloia*) and Sugar Gum occurred. Swamp Mahogany (*E. robusta*) occurred on poorly drained areas. The layered open forest consisted mainly of Iron Bark (*Eucalyptus crebra*) associated with an understorey of vine forest species as well as lantana in the more disturbed areas. The ground layer was fairly sparse although vine forest species tend to 'clump' allowing grasses in between. Where this vegetation type intergraded with closed vine forest, *E. crebra* often occurred as an emergent in the latter. The shrub layer was absent in poorer soils, particularly skeletal soils and in frost hollows. In these areas, grasses such as Kangaroo Grass (*Themeda australis*), Bladey Grass (*Imperadum cylindricum*), Red Natal Grass (*Rhynchelytmm repens*), *Aristida* sp. and *Lomandra* sp. were common. At the time of the survey there was approximately 840 ha of this vegetation type in the area, mostly on freehold land.
Semi-evergreen vine thicket	Semi-evergreen vine thicket is a type of dry rainforest which is characterised by dense closed canopy vegetation with a high density of a range of vines and woody climbers. Several of the canopy species are deciduous. Species richness is typically high compared to the surrounding Eucalyptus woodlands, but tree diameter and height are usually less than in more mesic rainforest environments. Prior to mining, semi-evergreen vine thicket occurred along the higher slopes of the Cooyar Range and along spurs and hilltops to the west. The semi-evergreen vine thicket was variable in stature, with the lowest formations occurring on hill tops, possibly reflecting more shallow soils. Across this landscape this vegetation type was restricted to more fertile soils where moderately fertile, acidic, friable red earths occur associated with Tertiary basalt flows. The soils have low to very low phosphate levels with much of the soil nutrients held within a well-developed soil humus layer.

Vegetation type	Description
	Characteristic species of the semi-evergreen vine thicket included emergent Hoop Pine (*Araucaria cunninghamii*), occasional Bunya Pines (*Araucaria bidwillii*), and Narrow-leaved Red Ironbark (*Eucalyptus crebra*). Canopy species included Crow's Ash (*Flindersia australis*), Red Ash (*Alphitonia excelsa*), White Beech (*Gmelina leichardtii*), and Black Bean (*Castanospermum australe*). Patched of depauperate semi-evergreen vine thicket were also present across ML6674. Small isolated patches occurred across agricultural lands, with more extensive strips present as fire breaks in areas proposed to be planted with hoop pine within the State Forest area. The semi-evergreen vine thicket across agricultural lands was regenerating in places. The semi-evergreen vine thicket covered 570 ha with 439 ha (77%) of this within the State Forest.
Plantation forest	Plantation forest, comprising mostly of Hoop Pine (*Araucaria cunninghamii*) and to a lesser extent *Pinus radiata*, covered an area of approximately 920 ha in State Forest 289. Plantations were establishment in areas that were previously covered in the original semi-evergreen vine thicket. The semi-evergreen vine thicket was clear-felled, windrowed and burnt prior to planting.
Grassland/ improved pasture	A large area of the pre-mining land of ML6674 (approximately 1,710 ha) was grassland/cattle pasture with occasional land cultivated for crops. The grassland supported scattered remnant Eucalypts and occasional patches of regenerating semi-evergreen vine thicket and Acacias. Common weeds included Lantana (*Lantana camara*) and Cotton Bush (*Gomphocarpus physocarpus*). Areas under arable crops included land cultivated for grain, oil seed and fodder crops. Winter cereal crops may have included wheat, barley and oats while fodder crops include sorghum, millet, lucerne and cow peas. Other crops occasionally grown included soya beans, linseed, sunflower, cotton, pineapple, potatoes, *Setaria* sp. and *Dubosia leichardtii* for the pharmaceutical industry.
Freshwater vegetation	Freshwater vegetation was associated with the ephemeral Meandu Creek and tributary of the Barnett River system. Aquatic flora mostly comprised of various species of blue green algae (e.g., *Chara* spp), diatoms and the herbaceous native floating pond weed (*Potamogeton tricarinatus*) and the native rice-field water nymph (Najas graminae), common in still or slow- moving water. Occasional patches of Swamp Lilly (*Ottelia ovalifolia*) were also present.

2.1.8.2 Pre-mining vegetation survey of K2E ASA

A terrestrial ecological assessment was undertaken recently of the K2E ASA and surrounds (WSP, 2021b). The assessment included both desktop analysis and field verification of the presence of vegetation communities.

Field verification surveys confirmed that the majority of the K2E ASA consists of previously cleared non-remnant vegetation associated with Hoop Pine (71.4%) and mixed hardwood timber plantations (11%) as well as areas of non-remnant cleared mixed grassland, regrowth and tracks (8.2%). The remainder of the K2E ASA comprises a narrow strip of remnant vegetation associated with semi-evergreen vine thickets (RE 12.5.13c) (8.8%) and notophyll vine forest (RE 12.11.11) (0.5%).

Field verified vegetation communities and regulated vegetation (regional ecosystems) within the K2E ASA are summarised in Table 2.16 and shown on Figure 2.17.

Table 2.16 Field verified vegetation communities and regional ecosystems in the K2E ASA

Vegetation community description	Regional ecosystem	VM Act status	Extent within K2E ASA (ha)
Low microphyll vine forest and semi-evergreen vine thicket with emergents on deeply weathered remnant Tertiary surfaces	12.5.13c	Endangered	16.7
Microphyll to notophyll vine forest +/- *Araucaria cunninghamii* on interbedded volcanics	12.11.11	Least concern	1.0
Hoop Pine plantation	n/a	n/a	139.5
Juvenile mixed hardwood plantation	n/a	n/a	13.0
Non-remnant cleared mixed grassland, regrowth and tracks	n/a	n/a	15.6
Total			**185.8**

Field surveys were undertaken in both dry and wet seasons during the period of August 2017 to December 2021. The flora surveys conducted during this period identified 95 flora species from within the K2E ASA and surrounds. While two threatened flora species namely *Callitris baileyi* and *Cossinia australiana* were assessed as having a moderate likelihood of occurring with the K2E ASA, neither were detected during the field surveys. One threatened species, *Haloragis exalata subsp. velutina* was recorded from within ML6674 along Rocky Creek outside of the K2E ASA during the field survey.

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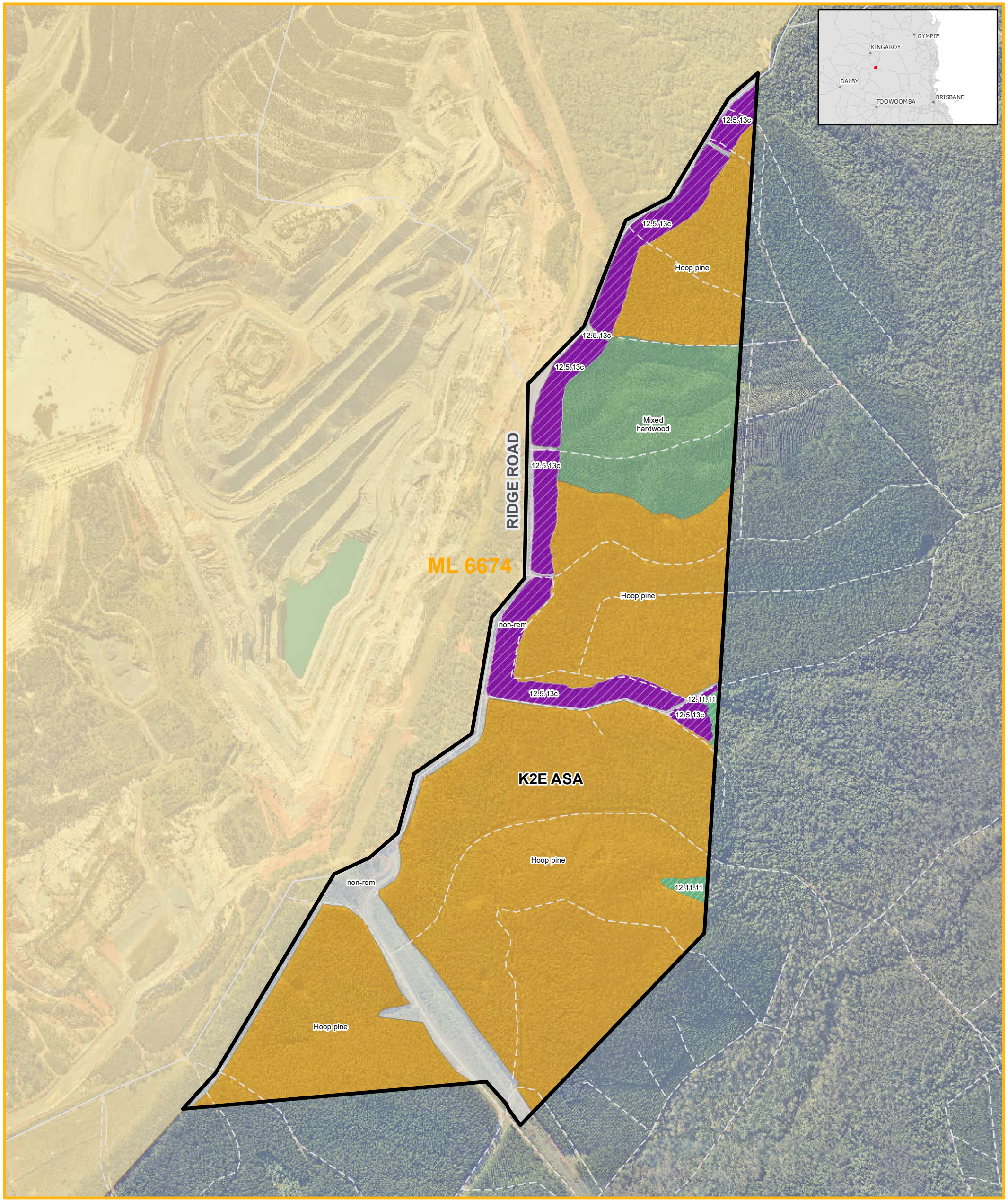
Figure 2.17
Field verified vegetation communities and regional ecosystems – K2E ASA



Legend

- K2E ASA
- Mining Lease (ML6674)
- Approved Surface Right

Field verified vegetation community (status)

- 12.5.13c Endangered (Category B)
- 12.11.11 Least Concern (Category B)
- Category A or B area containing of
- Non-remnant; n/a

Field Verified Vegetation Community

- Cleared non-remnant vegetation along roads and tracks
- Microphyll to notophyll vine forest +/- Araucaria cunninghamii on interbedded volcanics
- Mixed Hardwood plantation
- Hoop pine plantation
- Low microphyll vine forest and semi-evergreen vine thicket with emergents on deeply weathered remnant Tertiary surfaces
- Non-remnant cleared mixed grassland, regrowth and tracks

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2.1.9 Fauna presence and populations

2.1.9.1 Pre-mining survey of the Meandu Mine site

A survey of the fauna within ML6674 was undertaken during May 1979 to a limited extent. In addition to this survey, during October 1976, the Department of Forestry and Wildlife Research Group had studied fauna in nearby State Forest areas. Freshwater vertebrates and invertebrates as well as reptiles and bats were the least extensively surveyed groups.

The native fauna of the area was found to have been influenced by clearing of vegetation for plantation forestry and for agricultural purposes, by fire and by the introduction of exotic animals. The overall pattern of habitat change as a result of these activities was a reduction in the area of forest (both vine forest and open forest), a proportionate increase in the area of grassland and cultivation as well as the likely simplification of the remaining eucalypt forest.

Clearing of forested areas had resulted in the wider distribution of largely open country species such as the grey kangaroo, galah, sulphur crested cockatoo and black-backed magpie. Introduced mammal species such as cattle (*Bos taurus*), the hare (*Lepus europaeus*) and the fox (*Vulpes vulpes*) as well as birds like starlings (*Sturnus vulgaris*) were found to inhabit the open forest areas.

The agricultural lands of ML6674 were not known to support populations of any rare or endangered species as native vegetation in these areas had already been removed prior to development of Meandu Mine. However, species such as the Rufous Rat Kangaroo (*Aepyprymnus rufescenis*) were considered likely to occur in the area. Areas of relatively undisturbed vine forest were reported to support populations of the Black-breasted Button-quail (*Turnix melanogaster*).

Three sites on the Meandu Creek were surveyed to provide baseline information about aquatic fauna. Of the fauna collected or known to be present in Meandu Creek, none was found to have a special conservation value or scientific interest. However, Lungfish (*Neoceratodus forsteri*) which was known to occur in the Burnett River system and which may have been present downstream of the Meandu Mine site in Barker Creek was of special scientific and conservation interest as it is unique and of limited distribution.

2.1.9.2 Recent pre-mining survey of the K2E ASA

The field surveys undertaken during the period of August 2017 to December 2021 identified one hundred and twenty-two (122) fauna species from either within the K2E ASA or immediate surrounds, including 81 birds, 35 mammals (including 18 microbat species), 3 reptiles and 3 frogs. Two pest animal species (the Feral Dog (*Canis familiaris*) and Feral Cat (*Felis catus*)) were recorded within the K2E Project study area on motion sensor cameras during seasonal surveys. Birds were the most diverse group of terrestrial vertebrate fauna recorded, followed by mammals (refer to Table 2.17).

Table 2.17 Summary of terrestrial fauna identified from the K2E Project study area

Faunal group	Terrestrial fauna species (number)			
	Species diversity	Introduced species	Threat-listed species	Migratory species
Birds	81	0	4	2
Mammals	35	2	2	
Reptiles	3	0	0	0
Amphibians	3	0	0	0
Total	**122**			

Six threatened and/or migratory fauna species were recorded from the K2E ASA and immediate surrounds during field surveys. These were:

- Black-breasted Button-quail listed as Vulnerable under the NC Act and EPBC Act
- Greater Glider listed as Vulnerable under the NC Act and EPBC Act
- Powerful Owl listed as Vulnerable under the NC Act
- Short-beaked Echidna listed as Special Least Concern under the NC Act; and
- Black-faced Monarch and Rufous Fantail listed as Special Least Concern under the NC Act and Migratory under the EPBC Act.

Of these species the Black-breasted Button-quail, Short-beaked Echidna, Black-faced Monarch and Rufous Fantail were recorded within the K2E ASA.

Three additional threatened and/or migratory fauna species were assessed as having a moderate or high likelihood of occurring in the K2E ASA (Spotted-tail Quoll, Oriental Cuckoo and Spectacled Monarch). A further five threatened fauna species were assessed as having a moderate or high likelihood of occurring in the study area (but not in the K2E ASA due to the lack of suitable habitat resources). These species are Tasked Frog (*Adelotus brevis*), White-throated Needletail (*Hirundapus caudacutus*), Northern Quoll (*Dasyurus hallucatus*), South-eastern Long-eared Bat (*Nyctophilus corbeni*), Koala (*Phascolarctos cinereus*). None of these species were detected from study area during field surveys.

2.1.10 Pre-mining land use

2.1.10.1 Pre-mining land use mapping for the Meandu Mine and surrounds

The pre-mining land use of the Meandu Mine and surrounds generally included agriculture, rural residential, forestry, and other small mining operations.

Immediate surrounds

Within the immediate locality of the Meandu Mine, extensive areas were used for forestry purposes (open eucalypt forest (approximately 21%), plantation forest (23%) and closed vine forest (14%)), by the then Queensland Department of Forestry. State Forest 289 extended around the east, south and west of ML6674. The forest contained stands of rainforest, eucalypt forest and hoop pine plantations which had managed for timber production since the 1930's.

Before the establishment of the Meandu Mine, the extent of mining activity within the sub-region was small. Several small leases for clay, sand and gravel extraction were present.

Meandu Mine site

By area, the largest land use at the Meandu Mine site was agricultural purposes, at varying intensities, which included two principal activities – beef production and cropping. A mix of agricultural activities was involved (e.g., beef and/or dairy cattle was used to clear away crop residues). Crops such as sorghum and corn were grown within the area, generally located along the flats of the Meandu Creek and Black Creek systems. The Meandu Mine site area had 9 rural residences and associated farm buildings, 5 of which were occupied permanently.

The current mining lease (ML6674) included part of the Cooyar Range Forest (State Forest 289) (now Yarraman State Forest) on its eastern side. The forest contained stands of rainforest, eucalypt forest and hoop pine plantations which had managed for timber production since the 1930's.

Figure 2.18 shows the pre-mining land use of the Meandu Mine, based on the land use mapping produced by the Queensland Department of Primary Industries in 1982 for the South Burnett region. The quality of the image in this map is a result of the fact it was digitised from the original publication and as a result there are minor resulting translation and scaling issues. Nonetheless it functions to give the spatial relationships of the land use distribution.

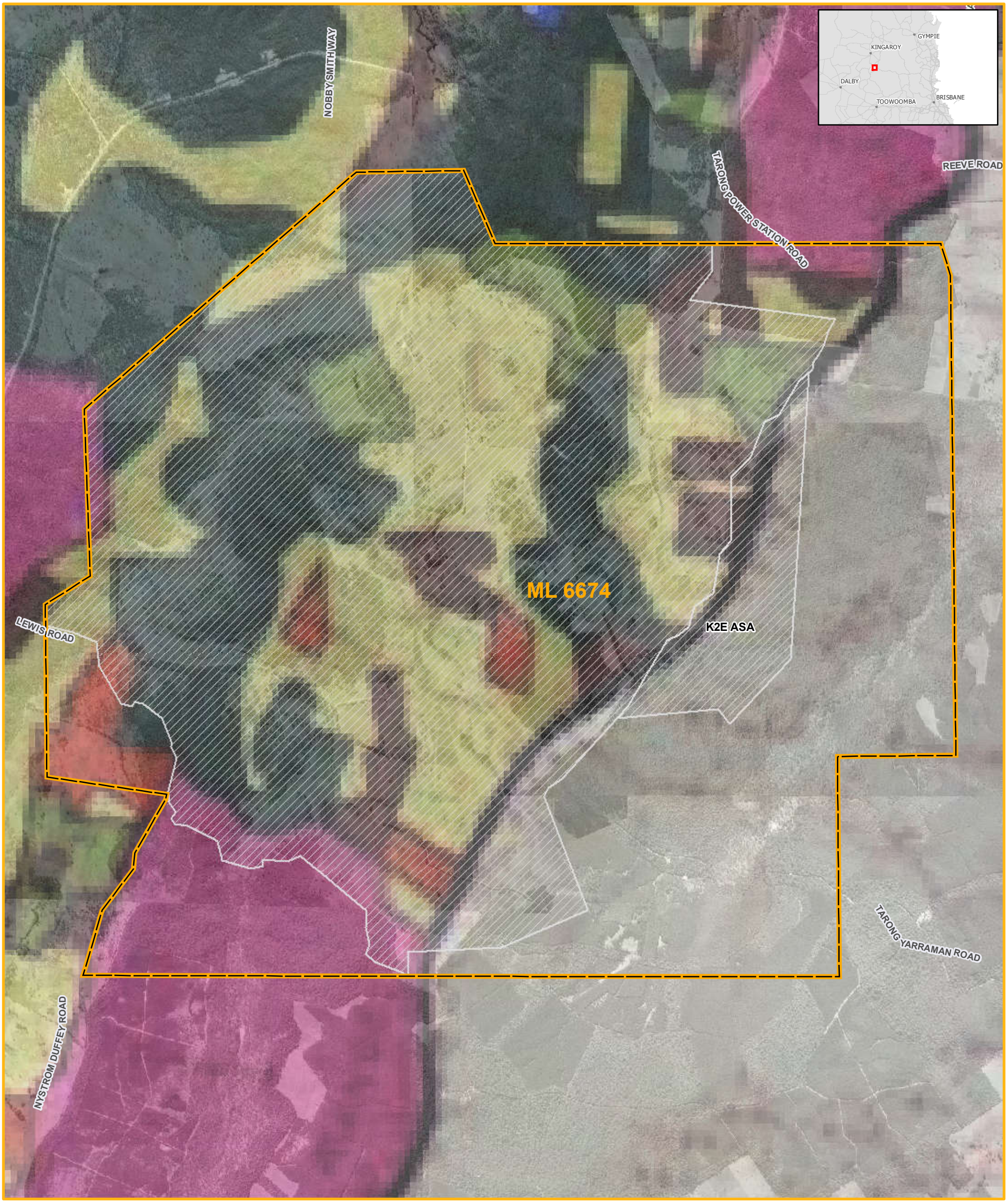
2.1.10.2 Pre-mining (current) land use – K2E ASA

The pre-mining (current) primary land use of the K2E ASA is State Forest (Yarraman State Forest) which is used for forestry plantation. HQPlantations manages the forestry plantation in Yarraman State Forest under a 99-year Plantation Licence (PLP0289) which grants rights to manage, harvest and re-grow plantation timber on Government owned land.

Ridge Road forms the western boundary for a significant portion of the K2E ASA, running in a general north to south direction before dissecting the southern part of the K2E ASA in a north-west to south-east direction. Powerlink Queensland's (Powerlink) Feeder 831 275 kiloVolt (kV) transmission line runs immediately to the west of the K2E ASA in an easement across the approved surface rights area of Meandu Mine before also dissecting the K2E ASA in a north-west to south-east direction, along the same alignment as Ridge Road. No powerline easements exist within the K2E ASA. A number of unsealed tracks associated with forestry operations are located within the KSE ASA (Figure 2.19).

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.18
Pre-mining land uses of Meandu Mine and surrounds



Legend

- Mining Lease (ML6674)
- Approved Surface Rights Area

Landuse

- Regular cultivation
- Crop-pasture rotation and / or improved pasture
- Cleared (< 10% of timber remaining)
- Uncleared (< 10% of timber removed)
- Partly cleared
- State Forest and Timber Reserves

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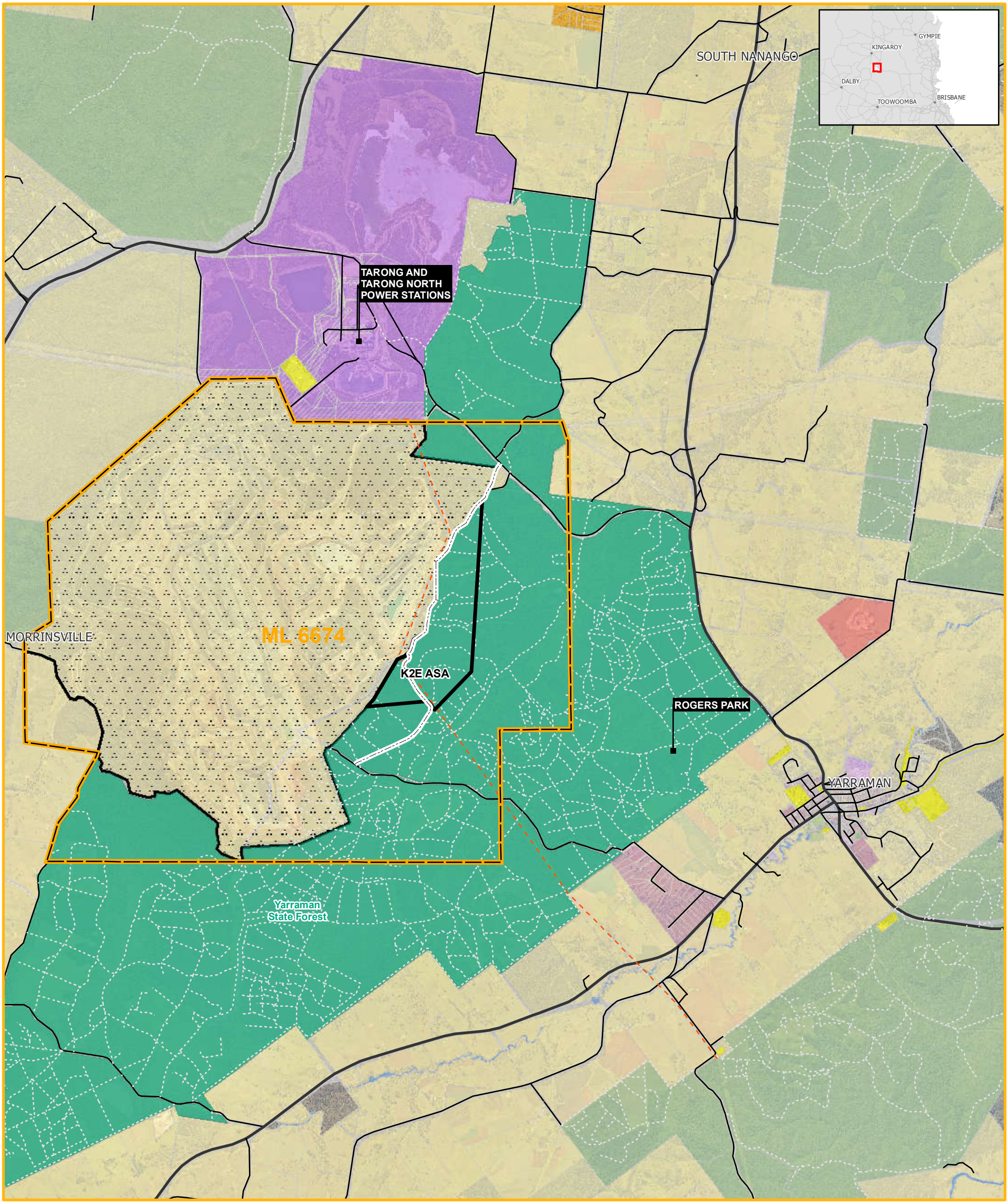
Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.19
Current land use of the K2E ASA



Legend

- Existing Feeder 831 Transmission Line
- Ridge Road
- Highways
- Secondary Roads
- Local roads
- Tracks
- K2E ASA
- Mining Lease (ML6674)
- Approved Surface Rights Area
- Yarraman State Forest

Land Use Zones

- Easement
- Community Facilities
- Local Centre
- Low-Medium Density Residential
- Emerging Communities
- Limited Development (Constrained Land)
- Rural Residential / Rural
- Low Impact Industry
- Medium Impact Industry
- Special Industry
- Extractive Industry
- Environmental Management and Conservation / Open Space
- Sport and Recreation
- Transport Corridor
- Watercourse

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2.1.11 Underlying landholders

The properties (Lot on Plan numbers) underlying the approved surface rights area and the K2E ASA are outlined in Table 2.18.

Table 2.18 Lot on Plan numbers for approved surface rights area of ML6674 and K2E ASA

Applicable area	Property details	Land tenure	Landholder/owner[1]	Registered Title Holder
Previously approved surface rights area (prior to January 2022)	Lot 10 on SP305494	Freehold	TEC Coal Pty Ltd	TEC Coal Pty Ltd
	Lot 111 on FY817	Term Lease (TL233813)	TEC Coal Pty Ltd	The State of Queensland represented by the Department of Resources Land Services
	(part of) Lot 1 on SP181280	Term Lease (TL233958)	TEC Coal Pty Ltd	The State of Queensland represented by the Department of Resources Land Services
	Lot 2 on RP169258	Freehold	TEC Coal Pty Ltd	TEC Coal Pty Ltd
	Lot 3 on RP176969	Freehold	TEC Coal Pty Ltd	TEC Coal Pty Ltd
	Lot 289 on FTY1859	State Forest	The State of Queensland (Represented by the Department of Environment and Science)	The State of Queensland (Represented by the Department of Environment and Science)
	Lot 11 on SP305493	Term Lease (TL238524)	TEC Coal Pty Ltd	The State of Queensland represented by the Department of Resources Land Services
	Lot 101 on SP305492	State Forest	The State of Queensland (Represented by the Department of Environment and Science)	The State of Queensland (Represented by the Department of Environment and Science)
	Lewis Road	Road	South Burnett Regional Council	The State of Queensland (Represented by the Department of Resources)

Applicable area	Property details	Land tenure	Landholder/owner	Registered Title Holder
K2E ASA	Lot 289 on FTY1859 (Yarraman State Forest)	State Forest	The State of Queensland (Represented by the Department of Environment and Science)	The State of Queensland (Represented by the Department of Environment and Science)
	Ridge Road	Road	Toowoomba Regional Council and South Burnett Regional Council	The State of Queensland (Represented by the Department of Resources)
	Unnamed Road	Road	Toowoomba Regional Council and South Burnett Regional Council	The State of Queensland (Represented by the Department of Resources

Notes: 1 – For the purposes of the EP Act

2.2 Project description

Legislative requirements:

As required in sections 126C(1)(b) and (c)(ii) of the EP Act, a description of the proposed project must be included in the rehabilitation planning part. The project description must include the following details:

- mining tenements
- primary mine features/infrastructure on site (e.g. TSF, waste rock dump, etc.)
- type of mining operation
- proposed duration of operation as a whole.

2.2.1 Mining tenements and underlying tenure

The mining tenement relevant to the Meandu Mine is Mining Lease (ML) 6674. The underlying properties which are impacted by activities on the operational area (surface rights area) of ML6674 are outlined in Table 2.19. Figure 2.20 shows the boundary of ML6674, the operational area (surface rights area) of Meandu Mine and associated tenements.

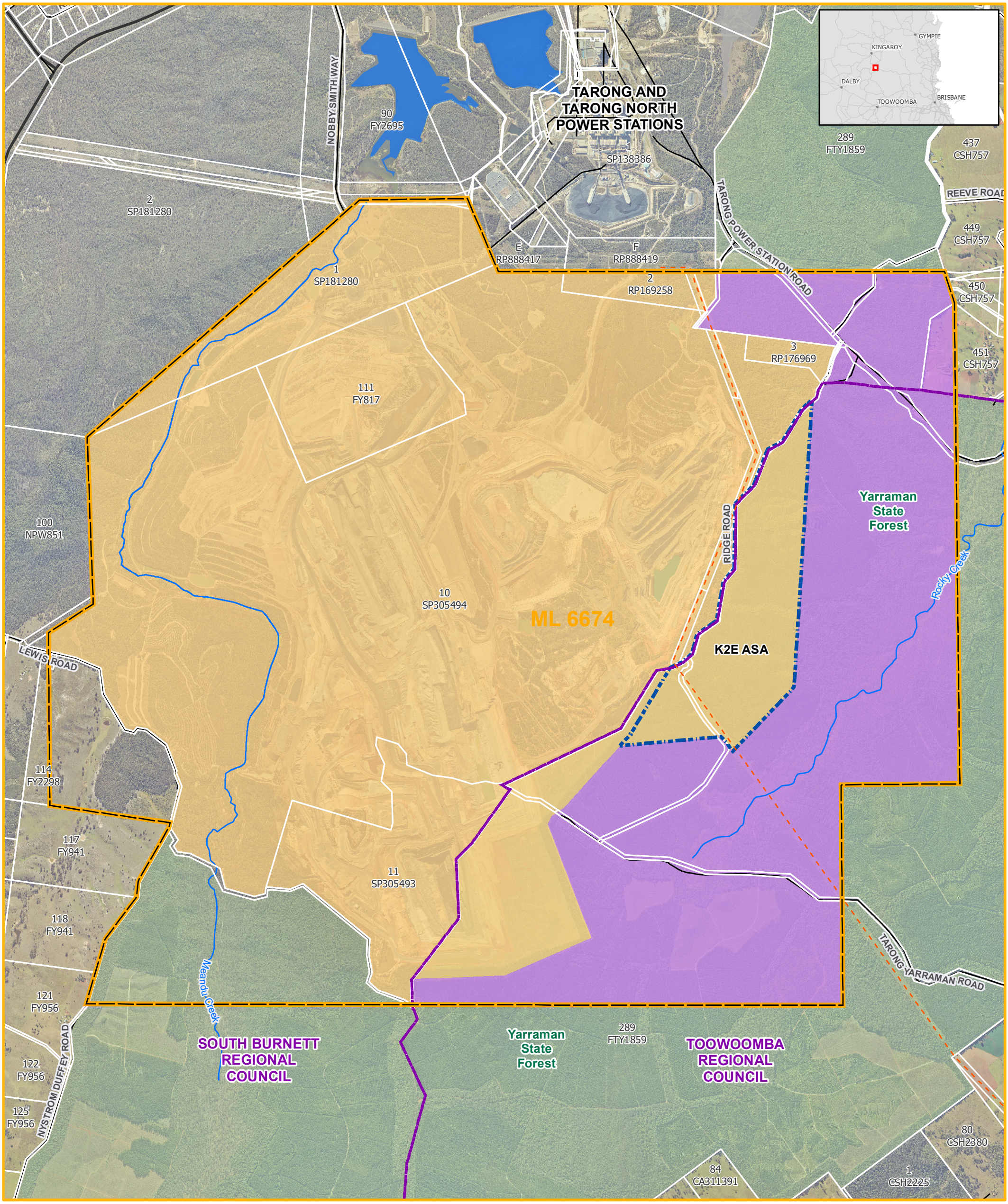
This PRC Plan is relevant only to ML6674 as per the DES Progressive Rehabilitation and Closure Plan Transition Notice issued by DES, reference number EPML00709113/101/0008031-001(E), issued on 31 August 2020 for land relating to ML6674 (refer Appendix A).

Table 2.19 Tenure summary for ML6674

Mining lease	Area (ha)	Expiry date	Tenure holder/ applicant name	Surface rights area land tenure (properties)	Surface rights area land tenure (easements)
ML6674	4,267 ha	28/02/2023	TEC Coal Pty Ltd		Lot A on RP194488 Lot BB on SP110163 Lot B on RP194488 Lot C on RP194488 Lot D on CP826323 Lot D on RP194488 Lot E on RP194487 Lot F on RP194487 Lot G on RP194486 Lot H on RP194486 Lot J on RP840564

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.20
Property and underlying landholders map



Legend

- Existing Feeder 831 Transmission Line
- Ridge Road
- Watercourse
- Cadastre
- Local Government Areas
- K2E ASA
- Mining Lease (ML6674)
- Yarraman State Forest
- Exploration Area
- Meandu Mine Surface Rights Area

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2.2.2 Primary mine features and infrastructure on-site

The primary features and infrastructure in place and proposed at the time of this PRC Plan for the Meandu Mine are summarised in Table 2.20 and illustrated in Figure 2.21 and Figure 2.22. Water management structures and Retention Dams (RD) are shown separately in Figure 2.23.

Table 2.20 Meandu Mine primary features and infrastructure

Domain	Type	Description
Mine infrastructure	Infrastructure	• CHPP fixed plant, ROM and Raw Stockpiles • Overland conveyor to Tarong power stations • Administration and Support Services Area • Workshop/Store Area • Gatehouse • Tyreshop and Bucketshop • Storage sheds associated with Dragline Shutdown Area
	Services	• Power – Incoming Line • Power – Site Transformer and Switchboard, internal lines • Raw Water System • Sewage Farm • Fuel Farm • Explosive Compound

Mine waste storage	Tailings Storage	• K2W TSF (active)
		• K4S TSF (future)
		• NWB Tailings Storage Facility (TSF) (under rehabilitation)
		• Decommissioned TSF:
		  ○ NWA Tailings Storage Facility
		  ○ K2 TSF
		  ○ RD16 TSF (Converted RD)
		  ○ Ramp 3 TSF

	Ash Storage	• K2W-N Ash Storage Facility (ASF) (active) • K4S ASF (future)
	Mixed Plant Rejects (MPR) Storage	• MPR Storage Cells (emplaced and dumped over in advancing spoil dumps)

Domain	Type	Description
Mine pit	Active, Suspended, Depleted Pits and Proposed Final Voids	• Historical pits mined prior to TEC Coal ownership (now rehabilitated) • NWA/NWB (depleted pits – converted to TSF) • K2W and K2N (depleted pits, converted to ASF/TSF) • Central, Ramp 5, K4E, K4S (active pits) • K2E (temporarily suspended pit with planned future mining activities) • K4E, K2E (yet to be completed: proposed final voids)
Creek diversion	Meandu Creek Diversions	• South (upstream) (2005) • Central (1992) • North (downstream) (1986)
Water storage/ management	Retention Dams (RD)	• 24 Retention Dam sites across the surface rights area (locations are shown in Figure 2.23)
Undisturbed area	Areas within ML6674 that are undisturbed by mining	

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.21
Meandu Mine Key Features

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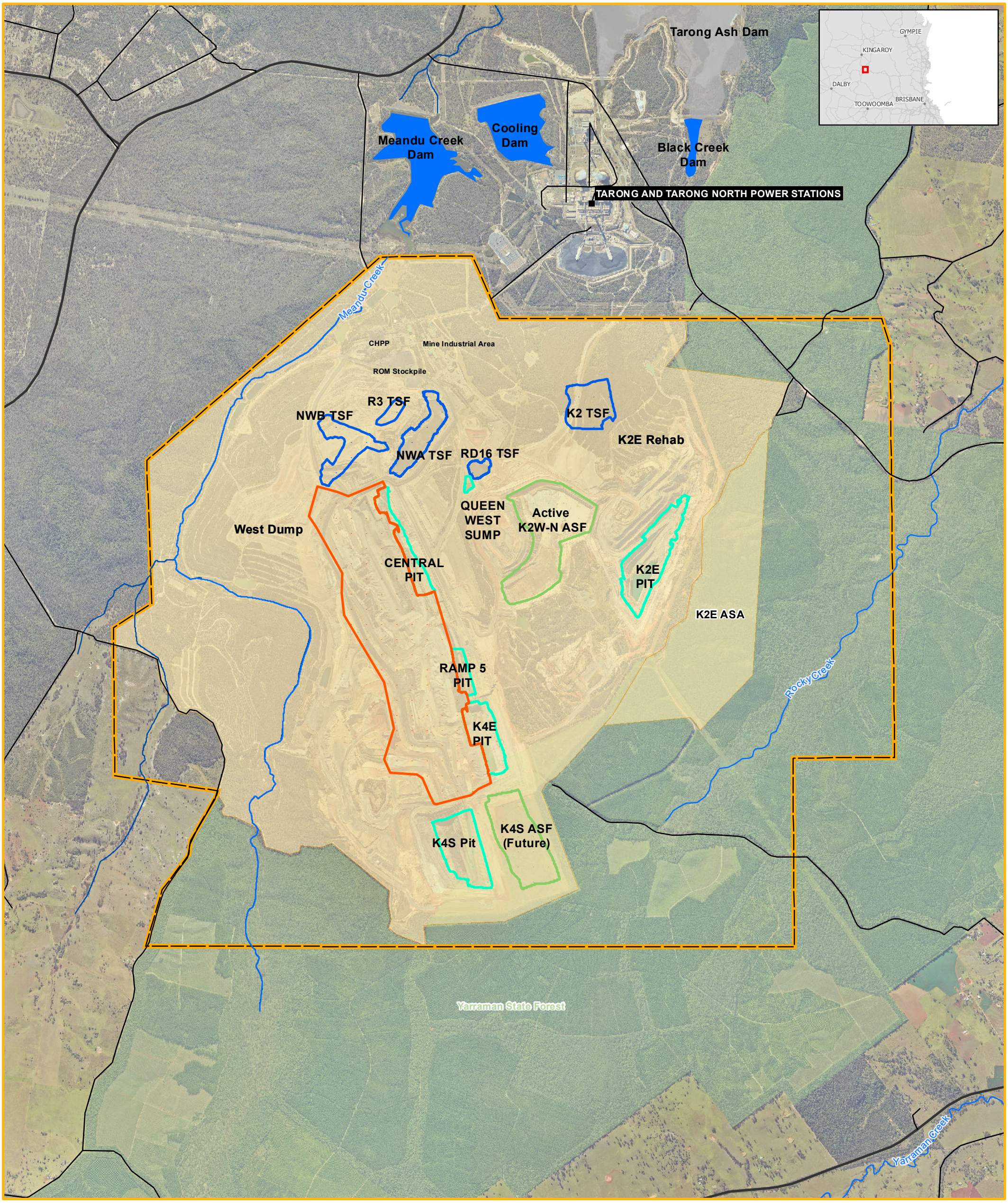

Legend

- Watercourse
- Active MPR storage areas
- Active pits/ voids
- Ash/ tailings storage areas (active and future)
- Historical TSFs in different stages of rehabilitation
- Mining Lease (ML6674)
- Tarong Ash Dam
- Approved Surface Rights Area
- Yarraman State Forest

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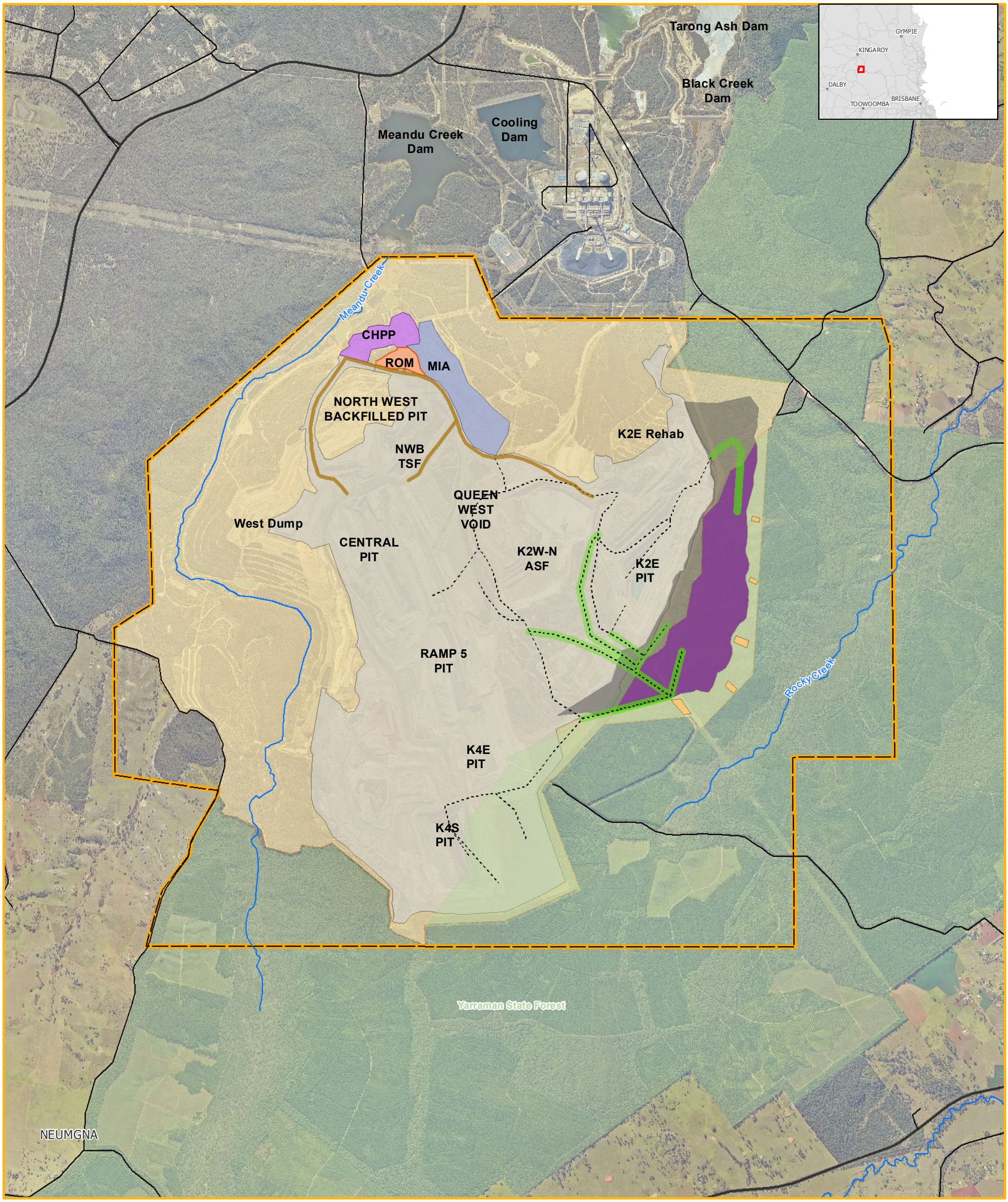
Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.22
Meandu Mine Infrastructure



Legend

- Coal Haul Roads
- Main Haulage Roads
- Watercourse
- Watercourse
- Extention to Main Haulage Roads
- Mining Lease (ML6674)
- Indicative additional extent of K2E pit
- Indicative additional extent of K2E Pit
- ROM Stockpile
- Indicative Sediment Basin
- Yarraman State Forest

Existing Infrastructure

- MIA
- CHPP
- Active Mine Area CY21
- Approved Surface Rights Area

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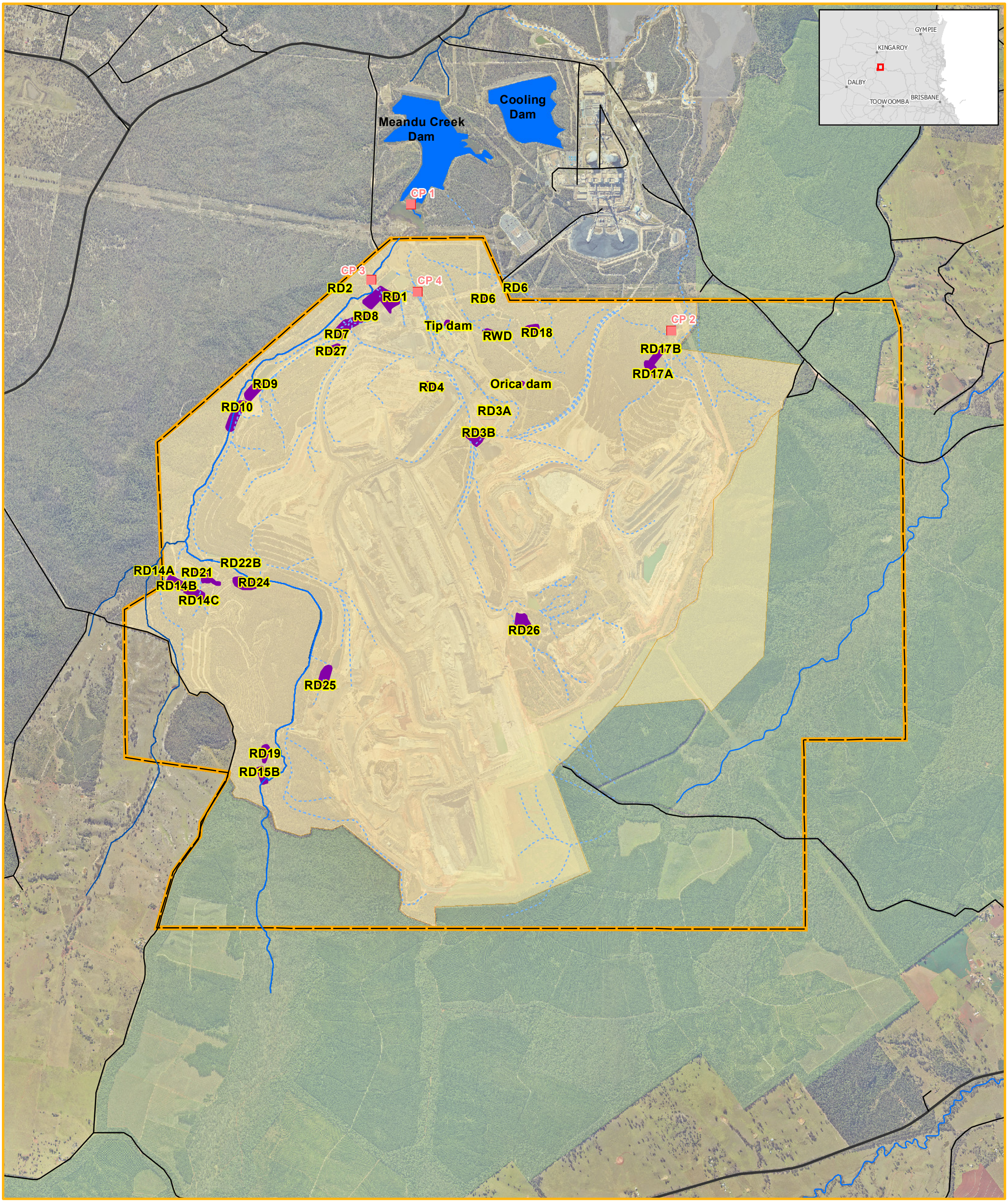
Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.23
Overview of water drainage channels and retention dams



Legend

- Compliance Points
- Drainage
- Watercourse
- MINING_Stanwell_RetentionDamsv2_220524_AMG56
- Mining Lease (ML6674)
- Retention Dams
- Approved Surface Rights Area
- Yarraman State Forest

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2.2.3 Type of mining operation

Meandu Mine currently has four active pits and one temporarily suspended pit (refer Table 2.20) and is capable of supplying the adjacent Tarong power stations with approximately 7 Mtpa of product coal. Meandu Mine operates using a multiple pass strip mining method with a dragline with supporting truck and shovel fleets. Under EA EPML00709113 Meandu Mine is authorised to extract up to 11.0 Mtpa of ROM coal. In addition to the mining operations, Meandu Mine includes a Coal Handling and Preparation Plant (CHPP), where mined coal is crushed, screened, washed and loaded to an overland conveyor for transport to the Tarong power stations.

Mining activities at Meandu Mine include:

- exploration drilling
- clearing of vegetation
- stripping and stockpiling of topsoil from disturbance areas
- pad preparation followed by drilling and blasting
- overburden and interburden removal using truck and excavator, dragline, dozers and scrapers
- coal mining and transport
- coal processing
- coarse and fine reject disposal
- storage of coal combustion products (ash) produced at the Tarong power stations in mine voids
- on-site disposal of waste tyres
- maintenance of water management structures and systems including sediment controls
- spoil dump construction and reshaping; and
- rehabilitation and monitoring of disturbed land.

Table 2.21 provides a high-level description of the key mining and processing related activities. The description provided in the sections below is current at the time of preparing this document and minor changes to mining processes may and most likely will change in future as a result of new technology and progression of the LOM Plan.

Table 2.21 Summary of existing key mining activities

Key site activities	Description
Coal mining	Meandu Mine operates using a single dragline with supporting truck and excavator fleets. Meandu Mine supplies the feed coal for the Tarong power stations and is therefore linked to Stanwell's long-term business objectives for these stations. All material at Meandu Mine is blasted, with the exception of the overlying Tertiary sediments. Preparation of the area for mining includes vegetation clearing whereby timber is removed to stump level and stumps and debris are left in-situ until such time that the area is required for mining. Prior to mining, the next area in sequence is grubbed of remaining stumps and groundcover removed. Topsoil is progressively stripped and stockpiled for later use in rehabilitation, ahead of mining.

Key site activities	Description
Waste material storage and disposal	Waste rock material removed in advance of coal mining is comprised of: • overburden, which is located above the upper coal seam • interburden, which is located between adjacent coal seams • coal roof, coal floor and coal partings, which is located adjacent to coal seams; and • spoil material, which has previously been dumped and is rehandled to provide access to the targeted coal seams. Waste rock material is moved by dragline and excavator/haul truck fleets to in-pit or ex-pit overburden dumps, appropriate to mine plan and mining location.
Coal handling and preparation plant (CHPP) operation	Coal is transported to the ROM stockpiles or the ROM bin at the CHPP in rear dump trucks. The CHPP processes include screening, crushing and washing using gravity separation to achieve product coal specifications. During the CHPP process, raw coal is separated into coal and non-coal materials utilising density separation via jigs and spirals. Product coal is then transported via a 1.5 km overland conveyor to the Tarong power stations.
Reject disposal and storage	Dewatered fine rejects are deposited into the reject trench prior to mixing with coarse rejects at the CHPP. The resultant mixed plant rejects are then trucked to the current rejects storage location (refer Figure 2.21). Mixed plant rejects are dumped within in-pit spoil dumps, either within shallow cells that are progressively covered with overburden material, or co-mingled with spoil in a tip head configuration. Rejects are placed at least 6 m beneath the final landform surface, capped with a non-acid forming (NAF) spoil cover system and rehabilitated as per EA requirements and Sections 6.1.3 and 6.1.4 of this PRC Plan.
Tailing disposal and storage	Coal tailings (fine rejects) are thickened in the CHPP thickener and treated with calcium hydroxide to attain a broadly neutral pH. They are then pumped in slurry form to solid bowl centrifuges, where they are dewatered to the required moisture content for transport. Dewatered fine rejects are comingled with the coarse rejects and the resulting Mixed Plant Rejects are trucked to the rejects storage area (refer Figure 2.21). Water that is recovered from the solid bowl centrifuges is recycled back through the CHPP system or otherwise re-used according to site procedures and approvals. Future tailings placement strategies may result in the recovered water being pumped to the Tarong power stations or to the mine water management system. Alternative tailings storage is retained for emergency tailings disposal in the event that the centrifuges are by-passed during breakdowns or for maintenance or repairs. In this instance wet tailings are pumped as a slurry to a dedicated tailings storage facility, which is currently the K2W-N ASF/TSF.

Key site activities	Description
Coal combustion product (Ash) disposal and storage	Ash is produced during the coal combustion process at the power stations as a by-product of power generation. Dense-phase ash slurry is pumped from the Tarong power stations to Meandu Mine for storage in disused mine voids as approved under Conditions A18 – A21 of EA EPML00709113. The current storage facility for coal combustion products is the K2W-N mine void, which is dual purposed for ash and tailings. Once this facility achieves target fill level the depleted K4S void will become the ash and tailings storage facility at the Meandu Mine for the remainder of the mine life (refer Figure 2.21).
Water storage and management	A comprehensive drainage and retention system exists at the Meandu Mine covering the operational and industrial areas, CHPP, workshops and the warehouse. This system is maintained and upgraded to preserve the separation of clean and dirty water, maximise water recycling and minimise the need to discharge water from the mine area (refer Figure 2.23).

2.2.4 Proposed duration of the operation

The 2021 LOM Plan for the Meandu Mine is based on the forecast plans for the continuation of mine activity to support ongoing generation at Tarong power stations. Based on electricity market forecasts and Tarong power stations estimated economic life, coal mining operations to support generation are expected to continue through to 2037. Following the completion of coal mining operations, bulk earthworks utilising the mine production equipment is expected to continue for a further 3 years to the end of 2040 to move and reshape in accordance with the final design landform. Revegetation, monitoring and maintenance will continue until relinquishment of the EA.

The indicative annual pit progression for coal production for Meandu Mine up to 2037 is illustrated in Figure 2.24. As shown, mining involves a gradual progression of the Central, Ramp 5, K4E and K4S pits to the north-east, then transition to progression of the K2E pit in the north, central and southern mining sub-areas in the latter years of production.

The proposed rehabilitation timing based on the 2021 LOM Plan and approved mining areas (assuming grant of the K2E ASA) is detailed further in Section 2.3, Section 2.4, and the PRC Plan Schedule (Section 9). The rehabilitation plan is shown as Figure 2.28.

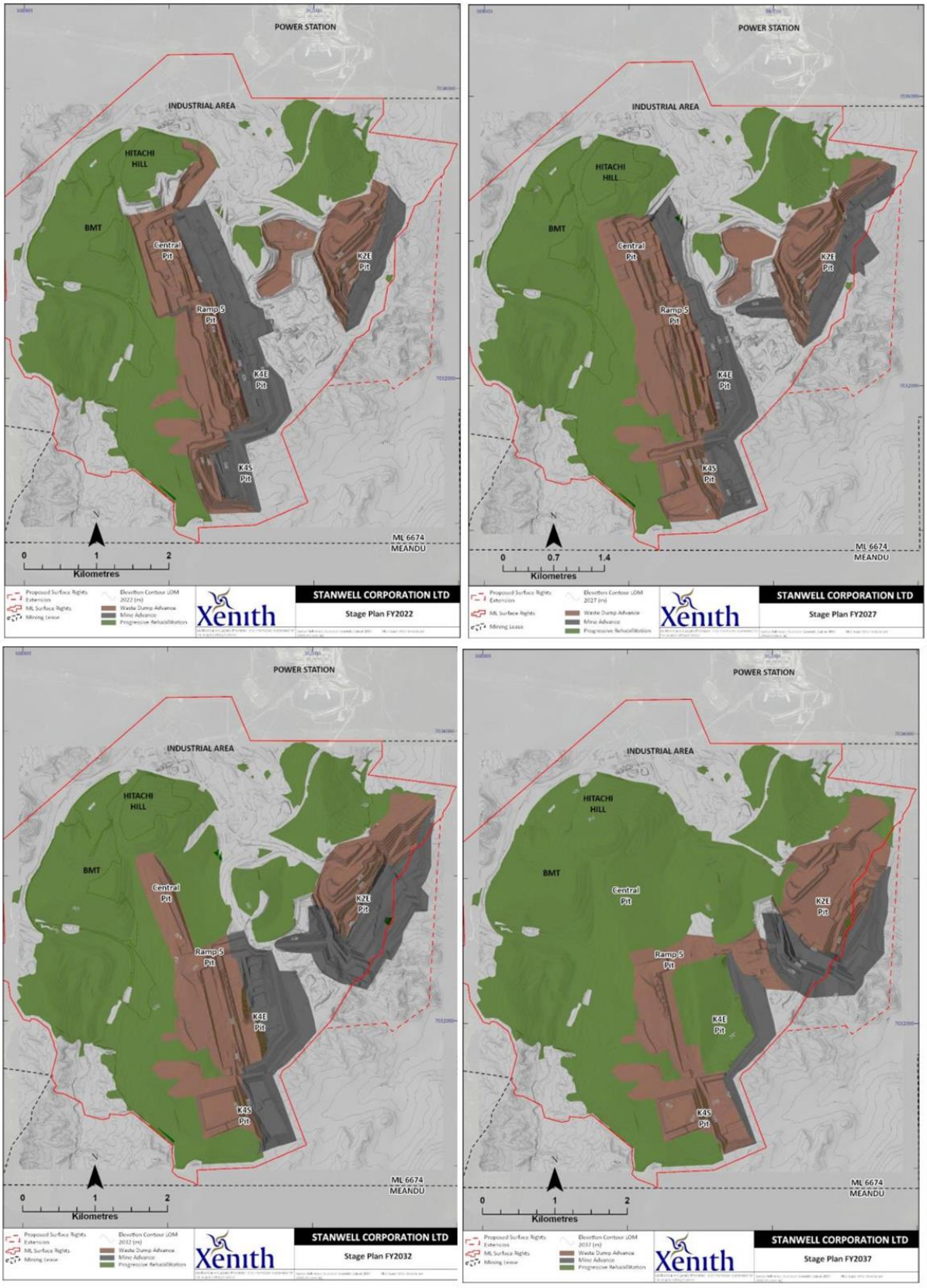


Figure 2.24 Indicative life of mine plan pit progression to FY2037

2.3 Design for closure

PRC Plan Guideline (Section 3.1):

One of the main purposes of the PRC plan is for applicants to plan for how and where environmentally relevant activities will be carried out on land in a way that maximises the progressive rehabilitation of the land to a stable condition. The rehabilitation planning part of the PRC plan must explain how progressive rehabilitation and closure has been considered in the design of the mine site.

Proactively designing for closure will maximise the progressive rehabilitation of the land to a stable condition and will minimise the long-term management requirements and costs at closure. All aspects of the mine site should be designed for closure including mine landform locations, construction and operation of the mine. For example, the locations of mine structures should be planned to ensure they do not limit options for future rehabilitation or delay an area of land becoming available for rehabilitation or improvement.

To demonstrate that rehabilitation will be maximised for the mine site, the rehabilitation planning part of the PRC plan for new or expanding sites must include a description of how the following aspects have been designed for closure:

- location of mine features/infrastructure, having regard to the following considerations:
    - protection of environmental values of the site and receiving environment, including matters of National Environmental Significance, matters of State Environmental Significance and matters of Local Environmental Significance
    - surrounding land uses and proximity to sensitive receptors
    - proximity to the open-pit exit or exits
    - the gradient of the footprint area, both for the direction of drainage from the landform and for the dumping costs
    - local and regional topography
    - surface and ground water features (quality, quantity and seasonal variation)
    - geotechnical conditions (i.e. soil/rock characteristics) and suitability for the structure type (i.e. presence of structural features that may transmit seepage)
    - competing water and land uses
    - visual impact
- size, shape and design of mine features/infrastructure (e.g. waste rock dump design)
- mining methods (such as utilising underground methods versus extraction via an open cut pit).

Consistent with the requirements of the PRC Plan Guideline, transitional PRC Plans are not required to demonstrate how the site has been designed for closure for existing or approved disturbance. The following subsections however describe the guiding principles and rehabilitation sequence developed by TEC Coal for closure design of the Meandu Mine.

2.3.1 Overview of approach for design for closure

Meandu Mine was designed and constructed in 1981, at a time of limited legislation, science and regulation regarding the principles of mine closure and rehabilitation. Meandu Mine was purchased in 2008 by Tarong Energy (now Stanwell) which has engaged extensively in community and stakeholder consultation and implemented an extensive monitoring program to assess potential impacts from mining operations on sensitive receptors. The outcomes of this consultation (Section 3) and monitoring have driven updates to the LOM Plan, rehabilitation outcomes and the overall closure objectives the Meandu Mine.

The following sections provide criteria that has been established for the ongoing design (including design for closure) of the Meandu Mine. Also outlined are the factors taking into consideration in developing the rehabilitation sequence for the Meandu Mine. The LOM Plan will consider these principals and sequencing future LOM Plan development and will also be reflected in the annual Estimated Rehabilitation Cost (ERC) process.

2.3.1.1 Design for closure: specific principles applied for the K2E ASA

Transitional PRC Plans are required to address design for closure in respect of any mine site expansion. Therefore, Meandu Mine has given express consideration to design for closure with respect to the planning of the K2E ASA and specifically addresses the following dot points from the PRC Plan Guideline:

- location of mine features/infrastructure
- size, shape and design of the features; and
- mining methods of the K2E Project that have been considered to maximise progressive rehabilitation.

Design for closure of the K2E ASA has included the following explicit considerations (as well as the general site wide approach adopted by TEC Coal for design for closure):

1. Built infrastructure to support mining operations has been minimised to include fill points, electricity reticulations and water retention systems. It has been designed as a satellite operation and as such will utilise the existing CHPP, mining workshops and administration and maintenance facilities.
2. The mining sequence has been revised in the 2021 LOM Plan to facilitate progressive rehabilitation through the splitting of the overall footprint of the mining area into three sub-regions, allowing for acceleration of the rehabilitation sequence from north to south and earlier achievement of rehabilitation milestones than the previous LOM Plan.
3. Size, shape and extent of the K2E final void has been minimised in comparison to the preceding LOM Plan, as detailed in Section 2.3.3.2 – Required fill for final voids and the Landform Design Report (Appendix H).
4. Gradients have been designed for the final lowwall profiles and final highwall to support the selected PMLUs while achieving geotechnical stability.
5. Landform shapes have been designed to facilitate return of area to the Rocky Creek catchment at closure, while also reducing the footprint of the final void catchment. Visual amenity was considered during the design of the landform and the development of the mining sequence to ensure that the final landform is consistent with the surrounding topography and minimises impact on sensitive receptors during operations and post-closure.

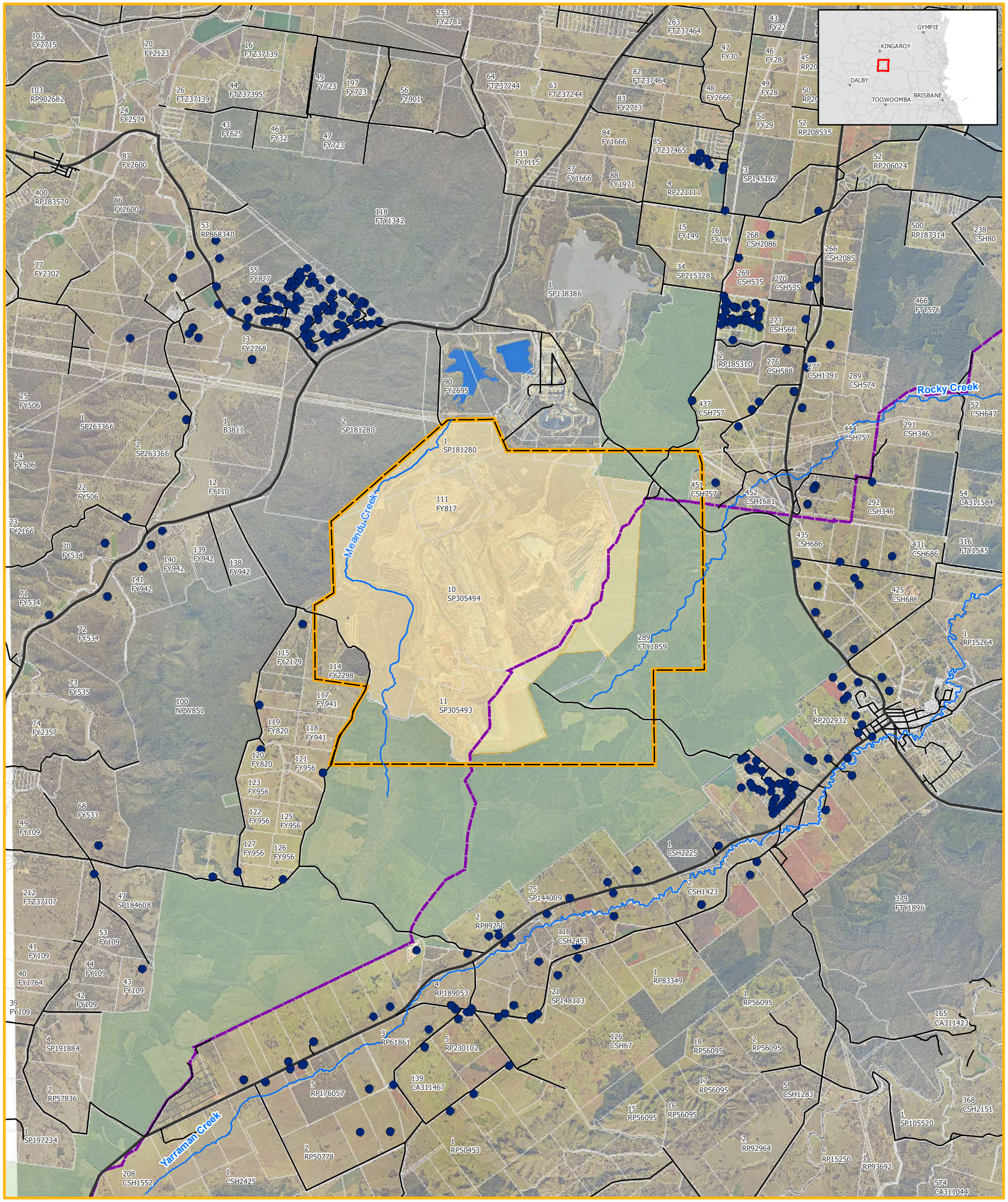
2.3.1.2 Landform design principles

TEC Coal has commissioned and undertaken extensive studies to ensure that the Meandu Mine final landform is safe, stable, non-polluting and able to sustain a PMLU. To achieve this final landform design the following guiding principles relevant to rehabilitation and closure have been developed:

- Minimise disturbance and pit limits: Reduce where practicable the disturbed area at the end of mine life to meet the maximum coal requirement. Pit limits are to be designed in consideration of the final slope design criteria.
- Prioritise in-pit dumping: Prioritise the dumping of waste material within pit limits, rather than the creation or further development of out-of-pit dumps. This will also assist in reducing the volume of material required to be reshaped into the final landform and supports minimising final void volumes.
- Selective waste placement and materials balance: ability to achieve the required cover design has been integrated into the LOM process and is capable of providing materials balance to ensure correct cover for PMLU allocation is achieved. This requires stockpiling of some materials above final landform design for an interim period to ensure sufficient volumes for achieving final landform design.
- Minimise box cut extents: Minimise the extent of the new box cuts to reduce the requirement for out-of-pit dumping and prioritise/maximise in-pit dumping.
- Minimise void footprints: Prioritise practices which achieve a reduced final void footprint and volume. This will also support the reduction of closure costs associated with landform shaping and establishment, bulk waste handling, placement and reshaping.
- Consider sensitive receptors and surrounding land uses: Establish PMLUs which integrate with the surrounding land uses. Design the final landform in consideration of sensitive receptors to be consistent with the surrounding natural topography in both extent and form. The location of sensitive receptors surrounding the Meandu Mine is shown on Figure 2.25.

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.25
Sensitive Receptors



Legend

- Sensitive Receptors
- Watercourse
- Mining Lease (ML6674)
- Local Government Areas
- Cadastre
- Approved Surface Rights Area
- Yarraman State Forest

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2.3.1.3 Infrastructure

The majority of infrastructure at Meandu Mine was built during mine construction prior to regular coal deliveries to the power station which commenced in 1984. The infrastructure precedes the introduction of the requirement for PRC Plans, and as such infrastructure has not been specifically designed and built with consideration of mine closure and rehabilitation.

The existing infrastructure will continue to form the operations base and support mine operations to mine closure. No additional significant processing or handling infrastructure (e.g., CHPP, ROM stockpiles or product stockpiles) is anticipated to be required at the Meandu Mine. Minor additional water/sediment management infrastructure is required in the K2E area to meet and maintain environmental compliance, however where they occur their design will be such that integration into the PMLU will be enabled.

Stanwell have developed the following additional guiding principles to assist with planning for closure and rehabilitation of certain infrastructure areas at the Meandu Mine:

- Operational infrastructure:
    - Coal processing infrastructure, explosives infrastructure, washdown facilities, laydown areas and remote storage sheds: to be decommissioned and removed.
    - Coal/rejects stockpiles: material beneath stockpiles is to be removed and hauled to appropriate pit dump locations in accordance with the management of residual contaminants strategies discussed in Section 6.5.6.
    - Mobile Equipment Maintenance workshop hardstand (refuelling area) and bulk fuel storage area: to be decommissioned and removed. Material located on the hardstand and storage area is to undergo bioremediation.
    - Landholder Retained infrastructure: none to be retained.
    - Permanent infrastructure: the private road within the ML that connects the current mine infrastructure area to Nobby Smith Way (the gazetted public road providing access to Meandu Mine) will remain post closure to provide all weather access to the Beef Cattle Grazing PMLU. This is detailed in Section 6.5.1.3.
    - Essential management infrastructure: No items with potential to cause a material impact on the relevant PMLUs will be retained post closure.
    - Minor items, such as access trails and fencing, that enable appropriate land management practices to continue post-closure will remain in place. These features will be minor in nature, integrated into and directly support the PMLUs.

Further information on landform design and rehabilitation of the built infrastructure at the Meandu Mine is provided in Sections 6.1.5 and 6.5 respectively.

2.3.2 Meandu Mine PRC Plan rehabilitation sequence

2.3.2.1 Background

The Meandu Mine is a relatively intense operation compared to most Queensland coal mines. The pits are up to 270 m deep in a multi-seam configuration, and the mine has an operational strike length limited to approximately 3.5 km. This represents at 7–11 Mt ROM per annum production rate a mining intensity of some 2–3 Mt ROM tonne production per kilometre of strike length per annum. The outcome of this constrained footprint is that the steep and deep final voids still open at cessation of coal mining require adjoining footprint both for active waste dumping and to stockpile material for rehabilitation processes at the cessation of mining.

Progression of mining and disturbance has been from north-west to south-east and continues in this direction. As at January 2022 the majority of surface disturbance planned within the surface rights area (excluding the K2E Project) has already occurred (refer Figure 2.26).

To achieve the LOM Plan, multiple mining pits are in production until the latter part of mine life. In the last period of operations, the operations will fully transition to the K2E pit and the majority of coal production will be predominantly from this one pit.

The key items impacted the completion of rehabilitation in the last decade of mine life are as follows:

- achieving an optimised environmental outcome in terms of:
    - minimising the number, area and depth of final voids
    - meeting requirements for PMLUs, including maximising the area of landform suited to Beef Cattle Grazing
    - providing for required complementary water storages for the allocated PMLUs
- provision of the correct placement of NAF and PAF materials, and selective waste placement to achieve capping and cover designs; and
- beneficial placement of power station ash to fill voids to improve average elevation of the final landform closer to the original surface.

The storage of ash in mining voids avoids the construction or extension of ash storage facilities at the adjoining Tarong power stations. To facilitate ash storage, a dedicated depleted pit void remains unrehabilitated until power generation ceases at the Tarong power stations. This consequently reduces the available in-pit space to place waste and defers the final fill and cover installation of these pits (capping, desiccation, fill, settlement and cover placement).

To facilitate these constraints, select volumes of NAF spoil will be dumped above the final landform elevation at Central, Ramp 5, K4E and K4S pits to provide sufficient volumes nearby required final placement locations to minimise the final rehandling of the waste to achieve the final landform design. These stockpiling activities, and the later reclamation and landform construction process, are included in the current LOM Plan and the timings and footprints shown in the PRC Plan Schedule.

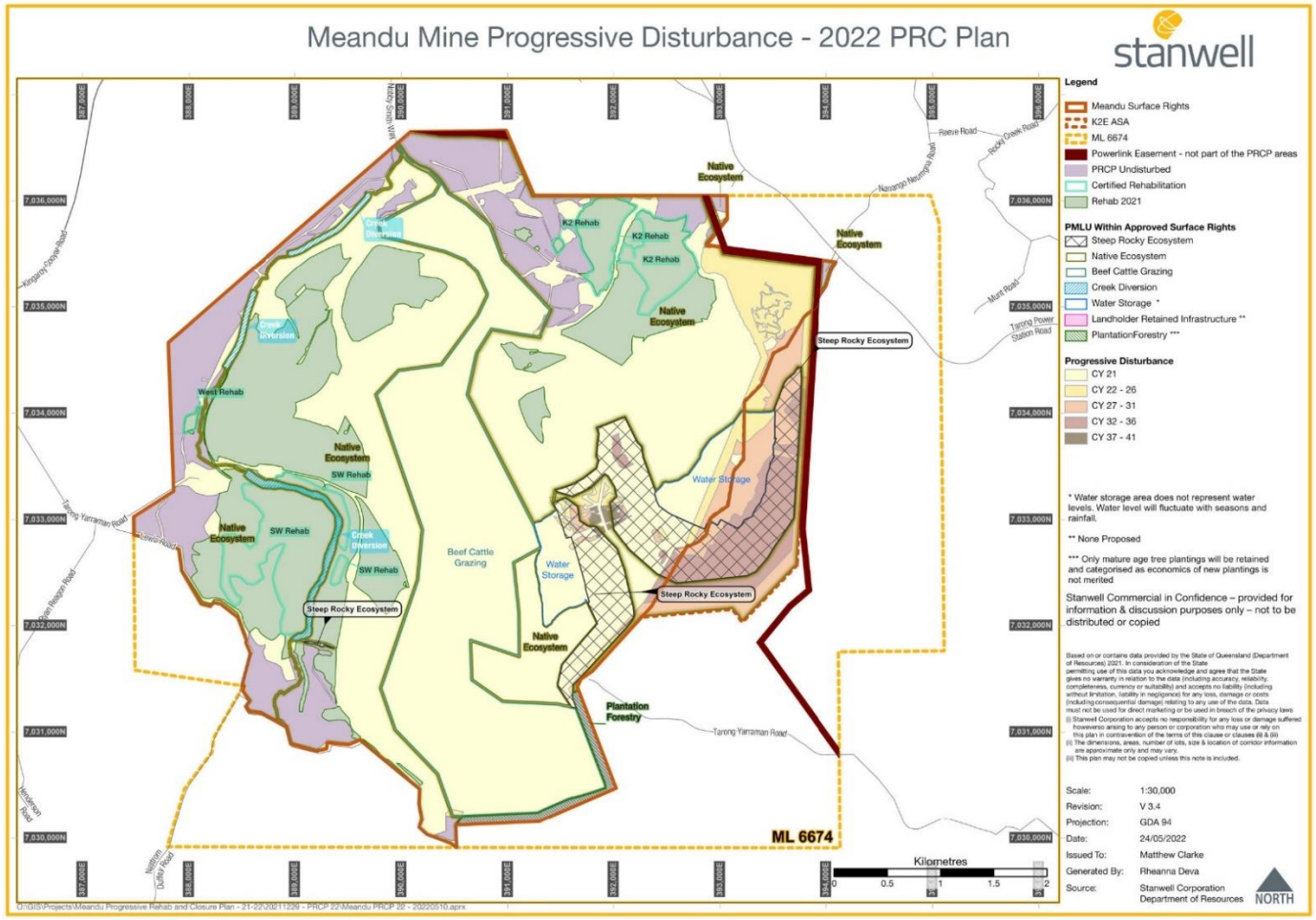


Figure 2.26 Meandu Mine Progressive Disturbance – 2022 PRC Plan

2.3.2.2 Rehabilitation sequence timing risks and contingency

The Meandu rehabilitation sequence considers and provides contingency in timing for a number of risks including some identified from the risk assessment process (refer Section 7):

- Climate change: while indicating generally drier conditions, it is anticipated that the wet season will potentially be more dry/wet cyclical with greater intensity during each cycle. This may also result in increased rainfall frequency and intensity impact in the November to February wet period, causing delay in the ability to haul and place waste.
- Aging mobile fleet/plant availability: the mobile fleet is currently expected to be approaching expected operating life towards the end of the LOM Plan. While fleet numbers should be adequate to address risks of reduced availability or catastrophic equipment failure or decommissioning, potential exists for delay particularly in the 2036–2040 period.
- Desiccation period: site experience and prior assessments in regard to the desiccation period for both coal power station ash and tailings, before sufficient strength exists to support placement of the initial capping layer. The period for desiccation is influenced by a number of factors including the size and depth of the deposited waste, method of deposition and the impact of any cyclical period of wet weather during the summer period. This risk has been reduced in the 2021 LOM Plan as at both K2W-N and K4S (the final two ASF / TSFs) the final layer for deposition will now be power station ash, for which there is greater confidence in the ability to form a hardened crust within the allowed schedule timeframe (than for the equivalent tailings material).
- Settlement period: site experience also exists in regard to settlement in a number of circumstances for both general waste in dumps as well as for capping and final bulk waste placement above ASFs and TSFs. The current K2W-N and K4S facilities will have a significantly greater maximum deposition depth than previous facilities, and so there is risk in the adequacy of timing allowances made in the schedule for settlement of these facilities in particular. General waste dumps settlement timing allowance risks are comparatively small due to the staged dumping sequence, track rolling of lifts by dozer and relatively low maximum height of individual dump lifts.

Risks relating to NAF/PAF material placement and the mass balance of suitable materials to achieve capping, general cover and final cover requirements have been specifically addressed by scheduling these (other than topsoil) within the LOM Plan. The LOM Plan is rerun in detail every 2 years including source/destination scheduling and mass balance evaluation of required material types required to complete landform construction and rehabilitation to design.

As a result of the above risks, the rehabilitation sequence provided in this PRC Plan includes a contingency provision of 12 months for the completion date for bulk waste placement and a further 12 months for final landform shaping to design. Table 2.22 summarises the contingency included in the PRC Plan rehabilitation sequence.

Table 2.22 Rehabilitation timing contingency

Risk to completion	Timing contingency
Climate change	Included in settlement risk contingency
Equipment reliability	During coal mining operations, addressed by mobile fleet maintenance program. During bulk waste relocation and reshaping post coal mining operations, addressed through equipment redundancy (mobile fleet available is well in excess of that required to complete the work).
Ash and tailings desiccation prior to commencement of capping	12 months
Settlement, NAF / PAF material placement and overall rehabilitation landform contingency for unforeseen events	12 months
Final profiling and subsoil development	12 months

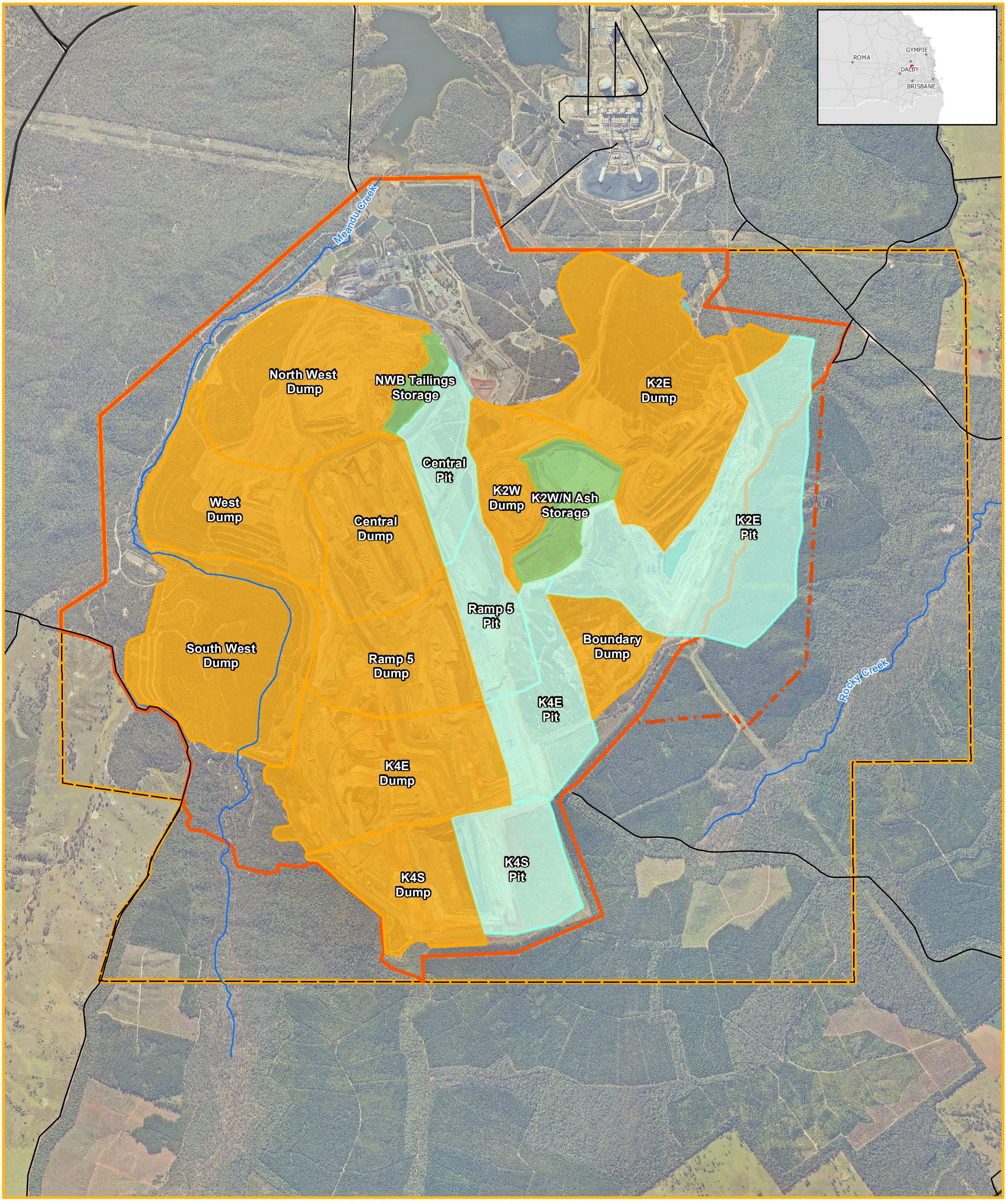
2.3.3 Factors impacting on waste placement

2.3.3.1 Initial out-of-pit dumps/K2E box cut

The initial pits at Meandu Mine placed waste out-of-pit in the central portion of the surface rights area. As pits have become depleted, waste and rejects have now been able to be placed in pit or in in pit advancing waste dumps at elevation above original surface. This includes historical out-of-pit waste dumps that have now been relocated and incorporated into the landform design. The pit and dump boundaries at the Meandu Mine are shown on Figure 2.27.

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.27
Meandu Mine pit and dump boundaries



Legend

- Approved Surface Rights Area
- K2E ASA
- Mining Lease (ML6674)
- Dump
- Pit
- Storage

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The recommencement of mining in the K2E pit is scheduled for FY2024. Initially the box cut waste material will all need to be dumped out of the K2E pit. It is not feasible to place this material in the K2E dump or on the highwall as there is insufficient space available within the dump footprint or maximum heights. The ash storage at K2W-N remains active and so dumping can also not occur here until the completion of ash placement, desiccation, and capping prior to bulk dumping. This results in a number of years of waste from the K2E pit being dumped to NWB TSF as bulk waste as well as into the Central in-pit dump. After the transition of ash and tailings placement from K2W-N to K4S, and after K2W-N has desiccated and received the initial capping layer, waste from the K2E pit can then be utilised to develop the final landform at K2W-N. Following this period, there is sufficient waste capacity in the K2E dumps to accept the majority of the remaining waste other than that volume required to achieve final landform in the Western pits.

2.3.3.2 Constraints on dig/dump schedule

Multiple thick coal seams are mined in a tight sequence at Meandu Mine, requiring strict adherence to both dig and dump plans to ensure adequate placement capacity of in-pit and above original ground surface dumps to accept the waste material.

Swell factor

Typically, in-situ material at Meandu Mine has a swell factor of 12–15% once blasted or excavated, resulting in an increased placed volume in dumps. As the mine gets deeper, an increasing strip ratio (of waste volume mined per tonne of coal extracted) builds and so the volume of waste to be placed expands with swell accordingly.

Maximum dump height above pit floor for stability

Geotechnical analysis has been completed to evaluate and place a limit on the maximum height of waste dumps above pit floor level. This is a constraint as to the height of dumps and capacity of dumps in the mine plan.

Western dumps reaching target elevation for transition to Beef Cattle Grazing PMLU

Prior to 2022, the Western dump areas have been designed and constructed with a slope profile increasing in elevation from west to east. The waste dumps have been able to accept the incremental strip by strip waste in advance from the working coal mining strip, including accepting a material volume of waste that was originally placed in the early history of Meandu Mine and which has now been reworked and incorporated into the rehabilitation profile.

The continuation of the build in slope elevation of the Western dump areas will cease within the next 1–2 years of operation in accordance with the mine plan and waste material balance in the LOM Plan. The landform will form the Beef Cattle Grazing PMLU “plateau” of lower gradient, which will limit the ability of the western dumps to accept the full volume of waste placement from active mining strips.

Required volume for mixed plant rejects (MPR) cover and Central pit void fill

The majority of MPR cells in the LOM Plan are positioned in the Central and Ramp 5 dump areas, with more limited volume at the more distant K4E dump, and subject to the availability of suitable locations and elevations in the mine schedule for PAF waste placement. Ongoing MPR cell placement requires ongoing supply of NAF dump over waste and eventually adequate NAF volumes for installation of cover.

Sufficient waste and NAF cover is required to be stockpiled to fill the final Central void and tie it into the surrounding landforms.

Required fill for final voids

In the 2021 LOM Plan, TEC Coal has endeavoured to reduce the size (footprint and depth) of the two final voids at the site compared to what is currently shown in the EA, preceding submissions, and in comparison to prior LOM plans.

The Central pit depletes in the period 2032–2037, and the final void is filled with above profile material and direct dumping to key into the western side of the K2W dump.

The K4E pit depletes late in the mine life and K2E pit remains the active coal production pit until cessation of coal mining operations. At the end of the life of the K4E pit, a substantial volume of fill is required to achieve the final landform design and to meet the requirements of long-term geotechnical stability design criteria of the final highwalls.

To provide suitable volumes of NAF fill for both pits requires waste volumes to be built above the final landform profile for later relocation by excavator and truck, or potentially by dozer push or dragline operations.

For the K2E pit, the additional fill material needed to backfill the final void can be accumulated in-pit in the lowwall dump. For the K4E pit, there is insufficient dump room for the necessary backfill material to be stored in-pit prior to it being needed. As a result, this material needs to be placed above final landform and “stockpiled” in dumps until later in the mine schedule when mining of K4E pit is completed. Where possible, this material is stored adjacent to the K4E final void, however, some material needs to be stored in the adjacent Ramp 5 and Central pit dumps to ensure safe geometries are achieved while still progressing as much rehabilitation footprint as is feasible.

Similarly, a substantial volume of waste (including sufficient NAF to meet cover requirements) needs to be provided for the final backfill and coverage of the ash storage facility in the K4S pit at the end of mine life. The K4S pit depleted void remains in use for power station ash and tailings storage after the cessation of coal mining operations (until the coal stocks are depleted and the power station is decommissioned) and is unavailable for waste placement until final ash placement, desiccation and initial capping. The LOM Plan provides for storage of the required volume of fill above final landform at both K4E and K4S dumps to minimise relocation distances at the end of mine life and minimise the disturbance footprint and resources required to achieve the final profile after mining ceases.

Through the above measures, including the placement of power station ash in the depleted voids, the number of final voids is minimised to two, and the area and depth of the final voids is minimised. This is particularly evident in comparison to the preceding LOM Plan and draft final landform included in the current version of the EA. It also results in the average final landform elevation being closer to the original average landform elevation than was achieved in preceding LOM plans.

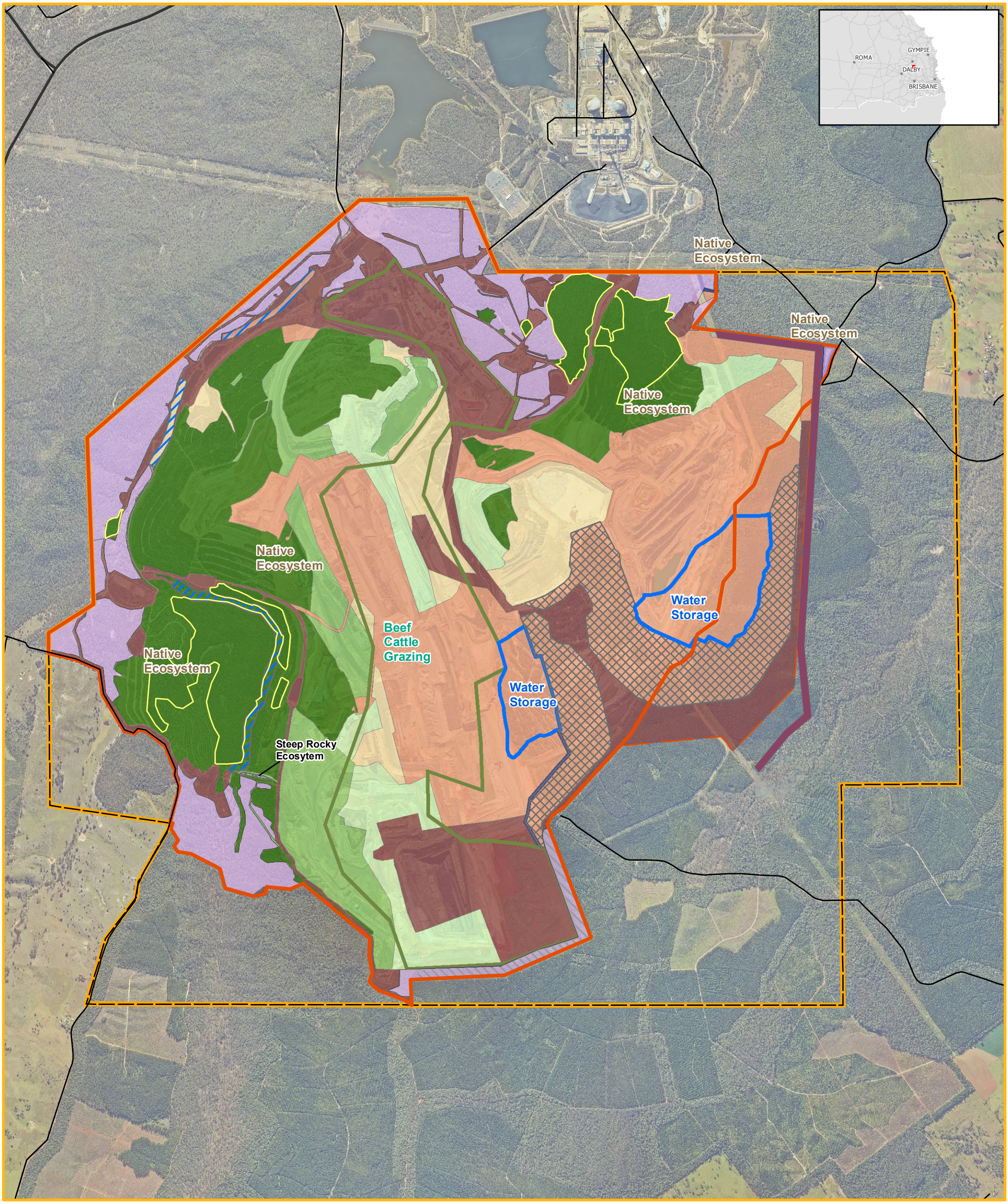
2.3.4 Rehabilitation sequence

This section provides a summary of the Meandu Mine rehabilitation sequence from 1 January 2022 to end of mine life. As can be observed in Figure 2.24 and Figure 2.28:

- current operations in the Western pits (Central, Ramp 5, K4E and K4S) continue with rehabilitation following from west to east, graduating from sloping Native Ecosystem PMLU into the Beef Cattle Grazing PMLU plateau
- K2E commences in late FY2024 / early FY2025. Initial out of pit waste is utilised to build NWB TSF to profile and then is stockpiled for MPR cover and Central final void fill in Central dumps
- the first pit depleted in the Western area is K4S. This pit is then utilised to store ash and tailings, and so waste for fill is placed in the K4S and K4E dumps above final landform design elevation to provision for covering the ash storage facility after mine closure
- Ramp 5 pit is the next Western pit to be depleted. The timing is suitable for scaling up of production from K2E, with the schedule provisioning excess waste from K2E to Ramp 5 after placement at NWB TSF then Central. The MPR cells progress into the Ramp 5 area and are sequentially dumped over with NAF
- once Central Pit is depleted, the stockpiled waste on the Central pit lowwall dumps, supplemented by direct haul/dump from K2E is utilised to fill and tie the pit into the K2W-N western limit to achieve the final landform design. Reshaping is completed in FY2037. The stockpiling of material above profile before this point in time enables the backfilling of this pit and the lack of residual void
- K4E pit is the last western pit to be depleted, approximately 4 years prior to cessation of coal mining operations). The reshaping of the final landform and relocation of requisite waste material stored above the final landform design is complete by the end FY2041
- in K2E, coal mining operations complete in FY2037. This is followed by reshaping of lowwall dumps into the void to achieve the final landform design for the Water Storage PMLU, and any remedial works to support establishment of the Steep Rocky Ecosystem PMLU of the final highwalls (including coal seam cover installation etc). The final profile of the K2E Pit void includes considerable volumes of backfill to reduce the size and depth of the residual void, and this reshaping work is completed by the end of FY2041.

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 2.28
Progressive rehabilitation and certified rehabilitation areas



Legend

- Progressive Rehabilitation Certification Area
- Powerlink Easement - Not a part of PRCP areas
- Approved Surface Rights Area
- K2E ASA
- Mining Lease (ML6674)
- PRCP Undisturbed

PMLU within Surface Rights	Progressive Rehab
Beef Cattle Grazing	CY 21
Creek Diversion	CY 22 - 26
Native Ecosystem	CY 27 - 31
Plantation Forestry	CY 32 - 36
Steep Rocky Ecosystem	CY 37 - 41
Water Storage	CY 42 - 46

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(i) Stanwell Corporation accepts no responsibility for any loss or damage suffered howeverso arising to any person or corporation who may use or rely on this plan in contravention of the terms of this clause or clauses (ii) & (iii)
(ii) The dimensions, areas, number of lots, size & location of corridor information are approximate only and may vary.
(iii) This plan may not be copied unless this note is included.

Scale:	1:30,000
Revision:	DRAFT
Projection:	GDA 1994 MGA Zone 56
Date:	19/05/22
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Source:	Stanwell Corporation Department of Resources

NORTH

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2.3.5 Identification of when land becomes available for rehabilitation

Identification of when land becomes available for rehabilitation is summarised in Table 2.24 by rehabilitation area, in conjunction with the description of relevant activities, active period of activities and the relevant PMLU.

2.3.6 Final Site Design Map

For ease of DES reference the final site design map included in the PRC Schedule is included here as Figure 2.29.

2.3.7 Reference Map – Rehabilitation Areas

For ease of DES reference the reference map from the PRC Schedule showing the rehabilitation areas is included here as Figure 2.30.

2.3.8 Rehabilitation Areas: Rehabilitation Milestone status at commencement

Three of the Rehabilitation Areas noted in Figure 2.30 commence the PRC Plan significantly advanced in the sequence of rehabilitation milestones. This is due to the extensive existing rehabilitation undertaken at Meandu Mine. A summary of the status of these areas is in Table 2.23. The total area shown in Table 2.23 is 613.7 ha, slightly less than the cumulative 631 ha of rehabilitation to date, the difference representing the small area of historic rehabilitation that is necessary to be resumed for mining progression.

Table 2.23 Rehabilitation Areas – start Rehabilitation Milestone

Rehabilitation area	RM4	RM6	RM9	Justification of start rehabilitation milestone
RA5 – Native Ecosystem		449.1 ha	152.8 ha	Areas shown as complete to first milestone in Figure 2.29 have been profiled to required design gradient, topsoiled and seeded with a native ecosystem species mix. Rejects have been placed at least 6 m below final landform surface for areas constructed since 2016. Areas identified as complete to RM9 have been progressively certified (refer to Figure 2.28).
RA7 – Steep Rocky Ecosystem	0.4 ha			SW pit endwall has been excavated to final design.
RA8 – Creek Diversion		11.4		Southern (2005) diversion has been profiled, topsoiled and seeded according to criteria in approved design report (URS, 2010).
Total	0.4 ha	460.5 ha	152.8 ha	

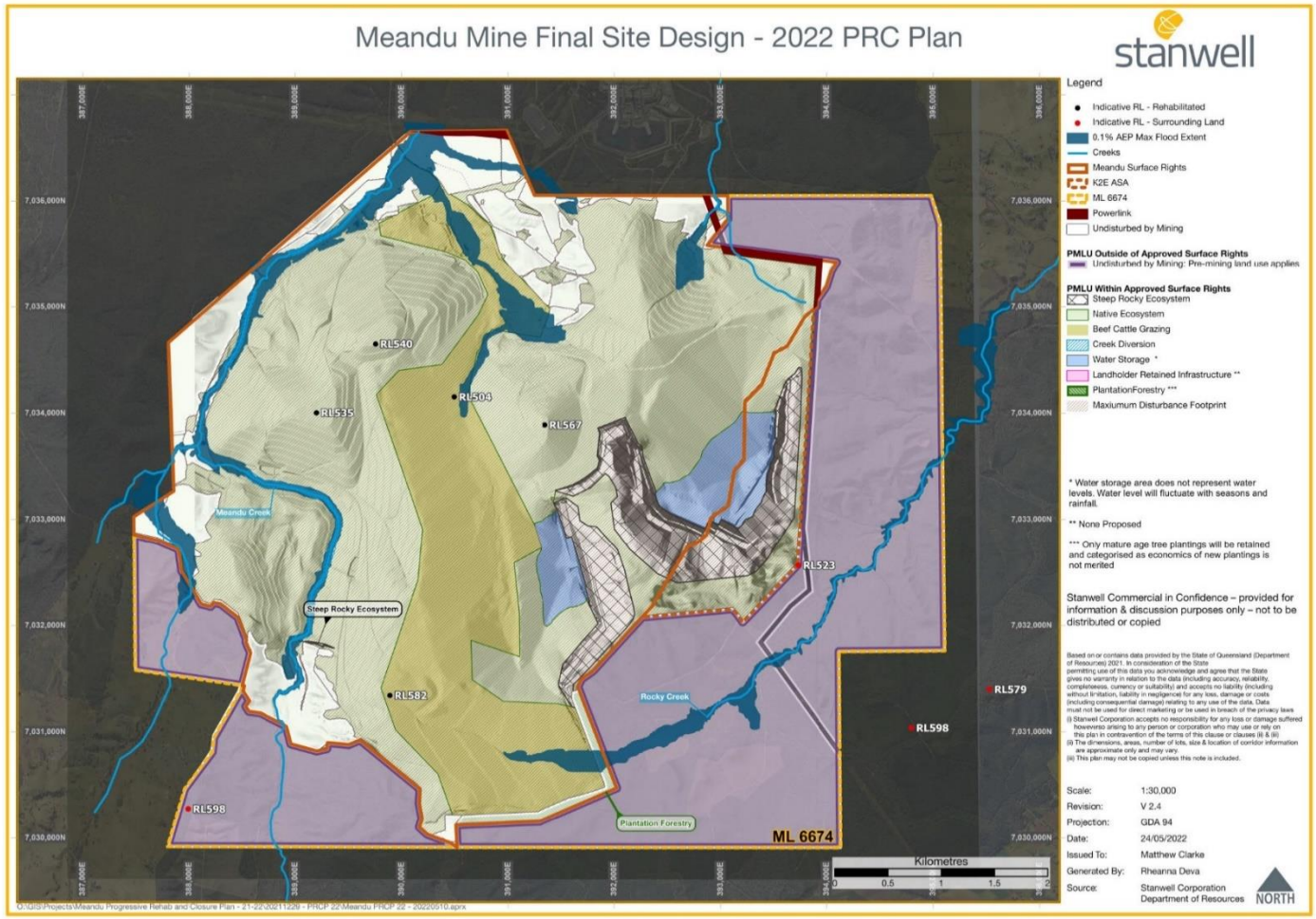


Figure 2.29 Final Site Design Map – 2022 PRCP

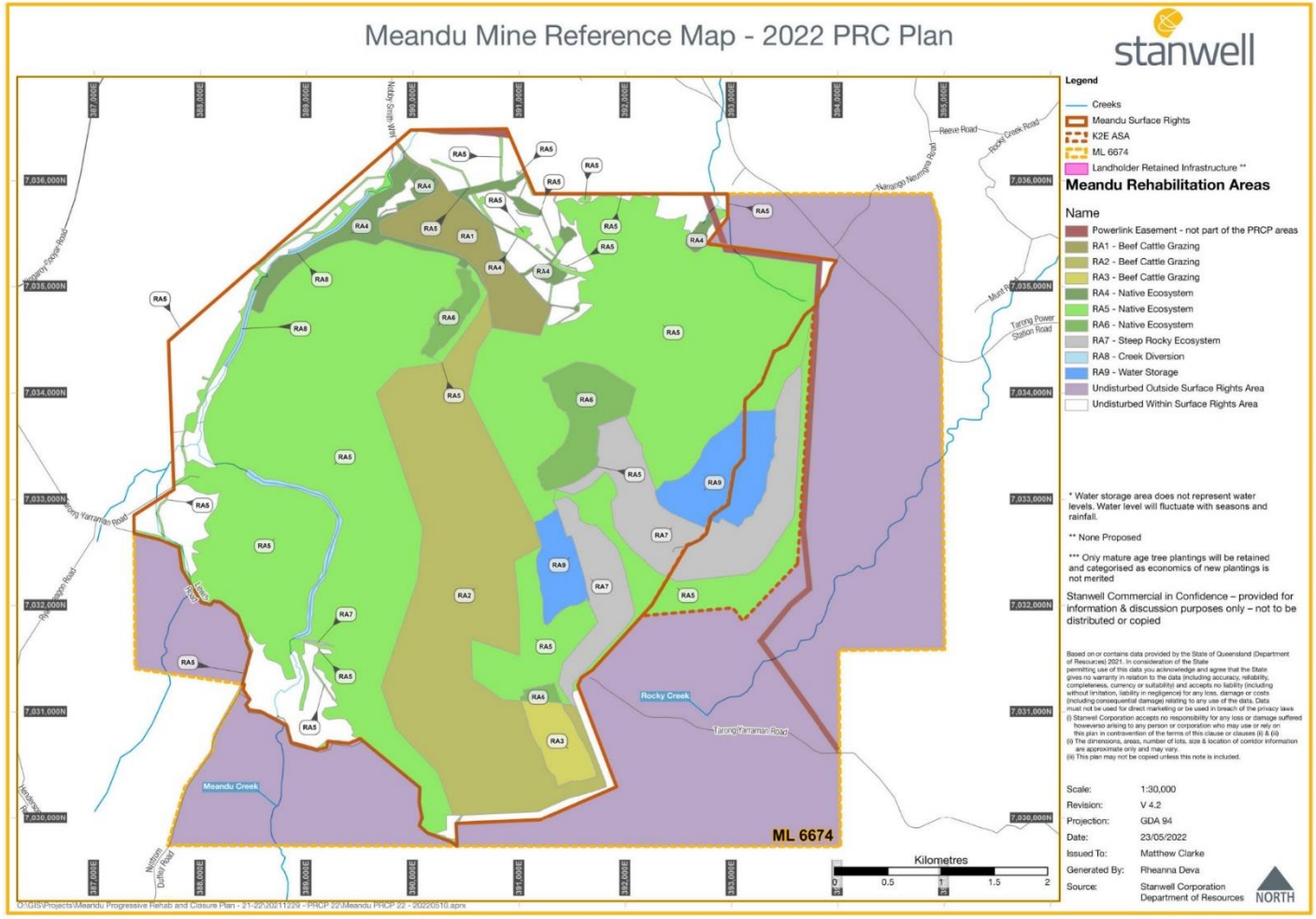


Figure 2.30 Reference map – Meandu Mine Rehabilitation Areas – 2022 PRCP

2.4 Rehabilitation/improvement planning

Legislative requirements:

In order to meet the legislative requirements in sections 126C(1)(b) and (c)(ii) of the EP Act, the rehabilitation planning part must include:

- identification of all relevant activities on the mine site
- the predicted duration of each of the relevant activities proposed for the mine site
- the size/extent of the relevant activities
- whether the different relevant activities can be progressively rehabilitated.

Under section 126C(1)(j) of the EP Act, transitional PRC plans must also include the following details about any existing rehabilitation already completed at the time of submission of the proposed PRC plan:

- a description of the rehabilitation works previously carried out
- when the rehabilitation works commenced and were completed
- whether the rehabilitation has been applied for or approved as progressively certified under the EP Act.

Spatial information outlining the location of all existing rehabilitation must also be submitted as part of the proposed PRC plan.

2.4.1 Relevant activities

The relevant activities at Meandu Mine that will require rehabilitation are provided in Table 2.24. This table provides information on the duration of each activity from when the activity commences until the area is available for rehabilitation.

The activities are grouped by rehabilitation area (RA). A rehabilitation area is defined in the PRC Plan Guideline as an area of land in the post-mine land use to which a rehabilitation milestone for the post-mining use relates. The RAs for Meandu Mine are referred to throughout this PRC Plan and are summarised in Table 2.24. These are further detailed in Part B: Section 9 PRC Plan Schedule. For ease of reference, Figure 9.2 from the PRC Plan Schedule is repeated here as Figure 2.30.

Table 2.24 Relevant activities requiring rehabilitation at Meandu Mine

Relevant activity and assigned RAs	Duration of rehabilitation activities	Size (ha)	Availability for progressive rehabilitation	Proposed PMLU
RA1: Infrastructure	2043–2046	78.2	Available for progressive rehabilitation from 2042	Beef Cattle Grazing
RA2: General mining activity	2029–2046	445.8	Available for progressive rehabilitation from 2029	Beef Cattle Grazing
RA3: Ash and tailings storage	2038–2046	31.8	Available for progressive rehabilitation from 2038	Beef Cattle Grazing

Relevant activity and assigned RAs	Duration of rehabilitation activities	Size (ha)	Availability for progressive rehabilitation	Proposed PMLU
RA4: Infrastructure	2043–2039	67.4	Available for progressive rehabilitation from 2042	Native Ecosystem
RA5: General mining activity	Current–2046	1447.4	Available for progressive rehabilitation from 2021	Native Ecosystem
RA6: Ash and tailings storage	Current–2046	79.5	Available for progressive rehabilitation from 2021	Native Ecosystem
RA7: Excavated highwalls (general mining activities)	Current–2046	204.0	Available for progressive rehabilitation from 2021	Steep Rocky Ecosystem
RA8: Meandu Creek Diversion – South, Central and North (general mining activity)	Current–2039	19.0	Available for progressive rehabilitation from 2021	Creek Diversion
RA9: K2E final void, K4E final void (general mining activity)	2038-2046	107.4	Available for progressive rehabilitation from 2038	Water Storage
Undisturbed within Surface Rights Area	–	326.3	Undisturbed Within Surface Rights Area (no rehabilitation will be required)	
Undisturbed within ML6674 and outside Surface Rights Area	–	1414.3	Undisturbed Outside Surface Rights Area (no rehabilitation will be required)	
Powerlink easement		45.4	Powerlink responsible for management and mining activities are restricted. Areas disturbed by mining activities (e.g. which are planned to cease to be part of the easement and are within the K2E pit and dumps footprint) are assigned a PMLU as part of the PRC Plan. Areas undisturbed by mining activities do not form part of the PMLU allocated and retain pre-mining land uses.	
Total		**4266.6**		

2.4.2 Rehabilitation milestones

As required under section 126D of the EP Act, rehabilitation milestones for all rehabilitation areas that have a PMLU at Meandu Mine have been developed, identifying each significant event or step necessary to rehabilitate the land to a stable condition.

In developing the rehabilitation milestones, consideration has been given to the reference milestones provided in the PRC Plan Guideline, the PRC Plan risk assessment (Section 7) and PMLUs allocation (Section 4.1.2), and as required other site-specific factors.

The following sub-sections provide a description of how the relevant rehabilitation milestones are developed.

2.4.2.1 Consideration of Meandu Mine Land Outcome Documents (LODs)

Milestones and criteria need to consider the technical requirements from contributing specialist reports to the PRCP as well as relevant LODs (refer Table 1.1). The primary LOD document considered in developing milestones and criteria is the Meandu EA EPML00709113. Secondary LODs assessed while finalising the milestones included:

- Waste Management Plan; and
- Plan of Operations.

While not considered a LOD, the development of this PRC Plan has also considered the applicable Landholder agreements in regard to PMLU and suitability.

Table 2.25 details the information that was considered during milestone development from review of the above documents.

Table 2.25 Rehabilitation milestone considerations based on LOD review

LOD reviewed	Rehabilitation Milestone considerations
EA EPML00709113:	
Appendix 7 – Final land use and rehabilitation success criteria for landforms	The items listed in Appendix 7 are consistent with/and have been adequately transitioned to the Rehabilitation Milestones.
Condition D8	Decommissioning of bores must be in accordance with the minimum Standard of Water Bores in Australia – Addressed by RM1.
Condition G1 to G15	Conditions are consistent with the RMs. Condition G8 Deep Drainage (seepage) – Deep drainage (seepage) from the domain is non-polluting to recognised groundwater sources as assessed by an appropriately qualified person. This is addressed by RM8.
Conditions H12, H27 and H28	Decommissioning of regulated structures – Addressed by RM1 and RM4.

LOD reviewed	Rehabilitation Milestone considerations
Waste Management Plan (28 July 2020 version):	

Sections 6.8 and 7.7	For the Tailing Storage Facility (TSF), Section 6.8 of the report implied the following rehabilitation steps are critical to form part of the 'milestones':
	• capping
	• incorporation into final landform design
	• drainage works (graded banks and rock waterways)
	• topsoil placement
	• contour ripping and seeding
	• post-seeding, the rehabilitated area will be assessed as per the site Land Rehabilitation Inspection Checklist (8512-SE-F1125) to ensure it meets the relevant quality criteria as stated in Schedule G of the EA; and
	• ongoing maintenance and monitoring.
	For Ash Storage areas (applicable to Central Pit, K4S, K2W-N, K4E. K2E, Ramp 5), Section 7.7 of the Waste Management Plan stated the following rehabilitation steps are critical to form part of the 'milestones':
	• desiccation phase (if required)
	• cover materials identification (suitability, NAF, low permeability)
	• construction design: geo-mechanical analysis, verification testing
	• final cover system
	• capping depth:
	  ○ planned construction sequence
	  ○ first spoil layer
	  ○ subsequent dumping to final landform
	• landform surface drainage
	• topsoiling
	• final rehabilitation works (ripping and seeding)
	• monitoring and maintenance.
	The above points are addressed by RM3 and RM4.

Plan of Operations January 2019 – December 2020 (rev date: 14/12/2018)	
Section 6	Section 6 of the Plan of Operations lists the following rehabilitation steps are critical to form part of the 'milestones': • landform preparation • erosion control • topsoil placement; and • ripping and seeding. These items are consistent with and are addressed by RM4, RM5 and RM6.

The review of the three LODs suggests that the information should be considered for rehabilitation milestone development from the current EA EPML00709113 and the Plan of Operations January 2019 – December 2020 (rev date: 14/12/2018) are covered in the rehabilitation milestones.

2.4.2.2 Development of relevant milestones

Table 2.26 outlines the nine rehabilitation milestones for Meandu Mine and their relationship to the reference milestones in the PRC Plan Guideline.

Table 2.27 through to Table 2.35 outline the general success criteria prescribed in the Meandu Mine EA and their relevance to each rehabilitation milestones, rehabilitation area and PMLUs for the development of this PRC Plan.

TEC Coal assessed the reference milestones in the PRC Plan Guideline against the LODs and objectives for the rehabilitation at Meandu Mine. Where applicable and appropriate to the site-specific conditions and outcomes required for each PMLU, the reference milestones were adopted. This covered seven of the nine rehabilitation milestones as noted in Table 2.26.

Table 2.26 Meandu Mine rehabilitation milestone reference comparison to PRC Plan Guideline reference milestones

Milestone reference	Meandu rehabilitation milestone	Equivalent PRC Plan Guideline milestone
RM1	Infrastructure decommissioning and removal	Infrastructure decommissioning and removal
RM2	Investigation and/or remediation of contaminated land	Remediation of contaminated land
RM3	Installation of cover systems over ash and tailings storage facilities	Installation of cover system/cap
RM4	Landform development and reshaping	Landform development and reshaping/profiling
RM5	Surface preparation	Surface preparation
RM6	Revegetation (all applicable PMLUs)	Revegetation
RM7	Achievement of initial surface requirements	Achievement of surface requirements (PMLU specific)
RM8	Water quality at rehabilitated state	No equivalent milestone
RM9	Achievement of PMLU	Achievement of post-mining land use to stable

TEC Coal has proposed one additional site-specific rehabilitation milestone that is not included in the PRC Plan Guideline reference milestones list. This is:

- RM8: Water quality at rehabilitated state.

Table 2.27 Generic and PMLU specific milestone criteria with proposed indicators and milestone criteria justification for Rehabilitation Milestone 1 (RM1)

Milestone reference	Rehabilitation milestone	Generic milestone criteria	Additional PMLU specific criteria applicable to RM1						
			Beef Cattle Grazing	**Native Ecosystem**	**Steep Rocky Ecosystem**	**Plantation Forestry**	**Creek Diversion**	**Water Storage**	**Landholder Retained Infrastructure**
RM1	Infrastructure decommissioning and removal	**a** All services are disconnected. **b** All buildings demolished and removed. **c** Hardstands and roads (bitumen, blue metal, aggregate etc) are removed. **d** Infrastructure (pipelines, signage etc) are removed. **e** Any non-retained boreholes are decommissioned. **f** Machinery not required for rehabilitation removed off-site. **g** Any fences not needed for safety or security purposes are removed.	**h** The private road that is within the Beef Cattle Grazing PMLU and links the Beef Cattle Grazing PMLU to the end of (the local gazetted road) Nobby Smith Way remains in place to provide all weather vehicle access to the Beef Cattle Grazing PMLU.	No additional criteria.	No additional criteria.	No additional criteria.	No additional criteria.	No additional criteria.	PMLU not utilised.
			INDICATORS and SMART JUSTIFICATION for RM1 criteria						
			Indicator/(s)	**Justification for criteria**	**S – Specific**	**M – Measurable**	**A – Achievable**	**R – Reasonable/relevant**	**T – Time specific**
			Visual inspection and review of: Service termination records. Decommissioning and removal of all built infrastructure listed in the PRC Plan and applicable ERC submission.	The criteria are designed to ensure mining infrastructure and equipment is removed and the area is prepared for the commencement of milestones RM2, RM3 and RM4 as appropriate.	All site infrastructure is covered in the list of items in the PRC Plan and applicable ERC submission and follows a logical demolition sequence that is well established and correlates to the example milestone provided by DES.	Service termination records and checklist for infrastructure removal completed. Subsequent milestones are then able to be completed without disruption.	Process of removal of services and infrastructure is outlined in Section 6.5.3 of this PRC Plan and has been developed by experienced demolition contractors.	Having the site-specific list instead of the generic PRC Plan Guideline list ensures that all infrastructure items are decommissioned and removed prior to any following rehabilitation activities. Completion of the demolition checklist and removal of all listed infrastructure ensures the areas are ready to progress to RM2 or RM4 as applicable.	The PRC Plan Schedule includes the timeframes developed by demolition experts with adequate allowance for potential delays due to weather, transport, critical labour skills or equipment based on both the demolition contractors' professional experience and the experience of TEC Coal in operating Meandu Mine.

Table 2.28 Generic and PMLU specific milestone criteria with proposed indicators and milestone criteria justification for Rehabilitation Milestone 2 (RM2)

Milestone reference	Rehabilitation milestone	Generic milestone criteria	Additional PMLU specific criteria applicable to RM2						
			Beef Cattle Grazing	**Native Ecosystem**	**Steep Rocky Ecosystem**	**Plantation Forestry**	**Creek Diversion**	**Water Storage**	**Landholder Retained Infrastructure**
RM2	Investigation and/or remediation of contaminated land	**a** Contaminated land investigations to be carried out by a suitably qualified person. **b** Removal and disposal, or appropriate treatment onsite, of any contaminated materials or soils. **c** Removal and disposal of plastic/ geofabric liners from dams/leach pads etc. **d** Carry out validation testing to confirm that the remediation/ removal has been completed.	No additional criteria.	No additional criteria.	No additional criteria.	No additional criteria.	No additional criteria.	No additional criteria.	PMLU not utilised.
			INDICATORS and SMART JUSTIFICATION for RM2 criteria						
			Indicator/(s)	**Justification for criteria**	**S – Specific**	**M – Measurable**	**A – Achievable**	**R – Reasonable/relevant**	**T – Time specific**
			Certification as required by a suitably qualified person.	The criteria outlined by DES in the example PRC Plan Rehabilitation milestone 'Remediation of contaminated land' have been assessed as both representative and appropriate criteria for application at Meandu Mine and are therefore adopted as the criteria.	The criteria specifically consider the sequence necessary to ensure that risks to human health and the environment are appropriately managed.	Contaminated land investigation report(s) clearly define activities required to manage any potential ongoing risk to human health and the environment. Validation testing confirms remediation/removal as listed in milestone criteria d.	Contaminated land investigation and remediation will be undertaken to the relevant state and national guidelines, including sampling and analysis verification (SAP) standards. These standards have been developed to be practical and executable.	Demonstrates that the rehabilitation and receiving environment is not negatively impacted by hazardous contaminants. Certification from a suitably qualified person (as required) establishes that the area is ready to proceed to RM4 as applicable.	The PRC Plan Schedule includes timeframes developed from current contamination procedures with allowances for weather, equipment and labour (specific skill) delays.

Table 2.29 Generic and PMLU specific milestone criteria with proposed indicators and milestone criteria justification for Rehabilitation Milestone 3 (RM3)

Milestone reference	Rehabilitation milestone	Generic milestone criteria	Additional PMLU specific criteria applicable to RM3						
			Beef Cattle Grazing	**Native Ecosystem**	**Steep Rocky Ecosystem**	**Plantation Forestry**	**Creek Diversion**	**Water Storage**	**Landholder Retained Infrastructure**
RM3	Installation of cover system over coal combustion products, and tailings storage facilities	**a** Cover systems on tailings and coal combustion productions are designed and installed in such a way as to effectively minimise the infiltration of water into the tailings deposition area and the likelihood of any erosion occurring in the final cover system. **b** Cover systems on coal combustion products and tailings are designed by a suitably qualified and experienced person. **c** Coal combustion products and tailings storage areas have undergone an appropriate period of desiccation to allow safe and effective placement of the initial capping layer. **d** Coal combustion products are at least 2 m below and tailings at least 6 m below final landform surface. **e** Decommissioning report from a suitably qualified person confirming that the facility has been successfully capped, includes a layer to minimise the infiltration of water into the underlying material and, the capped surface levels provide effective drainage of surface runoff to mine drainage systems.	No additional criteria.	No additional criteria.	No additional criteria.	No additional criteria.	No additional criteria.	No additional criteria.	PMLU not utilised.
			INDICATORS and SMART JUSTIFICATION for RM3 criteria						
			Indicator/(s)	**Justification for criteria**	**S – Specific**	**M – Measurable**	**A – Achievable**	**R – Reasonable/relevant**	**T – Time specific**
			Practical completion report required from a suitably qualified and experienced person. Visual inspection as required by a suitably qualified person of cover system during construction and following completion.	The criteria for the milestone have been set such that the land area is appropriately prepared for the following Rehabilitation Milestones (RM4 and RM5). The specific thickness and drainage criteria are consistent with the relevant LOD criteria in the Meandu Mine EA (EPML00709113) for design and placement of appropriate cover systems on stored coal combustion products and tailings.	Site specific requirements have been taken from existing LODs: Meandu Mine EA (EPML00709113) and Appendix K – Meandu Mine Waste Characterisation Report (WSP, 2021).	Practical completion report from a suitably qualified person as per f).	The criteria are based on known and reasonable industry construction techniques that have been implemented successfully at Meandu Mine and adjusted based on site specific experience. Applicable criteria from LODs (Meandu Mine EA EPML00709113 and the Meandu Mine Waste Characterisation Report (WSP,2021)) have been applied.	Successful capping of coal combustion products and tailings is necessary for the longevity of rehabilitation. Current site procedures have been developed from previous successful placement of capping and dust suppression layers and the data from these tasks has been incorporated into this PRC Plan.	The PRC Plan Schedule timeframes have been developed from historical cover system projects that have been undertaken at the Meandu Mine site and are in accordance with industry standards. There is a high degree of confidence in the cover system over coal combustion products and tailings storage facilities in the PRC Plan Schedule.

Table 2.30 Generic and PMLU specific milestone criteria with proposed indicators and milestone criteria SMART justification for Rehabilitation Milestone 4 (RM4)

Milestone reference	Rehabilitation milestone	Generic milestone criteria	Additional PMLU specific Criteria applicable to RM4						
			Beef Cattle Grazing	**Native Ecosystem**	**Steep Rocky Ecosystem**	**Plantation Forestry**	**Creek Diversion**	**Water Storage**	**Landholder Retained Infrastructure**
RM4	Landform development and reshaping	**a** Bulk earthworks achieve required landform mass balance – excluding allowance for access required for ongoing maintenance or required for PMLU purposes. **b** For all landforms constructed after 2016, the upper 6 m of material beneath the final landform surface is NAF. Mixed Plant Rejects (MPR) are located a minimum of 6 m beneath the final landform surface. **c** Subsoil material meets the criteria for the relevant PMLU. **d** Completed general reshaping achieves the overall landform slope. **e** Any designed waterways, drains and erosion and sediment control systems are installed. **f** Non-regulated dams not included as a feature of the final landform design for the PMLU have been filled. **g** Regulated dams/structures have been decommissioned and profiled according to the requirements of the decommissioning and rehabilitation plan for the structure developed by a suitably qualified and experienced person.	**h** Slopes are constructed such that the overall grade meets the following: • 80% of slopes are ≤ 15%, minor areas are up to a maximum of 25% • Factor of Safety ≥1.5 is achieved. **i** Subsoil layer placed as part of the 6 m NAF dump cover is of suitable properties and of sufficient thickness to achieve Class 1, 2 or 3 land suitability criteria for beef cattle grazing as described in Table 6.10 of this PRC Plan.	**j** Slopes constructed such that the overall grade meets the following criteria: • the majority of slopes are ≤ 17%, minor areas are up to a maximum of 25% • Factor of Safety ≥1.5 is achieved.	**k** Slopes constructed such that: • the landform provides a diversity of slopes, including a mix of predominately flat benches and batters up to 80 degrees, that create a varied environment for the future establishment of niche habitats • Factor of Safety ≥1.5 is achieved at the projected stable crest. **l** Install a cover system on exposed residual coal seams where identified as appropriate by a suitably qualified person.	Where pre-mining land surface remains and area is undisturbed by mining, no requirements.	**m** Landform is in accordance with conditions of the approved design plans.	**n** Slopes constructed such that: • Factor of Safety ≥1.5 is achieved	PMLU not utilised.

INDICATORS and SMART JUSTIFICATION for RM4 criteria						
Indicator/(s)	**Justification for criteria**	**S – Specific**	**M – Measurable**	**A – Achievable**	**R – Reasonable/relevant**	**T – Time specific**
Quality assurance and controls on landform construction are in accordance with Section 6.1.5.7 of this PRC Plan and include: • approval of design plans by relevant operations and planning personnel • field verification of construction process by relevant supervisors and technical team members • a survey of the final landform to confirm the overall slope requirements are achieved in accordance with the PMLU specific criteria.	The criteria have been set to ensure that the land area will be ready for surface preparation (RM5). Namely, that the area must have achieved: • surface levels and slopes consistent with the approved final landform design • bulk materials placement within the PMLU subsoil zone is appropriate for the location and the materials have characteristics appropriate for the specific PMLU • drainage and erosion control mechanisms installed as designed.	The specific requirement for landform design and material selection is outlined in the generic and PMLU specific milestone criteria. Water control, drainage and containment addressed by criteria for this milestone (c, e, f)	Regular monitoring against design during implementation with regular site surveys and geotechnical inspections during implementation and at completion.	The design and implementation are based on current site-specific procedures that have been successfully developed and executed during the current site operations. The indicators are listed, along with further executable detail and justification, in Section 6.1.5.7 of this PRC Plan.	Provides a land area that is appropriately built and formed for RM5 (surface preparation). To address drainage and erosion control in preparation for the subsequent milestone(s) including RM5 and RM6.	The PRC Plan Schedule includes timeframes and locality specific considerations that have been developed from the current site procedures and construction times, with allowance made for weather, labour and equipment related delays.

Table 2.31 Generic and PMLU specific milestone criteria with proposed indicators and milestone criteria justification for Rehabilitation Milestone 5 (RM5)

Milestone reference	Rehabilitation milestone	Generic milestone criteria	Additional PMLU specific criteria applicable to RM5						
			Beef Cattle Grazing	**Native Ecosystem**	**Steep Rocky Ecosystem**	**Plantation Forestry**	**Creek Diversion**	**Water Storage**	**Landholder Retained Infrastructure**
RM5	Surface preparation	**a** Remediate active erosion or subsidence as required prior to the application of topsoil. **b** Undertake testing of topsoil prior to spreading such that characterisation can be assessed and the topsoil identified to be suitable for the nominated PMLU. Where necessary, improvements to the soil such as amelioration or blending are to be undertaken to achieve the recommendations for the nominated PMLU. **c** Source, haul and spread topsoil of appropriate properties to a nominal depth of 0.2 m to the applicable footprint (e.g. not including rock armoured areas or constructed drains).	**d** Post topsoil placement, the surface is to be contour ripped to a nominal depth of 0.3–0.5 m to aid in erosion control and vegetation root penetration where needed.	**e** Post topsoil placement, the surface is to be contour ripped to a nominal depth of 0.3–0.9 m to aid in erosion control and vegetation root penetration where needed.	No additional criteria. Note: no topsoil to be placed within the Steep Rocky Ecosystem PMLU [subject to outcomes of the rehabilitation trial].	Where pre-mining land surface remains and the area is undisturbed by mining, no requirements.	No additional criteria.	For clarity, topsoil is to be placed only in the littoral zone[1]. The topsoiled area is to be contour ripped to a nominal depth of 0.3–0.9 m to aid in erosion control and vegetation root penetration where needed. [1] down to the higher of either (i) the lower RL of the modelled void water level fluctuation or (ii) the actual rebounded water level.	PMLU not utilised.
			INDICATORS and SMART JUSTIFICATION for RM5 criteria						
			Indicator/(s)	**Justification for criteria**	**S – Specific**	**M – Measurable**	**A – Achievable**	**R – Reasonable/relevant**	**T – Time specific**
			Quality assurance and controls on surface preparation in accordance with Section 6.1.5.7 of this PRC Plan, with controls specific to RM5 including: • testing of topsoil to ensure adequate characterisation and allocation to the appropriate PMLU and improvements are undertaken where required • a survey of the final landform to confirm topsoil is spread to the nominal depth • survey reconciliation of topsoil register at the completion of works to ensure accurate tracking of available material.	The criteria have been set to ensure that the surface is at a state that is appropriate for revegetation to take place (RM6) – namely that the surface must achieve the requirements of Section 6.1.4 of this PRC Plan, including: • appropriate topsoil type and thickness for the selected PMLU • amelioration undertaken to achieve appropriateness of stability, water holding capability, resistance to erosion and nutrients for the vegetation.	Topsoil appropriate to the relevant PMLU will be used, with surface works and amelioration/blending undertaken as needed.	The indicators list key metrics including soil parameters and overall thickness that can be observed and reported.	Meandu Mine has 153 ha of certified rehabilitation that was rehabilitated using the surface preparation methods underpinning this milestone. The processes utilised successfully for the Native Ecosystem PMLU certification have been adopted with expert external input for the other PMLUs as necessary. The methods used are consistent with methods used successfully at Meandu Mine and across the industry.	Ensures that each rehabilitation area is appropriately prepared to undertake successful revegetation (RM6) for the specific PMLU.	The PRC Plan Schedule includes timeframes that are based on the current Meandu Mine site specific procedures, with allowance made for weather, labour and equipment related delays.

Table 2.32 Generic and PMLU specific milestone criteria with proposed indicators and milestone criteria justification for Rehabilitation Milestone 6 (RM6)

Milestone reference	Rehabilitation milestone	Generic milestone criteria	Additional PMLU specific criteria applicable to RM6						
			Beef Cattle Grazing	Native Ecosystem	Steep Rocky Ecosystem	Plantation Forestry	Creek Diversion	Water Storage	Landholder Retained Infrastructure
RM6	Revegetation (all applicable PMLU's)	**a** Species selection is in accordance with the specific criteria for each PMLU. **b** Species seeding rate and/or tubestock planting rate is in accordance with the requirements of the specific criteria for each PMLU.	**c** Species selection and seeding rates comprise: • a mixture of annual and perennial pasture species • a high percentage of 3P grasses (palatable, productive and perennial) • inclusion of desirable forbs (e.g. legumes) • species that flower in different seasons • where assessed as necessary, achievement of an initial cover crop. **d** Light grazing, or slashing, to take place during the first summer/autumn season after the pasture seeds. **e** Species mix and seed rates is adjusted where necessary in line with the results of the Beef Cattle Grazing Trial. **f** Shelter belts of trees, with appropriate species selected from the Native Ecosystem PMLU species mix to be in 50–100 m widths.	**g** Species selection and seeding rates comprises a mixture of plant species similar to local regional ecosystems (RE), based on benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7.	No seeding rate requirements apply, adjusted, if necessary, in line with the results of the Steep Rocky Ecosystem monitoring trial.	Where pre-mining land surface remains and area is undisturbed by mining, no requirements.	**h** Vegetation is to be a mixture of plant species substantially reflecting on those found in local riparian regional ecosystem (RE 12.3.3), with species and seeding rates to be suitable for wet ground conditions or irregular inundation.	**i** Species selection only applies to the littoral zone[1]. Vegetation is a mixture of plant species substantially reflecting those found in local riparian regional ecosystem (RE 12.3.3), with species and seeding rates suitable for wet ground conditions or irregular inundation. [1] down to the higher of either (i) the lower RL of the modelled void water level fluctuation or (ii) the actual rebounded water level.	PMLU not utilised.

INDICATORS and SMART JUSTIFICATION for RM6 criteria						
Indicator/(s)	**Justification for criteria**	**S – Specific**	**M – Measurable**	**A – Achievable**	**R – Reasonable/relevant**	**T – Time specific**
Monitoring and controls as specified in Section 8 of the PRC Plan and including: • completion of seeding to target rates • visual inspection of revegetation area.	The PRC Plan and Revegetation Plan (Appendix L) outlines the appropriate inputs and assessment of the criteria for successful establishment of a stable PMLU (RM7). Analysis of seed mixes includes the forecast impacts of climate change; for Meandu Mine this is modelled as slightly drier and marginally warmer, no artificial watering support and bushfire resistance.	The species mix and seed rates are specific for each PMLU and are aligned with local RE for Native Ecosystem, Creek Diversion and Water Storage (littoral zones), and aligned to productive cattle grazing pasture strategy for the Beef Cattle Grazing PMLU.	Seeding rates and species mix are defined and able to be measured.	The Meandu Mine site has 153 ha of certified rehabilitation that was rehabilitated using the processes and criteria that are detailed in this and the preceding Rehabilitation Milestones.	Develops the species diversity and density required to achieve successful future vegetation and surface requirements in RM7, RM8 and RM9.	The PRC Plan Schedule includes timeframes that are based on the current Meandu Mine site experience with the seeding and establishment of vegetation, with allowance made for weather, labour and equipment related delays.

Table 2.33 Generic and PMLU specific milestone criteria with proposed indicators and milestone criteria justification for Rehabilitation Milestone 7 (RM7)

Milestone reference	Rehabilitation milestone	Generic milestone criteria	Additional PMLU specific criteria applicable to RM7						
			Beef Cattle Grazing	**Native Ecosystem**	**Steep Rocky Ecosystem**	**Plantation Forestry**	**Creek Diversion**	**Water Storage**	**Landholder Retained Infrastructure**
RM7	Achievement of initial surface requirements	**a** Monitoring of vegetation to confirm that species growth and composition is appropriately progressing to meet requirements of the criteria for RM9. **b** Monitoring of landform condition to demonstrate that the land remains stable and non-polluting. **c** Intervention and remediation as required to maintain a trajectory that will achieve RM9. **d** Maintenance of any access required for monitoring and fire safety. **e** Installation of any required land improvements in accordance with the specific criteria for each PMLU.	**f** Regular light grazing/slashing is undertaken to encourage growth and continue self-seeding cycle. **g** Rapid assessment in year 1. Monitoring of land capability utilising dry season yield per hectare in years 3 and 5 and every 5 years thereafter. **h** Stock fencing is installed where required.	**i** Rapid assessment in year 1. BioCondition assessment in years 3 and 5 and every 5 years thereafter. **j** Number of native species of native trees, shrubs and grasses equals or exceeds the RM9 criteria of 4, 6 and 4.	**k** Presence of a mosaic of bare and vegetated land surfaces. **l** Presence of a variety of plant assemblages. **m** Plant assemblage structure consistent with that occurring on the trial sites.	Where pre-mining land surface remains and area is undisturbed by mining, no requirements. Otherwise: **n** for Hoop Pine Plantations ≥ 150 trees per hectare **o** for Hardwood Plantation ≥ 100 trees per hectare.	**p** Records retained of as-built drawings and certification that creek diversions are operating in accordance with approved design and associated criteria. **q** Vegetation establishment and geotechnical stability assessed at years 1, 3 and 5, and every 5 years thereafter. Morphological stability assessed every 5 years.	**r** Bi-annual water quality monitoring between years 1–10 with analysis by a NATA accredited laboratory. Analytes monitored are to include: TDS, Calcium, Magnesium, Nitrate, Nitrite, Sulfate, Cobalt, nickel, Zinc, Arsenic, Boron, Selenium, Molybdenum, Fluoride. **s** Vegetation establishment for the littoral zone[1] assessed at years 1, 3 and 5, and every 5 years thereafter. [1] down to the higher of either (i) the lower RL of the modelled void water level fluctuation or (ii) the actual rebounded water level.	PMLU not utilised.

INDICATORS and SMART JUSTIFICATION for RM7 criteria						
Indicator/(s)	**Justification for criteria**	**S – Specific**	**M – Measurable**	**A – Achievable**	**R – Reasonable/relevant**	**T – Time specific**
Monitoring and controls as specified in the generic milestone criteria and additional specific criteria for each PMLU.	The criteria for RM7 are specific, and have been developed such that the progression towards RM9 (stable landform and PMLU) is monitored. The criteria require intervention and remediation when appropriate progression towards RM9 is not evident.	The multiple assessment types are detailed with timeframes. The criteria listed require that landform condition, diversity, coverage and growth of vegetation species is tracked.	The nominated monitoring methods are standard industry practice and will provide all necessary data to assess the progress of the PMLU towards RM9 (stable landform and PMLU).	The monitoring and maintenance items have been selected based upon site specific experience, Meandu Mine site specific studies and broad industry experience.	This milestone is relevant and reasonable as it provides timely indications that the rehabilitation process is either progressing the land towards a stable condition or requires maintenance to achieve RM9.	The PRC Plan Schedule includes appropriate timing to allow for vegetation development, with appropriate contingency allowance for weather and climatic delays.

Table 2.34 Generic and PMLU specific milestone criteria with proposed indicators and milestone criteria justification for Rehabilitation Milestone 8 (RM8)

Milestone reference	Rehabilitation milestone	Generic milestone criteria	Additional PMLU specific criteria applicable to RM8						
			Beef Cattle Grazing	**Native Ecosystem**	**Steep Rocky Ecosystem**	**Plantation Forestry**	**Creek Diversion**	**Water Storage**	**Landholder Retained Infrastructure**
RM8	Water quality at rehabilitated state	For the relevant drainage areas upgradient of CP3: **a** Water quality in Meandu Creek shows progressive improvement over time, assessed annually at location CP3 and as indicated by the median concentration of the following analytes pH, Eh, EC, major Ions, Total Alkalinity/Total Acidity & Total Hardness, Fluoride, Ammonia, Nitrate, Nitrite, Copper, Mercury, Cobalt, Iron, Molybdenum, Aluminium, Arsenic, Cadmium, Chromium, Lead, Nickel, Zinc, Boron, Manganese, Selenium, Vanadium. Hardness corrections is applied to metals such as copper to measure acute toxicity to biota. **b** Aquatic ecology health monitoring is undertaken every 3 years in Meandu Creek between RD10 and RD1, and shows a progressive improvement, or is similar to, other ephemeral waterways in the region, with respect to the measurement of (i) aquatic habitat (through bioassessment score) (ii) riparian vegetation and (iii) diversity of macroinvertebrate communities. **c** Groundwater monitoring assessed annually in the NWBV using GW monitoring bores GW34, GW48, GW49 and GW75 (or suitable replacement bores in the NWBV area) demonstrates stable or improving median levels of the following analytes: EC, pH, TDS, Total Acidity/Total Alkalinity, Total hardness, major ions and metals/metalloids indicative of AMD or SMD. For the relevant drainage area upgradient of CP4 (QW): **d** Monitoring of movement and/or concentration of EC levels indicates a trend that salinity is not increasing and remains static to the extent that likelihood of future mobilisation towards the receiving environment (Meandu Creek) at existing concentrations is unlikely to cause any detrimental impact. For the relevant drainage area associated with location CP2 (BC): **e** Monitoring of movement and/or concentration of EC levels indicates a trend that salinity is not increasing and remains static to the extent that likelihood of future mobilisation towards the receiving environment (Meandu Creek) at existing concentrations is unlikely to cause any detrimental impact.	No additional criteria.	No additional criteria.	No additional criteria.	Where pre-mining land surface remains and area is undisturbed by mining, no requirements.	No additional criteria.	No additional criteria.	PMLU not utilised.
			INDICATORS and SMART JUSTIFICATION for RM8 criteria						
			Indicator/(s)	**Justification for criteria**	**S – Specific**	**M – Measurable**	**A – Achievable**	**R – Reasonable/relevant**	**T – Time specific**
			Monitoring of analytes as specified in the generic milestone criteria for RM8.	RM8 protects the health of the receiving environment by considering groundwater, surface water and the Water Storage PMLU. The criteria addresses both water quality and ecological indicators, providing an appropriate and thorough method for assessing the health of the system and the status (e.g. trends) of any contaminants of concern.	Specific analytes for all relevant water qualities are specified in the generic milestone criteria for RM8. Specific criteria for aquatic ecology in Meandu Creek are specified in the generic milestone criteria for RM8.	The specific analytes and conditions are defined within the milestone criteria.	The water qualities apply to the relevant analytes and have been developed with the appropriate industry experts for ecological values, geochemistry and water systems.	The criteria have been developed to maintain a healthy aquatic ecology in the receiving environment, including Meandu Creek adjacent to Meandu Mine and in Meandu Creek Dam downstream of the mine.	Detailed timings for monitoring of the analytes in the specific locations are included in the generic milestone criteria for RM8.

Table 2.35 Generic and PMLU specific milestone criteria with proposed indicators and milestone criteria justification for Rehabilitation Milestone 9 (RM9)

Milestone reference	Rehabilitation milestone	Generic milestone criteria	Additional PMLU specific criteria applicable to RM9						
			Beef Cattle Grazing	Native Ecosystem	Steep Rocky Ecosystem	Plantation Forestry	Creek Diversion	Water Storage	Landholder Retained Infrastructure
RM9	Achievement of PMLU	**a** A hazard assessment by an appropriately qualified and experienced person is undertaken and concludes that safety hazards in the applicable PMLU are analogous to the hazards in equivalent land use sites in the surrounding unmined landscape. [Note: Use of an equivalent land use site does not apply to the Steep Rocky Ecosystem or Water Storage PMLUs, however hazard assessments are required for both, consistent with the PMLU specific criteria in this table]. **b** Indicators for runoff demonstrate the following suitable water quality parameters for EC and pH: ○ pH: 5.5–9.0 (median) ○ EC: <2037 µS/cm (median) [Note: does not apply to Water Storage PMLU or the undisturbed by mining Plantation Forestry PMLU].	**c** A land suitability assessment is undertaken by an appropriately qualified and experienced person using 'Regional Land Suitability Frameworks for Queensland (2013)', which confirms that grazing land meets either Class 1, 2 or 3 land suitability for grazing. **d** >50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 18%. **e** >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 18%.	**f** >50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 20%. **g** >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 20%. **h** Vegetation comprises a mixture of plant species similar to local regional ecosystems based on benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7. **i** Number of native species of native trees, shrubs and grasses equals or exceeds 4, 6 and 4 respectively. **j** Tree canopy cover is at least 20%.	**k** A hazard assessment is undertaken by an appropriately qualified and experienced person, which confirms an acceptable residual hazard ranking is achieved. [Note: Comparison to an equivalent land use site is not required].	Where pre-mining land surface remains and area is undisturbed by mining, no requirements. Otherwise: **l** a land suitability assessment is undertaken by an appropriately qualified and experienced person using 'Regional Land Suitability Frameworks for Queensland (2013)', which confirms that plantation land meets either Class 1, 2 or 3 land suitability for plantations. **m** for Hoop Pine Plantations ≥ 150 trees per hectare. **n** for Hardwood Plantation ≥ 100 trees per hectare.	**o** An assessment by an appropriately qualified and experienced person confirms that the creek diversion is functioning as designed and the performance and integrity of the watercourse diversion and/or adjacent watercourses is not threatened. [Note: For the hazard assessment the equivalent land use site in the surrounding landscape is creeks.] **p** Vegetation is a mixture of plant species substantially reflecting those found in local riparian regional ecosystem (RE 12.3.3), with species suitable for wet ground conditions or irregular inundation.	**q** A hazard assessment by an appropriately qualified person is undertaken and confirms that the water storages are designed and constructed such that they are safe for humans, stock and wildlife. [Note: Comparison to an equivalent land use site is not required] **r** Vegetation in the littoral zone is to be a mixture of plant species substantially reflecting those found in local riparian regional ecosystem (RE 12.3.3), with species to be suitable for wet ground conditions or irregular inundation. **s** Water storages contain water of a suitable quality for native wildlife and/or livestock ingestion using the following indicators: ○ TDS: <5,000 mg/L ○ Calcium: ≤1,000 mg/L ○ Magnesium: ≤2,000 mg/L ○ Nitrate: ≤400 mg/L ○ Nitrite: ≤30 mg/L ○ Sulfate: ≤1,000 mg/L ○ Cobalt: ≤1 mg/L ○ Nickel: ≤1 mg/L ○ Zinc: ≤20 mg/L ○ Arsenic: ≤0.5 mg/L ○ Boron: ≤5 mg/L ○ Selenium: ≤0.02 mg/L ○ Molybdenum: ≤0.15 mg/L ○ Fluoride: ≤2 mg/L	PMLU not utilised.

INDICATORS and SMART JUSTIFICATION for RM9 criteria						
Indicator/(s)	**Justification for criteria**	**S – Specific**	**M – Measurable**	**A – Achievable**	**R – Reasonable/relevant**	**T – Time specific**
Assessment by appropriately qualified and experienced person.	The primary LOD (the Meandu Mine EA EPML00709113) conditions have been incorporated into this rehabilitation milestone as they are appropriate to ensure that a stable land condition is achieved.	The site-specific success criteria are detailed for each PMLU. The criteria address each of the four objectives for the rehabilitated landform, that it should be safe, stable, non-polluting and able to sustain the nominated PMLU.	The success criteria cover all aspects of the stable landform and PMLU in accordance with the PRC Plan Guideline.	The success criteria were developed for the Meandu Mine EA in 2020 and approved by DES as appropriate to the Meandu Mine site. In 2021 153Ha of rehabilitation were certified using these success criteria.	The success criteria were developed for the Meandu Mine EA in 2020 and approved by DES as appropriate to the Meandu Mine site. They address each PMLU and each of the rehabilitated landform objectives of safe, stable, non-polluting and able to sustain the nominated PMLU.	The PRC Schedule includes the required timing, through all pre-requisite rehabilitation milestones, to achieve RM9. The schedule includes appropriate contingency allowance for weather and climatic delays.

2.4.2.3 Justification for site-specific milestones

Justification for RM8: Water quality at rehabilitated state

RM8 directly addresses both:

- the PRC Plan risk assessment (Section 7) in regard to the three potential seepages identified in the groundwater technical modelling report by ensuring clear criteria are in place for the groundwater, surface water and receiving environment health
- the Meandu Mine EA criteria G8 – requiring any seepage to be non-polluting to recognised groundwater sources as assessed by an appropriately qualified person.

By introducing an additional rehabilitation milestone RM8, TEC Coal are able to clearly demonstrate in the rehabilitation sequence that the achievement of the water quality outcomes are a critical step towards rehabilitation success and the achievement of the stable landform.

2.4.3 Summary of rehabilitation completed to date

Progressive rehabilitation at Meandu Mine commenced shortly after mining in the mid-1980s (first record in 1985). Up to December 2021, a total of 631 ha of disturbance has been rehabilitated (of which approximately 17 ha is planned to be re-disturbed due to revision of LOM Plan), representing approximately 29% of the total mining disturbance footprint (by December 2021). The majority of the existing rehabilitation has a PMLU of Native Ecosystem. Much of this rehabilitation is contiguous with adjoining Yarraman State Forest and Tarong National Park.

The condition of rehabilitation at Meandu Mine has been comprehensively monitored over the past 25 years. A monitoring and maintenance program has been developed to relate to the PRC Plan RMs and has been included in Section 8.

A summary of the history of the existing rehabilitation including the location, general methodology, when the rehabilitation works commenced and were completed (where records are available), area of rehabilitation for each location at the time and the current status of the area are provided in Appendix L – Meandu Mine Revegetation Plan.

On 7 April 2021, TEC Coal applied for Certification of Progressive Rehabilitation of 214 ha, of which, 153 ha were certified by DES. Figure 2.28 shows the proposed progressive rehabilitation at the Meandu Mine along with the certified rehabilitation areas. Rehabilitation dates shown in Figure 2.28 represent the date when the first relevant milestone for each area is scheduled to be completed.

3 Community consultation

Legislative requirements:

In accordance with section 126C(1)(c)(iii) and (iv) of the EP Act, the rehabilitation planning part of the PRC plan must include:

- details of the consultation undertaken by the applicant in developing the proposed PRC plan, and
- details of how the applicant will undertake ongoing consultation in relation to the rehabilitation to be carried out under the plan.

Guideline: Progressive rehabilitation and closure plans (PRC plans) ESR/2019/4964, Version 2.00, Last reviewed: 17 Mar 2021 (Section 3.5)

In developing the proposed PRC plan, the community should at least be engaged on the plan for the mine, PMLUs or NUMAs, areas of disturbance, rehabilitation and management methods, progressive rehabilitation, and closure timeframes. Ongoing community consultation should continue throughout the stages of the mine life so that progressive rehabilitation and the socio-economic and environmental impacts related to mine closure can be discussed with the community.

Community consultation carried out through different processes (such as an EIS) may be used to address the requirements in section 126C(1)(c) of the EP Act. The details of this consultation must be provided in the rehabilitation planning part of the proposed PRC plan).

Transitional PRC plans are still required to meet the legislative requirements in section 126C(1)(c) of the EP Act. All proposed PRC plans must contain a community consultation plan regardless of whether the site has an existing EA.

Information Note: Community consultation for Progressive Rehabilitation and Closure Plan, ESR/2019/5101, Version 1.00, Effective: 01 Nov 2019

It is the responsibility of the applicant to identify, notify and engage the community regarding the rehabilitation and closure of the site and provide them the opportunity to comment. When selecting members of the community to engage with, applicants must consider who in the broader community is directly influenced by the rehabilitation process or final land outcomes.

This section of the PRC Plan outlines information on community consultation including Stanwell's community consultation register and the Community Consultation Plan (Appendix G).

3.1 Consultation and engagement

Stanwell undertakes regular community consultation and has done so since purchasing Meandu Mine in 2008. Local landholders, community groups, nearby residents, Traditional Owners and the local councils are all important community members in Stanwell's interactions with the local and broader community.

Regular consultation with the local landholders has principally been in the form of site tours, individual property visits and through formally convened (i.e., planned) community information sessions and neighbourhood consultative committee meetings. Members of the community are kept up-to-date with the LOM Plan updates and planned rehabilitation outcomes.

Formal, specific consultation with the community for this PRC Plan was undertaken from May 2020 and is ongoing. Informal consultation occurred prior to 2020 and will continue until the EA is surrendered (at the completion of all rehabilitation). This consultation is in accordance with Stanwell's strategy and plans for community engagement.

Stanwell has undertaken extensive community engagement to assist in the preparation of this PRC Plan.

Stanwell's overarching engagement objective is to ensure identified community groups (representing the broader community) have been adequately informed and have had an opportunity to provide their views and inputs on the PMLUs and are supportive that the end result will be a positive legacy for future generations.

Other key objectives of Stanwell's consultation are listed below.

3.1.1 Engagement objectives

Stanwell will lead the engagement with the community in ways that:

- use clear, accurate and timely communication and in summarised forms that can be readily understood to facilitate clear understanding and support community members making informed responses. Further information and detail may be provided in response to specific questions and supporting discussions
- actively seek out community groups or members with a direct interest in the mine plan, its extent and ongoing rehabilitation methods, staging and outcomes
- establishes accessible and inclusive ways for participation in the development of Meandu Mine and PRC Plan including receiving progress reports during the LOM
- identifies and explains the engagement process, the role of the community in the process, and communicates how community input will be considered and inform the development and revision of Meandu Mine and PRC Plan
- measures Stanwell's engagement activities to understand the effectiveness of the engagement and identify opportunities to improve the quality (e.g., content, clarity etc.) of future engagement.

Stanwell will also ensure that engagement:

- meets the legislative requirements for community consultation ahead of the lodgement of the PRC Plan and ongoing throughout the LOM
- takes a strategically considered approach to identifying those community members or groups with a direct interest in the LOM Plan, its extent and ongoing rehabilitation methods, staging and outcomes, and identifies and includes any new or additional community members or groups that may be identified in the future
- ensures that the personnel involved in developing, managing and administering Meandu Mine and the PRC Plan understand the social, environmental and economic needs and expectations of identified community members or groups, and can articulate how those needs and expectations have been considered
- continues throughout the LOM and PRC Plan
- contributes to the value of the approved PMLUs
- identifies and monitors potential reputational risks with the potential to create future issues that may impact upon Meandu Mine and PRC Plan, rehabilitation methods and staging and scheduled implementation.

Aligned to the requirements set out in Section 3.5 of the PRC Plan Guideline, this section incorporates the following information:

- summary of relevant community members or groups
- overview of consultation tools used through the consultation process
- consultation register
- summary of consultation outcomes; and
- a summary of the Community Consultation Plan (Appendix G).

3.1.2 Relevant community members

The development phase of a PRC Plan offers the community an opportunity to influence the rehabilitation and land outcomes.

Section 3.5 of the PRC Plan Guideline requires proper identification and selection of community members for consultation, reflective of who in the broader community is directly influenced by the rehabilitation process or final land outcomes.

Members of the community may include:

- affected landholders
- traditional owners
- local government; and
- local community groups.

Further, Information Sheet ESR/2019/5101 notes that members of the community should have a genuine interest in one or more of the following:

- the land where the activity will occur
- the land adjacent to where the activity will occur; or
- the land/amenities surrounding where the activity will occur that are likely to be impacted by the activity.

The geographical extent of community members consulted in relation to the Meandu Mine PRC Plan addresses all of the above categories. For ease of understanding, the distribution of consultation within 15 km of Meandu Mine is illustrated in Figure 3.1. This figure does not include the consultation that occurred outside that radius, or after January 2022.



Figure 3.1 PRC Plan Consultation map

For the development of the PRC Plan, Stanwell's engagement focussed on those community members with a genuine interest in the land – which was assessed as falling under one of the following interest categories:

- direct impact – underlying and adjacent land holders
- cultural interest – e.g. indigenous communities, Traditional Owners including Native Title holders
- heritage interest – state or local government or relevant community groups where heritage value is identified on the land the activity is to occur
- recreational interest – relevant community groups who use the immediate, adjacent, upstream or downstream land for recreational purposes
- land use interest – e.g. overlapping tenure holders, agricultural entities or local government where a planning scheme is in place; and
- health interest – e.g. state or local government or relevant community groups who have health concerns relation to the rehabilitation processes and final land outcomes for the Meandu Mine site.

To support the consultation process, a detailed community consultation register was developed and is maintained as part of the Community Consultation Plan (Appendix G). A summary of interest categories used to identify basis for consultation inclusion and derived from the detailed register is presented in Table 3.1.

Table 3.1 details those interest categories Stanwell has identified as having a direct interest in Meandu Mine and PRC Plan and those who will be engaged throughout the development and life of the PRC Plan.
A separate register includes records individual contributions from community members and functions as a tracking tool to ensure Stanwell complies with the final approval.

Table 3.1 Relevant community categories and selection

Interest category	Nature of interest	Basis for engagement
Internal Stakeholders	Direct Land use Environmental Heritage	Stanwell owns the Tarong power stations, Meandu Mine and holds several thousands of hectares of farming land in the Kunioon, Goodger, Hodleigh areas. Each asset's purpose is directly linked to the capacity of the Tarong power stations to generate electricity through to the end of technical life. Consultation with internal stakeholders captured feedback to ensure that consideration of progressive rehabilitation and PMLUs for the purposes of complying with the PRC Plan legislation is aligned to the future rehabilitation of projects at all sites within the South Burnett. This also recognises the importance of aligning the PRC Plan for Meandu Mine with the ongoing development of the Tarong power stations' closure plan.
Make Good Agreement Landowners	Direct Land use Environmental	Stanwell has six make good agreements with adjacent landowners. Although there is no evidence that mining activities within the current surface area of ML6674, including within the K2E ASA, will have any adverse impact, these landowners have expressed concern about their groundwater being impacted by mining operations, and so have a direct interest in the management of Meandu Mine and any post-mining plans.
Adjacent Landowners	Direct Land use Environmental Heritage	In 2017 Stanwell established the Near Neighbour Consultative Committee (made up of over 40 property owners) to ensure community members were provided with opportunities to provide feedback on Stanwell's South Burnett operations and projects, inclusive of Meandu Mine and Tarong power stations. Historically (prior to COVID-19 impacts), Stanwell hosted an annual face-to-face event for neighbours to attend and interact directly with Stanwell employees. The members of this group include adjacent landowners, near neighbours with Stanwell-owned environmental monitoring equipment on their properties, key community members with an interest in Stanwell's operations, local government divisional councillors and near neighbours to the Tarong power stations and Meandu Mine who have expressed concerns or lodged complaints in the past (relating to Stanwell's operations in the South Burnett). Engagement with the near neighbours continues on a regular basis as outlined in the Community Consultation Plan.

Interest category	Nature of interest	Basis for engagement
Downstream	Direct Land use Environmental Heritage	Water releases from Meandu Mine are captured in the Meandu Creek Dam which is operated by the Tarong power stations. The Meandu Barker Creek Water Advisory Committee (MBCWAC) was established in conjunction with the construction of Tarong Power Station. The Department of Regional Development, Manufacturing and Water (DRDMW) who oversee bores and creek irrigation licences also plays a role with Stanwell in ensuring downstream landowners (in particular those who have irrigated agriculture) have a direct line of communication to Stanwell about current and future water release strategies. Stanwell engages directly with the President of the MBCWAC to plan water release strategies for the Tarong power stations. The MBCWAC is comprised of both irrigators and graziers. Stanwell works with MBCWAC and DRDMW to facilitate an annual meeting to discuss issues relating to our water strategy and to provide an update on our operations in the South Burnett.
Traditional Owners	Direct Land use Cultural Recreational	Stanwell currently engages with the Wakka Wakka People via Queensland South Native Title Service, which is the legal representative for the Wakka Wakka People in the Wakka Wakka #3 People native title claim (in which a determination of native title was made by consent on 12 April 2022). The majority of Meandu Mine's surface rights area is situated within the Wakka Wakka #3 People native title claim area. The Wakka Wakka People have also asserted that areas adjacent to the claim boundaries are also part of their traditional country and on that basis, Stanwell has also engaged with the Wakka Wakka People in relation to cultural heritage responsibilities for surface rights area extension projects i.e., Stanwell's 2016 Surface Rights Extension project and King 2 East surface rights extension project.
Local Government	Direct Land use Environmental Heritage	Meandu Mine's surface rights area is located in both South Burnett and Toowoomba Regional Council local government areas (LGAs). Ridge Road forms the boundary between the Toowoomba and South Burnett regional council LGAs and is jointly managed by both regional councils. Both local governments have a potential future social and regulatory responsibility in relation to how the Meandu Mine rehabilitation and PMLUs support their strategic planning. Rates are paid to both of the regional councils relative to the Meandu Mine footprint within each of the LGAs.

Interest category	Nature of interest	Basis for engagement
Historical societies and local historians	Land use Environmental Heritage Cultural	Stanwell recognises that Meandu Mine was built on property owned by long-standing community members, some of whom continue to remain active in the community or own other property adjacent to Meandu Mine. Meandu Mine is located within the original Tarong Station footprint, one of many large cattle stations spread across the eastern Darling Downs. The local area, particularly with Nanango being Queensland's fourth oldest town, is well known for documenting and celebrating its history. Stanwell's operations and projects have disrupted inter-generational ownership as well as a sense of place, and to enable Stanwell to maintain its social licence to operate, historians and representatives from the Yarraman & District Historical Society are actively encouraged to provide feedback and historical context and perspective in relation to PMLUs and ongoing operations.
Underlying/adjacent owners, that are part of the Queensland Government or HQPlantations which manages adjoining State Land	Direct Land use Environmental Health	Government stakeholders with responsibility for or roles in approving how Meandu Mine's operations interact now or in the future with legislated requirements. Government stakeholders who lease State land to Stanwell as the current owner of Meandu Mine, and who may be requested in future to consider an application to freehold these leasehold parcels. Commercial stakeholders who hold an underlying interest in land within ML6674 and who currently have commercial leases or business operations on that land. Potential future interest in PMLUs, such as plantation forestry.
Local community and environmental groups	Direct Land use Environmental Heritage Recreational Health	Stanwell's long established community relations networks include active feedback from and support for local community organisations including rural fire brigades, and environmental groups such as local landcare organisations. Stanwell engages with these organisations in our asset communities and surrounding regions (refer to Figure 3.1). This is to ensure Stanwell’s operations and projects have qualitative local knowledge, to offer employment and other financial support. Meandu Mine's operations interacts with both the Burnett Mary and the Brisbane River catchment systems and are surrounded by State Forest and commercial plantation forestry operations where fire risk management is a constant requirement.

Based on the interest categories identified in Table 3.1 above, a summary of key community members included in consultation are shown in Table 3.2.

Table 3.2 Summary of key community members included in consultation

Community member type	Nature of interest	Consultation group
Internal Stanwell/TEC Coal	Direct Land use Environmental Heritage	Multiple stakeholder groups representing management, engineering, group strategy, legal and the land and property team were engaged (two internal divisions – Operations team and Land Property team)
Make Good Agreement Landowners	Direct Land use Environmental	All make good agreements landowners were consulted
Adjacent/Underlying Landowners	Direct Land use Environmental Heritage	Individual landowners consulted as per Community Consultation Register (refer Section 3.2) Department of Resources Department of Environment and Science (DES) Near Neighbour Consultative Committee HQPlantations
Downstream	Direct Land use Environmental Recreational Heritage	The Meandu Barker Creek Water Advisory Committee (MBCWAC) The Department of Regional Development, Manufacturing and Water (DRDMW) Tarong power stations Recreational Fishing members - Kingaroy Sport Fishing Club
Traditional Owners	Direct Land use Cultural Recreational	Queensland South Native Title Service Wakka Wakka People represented by the Wakka Wakka #3 People Native Title Applicant Group
Local/State Government	Direct Land use Environmental Heritage	South Burnett Regional Council Toowoomba Regional Council local government areas Department of Environment and Science
Historical societies and local historians	Land use Environmental Heritage Cultural	Yarraman & District Historical Society

Community member type	Nature of interest	Consultation group
Underlying/adjacent owners, that are part of the Queensland Government or for HQPlantations who manage adjoining State Land	Direct Land use Environmental Health	Department of Environment and Science (DES) The Department of Regional Development, Manufacturing and Water (DRDMW) Department of Resources (DoR) HQPlantations
Local community and environmental groups	Direct Land use Environmental Heritage Recreational Health	Burnett Mary Group – Burnett Catchment Care Association Queensland Fire and Emergency Services South Burnett Grazing Network Bunya Valley Landcare

3.1.3 Consultation tools and methods

A range of consultation tools were used to engage with the community during the PRC Plan consultation process. These tools included:

- direct community and stakeholder contact (e.g. face-to-face meetings, emails and phone calls)
- online surveys
- information packs
- community information sessions
- local community events
- community newsletters; and
- website articles about Stanwell's progressive rehabilitation.

A summary of the consultation techniques for community and stakeholder groups is outlined in Table 3.3.

Table 3.3 Summary of consultation techniques for community and stakeholder groups

Consultation technique	Make Good Agreement landowners	Adjacent landowners	Downstream	Traditional Owners	Local Government	Historical societies and local historians	Underlying/adjacent owners, that are part of the Queensland Government or for HQPlantations who manage adjoining State land	Local community and environmental groups
Direct community member contact	✓	✓	✓	✓	✓	✓	✓	✓
Online surveys	✓	✓	✓	✓	✓	✓	✓	✓
Information packs	✓	✓	✓	✓	✓	✓	✓	✓
Community information sessions	✓	✓	✓	✓	✓	✓		✓
Local community events	✓	✓	✓		✓		✓	
Community newsletters	✓	✓		✓		✓		
Website/Phone/ Email	✓	✓	✓	✓	✓	✓	✓	✓

Note: Where proposed engagement tactics include face-to-face activities, they will continue to be modified in line with current COVID-19 advice and restrictions at the time. Strategies successfully used to date include small group meetings or one-on-one discussions while socially distanced, online feedback and presentations, video discussions and presentations.

For further detail on each of these consultation methods refer to the Community Consultation Plan included as Appendix G.

3.1.4 Summary of the initial PRC Plan consultation package

At the commencement of preparation for the PRC Plan submission (2020 to 2021), Stanwell undertook an extensive and dedicated consultation program. This included a written pack of information designed to address the requirements listed in the (then current) PRC Plan Guideline (ESR 2019/4964 Version 1.00, dated 01 Nov 2019). A copy of this consultation pack was provided to DES as part of Stanwell's pre-lodgement engagement for the Meandu Mine EA amendment process that resulted in the approval of an amended EA in February 2021. This pack included:

- background on the PRC Plan requirements and the transition
- details on the existing (Native Ecosystem, Water Storage and Retained Infrastructure) and proposed (then new) PMLUs of Beef Cattle Grazing and Plantation Forestry
- details of the LOM Plan mining sequence
- an invitation to provide suggestions and inputs on the PMLU selection and allocation, as well as rehabilitation outcomes and process
- rehabilitation goals and details on the surface rights and disturbance areas
- an overview of the proposed final landform shape and extents for feedback
- the rehabilitation design criteria and the process of how rehabilitation has historically been carried out at Meandu Mine
- indicative maps showing different options for final land use allocations and types to prompt further discussion and feedback
- details and maps showing progressive rehabilitation and progressive disturbance proposed across the LOM Plan
- a series of Frequently Asked Questions and answers; and
- an invitation to provide further feedback in addition to the in-person feedback provided during the individual sessions, through an online survey, a hard copy of a questionnaire or verbally at any point to Stanwell's Community Relations team.

3.2 Community consultation register

Table 3.4 provides a summary of the key consultation undertaken throughout the engagement process, aligned with the requirements of the PRC Plan Guideline and in accordance with section 126C(1)(c)(iii) of the EP Act. The detailed Community Consultation Register maintained for internal records includes a further three columns against each consultation including information on:

- how issues were considered
- decisions/outcomes; and
- commitments.

For the purposes of this submission, these last three requirements are addressed as topics in the following sections.

The version of the Community Consultation Register that is current at the time of submission of this PRC Plan is included as Attachment A of the Community Consultation Plan included as Appendix G.

Table 3.4 PRC Plan community consultation register

Consultation date	Community member/ stakeholder	Consultation type	Information provided	Issues raised by community
November 2019 – December 2021	Make Good Agreement landowners	Phone calls Face to face meetings Attendance at community information session and provision of information pack	Project information Proposed PMLUs Indicative maps Frequently asked questions	Water security Feral animal management Landform – spoil dumps lower/similar to original landforms
November 2019 – December 2021	Adjacent landowners	Phone calls Emails Face to face meetings Attendance at community information session and provision of information pack	Project information Proposed PMLUs Indicative maps Frequently asked questions	Water security Water suitability for stock Feral animal management (dogs, pigs and other pests) Option to purchase land back
June 2020 – November 2021	Downstream landowners	Face to face meetings (information presented at the Meandu Barkers Creek Water Advisory Committee meeting)	Project information Proposed PMLUs Indicative maps Frequently asked questions	Feral animal management (dogs, pigs, vermin and other pests)
August 2021 – September 2021	Traditional Owners	Face to face meetings Information pack provided via email to Wakka Wakka # 3 People Applicant Group via Queensland South Native Title Services and Archeo Cultural Heritage Services Pty Ltd (Technical Advisers)	Project information Proposed PMLUs Indicative maps Frequently asked questions	No feedback provided

Consultation date	Community member/ stakeholder	Consultation type	Information provided	Issues raised by community
June 2020 – December 2021	Local Government	Phone calls Face to face meetings Attendance at stakeholder engagement session and provision of information pack	Project information Proposed PMLUs Indicative maps Frequently asked questions	Ensure that native wildlife returns to the area
May 2020	Historical societies and local historians	Face to face meetings Attendance at community information session and provision of information pack	Project information Proposed PMLUs Indicative maps Frequently asked questions	Pest management Fire management risks Sustainability of timber industry and impacts of logging trucks on local roads
June 2020	Underlying/adjacent owners, that are part of the Queensland Government or for HQPlantations which manages adjoining State Land	Face to face meetings	Project information Proposed PMLUs Indicative maps Frequently asked questions	Fire management risks Acid mine drainage Landform stability (erosion modelling) Water management
May to June 2020	Local Community & Environment Groups	Face to face meetings Attendance at community information session and provision of information pack	Project information Proposed PMLUs Indicative maps Frequently asked questions	Native vegetation similar to existing rehabilitation is desirable Water quality Grazing impacts – compacts soil and consumes native vegetation

3.2.1 How the issues have been considered

Stanwell consulted widely with the community prior to commencing detailed work on the PRC Plan, the preparation of supporting LOM plans, review of rehabilitation methods and staging, assessment of final landform and allocation of appropriate PMLUs. This commitment to early and detailed consultation allowed Stanwell to allocate PMLUs in strong alignment with community expectations.

Stanwell has considered the feedback from all consultation and identified three main themes that required addressing in the development of the LOM Plan, review of rehabilitation methods and phasing and selection and allocation of PMLUs and landforms at Meandu Mine:

a include PMLUs that will provide an opportunity for economic return to the community post-mining such as Beef Cattle Grazing and Plantation Forestry
b continue to support and maintain (weed, fire, pest management) the native ecosystem and provide connectivity for fauna throughout the land parcel; and
c ensure that that PMLUs are supported by adequate onsite access to and storage of water (firefighting reserve and wildlife support for Native Ecosystem and stock watering for Beef Cattle Grazing).

As a result of this early feedback and input:

- Stanwell chose to proceed with an application to amend the existing EA EPML00709113 to include an additional two PMLUs: Beef Cattle Grazing and Plantation Forestry. This process entailed further engagement and feedback from DES, which resulted in the creation and approval of two further PMLUs: Creek Diversion and Steep Rocky Ecosystem. The amended EA was approved and issued in February 2021
- it was identified that, as part of the PRC Plan preparation, a land management plan for Meandu Mine required development considering the revised PMLUs and specifically addressing weed, fire and pest management would need to be developed
- it was identified that, in development of the Beef Cattle Grazing (and potentially other PMLUs), connectivity in some form between areas of Native Ecosystem would be required to be provided in regard to both landform design and revegetation
- it was identified that, in design of the final landform, water storage provision is required for supporting (in particular) the Beef Cattle Grazing and Native Ecosystem PMLUs. Consideration and modelling of long-term water levels and quality to ensure that stored waters are of a capacity and suitably located in terms of catchment and groundwater flows was identified as a key assessment requirement.

3.2.2 Outcomes and commitments made by Stanwell

The PRC Plan Guideline requires confirmation of the extent to which each proposed PMLU is consistent with the outcome of consultation with the community in developing the plan. The Meandu Mine PRC Plan is highly aligned to community consultation inputs for all PMLUs (noting that limited or no input was received for PMLUs of Creek Diversion, Landholder Retained Infrastructure and Steep Rocky Ecosystem). The main community interest related to PMLUs of Native Ecosystem, Beef Cattle Grazing, Plantation Forestry and Water Storage.

The feedback received from the community consultation for PMLUs of Native Ecosystem, Beef Cattle Grazing, Plantation Forestry and Water Storage resulted in the following outcomes and commitments in the LOM Plan, this PRC Plan and the associated PRC Plan Schedule:

- The community is strongly in favour of PMLUs with an economic return and particularly in favour of Beef Cattle Grazing. As a result of this feedback, following financial assessment and investigation of appropriate top and sub-soil requirements, Stanwell has included approximately 550 ha of Beef Cattle Grazing in the PMLU allocation for the PRC Plan. This outcome is a direct result of the community consultation and feedback received.
- The majority of the community and near neighbours consulted (including the adjoining plantation forestry licence holder), provided clear feedback that further allocation of Plantation Forestry PMLU within the Meandu footprint would neither provide economic, visual or ecological value to the region. As a result of this feedback, the Plantation Forestry PMLU has been restricted to only existing mature trees, with no additional plantings considered in the PRC Plan.
- The community feedback from near neighbours and other surrounding landholders highlighted the importance of not creating any additional demand for local water resources, and, if possible, increasing water storage. This feedback reinforced the importance of water assessment in the PRC Plan preparations, and the scope of water modelling for the water storages included assessment of the water storage volumes with scenarios for maximum and minimum use to support the associated PMLUs. A balance between the size and extent of final voids and their capacity has been considered and included in the final landform design. Consideration of the location of the final voids has driven the selection of location of void storage of power station ash and tailings to minimise the effects of potential contaminant migration to the water storages selected to ensure that suitable water quality is maintained.
- Many parts of the community expressed a desire for Native Ecosystem to continue to play a major part in the post-closure use of the Meandu Mine footprint. This strong feedback across the different groups consulted was an important consideration in the decision to allocate parts of the future rehabilitation areas to this PMLU, and to facilitate Native Ecosystem connectivity through the Beef Cattle Grazing PMLU by using appropriate species from the Native Ecosystem PMLU as the basis of shelter belts within the Beef Cattle Grazing PMLU footprint.
- The PRC Plan specifically considers each PMLU and addresses management of weeds, pests and fire in response to input from near neighbours and other surrounding landholders. The community acknowledged and commended Stanwell for the impact of the feral animal management measures (see Section 8.4) currently in place, and in particular in relation to positive outcomes of the wild dog baiting scheme.

3.3 Ongoing consultation

The Community Consultation Plan for Meandu Mine is attached in Appendix G. The engagement and communication plan explains how the current and ongoing community consultation regarding the PRC Plan will be undertaken. Stanwell has an existing strategy and commitment to consultation and community relations across all of its activities in the Southern Burnett region, and the PRC Plan consultation will be integrated into these overarching objectives. Table 3.5 summarises the key aspects of the Community Consultation Plan.

Table 3.5 Summary of key aspects of the Community Consultation Plan

Community Consultation Plan					
Objective	**Relevant community members**	**Engagement type**	**Proposed consultation frequency**	**Released information**	**How feedback/comments are considered**
To ensure identified community members maintain their support, have a current understanding and know how they can provide ongoing feedback and receive more information about Meandu Mine's LOM Plan, approved PRC Plan, rehabilitation methods and staging and the progress of rehabilitation.	Internal community members Make Good Agreement Landowners Adjacent Landowners Downstream Traditional Owners Local Government Historical societies and local historians Underlying/adjacent owners, that are part of the Queensland Government or for HQPlantations which manages adjoining State Land Local Community & Environmental Groups	Face to face information and consultation sessions where consulted stakeholder group representatives are present (hosted by Stanwell)	Annually (min) and as scheduled (usually 6 months)	Rehabilitation progress/timelines updates; feedback and consultation on progress and opportunity to gain new information for consideration and/or feedback	Feedback recorded in PRC Plan project portal within Consultation Manager register. Community Relations team and mining teams consider, identify any actions and respond to community members. All feedback to be collated and reviewed minimum annually by Stanwell relevant teams. Community members advised and an agreed response/plan documented and implemented in Consultation Manager.
		Relevant PRC Plan updates included in speech notes where Stanwell is represented at community engagement events (hosted by others)	Ongoing and where invited by others to provide a speech or presentation on current activities	Rehabilitation updates, invitation to identify new information or feedback	

Community Consultation Plan					
Objective	**Relevant community members**	**Engagement type**	**Proposed consultation frequency**	**Released information**	**How feedback/comments are considered**
		PRC Plan update and content included in community and near neighbour newsletters, print and social media	Annually (min); Newsletters (6 monthly) Social Media/print (annually)	Rehabilitation updates, feature stories, education and awareness pieces and feedback options about PRC Plan's progress	
		Stanwell's website	Ongoing	Feature stories, education and awareness pieces and how feedback can be provided	
		Stanwell website – online feedback forms	Ongoing	Where more information can be obtained and feedback provided for Stanwell's consideration	

Community Consultation Plan					
Objective	**Relevant community members**	**Engagement type**	**Proposed consultation frequency**	**Released information**	**How feedback/comments are considered**
To facilitate opportunities where existing and/or new stakeholders who have an identified interest in the PRC Plan and PMLU's can provide ongoing feedback for Stanwell's consideration	Internal community members Make Good Agreement Landowners Adjacent Landowners Downstream Traditional Owners Local Government Historical societies and local historians Underlying/adjacent owners, that are part of the Queensland Government or for HQPlantations which manages adjoining State Land Local Community and Environment groups	Face to Face information and consultation sessions where consulted stakeholder group representatives are present (hosted by Stanwell)	Annually (min) and as scheduled (usually 6 months)	Rehabilitation progress/ timelines updates; feedback and consultation on progress and opportunity to gain new information for consideration and/or feedback	Feedback recorded in PRC Plan project portal within Consultation Manager register. Community Relations team and mining teams consider, identify any actions and respond to community members. All feedback to be collated and reviewed minimum annually by Stanwell relevant teams. Community members advised and agreed response/plan documented and implemented in Consultation Manager.
		Relevant PRC Plan updates included in speech notes where Stanwell is represented at community engagement events (hosted by others)	Ongoing and where invited by others to provide a speech or presentation on current activities	Rehabilitation updates, invitation to identify new information or feedback	

Community Consultation Plan					
Objective	**Relevant community members**	**Engagement type**	**Proposed consultation frequency**	**Released information**	**How feedback/comments are considered**
		PRC Plan update and content included in community and near neighbour newsletters, print and social media	Annually (min); Newsletters (six monthly) Social Media/print (annually)	Rehabilitation updates, feature stories, education and awareness pieces and feedback options about PRC Plan's progress included	
		Stanwell's website	Ongoing	Feature stories, education and awareness pieces and how feedback can be provided	
		Stanwell website – online feedback forms	Ongoing	Where more information can be obtained, and feedback provided for Stanwell's consideration	

3.4 Public interest evaluation (not required)

The final rehabilitated landform of Meandu Mine will not include any NUMAs. NUMAs are defined under section 112 of the EP Act as an area of land the subject of a PRC Plan that cannot be rehabilitated to a stable condition after all relevant activities for the PRC Plan carried out on the land have ended. As there are no NUMAs, a public interest evaluation under the EP Act is not required.

4 Post-mining land use

Legislative requirements:

In accordance with section 126C(1)(d) of the EP Act, the rehabilitation planning part of the PRC plan must state the extent to which each post-mining land use for land identified in the PRC plan schedule for the plan is consistent with:

a the outcome of consultation with the community in developing the plan, and
b any strategies or plans for the land of a local government, the State or the Commonwealth.

PRC Plan Guideline (Section 3.2)

A PMLU is defined under section 112 of the EP Act as the purpose for which the land will be used after all relevant activities for the PRC Plan carried out on the land have ended. Relevant activity for a PRC plan is defined in the EP Act as the relevant activities to be carried out on land the subject of the plan. It is not the intention of this definition to include third-party activities or assets that continue to exist once mining activities have ceased, such as third- party pipeline easements, power easements or overlapping tenures for other EAs.

The rehabilitation planning part of the PRC plan must include a detailed description of the nominated PMLU(s) for the site. The description must include (where relevant), but is not limited to:

- a description of the use of the land
- if applicable, the specific vegetation types (e.g. RE 13.2.9) or land suitability classification (e.g. Class 4)
- identification of any permanent or essential management infrastructure to be included as part of the PMLU
- completion criteria for measuring whether the PMLU has be successfully achieved.

Where a PMLU has been previously addressed in a land outcome document and is able to be transitioned into the PRC plan schedule, the holder is not required to complete the information requirements under section 126C(1)(j) of the EP Act in this section for those PMLUs.

However, the legislative requirements under section 126C(1)(d) of the EP Act still apply. All PMLUs transitioned into the PRC plan schedule must still meet the requirements of a PMLU explained in this section, particularly that the PMLU can be rehabilitated to a stable condition.

4.1 Nominated PMLUs

4.1.1 PMLU types under Meandu Mine EA

ML6674 has seven approved PMLUs under EA EMPL00709113 that are to be transitioned into the PRC Plan:

- Native Ecosystem
- Creek Diversion
- Beef Cattle Grazing
- Plantation Forestry
- Water Storage
- Landholder Retained Infrastructure; and
- Steep Rocky Ecosystem.

An overview of these PMLUs is provided in the following sections with the allocated geographical extent of each PMLU within ML6674 illustrated on Figure 4.1.

4.1.1.1 Native Ecosystem PMLU

The Native Ecosystem PMLU will include areas of vegetation that are similar to three locally occurring regional ecosystems:

- RE 12-9-10.7: *Eucalyptus crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, Angophora spp., *E. melanophloia* woodland on sedimentary rocks
- RE 12.9-10.18: *Angophora leiocarpa*, *Eucalyptus crebra* woodland on sedimentary rocks; and
- RE 12.11.7: *Eucalyptus crebra* woodland on metamorphics +/- interbedded volcanics.

These regional ecosystems comprise open woodland or forest and exist in State forests and National Parks surrounding the Meandu Mine. TEC Coal proposes that the Native Ecosystem PMLU rehabilitation will be similar to these remnant vegetation types, but not specific to any particular regional ecosystem.

The completion criteria for measuring whether the Native Ecosystem PMLU has been successfully achieved are to meet the success criteria outline in the Meandu Mine EA which include:

- A. Native plant species richness reached the following count:
    - Trees ≥4 count
    - Shrubs ≥6 count; and
    - Grass ≥4 count
- B. Cover:
    - Tree canopy cover is at least 20%.

Native Ecosystem is a pre-mining land use of the local area and during the community consultation (refer Section 3), positive sentiment for its inclusion as a PMLU has been received.

The Native Ecosystem PMLU is consistent with the aims of Wide Bay-Burnett and Darling Downs Regional Plans and compatible with the land use zones defined by both the Toowoomba and South Burnett regional council planning schemes (refer Section 4.2).

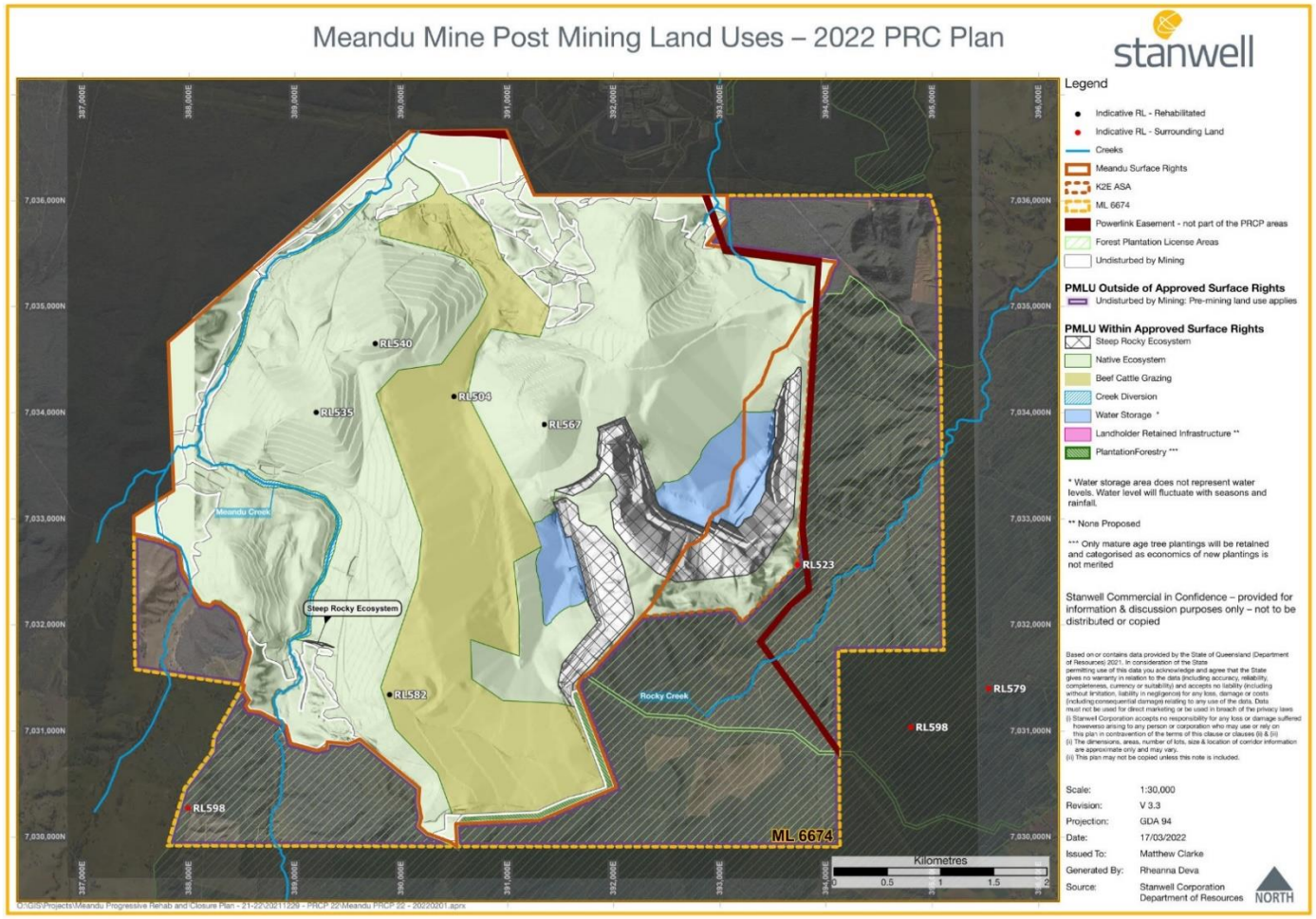


Figure 4.1 Meandu Mine PMLUs' – 2022 PRC Plan

The majority of the undisturbed by mining footprint is assigned the PMLU of Native Ecosystem. These areas will continue to be maintained and managed for weeds, bushfire management and feral animal controls, but will otherwise not be subject to the rehabilitation criteria and milestones. The pre-existing vegetation structures and species mix will be retained in their original state without modification or supplementation.

Where appropriate, shallow retention dams within the Native Ecosystem PMLU footprint will be incorporated as essential management structures to support the re-establishment of fauna within the area. Over time the retention dams will be allowed to naturally regress through silting processes and to establish suitable vegetation. These will continue to act as water sinks and natural ponds mimicking the pre-mining ecosystem along the creek and gully alignments. There are no retention dams within the catchment of the NWBV that will be treated in this manner.

In limited areas in the north-east corner of the existing surface rights area, regrowth of semi-evergreen vine thicket has been observed. This area was cleared as part of historical preparatory works for mining activities in the early 2000's that were subsequently not executed. This area will continue to be monitored and should the semi-evergreen vine thicket regrowth be shown to be on trend at cessation of mining to achieve the canopy and undergrowth cover as per the Native Ecosystem milestone then this ecosystem will be retained in preference to the clearing and re-establishment of open eucalypt forest.

Minor features that form an essential part of the Native Ecosystem PMLUs will be developed and maintained on site. Examples of these items include fire management, weed management and general access trails and the associated minor crossing points in gullies. These items are consistent with the Native Ecosystem PMLU.

4.1.1.2 Creek Diversion PMLU

Diversions of Meandu Creek are included with the PMLU of Creek Diversion. Three sections of creek diversion have historically been constructed within the Meandu Mine surface rights area since mining commenced. These works were undertaken as follows:

- 1985–1986: approximate 1.0 km diversion of Meandu Creek through in-situ material, with RD7 (see Figure 4.2) constructed within the original drainage channel
- 1991–1992: approximate 0.8 km diversion of Meandu Creek through in-situ material, with RD10 (see Figure 4.2) constructed within the original drainage channel; and
- 2000–2005: approximate 2.4 km diversion of Meandu Creek through backfilled spoil, which was approved and constructed under Water Licence 102005 to allow mine progression through the south-west pit area.

The completion criteria for measuring whether the Creek Diversion PMLU has been successfully achieved are to meet the success criteria outlined in rehabilitation milestone RM9. These criteria are designed to demonstrate that the creek diversion is functioning as designed and that the performance of the watercourse diversion and/or adjoining watercourses is not threatened and have been sourced from the Meandu Mine EA. All permanent engineering structures and essential management infrastructure associated with the diversion channels have been constructed and certified according to approved designs and will be retained as part of the Creek Diversion PMLU. Vegetation type and species selected to revegetate the area have been included in Appendix L – Meandu Mine PRC Plan Revegetation Plan.

No specific input has been received during community consultation regarding Creek Diversion PMLU, however the Department of Regional Development, Manufacturing and Water has been consulted during preparation of this PRC Plan. TEC Coal considered it is a necessary PMLU type due to physical constraint.

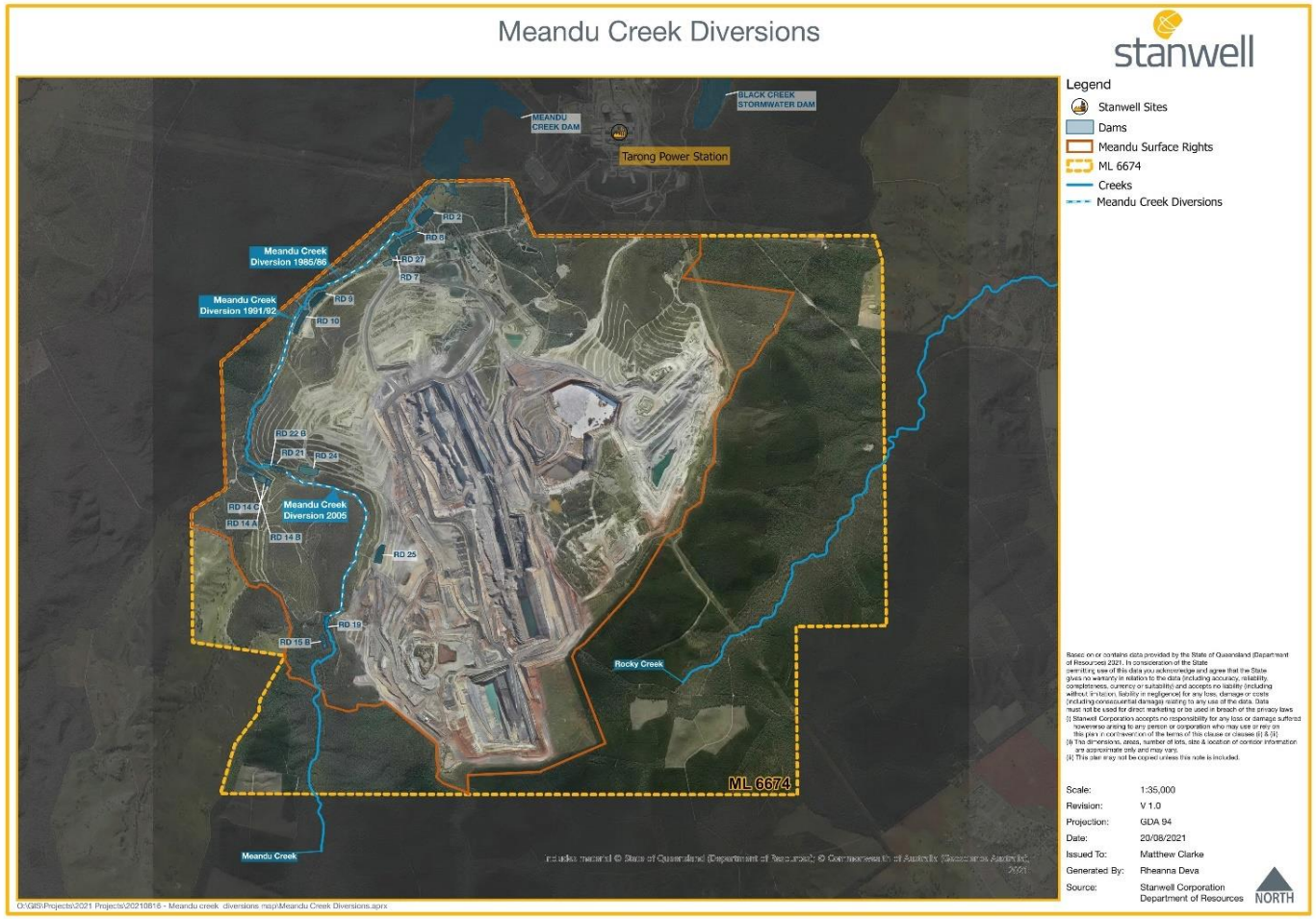


Figure 4.2 Meandu Mine Creek Diversions and associated retention dams

The areas associated with the Creek Diversion are located only within the South Burnett local government area and have been/or will be rehabilitated to riparian native ecosystems. This PMLU is consistent with the aims of Wide Bay-Burnett Regional Plan and compatible with the land use zones defined by the South Burnett regional council planning scheme (refer Section 4.2).

Minor features that form an essential part of the Creek Diversion PMLU will be maintained and developed on site. Examples of these items include fire management, weed management and general access trails. These items are consistent with the Creek Diversion PMLU.

4.1.1.3 Beef Cattle Grazing PMLU

The rehabilitation objectives for the Beef Cattle Grazing PMLU are to achieve a sustainable Beef Cattle Grazing land use. TEC Coal has developed a strategic plan for achieving Beef Cattle Grazing as a sustainable PMLU at Meandu Mine. The objectives of the strategic plan are to:

- demonstrate the suitability of rehabilitation for beef cattle grazing
- maintain or improve the land condition of the rehabilitation and prevent land degradation; and
- integrate the rehabilitated pasture lands with critical grazing management infrastructure to create an economically viable grazing enterprise.

Species to be used to revegetate the Beef Cattle Grazing area have been discussed in Appendix L – Meandu Mine PRC Plan Revegetation Plan. The completion criteria for measuring whether the Beef Cattle Grazing PMLU has been successfully achieved is that the grazing land has met Class 1, 2 or 3 land suitability for grazing in accordance with EA EMPL00709113 requirement.

Beef Cattle Grazing is a pre-mining land use of the local area and is strongly supported by the community for inclusion as a PMLU type. Community consultation provided feedback to TEC Coal to modify earlier indicative PMLU allocations to include Beef Cattle Grazing if viable. TEC Coal has undertaken further consideration of Beef Cattle Grazing and has determined that it is an economic PMLU, and it therefore has been prioritised where landform slope meets the requirements for the PMLU criteria.

The Beef Cattle Grazing PMLU is consistent with the aims of Wide Bay-Burnett and Darling Downs Regional Plans and compatible with the land use zone (Rural Zone) defined by both the Toowoomba and South Burnett regional council planning schemes (refer Section 4.2).

Minor features that form an essential part of the Beef Cattle Grazing PMLU will be maintained and developed on site. Examples of these items include:

- fire management, weed management and general access trails and the associated minor crossing points in gullies
- pumping infrastructure and water supply network will be required for cattle watering, including header tank and troughs (as required); and
- stock fencing to define laneways, paddocks and to exclude stock from dams and lakes.

These items are consistent with the Beef Cattle Grazing PMLU.

4.1.1.4 Plantation Forestry PMLU

Plantation Forestry as a PMLU is currently planned to be allocated where there are existing mature plantation trees remaining on the surface rights area in undisturbed areas. This only occurs in the residual plantation forestry footprint located against the boundary of the surface rights area at the southern end of the Meandu Mine, where a narrow strip (from 40–90 m, typically 80 m in width), contiguous with the mining lease ML6674 boundary remains unharvested. This area lies adjacent to companion mature plantings. The area assigned the Plantation Forestry PMLU remain undisturbed by mining and will not be required to undergo rehabilitation works.

During the community consultation (refer Section 3), negative sentiment for the inclusion of Plantation Forestry as a PMLU has been received. Instead, preference has been given to Beef Cattle Grazing as a PMLU for the majority of areas that were originally proposed to be Plantation Forestry. HQPlantations as the licence holder for the current Hoop Pine plantation has also advised TEC Coal that it has limited interest in new plantings based on economic grounds. Therefore, TEC Coal has made the decision to retain mature age tree remnant plantation within the HQPlantations Licence Area only, with no intent to initiate new plantings or allocate any new area within the surface rights area to the Plantation Forestry PMLU.

As there are no plans to establish Plantation Forestry PMLU footprint, this PMLU does not consider in any detail the seeding and planting requirements for this PMLU.

The Plantation Forestry PMLU will be located only within the Toowoomba Regional Council LGA. This PMLU is consistent with the aims of Darling Downs Regional Plan and compatible with the land use zone (Open Space) defined by the Toowoomba Regional Council planning scheme (refer Section 4.2).

Minor features that form an essential part of the Plantation Forestry PMLU will be maintained and developed on site. Examples of these items include fire management, weed management and general access trails and the associated minor crossing points in gullies. These items are consistent with the Plantation Forestry PMLU.

4.1.1.5 Water Storage PMLU

Regionally significant water storages, dams and reservoirs occupy less than <0.5% of land within the natural resource management area (Department of Science, Information Technology, Innovation and the Arts, 2012). At a local level, water storages are important for stock and domestic supplies and assist native animals, particularly in times of drought. The Water Storage PMLU will be a minor component of rehabilitation at Meandu Mine, consisting of the final voids (K4E and K2E).

This PMLU also includes the littoral zone that is located between the upper and lower modelled water levels, or the actual rebounded water level, in each final void.

In accordance with the current EA requirements, the completion criteria for measuring whether the Water Storage PMLU has been successfully achieved are that the water storages contain water of suitable quality for native wildlife and/or livestock ingestion, measured using the indicators of TDS (< 5,000 mg/L), Calcium (≤1,000 mg/L), Magnesium (≤2,000 mg/L), Nitrate (≤400 mg/L), Nitrite (≤30 mg/L), Sulfate (≤1,000 mg/L), Cobalt (≤1 mg/L), Nickel (≤1 mg/L), Zinc (≤20 mg/L), Arsenic (≤0.5 mg/L), Boron (≤5 mg/L), Selenium (≤0.02 mg/L), Molybdenum (≤0.15 mg/L) and Fluoride (≤2 mg/L).

Stable and reliable water supply for the successful and sustainable operation of Beef Cattle Grazing as a PMLU is a key concern of near neighbours and the broader community (refer Section 3). The storage facilities have been assessed across nil, minimum and maximum extraction scenarios in support of the other PMLUs. Similar to the Creek Diversion PMLU, TEC Coal considered it is a necessary PMLU type due to physical constraint. The Water Storage PMLU also provides post-mining future beneficial use to aspects of sustaining fauna within the Native Ecosystem and Beef Cattle Grazing PMLUs, and provides a resource for bushfire management and control for both the Native Ecosystem and Plantation Forestry areas outside of the surface rights area.

The Water Storage PMLU is consistent with the aims of Wide Bay-Burnett and Darling Downs Regional Plans and compatible with the land use zones defined by both the Toowoomba and South Burnett regional council planning schemes (refer Section 4.2).

4.1.1.6 Landholder Retained Infrastructure PMLU

The Landholder Retained Infrastructure PMLU will not be allocated at the Meandu Mine. Community consultation did not provide any specific guidance nor make a case for retention of infrastructure as a PMLU. Following the community consultation, and subsequent assessment against the local planning schemes (refer Section 4.2), the decision was made to remove all permanent infrastructure prior to surrender of the mining lease and the PRC Plan, with the exception of a short extent of private road to remain within the Beef Cattle Grazing footprint as permanent infrastructure to provide all weather access for that PMLU and prevent unnecessary further disturbance to Meandu Creek. Further details on this are provided in Section 6.5.1.4. The infrastructure is not currently considered suitable for retention to support the proximal Native Ecosystem or Beef Cattle Grazing PMLUs.

The success criteria for infrastructure decommissioning and removal are detailed as follows:

- all services are disconnected
- all buildings are demolished and removed
- remove hardstands and roads (bitumen, blue metal, aggregate etc) except those retained for a PMLU
- remove infrastructure (fences, pipelines, signage etc) except those retained for a PMLU
- decommission any non-retained boreholes
- machinery not required for rehabilitation removed off-site; and
- remove any fences not needed to maintain safety and security aspects.

Further information regarding the decommissioning of infrastructure is provided in Section 6.5, with success criteria for infrastructure decommissioning and justification are outlined in rehabilitation milestone RM1 (Table 9.2 in Section 9).

4.1.1.7 Steep Rocky Ecosystem PMLU

The Steep Rocky Ecosystems PMLU is a naturally evolving ecosystem that develops as a mosaic of plant and animal assemblages of different structure and composition across a steep rocky post mining landscape and is a specific application for excavated walls that will remain at the end of Meandu Mine life. No specific community feedback was received regarding Steep Rocky Ecosystem. This represents an approach agreed with the DES during the 2020 negotiations to amend the Meandu Mine EA with respect to allowable PMLUs and their associated success criteria. The Steep Rocky Ecosystem PMLU design considers the requirements for final highwall rehabilitation which includes a combination of steep batters and benches offering variable geometries suitable for the establishment of self-sustaining floral and faunal assemblages.

The Steep Rocky Ecosystem PMLU rehabilitation objective is to facilitate the establishment of self-sustaining plant and animal assemblages and associated ecosystem processes across the post-mining steep rocky landscape, through key processes including:

- geo-technical and geo-chemical landform evolution
- sediment transport, sorting and soil development
- development of stable hydrological systems
- establishment and reproduction of plant and animal assemblages
- development of structural and tropic complexity; and
- development of diverse plant and animal assemblages in a mosaic reflecting the range of evolved landforms and substrate characteristics across the steep rocky landscape.

The specific vegetation types for the Steep Rocky Ecosystem PMLU are detailed in Appendix L – Meandu Mine PRC Plan Revegetation Plan. Consistent with the current EA EMPL00709113, the Rehabilitation Milestone criteria for the Steep Rocky Ecosystem PMLU include:

- the landform provides a diversity of slopes including mix of predominately flat benches and batters up to 80 degrees that create a varied environment for the future establishment of niche habitats; and
- native plant species richness per appropriate ecosystem outcome, adjusted to meet geotechnical stability requirements.

More detailed and specific success criteria have been developed and included in Appendix L – Meandu Mine PRC Plan Revegetation Plan and these are:

- presence of a mosaic of bare and vegetated land surfaces
- presence of a variety of plant assemblages
- plant assemblage structure consistent with that occurring among nearby analogous examples
- large fauna use steep rocky landscape for feeding, roosting and/or breeding
- plant assemblages support an invertebrate assemblage with a structure and composition similar to that occurring in nearby analogous assemblages
- successful reproduction and soil seed bank establishment in plant assemblages
- seasonal changes in plant and invertebrate assemblages in a way that is consistent with that occurring among a range of nearby analogous assemblages
- responses to environmental stressors in plant and invertebrate assemblages is consistent with the range of change detected among nearby analogous assemblages; and
- facilitated species colonisation and establishment.

The inclusion of Steep Rocky Ecosystem as a PMLU is directly attributable to the feedback received from DES and is addressing the need to proactively utilise the inherent topographic constraints in the final voids. No specific input has been received during community consultation regarding Steep Rocky Ecosystem PMLU.

The Steep Rocky Ecosystem PMLU will facilitate the natural repopulation of suitable flora species endemic to the site and in doing so support establishment of suitable fauna populations. It is a type of land use that consistent with the aims of Wide Bay-Burnett and Darling Downs Regional Plans and compatible with the land use zones defined by both the Toowoomba and South Burnett regional council planning schemes (refer Section 4.2).

Minor features that form an essential part of the Steep Rocky Ecosystem PMLU will be maintained and developed on site. Examples of these items include:

- fire management, weed management and general access trails and the associated minor crossing points in gullies; and
- safety bunding and land shaping at the stable crest which forms part of the landform design.

These items are consistent with the Steep Rocky Ecosystem PMLU.

4.1.1.8 Areas undisturbed by mining

While the PMLUs described in Sections 4.1.1.1 to 4.1.1.7 have been developed with the whole area of the Meandu Mine ML6674 in mind, their applicability is solely for allocation within the surface rights area of the Meandu Mine. There are undisturbed areas both within and outside of the surface rights areas of ML6674.

Undisturbed areas outside of the surface rights area

Outside of the surface rights area there has been limited disturbance in relation to mining activities. The disturbance is limited to exploration drilling sites (which are in the process of being rehabilitated and returned to the applicable landholder) or groundwater monitoring bores.

All other parts of the footprint of ML6674 outside of the surface rights areas remain as they were pre-mining or have evolved without the influence of mining. Consequently, their PMLU is the same as their pre-mining land use, as advised by DES. Land use in the pre-mining area outside of the surface rights area include a dominance of Plantation Forestry and Native Ecosystem, but also contain infrastructure (including roads, power transmission lines and associated Powerlink easement), Beef Cattle Grazing and other relatively minor proportion uses.

Undisturbed areas inside of the surface rights area

Within the surface rights area there are areas that remain undisturbed by mining activities at the cessation of mining in 2037. These areas are predominantly located at the edges of the surface rights area along the north and western edges. With the sole exception of the footprint associated with the Plantation Forestry PMLU on the southern boundary of the surface rights area, these areas have been assigned the PMLU of Native Ecosystem. These areas will continue to be maintained and managed for weeds, bushfire management and feral animal controls, but will otherwise not be subject to the rehabilitation criteria and milestones. The pre-existing vegetation structures and species mix will be retained in their original state without modification or supplementation.

4.1.2 Allocation of PMLUs for the PRC Plan

4.1.2.1 Considerations in the allocation of PMLUs

TEC Coal has transitioned the approved PMLUs in the current EA EMPL00709113 into this PRC Plan. The allocation remains similar to the indicative map showing PMLU distribution that has been included in the current EA, with any changes due to the results of the detailed consultation and planning that has been undertaken since the relevant EA Amendment submission and negotiation with DES in 2020. This is entirely consistent with the development and discussion with DES at the time as to the purpose of the indicative map in the EA and the future changes that would occur to the allocation prior to submission of this PRC Plan.

As such, TEC Coal is not required to justify the selection of the PMLUs as per section 126C(1)(j) of the EP Act. However, in making the allocation of PMLUs for ML6674, TEC Coal has considered the additional inputs from the community consultation and review of the PRC Plan Guideline, additional technical studies and reference information used in preparing the PRC Plan. The aspects considered included:

- pre-mining land use (refer Section 2.1.10)
- community consultation (refer Section 3)
- PMLU economic viability (or holding cost)
- existing mining disturbances including three segments of creek diversion of Meandu Creek
- existing mine rehabilitation (Native Ecosystem) completed to the end of 2021 – Progressive Rehabilitation Certification of approximately 153 ha of Native Ecosystem, indicating that the risk of achieving successful rehabilitation for this PMLU type is very low (refer to Section 2.4.3)
- design final landform, slopes and final void locations, and ability to support the PMLUs (refer to Section 6, particularly Sections 6.1.5 and 6.3); and
- selective material placement and ability to support the PMLUs (refer to Section 6.1.6).

4.1.2.2 PMLU allocation

Of the seven approved PMLUs, four of them are location-specific and are subject to physical constraints. These are:

- Water Storage (e.g., constrained by the final void areas which are below the final water table)
- Steep Rocky Ecosystem (constrained by the steep, benched and battered, final highwall areas)
- Creek Diversion (constrained by the three creek diversions in place at the completion of rehabilitation activities); and
- Landholder Retained Infrastructure (not used – but this has been retained and transitioned into the PRC Plan to allow for potential future amendment to the PMLU allocation should beneficial use to a willing landholder be identified as part of ongoing consultation and planning).

Some flexibility is available to TEC Coal in the allocation of the remaining three PMLUs, of Native Ecosystem, Beef Cattle Grazing and Plantation Forestry. The final allocation of these three PMLUs considered the following constraints:

- all historic rehabilitation work at Meandu Mine was aimed at predominantly Native Ecosystem or Creek Diversion PMLUs
- the landform design must address the safe, stable, non-polluting and able to sustain a PMLU criteria across the entire surface rights area
- retaining the existing vegetation and structure within the footprint of undisturbed areas at cessation of mining
- the extent of the plantation licence areas held, and proximity of plantings by HQPlantations; and
- the preference of the community for achieving (where suitable and economically viable) the Beef Cattle Grazing PMLU.

Table 4.1 summarises the key assessment undertaken for Native Ecosystem, Beef Cattle Grazing and Plantation Forestry PMLUs against each of the criteria outlined in the PRC Plan Guideline.

Table 4.1 Assessment of applicable PMLUs against PRC Plan Guideline criteria

PRC Plan Guideline	PMLU		
	Native Ecosystem	Beef Cattle Grazing	Plantation Forestry
Regulatory Constraints	Consistent with the relevant regulations and management plans.		
Physical Constraints	The historic, and future, landforms have been designed to suit the maximum stable gradients sustainable for Native Vegetation (<17% overall slope, with limited areas of up to 25%).	Suitable to the lower slope areas of the final landform, analogous to the pre-mining landscape and distribution of cattle grazing. Slopes are less than 15%, and more typically, less than 10%.	Suitable to the lower slope areas of the final landform, analogous to the pre-mining landscape and distribution of cattle grazing. Slopes are less than 15%, and more typically, less than 10%.
Chemical characteristics	Native Vegetation has historically been used as part of the vegetative cover above tailings and rejects storage areas.	Subject to assessment by a suitably qualified and experienced person on the soil cover system in place.	Not preferred due to the depth of root system and need for subsoil suitable for plantation forestry.
Available rehabilitation methods	Able to be established utilising the systems and process currently documented and active at Meandu Mine.		Requires additional controls on subsoil placement.
Relative costs of each rehabilitation option	Cheapest to establish as requires the least subsoil management and surface treatment.	More expensive – criteria for subsoil, topsoil, surface preparation and management of vegetation required.	More expensive – criteria for subsoil, topsoil, surface preparation and management of vegetation required.

PRC Plan Guideline	PMLU		
	Native Ecosystem	Beef Cattle Grazing	Plantation Forestry
Potential economic benefits of each option for the community or landholder	Not applicable.	Highly likely to have economic return.	No likely economic return.
Potential social benefits of each option	Maintaining/extending connectivity to the adjoining State Forest.	Strong affinity with Beef Cattle Grazing in the local area – major land use throughout the South Burnett.	Well established agricultural activity in the South Burnett, adjoining plantation areas pre-date the mining activities.
Compatibility with surrounding land uses	Consistent with the remnant vegetation in the adjoining Tarong State Forest area to the north-west and north of the ML.	Strong affinity with Beef Cattle Grazing in the local area – major land use throughout the South Burnett. Adjoining properties have cattle grazing activities currently.	Well established agricultural activity in the South Burnett, adjoining plantation areas pre-date the mining activities.
Land use before mining commenced	Areas of native vegetation existed as a pre-mining land use.	Grazing was a pre-mining land use.	Limited areas of Plantation forestry existed within the mining area pre-mining, in the regions that the PMLU is proposed.
Options for retaining/ transitioning infrastructure	Not applicable.	Not applicable. Where needed, specific supporting items will be constructed e.g., fences, cattle yards.	Not applicable. Only existing established plantation trees will be used as a PMLU.

4.1.2.3 Further consideration of Beef Cattle Grazing versus Plantation Forestry

The only use of the Plantation Forestry PMLU is where pre-existing plantation trees, established by the original plantation licence holder (HQPlantations), remain in place at the end of mining. This is a small slice of land at the southern extent of the surface rights area that shares a border with the adjoining Plantation Forestry under the management of HQPlantations. This decision is made based on the following reasons:

- The subsoil criteria for Plantation Forestry align with the criteria required for the subsoil utilised for the Beef Cattle Grazing PMLU.
- The land gradient criteria (slopes must be less than 15%) align with the criteria required for the Beef Cattle Grazing PMLU.
- The feedback received from consultation across the community and stakeholder groups is strongly in favour of Beef Cattle Grazing and clear in the preference for this PMLU over the Plantation Forestry PMLU (refer Section 3).

- Risk associated with the significant uncertainty in successfully establishing the plantation species in the rehabilitation material. There is a lack of adequate time to mature, harvest and assess plantings as a trial (i.e., for 30+ year tree maturation windows, a trial cannot be adequately concluded, and quality of harvest confirmed within the PRC Plan Schedule to commit to more extensive planting even if it was a proven viable PMLU).
- Economic modelling showed no positive return in the establishment of new plantation area.

Given the commonality between the input requirements for the Beef Cattle Grazing and Plantation Forestry PMLU, the expressed community preference for Beef Cattle Grazing, and the better economic return of Beef Cattle Grazing, the suitable areas of the final landform have preferentially been allocated to Beef Cattle Grazing. This minimizes the risk to future PMLU success by focusing on an allocation that is in alignment with expectations and has a high likelihood of being economically self-supporting.

4.1.2.4 Footprint and allocated area of PMLUs

The allocated geographical extent of each PMLU within ML6674 is illustrated in Figure 4.1. The area of each PMLU allocation and associated area and domains are shown in Table 4.2.

Table 4.2 Meandu Mine PMLUs, allocated area and relevant domains

PMLU	Area allocated (ha)	Relevant activities
Native Ecosystem	1,902.1	Central pit, Haul Road, K2E Waste Dump(s), K2E pit, K2W-N Ash and Tailings Storage Facility, K4E pit, K4S pit and Ash and Tailings Storage Facility, Meandu Creek, Mine Infrastructure Area, Ramp 5 pit, portion of western waste dumps, undisturbed areas
Creek Diversion	19.0	Creek Diversion
Beef Cattle Grazing	555.8	Central pit, Haul Road, K4E pit, K4S pit and Ash and Tailings Storage Facility, Mine Infrastructure Area, Ramp 5 pit, portion of western waste dumps
Plantation Forestry	18.5	Undisturbed area along K4S boundary
Water Storage	107.4	K2E pit, K4E pit
Steep Rocky Ecosystem	204.0	K2E pit, K4E pit, K2W-N pit, SW pit
Total PMLU within Surface Rights Area	**2,806.9**	Total area under responsibility of TEC Coal. Excludes Powerlink easement
Powerlink Easement	45.4	Under responsibility of Powerlink
Within ML and Outside Surface Rights Area	1,414.3	Pre-mining land use applies. Excludes Powerlink easement
Total Mining Lease Area	**4,266.6**	

4.2 Regional planning integration

Meandu Mine is located within two regional plan areas, the Wide Bay-Burnett Regional Plan and the Darling Downs Regional Plan.

4.2.1 Wide Bay-Burnett Regional Plan

The Wide Bay-Burnett Regional Plan was implemented in 2011 as a statutory instrument providing strategies aiming to address economic, social and environmental issues in the region, including identifying strategic infrastructure and service needs and support economic prosperity.

The proposed PMLUs within the Wide Bay-Burnett Regional planning area for Meandu Mine include Native Ecosystem, Beef Cattle Grazing, Water Storage, Creek Diversion and Steep Rocky Ecosystem. These PMLUs are consistent with the aim of the Wide Bay-Burnett Regional Plan to support the region's economic growth and ecological sustainability. The Wide Bay-Burnett Regional Plan states that development in regional landscapes needs to be responsibly planned to complement, protect, and enhance landscape values, including areas of significant biodiversity value, rural production, scenic amenity, and landscape heritage. Development of the PMLUs has aimed to integrate with the existing land uses and environmental values in the surrounding area (refer Section 4.2.3).

4.2.2 Darling Downs Regional Plan

The Darling Downs Regional Plan was implemented in 2013 as a statutory plan that sets intentions to enable opportunities for economic growth and diversity in the region, to protect areas of regionally significant agricultural production, and to identify infrastructure outcomes that will support economic growth.

The proposed PMLUs of Meandu Mine within the Darling Downs Regional planning area include Steep Rocky Ecosystem, Water Storage, Beef Cattle Grazing and Native Ecosystem. Development of these PMLUs would be consistent with the aim of the Darling Downs Regional Plan in enabling opportunities for economic growth to ensure the regions are resilient and prosperous and protect areas of regionally significant agricultural production from incompatible resource activities while maximising opportunities for co-existence of resource and agricultural land uses.

4.2.3 Local Government legislation

The local planning schemes for the Toowoomba Regional Council and South Burnett Regional Council are the Toowoomba Regional Council Planning Scheme 2022 and South Burnett Regional Council Planning Scheme 2017 respectively.

Under the South Burnett Planning Scheme 2017, most of the land of Meandu Mine is identified as "Rural Zone" which has a purpose defined as to:

(a) Provide for rural uses and activities; and

(b) Provide for other uses and activities that are compatible with -

(i) existing and future rural uses and activities; and

(ii) the character and environmental features of the zone; and

(c) Maintain the capacity of land for rural uses and activities by protecting and managing significant natural resources and processes.

The Rural Zone primarily accommodates cropping or animal husbandry and ancillary detached dwellings. The PMLUs proposed are considered to be compatible with the planning scheme.

The Toowoomba Regional Planning Scheme 2022, incorporating Amendment 1 identifies the area on the east side of Meandu Mine as being in the “Open Space Zone” which has a purpose defined as to provide:

> *(a) a variety of cultural, educational, leisure, recreation and sporting uses and activities, including, for example -*
>
> *(i) parks, playgrounds or playing fields for the use of residents and visitors; and*
>
> *(ii) parks, or other areas, for the conservation of natural areas; and*
>
> *(b) facilities and infrastructure to support the uses and activities stated in paragraph (a).*

The PMLUs proposed including the Native Ecosystem, Steep Rocky Ecosystem and Water Storage are compatible with the “Open Zone” defined in the planning scheme while the Beef Cattle Grazing is compatible as the “Rural Zone” land uses.

It is also noted that both the South Burnett Planning Scheme 2017 and Toowoomba Regional Planning Scheme 2022 is acknowledged as integrating all State government planning policy interests and provisions.

5 Non-use management area

Legislative requirements:

In accordance with sections 126C(1)(d), (g) and (h) of the EP Act, for each proposed non-use management area, the rehabilitation planning part of the PRC plan must:

- state the reasons the applicant considers the area cannot be rehabilitated to a stable condition include copies of reports or other evidence relied on by the applicant for each proposed non-use management area
- state the extent to which the proposed non-use management area is consistent with the outcome of consultation with the community in developing the plan, and
- state the extent to which the non-use management area is consistent with any strategies or plans for the land of a local government, the State or the Commonwealth.

PRC Plan Guideline (Section 3.3)

A NUMA is defined in the EP Act as an area of land the subject of a PRC plan that cannot be rehabilitated to a stable condition after all relevant activities for the PRC plan carried out on the land have ended. Proposed NUMAs must be justified under the criteria set out in section 126D(2) of the EP Act.

NUMAs are defined under section 112 of the EP Act as an area of land the subject of a PRC Plan that cannot be rehabilitated to a stable condition after all relevant activities for the PRC Plan carried out on the land have ended.

The final Meandu Mine rehabilitated landform will **not** include any NUMAs.

As a result, a public interest evaluation under the EP Act is not required.

6 Rehabilitation management methodology

Legislative requirements:

In accordance with section 126C(1)(e) and (i), the rehabilitation planning part of the PRC plan must:

- for each proposed post-mining land use 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
- for each proposed non-use management area, state the proposed methodology for achieving best practice management of the area to support the management milestones under the proposed PRCP schedule for the area.

PRC Plan Guideline (Section 3.6)

The proposed rehabilitation or management methodologies will underpin the development of the milestone criteria and support how the proposed PMLU will be achieved or the NUMA will be managed. As per section 126C(1)(j) of the EP Act, the administering authority requires information describing how the proposed rehabilitation or management methodologies have been developed and will be implemented.

This section identifies a number of studies or reports that must be provided in the proposed PRC plan. If any of the required information outlined below is not relevant to the specific operation, the applicant must provide justification in the PRC plan outlining why the information is not required.

6.1 General rehabilitation practices

PRC Plan Guideline (Section 3.6.1)

This section outlines the range of information that the administering authority considers is necessary to underpin the development of the rehabilitation or management methodologies applicable to new and existing mines for most domains. The applicant must include the information as appendices to the rehabilitation planning part.

The proposed rehabilitation or management methodologies underpin the development of milestone criteria and support how the proposed PMLUs will be achieved. As per section 126(1)(j) of the EP Act, the administering authority requires information describing how the proposed rehabilitation or management methodologies have been developed and will be implemented. Relevant information for the Meandu Mine is presented in this section including rehabilitation or management methodologies for tailing storage facilities (including ash storage facilities and mixed plant rejects) (Section 6.2), and of final voids (both residual and backfilled voids) (Section 6.3) and built infrastructure (Section 6.5).

6.1.1 Hydrogeology

PRC Plan Guideline (Section 3.6.1)

Assess the hydrogeology of the site and all connected strata, and develop a conceptual model of the mine site's groundwater systems. This information must be integrated into the design of rehabilitation strategies and choice of PMLU or NUMA.

6.1.1.1 Hydrogeological context

Conceptualisation of the groundwater systems

The geology and geological controls governing the occurrence of groundwater at Meandu Mine is described in Section 2.1.5 with specific locations as shown in Table 6.1.

Table 6.1 Sections of the PRC Plan that address the hydrogeology elements of the PRC Plan Guideline

PRC Plan Guideline requirement	Section of PRC Plan addressing item
Integration of hydrogeology into rehabilitation strategies and choice of PMLU	Section 4.1.1.5 and Section 6.3 of this PRC Plan Sections 6.2 and 6.3 of Appendix I.
Groundwater occurrence and aquifers/aquitards	Sections 2.1.5.2 and 2.1.5.3 of this PRC Plan Section 4.1 of Appendix I.
Locating groundwater recharge and discharge locations	Section 2.1.5.6 of this PRC Plan Section 4.2 of Appendix I.
Groundwater quality within each of the aquifers	Section 2.1.5.7 of this PRC Plan Section 4.3 of Appendix I
Current and potential future uses of groundwater	Section 2.1.5.5 of the PRC Plan Section 4.4.2 of Appendix I
Groundwater flow direction and velocity	Sections 2.1.5.3 and 2.1.5.5 of this PRC Plan Sections 4.5.2 and 4.6 of Appendix I
Development of potentiometric mapping	Section 6.1.1.1 of this PRC Plan Section 4.5 of Appendix I
Contaminant transport	Sections 6.1.1.4 and 6.1.7 of this PRC Plan Sections 5.1 and 5.2 of Appendix I.
Potential changes to groundwater level from dewatering or waste storage	Section 6.1.1.1 of this PRC Plan Section 6.5 of Appendix I.

Integration of hydrogeology into design of rehabilitation strategies and choice of PMLU

The rehabilitation areas were broken-up with consideration of the hydrogeological modelling results (refer Section 6.1.1.4) in regard to the following key items:

- Location of waste storage facilities and overall landform design was undertaken following Identification of potential contaminants of concern. This was then assessed utilising the flow paths and potential transport of contaminants to confirm appropriate final locations in the LOM Plan for ash and tailings storage.
- Areas with current management actions in place requiring management of ground or surface water quantities or qualities have been assigned unique rehabilitation areas and associated milestones in the PRC Plan Schedule to ensure clarity of the criteria and sequence towards a stable landform.
- Final void locations were assessed to be appropriate for the water storage PMLUs. Long-term water quality within those storages were assessed against the criteria necessary to support the adjoining PMLU of Beef Cattle Grazing and found to be safe, stable and able to support the PMLU.
- Final void locations and geometry were assessed to validate that as a system they would operate as a sink and ensure no release of any contaminate to the broader environment.

The modelling confirmed that the initial allocation of PMLU footprints were appropriate.

Groundwater modelling and incorporation of results

In accordance with the requirements of the PRC Plan Guideline, SLR was commissioned by Stanwell to undertake surface water and groundwater studies at Meandu Mine specifically for the purposes of the PRC Plan. SLR undertook numerical groundwater modelling, contaminant transport modelling and void hydrological modelling with the aim of determining if the final landforms (including proposed voids) would meet the *Rehabilitation requirements for mining resource activities (Queensland Government,* ESR/2016/1875 (2014)) to ensure safe, stable and non-polluting landforms that are able to support the designated PMLUs.

The following subsections provide a synopsis of the numerical modelling works undertaken, including model setup, key outputs and conclusions. For more detail on the modelling studies, the Meandu Mine PRC Plan Groundwater Technical Report developed by SLR (2022a) is attached in Appendix I.

Conceptualisation of groundwater flow and potentiometric mapping

Through data collected from the Meandu Mine groundwater monitoring network, potentiometric maps for each hydrostratigraphic unit encountered on the Meandu Mine site have been developed. These maps are provided in Section 4.5.2 of Appendix I – Meandu Mine PRC Plan Groundwater Technical Report. Generally, the potentiometric profiles (and groundwater flow dynamics) for each hydrostratigraphic unit are conceptualised as follows (SLR, 2022a):

- Unconfined Alluvium, Regolith and Spoil – where saturated, the unconfined units are conceptualised as hydraulically connected.
- Basalt – groundwater flow direction cannot be interpreted as water level data for only one bore is available. However, flow is expected to be primarily influenced by topography, and to a lesser degree, by fracture orientation.
- Tarong beds – groundwater flow direction in the Tarong beds is complex and discontinuous. Due to the nature of this system, potentiometric contour maps have not been produced.
- Maronghi Creek beds – water level data is only available for two bores in the Maronghi Creek beds (GW64 and GW65) which is insufficient to develop a groundwater level contour map.

The direction of groundwater flow at Meandu Mine generally mimics the surface topography of the area. Toward the east and south-east of the mining lease (i.e., outside of the surface rights area), groundwater is expected to flow towards Yarraman Creek (refer Figure 2.11). However, in the coal seams, the groundwater divide does not coincide with the surface water divide, and groundwater in the coal is expected to flow primarily towards Meandu Mine (refer Section 2.1.5). In the vicinity of the pits, groundwater flow is toward the pits where the groundwater is removed by evaporation and/or pumping (refer Figure 2.10). Meandu Creek Dam is inferred to exert control over the water table elevation in its vicinity (SLR, 2022a). Additional details regarding groundwater flow dynamics are provided in Figures 44, 45, 46 and 47 of Appendix I – Meandu Mine PRC Plan Groundwater Technical Report (SLR, 2022a). Meandu Creek Dam is inferred to exert control over the water table elevation in its vicinity (SLR, 2022a).

The conceptualised potentiometric contours for the alluvium and regolith (derived from groundwater bores for conceptualisation) are shown on Figure 6.1.

6.1.1.2 Numerical groundwater modelling – introduction and calibration of the model

As per the requirements of Section 3.6.1 (Hydrogeology sub-heading) of the PRC Plan Guideline, a numerical groundwater model was developed by SLR in parallel with, and consideration of, several other hydrogeological studies. The purpose of these studies was to develop an improved understanding of the hydrogeological regime at Meandu Mine so water quality impacts from mining can be better understood and so suitable controls could be developed to protect environmental values. The following aspects of the hydrogeological regime, as determined from the numerical groundwater model and supporting studies, were investigated in detail. These are:

- potential changes to groundwater levels due to dewatering, water infiltration and waste storages
- long-term recovery of groundwater levels post-mining; and
- transport modelling and the potential for contaminant seepage to groundwater.

The following sub-sections provide a summary of the setup, calibration, and predictive results of the hydrogeological numerical model.

Model set-up and calibration

Development of the hydrogeological numerical model was based on the existing (peer reviewed) groundwater model developed to assess potential impacts to groundwater from the K2E Project (K2E Project groundwater model). Since the K2E Project groundwater model focused on specific areas relevant to the K2E Project, the PRC Plan groundwater model needed to be further developed to suit the purposes of the PRC Plan (i.e., including the remaining areas of the Meandu Mine). No major structural changes were made to the (existing) K2E Project groundwater model, however, for the purposes of the PRC Plan the model was transferred from MODFLOW-SURFACT to MODFLOW-USG code. The transference is considered consistent with industry standards to provide for improved model calibration and run time (SLR, 2021) and improved results.

The groundwater numerical model is a large-scale ‘regional’ model that covers the entire ML6674 footprint and extends into the surrounding area. It comprises 15 layers of 40 m x 40 m grid cells, moving to 80 m x 80 m grid cells towards the outer edges of the model (where less resolution is required) (Figure 6.2). Each layer of the groundwater model represents the relevant hydrostratigraphic units present at the Meandu Mine (Table 6.2).

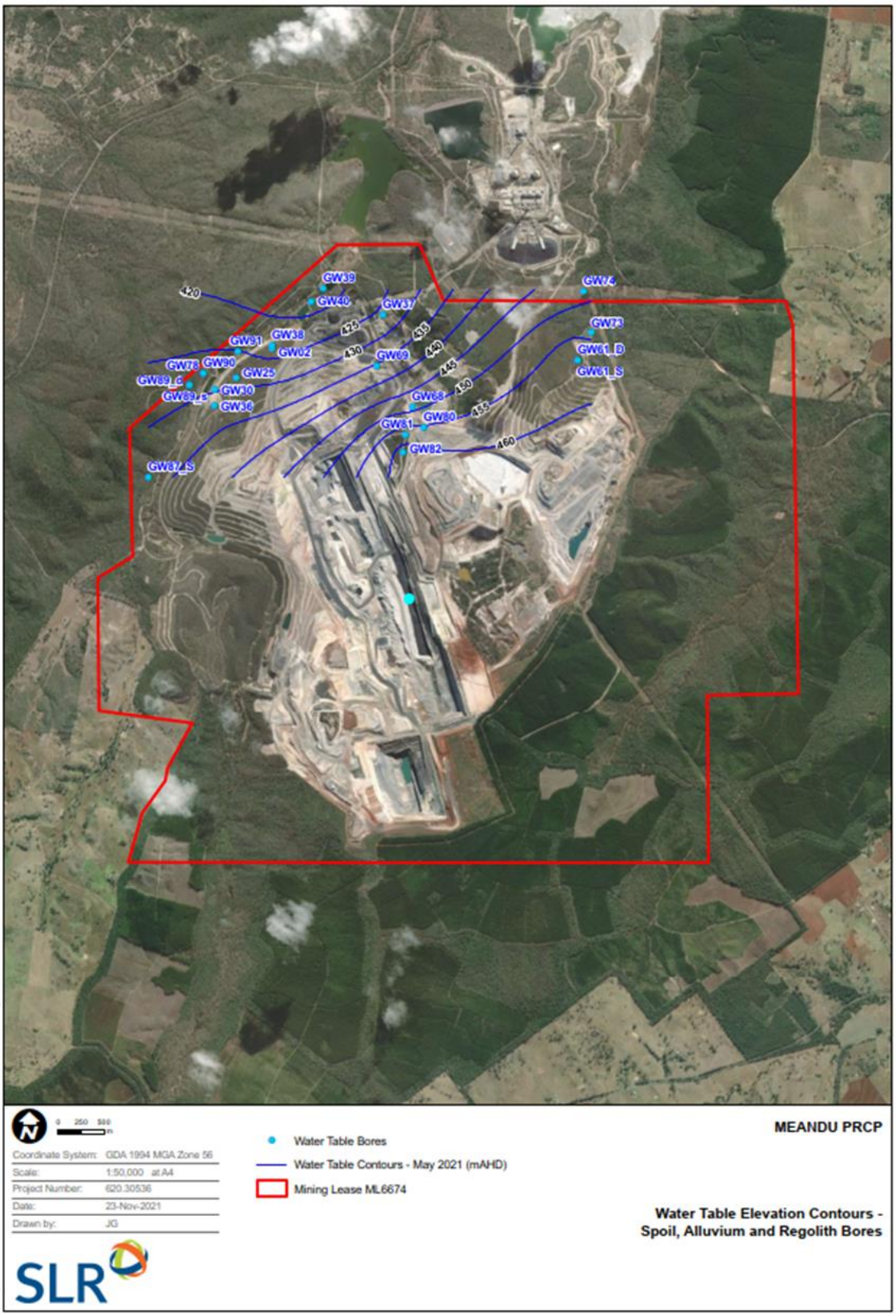
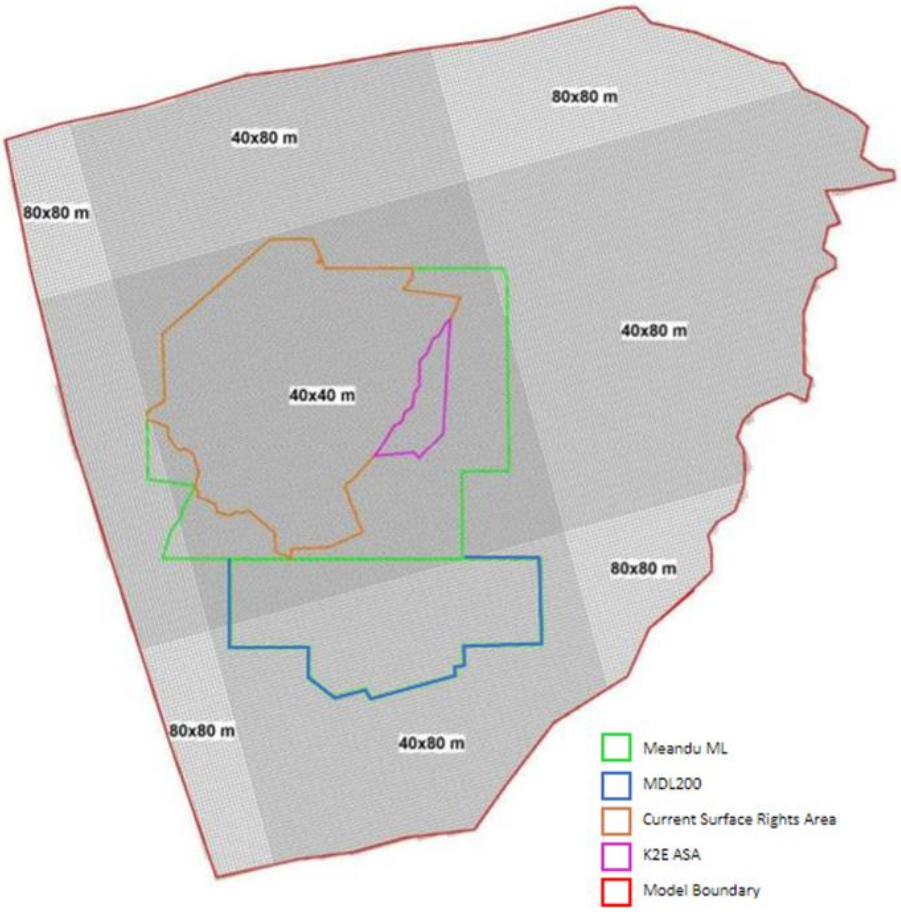


Figure 6.1 Potentiometric contours for alluvium and regolith (derived from groundwater bores)

Model boundary conditions for the PRC Plan groundwater model remained consistent with the K2E Project groundwater model. For transparency and completeness, the following were considered by SLR (2021) for the establishment of model boundary conditions. These are:

- flow conditions applied to the eastern and north-eastern model boundaries follow Yarraman Creek
- no flow conditions applied to the northern, southern and western model boundaries
- inflows and outflows from:
    - recharge and evapotranspiration
    - Meandu Creek Dam
    - Meandu Creek (downstream of Meandu Creek Dam)
    - ephemeral creeks
    - ash and tailings storages
    - mining (voids versus natural ground etc.,)
    - dewatering bores; and
    - barriers (i.e., barriers affecting groundwater flow such as major geological faults.



Source: JBT, 2021 in SLR, 2022a

Figure 6.2 Model grid

Table 6.2 Model layers

Layer	Top of layer	Base of layer	Description
1	Topographic Surface	Top Triassic	Basalt, Quaternary alluvium, upper layers of Triassic regolith (within Tarong Basin)
2	Top Triassic	Base Regolith	Quaternary alluvium, Regolith (weathered coal measures)
3	Base Regolith	to Ace 1 Roof	Fresh Triassic coal measures below regolith but above Ace Seam; Top of Maronghi Creek beds
	Ace 1 Roof	Ace 3 Floor	Package of Triassic sediments that includes Ace Seams
4	Ace 3 Floor	King 2 Roof	Interburden_1 (interburden between coal seams)
5	King 2 Roof	King 4 Floor	Package of Triassic sediments that includes King Seams
6	King 4 Floor	Queen A1 Roof	Interburden_2 (interburden between coal seams)
7	Queen A1 Roof	Queen A3 Floor	Package of Triassic sediments that includes Queen A Seam
8	Queen A3 Floor	Queen B1 Roof	Interburden_3 (interburden between coal seams)
9	Queen B1 Roof	Queen B3 Floor	Package of Triassic sediments that includes Queen B Seam
10	Queen B3 Floor	Queen C1 Roof	Interburden_4 (interburden between coal seams)
11	Queen C1 Roof	Queen C3 Floor	Package of Triassic sediments that includes Queen C Seam
12	Queen C3 Floor	Queen D1 Roof	Interburden_5 (interburden between coal seams)
	Queen D1 Roof	Queen D3 Floor	Package of Triassic sediments that includes Queen D Seam
	Queen D3 Floor	Queen E1 Roof	Interburden_6 (interburden between coal seams)
	Queen E1 Roof	Queen E3 Floor	Package of Triassic sediments that includes Queen E Seam
	Queen E3 Floor	Queen F1 Roof	Interburden_7 (interburden between coal seams)
	Queen F1 Roof	Queen F3 Floor	Package of Triassic sediments that includes Queen F Seam
	Queen F3 Floor	Queen G1 Roof	Interburden_8 (interburden between coal seams)
13	Queen G1 Roof	Queen G3 Floor	Package of Triassic sediments that includes Queen G Seam
14	Queen G3 Floor	Queen H1 Roof	Interburden_9 (interburden between coal seams)
	Queen H1 Roof	Queen H3 Floor	Package of Triassic sediments that includes Queen H Seam
	Queen H3 Floor	Queen J1 Roof	Interburden_10 (interburden between coal seams)
	Queen J1 Roof	Queen J3 Floor	Package of Triassic sediments that includes Queen J Seam
	Queen J3 Floor	Basement	Triassic below Queen Seam
15	Triassic Basement	Base of Maronghi Creek beds	Base of Maronghi Creek beds (occurs below Triassic in Tarong Basin, and is the only unit present east of the basin boundary fault

Source: adapted from JBT, 2021 in SLR, 2022a (refer Appendix I – Meandu Mine PRC Plan Groundwater Technical Report)

The calibration of the PRC Plan groundwater model utilised the PEST++ software (White *et. al.,* 2020) to identify optimal hydraulic parameters and recharge rates to achieve the best statistical calibration based on observed and simulated water levels. This process helps to improve the overall functionality of the model so that it can be used as a predictive tool.

Eighty-two (82) groundwater bores with known screened lithologies and available water level data (totalling to 1,390 datasets) were included in the calibration process. These points spatially extend from the mining lease boundaries and cover the key environmental receptors and surface/groundwater features of the area (e.g., Meandu Creek, the Boulevard Fault, Maronghi Creek Beds, ash storages, and other process waste storage areas etc.).

All hydrostratigraphic units (Table 6.2) encountered on site were then calibrated against the following set of parameters. These are:

- Horizontal Hydraulic Conductivity
- Vertical Hydraulic Conductivity
- Specific Yield
- Storage Coefficient; and
- Rainfall recharge.

All of the above-listed set of parameters were within the bounds of measured and/or estimated values for the Meandu Mine (refer JBT (2021a)). Recharge rates from rainfall were also calibrated to determine average yearly recharge.

SLR (2022a) also undertook an assessment of the calibration of the PRC Plan groundwater model (using industry-standard transient calibration statistics to determine if the model is consistent with the requirements of the Australian Groundwater Modelling Guidelines. This was done by assessing the error between modelled and observed (measured) water levels in terms of the root mean square (RMS). The acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS error, to the total head change in the system is small, the errors are considered small in relation to the overall model response(s). The total measured head change across the model domain is 84.9 m; therefore, the ratio of RMS to the total head loss (SMRS) is 6.8%. This indicates a reasonable calibration and is within the Australian Groundwater Modelling Guidelines of 10% Scaled RMS (Barnett *et. al*., 2012).

Usage of the numerical groundwater model

The set-up and calibration of the PRC Plan groundwater model was completed as per industry standards so it could be used as a predictive tool for calculating post-mining groundwater levels. The calibrated model has also been used for void hydrological modelling, contaminant transport modelling and development of potentiometric maps. These are discussed in more detail in Sections 6.1.1.3 and 6.1.1.4.

6.1.1.3 Void hydrological modelling

Hydrological modelling of the proposed final landform (including residual voids) was undertaken with the intent of addressing the sections of the PRC Plan Guideline that cover flood risk and final void water levels. Specifically, the hydrological modelling is intended to determine the risk of inundation by flooding of residual voids, flood risk to the stability of other final landforms such as rehabilitated spoil dumps and assessing the long-term water balance and water level in the voids, including the potential for overflow of the voids.

To determine whether *Section 3.4* of the PRC Plan Guideline applies to Meandu Mine, hydrologic modelling was undertaken to estimate runoff hydrographs at various locations throughout the catchments of Meandu and Rocky creeks (SLR, 2022b). A separate model was developed for each catchment using the Watershed Bounded Network Version 2019 (WBNM). Sub-catchments were defined on the post-mining model landform supplemented with publicly available LiDAR data and using Bureau of Meteorology and Australian Rainfall and Runoff (ARR) rainfall and runoff data, 50%, 2%, 1% and 0.1% Annual Exceedance Probability (AEP) storm events applied to the models to determine flow hydrographs and a probable maximum flood (PMF). Further details on the hydrologic modelling and surface water modelling utilised in the void simulations is provided in Section 6.1.2.

Predictive void model set-up and calibration

Two predictive models were simulated to assess the long-term impact of the Meandu Mine on groundwater:

- **Baseline Groundwater Model –** used to estimate groundwater levels in a scenario in which no mining occurred at the Meandu Mine (i.e., to determine baseline groundwater conditions). This was achieved by removing (SLR, 2022a):
    - all mine related boundary conditions (i.e., model packages representing the surface water features; mining and spoil placement); and
    - recharge and hydraulic parameter zones associated with spoil and fault zones (i.e., the Boulevard Fault is assumed to remain a hydraulic barrier to groundwater flow, in accordance with previous investigations reported in JBT (2021)).
- **Post-mining Groundwater Recovery Model (Long-Term Closure) –** used to estimate groundwater levels and interactions in consideration of alterations in the landform caused by mining. Undertaken in two parts (SLR, 2022a):
    - *Initial model* – short-term recovery simulation to ascertain groundwater inflows to the residual voids based on the final landform.
    - *Predictive model* – recovery simulation using information from the LOM planning (to closure) as well as long-term modelling of the post-mining landform (integrated with inputs from the surface water model and surface water balance).

The results of the initial model and the predictive model are integrated with the surface water model through an iterative approach to ensure that both models are consistent with one another. Each of the models are run for consistent time periods and under the same natural stresses (e.g., rainfall recharge and evapotranspiration) to produce comparable outputs which are then used to ascertain potential groundwater impacts from operation of the Meandu Mine.

The predictive model timing comprises the mining period of 2022 to 2045 and a 300-year recovery period (i.e., 2045 to 2345). The model stress periods are shown in Table 6.3.

Table 6.3 Predictive model timing – Final void hydrological modelling

Model period	Interval	Stress period	Date from	Date to
Mining	Monthly	84–91	01-05-2021	01-01-2022
	Quarterly	92–185	01-01-2022	01-07-2045
Recovery	Yearly	186–190	01-07-2045	01-07-2050
	10 years	191–195	01-07-2050	01-07-2100
	20 years	196	01-07-2100	01-07-2120
	25 years	197	01-07-2120	01-07-2145
	200 years	198	01-07-2145	01-07-2345

Since the void hydrological modelling was performed using the 'transport functionality' in MODLOW USG, no specific calibration was required.

Key void model outputs

The long-term groundwater modelling undertaken by SLR concludes that the proposed residual voids (K2E and K4E pits) would together act as a system to form groundwater 'sinks' which receive groundwater inflows from approximately 50% of the surrounding mining area (including backfilled voids [K4S and K2W-N which store coal combustion product and tailings storage] as well as part of the RAMP 5 backfilled void). The results of the model indicate that the risk of water stored in the final voids impacting on surrounding landholders is very low (SLR, 2022a).

Separately the long-term groundwater modelling also indicates that groundwater stored below backfilled voids in the north-west and west of the Meandu Mine may migrate over time westwards or north-westwards towards Meandu Creek upstream of Meandu Creek Dam adjacent to the mine. Seepage from this area may migrate towards Meandu Creek Dam. This scenario is currently being mitigated through planned rehabilitation and dewatering activities (refer to Section 6.1.7.2).

Hydrochemical modelling predicts that the water quality of the final voids will be suitable for the proposed PMLU of Water Storage for stock watering in all scenarios except for the climate change scenario with 20% decline in rainfall. Increased extraction of water for stock use appears to prevent an increase in salinity by preventing evapoconcentration of salt (refer further to Section 6.3) meaning that extraction levels can be varied in the future to manage the void water salinity in a low rainfall scenario.

6.1.1.4 Contaminant transport model

As stated under Section 6.1.1.2 the primary objective of the PRC Plan groundwater model was to predict post-mining water levels across the entire mine site and the associated impacts (if any) on environmental receptors/values. Predicted water levels were then used to assess the transport potential of contaminants of concern in groundwater, including their subsurface (spatial) extents and the potential for surface expression. Predictions from the contaminant transport modelling used the results (i.e., groundwater flow gradients) from the hydrogeological modelling of the final void groundwater modelling as described in Section 6.1.1.3 and in Section 4.7.4 of Appendix I – Meandu Mine PRC Plan Groundwater Technical Report (SLR, 2022a).

Contaminants of concern

To determine and characterise potential contaminants of concern, from latent sources, laboratory kinetic leaching column (KLC) tests of deposited waste was conducted by RGS (2020). Results from these KLC tests where then compared to measured groundwater quality within the area/s of spoil/mine waste.

KLC testing was conducted where 22 columns were leached for approximately 15 months and, 12 columns were leached for approximately 32 months. The mine waste material placed in each column was site representative of the materials generated from current mining operations. The mine waste placed in the columns represented, either a single source material or, mixed plant materials.

Sources of contamination

Known sources for contaminants at the Meandu Mine are shown on Figure 6.3 and described below as:

- The Hitachi Hill and western reject area, which includes three large areas of potential contaminant, directly upstream of Meandu Creek. These are:
    - the North-West Rejects: An area adjacent to the road and Meandu Creek used to disposed reject waste material between 1986 and 2012
    - the West Overburden Reject: An area on the western side of the mine where mine rejects have been disposed from 2014 to 2018; and
    - Hitachi Hill: The Hitachi Hill dump was progressively formed over several legacy mine features including the North-West Pit, which was used to store tailings (the NWA TSF) and backfilled with spoil and rejects up to 2015.
- Tailing dams:
    - the NWB TSF is located upgradient of the NWA TSF and was used for tailings deposition after the NWA TSF. The NWB TSF is currently undergoing decommissioning
    - historical tailings dams (excluding the one within Hitachi Hill) including the NWB TSF, the RD16 TSF (KW2 TSF), Ramp 3 TSF, and the K2 TSF.
- Mixed ash and tailings dams which include:
    - existing K2W and K2W-N
    - planned future K4S.

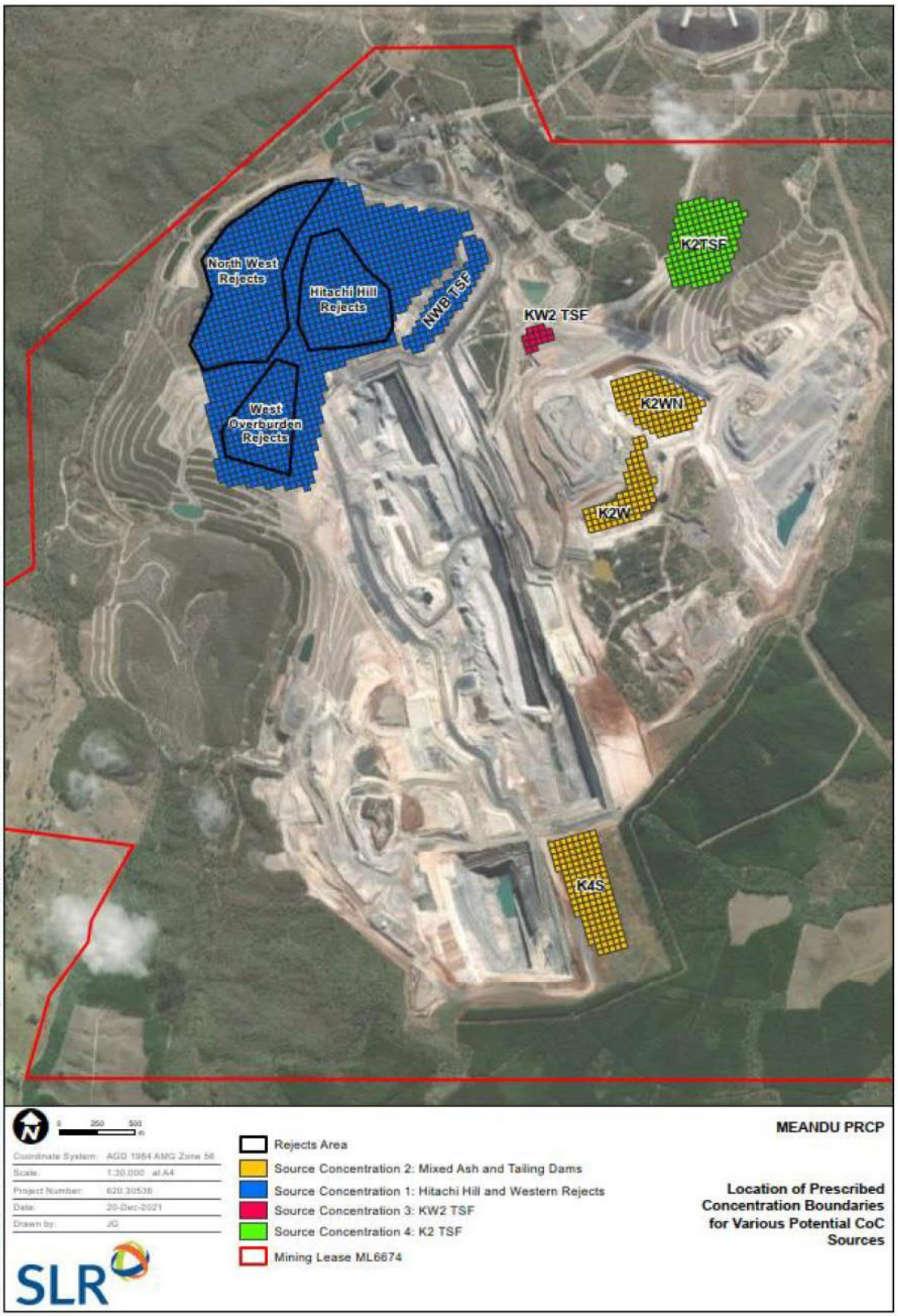


Figure 6.3 Location of prescribed concentration boundaries for various potential sources (SLR, 2022a)

Results from the KLC testing indicated that the concentrations of the contaminants of concern were generally found to be in lower concentrations than measured from the groundwater data in historic storage areas of these contaminants, in particular in the NWBV (WSP, 2021c – Appendix K). This is evident in the Hitachi Hill area (i.e., mixed waste) (Figure 6.3) where sulfate concentration, over time, shows a rapid decrease from the KLC tests; however, sulfate concentrations in groundwater have remained relatively consistent (i.e., mainly below 1,000 mg/L) since 2015 (the year when waste deposition ceased around the Hitachi Hill area). Additionally, sulfate concentrations in groundwater, after a period of 6 years, are mostly greater than sulfate concentration from observed KLC tests after 3 years. Therefore, to ensure conservative results, where available, measured groundwater data, as represented by the nearest relevant (geographically) available groundwater bore, was used to define contaminant of concern source concentration. Contaminants of concern were selected based on being representative of potential sources as well as general water quality indicators. The representative data for each contaminant source, including how each value was calculated (i.e., 80th percentile or maximum value), is shown in Table 6.4 (as extracted from Table 29 of Section 4.7.4.1.2 in Appendix I – Meandu Mine PRC Plan Groundwater Technical Report (SLR, 2022a)).

Table 6.4 Contaminants of concern concentration data for each source area

Contaminant source	Northern Area	K2 TSF	RD16 (K2W) TSF	K2W, K2W-N and K4S
Representative data	GW34, GW35, GW48, GW49, GW75 (80th percentile)	GW72 (80th percentile)	GW82 (80th percentile)	KLC#1^ (maximum value)
pH (-)	6.1	6.0	4.5	8
EC (µS/cm)	3,349	2,824	28,424	6,470
Sulfate (mg/L)	849	568	1,524	1,980
Aluminium (mg/L)	0.005*	0.02	9.24	1.9
Cobalt (mg/L)	0.32	0.086	0.715	0.079
Iron (mg/L)	48.8	146	9.8	0.11
Manganese (mg/L)	40.4	11.6	36.7	4.6
Nickel (mg/L)	0.22	0.086	0.5	0.067
Zinc (mg/L)	0.58	0.134	5.29	0.58
Selenium (mg/L)	0.005*	0.005*	0.01	0.08
Vanadium (mg/L)	0.005*	0.005*	0.005*	0.34
Molybdenum (mg/L)	0.0005*	0.0005*	0.0005*	0.46

^ RGS (2020), KLC test number 1; * Reported values are below the limit of reporting (LOR). 0.5 x LOR was used as source concentration.

Contaminant pathways

The generalised seepage pathways identified at the Meandu Mine are as follows:

- groundwater seepage via voids from either the natural ground surface or the deepest mined surface (WSP, 2018)
- seepage from spoil filled voids that occurs when the water level in the spoil rises to a level where seepage from the void is possible via topographic low points (e.g., pre mining drainage channels or haul roads into the pit) (WSP, 2018); and
- seepage from spoil that has been dumped out of the pit, which tends to follow topography (WSP, 2018).

Refer to Section 6.1.7 of this PRC Plan and Section 5.2.3 of Appendix I – Meandu Mine PRC Plan Groundwater Technical Report for more information pertaining to site-specific seepage pathways for those locations shown on Figure 6.3.

Contaminant transport model set-up and calibration

SLR undertook contaminant transport modelling for Meandu Mine using the transport functionality in MODLOW USG – Transport (V1.4.0). The version of MODFLOW USG – Transport 0 includes two packages to simulate mass contaminant transport. These are:

- Block Centred Transport, which defines the transport parameters for the model (e.g., dispersion and porosity); and
- Prescribed Concentration Boundary, which defines the location and mass concentration of the contaminant sources.

As the contaminant transport simulations were undertaken using the 'transport functionality' in MODLOW USG, no specific calibration is required however site-specific parameters such as contaminants of concern and sources/pathways were integrated.

One of the limitations of the numerical groundwater model, specifically when using it for contaminant transport modelling, is that the concentrations of contaminants of concern (at the source) had to be set up as 'constant over time' (Table 6.5). The constant source approach is ultra-conservative as it does not consider the impacts of any natural attenuation or decay of contaminants over time. It must be acknowledged that natural attenuation/decay in source materials will occur over decades/centuries of mobilisation.

Table 6.5 Transport model timing

Model period	Interval	Stress period	Date from	Date to	Contaminant of concern sources active
Transport – Recovery	Yearly	186–190	01-07-2045	01-07-2050	✓
	10 year	191–195	01-07-2050	01-07-2100	✓
	20 year	196	01-07-2100	01-07-2120	✓
	25 years	197	01-07-2120	01-07-2145	✓
	200 years	198	01-07-2145	01-07-2345	✓
	400 years	199	01-07-2345	06-02-2745	✓

Predicted concentrations of contaminants of concern with time shows that that near equilibrium is reached after 700 years. Although some bores are still showing increasing concentration after 700 years, this is attributed to the modelling assumption that sources of potential contamination have a constant concentration (still active at 100% potential after 700 years) and assumes no natural attenuation or decay is occurring. It is acknowledged by SLR (2022a) (refer Appendix I) that natural attenuation/decay is highly likely to occur.

Key model outputs

The contaminant transport model for the Meandu Mine was run over a period of 700 years to achieve near equilibrium.

The spatial distribution of each contaminant of concern following a period of 700 years as predicted by the contaminant transport model is shown on concentration contours maps provided in Appendix D of Appendix I – Meandu Mine PRC Plan Groundwater Technical Report.

It must be noted that the results of the contaminant transport modelling are considered 'ultra conservative' as the model does not account for natural attenuation and decay of contaminants within the system.

Consistent with previous observations and known locations, and confirmed through the application of the site numerical groundwater model, the following key areas will be carried forward to the PRC Plan risk assessment are:

- seepage expression downgradient of the NWBV, which is predicted to report to Meandu Creek noting that seepage water quality has shown a decrease in the concertation of key analytes since the Environmental Evaluation investigation
- a salinity plume extending from the QW area towards Meandu Creek to the north, relatively confined to shallow regolith material; and
- contaminants of concern migration through groundwater toward Black Creek, with potential for surface expression.

A Final Void Water Balance Model and IWBM water quality modelling were conducted in conjunction with the groundwater model to provide further assessment of likely final void and water quality conditions. Based upon the modelling undertaken herein, the areas of risk previously identified and identified within this scope of work that are to be carried forward in the PRC Plan assessment are summarised in Table 6.6.

Table 6.6 Areas of risk to be carried forward in PRC Plan assessment based on modelling

Risk areas identified		Assessment history	Assessment methodology	Findings	
Voids	Two proposed voids: K4E and K2E.	SLR 2022	3D topographic model established. Stage-storage surface area curves developed based on final landform topography. Water balance model established.	***Short-term impact (Post mining run up to year 2045)***	***Long-term impact (300 year recovery)***
				K2E void: Average groundwater inflow to K2E void is 0.1 ML/d while void contribution to the surrounding groundwater is 0.01 ML/d.	K2E void: Average groundwater inflow to K2E void is 0.18 ML/d while void contribution to the surrounding groundwater is 0.01 ML/d.
				K4E void: Average groundwater inflow to K4E void is 0.2 ML/d while void contribution to the surrounding groundwater is 0.3 ML/d.	K4E void: Average groundwater inflow to K4E void is 0.1 ML/d while void contribution to the surrounding groundwater is 0.21 ML/d.
				(K4E, K2E) at closure. No void is within floodplain. For both modelled scenarios: K4E is a flow through system towards east (i.e. K2E), therefore primarily a source. K2E primarily a sink to surrounding environment.	

Risk areas identified		Assessment history	Assessment methodology	Findings
NWBV	Seepage expression occurred at Bullgang Corner and Ramp 7. Only site of historical expression of seepage (WSP, 2018).	WSP 2018 SLR 2022	Numerical Groundwater Model (MODFLOW-SURFACT) Numerical Groundwater Model (MODFLOW-USG) IWBM predicted concentrations of CoC at key points of interest	As outcome of WSP, 2018, management actions and data collected has demonstrated that surface seepage is on track to be eliminated as a result of pumping out from NWBV to achieve target water RL. Comparison between the two time periods shows on-average there has been a significant decrease in all key analytes since the WSP (2018) study. Model indicates potential for future re-occurrence of surface seepage and near surface seepage associated with the predicted rebound in groundwater levels in the NWBV.
QW Salinity Plume	Identification of salinity plume extending from the QW area (located in the centre of the Mine) towards Meandu Creek to the north.	WSP, 2018 JBT 2018 in WSP, 2018 SLR 2020 in SLR 2022 SLR 2022	Numerical Groundwater Model (MODFLOW-SURFACT) Groundwater Data Review and Conceptual Groundwater Model Meandu Creek Saline Plume Investigation Numerical Groundwater Model (MODFLOW-USG) IWBM predicted concentrations of contaminants of concern at key points of interest	Contamination sources are unclear at this stage and may be linked to natural conditions and/or saline discharge from water infiltrating through the spoil. Monitoring of groundwater bores is continuing to confirm whether the plume is relatively static. The significantly lower EC of the QWBV sump water and of the RD16 TSF supernatant water indicated that this is not the source of salinity in the area. A review of the lithological data for impacted groundwater monitoring bores indicates that the plume is relatively confined to shallow regolith material. It is inferred that shallow groundwater seepage in the regolith entering Meandu Creek alluvium will report to Meandu Creek dam. The risk of harm to EVs from the saline plume have been identified as low and the plume has been interpreted to move very slowly (SLR, 2020).

Risk areas identified		Assessment history	Assessment methodology	Findings
Black Creek salinity plume	Contaminants of concern migration through groundwater toward Black Creek, with potential for surface expression.	WSP 2018 SLR 2022	Numerical Groundwater Model (MODFLOW-SURFACT) Numerical Groundwater Model (MODFLOW-USG) IWBM predicted concentrations of contaminants of concern at key points of interest	The potential source of contaminants within the Black Creek catchment may be derived from mine impacted areas (e.g. spoil or tailings of the K2E area), from areas that are unimpacted by mining to the east (i.e. natural drainage lines that drain the ridgetop basalt, or plantation forestry activities to the east) or from the area of the Tarong Power Station, including the coal stockpile which drains to this area (JBT, 2018a). This area is under ongoing monitoring and investigation. Determination of source yet to be established.

Further information is provided in Section 6.1.7 regarding the identified areas of concern for groundwater seepage.

Predicted water level in the alluvium and regolith at 300 years post-mining is shown in Figure 6.4. Potentiometric maps were generated for the key hydrostratigraphic units. An example of these is shown in Figure 6.5 representing the levels and gradients for the Queen D seam at equilibrium post mining. The supporting details and additional maps are located Appendix I – Meandu Mine PRC Plan Groundwater Technical Report (SLR, 2022a). Note that the Scenario 1 referred to in these figures refers to the extraction scenario discussed in Section 6.3.5.3.

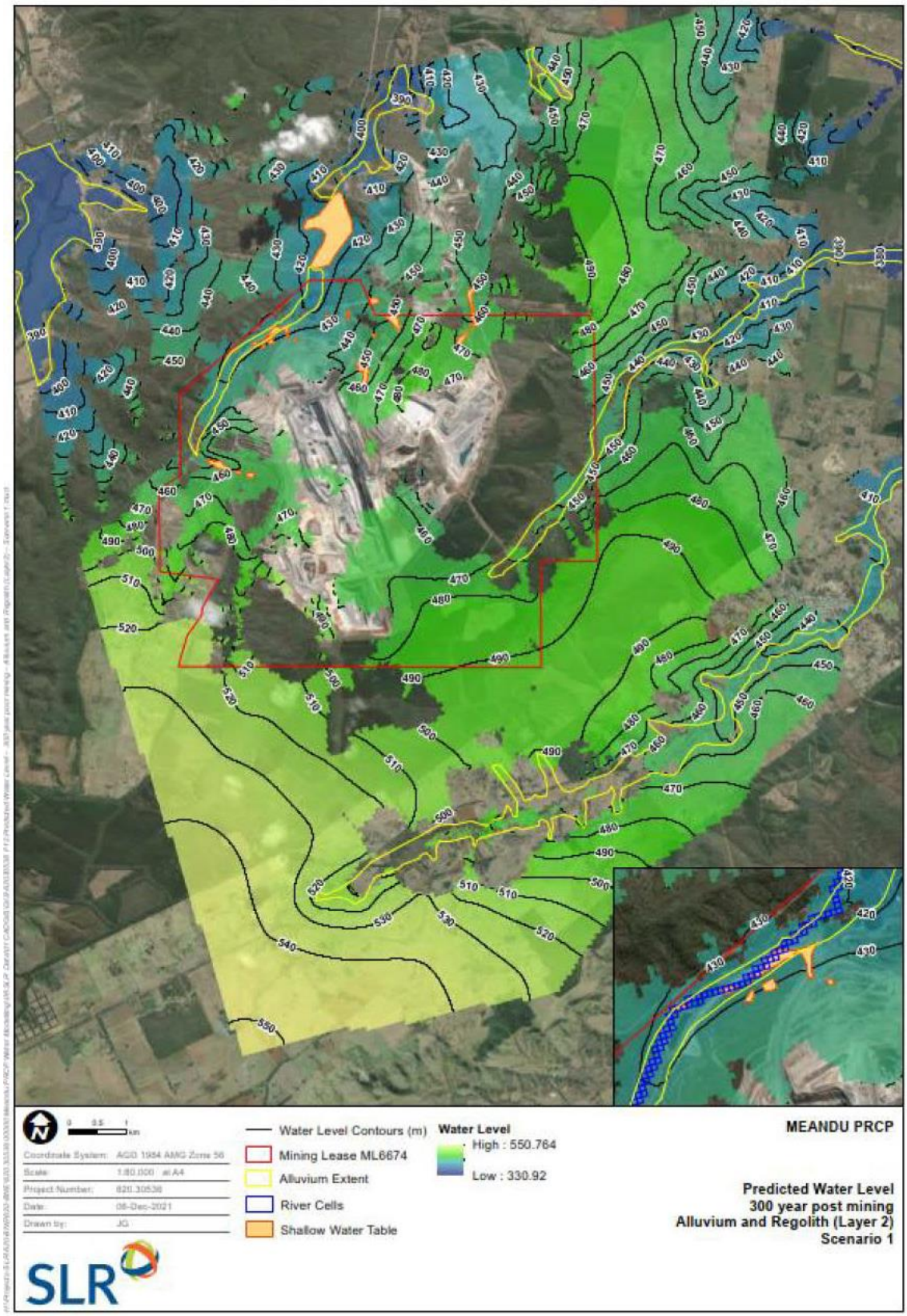


Figure 6.4 Predicted water level 300-years post-mining – Alluvium and regolith (Layer 2) (Scenario 1)

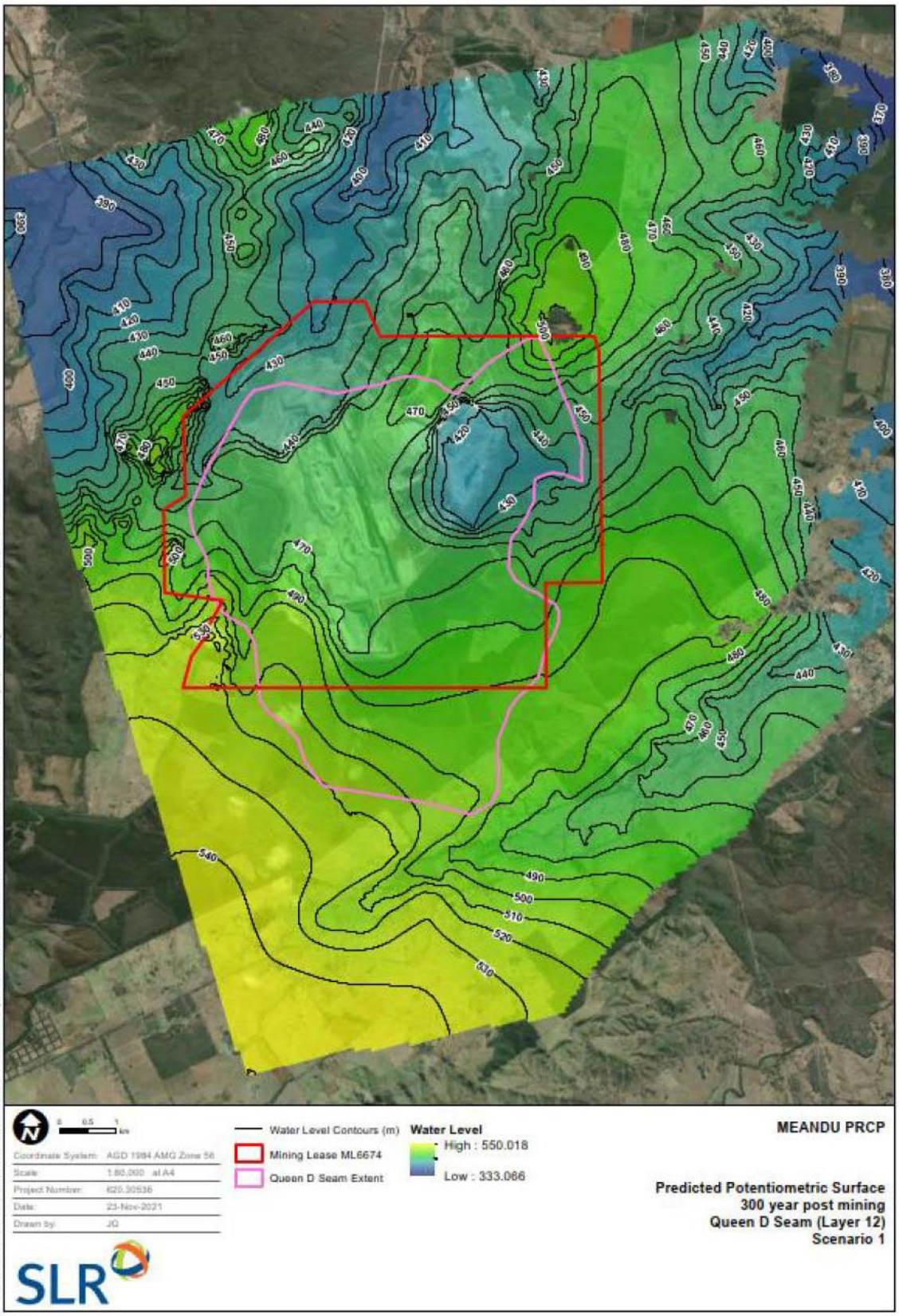


Figure 6.5 Predicted potentiometric surface 300-years post mining Queen D seam (Layer 12) Scenario 1

6.1.2 Flooding

PRC Plan Guideline (Section 3.6.1)

Section 3.4 of this guideline requires flood plain modelling for the purpose of voids located within a flood plain being rehabilitated to a stable condition. In addition to this, the applicant must also assess the flooding susceptibility and influence across the site. If flooding is a consideration, develop a hydrologic model of the catchment and a hydraulic model of the proposed mining area. Knowledge of flooding is integral to the rehabilitation planning process, including the placement and design of mine domains.

6.1.2.1 Overview

As described in Section 2.1.4 the Meandu Mine is located in the headwaters of the Barker and Barambah Creeks sub-basin, with a small portion of the Meandu Mine located within the headwaters of the Brisbane River sub-basin. Three ephemeral creeks (Meandu Creek, Black Creek and Rocky Creek) and their associated tributaries are relevant to the Meandu Mine. These ephemeral creeks convey surface water flow from the upstream reaches of their catchments through either natural or modified drainage lines to the downstream environment. Of particular note, both Meandu Creek and Black Creek are dammed on the downstream side of the Meandu Mine (related to Meandu Dam and Black Creek Dam), and Meandu Creek has been historically diverted in three locations.

Consistent with the requirements of the PRC Plan Guideline (Section 3.4), SLR were commissioned by Stanwell to undertake detailed hydrological and hydraulic modelling of surface water at the Meandu Mine to such an extent to determine if the final landform and proposed residual voids are influenced by surface water interactions (SLR, 2022b).

SLR determined through this modelling that there is no significant risk of ingress of flood waters to the final voids, and that the stability of stable landforms are not significantly impacted. SLR therefore considered that the flood risk profile for the Meandu Mine proposed final landform is acceptable.

The following subsections provide a brief summary of the modelling undertaken by SLR and the key outputs related to the Meandu Mine PRC Plan. Further detail is provided in Appendix J – Meandu Mine PRC Plan Void in Floodplain Modelling.

6.1.2.2 Hydrologic modelling

SLR undertook hydrologic modelling to estimate runoff hydrographs for use in hydraulic modelling at various locations throughout the catchments of Meandu Creek and Rocky Creek. SLR also completed a separate hydrological model for the catchments associated with both Meandu and Rocky creeks. The modelling included consideration of rainfall intensity-frequency-duration data and catchment extent.

To undertake this work, a Watershed Bounded Network Model Version 2019 (WBNM) was utilised which was run over each catchment area for 50%, 2%, 1% and 0.1% Annual Exceedance Probability (AEP) (with storm durations between 1 and 18 hours for each AEP event). The results of the WBNM model were analysed and the temporal pattern that produced a peak flow nearest to the mean of all 10 temporal pattern peak flows was adopted as the representative design storm.

A Probable Maximum Flood (PMF) assessment for both Meandu and Rocky creeks was also undertaken utilising the respective WBNM model. The WBNM results determined that the critical duration for both Meandu and Rocky creek catchments was less than 6 hours. Accordingly, SLR adopted the Generalised Short Duration Method to estimate the Probable Maximum Precipitation rainfall depths for each storm duration from 1 hour to 6 hours in accordance with catchment specific hydrologic data (SLR, 2022b).

The generated rainfall-runoff hydrographs at appropriate locations were then extracted for use in the hydraulic modelling (as inflow boundaries) (SLR, 2022b). Results of the WBNM hydrologic model were compared to the results of Rational Method and World Catalogue of Maximum Observed Floods flow estimations, which showed the model produced adequate results (SLR, 2022b).

6.1.2.3 Hydraulic modelling – flood assessment

Hydraulic modelling of the Meandu Mine final landform was undertaken by SLR utilising the TUFLOW (build 2020-10-AA) modelling software for the purpose of assessing the post-mining flooding conditions across both the Meandu Creek and Rocky Creek catchments (SLR, 2021b) as required by the PRC Plan Guideline. This work focused solely on the flood impacts and assessment of the final post-mining landform rather than a detailed assessment of the in-stream velocities at specific points of the creek diversion.

The model utilised a grid cells size of 10 m and the Digital Elevation Model as supplied by Stanwell consistent with the Meandu Mine final landform. A sub-grid sampling distance of 2 m was adopted, which was considered to provide adequate model resolution for the purposes of the assessment, given Meandu Creek and Rocky Creek have base widths of approximately 5 m or more. The model was calibrated using appropriate metrics for hydraulic roughness, inflows (as derived from the hydrologic modelling), downstream boundaries (as stage-discharge relationships) and critical duration (consistent with the hydrologic modelling).

Results

The 0.1% AEP flood event extents are shown in Figure 6.6.

The TUFLOW model results indicate that flow in both Rocky Creek and Meandu Creek are generally confined to the watercourse with little or no breakout flows occurring.

The results of the hydraulic modelling indicate that both proposed final voids (K2E and K4E) and the reformed spoil dumps of the final landform are not subject to inundation nor high velocities associated with flood events in Meandu Creek or Rocky Creek. None of the other features of the final landform are significantly impacted by flooding or high flow velocities in any of the AEP events assessed, including 0.1% AEP and PMF. The flood modelling work focused on the flood impacts and assessment to the landform, rather than a detailed assessment of the in-stream velocities at specific points of the creek diversion. By its nature the inputs and outputs are relative to the large scale of the analysis and are purposed to show the impact on the post-mining landform and flood extents. Nonetheless, the modelling shows the expected magnitude of flows in the drainage system, including Meandu Creek, and can be used to provide guidance on the magnitude of stream velocities and flows expected in the stream system during the simulated rainfall events. In this context, the model indicated velocities of up to 5 m/s occurred in localised areas of Meandu Creek during the 0.1% AEP event. In the same locations, velocities of 3 m/s and 4 m/s occur in the 50% and 2% AEP events respectively. While this may indicate the potential for scouring in this theoretical analysis, this is not considered relevant for the Meandu Creek diversion (system) for the following reasons:

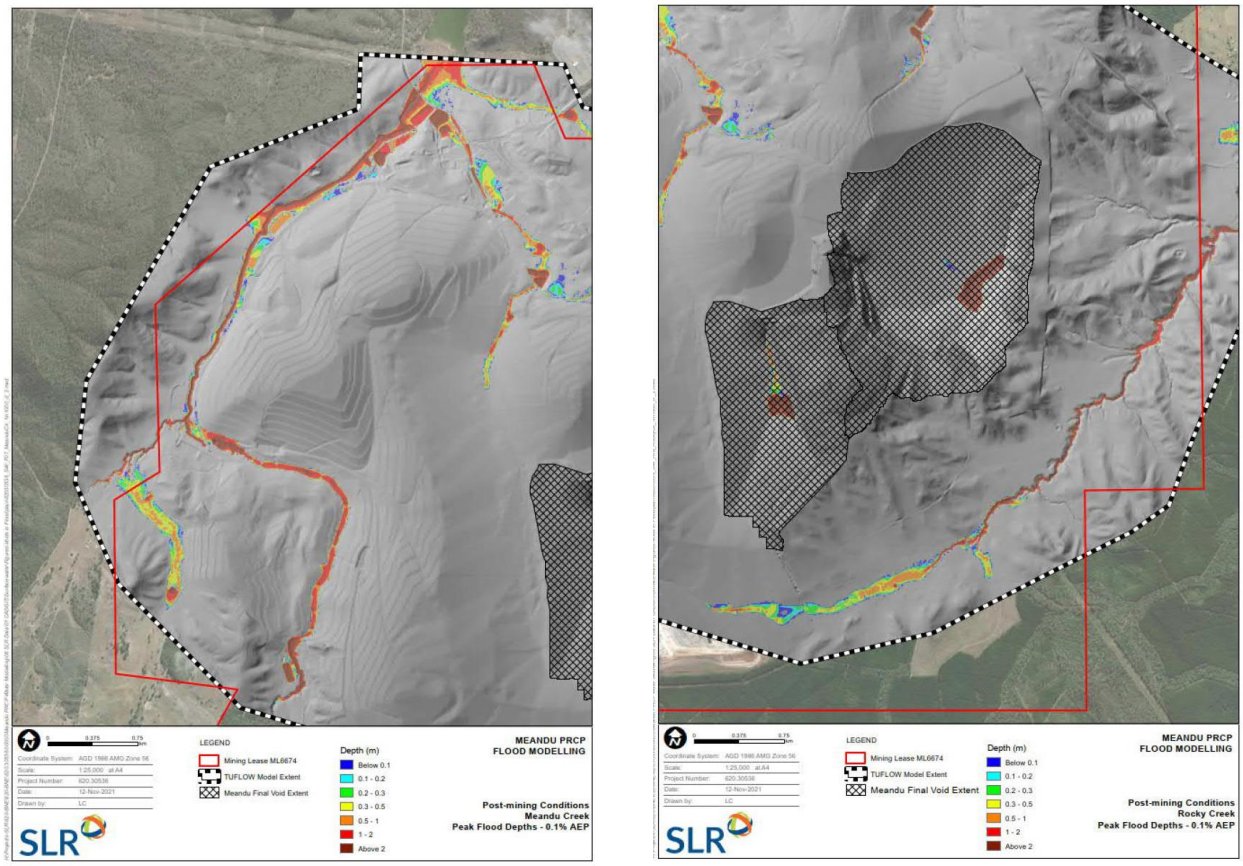
- The older (1980's and 1990's diversions) have been operating, and monitored, for 30 plus years of operations through multiple high flow and flood events. They are continuing to function appropriately and without any unexpected maintenance requirements.
- During the construction and certification of the 2005 creek diversion, flow modelling was undertaken utilising a hydrograph calibrated to actual flow events recorded in the Meandu Creek Catchment. The resulting design criteria for the 2005 Creek Diversion used velocities and flows greater than those indicated by the PRC Plan flood assessment by SLR. This means that the 2005 Creek Diversion has been designed against higher-than-simulated flow rates and volumes. This work also showed that the flow events estimated by the typical event simulation methods (including those used by SLR for the PRC Plan simulations) overestimated the actual system response in the Meandu Catchment. Therefore, it is likely that the current simulations undertaken for the PRC Plan are also overestimating the velocities that would be experienced in a real event.
- Areas of high flows are a common occurrence in these types of creek diversion systems. The system naturally accelerates flows during changes in gradient and aperture and is designed accordingly. Long-term geotechnical and morphological stability has been maintained through appropriate design provision of hydraulic and geotechnical treatments to the diversion and the surrounding landform.
- The Rehabilitation Milestones (RM9) include requirements for the Creek Diversions to be functioning as designed and that both the performance and integrity of the Creek Diversions are not threatened.
- Pre-mining velocities in Meandu Creek for the 0.1%, 2% and 50% AEP events have been assessed by Advisian utilising the same TUFLOW model created by SLR. The extents and distributions of the simulated flows rates were compared and indicate that, within the limitations of the available digital terrain model, the pre and post mining regimes are similar.

It is therefore considered that given there has been no material overall change in flow velocities in the creek diversion section from pre to post mining, the localised nature of these theoretical flow rates and the demonstrated performance of the Creek Diversion(s) to date through a number of high flow events, the stability of the post-mining creek diversion landform is considered unlikely to be materially different or reduced in comparison to the natural creek system.

In regard to potential downstream impacts, SLR concluded that the hydrologic regimes downstream of the Meandu Mine will not be significantly impacted by the proposed post-mining landform (SLR, 2021). This conclusion was drawn considering:

- the catchment area of Meandu Creek will remain similar to the pre-mining area. A small increase in catchment from the overall final landform is reduced and largely offset by approximately 0.05 km^2 which will return to the final voids (reducing the Meandu Creek catchment by approximately 0.05 km^2 i.e. less than 8% of the overall catchment area)
- Meandu Creek drains to the existing Meandu Creek Dam immediately downstream of Meandu Mine which will remain in place post-mining; and
- the catchment area and land use coverage of Rocky Creek following rehabilitation will be similar to pre-mining conditions (a result of the revised 2021 LOM Plan).

SLR noted that modelling illustrated that the hydrologic regime upstream of Meandu Mine will not be materially impacted given that the existing conveyance conditions of both Meandu Creek and Rocky Creek will not be significantly altered (SLR, 2021).



Meandu Creek **Rocky Creek**

Figure 6.6 0.1% AEP flood extents – Post-mining Meandu Creek and Rocky Creek

6.1.3 Waste characterisation

PRC Plan Guideline (Section 3.6.1)

Characterise mine wastes in a report that describes the likely physical behaviour and chemical reactivity of the waste materials under the conditions in which they would be stored. The report must address the constituent elements present, and their likely future speciation and mobility.

All mined material should be classified on its propensity to be potentially acid or non-acid forming, to generate neutral metalliferous or saline drainage, and its susceptibility to weathering.

6.1.3.1 Overview

Since 1990, a number of detailed studies have been undertaken relating to the geochemical characterisation of materials from the Meandu Mine. These have involved both static and kinetic leach column (KLC) testing (including the studies previously discussed in Section 6.1.1.4) of overburden, interburden and process wastes such as rejects, tailings and ash and most rock units. These studies have led to an evolving understanding of the geochemical behaviour of the rock at Meandu Mine, particularly the various waste streams. Many of the investigations undertaken to date have been in response to AMD events and were focussed on identifying the source of the AMD. A systematic program of geochemical testing has been implemented since 2016, creating a comprehensive geochemical database of behaviours of the specific rock units and waste streams at Meandu Mine. The Meandu Mine PRC Plan Waste Characterisation Report (WSP, 2021) (Appendix K) summarises these previous investigations. The report characterised the geochemical behaviour of the mined lithologies and generated wastes at Meandu Mine by assessing:

- historical surface water and groundwater quality for the 13 existing and former open pits, TSF supernatant and seepages at Meandu Mine; and
- historical mineralogical and chemical studies at Meandu Mine, including static and kinetic geochemical testing of mined lithologies and waste streams.

6.1.3.2 Meandu waste streams

A summary of waste streams produced at the Meandu Mine is provided in Table 6.7, including indicative annual volumes. Waste materials produced from operations at Meandu Mine, and disposed of or stored on-site, include:

- waste rock
- tailings and coal rejects; and
- coal combustion products.

Table 6.7 Meandu Mine waste streams overview

Waste	Projected indicative annual volume	Generation	Disposal/storage
Waste rock	27,500 kbcm	Free-dig or blasted material moved in advance of coal mining.	Moved by dragline or truck and shovel to in-pit/out-of-pit dumps, appropriate to LOM Plan and material characterisation.
Contingency tailings	120 k tonnes	Fine rejects from CHPP coal processing that bypass the solid bowl centrifuges when down for maintenance.	Pumped as slurry to dedicated Tailings Storage Facility.
Mixed plant rejects	920 k tonnes (excluding dirt tailgate)	Blending of coarse rejects and dewatered tailings generated from coal processing at the CHPP.	Haulage to dedicated in-pit rejects cells.
Coal combustion products	1.35 Mt	By-product of coal combustion process that is captured from flue gases using precipitators.	Pumped as slurry to dedicated ash storage facilities (currently K2W-N).

6.1.3.3 Mine waste geochemistry and minerology

The Meandu Mine PRC Plan Waste Characterisation Report (WSP, 2021b) (Appendix K) summarises the various geochemical studies undertaken to date at the Meandu Mine and describes the physical behaviour and chemical reactivity of waste materials stored at the Meandu Mine and the relevant management measures implemented to reduce environmental risk.

Summaries of the mineralogy and geochemistry of materials at Meandu Mine are provided in the sub-sections below. This information has been collated from geochemical waste characterisation studies undertaken at the Meandu Mine since the 1990's. A description, including key outcomes, of each of the studies used to create this summary can be found in Table 4.1 and Table 4.2 of Appendix K – Meandu Mine PRC Plan Waste Characterisation Report.

The geochemical investigations conducted to classify the lithologies and waste streams at Meandu Mine included:

- Static testing:
  - acid base accounting
  - net acid generation testing; and
  - other (paste pH and EC measurements to inform acidity and salinity).
- Kinetic testing:
  - kinetic net acid generation tests
  - acid buffering characteristic curve; and
  - kinetic column leach tests.

- A comprehensive review of the systematic geochemical testing program was undertaken by SRK in 2019 (in WSP 2021b), which determined the geochemical testing program at Meandu Mine to be both volumetrically and spatially representative of all materials being mined and all process waste streams.

Mineralogy

Infrared spectrometry was implemented using Hylogger™ technology to investigate the mineralogical phases present in the wavelength range between 300–2,500 nm and 6,000–14,500 nm in rock units at Meandu Mine. Results are largely as expected for a fluvial sedimentary domain with interbedded coal seams, with the dominant minerals throughout being quartz and kaolinite, with secondary quantities of feldspar and other clays. Carbonates (siderite, dolomite, ankerite, calcite, magnesite) were detected at trace levels only, with only a few detections of calcite in the Queen coals. Siderite has the lowest reactivity and buffering capacity of the carbonates present at Meandu Mine (EGi 2016 in WSP (2021b)).

Jarosite (iron sulphate) and gypsum (calcium sulphate) were detected at trace levels in the samples; however, their presence is important as these two minerals are common by-products of pyrite oxidation (jarosite) and subsequent acid neutralisation (gypsum). The absence of pyrite in the Hylogger™ results is of interest, given the common identification of pyrite in the geological logs. This highlights the low quantities of pyrite in the Tarong beds at Meandu Mine. Pyrite was only identified in the geological logs in association with coal, with the exception of a 0.36 m thick interval of siltstone in the interburden of drill core 8029C.

Geochemistry

Mine spoil and interburden/overburden

The results of the static testing of the overburden/interburden material undertaken at the Meandu Mine indicate that the great majority of the overburden material and approximately 85% of the interburden is classified as NAF. The static testing results of the spoil also suggest that the majority of the spoil is NAF, although the material is highly heterogeneous and isolated areas of actual acidity and PAF material have been identified (QGESS 2017 in WSP (2021b)). Sulphidic material is limited almost exclusively to organic lithotypes in the mine stratigraphy (SRK 2019 & 2021 in WSP (2021b)). While the initial results of the KLC testing suggest there are exceptions to the rule, with the weathered sandstone column generating appreciable acidic leachate for the duration of the testing, re-logging of the specific source column has highlighted that this material was associated with the coaly/ carbonaceous mudstone unit rather than a pure sandstone unit.

Spoil from the overburden is considered unlikely to generate significant AMD and any small pockets of acid generated should be diluted/buffered by non-acidic drainage from the majority of rock. Spoil from the interburden units has a higher potential for AMD generation due to the higher content of organic material in the rock; however, significant AMD generation is considered unlikely due to the majority of NAF material in the units.

The overburden/interburden appears to have variable potential for generating neutral mine drainage (NMD)/Saline Mine Drainage (SMD), with static testing suggesting most material has a low potential for generating saline drainage and isolated parts of Meandu Mine may generate leachate with one or more elevated metal concentrations. The KLC testing indicated the potential for saline metalliferous flushes being generated from overburden when first mined and exposed to rainfall. Ongoing drainage with elevated selenium, aluminium and iron may also be generated by the overburden; however, leaching of other metals from the tests appears to be related to sulphide oxidation.

A number of seeps have been identified over the life of the Meandu Mine, usually at the toe of active or rehabilitated spoil/reject dumps. The most problematic and persistent of these is the expression of AMD on Ramp 7 and in Bullgang Drain at or near the toe of RSA1, which have been identified as the root cause for the non-conformance of surface water quality compliance conditions and resultant environmental notice issued by DES in 2016 (WSP, 2018). The nature and cause of the AMD expression at RSA1 has been the subject of several investigations (EGi, 2016 and RGS, 2018 in WSP (2021b)) and much of the earlier waste characterisation at Meandu Mine.

Current consensus is that the expression of AMD at Ramp 7 and Bullgang Drain is a result of the oxidation and subsequent flushing of oxidation products from historically placed coarse rejects on RSA1 and in the North-West Backfilled Void (NWBV) generally (WSP, 2018). Static and kinetic testing confirms the coarse reject waste stream to be PAF and ongoing waste management is required to prevent further occurrences of AMD at Meandu Mine through preventing the oxidation of the coarse rejects. There is also the potential for the coarse rejects to generate NMD, even if co-mingled with tailings; therefore, prevention of oxidation of the coarse rejects is important regardless of the co-disposal strategy of the waste streams.

Tailings/coal rejects

The tailings at Meandu Mine are considered to be PAF; however, a combination of the addition of $Ca(OH)_2$ at the CHPP and the fine grain and low permeability of the tailings creates a significant lag time (>24 months) before the onset of the effects of oxidation. The supernatant water quality from the TSFs support the conclusion that the tailings are unlikely to generate acid provided they remain saturated and/or oxygen ingress is limited (i.e., reducing potential for oxidation).

The tailings are considered to have a low potential for the generation of SMD in the short and long-term. There is the potential for the tailings to generate NMD, particularly with regard to dissolved manganese, zinc and nickel; however, this will be reduced if oxidation of the tailings is prevented.

Coal combustion products

The findings of the geochemical assessment of the coal combustion products are quite definitive with regards to AMD potential, as all samples were classified as NAF. The actual acidity of the coal combustion products is neutralised during processing at the Tarong power stations. The coal combustion products appear to have the potential to generate a slightly saline “first flush” with elevated metals; however, the potential for ongoing SMD is considered very low. The potential for coal combustion products to develop NMD is considered to be very low, with the exception of vanadium, molybdenum and strontium.

Geochemical classification

A site-wide geochemical classification system for waste streams was developed at the Meandu Mine based on industry standard practice acid base accounting methods, using total sulphur content and the neutralising potential ratio (NPR) (maximum potential acidity divided by acid neutralising capacity (ANC)). The geochemical classification system is a three-class system and is shown in Table 6.8.

Table 6.8 Geochemical classification system for mine waste materials (SRK 2019 in WSP (2021b))

Material type	Classification criteria
Non-Acid Forming (NAF)	Total Sulfur (TS) < 0.05% or 0.05% TS <0.2% and NPR > 2, or weathering logs extremely weathered (XW) and highly weathered (HW)
Uncertain (UC)	0.05 < TS% < 0.2% and NPR ≤ 2
Potentially Acid Forming (PAF)	TS% > 0.2%

The above three-class waste classification system is considered functional in an operational setting and will align with mine's waste management strategy. As such, the system has been adopted by Meandu Mine for ongoing waste classification (including rejects, tailings and coal combustion products) and has been incorporated into the operating mine geological block model to manage waste disposal and rehabilitation requirements (Appendix K – Meandu Mine PRC Plan Waste Characterisation Report (WSP, 2021b)).

6.1.3.4 Geological block model

A geological block model of Meandu Mine has been developed to facilitate improved mine planning by incorporating material design parameters into the 2021 LOM Plan. Material characterisation outcomes from geochemical characterisation studies have been incorporated into the geological model where appropriate, with rehabilitation suitability generally aligning with lithological units. Yearly iterations have built on the original model to incorporate the most up-to-date data. The geological block model (JB Mining, 2021) contains the following units:

- Soil – assumed to be 0.2 m thick.
- Tertiary – virgin topography to Base of Tertiary (BUTE):
    - red clay interval (formally laterite)
    - basalt flows
    - lignite; and
    - other rock types.
- Triassic – BUTE to Tarong beds (inclusive):
    - upper Triassic (finer grain rocks – claystone, mudstone, sandstone, siltstone)
    - conglomerate/sandstone (predominately conglomerate and coarse sandstone with minor fine-grained rock bands)
    - coaly/carbonaceous mudstone (thin unit of carbonaceous mudstone, claystone and inferior coal contained within larger conglomerate/sandstone unit)
    - shale – (carbonaceous shale and mudstone with minor other rock types), and
    - Tarong beds consisting of multiple coal seams and non-coal interburden material.

The block model (JB Mining, 2021) currently classifies the coaly/carbonaceous mudstone unit (CM) as PAF and all other overburden as NAF as the amount of non-CM overburden classified as PAF during waste characterisation was considered insignificant at the scale of mining. Conservatively, all interburden within 2 m of the roof and floor of modelled coal seams has been classified as PAF in the model. The remainder of the interburden has been classified as NAF. To improve the reliability of the model so that PAF units can be identified ahead of mining and managed appropriately, drilling, sampling and analysis is ongoing (Section 6.1.3.6).

TEC Coal will continue to develop the block model utilised at the Meandu Mine using the results of ongoing geochemical characterisation studies to further inform mine planning, rehabilitation planning and LOM design.

6.1.3.5 Management measures

Conservative waste management procedures have been developed at the Meandu Mine to minimise the risk of AMD generation across Meandu Mine during operation and post-closure. Each significant rock unit at the Meandu Mine has been classified according to material design parameters (Table 6.9), the management of which is assigned in mine planning procedures. Specific management procedures are undertaken for each mine waste material and are discussed in the following subsections.

Table 6.9 Meandu Mine Material Design Parameters

Material	NAF	PAF[1]	Suitable for dump cover	Depth below final landform	Notes
Topsoil	■		■	–	Average stripping depth 0.2 m.
Weathered Basalt[2]	■		■	–	Basalt (BA1) lithology and red clay unit. Suitable for use as grazing subsoil.
Fresh Basalt	■		■	–	Basalt BA3, BA5 lithologies. Suitable for rock lining and riprap.
Other Tertiary Rock Types[2]	■		■	–	Includes Tertiary Sediments (TE) lithologies (tertiary sediments) and Basalt BA2, BA4 lithologies (partially weathered basalt). Excludes Lignite (LG) which is PAF.
Weathered Triassic Sandstone[3]	■			2 m	Includes Upper Triassic (UT) and conglomerate CG(1/2) which are potentially dispersive, erodible and exhibit low PAWC.
Weathered Triassic Coaly Mudstone		■		6 m	Includes Coaly Mudstone (CM) unit, consisting carbonaceous and inferior coal units. Currently limited to K4E between conglomerate CG(1) and CG(2).
Fresh Triassic Non-Coal Rock	■		■	–	Shale (SH) and Triassic Interburden (TI) units, consisting of non-organic and carbonaceous non-coal lithologies.
Fresh/ Weathered Triassic Coal[4]		■		6 m	Major modelled coal seams (CO) and transitional/inferior coal units (CU, CN, CW, CY lithologies).
Spoil (NAF)	■		■	–	Material quality in historical dumps and rehabilitation areas is variable and assessed as required.
Spoil (PAF)		■		6 m	

Material	NAF	PAF(1)	Suitable for dump cover	Depth below final landform	Notes
Rejects		■		6 m	Not to be dumped on pit floors. Includes MPRs and rehandled coarse rejects.
Tailings		■		6 m	Stored in designated facilities (currently within the ash storage facility).
Power Station Ash	■			2 m	Stored in specific voids as per EA conditions.

(1) Where possible PAF material should be dumped within pit void catchments.

(2) Weathered basalt preferred for use as subsoil in grazing rehab areas (minimum 1.5 m loosely placed depth). Laterite not to be placed within dump cover where possible except in minor quantities (≤20%). TE may be suitable as grazing subsoil if required, pending assessment.

(3) May be used as dump cover in native vegetation rehab if other controls are in place, i.e., shallower slopes, blending with other material and/or amelioration. Blocky conglomerate in lower portion of CG unit is more erosion resistant and may be suitable as dump cover pending assessment.

(4) Transitional coal bands are concentrated adjacent to the major coal seams (within 2 m of roof and floor of the modelled coal seams). Coal units can be mixed at a rate of 15% with NAF units to produce an overall NAF blend, that is to be kept at least 6 m below final landform.

Interburden/overburden

All interburden within 2 m of the roof and floor of modelled coal seams has been conservatively classified as PAF in the model and will be placed >6 m below final landform as per the LOM Plan. The remainder of the interburden has been classified as NAF.

Overburden at the Meandu Mine is classified as NAF in the forward LOM Plan except for separate units of coaly mudstone (CM) and lignite (LG), classified as PAF, which will be placed greater than 6 m below final landform. NAF overburden will be used as cover material generating a capping of NAF at least 6 m thick across the final landform design. Isolated occurrences of PAF in the overburden are generally too small to be of consequence at a mine scale, but where feasible these PAF units will be segregated and placed at least 6 m below the final design landform.

Tailings/coal rejects

Tailings at the Meandu mine are classified as PAF. Tailings have a significant lag time before acid generation. Solid bowl centrifuges have been installed to dewater tailings which will allow the majority of tailings to be co-mingled and disposed with coal rejects into dedicated disposal areas. Coal rejects are to be placed within the disposal area less than two weeks after stockpiling. The rejects disposal area is to be capped with at least 6 m of NAF material and final earthen capping to promote plant growth and restrict moisture ingress. A thickness of cover plot for the NWB TSF is included as Figure 6.25.

Contingency tailings disposal will occur when the solid bowl centrifuges are off-line, with the tailings disposed into the K2W-N Pit and later into K4S Pit. Tailings will be kept saturated to prevent oxidation. Contingency tailings deposition will be managed so that the tailings do not come into contact with the constructed northern embankment. The final TSFs will be capped with a NAF material to form the initial layer that is in contact with the tailings, and at least 6 m of the final landform surface to minimise infiltration of water and the likelihood of any erosion occurring to the final cover system (refer further to Section 6.2).

Coal combustion products

Coal combustion products at the Meandu Mine are classified as NAF. Coal combustion products are stored in the dedicated K2W-N ASF which has a planned operational closure in approximately 2028. Following completion of ash and contingency tailing storage in K2W-N, placement of ash and tailings in a void within K4S pit will then be undertaken. Rehabilitation will comprise a period of desiccation/consolidation following by capping with NAF spoil to a level that fits in with the surrounding final landform and has a minimum thickness of 2 m, which will be free-draining and minimise infiltration of water into the landform (refer further to Section 6.2). The majority of the footprint of the K2W-N ASF and all of the footprint of the K4S ASF will have final cover thicknesses greater than 2 m. Thickness of cover plots for the ASFs are shown in Figure 6.26 and Figure 6.27 respectively.

Final highwalls

The current LOM Plan proposes to limit the final pit voids post-mining completion to K2E and K4E pits. Final highwalls will also be located in the K2W-N ASF and SW pit. The planned PMLU of the residual voids is for Steep Rocky Ecosystems and Water Storages, with the aim of containing water of a suitable quality for native wildlife and/or livestock ingestion. Specific AMD, SMD and/or NMD management of the final highwalls is not expected to be required as geochemical testing suggests the relative volume of potentially problematic rock likely to be exposed in the final void highwalls is insignificant at the scale of mining (refer further to Section 6.3).

6.1.3.6 Additional sampling/testing

TEC Coal undertook a gap analysis of geochemical waste classification undertaken to date against the PRC Plan Guideline requirements. Although the geochemical dataset at Meandu Mine was considered adequate for the development of the PRC Plan, the gap analysis recommended additional geochemical sampling and testing to provide greater surety of the geochemical characterisation of in-situ material still to be excavated at Meandu Mine. The additional works are described below:

- additional sampling and static testing of sections of Meandu Mine forward planning area identified as having low sample densities (north-east of K2E pit)
- comprehensive sampling and kinetic testing program of:
    - overburden/interburden lithologies to verify the classification of non-acid forming (NAF) and PAF materials at Meandu Mine more accurately, particularly lithotypes with UC classification
    - material representative of the final pit highwalls (K2E and K4E pits) to verify the geochemical kinetic properties of the final pit walls to inform future residual void water quality modelling updates. This will include remnant coal samples as this material has been classified as PAF will likely have the highest risk for AMD generation.

Drilling and analysis of the area north-east of the K2E pit is proposed to be undertaken within the 2022-2024 exploration program. Additional kinetic testing columns of overburden/interburden and rejects were commenced in in September 2021.

Ongoing additional geochemical sampling and testing is expected to be undertaken opportunistically throughout the operation of Meandu Mine so that any changes to the long-term LOM Plan can be incorporated into ongoing waste, rehabilitation and AMD management planning.

6.1.4 Soil and capping material

PRC Plan Guideline (Section 3.6.1)

The rehabilitation and management methodology should include that soil assessment activities are supplemented by additional surveys conducted at appropriate intervals to assess soil resources in planned disturbance areas. In addition to the assessment of soils, the proposed rehabilitation methodologies in the rehabilitation planning part must also address topsoil management. Topsoil management must ensure sufficient topsoil quantity and quality is available in those instances that waste rock or tailings cannot support the proposed PMLU. Integrated soil and waste rock characterisation and mapping should form the foundation of the rehabilitation strategies. The available soil resources and capping material should be assessed prior to the commencement of operations.

6.1.4.1 Qualitative assessment

A thorough material sampling and characterisation investigation was conducted by Stanwell to assess the rehabilitation suitability of waste rock and soil material available at the Meandu Mine (Landloch, 2021a). The program was specifically designed to assess material suitability with regard to meeting nutrient, chemistry, erodibility and water storage capacity requirements for the proposed PMLUs of Native Ecosystem and Beef Cattle Grazing. The results of the investigation are summarised in the following sections.

Topsoil

The distribution of soils at Meandu Mine can be generally divided into two areas. Prior to mining, the western half of Meandu Mine had sandy and silty loam surface soils over sodic clays (lithosols, sodosols, kandosols and dermasol) derived from Upper Triassic and Triassic Sediments (referred to as “grey topsoil” in the Meandu Mine planning material balance). The eastern half of Meandu Mine, including the K2E ASA, has clay to sandy clay loams over kaolinitic clays (ferrosols) derived from deeply weathered basalts and fresh basalts, or sodic clays (dermasols) and derived from Tertiary Sediments (Landloch, 2021a).

Chemistry

Soil chemical data for Meandu Mine has been derived by the collection of *in-situ* soils from areas planned for future stripping and mining, including the K2E ASA. Data is available for both the grey topsoil and the basalt-derived ferrosols in the K2E ASA. In addition, existing stockpiles of previously stripped topsoils have been surveyed and characterised physically and chemically to inform suitability for use as growth media for the planned PMLUs of Beef Cattle Grazing and Native Ecosystems (Landloch, 2021b, 2021d).

Both soil types generally had pH levels in the strongly acidic to moderately acidic range (pH 4.0–6.5) with <10% of samples in the neutral range. All soil EC values indicated non-saline conditions, which correlated with low soluble chloride content in the soils. Cation Exchange Capacity (CEC) for both soil types was mostly very low to low with approximately 20% of samples medium CEC and two samples with high CEC. All soils were acceptable for rehabilitation with regard to acidity, salinity and CEC, although a high proportion of the soils are marginal with respect to pH and CEC, and may require nutrient application. The nutrient data available suggests that the soils are relatively fertile, with total nitrogen concentrations of 700–2,911 milligrams per kilogram (mg/kg), total Kjeldahl nitrogen concentrations of 690–7,950 mg/kg and phosphorus concentrations of 5–212 mg/kg (Landloch, 2021d).

Exchangeable sodium percentages of the topsoils ranged from 0.7 to 21.3%, averaging approximately 3% in the ferrosols and 7% in the grey topsoils. The majority of topsoil ESP values are considered suitable for rehabilitation purposes.

Dispersivity and particle size distribution

The need for topsoil to provide a surface growth medium on the covers was identified through previous rehabilitation works at Meandu Mine due to the potential dispersivity of several material units (see below). Dispersivity of soils in the K2E ASA was assessed through Emerson Aggregate Testing and indicated 60% of the tested soils were non-dispersive with carbonate or gypsum present with all but one of the other soil samples being non-dispersive. Laboratory dispersivity testing indicated all ferrosols and most grey topsoils were non-dispersive with two grey topsoil samples showing a slightly dispersive nature.

Particle size distribution (PSD) tests of soils from the K2E ASA showed the most common soil type to be sandy clay but soil types ranged from pure clay to clayey gravels. Texturally there was no significant difference between the ferrosols and grey topsoils.

Erodibility

Successful rehabilitation across several landforms at Meandu Mine has shown that the establishment of high levels of ground surface cover prevents significant erosion of placed topsoil. Previous studies, including rainfall simulation trials in rehabilitation areas at Meandu Mine have shown links between erosion rate, vegetation cover and rainfall density and found that a 50% vegetation cover level reduces erosion rates from rehabilitated slopes to acceptable levels (Loch 2000, Carroll et. al 2001). A ground cover level of 50% for the Native Ecosystem and Beef Cattle Grazing PMLUs is considered a conservative target to mitigate erosion risk and prevent land degradation, and correspondingly has been adopted as the success criteria in both the preceding EA and in the relevant RM criteria.

Historically the topsoil used for rehabilitation has been derived from sedimentary lithologies (grey topsoil), with some ferrosols being utilised more recently as they have become available due to mine progression. Future PMLU as Beef Cattle Grazing land will preferentially use ferrosols as topsoil to provide the higher PAWC and nutrient requirement for pasture (Section 6.2.1). An assessment of the erosion hazard of the preferred profiles using available soil material (grey loams and red ferrosol) was conducted to confirm the proposed topsoil for final landform would meet the erodibility criteria (Landloch, 2021c).

Rainfall simulation was applied on soil plots and flumes in a laboratory environment at a 20% gradient with sediment runoff measured gravimetrically to provide accurate soil erosion rates to apply to Water Erosion Prediction Projection (WEPP) model for Meandu Mine. The two main soil types present at Meandu Mine (ferrosols and grey topsoil) were used in the experiment.

In the long-term, ground cover levels of established vegetation areas are expected to be approximately 70% (substantially higher than the 50% vegetation cover expected to deliver suitable erosion risk mitigation at the completion of RM9), based on rehabilitation monitoring supporting Meandu Mine's 2021 rehabilitation certification application that included rehabilitation ranging in age from 9 to 24 years. WEPP modelling outputs for long-term erosion utilising the 70% cover figure were therefore used as the basis for final rehabilitation design. At these cover levels, for slope gradients up to 15% and to achieve a tolerable soil loss rate of 5 t/ha/year, the WEPP modelling indicated that slope lengths of up to 125 m should be suitable for ferrosol topsoil with lengths of up to 70 m suitable for grey loams (Landloch, 2021c). It should be noted that the modelling is designed for pasture scenarios and erosion rates for native vegetation will be lower than reported as tree canopy cover will reduce runoff through canopy interception and evaporation of rain. Future erosion studies (such as field rainfall simulation) may further refine the allowable slope lengths for the different soil types.

Water holding capacity

Plant available water capacity (PAWC) for the soils at Meandu Mine indicated PAWC of 15.5–33.1% for the ferrosols, averaging approximately 30%, and 19.1–31.5% for the grey topsoil, averaging approximately 20% (Landloch 2021d). The average PAWC values for the grey topsoil may be insufficient to sustain improved pasture for grazing (Landloch 2021b) but is sufficient to sustain native vegetation. In contrast, the ferrosols at the site have PAWCs are considered suitable for improved pasture.

Red Clay (RED)

The red clay was found to be moderately acidic with an average pH of ~5 (Landloch, 2021a). Whilst not ideal for growth media, this level of acidity is acceptable for rehabilitation purposes. The EC and chloride concentrations of all samples was low, indicating the salinity of the red clay is satisfactory for rehabilitation purposes. CEC values for the red clay were suitable for rehabilitation, but relatively low, indicating this material may have a lower capacity to retain positive ions and cycle fertility.

ESP of the red clay ranged from low (<15%) and suitable to high (>30%) and unsuitable for rehabilitation. ESP-EC ratios of RED material suggested it was somewhat dispersive; however, Emerson Aggregate Testing showed the red clay to be non-dispersive.

PAWC results for the red clay (ferrosol sub-soil) ranged from 20.6–28.4%, which is sufficient to support native vegetation and improved pasture for grazing (Landloch 2021d).

The red clay is considered suitable for rehabilitation but given the uncertain dispersive quality and the relatively low CEC, this material will require topsoil cover to limit erosion (Landloch, 2021a).

Weathered Basalt (WB)

WB was found to be moderately acidic with an average pH of ~5 (Landloch, 2021a). Whilst not ideal for growth media, this level of acidity is acceptable for rehabilitation purposes. Excepting one elevated outlier, the EC and chloride levels in WB were low and suitable for rehabilitation purposes with respect to salinity. The CEC values for WB were suitable for rehabilitation, but mostly relatively low, indicating the material may have a lower capacity to retain positive ions and cycle fertility.

ESPs of WB were mostly low (<15%) and suitable with one marginal outlier. The ESP-EC ratio suggested the material was potentially dispersive; however, Emerson Aggregate Testing results were generally non-dispersive or marginally dispersive.

The two reported laboratory measurements of WB PAWC returned values of 114 mm/m and 312 mm/m, indicating the material can hold sufficient water to support native vegetation and improved pasture for grazing.

The WB is considered suitable for rehabilitation but given the uncertain dispersive quality and the relatively low CEC, this material will require topsoil cover to limit erosion (Landloch, 2021a).

Overburden/interburden/spoil

The geochemistry of the waste material including the overburden, interburden and existing spoil has been covered in detail in Section 6.1.3 of this PRC Plan and Appendix K – Meandu Mine PRC Plan Waste Characterisation Report (WSP, 2021), particularly with regard to the formation of AMD, SMD and NMD. In general, the Triassic sediments at Meandu Mine are geochemically benign, with PAF rock limited to carbonaceous material, primarily the highly carbonaceous coal material. As a conservative measure, the LOM Plan assumes all material within 2 m of a coal seam is PAF and will be disposed of as such. Only material confirmed as NAF will be used within 6 m of the final landform surface.

Overburden/interburden materials were generally slightly to moderately acidic and considered to have suitable to marginal pH levels acceptable for rehabilitation (Landloch, 2021a). Excepting two outliers in Tertiary sediments, EC levels and chloride concentrations were low for all lithologies and the salinity of the material is considered suitable for rehabilitation. Most overburden/interburden had relatively low CEC levels, but all were suitable for rehabilitation.

There is a broad range of ESPs in the overburden/interburden, with shale and Triassic interburden low or marginal, conglomerate sandstone and Tertiary sediments low to high and Upper Triassic sediments mostly high and unsuitable for surface cover material. ESP:EC ratios suggest all of the overburden/interburden is dispersive; however, Emerson Aggregate Testing indicates that basalt, Upper Triassic and Triassic interburden were not dispersive and conglomerate sandstone, shale and Tertiary sediments were generally not dispersive but did have highly variable results.

The overburden/interburden materials, particularly the Upper Triassic and sandstone conglomerate materials, are generally not considered suitable for surface rehabilitation due to their moderate to high sodicity and their propensity to dispersion as there will be a high erosion risk if surface runoff on spoil areas is not well managed. Therefore, topsoil cover is required on NAF overburden/interburden. However, provided the material is confirmed NAF, overburden/interburden is suitable as cover material beneath the topsoil growth medium.

The limited data available for overburden/interburden PAWC indicates the waste rock generally ranges from 97 to 226 mm/m with one shale sample returning a PAWC of only 6 mm/m. These results suggest the majority of the overburden/interburden at Meandu Mine has a PAWC sufficient to support improved pasture grazing (Landloch 2021a). Moisture contents measured in five samples collected from the K2E spoil dump returned available water percentages of 11% to 19% for Triassic sandstone/siltstones and 23% for weathered basalt (QGESS 2021), indicating that actual deposited spoil has significant water retaining capacity.

Summary

In summary, there are suitable materials present on the Meandu Mine to provide capping and growth medium adequate to meet the requirements of the proposed PMLUs. Characterisation according to the material types in the geological model used as the basis of the LOM Plan according to suitability for PMLU is summarised in Table 6.10. Quantitative assessment of the amount of available suitable material is discussed in Section 6.1.4.2.

Table 6.10 Rehabilitation Material Sources for PMLUs (adapted from Landloch 2021a)

Material unit	Description	Properties and constraints	Native vegetation	Grazing
RED	Laterite and subsoil; plastic clays (not claystone). Well drained material. Laterite has low PAWC.	Red clay subsoils have relatively low geotechnical stability, are plastic when wet.	Clay lithology suitable for topsoil. Laterite has high strength and low porosity, best as dump cover below 2 m.	Clay lithology suitable for topsoil. Other RED material may be suitable for cover in areas of low gradient. Laterite has high strength and low porosity, best as dump cover below 2 m except in small quantities.
WB	Weathered Basalt; clay, claystone where low salinity, low chloride and <20% rock.	Any stripped topsoil has very high rehabilitation value. Clay can contain high salinity and chloride but will rapidly leach below the root zone.	Clay suitable but not highest value use. Save this material for grazing PMLU.	Suitable and preferred for use in grazing PMLU in areas of low gradient (<17%) where $EC_{1:5}$<0.5 dS/m and Chloride levels are marginal or satisfactory. 0.8 m depth of dump cover required plus 200 mm topsoil.
TE	Tertiary Sediments	Low chemical and physical fertility. Can have high salinity and chloride. Can be dispersive.	Clay marginally suitable for dump cover and potentially subsoil. May need Gypsum or lime at 5 t/ha/100 mm layer.	Clay marginally suitable for dump cover and potentially subsoil. May need Gypsum or lime at 5 t/ha/100 mm layer.
BA	Fresh Basalt (unweathered); topsoil may crack and should not be used over dispersive dump cover (conglomerate, sandstone).	Clay suitable for use as dump cover if salinity and clay limits not exceeded and rock content allows effective handling.	Basalt rock can be used for rock armouring steep gradients (18–33%) in native vegetation or steep terraced landforms.	Clays can be used as dump cover below 1 m in grazing PMLU or potentially above PAF cells due to relatively high neutralising capacity.
UT	Upper Triassic; potentially sodic and dispersive. Claystone may be saline.	Potentially sodic, dispersive and/or saline.	Suitable dump cover to 15% gradient beneath 0.2 m of non-cracking topsoil. Claystone not within 1 m of surface.	Unsuitable within 2 m of surface due to potential dispersion, low PAWC and high erodibility.

Material unit	Description	Properties and constraints	Native vegetation	Grazing
CG	Conglomerate Sandstone; conglomerate, sandstone, claystone.	Potentially sodic, dispersive and/or saline.	Suitable dump cover to 15% gradient beneath 0.2 m of non-cracking topsoil. No Claystone within 1 m of surface. Otherwise suitable dump cover.	Unsuitable within 2 m of surface due to potential dispersion, low PAWC and high erodibility. Claystone unsuitable.
CM	Weathered coaly mudstone/inferior coal.	Coaly mudstone can be PAF.	Unsuitable for dump cover.	Unsuitable for dump cover.
SH	Shale; shale, siltstone, carbonaceous mudstone.	Limited dispersion, chloride, pH and CEC.	Suitable dump cover below 0.2 m if NAF.	Suitable dump cover below 0.8 m if NAF.
TI	Triassic Interburden non-organic; claystone, siltstone, sandstone, mudstone.	Not dispersive, suitable chloride, pH and CEC.	Suitable dump cover below 0.2 m if NAF to 17% gradient, potentially to 20% for select materials.	Suitable dump cover below 0.5 m if high PAWC and confirmed NAF.
TI	Triassic Interburden organic; carbonaceous siltstone, carbonaceous mudstone.	Suitable sodicity, chloride, pH and CEC, some zones can be PAF.	Suitable dump cover below 0.2 m if confirmed NAF.	Suitable dump cover below 0.8 m if confirmed NAF.
SP	Historic spoil of mixed origin.	Highly variable in composition and attributes. Placement within profile to be determined from characterisation programs.	Basalt suitable for rock armouring steep slopes >17%, otherwise may be unsuitable within 1 m of surface (potential for low PAWC).	May be unsuitable within 4 m of surface due to high variability and potential for high salinity, high dispersion, low PAWC. Testing to be undertaken in advance of mining to confirm suitability.

6.1.4.2 Material balance

Cover material available for specific PMLUs was assessed against the LOM Plan to confirm material availability required to complete rehabilitation. The relative cover material requirements and available source material for each PMLU is shown in Table 6.11. Note that for each PMLU and underlying waste covered the specifications are cumulative for thickness. For example, for the Native Ecosystem PMLU, total thickness of 6 m NAF material is achieved through 5.8 m of generic NAF material with 0.2 m of Grey Topsoil as cover.

Table 6.11 PMLU cover material requirements, availability and potential source at Meandu Mine (post 2022)

PMLU	Waste covered	Cover specifications	Cover volume required (m^3)	Potential source of cover material
Native Ecosystem	NAF Spoil*	0.2 m Grey Topsoil	2,101,971	Current topsoil stockpiles, stripped topsoil from K2E
	PAF MP Rejects	5.8 m NAF Spoil	60,957,151	Mined overburden/ interburden from all pits
	Tailings	5.8 m NAF Spoil	760,167	Mined overburden/ interburden from K2E
	Coal combustion products	1.8 m NAF Spoil	975,854	Mined overburden/ interburden from K2E
Beef Cattle Grazing	NAF Spoil*	0.2 m Red Topsoil OR 0.2 m Grey Topsoil where testing verifies suitable properties (subject to outcomes of trial)	1,098,435	K4E, K4S and K2E ASA stripped topsoil, current topsoil stockpiles (ferrosols)
		0.8 m Red Subsoil (RED & Weathered Basalt) OR 0.8 m subsoil material where testing verifies suitable properties (subject to outcomes of trial)	4,393,741	K4E, K4S and K2E ASA red clay from RED and WB Horizons
	PAF MPRs	5 m NAF Spoil	23,950,732	Mined overburden/ interburden from all pits

* Includes NAF Spoil used to cover PAF MPRs, tailings and coal combustion products.

Table 6.12 provides an overall balance of cover material required versus material available. Required and available material volumes have been generated from the LOM Plan with NAF spoil comprising overburden/interburden which has been classified as NAF (Section 6.1.3). Table 6.12 demonstrates that sufficient material is available for installation of cover systems over processed waste where required that will meet the design criteria established to provide a final rehabilitated landform suitable for each relevant PMLU.

Table 6.12 Total cover material balance at Meandu Mine (post 2022)

Cover material	Volume required (m^3)	Volume available (m^3)
Grey Topsoil	2,101,971	3,220,200
Red Topsoil	1,098,435	1,117,100
Red Subsoil	4,393,741	29,504,000
NAF Spoil	86,643,904	225,250,000

Location and accessibility

The volumes of available cover materials as quoted in Table 6.11 and Table 6.12 are all located within the existing surface rights area of Meandu Mine (including the K2E ASA). Existing Grey Topsoil stockpiles are spread across most areas of the mine, but are all accessible with medium scale or heavy machinery. Accessing the Red Topsoil and Subsoil will involve pre-stripping in the K4E and K4S areas and the proposed K2E ASA and transfer of the material to the Beef Cattle Grazing PMLU area in the centre of the mining area. Assessment of existing topsoil stockpiles has also identified a number of stockpiles containing ferrosol material that is deemed suitable for use in these areas (Landloch, 2021d). Progressive advance of the mining pits will provide NAF spoil in the form of the overburden/interburden removed to access the coal seams, with the K2E and K4E pits remaining as final voids and the overburden/interburden from these two pits used to complete infill and covering of K4S, Central and Ramp 5 pits. The LOM Plan includes all necessary haulage of subsoil materials to achieve the required PMLU footprint and distribution.

Topsoil stockpiles are positioned within the active mining area and are reclaimed in such a way as to achieve coverage with the existing haulage fleet. Subsoil and NAF spoil cover materials have a haulage length range across the 2021 LOMP generally from 1 km to 5 km (one way). During the re-establishment of K2E pit and until in-pit dumps are available, NAF material is scheduled to be hauled longer distances (6 to 11 km) to the western pit dumps, to provide the NAF volumes required to achieve the final landforms in those areas.

6.1.4.3 Topsoil management

The stripping of in-situ topsoil occurs progressively at the Meandu Mine as operations extend into undisturbed areas of the approved surface disturbance area. To assist with this process, the Meandu Mine maintains an internal Topsoil Handling Procedure which covers the planning, stripping and stockpiling of topsoil at the Meandu Mine.

The topsoil handling procedure at the Meandu Mine includes:

- Planning:
    - a permit to clear or disturb land must be obtained prior to conducting any activity which will cause disturbance to in-situ topsoil
    - prior to disturbance occurring, a topsoil assessment must be conducted to identify area specific stripping depths and volumes
    - based on the outcomes of the above, a suitable topsoil stockpile location or application area will be identified
    - the locations of topsoil stripping operations and surveyed areas and volumes are to be recorded within the Topsoil Stockpile Register
    - consideration is to be given to drainage and erosion processes when stripping and stockpiling to prevent loss of topsoil and reduce potential for weed spread
    - all topsoil stockpiles are to be signposted for ease of identification; and
    - ripping/seeding operations of placed topsoil is to occur as soon as possible after placement to minimise erosion.
- Stripping and stockpiling:
    - mobile equipment will be utilised to remove in-situ topsoil
    - topsoil stripping and spreading activities are not to be conducted in high winds or heavy rain
    - where possible topsoil will be spread directly onto reshaped areas to maintain the natural seed store in the soil
    - where topsoil cannot be directly placed on rehabilitated areas, topsoil will be stockpiled. The height of newly established topsoil stockpiles must be limited to less than 5 m to assist with maintaining nutrient value
    - topsoil stockpiles may be relocated (as required) and established at heights greater than 5 m so long as they do not exceed the thickness of the original stockpile (up to a maximum of 10 m)
    - subsoil materials are not to be removed and collocated with topsoil
    - stockpiles may be sown with a cover crop to minimise erosion (with preference given to the intended target species for rehabilitation).

Surface preparation process

A detailed description of the cover system design to be implemented at the Meandu Mine is provided in Section 6.1.6. With regard to topsoil and surface preparation the sequence is generally undertaken:

- Topsoil is to be spread evenly to a depth of approximately 200 mm by scrapers and small dozers over the compacted NAF Spoil for the Native Ecosystem PMLU and over the red clay subsoil for the Beef Cattle Grazing PMLU.
- Post topsoil placement, the surface is to be contour ripped to a depth of 0.3–0.5 m (Native Ecosystem PMLU and Beef Cattle Grazing PMLU) with small dozers to aid in erosion control, root penetration and shallow moisture infiltration.
- Seeding and fertilizer addition are applied in conjunction with contour ripping. An independent seed viability analysis will be conducted on the local supplier's seed stocks prior to delivery.

- Only topsoil that has been adequately characterised and considered suitable for vegetation growth as prescribed for the relevant PMLU will be used. Characterisation results should indicate whether soil improvements are necessary such as amelioration or blending. Application rates for fertilizer are historically 100–150 kg/ha; however, soil characterisation results may indicate differing rates are required.

Ameliorants and fertilisers

Some soils and mine spoils may have physical and chemical characteristics that will otherwise limit plant establishment and have a high potential for erosion. Where soil suitability is classified as poor, analysis of the soil stockpiles is undertaken to determine the requirements for fertiliser and other ameliorants (Landloch, 2021a).

Currently, for poor quality soils, fertiliser is applied at the same time as ripping and seeding, at a rate of 100–150 kg/ha. Since 2017, the fertiliser used is a 60/40 blend of Impact 56 (N-13.5%:P-15.2%:K-12.5%: S-1.1%) and Ozcal (fine granular lime).

To stabilise dispersive sodic subsoils agricultural gypsum or lime may be applied at a rate of 5 t/ha/100 mm layer. The gypsum improves the soil structure reducing the dispersiveness and increases the water holding capacity.

6.1.5 Landform design

PRC Plan Guideline (Section 3.6.1)

The final landform design must be based on the proposed PMLUs and NUMAs and demonstrate that the land will be safe and structurally stable.

6.1.5.1 Overview

To support the development of the post-mining landform at the Meandu Mine, Stanwell has commissioned and prepared a series of reports underpinning the design of the post-mining landform. The key reports are:

- Landform Design Report Meandu Mine (Appendix H); and
- Meandu Mine: Landform evolution simulations (referred to within Appendix H and Appendix M).

The Landform Design Report Meandu Mine (Appendix H) outlines the information used to develop and inform the proposed post-mining landform. The report builds in the outcomes and recommendations of a series of plans/reports prepared for the Meandu Mine along with a history of rehabilitation programs and successful rehabilitation. The report demonstrates how the proposed final post-mining landform achieves the following objectives:

- safe for humans, livestock and native fauna (safe)
- achieves long-term geotechnical stability (stable)
- does not cause environmental harm to the surrounding environment (non-polluting)
- minimises, as far as is practicable, the footprint of the two final voids; and
- supports the proposed PMLUs.

The landform evolution simulations (Landloch, 2022) detail long-term erosion modelling of the post-mining landform over a period of 500 years. The evolution modelling utilises material characterisation data from previous studies undertaken at Meandu Mine including dispersivity and erodibility.

Table 6.13 summarises the design requirements of the final landform.

Table 6.13 Meandu Mine design method requirements

Aspect	Landform requirements
PMLU	Slopes and material suitable for the proposed PMLU for the area.
Landform stability	>1.5 Factor of Safety achieved for Geotechnical Stability of all PMLUs. Appropriate setback allocated for final highwalls in the Steep Rocky Ecosystem PMLU assessed at projected stable pit crest, with no key infrastructure or assets located between highwall crest and setback line.
Material characterisation and placement	Material placement to comply with the Material Design Parameters (Table 6.9).
Material balance	Sufficient material availability to comply with the Material Design Parameters (Table 6.9).
Sensitive receptors and visual amenity	Final landform aims to blend into the surrounding land uses and shapes so as to minimise any negative visual amenity at sensitive receptors.
Final Voids	Final void extents minimised as much as is practicable given the geometry and water storage constraints.
Water Balance	Water retained within the final voids to at a minimum meet the requirements for the water storage PMLU. Maintain or improve catchment area (relative to the 2019 LOM Plan) proposed to be returned to Rocky Creek post closure without impacting unduly on any downstream erosion issues.

6.1.5.2 Landform design

The proposed post-mining landform is presented on Figure 6.7 (including contours and spot heights), progressive disturbance and rehabilitation figures to achieve the proposed post-mining landform are presented on Figure 2.28 and Figure 2.29 respectively. The proposed post-mining landform was developed by Xenith (2021) as part of the 2021 LOM Plan and provides a refinement of and improvement to the 2019 LOM Plan.

The key features of the Meandu Mine post-mining landform are (Figure 4.1):

- two final voids (K2E and K4E)
- rehabilitated backfilled pits, including former TSF and coal combustion products in-pit storage
- out-of-pit waste emplacements
- the three Meandu Creek diversions; and
- rehabilitated infrastructure areas.

Residual voids

The Meandu Mine post-mining landform will contain two residual voids (K2E and K4E). The residual voids have been considered in the design of the post-mining landform as follows:

- maintain or optimise the location and geometry of the two final voids
- where practicable and economically viable, minimise size, depth and volume of final voids
- ensure drainage into the final voids is in alignment with the water storage requirements (i.e. is internally draining for both surface water and groundwater)
- assess against the final highwall setback criteria, to avoid key assets/ infrastructure between the FoS 1.5 setback line and pit crest and provide adequate standoff from the Meandu Mine site boundary; and
- design final slopes in accordance with geotechnical recommendations to provide long-term geotechnical and erosional stability.

The location of the water bodies that are expected to accumulate within the Meandu Mine residual voids is shown on Figure 4.1 (i.e. landform area below natural topography). Table 6.14 describes the surface area, maximum depth and volume of each residual void, relative to the lowest point in the topography immediately surrounding each void.

Table 6.14 Meandu Mine residual voids (Xenith, 2021)

Void	Surface area (ha)	Maximum depth (m)	Maximum volume (Mm^3)
K2E	245	143	147
K4E	66	51	12

Details on the rehabilitation planning and modelling of the final voids is included in Section 6.3.

Rehabilitated backfilled mining voids and out-of-pit waste emplacements

The design considerations for the final landform over the rehabilitated backfilled pits and out-of-pit emplacements are as follows:

- integrate selective topsoil/subsoil placement to meet requirements for each PMLU
- maintain a general alignment to the existing constructed landforms
- enable the grazing PMLU footprint. Target similar size footprint as the previous iteration and target an average gradient of equal or less than 15%
- assign a maximum overall grade of 7.5 degrees for LOM conceptual design (8 degrees for in-pit lowwall), noting detailed design will result in localised steepening in individual areas
- final landform slopes (excluding final highwalls) to be generally designed <17%, with minor areas up to a maximum of 25% to achieve tie-in with surrounding areas
- achieve and optimise offsite drainage objectives for catchment return to Rocky Creek from the rehabilitated landform.

Additional material placement considerations exist for the rehabilitation of backfilled voids used to store mixed plant rejects, tailings and/or coal combustion products as follows:

- integrate selective waste placement in accordance with design guidelines for material characterisation
- achieve minimum PAF (6 m) and coal combustion product (2 m) capping waste placement requirements as indicated in Section 6.1.6.2
- achieve LOM power station coal combustion product storage, with a contingency tailings storage portion, within a pit void facility (K2W-N and K4S)
- achieve progressive LOM placement of mixed plant rejects within pit void catchments (Central, Ramp 5 and K4E pits) excluding the planned K2E ASA.

Rehabilitated infrastructure areas

Permanent infrastructure that will remain post-closure at Meandu Mine is limited to private road that connects the current mine infrastructure area to the end of Nobby Smith Way. This will remain post-closure wholly within the footprint of the Beef Cattle Grazing PMLU to provide all weather access to the PMLU and avoid having to undertake further disturbance of Meandu Creek.

Built Infrastructure areas at the Meandu Mine are listed in Table 2.19 and comprise:

- CHPP and ROM and Raw stockpiles
- overland conveyor to Tarong power stations
- administration and support service area (mine infrastructure area)
- workshop/store area
- gatehouse
- tyreshop and bucketshop
- dragline shutdown area
- supporting services (e.g. access roads, power reticulation, raw water supply, sewage systems, fuel storages and explosives compound); and
- water management infrastructure (e.g. diversions, drains, dams and water storages).

Due to the ongoing and progressive nature of mining, the above infrastructure areas will be required up to the cessation of mining activities (with some required for closure activities). Accordingly, TEC Coal will seek to decommission and rehabilitate these areas consistent with this PRC Plan as soon as practicable.

Further information on decommissioning of infrastructure is provided in Section 6.5.

Retained infrastructure areas

No infrastructure is currently proposed as Landholder Retained Infrastructure, and accordingly there is no allocation of this PMLU in the Meandu Mine PRC Plan. Accordingly, there is no requirement for signed landholder statements accepting responsibility for infrastructure once mining has ceased.

6.1.5.3 Landform design plans

The final 3D landform from the 2021 LOM underpinning the 2022 PRC Plan submission achieves the objectives outlined in Section 1 and design criteria in Section 2. It maintains two final voids in K2E and K4E pits. A smoother and gentler slope has been achieved in Central, Ramp 5 and the upper slopes of K4E. Overall grades have been kept below 7.5 degrees, for spoil dump areas that have been reshaped as part of the 2021 LOM final landform. Figure 6.7 shows the 2021 final landform conceptual design. Minor subsequent amendments have been made to the landform to tailor specifically to mine progress, and to ensure achievement of appropriate cover and drainage objectives.

The Beef Cattle Grazing PMLU has been nominated for areas in the Central pit areas with overall grade generally <10% but in specific areas an overall grade of up to 15% has been designed. Figure 6.8 is a grade plot of the final landform with the nominal footprint of the Beef Cattle Grazing PMLU defined by the red dashed polygon. The conceptual final landform as illustrated in Figure 6.7 and Figure 6.8 has been used as the basis for the detailed rehabilitation design for execution. This includes the design of any required waterways and is the landform from which the selective placement of material will be scheduled in the short term and annual mining plans.

Watersheds/catchments

In development of the final landform the two key drainage objectives were:

- to reduce where possible the catchment area for the final voids; and
- to return as much area as was reasonable of the K4S rehabilitated area to the Rocky Creek catchment without causing downstream stream erosion issues.

The application of these objectives to the 2021 LOM Plan has resulted in an improved balance of catchment returns to Meandu Creek and Rocky Creek relative to the previous 2019 LOM iteration. The current LOM Plan provides the opportunity for catchment return from some of the northern K2E mining area to Rocky Creek. Waterways have been designed into the landform adjacent to the K2E and K4E final voids, to reduce the respective catchments reporting to these voids.

As can be seen in Figure 6.9, which shows the indicative drainage of the final landform and the major catchment areas, much of the K4S landform has been engineered to return the area to the Rocky Creek catchment. The remaining Western pit areas drain north into Meandu Creek. In K2E a portion of the landform area drains into the Rocky Creek catchment while the rest drains north into the Black Gully catchment and ultimately Meandu Creek (via Black Creek Dam).

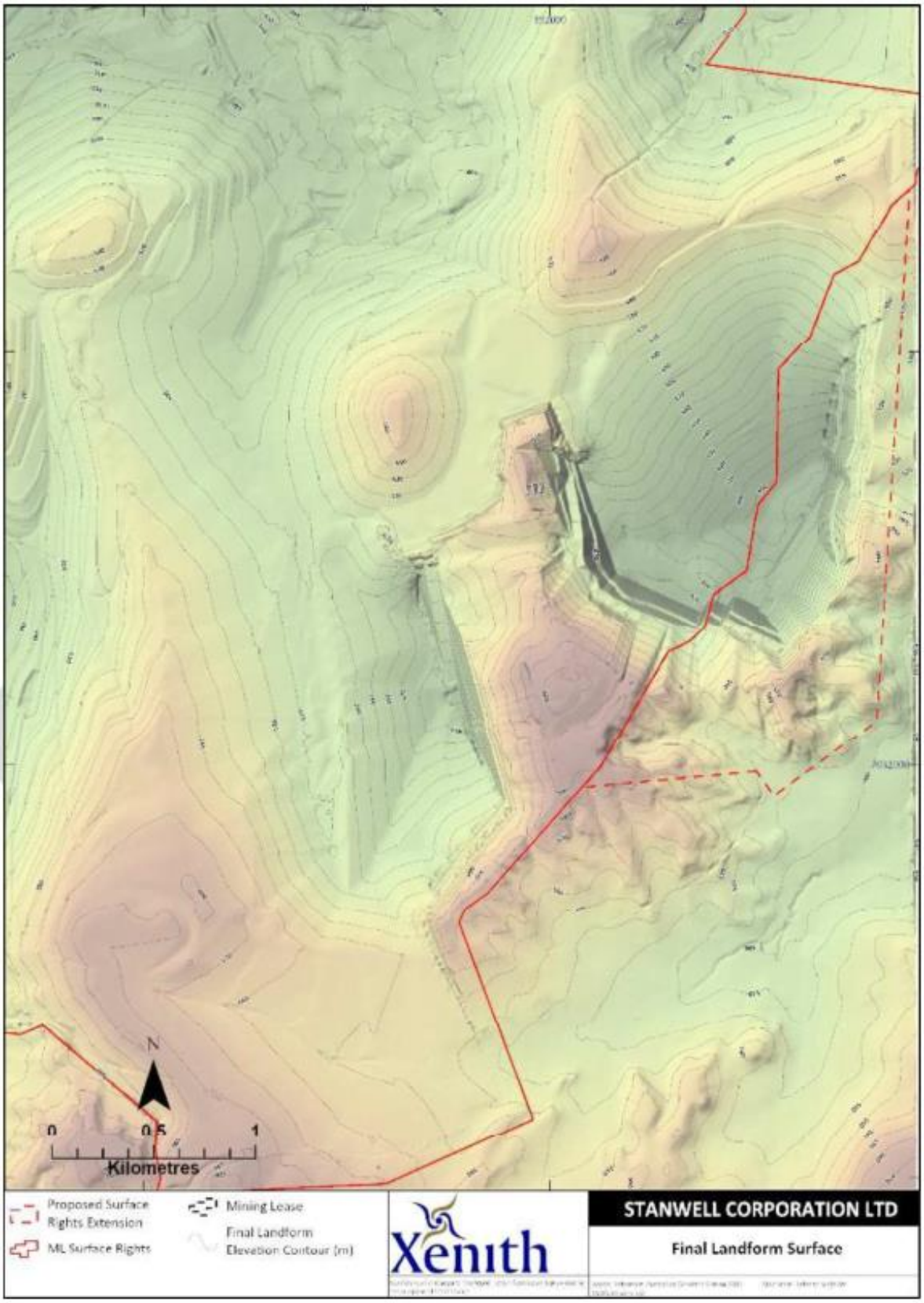


Figure 6.7 Meandu Mine final landform design

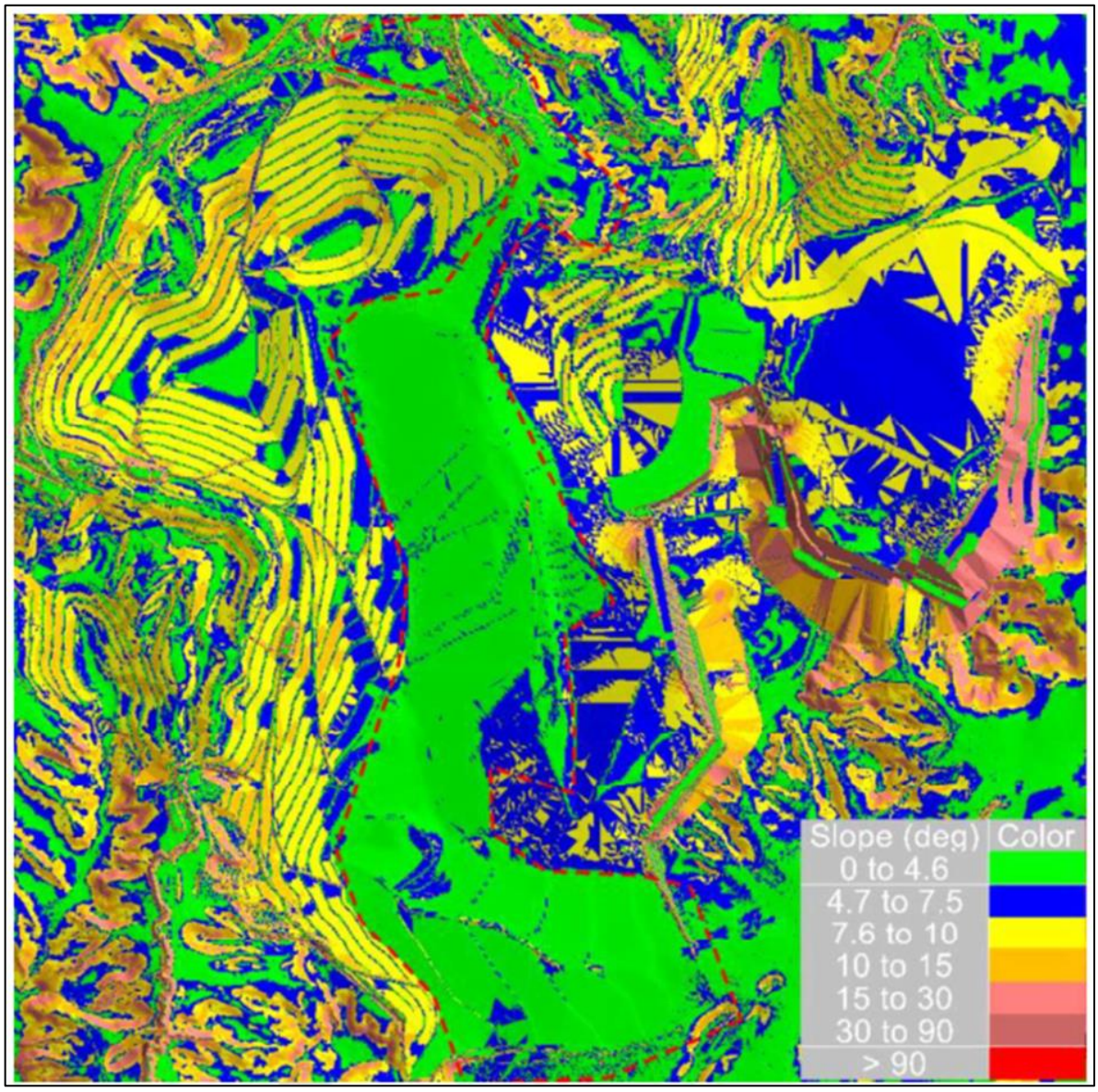


Figure 6.8 Meandu Mine final landform grade (degrees)

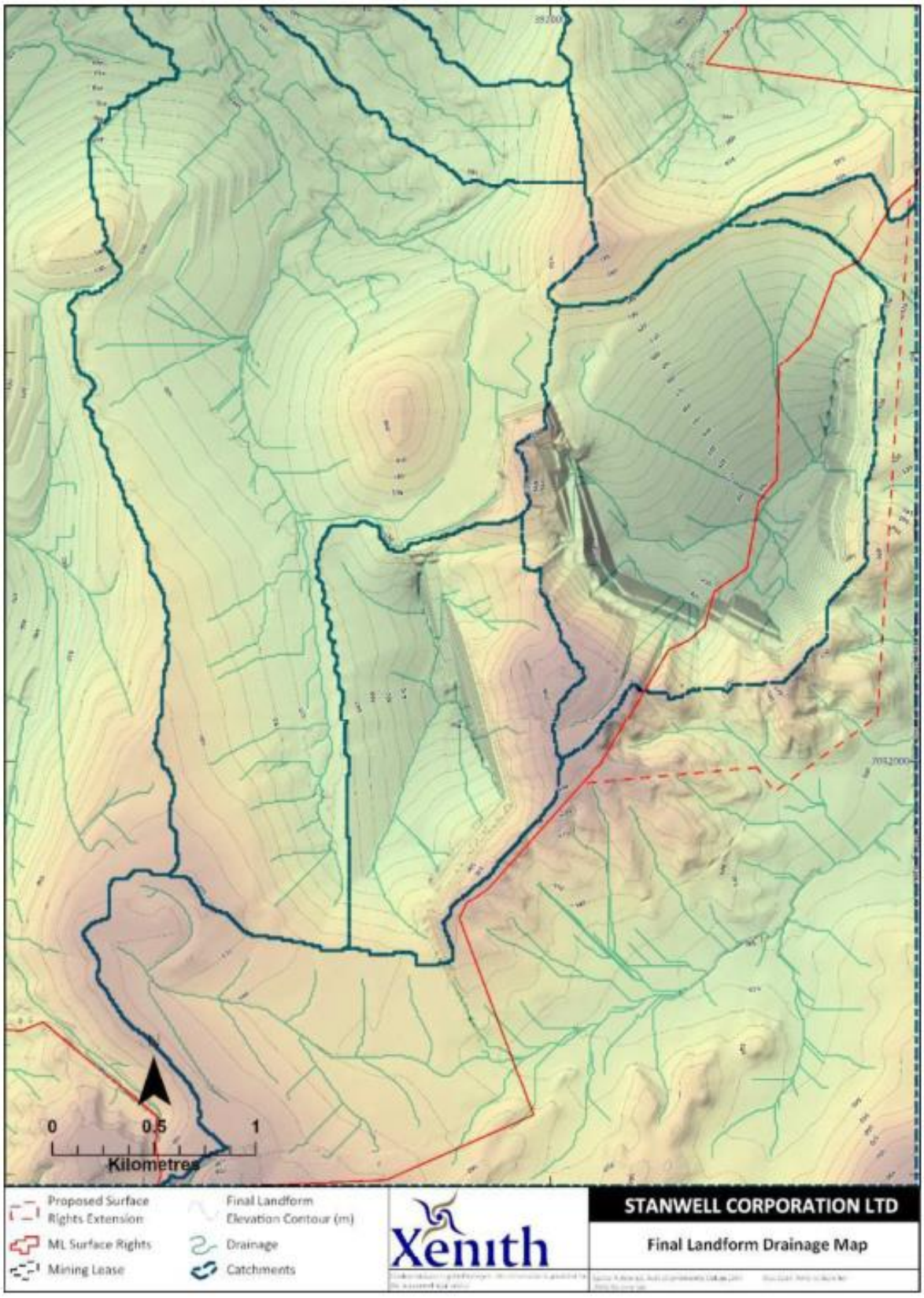


Figure 6.9 Indicative Meandu Mine final landform drainage map

6.1.5.4 Landform design process

Development of a final landform is a reiterative process as new information and considerations are important. Figure 6.10 shows the general process.

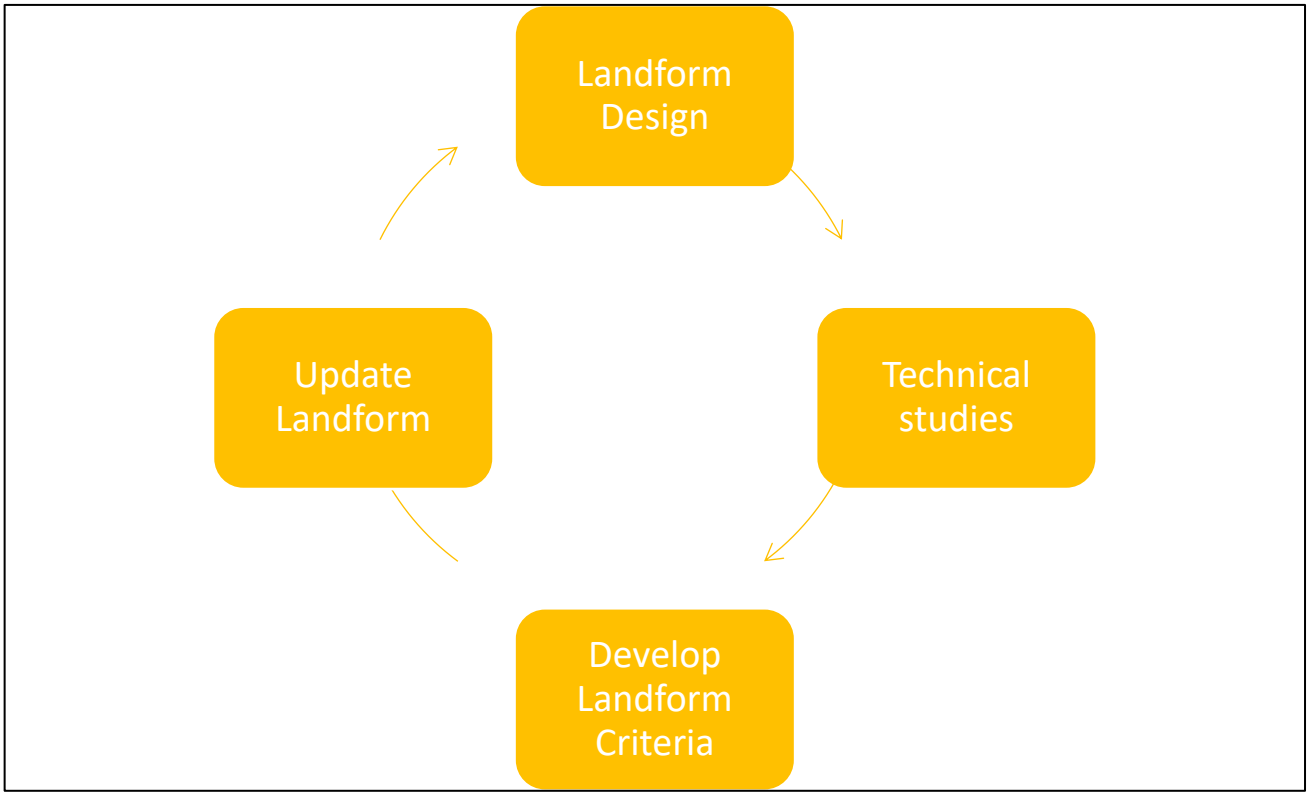


Figure 6.10 Landform design process

The process for developing the current design landform at Meandu Mine started by using the 2019 LOM final landform design as a preliminary design. Technical studies were undertaken to develop and refine the design criteria including erosion and landform evolution modelling, waste characterisation, flood modelling and mine planning.

The final landform has been developed using the process outlined below, to meet the key objectives outlined in Section 6.1.5.1:

- utilise the 2019 LOM final landform as a starting point, which was based on an optimisation study addressing mine planning and coal supply over the life of the Tarong power stations
- reserve the major material types and develop an initial dumping schedule that considers selective placement of material types within the landform
- design the final landform based on the as-dumped landform of the initial dumping schedule
- update the dumping schedule to achieve the designed final landform, where possible reducing the bulk earthwork volume required at closure
- develop a bulk earthworks schedule to achieve the final landform post mining
- refine drainage requirements including localised regrading to optimise landform stability
- determine progressive disturbance and rehabilitation areas from mining and dumping stage plans; and
- generate final landform for the 2022 PRC Plan submission.

Any future iterations to the final landform will follow a similar process to that outlined here.

The Deswik Landform Engineering tool and 3d Dig were used to undertake the design work. Multiple iterations of the final landform were performed and reviewed before arriving at the final landform design for closure.

The 2021 LOM Plan incorporates the following improvements from the preceding 2019 LOM Plan:

- incorporating results from the 2020 Geotechnical Stability of Final Highwalls assessment into final highwall designs
- redefining K2E pit limits by reducing boxcut movements, maximising in-pit dumping and realigning strips; and
- reserving of staged pits in K2E to be used for access and haulage efficiencies.

6.1.5.5 Long-term stability of the final landform

The geotechnical criteria used in the landform design is based on the Meandu Mine Geotechnical Reference Report (Sherwood Geotechnical and Research Services, 2020), which is regularly updated to represent a compilation of information that is current to the issue date of the report. It includes a guide to geological and geotechnical conditions and recommended parameters for stability and groundwater pressure analysis purposes. Geotechnical recommendations for excavated slopes are based on a combination of back analyses of prior instabilities, design analyses based on adopted strength parameters, and observations of slope profiles that have demonstrated acceptably stable performance.

Final void highwall and lowwall stability has been assessed by Henderson Geotech (2020 and 2021) and results have been incorporated into the landform design process. The details are included in Section 6.3.4 Final Void Stability and the in Appendix M – Meandu Mine PRC Plan – Void Closure Plan (WSP, 2022a)). Other aspects of final landform relating to the final voids covered in Section 6.3 include optimisation of void minimisation, water balance and water quality.

Rehabilitated spoil landforms

Henderson Geotech (2021) assessed the geotechnical stability of out-of-pit rehabilitated spoil landforms, using limit equilibrium slope stability analyses with strength properties selected from Meandu Mine Geotechnical Reference Report (Sherwood Geotechnical and Research Services, 2020). In all likely scenarios analysed, the FOS against geotechnical instability was greater than 1.5 given the following key geometries:

- out-of-pit dump height – up to 130 m above in-situ ground; and
- spoil slopes – up to 25%.

Sensitivity analyses run using Slope2 stability software returned a minimum FOS of 1.64, as shown in Figure 6.11.

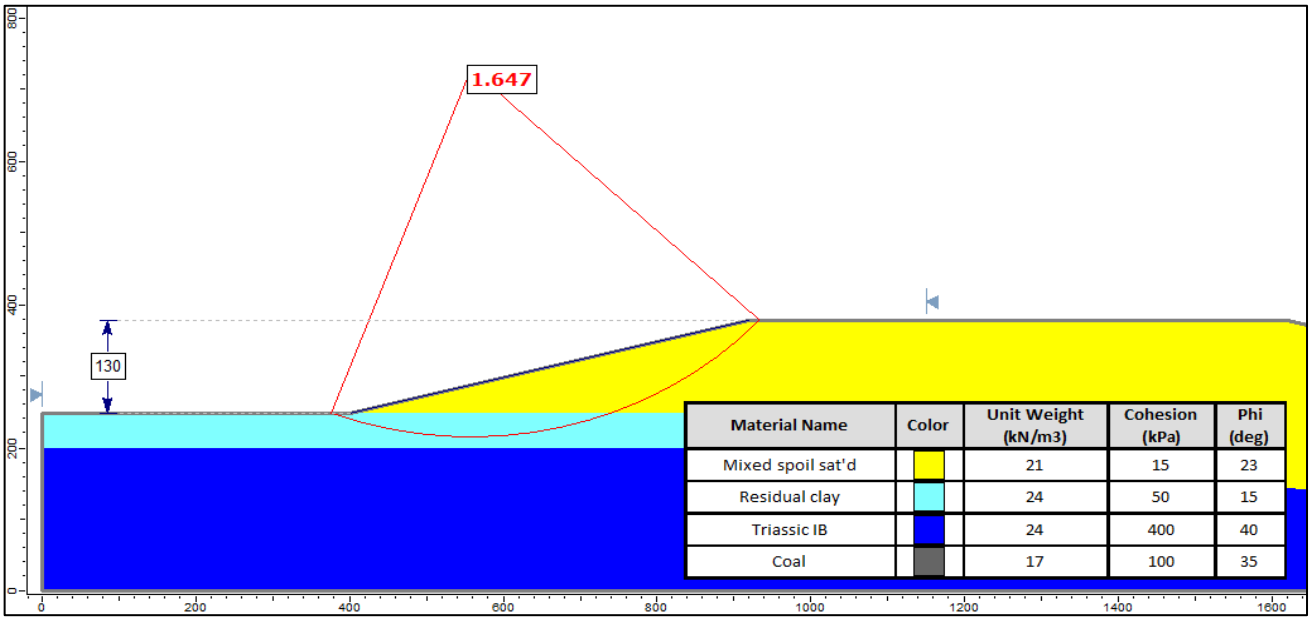


Figure 6.11 Analysis of out-of-pit spoil worst case geometry and materials (Henderson Geotech 2021)

Based on the limit equilibrium analyses performed, the proposed final rehabilitated spoil landform designs exceed the minimum required FOS of ≥1.5 for long-term geotechnical stability both in-pit and out-of-pit and are therefore considered to meet the PMLU criteria.

An assessment has been made on the suitability and availability of material for use in the rehabilitated spoil landforms, which is summarised in Section 6.1.4. Aspects of the cover design are included in Section 6.1.6.

Erosion modelling

The WEPP runoff/erosion model (the WEPP Model) was used to simulate final landform stability parameters including data for rainfall, runoff, and sediment loss for a range of expected slope configurations (Landloch 2021c in WSP, 2022a (Appendix M – Meandu Mine PRC Plan Void Closure Plan)). Soil erosion parameters were derived from laboratory rainfall simulation testing on samples collected from Meandu Mine of red ferrosol and grey sedimentary topsoils, being the two main soil types at Meandu Mine. The WEPP Model was used to determine acceptable slope lengths for varying gradients and ground cover levels, the results from which were used as inputs for the detailed final landform design.

The WEPP modelling found that on ferrosol topsoil erosion should be less than rates considered sustainable (5 t/ha/year) for grazing on slopes up to 15% where surface cover is kept at 70% or greater and slope length limited to 125 m. For grey topsoil sustainable erosion rates on slopes up to 15% require 70% cover and slope lengths less than 70 m (Landloch 2021c in WSP, 2022a (Appendix M – Meandu Mine PRC Plan Void Closure Plan)).

The SIBERIA landform evolution model was then used to simulate the long-term development of the final landform at Meandu Mine and estimate erosion rates, rill/ gully development and deposition over a period up to 500 years (Landloch, 2022). The soil erosion parameters obtained during WEPP model development were used to calibrate the SIBERIA model. Calibration of the SIBERIA model to the WEPP results was undertaken by comparison of simulations on an example gradient of 14% and batter slopes of 45-90 m. SIBERIA is a long-term model that is designed to represent a mature vegetation community; therefore, it is more realistic to utilise the expected long-term ground cover levels of 90% for the Native Ecosystem PMLU and 80% for the

Beef Cattle Grazing PMLU that are based on monitoring results and observations, trajectories and cover levels representative of similar land uses. Red clay soil was assigned to the Beef Cattle Grazing PMLU and grey loam for the Native Ecosystem PMLU.

Modelling in SIBERIA is undertaken to provide a guide to future design work, and to indicate the relativity in performance between areas in the model. The SIBERIA modelling showed that the landform is stable in the long-term, with erosion rates predicted to decline from an initial rate of 5 t/ha/yr in the first 100 years to approximately 2 t/ha/yr over the next 400 years. Maximum gully depth is 0.85 m to 1.19 m after 100 years and are simulated to increase to 2.61 m after 500 years. The vast majority of gully development is less than 0.3 m deep after 500 years. It should be noted that the SIBERIA model also assumes that no maintenance or intervention would be undertaken. The location of erosion for the 500-year simulation is shown on Figure 6.12.

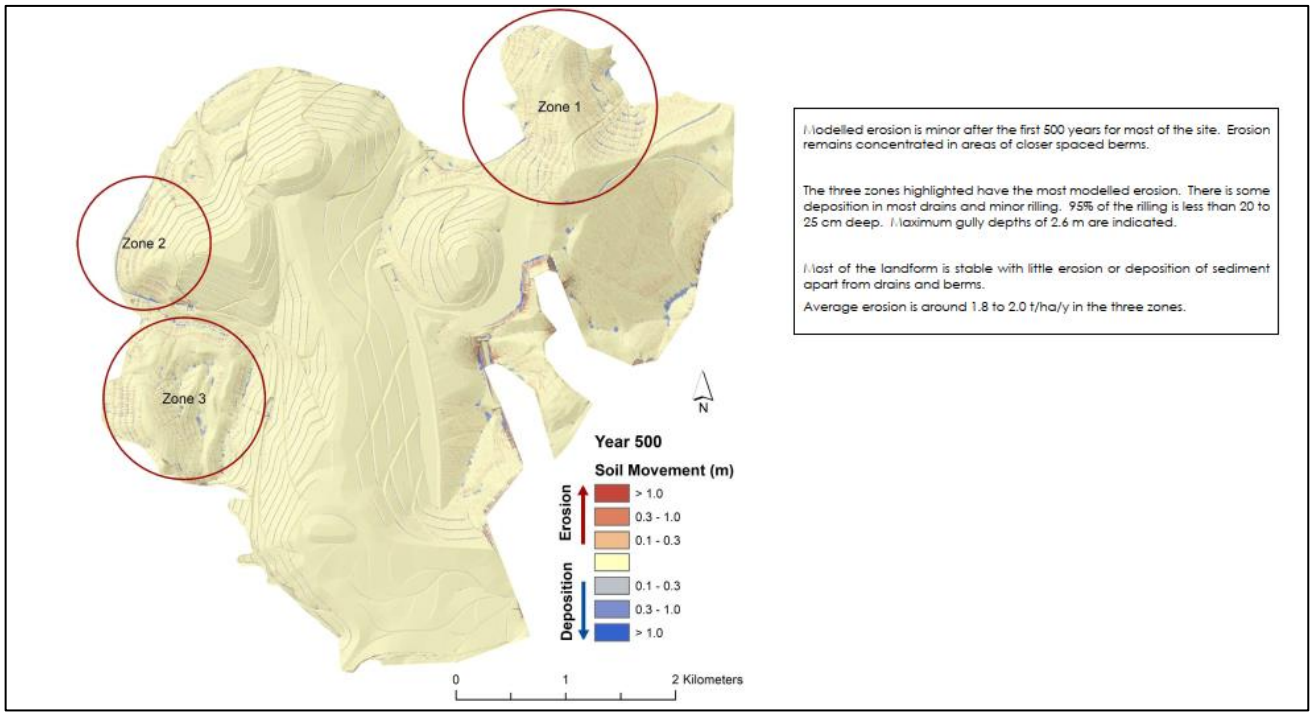


Figure 6.12 Meandu Mine SIBERIA modelled erosion after 500 years (Landloch 2022 in WSP 2022 – Appendix M)

The erosion modelling for Meandu Mine predicts that erosion rates should be near or below the rate of 5 t/ha/y for the 500-year timeframe modelled. This is considered an acceptable value for a rehabilitated mine site and provided the assumed vegetation cover is retained, should allow for the sustained PMLUs of Beef Cattle Grazing and Native Ecosystems as prescribed in the Meandu Mine EA.

Long-term settlement

During mining operations, material will bulk up to a loose density and once placed within spoil dumps will undergo a process of self-weight, collapse and degradation-induced settlement over time (Williams and Kho 2013). Material placement associated with landform construction accounts for the majority of self-weight settlement; at Meandu this process involves paddock dumping by circa 400–500 t trucks in short lift tip-heads (10–20 m), followed by track dozing by 110 t class dozers to spread, consolidate and/or reshape, with regular watering throughout the process. Collapse settlement occurs in association with water infiltration, and wetting-up of the material and degradation-induced settlement results from degradation of the material upon exposure to weather cycles.

Progressive survey monitoring and reconciliation has determined bulking factors (swell factors) for use in short- and long-term planning and these are regularly reviewed over time. The assumed swell factor that has been used in the 2021 LOM Plan is 1.12 (i.e., 12% increase in volume compared with in-situ). This was reduced from 1.15 in the 2019 LOM Plan based on ongoing reconciliation calculations. Survey monitoring of the profiled landform is undertaken to identify areas of settlement that may require additional material and/or re-profiling. Due to the staged dump formation and shallow tip-heads associated with progressive MPR placement, this is generally minor in general spoil dump areas. Longer term monitoring is undertaken for tailings and ash storage areas before final profiling, topsoil placement and seeding is performed, to allow the underlying material to consolidate and settle and remediation to be undertaken if necessary.

6.1.5.6 Method of construction

Bulk earthworks

The landform design has been developed assuming the current mining fleet (or similar) at Meandu Mine will be utilised across the 2021 LOM Plan, including a Bucyrus 1370 dragline and various hydraulic excavator units loading rear-dump truck fleets. Bulk earthworks of material to achieve the final landform was scheduled in the mine planning software program SPRY including dig, destination and haulage and this has enabled development of a schedule of quantities and accurate calculation of equipment hours.

The 2021 LOM Plan has scheduled the bulk rehabilitation earthworks to commence toward the end of mining in each of the final pit areas and that the excavator fleet will be utilised for rehabilitation. Key tasks associated with the bulk earthworks schedule include backfilling and shaping the K2E and K4E final voids and capping and backfilling the K4S void. The LOM Plan schedule utilised dozer push or truck and excavator for bulk movement of materials, based on distance to be moved.

Rehabilitation construction methodology

Following excavation, spoil and subsoil material is selectively handled and placed in accordance with materials placement guidelines during excavation to produce the profile required for the relevant PMLU, after which reshaping is performed by dozers and scrapers (including relevant cover placement) to achieve the final landform. Preparation includes profiling the slope to achieve specifications outlined in the Meandu Mine EA, contouring and establishing drainage systems. The dump locations for waste material are classed as either in-pit or out-of-pit. In-pit dumps are located within the footprint of previously mined out areas, with all other dumps considered to be out-of-pit. A majority of the waste material at Meandu is placed into in-pit dumps.

Draglines dump in-pit, generally within the previous strip void, whereas trucks can accommodate more flexibility in their dumping locations and dump both in-pit or out-of-pit. This flexibility allows selective handling to occur and sufficient material to be dumped in areas to achieve the final landform as per the PRC Plan and in accordance with the current LOM Plan. Through strategic planning of the mining sequence and the associated dump progression, a final undulating profile has been designed that achieves the visual amenity criteria and ties into the existing landscape and features while also providing for the allocated PMLUs.

Material classification is considered when determining the mining and dumping sequences and is detailed in Section 6.1.3. Detailed construction methodologies for the final covers are included in Section 6.1.6.5.

6.1.5.7 Quality assurance/quality control

Mine planning

The LOM Plan is typically revised every 2–3 years as part of the business planning cycle. The actual ash deposition, rehabilitation and pit progress is provided as an input to the LOM Plan revision. Each revision will include consideration of the same information detailed in this report, for example production targets, power station life, material placement and balances, final void location and extents, and highwall stability.

Exploration drilling is undertaken periodically to further define the resource, geological structures and material properties. Characterisation and mapping of material to be mined from the pit is undertaken to identify problematic source material. This information is used to update the geological model and material characterisation register that informs progressive mine planning.

Landform design

Meandu Mine has a design/plan review and signoff process to verify that the final landform constructed meets the design criteria and objectives. Relevant checks and consent are obtained prior to commencing construction and/or progressing specific rehabilitation items, including signoff by the responsible operations and planning personnel.

The LOM Plan (including overall landform design and material placement components) is reviewed and approved by relevant parties prior to release. Detailed rehabilitation design is undertaken based on the LOM Plan final landform, for areas becoming available for rehabilitation in the short and mid-term mine planning timeframes, and is reviewed and approved for use with each annual mine plan submission under the Mining Services Agreement.

Prior to works being undertaken a dump plan is developed which considers the final landform design, approved dump shell and selective material placement. A Safe Truck/Shovel Design Checklist is used which refers to the Meandu Mine Geotechnical Reference Report for details on schematics. Weekly planning meetings are conducted to that track landform construction progress and status.

Material placement

Meandu Mine has a number of planning, inspection and monitoring requirements in place to provide ongoing material characterisation and placement in accordance with the final landform design.

Planning and design involves developing a pre-strip design based on the knowledge and understanding of how much and which parts of the overburden profile can be used in the rehabilitation process. A dig plan is developed identifying the relevant material types and dump plans match the material type with a suitable dump location. The dumps are constructed with consideration to the parameters outlined in the Material Movement Design Parameters (summarised in Table 6.9).

All dig and dump plans are discussed at weekly planning meetings and communicated to the truck and shovel supervisors and crew.

Periodic records of PAF material placement will be maintained, that may refer to weekly meeting minutes, Wenco tracking data, location screenshots and summary polygons. An annual summary of all PAF and NAF dump locations will be collated from the monthly reports of that year.

Tailings and ash deposition will be tracked monthly, including pumped quantities and stored volumes calculated from survey data. An annual reconciliation of material volumes and locations will be undertaken.

Final landform shaping

Material placement is undertaken using GPS-equipped equipment to guide dump construction according to design. Material type is recorded for each load and allows tracking of material from source to destination. Field verification is undertaken by regular inspections by supervisors, the mine geologist and Open Cut Examiner (OCE). Compliance to dump design is verified by regular survey.

High precision GPS is installed on dozers and graders involved in final landform reshaping. Design plans are uploaded to equipment that guide earthworks activities with alerts that flag cut-fill requirements for each area. Compliance to design is verified via regular surveys. Topsoil placement does not occur until the reshaped landform has been assessed and approved by a representative from the Meandu Mine Environmental team.

Subsoil and topsoil selection and placement

Soil requirements (including source locations) are nominated in the rehabilitation program for each year with consideration of the suitability of the soil to meet PMLU requirements. Soil analysis is undertaken to determine amelioration requirements. If soil is used from (or added to) a stockpile, survey reconciliation is undertaken to calculate the volume used and the stockpile volume updated in the topsoil register.

Rehabilitation monitoring

Meandu Mine has a rehabilitation monitoring programme which outlines the monitoring approach and methodologies and is detailed in Section 8. The monitoring schedule approach is based on the age of the rehabilitation with intensive monitoring at the commencement and early years of rehabilitation establishment and less frequent monitoring as the rehabilitation progressively ages.

The Rehabilitation Monitoring Field Sheet is used to record data consist with the rehabilitation methodology. Meandu Mine uses a Land Rehabilitation Assessment Inspection checklist which identifies inspection criteria for each stage of rehabilitation. The form identifies hold points so that each rehabilitation stage/milestone can receive signoff from the Environmental Advisor to confirm rehabilitation is satisfactory before moving on to the next stage/milestone. Further details on the monitoring are provided in Section 8.

6.1.5.8 Trials to verify predicted success

Existing landform and rehabilitation success

In 2021, Stanwell received progressive rehabilitation certification of approximately 153 ha of rehabilitation at Meandu Mine from the Queensland Department of Environment and Science. A Progressive Rehabilitation Report was developed by Highlands Environmental (2020) to support the application. All rehabilitated areas included in that application have a PMLU of Native Ecosystem. Rehabilitation monitoring is discussed in Section 8.3.

Geotechnical stability was assessed using the same methodology described in Section 6.1.5.5 and found that the design FOS of the landforms always exceeded the 1.5 threshold. Progressive rehabilitation monitoring had determined that groundcover, comprised of living plants, litter and rocks, exceeded the benchmark of 50% that was used as a criterion for erosional stability.

The rehabilitation area drains to Meandu Creek and into Meandu Dam via a series of retention dams on the mine site. These dams are monitored frequently, and several are considered to provide a conservative representation of the quality of runoff from rehabilitation. The median pH and electrical conductivity within these retention dams meets the completion criteria for pH (5.5–9) and EC (<2,037 µS/cm).

Planned rehabilitation trials

Two rehabilitation monitoring trials are planned to verify PMLU success. These are defined in more detail in Section 7.5 and summarised below:

- Beef Cattle Grazing – Soil Performance Trial; This is a common land use in the region, but no prior rehabilitation has been undertaken for this PMLU at Meandu Mine. The trial will compare different subsoil combinations utilising available site materials, to confirm and expand the combinations that will support vegetation establishment and the target livestock carrying density.
- Steep Rocky Ecosystem – Monitoring Trial: This will involve monitoring a number of exposed final benched pit walls that will form part of this PMLU footprint as part of a longitudinal study to assess elements of native species ecosystem development (soil development, vegetation establishment and fauna development). The results of this trial will be utilised to create an expected trend for the rehabilitation timeline and success assessment for the final mined highwalls at the end of the LOM.

6.1.5.9 Limitations and assumptions

The 2021 LOM final landform design has been developed on the following assumptions and limitations:

- The starting point of the final landform design used was the 2019 LOM Plan final landform.
- The 2021 LOM Plan is based on a fuel supply scenario meeting the requirements of the Tarong power stations for a particular energy market case. Production rates may need to be varied from year to year due to changes in requirements to meet power station demand, and this will impact on the timing of coal and waste mining, and the progress of rehabilitation. The general sequence of mining under these circumstances is expected to follow that indicated in the LOM Plan.
- The landform design was constrained by the existing surface rights and proposed K2E ASA boundaries. Existing rehabilitation is not re-disturbed other than a small section adjacent to the northern end of the K2E pit necessary to facilitate the planned coal production in that area. The landform otherwise integrates with the existing rehabilitation.
- Geotechnical criteria and operation guidelines for interim pit progression walls have been based on advice provided in the Geotechnical Reference Report (Sherwood Geotechnical and Research Services, 2020).
- Operational highwall angles of 70 degrees are used for competent material, with the exception of dragline pass highwall angles in the K2E, Central and northern Ramp 5 pits which are 45 degrees.
- Final highwall design parameters are based on calculations in the Assessment of Geotechnical Stability of Final Highwalls (Henderson Geotech, 2020). The projected stable pit crest derived using this criteria has defined the final void boundaries in the 2021 LOM Plan and the actual final pit crest will be positioned between the as-mined design and project setback line, depending on localised conditions and corresponding highwall treatment.
- Meandu Mine will continue to be the storage location for the by-product ash generated from operation of the Tarong power stations to the end of its forecast life.
- Scheduling has assumed achievement of all minimum PAF (6 m) and ash (2 m) (including K2W-N and K4S ash storages) capping requirements in accordance with cover design requirements.

6.1.6 Cover design

PRC Plan Guideline (Section 3.6.1)

A cover design is required for the surface treatment of a mine landform or other waste material. Hence, the cover system design must be appropriate for the type(s) of waste the project will generate and reflect a risk-based approach. Where waste has the potential for AMD, neutral mine drainage or saline mine drainage, an appropriate cover system must be designed.

The cover design should include:

- identification and specification of the objectives of the cover system
- a detailed description of the design including the thickness of each layer
- a detailed description of construction methodology including any proposed staging of the cover system
- a quantitative assessment that identifies the location and quantity of proposed capping material available on-site
- proposed QA/QC for the construction of the cover system including the timely implementation of corrective actions where deviations from the design are identified.

6.1.6.1 Need for a cover system

The intention of a cover system design is to reduce the likelihood of potential environmental risks arising from the storage of waste streams, as well as to provide a suitable growth medium for revegetation of disturbed areas to a designated PMLU. Specifically, the final covers at Meandu Mine are intended as a management measure to minimise the risk of contaminants from the stored waste streams being released to the environment and negatively impacting the proposed PMLUs and surrounding environmental values.

As described in Section 6.1.3, the geochemical waste characterisation studies undertaken at the Meandu Mine have indicated that a final landform cover design is required for certain waste streams stored at the Meandu Mine. As some of these waste streams have the potential to generate AMD, NMD and SMD, the cover system must consider infiltration within the capping layer, as well as suitability to support the designated PMLU. In summary, the waste streams requiring specific consideration are:

- Historical coarse rejects: generally PAF with the potential to generate AMD and/or NMD.
- Historical tailings and future contingency tailings: PAF and potential to generate NMD but unlikely to generate AMD/NMD if saturated or oxidation limited for example through covering by coal combustion products, low potential for SMD.
- Mixed Plant Rejects (MPR): PAF, likely to generate AMD and/or NMD if allowed to oxidise.
- Coal combustion products: NAF but low potential to generate SMD and NMD.
- Spoil: CM unit, lignite and organic rich material adjacent to coal seams considered PAF, remainder NAF.

6.1.6.2 Cover system requirements

Specific cover design conditions are prescribed in the Meandu Mine EA with regards to cover designs over certain waste streams. The Meandu Mine EA conditions relevant to final cover designs that have informed the content of this plan are outlined in Table 6.15.

Table 6.15 EA EPML00709113 Current conditions relevant to cover system design

Condition number	Condition
Condition G9	**Tailings Deposition Area** When the deposition of tailings to an area ceases, the holder of the EA must install a final cover system to the tailings dam which effectively minimises: **a** infiltration of water into the tailings deposition area **b** the likelihood of any erosion occurring to the final cover system.
Condition G12	The final capping system over coal combustion products in the voids defined in **Table A1 – Authorised coal combustion product storage locations** must be at least 2 m deep and must include an upper layer of earthen material that is capable of sustaining plant growth, and must be designed and maintained to minimise erosion occurring to either the final capping system or the coal combustion products in the void.
Condition G13	Materials used in the construction of the capping layer over the coal combustion products in the voids defined in **Table A1 – Authorised coal combustion product storage locations** must achieve an in-situ permeability which is sufficiently low and/or be sufficient thickness so as to minimise infiltration of water into the landform.
Condition G14	Reject disposal areas must be covered by a minimum of 6 (six) metres capping designed in accordance with criteria determined by a suitably qualified and experienced person.
Condition G15	Reject disposal areas capped in accordance with **Condition G14** must include an upper layer of earthen material designed and maintained to sustain plant growth.

Although the specific design requirements prescribed in the Meandu Mine EA include minimum NAF spoil thicknesses, surplus NAF spoil is available at the Meandu Mine to provide for cover material. Therefore, in practice the thickness of NAF spoil acting as a cover between tailings, MPR or coal combustion products and the topsoil is likely to be thicker than the design specification.

Minimum topsoil and subsoil thicknesses for the Beef Cattle Grazing PMLU have also been developed to meet the requirements of the Meandu Mine grazing strategy (Highlands Environmental, 2020), implementation of which should lead to the sustainable success of this PMLU. Topsoil requirements for successful establishment of the Native Ecosystems PMLU have been determined by existing revegetation on rehabilitated spoil piles at the Meandu Mine.

6.1.6.3 Cover system specification

The cover system design at the Meandu Mine has been developed in consideration of the requirements of the Mine's EA conditions and the Meandu Mine grazing strategy (Highlands Environmental, 2020). The suitable cover materials were determined by the rehabilitation material characterisation (Landloch, 2021a). Specifications for the cover system design at the Meandu Mine, based on the waste covered and the desired PMLU is provided in Table 6.16. Other combinations of topsoil and subsoil may be utilised for the Beef Cattle Grazing PMLU provided they achieve the pre-requisites for Class 1, 2 or 3 land suitability.

Table 6.16 Meandu Mine PMLU Cover System Specifications

PMLU	Waste covered	Cover specifications	
		Material	Minimum thickness (m)
Beef Cattle Grazing	MPR PAF overburden/ interburden	Topsoil (Ferrosol preferred)	0.2
		Clay Subsoil (RED and WB preferred)	0.8
		NAF Spoil	5.0
		Minimum total cover thickness	6.0
	NAF overburden/ interburden[1]	Topsoil (Ferrosol preferred)	0.2
		Clay Subsoil (RED and WB preferred)	0.8
		Minimum total cover thickness	1.0
	Coal Combustion Products (K4S)	Topsoil (Ferrosol preferred)	0.2
		Clay Subsoil (RED and WB preferred)	0.8
		NAF Spoil	1.0
		Minimum total cover thickness	2.0
Native Ecosystem	MPR Tailings PAF overburden/ interburden	Topsoil	0.2
		NAF Spoil (overburden/interburden)	5.8
		Minimum total cover thickness	6.0
	Coal combustion products (K2W-N)	Topsoil	0.2
		NAF Spoil (overburden/interburden)	1.8
		Minimum total cover thickness	2.0
	NAF overburden and interburden[2]	Topsoil	0.2
		Minimum total cover thickness	0.2

(1) Assumes minimum 5.0 m thickness of only NAF overburden/interburden beneath the 1.0 m of topsoil/subsoil.

(2) Assumes minimum 5.8 m thickness of only NAF overburden/interburden beneath the 0.2 m of topsoil.

Material specification for NAF spoil

Material proposed for use as cover within 6 m of the final landform is to be NAF as defined by the geological mine model (used as an enhanced screening mechanism to identify NAF from other materials), which has been developed using the parameters detailed in Table 6.8. Supplementary geochemical testing of the parameters in Table 6.8 is to be conducted on proposed cover material if there is uncertainty in the nature of the material.

The following parameters are preferred for well-graded suitable material to use as NAF spoil forming the cover material immediately below the growth medium topsoil/subsoil (Sherwood Geotechnical and Research Services, 2015):

- minimum 10% passing 0.075 mm sieve size
- minimal particles > 450 mm diameter
- relatively small component of high plasticity swelling clays with Liquid Limit ≥50
- continuous grading curve with a minimum coefficient of uniformity of 4.

In addition, NAF material to be placed within 2 m of the surface is to have suitable PAWC and low dispersivity as recommended in Table 6.10. Therefore, Upper Triassic and conglomerate sandstone overburden is to be assessed for suitability relative to PMLU requirements before it can be scheduled as cover within 2 m of the final landform surface.

6.1.6.4 Infiltration

The minimisation of infiltration of water into underlying waste streams is a crucial aspect of the rehabilitation strategy and is prescribed by EA conditions *G8 Deep drainage (seepage), G9 Tailings Deposition Areas* and *G10 Acid Rock Drainage Management.* Infiltration modelling was commissioned by Stanwell to assess potential drainage of rainfall to and below the bottom of the rootzone of vegetated soil profiles constructed on capped spoil dumps, defined as “deep drainage” (Landloch, 2021d). Modelling was conducted on a number of scenarios for each of the cover specifications described in Section 6.1.6.3 to assess potential infiltration in Beef Cattle Grazing and Native Ecosystem PMLUs.

The modelling applied laboratory-derived hydraulic parameters for available topsoil materials grey topsoil and basalts (red topsoil and red clay) and variably compacted weathered Triassic overburden (95%, 90% & 85% compaction rates), the two lower rates being representative of compaction resulting from traffic compaction and track rolling using nominated landform construction techniques. Vegetation cover was modelled assuming a 75–80% cover for pasture (Beef Cattle Grazing PMLU) and 40%, 55% and 70% cover for native forest early establishment plantings, typical rehabilitation and mature rehabilitation respectively.

The results indicate that the grey loam soil has lower infiltration rates than the red ferrosol due to its higher runoff rate. Reduced permeability of the NAF spoil through increased compaction reduces deep drainage, as does the percentage of native forest cover in the Native Ecosystem PMLU. Overall, the results indicate that the percentage of rainfall moving below the root zone ranges from 0.3 to 5% depending on the scenario (Landloch 2021d).

When annual data was analysed it indicated modelled deep drainage is infrequent and highly episodic, with most years having no modelled deep drainage. Maximum modelled annual deep drainage ranged from 53 mm/y (Rhodes Grass pasture with grey topsoil, 1.8 m NAF spoil compacted to 95%) to 380 mm/y (Rhodes Grass pasture with red ferrosol topsoil and 5 m of NAF spoil compacted to 85%).

The modelling indicates that a certain volume of rainfall (substantially higher than the average) is likely to infiltrate through all proposed cover systems to below the root zone in years of higher rainfall. The movement of water through the deeper but unsaturated part of soils dumps and tailings facilities cannot be accurately modelled because of the unpredictable preferential flow paths created by cracks, layers of compacted or coarse material and localised perched water tables.

Geotechnical investigations of the north-west mining area (SGRS 2015) concluded that to minimise infiltration through the cover systems it is necessary to:

- provide an external surface that minimises accumulation of runoff by effective drainage (i.e., prevent pooling)
- provide a capping with the lowest practical effective void size; and
- maintain the integrity of the capping layer by providing a functional vegetative cover.

These three attributes will be achieved respectively through the final landform design criteria (discussed in Section 6.1.5), compaction of the NAF spoil layer by mine traffic compaction and densification through adopted dump construction/profiling techniques and provision of a suitable topsoil layer(s) to act as a growth medium.

It should be noted that the potential effects of the deep drainage rates on groundwater or surface water receptors are expected to be minimal, other than for the potential area of concern for seepage in the NWBV. The groundwater modelling (SLR, 2022 Appendix I) indicates that seepage that does infiltrate through the cover into underlying potentially reactive waste streams will migrate towards K2E final void, which acts as a groundwater sink. Therefore, the relatively small amount of leachate that may potentially infiltrate through the waste is expected to remain within the mining area and subject to natural attenuation. Seepage from the NWBV is separately addressed in the groundwater technical report (SLR, 2022 Appendix I) and in the criteria listed for RM8.

6.1.6.5 Construction methodology

The following sub-sections describe the construction methodology of the uppermost cover system (i.e., between 2–6 m) and does not include a description of the planning, emplacement, decommissioning and construction aspects of the disposal and closure of the MPR cells or voids back-filled with tailings and coal combustion products. These works will be below the minimum prescribed NAF spoil cover thickness and are summarised in Section 6.2 (for tailings and coal combustion products) and Section 6.3 (final voids) and detailed in Appendix M – Meandu Mine PRC Plan Void Closure Plan (WSP 2022).

To construct the covers to meet the design objectives, the following steps will be undertaken:

- selection of appropriate material
- placement of NAF material as specified in Section 6.1.6.3; and
- NAF material is to be regraded and contoured to the design/slope of the final landform.

Compaction of a 2 m layer of NAF (located above coal combustion products and tailings storage facilities), as follows:

- The NAF spoil to act as compacted layer of cover material (2 m thickness) to be placed and spread in 500 mm thick layers (loose). When placed the material shall contain minimal particles > 450 mm diameter and be sufficiently moist that a hand-sample does not liberate dust when dropped at waist-height.
- Each 500 mm layer shall be compacted using a 100-tonne class dozer or a Cat 825-class padfoot-wheeled compactor. A minimum of two passes of the machined track or wheel print shall cover every component of the compacted surface. The minimum number of passes may have to be increased under certain conditions to achieve effective compaction.
- Effective compaction shall be determined as minimal observable indentation left by normal protective footwear under normal walking conditions. Alternatively, effective compaction may be determined by the use of a 9 kg Dynamic Cone Penetrometer as described in Australian Standard AS1289.6.3.2, with a minimum blowcount of 3 blows per 100 mm averaged over the full thickness of the compacted layer.

NAF spoil covering areas of the final landform not underlain by tailings or coal combustion products will not require the above listed compaction, only requiring the compaction generated by the track rolling involved in the typical placement, regrading and contouring process (Stanwell, 2021).

Following placement of the NAF spoil and compaction (if required), suitable topsoil and subsoil as prescribed by the PMLU (Table 6.16) shall be sourced from existing topsoil stockpiles at Meandu Mine or, where possible, directly placed after removal from areas on the mining path being stripped at the time. Topsoil is to be placed and spread over the as-constructed surface of the compacted cover as follows (Stanwell, 2021):

- For the Beef Cattle Grazing PMLU only, red clay/weathered basalt subsoil, or an alternative subsoil mix that meets the PMLU criteria, will be placed to a minimum depth of 800 mm by scrapers and/or dozers.
- Topsoil will be spread evenly to a depth of approximately 200 mm by scrapers and/or small dozers over the profiled NAF Spoil for the Native Ecosystem PMLU and over the subsoil for the Beef Cattle Grazing PMLU.
- Post topsoil placement, the surface is contour ripped to a depth of 0.3–0.5 m with small dozers for the Beef Cattle Grazing PMLU or 0.3–0.9 m for the Native Ecosystem PMLU to aid in erosion control, root penetration and shallow moisture infiltration.
- Seeding and fertiliser addition are generally applied in conjunction with contour ripping. An independent seed viability analysis will be conducted on the local supplier’s seed stocks prior to delivery.
- Ripping/ seeding operations are to occur as soon as possible after topsoil placement to minimise erosion.
- Topsoil placement is not scheduled when heavy rain is predicted to prevent erosion loss.
- Only topsoil that has been adequately characterised and considered suitable for vegetation growth as prescribed for the relevant PMLU will be used. Characterisation results should indicate whether soil improvements are necessary such as amelioration or blending. Application rates for fertiliser are historically 100–150 kg/ha; however, soil characterisation results may indicate differing rates are required.

6.1.6.6 Suitability and availability of cover material

A thorough material sampling and characterisation investigation was conducted by Stanwell to assess the rehabilitation suitability of waste rock and soil material available at the Meandu Mine (Landloch 2021a). The results of this investigation are summarised in Section 6.1.4.1. The LOM Plan was interrogated to confirm material volumes required to achieve the final landform and the volumes of material available for use, the results of which are summarised in Section 6.1.4.2.

6.1.6.7 QA/QC of cover design

Prior to the commencement of construction on any final landform and associated cover system, a rigorous design check and approval process will take place. The landform design shall explicitly consider and present for signoff the following (Stanwell 2022):

- alignment with the current LOM Plan
- impact on the water drainage system including a check of flows and capacities
- designs for any required drainage, both for the area individually and inclusive of any future up stream catchment, for all drains – main, spine or contour
- consideration of any PAF materials dumped in the domain and provision of an adequate cover to the final landform surface; and
- material characterisation of the top 6 m of material to address erosion and PMLU specific requirements.

Before any construction commences approvals as required by the Rehabilitation Management and Monitoring Plan must be obtained.

Material placement is undertaken using GPS-equipped equipment to guide dump construction according to design. Material type is recorded for each load and allows tracking of material from source to destination. Field verification is undertaken by regular inspections by supervisors, the geologist and Open Cut Examiner (OCE). Compliance to dump design is verified by regular survey.

High precision GPS is installed on dozers and graders involved in final landform reshaping. Design plans are uploaded to equipment that guide earthworks activities with alerts that flag cut-fill requirements for each area. Compliance to design is verified via regular surveys. Topsoil placement does not occur until the reshaped landform has been assessed and approved by a representative from the site Environmental team.

Construction QA/QC testing is conducted by the earthmoving contractor with random independent verification testing by Stanwell. A Construction Quality Assurance Plan (CQAP) is developed prior to works to facilitate conformance with the specification. The CQAP stipulates the nature, frequency and, if relevant, size of the QA/QC samples. Indicative testing/inspection required for cover system installation including topsoil placement includes:

- material characterisation (geochemical, physical, nutrients)
- minimum layer thicknesses (NAF spoil, subsoil, topsoil)
- final landform slope
- drainage channel dimensional parameters; and
- compaction testing.

Soil requirements (including source locations) are nominated in the rehabilitation program for each year with consideration of the suitability of the soil to meet PMLU requirements. Soil analysis is undertaken to determine amelioration requirements. If soil is used from (or added to) a stockpile, survey reconciliation is undertaken to calculate the volume used and the stockpile volume updated in the topsoil register.

Annual rehabilitation monitoring is undertaken in accordance with the Meandu Mine Rehabilitation Monitoring Programme, which is detailed in Section 8. The condition of the rehabilitated sites is assessed against the benchmark and other relevant success criteria currently listed in Appendix 7 of the EA.

Monitored trials of the proposed rehabilitation program for Beef Cattle Grazing PMLU are proposed to confirm the prospective combinations of subsoil and topsoil suitable for developing a sustainable and stable PMLU. Details of the trials are included in Section 7.5.

The existing rehabilitation monitoring program uses age-based monitoring intervals. Monitoring is conducted at ages 1 year (within the first year – rapid assessment), 2 or 3 and 5 years of age and every 5 years after that. For rehabilitation areas that are less than 12 months old at the time of monitoring, rapid assessments are undertaken in the first year after establishment, which focuses on ground cover establishment and soil characteristics and stability (evidence of major erosion starting i.e. gullies or rills deeper than 100 mm) across the rehabilitated area.

When a rehabilitation site has been successfully established and is at least 2 years old, 50 m long permanent transects are established. The number of transects established depends on the size and shape of the rehabilitation area. Most areas have either 2 or 3 permanent transects. Parameters measured by the monitoring include:

- evidence of erosion such as the presence of gullies or rills
- groundcover
- species assemblage
- canopy cover (if relevant); and
- height and diameter at breast height measurements of relevant plants/trees.

The ultimate objective of rehabilitation assessment is to develop a path towards successful relinquishment or transition to the PMLU (i.e., Progressive Rehabilitation Certification). This will be demonstrated through achievement of completion criteria/progress towards benchmark conditions and predictions of resilience over time.

Corrective actions

If QA/QC testing reveals that any works are found to be not compliant with the design specification, the contractor is required to undertake rectification of the non-compliant items and conduct re-testing in accordance with the specification. Defects and repairs to be conducted to correct any defects or excursions from the specification include, but are not limited to (Stanwell 2022):

- Cover material that fails characterisation QA/QC testing will require remediation through removal, replacement and re-testing to the satisfaction of the principal.
- Areas of cover that do not conform to the required compaction and thickness criteria shall be repaired by the contractor by additional compaction or addition of relevant material to deficient layer until minimum thicknesses are met to the satisfaction of the principal.
- Non-conforming drainage channels will be re-established to the required criteria to the satisfaction of the site environment team

- Any deviations from the final landform slope criteria will be assessed on a site-specific basis with respect to the risk presented by the deviation to ascertain the specific rectification requirements (if any) to minimise re-sculpting earthworks. A small area of deviation may be managed by erosion control or fast-tracked revegetation works negating any need for re-sculpting. Larger areas of deviation may require re-design and changes to the LOM Plan.

If rehabilitation monitoring identifies areas that fail to meet the ongoing rehabilitation success criteria such as erosion issues (e.g., graded bank failures, active gully erosion on slopes) or poor vegetation establishment, then an intervention program will be established to arrest further decline. Potential actions include repair of graded banks, backfilling any erosion gullies and re-seeding poorly vegetated areas. The ongoing rehabilitation maintenance program is then updated and budgeted for with the objective of achieving long-term sustainability.

6.1.7 Water management

PRC Plan Guideline (Section 3.6.1)

The rehabilitation planning part must include a description of the following:

- a description of the contaminants that pose a risk to environmental values of the receiving environment
- source, pathway and fate of contaminants that have the potential to impact environmental values
- infiltration and seepage intervention and collection controls
- surface water diversions and long-term management requirements
- dewatering requirements
- ongoing water management and reduction requirements (i.e. treatment).

6.1.7.1 Overview of water management

Contaminants of concern

Contaminants of concern from mining activities at the Meandu Mine along with the potential sources, pathways and receptors of these contaminants has been identified in Appendix I – Meandu Mine PRC Plan Groundwater Technical Report (SLR, 2022a). Contaminants of concern relating to on-site infrastructure (e.g., hydrocarbons) will be managed as per contaminated land procedures (Section 6.5.6); therefore, this section only considers contaminants of concern potentially associated with mine waste materials present on the site post-closure. These contaminants of concern are summarised in Table 6.17.

Table 6.17 Potential sources of contamination, contaminants of concern and potential pathways and receiving waters (SLR, 2022a)

Source location	Potential contamination issue	Contaminant of concern	Paths and receptor locations	Receiving waters
K2W-N ASF K4S ASF	Coal combustion product-impacted seepage from the storage facility	EC, sulfate, fluoride, arsenic, boron, molybdenum, selenium, vanadium (as determined from regular TCLP testing undertaken at the Tarong power stations prior to conveyance to Meandu Mine)	Underlying and adjacent groundwater systems	Groundwater
NWBV	AMD	EC, pH, sulfate, cobalt, iron, manganese, nickel and zinc	Underlying and adjacent groundwater system, particularly the area to the west of NWBV adjacent to Meandu Creek	Groundwater/ Surface water
NWA TSF, NWB TSF, K2TSF	Saline drainage; metalliferous drainage, AMD	EC, TSS (Total Suspended Solids), manganese, nickel, zinc	Underlying and adjacent groundwater systems	Groundwater
Mixed Plant Rejects	Saline drainage; metalliferous drainage; AMD	EC, TSS, metals	Underlying and adjacent groundwater systems; Meandu Creek Diversion; dams via runoff	Groundwater/ Surface Water
Areas of waste rock (spoil) dumps, both in-pit and out-of-pit storage	Saline drainage; metalliferous drainage	EC, TSS, aluminium, iron, selenium	Underlying and adjacent groundwater systems; Meandu Creek Diversion; dams via runoff	Groundwater/ Surface Water

Source location	Potential contamination issue	Contaminant of concern	Paths and receptor locations	Receiving waters
In proximity to QW backfilled void	Saline drainage	EC	Shallow regolith along a natural drainage line towards retention dams RD1 and RD2	Groundwater
Area within the Black Creek catchment	Saline drainage; metalliferous drainage; AMD	EC, TSS, metals/metalloids	Shallow regolith along natural drainage lines toward RD17	Groundwater

Due to their contamination source potential, there are known areas of concern for ongoing rehabilitation of Meandu Mine. These are shown on Figure 6.13 and described below. These areas are:

- NWBV (North-West Backfilled Void)
- the area of the Queens West salinity plume; and
- the area of the Black Creek Catchment salinity plume.

These areas have been historically recognised as potential sources of contaminants (Meandu Mine Environmental Evaluation (WSP, 2018)) and are in various stages of maturity in terms of assessment. Groundwater modelling for the purpose of the PRC Plan concluded that there were no further areas beyond those already identified from the Meandu Mine Environmental Evaluation. During the planning phase of the Meandu Mine PRC Plan several risk assessment workshops were undertaken to address risks of contamination (refer Section 7) – no additional areas of groundwater or surface water contaminants of concern were identified requiring notification.

The fate of a contaminant should be described according to the processes involved in natural attenuation which reduces its effects on environmental values. These processes include biodegradation, diffusion, dilution, sorption, volatilisation and chemical and biochemical stabilisation. The role of the uptake by vegetation and animals in attenuation should also be considered. This information presented here and in Table 6.17 has been informed by the results from the contamination transport modelling undertaken by SLR (2022a) and outlined in Section 6.1.1.4.

6.1.7.2 Infiltration and seepage interception and collection controls

The potential exists for infiltration of rainfall through the final landform cover systems at Meandu Mine resulting in contact with potentially reactive contaminant sources as listed in Table 6.17. Reaction of the contaminant source/s with the infiltrated water may result in the release of contaminants of concern into seepage that may in turn result in environmental impact to the PMLUs and/or surrounding environment.

Cover systems for Meandu Mine have been designed with the intent of minimising rainfall infiltration (Section 6.1.6). However, the cover systems do not totally preclude the infiltration of rainfall – modelling undertaken by Landloch (2021d) utilising MEDLI indicated that depending on the specific cover system, stage of revegetation and intensity of the rainfall episode varying levels of deep drainage may occur.

Infiltration modelling of each of the cover specifications for the Beef Cattle Grazing and Native Ecosystem PMLUs conservatively assumed a constant, non-site specific infiltration rate for all rainfall events even though covers typically achieve a compaction level of 85–90% using standard dumping/trafficking techniques (Landloch 2021d – Section 6.1.6.4). The Landloch MEDLI infiltration modelling of deep drainage indicated that it is likely to be infrequent and episodic, with no infiltration in most years. However, high rainfall years will result in infiltration (below the root zone) of up to 380 mm/y.

Historical infiltration of rainfall into some areas of stored waste at the Meandu Mine has resulted in mobilisation of CoC and potential seepage issues as described in Section 6.1.7.2. Ongoing rainfall deep drainage into unrehabilitated spoil piles may result in ongoing contribution to seepage in these areas until after completion of cover systems installation and they have been fully vegetated and rehabilitated. To manage this seepage and in turn to limit potential impact to the receiving environment, the following operational controls have been implemented at Meandu Mine:

- QW sump: a section of the QW void has deliberately not been backfilled to act as a sump to facilitate water quality monitoring as well as to capture seepage issuing from the neighbouring spoil piles and undisturbed ground, some of which has been identified as saline. Seepage into the sump is pumped out and delivered into the Meandu Mine water management network.
- Historic NWBV: acidic seepage from the NWBV reporting to the surface at Ramp 7 was captured by RD7 and RD8 and not released to RD2 until water volumes had diluted the acidity, TDS and sulphate to below compliance levels. Since 2018, this seepage has been intercepted and treated with lime dosing in the lined RD27 to lift the pH before delivery of this water to the water management network. Ongoing seepage, when present, is being monitored to ensure contaminant concentrations can continue to be managed in this way. Longer-term management of this seepage is discussed in Section 6.1.7.3.
- Post-closure: no ongoing seepage collection and/or treatment is proposed. Groundwater modelling suggests the majority of seepage from rehabilitated areas will migrate in the direction of the K2E final void. Ongoing seepage from the NWBV is expected to both diminish in volume with time and continue the trend of reduction in concentration of contaminants of concern via both dilution of in spoil accumulation and attenuation prior to expression to receiving environment. The current pumping and treatment of the groundwater from the lower level of the NWBV will be complete by this time. Should monitoring suggest material and sustained deviation from these trends and likelihood of reoccurrence of AMD despite the actions described in Section 6.1.7.3, then strategies for long-term AMD management will be developed closer to closure. This has been addressed in Section 7.4.

6.1.7.3 Dewatering requirements

Dewatering of the groundwater within the NWBV is currently conducted from dedicated groundwater bores screened across the saturated backfilled spoil using submersible pumps. The reasoning behind this management strategy and the results to date are summarised below. Modelling suggests that dewatering will be required until closure to allow for treatment of the contaminants of concern from the initial charge in the basal section of the former void. By closure (between 2039 and 2045) the final landform will have been rehabilitated with a cover that minimises ongoing infiltration to the extent sufficient to prevent a recurrence of the seepage due to this source (SLR, 2022b).

6.1.7.4 Discussion of specific management areas

Three areas previously identified as requiring management were confirmed from groundwater monitoring conducted for the PRC Plan:

- North-west Backfilled Void
- Queens West saline plume; and
- Black Creek catchment saline plume.

The location of these areas is shown in Figure 6.13.

North-west Backfilled Void

The North-West Backfilled Void (NWBV) is the only area where AMD impacted seepage has historically expressed at the surface with surface expression occurring at Bullgang Corner and Ramp 7. The sources of AMD have been identified in WSP (2018) as likely from "*the oxidation of sulfide minerals placed (predominantly) into RSA1 from circa 1986 to 1995"* and *"the oxidation of sulfide minerals in rejects that have been emplaced (and left open to atmospheric conditions for more than six months) into the North-West Backfilled Pit".* The seepage at Ramp 7 and Bullgang Drain is interpreted to be the surface expression of groundwater that has seeped through the rejects at RSA1, mobilising pyrite oxidation products (sulfate, iron and manganese) and driven westwards by head from the groundwater beneath the NWBV and NWB TSF along the base of the rejects/spoil.

Since late 2021 seepage has been significantly reduced as a result of groundwater dewatering from the NWBV to achieve a target water level of RL432.7 m. Ongoing water quality analyses from the dewatering bores shows continual improvement (e.g. pH 5.5 to 6.8 and SO_4^{2-} in the range of ~ 800 mg/L).

Meandu Creek (upstream of Meandu Creek Dam) is the receiving environment/receptor of concern for waters to be (potentially) impacted by seepage waters originating from the NWBV. As shown on Figure 6.14 the Queen Seam (the lowest seam mined at Meandu Mine) does not exist beneath Meandu Creek to the west of the mining area and the sediments of the Tarong beds cease upstream of Meandu Creek Dam. This limits the hydraulic connectivity between the mined seams and Meandu Creek alluvium. Groundwater gradients are toward Meandu Creek Dam, which exert control onto water levels in the surrounding alluvium. It is thus inferred that shallow groundwater seepage in the regolith entering Meandu Creek alluvium will report to Meandu Creek Dam. It is noted that no evidence of adverse impacts from seepage waters from the NWBV to Meandu Creek were found as part of the Environmental Evaluation (WSP, 2018).

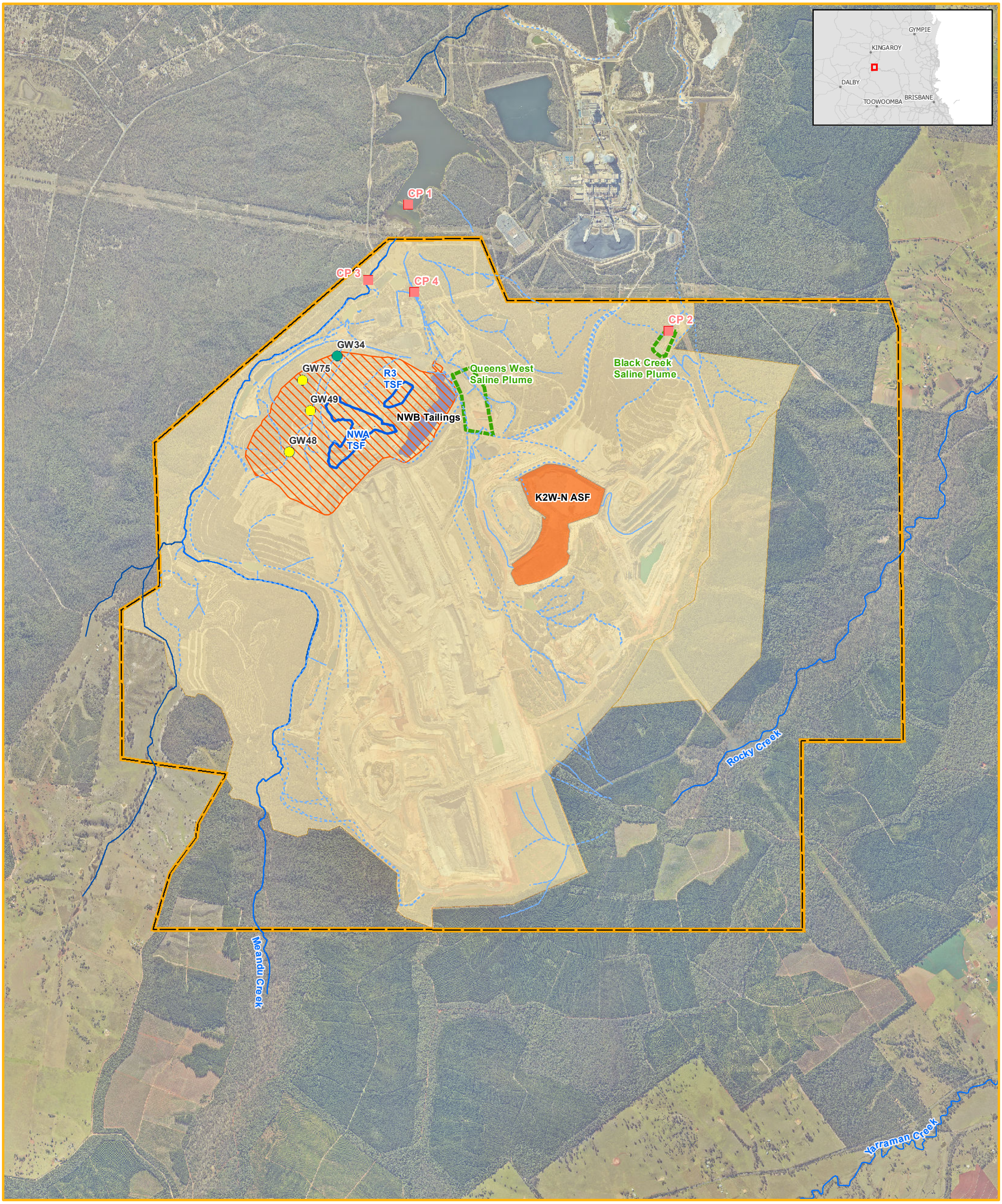
Specific pathways, related to the seepage waters from the NWBV, are identified as:

- prior drainage channels (e.g. at Bullgang Corner) underneath filled areas – seepage has been observed at the base of the spoil at Bullgang Corner; and
- Western NWBV area – diffuse seepage where the remnant natural material forms a relatively thin barrier to seepage (Figure 6.14).

The spoil saturation is inferred to originate from direct rainfall infiltration and seepage from the NWB TSF. Remediation efforts are ongoing with initial 2 m capping commenced in November 2021 and expected to be completed within approximately 2 years.

Meandu Mine – Progressive Rehabilitation and Closure Plan

Figure 6.13
Water Management Target Areas



Legend

- Groundwater Monitoring Bore – Spoil
- Groundwater Monitoring Bore – Queens Seam interbedded with sandstone/siltstone
- Compliance Points
- Drainage
- Watercourse
- Tailings
- NWBV
- Saline Plume
- K2W-N ASF
- NWB Tailings
- Mining Lease (ML6674)
- Approved Surface Rights Area

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(ii) The dimensions, areas, number of lots, size & location of corridor information are approximate only and may vary.
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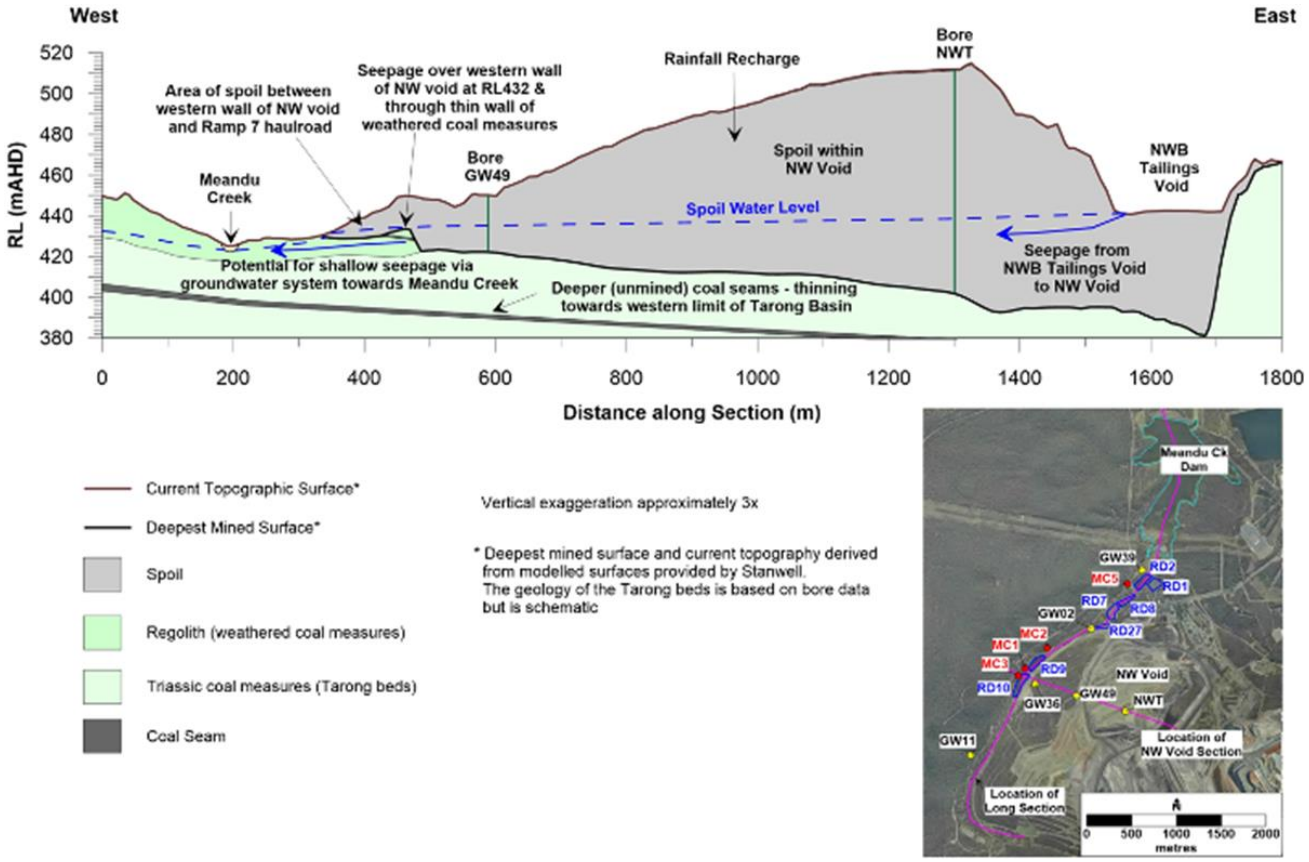


Figure 6.14 West-East Section through NWBV (Stanwell, 2020b in SLR, 2022)

Contaminant transport modelling of the voids backfilled with potentially reactive material indicates that most of the potential seepage will be captured by the groundwater sink formed by K2E final void. The exception is the NWBV, modelling of which suggests that seepage may impact Meandu Creek baseflow post-closure. Contaminant migration is to the north-west towards Meandu Creek, travelling approximately 400 m in 700 years. The model indicates that contaminant mass sourced from the backfilled pits may reach the surface waters of Meandu Creek through baseflow in the reach of the creek adjacent to the Meandu Mine north-west of the NWBV.

Minimisation of this risk is proposed through the ongoing dewatering of the NWBV to the end of the LOM, with the ongoing rehabilitation of the NWBV area including a constructed cover designed to minimise future rainfall infiltration, particularly over the decommissioned NWB TSF. The dewatering of the NWBV is designed to reduce the groundwater levels in the spoil to levels lower than the final NWA mine void lowwall (WSP, 2018), thus minimising ongoing seepage from this landform. Ongoing monitoring of groundwater levels in the NWBV and seepage at Ramp 7 and Bullgang Drain suggest this strategy is already reducing seepage volumes and concentrations of potential contaminants in the seepage. The final landform constructed covers should then reduce future infiltration through the spoil, rejects and tailings such that the future seepage is minimised. Further information around the cover design for the NWBV is outlined in Section 6.1.6.

As outlined in Table 7.6, the following measures are proposed to minimise, and improve upon, the groundwater seepage risk from the NWBV:

- continue monitoring of groundwater levels and water quality in the NWBV during:
    - pumping and periodic cessation of pumping
    - following completion of the NWB TSF capping system and generic bulk waste dump
    - during vegetation establishment to >50% coverage.
- develop clear monitoring milestones for key analytes to confirm the water quality is on trend to have no detrimental relative impact to the receiving environment and include in the PRC Plan and PRC Plan Schedule
- develop and include site-specific WQOs for key indicators and analytes in the receiving environment to preserve aquatic ecosystem health
- periodic reassessment and calibration of the water models to assess the effectiveness of the cover system.

Ongoing monitoring and continuation of existing short term management actions continue through the operating period of the mine, improving the predictive capacity of the models before closure.

Queens West saline plume

The saline plume extending from the Queens West Backfilled Void towards Meandu Creek has been assessed in a desktop study by SLR (2020). Contamination sources are unclear at this stage and may be linked to natural conditions and/or the result of unrecorded deposition of saline spoil and or rejects being deposited in the area during the rapid development of the historic QW pit in 2002 - 2004. The significantly lower EC of the Queens West Backfilled Void sump water indicated that this is not the source of salinity in the area. A review of the lithological data for impacted groundwater monitoring bores indicates that the plume is relatively confined to shallow regolith material.

Meandu Creek (adjacent to Meandu Mine) would be the receiving environment/receptor down gradient of the saline plume originating in the vicinity of the Queens West Backfilled Void in the event that it was to mobilise. Specific pathways related to the Queens West Backfilled Void salinity plume have been reported by SLR (2020) as regolith associated with a natural drainage channel running south to north towards retention dam RD4 in the direction of Meandu Creek. The migration pathway is also south to north in direction of groundwater flow (Figure 6.15).

As described in Section 6.1.7.2, it is inferred that shallow groundwater seepage in the regolith entering Meandu Creek alluvium will report to Meandu Creek Dam. The risk of harm to EVs from the saline plume have been identified as extremely low as the plume has been interpreted to move very slowly (SLR, 2020) and may never reach Meandu Creek Dam. This is being monitored routinely. To date, ongoing monitoring of additional groundwater monitoring bores has shown that the plume is relatively static.

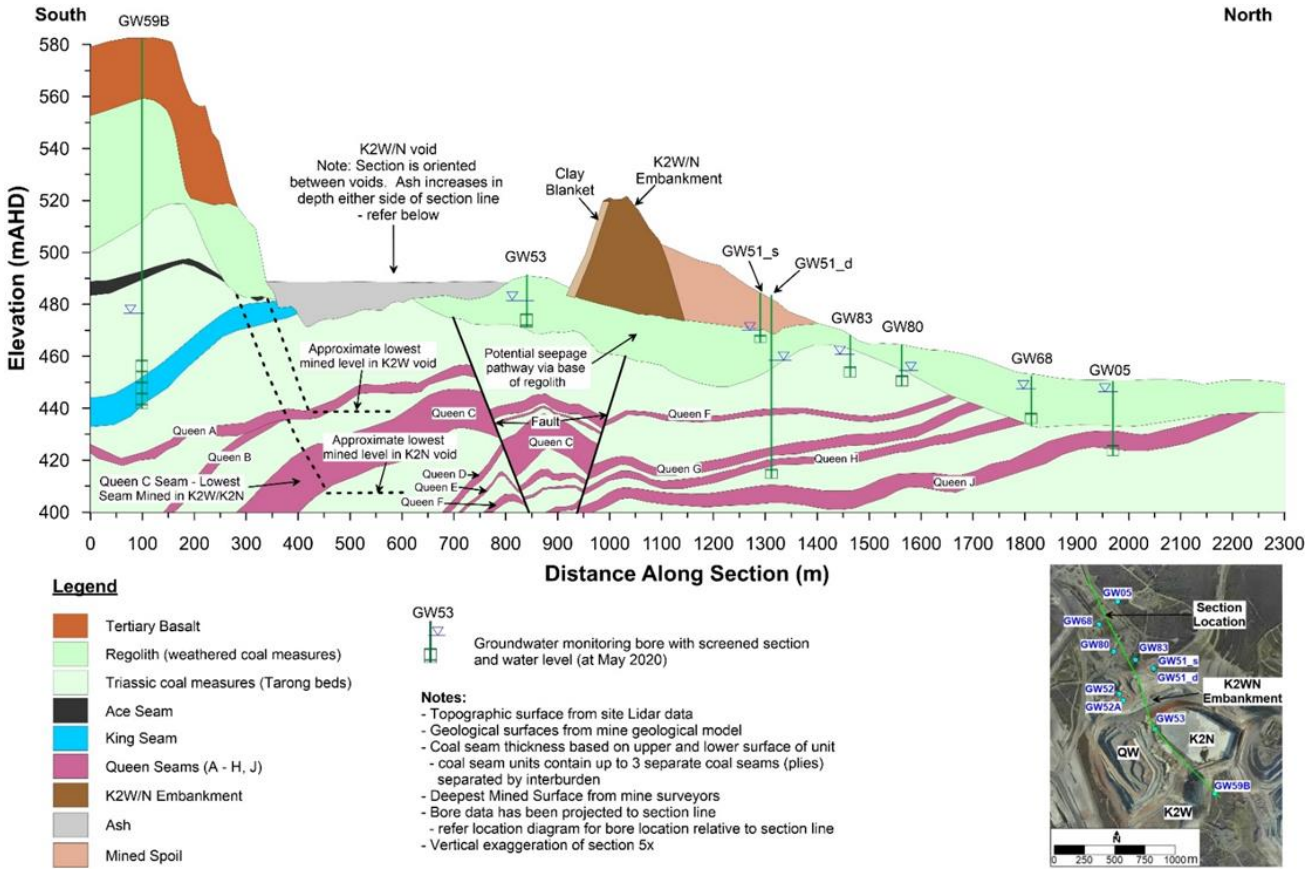


Figure 6.15 West-East section through K2W-N ASF (Stanwell, 2020b in SLR, 2022)

Monitoring data for impacted regolith monitoring bores shows that EC values and water levels are generally stable, with values generally declining northwards towards Meandu Creek. This indicates that the migration of the plume is very slow. Hydraulic parameter values support this observation with the regolith material showing a shallow hydraulic gradient and relatively low hydraulic conductivity. For example, general hydraulic conductivity calculations suggest it would take >180 years for waters from the Queens West plume to reach Meandu Creek. This does not consider diffuse or localised recharge or cross-formational flow and its dilution effects which would only further reduce any potential impact.

Black Creek catchment saline plume

An area within the Black Creek catchment in the north-eastern area of ML6674 recorded elevated EC, aluminium, zinc and low pH (WSP, 2018). The potential source of contaminants within the Black Creek catchment may be derived from mine impacted areas (e.g. spoil or tailings of the K2E area), from areas that are unimpacted by mining to the east (i.e. natural drainage lines that drain the ridgetop basalt, or plantation forestry activities to the east) or from the area of the Tarong Power Station, including the coal stockpile which drains to this area (JBT, 2018). Black Creek is the receiving environment receptor for the saline plume identified around K2E and RD17. Specific pathways related to the salinity plume and area within Black Creek catchment have been reported by WSP (2018) as likely regolith associated with a natural drainage channel running south to north towards RD17.

A desktop assessment of this area was conducted by SLR in 2022 as part of the PRCP supporting studies program. It recommended installation of additional monitoring bores and further data gathering to acquire information oriented at confirming the source of contaminants. The additional bores will be installed and integrated into the Meandu Mine groundwater monitoring network. This area remains under ongoing monitoring and investigation. General hydraulic conductivity calculations suggest it would take >100 years for waters from the Black Creek plume to reach areas downstream. This is particularly noteworthy considering the mine has only been in operation for ~40 years. Similar to the Queens West plume, the hydraulic conductivity does not consider diffuse or localised recharge, or cross-formational flow, and its dilution effects.

Black Creek is the receiving environment receptor for the saline plume identified around K2E and RD17. Specific pathways related to the salinity plume and area within Black Creek catchment have been reported by WSP (2018) as likely regolith associated with a natural drainage channel running south to north towards RD17.

During the operational life of the mine and Tarong power stations, the surface water from Black Creek Dam is captured and used at the Tarong power stations and hence the EV identified for this catchment is “industrial use”. The waterway has been de-gazetted. At closure (following mine rehabilitation), the discharge from Black Creek will continue to report to the Black Creek Dam and to Meandu Creek (only) during significant surface water flow events. The functionality of this final surface water system will be determined following completion of the Tarong power stations rehabilitation and closure plan).

6.1.7.5 Surface water diversions and collection controls

Surface water runoff is directed to the on-site erosion and sediment control and mine-affected water capture dams. In the event that rainfall/runoff events exceed the capacity of the water management system, overflow is directed to Meandu Creek Dam and Black Creek Dam. Releases from Meandu Creek Dam occur to downstream waterways in accordance with the Meandu Mine EA controlled release conditions. Therefore, contaminants such as oil and grease, surfactants, petroleum hydrocarbons can persist further downstream, along with dissolved contaminants.

Although the fate of these contaminants is considered to be Meandu Creek Dam, Black Creek Dam and their downstream creek systems, the impact on these systems is materially reduced due to the capture of contaminated runoff in onsite detention/retention dams. Furthermore, as the discharges from Meandu Mine are diluted with runoff from surrounding clean catchments prior to discharge from Meandu Creek Dam or Black Creek Dam, it is unlikely that contaminants would be at concentrations that would impact the downstream environment from Meandu Creek Dam.

6.1.7.6 On-going water management and reduction requirements

Based on the results of the hydrologic modelling undertaken for the final voids, ongoing surface water management post closure is unlikely to be required at Meandu Mine. These results indicate that the concentrations for each contaminant of concern are not predicted to exceed the PMLU water quality criteria, even at the 90th percentile. The model also shows that EC levels in final voids increase up to 5,500 µS/cm. This is significantly below the criteria for Water Storage PMLU of 9,197 µS/cm (TDS of 5,000 mg/L ÷ 0.5436); suggesting that the water is of suitable quality for stock water demands for at least 120 years. The final void water qualities are therefore unlikely to contain contaminants of concern that will negatively impact on the PMLU of Water Storage for stock watering (refer further to Section 6.3.5). The modelling of the different water extraction scenarios demonstrates that water extraction for the Beef Cattle Grazing PMLU within the minimum and maximum ranges shows that water quality remains suitable for stock in the long-term.

6.1.8 Revegetation

PRC Plan Guideline (Section 3.6.1)

The revegetation plan must propose activities that will establish self-sustaining vegetation communities that are appropriate for the intended PMLU (e.g., natural ecosystems, grazing, forestry and some agricultural and other land uses). Revegetation should, therefore, not only establish a ground cover, but also, in some domains, establish associated fauna habitat and other ecological services. The rehabilitation planning part must include details of the site preparation required for rehabilitation activities.

6.1.8.1 Revegetation objectives

The revegetation objectives for the Meandu Mine, consistent with the proposed PMLUs are outlined in Table 6.18.

Table 6.18 Revegetation objectives

PMLU	Revegetation objectives
Native Ecosystem (Terrestrial)	For the non-riparian Native Ecosystem PMLU, to revegetate with species that are similar to locally occurring regional ecosystems, which comprise open woodland or forest and exist in State forests and National Parks surrounding the Meandu Mine. To provide support to local fauna through: • planned proximity to water sources (both Water Storage and existing creeks); and • inclusion of native ecosystem flora species from the relevant regional ecosystems known to support local native fauna.
Beef Cattle Grazing	• To achieve a sustainable Beef Cattle Grazing land use for the area with the objectives of: ○ sustainably maintain beef cattle production on the PMLU footprint in accordance with this PRC Plan and Stanwell's Beef Cattle Grazing Strategy ○ maintaining or improving the land condition of the rehabilitation and prevent land degradation; and ○ integrating the rehabilitated pasture lands with critical grazing management infrastructure to create an economically viable grazing enterprise. • To enable fauna connectivity between adjoining Native Ecosystem PMLUs through provision of tree shelter belt/s with relevant and appropriate species selected from the Native Ecosystem PMLU seed mix.
Plantation Forestry	As discussed in Section 4.1.1.4, the only use of the Plantation Forestry PMLU is where pre-existing plantation trees, established by the original plantation licence holder (HQPlantations) remain in place at the end of mining in areas undisturbed by mining activities. As such no revegetation objectives are proposed for this PMLU.

PMLU	Revegetation objectives
Steep Rocky Ecosystem	To achieve the establishment of self-sustaining plant and animal assemblages and associated ecosystem processes across the post-mining steep rocky landscape subject to the over-riding requirement of maintaining geotechnical stability.
Creek Diversion	To achieve the following objectives: • support for a long-term self-sustaining vegetation community • maintain a stable landform; and • create a local microclimate, which will help with wind, temperature, water retention and pollination vectors.
Water Storage (littoral zone in the final voids only)	To achieve the following objectives: • revegetate with species that are similar to locally occurring regional ecosystems and are suitable for infrequent inundation and/or wet ground conditions • support for long-term self-sustaining vegetation community; and • provide stability to created/disturbed surfaces.

The revegetation of Plantation Forestry PMLU will not be discussed further in the following sections since no new plantings of Plantation Forestry are proposed to be undertaken at Meandu Mine. The only use of the Plantation Forestry PMLU is where pre-existing plantation trees, established by the original plantation licence holder (HQPlantations), remain in place at the end of mining in areas undisturbed by mining activities.

6.1.8.2 Key flora species

This section summarises key flora species for each proposed PMLU. Further details in terms of species lists of preferred species and seeding rates is provided in the Meandu Mine PRC Plan Revegetation Plan (Appendix L).

Native Ecosystem (Terrestrial)

Species selection for seeding of the Native Ecosystem PMLU has evolved from a low diversity species mix used in the mid-1980s (Japanese millet, *Acacia fimbriata*, *Eucalyptus crebra*, *E. trachyphloia* and *Corymbia citriodora*) to the current diverse species mix which comprises a range of plant lifeforms, including canopy tree species (Eucalyptus, Corymbia, Angophora and, *Lophostemon confertus*), sub-canopy species (Acacias), shrubs such as Cassinia, Hovea and Dodanea, the vine *Hardenbergia violacea* and native and non-native grass species including the cover crop *Echinochloa utilus*. Species choice reflects species that occur in different stages of stand development of the Native Ecosystem PMLU, including the use of nitrogen fixing legumes, the requirement to establish rapid ground cover to prevent erosion and the Rehabilitation Milestone criteria in the PRC Plan. A list of preferred species and seed rates is provided in Appendix L – Meandu Mine PRC Plan Revegetation Plan (WSP, 2022b).

Beef Cattle Grazing

Species for improved sown pastures in South-east Queensland include a combination of annuals and perennials. Perennial grasses and legumes that may include, Rhodes grass (*Chloris gayana*), Bisset creeping bluegrass (*Borthriochloa insculpta*) Glycine (*Neonotonia wightii*) and Lucerne (*Medicago sativia*).

Pasture species selection for the rehabilitation of Beef Cattle Grazing PMLU at Meandu Mine will be refined based on consultation with appropriate grazing consultants as well as considering the results of the proposed grazing trial (refer Table 7.7 of Section 7.5 and Appendix L – Meandu Mine PRC Plan Revegetation Plan). This will ensure that improved pasture species are appropriate for the site and include new higher performing varieties and species. The proposed grazing trial will provide further guidance on the timing for commencement of grazing following rehabilitation establishment and verification of sustainable stocking rates and production metrics.

The pasture seed mix may include a cover crop such as *Echinochloa esculenta* (Japanese Millet). The cover crop provides various benefits including:

- provides rapid vegetation cover minimising the risk of erosion from intense rainfall events
- improves water retention
- reduces opportunities for weed colonisation; and
- provides a source of organic carbon once hayed off.

In addition, pasture species selection will include assessment of the potential invasiveness for adjacent Native Ecosystem PMLUs.

Steep Rocky Ecosystem

A wide range of plant species are likely to establish in the Steep Rocky Ecosystem PMLU which is associated with the highwalls of the proposed final voids. A combination of trees and shrubs, Lianas, grasses, sedges, legumes and ferns may result from the natural repopulation post development of the slopes, based on a number of factors including adjacent natural species, soil type, gradient and moisture conditions. Table 8.4 of Appendix L – Meandu Mine PRC Plan Revegetation Plan provides an indicative species list for the Steep Rocky Ecosystem based on the initial natural repopulation survey conducted at Meandu Mine. The current species expected from natural repopulation considers soil development for long-term sustainability and water availability. The effects of predicted changes from climate change have been taken into account and the species list may be revised as more knowledge is gathered from the proposed rehabilitation trials (refer to Section 7.5).

Creek Diversion/Littoral Zones of final voids

Species selection for the Creek Diversion and littoral zones of final voids (located on the lowwall side of the voids) aims to achieve a long-term self-sustaining vegetation community and minimise the long- and short-term risks and maintenance requirements. Species have been chosen to suit the likely soil conditions present in the diversion and littoral zones of final voids, including irregular inundation and/or wet ground conditions. Species selected are assumed to already be present in the area and the intent is to contribute to the remnant vegetation communities at the upstream and downstream ends of the diversions.

Species selection was undertaken in 2010 based on the approved design plan and revegetation plan for the upstream (southern) diversion. Species include a combination of grasses; reeds, sedges and rushes; shrubs and trees. The full species list and the seed rate applied is included in Table 7.1 of Appendix L – Meandu Mine PRC Plan Revegetation Plan.

Progressive monitoring since completion of seeding has shown that the species selection is appropriate for the Creek Diversion PMLU. Given the similarity in conditions and applications, an internal environmental review concluded that the same list is appropriate to be utilised for the littoral zones of final voids.

6.1.8.3 Fauna habitat requirements

The south-west of the Meandu Mine surface rights area comprises a large area of rehabilitation of approximately 36.5 ha that is 15 years old. The area is clearly being utilised by fauna with evidence of macropods, diggings (possibly not from native animals), and high numbers of bird calls.

An area in the north-east of the Meandu Mine surface rights area contains established rehabilitation which is 10 years old. The monitoring site is being utilised by fauna with evidence of use by macropods and echidnas. Multiple bird calls were recorded and there were some plants which were considered likely to have been introduced by birds (i.e. *Dubosia* sp.) during past monitoring events.

Rehabilitation monitoring undertaken during 2021 at the western part of the Meandu Mine also shows that fauna usage was evident with rodents, small passerine birds and crows present. A finch nest was recorded and evidence of rabbit and macropod (Wallaby) grazing and throughfare usage was observed.

During the same monitoring event, fauna species were also recorded within the north-western part of Meandu Mine. These include finches and fairy wrens which are commonly found amongst *Lantana camara*, as well as evidence of bandicoot digs.

Section 2.1.9.2 notes species of conservation significance which have been recorded from the area surrounding the Meandu Mine during recent field surveys. Where consistent with a proposed PMLU, species of conservation significance will be targeted during rehabilitation works. The potential for this to be achieved for certain species of conservation significance is discussed in the following subsections. Targeted species would be confirmed during revegetation trials, particularly for the Steep Rocky Ecosystem PMLU.

Within the Beef Cattle Grazing PMLU, provision of tree shelter belt/s for cattle will also act as fauna corridors interconnecting the Native Ecosystem PMLUs either side.

Short-beaked Echidna (*Tachyglossus aculeatus*)

The Short-beaked Echidna has been recorded from the K2E ASA and surrounds during recent surveys. It has also been recorded from 10 years old rehabilitated areas in the north-east of the surface rights area. The Native Ecosystem PMLU comprising eucalypt forest species would provide suitable habitat for this species.

Koala (*Phascolarctos cinereus*)

Whilst not recorded from the K2E ASA or surrounds during recent surveys, there are historical records for the Koala within the locality. Suitable habitat for this species also occurs within ML6674 along Rocky Creek. Habitat for Koalas can be incorporated into the Native Ecosystem PMLU. This will be achieved by ensuring that trees established include food trees for Koalas. The tree species to be planted (via inclusion in the seed mix) vary by soil type but will include *Eucalyptus crebra*, *Eucalyptus moluccana* and *Eucalyptus tereticornis.*

Greater Glider (*Petauroides voians*)

The Greater Glider is largely restricted to eucalypt forests and woodland, with a diet comprising of eucalypt leaves and occasional flowers. It is found in abundance in montane eucalypt forest with relatively old trees and an abundance of hollows. It also favours forests with a diversity of eucalypts to cater for seasonal variation in food abundance. The Greater Glider has been previously recorded from within the eucalypt forests on ML6674 along Rocky Creek. The incorporation of eucalypt species into the Native Ecosystem PMLUs will assist in providing additional habitat resources for this species.

Spotted-tail Quoll (*Dasyurus maculatus*)

Whilst not recorded from the K2E ASA or surrounds during recent surveys, the species was considered to have a moderate likelihood of occurring within Yarraman State Forest due to the presence of suitable habitat, There is a historical record for the species from the Locality (approximately 6 km south-east of the mine). Suitable habitat for the species occurs in ML6674 within the Yarraman State Forest. The Spotted-tail Quoll prefers mature wet forest habitat. It has been recorded from a wide range of habitats, including:

- temperate and subtropical rainforests in mountain areas
- wet sclerophyll forest
- lowland forests
- open and closed eucalypt woodlands
- inland riparian and River Red Gum forests
- dry 'rainshadow' woodland
- sub-alpine woodlands
- coastal heathlands; and
- occasional sightings from open country, grazing lands, rocky outcrops and other treeless areas.

The PMLUs of Native Ecosystem, Beef Cattle Grazing and Steep Rocky Ecosystem PMLUs can provide potential habitat for the Spotted-tail Quoll. The rehabilitation of at Meandu Mine will include a range of vegetation types and landscapes such as eucalypt woodlands, riparian forests, grazing land, riparian/littoral zones of water bodies/waterways and rocky outcrops which are all potential suitable habitat for this species.

Northern Quoll (*Dasyurus hallucatus*)

The Northern Quoll was not recorded from the K2E ASA or surrounds during recent field surveys but was considered likely to have a moderate likelihood of occurrence within Yarraman State Forest due to the presence of suitable habitat. Historical records for the species are from Bunya National Park, 31 km to the west of the mine.

The Northern Quoll occupies a diversity of habitats across its range which includes rocky areas, eucalypt forest and woodlands, rainforests, sandy lowlands and beaches, shrubland, grasslands and desert. Northern Quoll habitat generally encompasses some form of rocky area for denning purposes with surrounding vegetated habitats used for foraging and dispersal. Surveys throughout Queensland have suggested Northern Quolls are more likely to be present in high relief areas that have shallower soils, greater cover of boulders, less fire impact and were closer to permanent water (DAWE, 2021).

Native Ecosystem and Steep Rocky Ecosystem PMLUs are potentially suitable habitats for encouraging population by the Northern Quoll. The rehabilitation of at Meandu Mine will include a range of vegetation types such as eucalypt woodlands, shrubland and grasslands. The Steep Rocky Ecosystem PMLU provides the habitat opportunity for Norther Quoll in particular, for the areas will be rocky, have high relief and shallow soils, and close to permanent water.

Threatened and migratory bird species

The semi-evergreen vine thicket and dry rainforest vegetation communities surround the Meandu Mine area provide know habitat for a number of threatened and migratory birds including the Black-breasted Button-quail (*Turnix melanogaster*) (Rufous Fantail (*Rhipidura rufifrons*) and Black-faced Monarch (*Monarcha melanopsis*)) and potential habitat for threatened and migratory birds including the Spectacled Monarch (*Monarcha trivigatus*), Oriental Cuckoo (*Cuculus optatus*) and Coxen's Fig-parrot, which all occur in rainforest habitats including subtropical rainforest, dry rainforest, littoral and developing littoral rainforest, and vine forest. Habitat for these threatened and migratory bird species, particularly the inclusion of subtropical rainforest and littoral rainforest species can be incorporated into the Native Ecosystem and Creek Diversion PMLUs.

Species of microchiropteran bat

Eighteen species of microchiropteran bat were recorded during recent fauna surveys of the K2E ASA and surrounds. Whilst no threatened species were detected, potential habitat for species such as the Southern Long-eared Bat (*Nyctophilus corbeni*) is present within the area. The presence of hollows, fissures and cracks within the Steep Rocky Ecosystem PMLU and its proximity to permanent water could provide potential habitat for a number of species of microbat.

6.1.8.4 Analogue sites for monitoring

Native Ecosystem PMLU

In 2012, the Queensland Herbarium commenced a project funded by the Australian coal industry's research program (ACARP) to develop a local benchmark for Meandu Mine rehabilitation based on an amalgam of three locally dominant regional ecosystems being:

- RE 12.9-10.7 *Eucalyptus crebra* +/- *E. tereticornis, Corymbia tessellaris*, *Angophora* spp., *E. melanophloia* woodland on sedimentary rocks
- RE 12.9-10.18: *Angophora leiocarpa*, *Eucalyptus crebra* woodland on sedimentary rocks; and
- RE 12.11.7: *Eucalyptus crebra* woodland on metamorphics +/- interbedded volcanics.

A single BioCondition Benchmark was developed for a self-sustaining Eucalypt woodland to open forest from 26 CORVEG sites (Neldner et al. 2012).

This benchmark has been used to assess the rehabilitation onsite using an adapted BioCondition methodology and is the basis for the rehabilitation milestone criteria in this PRC Plan.

Steep Rocky Ecosystem PMLU

Analogous landscapes within the footprint of the mine site will be identified and monitored to provide appropriate information to develop growth trends and compare the response to environmental stresses. Analogous sites will be selected from the existing Steep Rocky Ecosystem areas within the K2W-N and SW pit area. Characteristics which will be established will include but not be limited to:

- vegetation cover mosaics
- plant assemblages and ecosystem structure
- vertebrate and invertebrate fauna habitat; and
- abiotic assemblages.

These will constitute the rehabilitation trials for the Steep Rocky Ecosystem PMLU (refer Section 7.5).

6.1.8.5 Revegetation general approach

Site preparation

Native Ecosystem PMLU

Rehabilitation site preparation practices at Meandu Mine for the Native Ecosystem (terrestrial) PMLU are based on the following steps to revegetate mined lands:

- dumping the bulk landform to the overall target LOM profile
- dozer profiling of the bulk landform to achieve final profile and contour systems
- drain establishment (where required)
- erosion control works; and
- topsoil and ameliorants/topsoil placement.

Beef Cattle Grazing PMLU

For the rehabilitation of Beef Cattle Grazing PMLU at Meandu Mine, the overall site preparation practice will be similar to that used for the Native Ecosystem PMLU and is based on a similar six stages with additional specifications:

- dumping the bulk landform to the overall target LOM profile
- dozer profiling of the bulk landform to achieve final profile and contour systems
- drain establishment (where required) and with fencing to exclude/protect cattle from rock armoured drains/ steep banks
- erosion control works; and
- topsoil and ameliorants/topsoil placement.

Creek Diversion PMLU

Site preparation works for the Creek Diversion PMLU areas is consistent with the methodology utilised for rehabilitation of the upstream (south) diversion, including topsoil placement, surface contouring and ripping. Surface ripping is undertaken perpendicular to the expected flow of water, to minimise erosion and maximise water retention. The spacing between rip lines was determined by the slope of the land, which acts to reduce soil erosion and increase plant establishment rates. It is planned that the two downstream (central and north) diversions will undergo similar treatment where required.

Water Storage PMLU (littoral zone in final voids)

For the final void littoral zone which is located on the lowwall side of the void, the site preparation will include:

- reshape the slope into the void consistent with the adjacent PMLU
- topsoil the zone down to the lower reduced level (RL) of the modelled void water level fluctuation or the actual rebounded water level; and
- contour rip.

Steep Rocky Ecosystem PMLU

Site preparation in association with the Steep Rocky Ecosystem PMLU rehabilitation has been detailed further in Appendix L – Meandu Mine PRC Plan Revegetation Plan due to the complexity in nature. In general, it is proposed to undertake rehabilitation work on each final bench prior to excavating the next bench. Micro-topographical features on benches will be designed and constructed to regulate overland flow and assist water/sediment retention, that will include:

- sloping the benches to the toe of batters if stability is not compromised (in fresh Triassic material)
- constructing a series of shallow depressions along the bench to allow sediment accumulation and water retention; and
- allowing overflow from depressions to either sheet flow over the bench crest or flow along the bench to a suitably nominated discharge point.

Batters may be raked during excavation and/or benches ripped to leave a rough surface perpendicular to slope, subject to suitability of the material.

Seed preparation and seeding

Native Ecosystem PMLU

For the rehabilitation of Native Ecosystem PMLU, the current seed rate is 13 kg/ha which comprise 3 kg of the cover crop, 5 kg of native and non-native grass seed and 5 kg of mostly trees and shrubs. For the rehabilitation of Creek Diversion PMLU and the littoral zone of final void areas, depending on sections/land adjacent to low or high flow regimes, the current seed rate ranges from 9 kg/ha (low flow channel) and 15.9 kg/ha (high flow) (refer to Appendix L – Meandu Mine PRC Plan Revegetation Plan). Ripping and seeding will be undertaken prior to the wet season (target – end of September), but with a limit of no later than 10th December.

Beef Cattle Grazing PMLU

For the rehabilitation of Beef Cattle Grazing PMLU, seed bed preparation is an important aspect of establishing pasture grass species. Correct seedbed preparation includes:

- preparation of a firm seed bed for small pasture grass species
- provision of shade through practices such as cover crop establishment, to prevent desiccation of young seedlings of the pasture grass species
- avoiding ripping of soils that are hard setting or crust after rain (e.g. Inland Burnett forest soils (DAF, 2022)). Soils will require testing to determine the likelihood of forming crusts and setting hard after rain
- timing of preparation to avoid the risk of erosion from heavy rainfall events and to minimise weed colonisation. Ripping and seeding will be undertaken prior to the wet season (target – end of September), but with a limit of no later than 10 December.

It is important that seeding is undertaken as soon as practicable following topsoil spreading to improve seed germination. Works undertaken more than 2 days after topsoil placement often experience poor and patchy strike compared to areas where seed is sown directly after spreading due to increased soil moisture. Crusting occurring after the seed is laid tend to encapsulate the seed and therefore retain it and often enough to allow for intimate soil/seed contact.

Various options are available for seeding. A common problem with seeding is fluffy seeded grass species, which are seed with appendages (e.g. awns) that are hard to spread with some types of seeding machinery. Fluffy seed can be mixed with fertiliser, cracked grain or sieved sawdust to act as a carrier to improve the spreadability of the seed. Alternatively coated seed can be used that has a smooth surface.

Seed will be placed on the surface and lightly covered with soil. To achieve the best strike with most pasture grasses and legumes seed will not be buried more than 10 mm.

Seeding of target species (a combination of annuals and perennials) at a target rate of 3 kg/ha grass excluding the cover crop (this equates to a minimum of 1 kg of pure live seed[1] (pls) per hectare) and 3 kg/ha of legumes per hectare is recommended. Target species to include a high percentage of 3P grasses (palatable, productive and perennial), desirable forbs (e.g., native legumes such as Glycine) and a variety of other palatable species. While not being the main focus of the proposed Beef Cattle Grazing monitoring trial, seed rates and species will be confirmed and optimised at that time (refer Section 7.5).

Steep Rocky Ecosystem PMLU

For the rehabilitation of Steep Rocky Ecosystem PMLU, natural revegetation which utilises seed dispersal from adjacent vegetation will be the primary seeding approach, particularly on substrates derived from basaltic or conglomerate materials. Supplementation at the time of bench or slope development may also be considered. Planting or manual seeding drought (or stress)-tolerant species adapted to shallow soils on rocky substrates, if required to facilitate and enhance the rate of natural ecosystem development, may be adopted depending on the results of the proposed trial (refer Section 7.5).

Growth media and topsoil requirement

Topsoil is sourced from existing topsoil stockpiles at Meandu Mine or, where possible, directly placed from areas on the mining path being stripped at the time. The topsoil stockpiles vary in their physical and chemical properties reflecting natural variation in the original soil types (Vertosols, Sodosols, Dermosols and Ferrosols.) across the pre-mining landforms. Soil used for rehabilitation is stripped prior to mining to a depth of approximately 200 mm. The stripped soil is stored in various locations around the Meandu Mine site, with information kept in the Meandu Mine site's Topsoil Stockpile Register. Stockpile sizes vary from 1,500 m^3 to about 500,000 m^3 (average 40,000 m^3) with an average height of 6 m. Total volume is 3,020,000 m^3 which has been calculated to be sufficient to cover approximately 1,500 ha with 200 mm topsoil depth. This is currently sufficient to meet the projected requirements of the Meandu Mine site (Appendix L – Meandu Mine PRC Plan Revegetation Plan).

[1] Pure live seed per hectare (excluding seed coating weight) = $germination\ \% \times purity\ \% \div 100$

Native Ecosystem PMLU, Beef Cattle Grazing PMLU and Water Storage PMLU (Littoral Zone)

Topsoil that has been characterised as suitable for the Native Ecosystem PMLU is spread to a depth of approximately 200 mm after landform preparation, but as close as possible to ripping/seeding operations to minimise the erosion risk. The littoral zones on the lowwall side of the final voids will be spread with topsoil in a similar manner, down to the lower RL of the modelled void water level fluctuation or the actual rebounded water level.

The topsoil stockpiles at Meandu Mine site vary in their physical and chemical properties reflecting natural variation in the original soil types, however Ferrosols are preferred (but other soils can be utilised if assessed as suitable) for the Beef Cattle Grazing PMLU. Prior to placement the topsoil stockpiles will be characterised to ensure they meet the threshold values for Land Suitability Classes 1 and 2. Topsoil, same as the Native Ecosystem PMLU is spread to a minimum depth of approximately 200 mm after landform preparation. It is important to note that some of the topsoil salvaged from the K2E ASA may contain a vine thicket soil seedbank of pioneer species. Stockpiles will be monitored to determine if this is likely to result in pasture degradation from woody species establishment (refer Appendix L – Meandu Mine PRC Plan Revegetation Plan).

Topsoil placement involves:

- preparing the landform in accordance with the PRC Plan requirements for the final landform with respect to the Native Ecosystem and Beef Cattle Grazing PMLUs
- ensuring the surface is suitable for topsoil application (e.g. minimal rill/gully erosion)
- nominating the topsoil stockpile(s) to be utilised for the area or source location if to be directly placed from stripped areas in accordance with the topsoil requirements for the PMLU
- calculating the estimated quantity of suitable topsoil required for the area
- ensuring the equipment operators have been briefed on the topsoiling plan/requirements for the area
- scheduling topsoil placement to avoid heavy rain forecast
- applying the topsoil evenly at the nominated thickness of 200 mm
- for Native Ecosystem PMLU rehabilitation, if applicable, ensuring that areas where contour banks have been constructed are topsoiled, but excluding the bank inverts
- for Beef Cattle Grazing PMLU rehabilitation, if applicable, constructing contour banks where required to convey water to their intended discharge point at no greater than 2% to maintain velocities at levels that will minimise erosion. Banks constructed in sodic soils should have gypsum or lime applied at recommended rates to minimise potential tunnel erosion. Contour banks and drain invert should be topsoiled and managed to promote rapid establishment of perennial vegetation to minimise erosion. Banks should be inspected after significant rain events and ponding water or erosion issues repaired to ensure the long-term success of the drainage feature
- re-surveying topsoil stockpiles after topsoil extraction and deducting this quantity from the topsoil register
- in particular to the Beef Cattle Grazing PMLU rehabilitation, locating topsoil stockpiles away from weed species, where possible monitoring for weed establishment and spraying to control weeds, if required.

Steep Rocky Ecosystem PMLU

For the rehabilitation of Steep Rocky Ecosystem, selective placement of growth media is not expected to be required based on monitoring to date. Dead logs or mounds of soils/weathered materials may be incorporated into revegetated sites to promote return of fauna (ants, lizards). Small depressions will be created where possible and suitable, to promote water retention to allow establishment of ephemeral habitats that will attract fauna. More information and guidance will be available as a result of the proposed Steep Rocky Ecosystem trial (refer Section 7.5 and Appendix L – Meandu Mine PRC Plan Revegetation Plan).

Creek Diversion PMLU

Topsoil or growth media placement is unlikely required for the rehabilitation for creek diversions though the upper banks of creek diversion areas may be spread with additional topsoil if required, to assist water retention and vegetation growth.

Fertilisers and soil ameliorants

Some soils and mine spoils may have physical and chemical characteristics that will otherwise limit plant establishment and have a high potential for erosion. Where soil suitability is classified as poor, analysis of the soil stockpiles is undertaken to determine the requirements for fertiliser and other ameliorants (refer Appendix L – Meandu Mine PRC Plan Revegetation Plan).

Currently, for poor quality soils, fertiliser is applied at the same time as ripping and seeding, at a rate of 100–150 kg/ha. Since 2017, the fertiliser used is a 60/40 blend of Impact 56 (N-13.5%:P-15.2%:K-12.5%: S-1.1%) and Ozcal (fine granular lime).

To stabilise dispersive sodic subsoils agricultural gypsum is applied at a rate of 5 t/ha/100 mm layer. The gypsum improves the soil structure reducing the dispersiveness and increases the water holding capacity.

Weed management

For the Native Ecosystem, Creek Diversion and Water Storage (littoral zone) PMLUs, weed monitoring is undertaken regularly by mine personnel and periodically by external consultants for selected sites as a component of the annual rehabilitation monitoring program.

For the rehabilitation of Beef Cattle Grazing PMLU areas, depending on the previous vegetation cover of the salvaged topsoil, the existing soil seed bank may result in the regeneration of woody pioneer species, including Acacia species and or a range of weed species where soils are salvaged from previously disturbed sites. A weed management strategy will be developed reflecting the pre-existing vegetation cover type and on-site weeds within the vicinity of the topsoil stockpiles.

For herbaceous weeds in newly sown pastures herbicide-based weed control will be used. A suitable weed management program may involve spraying at about 3–6 weeks after sowing, prior to the first slashing. At this time weeds are still small and there should be approximately 70% or more ground cover.

Herbicide will be used that does not damage the newly established grasses and clover while providing effective weed control.

If required, weed management strategies specific to Steep Rocky Ecosystem PMLU rehabilitation will be developed as a result of the proposed trial (refer Section 7.5).

6.2 Tailings storage facilities

PRC Plan Guideline (Section 3.6.2)

The tailings require characterisation to determine the geochemistry, rheology and geotechnical parameters that influence the rehabilitation or management strategies and the capacity of the site to support revegetation.

The design for a TSF must include relevant elements:

a lining of TSF (i.e. embankments and base of structure)
b leak detection systems
c cellular design of TSF
d seepage collection systems
e design storage allowance
f spillway location
g designing TSF for progressive rehabilitation.

6.2.1 Meandu Mine tailing storage facilities

Current and historic Tailing Storage Facilities (TSFs) at the Meandu Mine comprise:

- NWA Tailings Storage Facility (TSF)
- NWB TSF
- Ramp 3 TSF
- K2 TSF
- RD16 TSF (Converted RD); and
- K2W TSF.

Meandu Mine also receives coal combustion products from the Tarong power stations which are currently co-disposed with contingency tailings in the K2W-N void. After closure of the K2W-N ASF/TSF the future coal combustion products will be co-disposed with contingency tailings in the K4S ASF/TSF. The location of the TSFs is shown on Figure 2.21.

Rehabilitation of the coal combustion products storage facilities is also considered within this section of the PRC Plan.

The majority of the following section is extracted from the Waste Management Plan (refer Appendix E), which for the purposes of the PRC Plan is considered a LOD.

6.2.2 Overview of process

The CHPP process generates waste streams composed of residual coal and mineral matter that are classified according to size fraction as tailings (fine to ultra-fine) or coarse (coarse rejects).

Under the current CHPP process, fine to ultra-fine, high ash slimes are bled out of the process water circuits and gravitate to the tailings thickener via the thickener feed launder. These tailings are thickened and treated with calcium hydroxide ($Ca(OH)_2$) to attain a broadly neutral pH in the CHPP thickener and pumped in slurry form to solid bowl centrifuges (SBCs). The SBCs are designed to dewater coal tailings to a moisture content that allows them to be loaded with coarse rejects by excavator into trucks for disposal. The co-loaded coarse

rejects and dewatered tailings (mixed plant rejects – MPR) can then be hauled by truck to dedicated reject cell dump areas or co-disposed in the spoil tiphead within the advancing lowwall spoil within the Meandu mining operation. The water that is recovered from the SBCs is recycled back through the CHPP system, or otherwise pumped to site storages for re-use, minimising raw water use at site.

Wet tailings disposal will continue to occur when the SBCs are off-line or not able to process 100% of the tailings stream. These tailings are pumped as slurry to a dedicated tailings storage facility (TSF), which is currently located within the King 2 West (K2W) pit void, a subsection of the K2W-N ASF. Tailings supernatant is pumped from K2W to the Tarong power stations or to surface water storages at the mine for re-use.

6.2.2.1 Tailings

Historically, the tailings generated by the CHPP were pumped as a thickened slurry of approximately 10–20% solid content to dedicated TSFs, initially in a valley fill TSF (K2 TSF) and then to in-pit TSFs when suitable locations became available in exhausted pits and ramps to disused pits.

The high water content of the tailings results in logistical problems with regards to ongoing operation and closure of the TSF as the tailings require significant area and time to dewater to an extent that allows for capping and rehabilitation. Due to their plastic nature and low load bearing capacity, saturated tailings present a less stable working surface for installation of initial capping and subsequent bulk waste placement to final landform by mining machinery, introducing complexity into their management during decommissioning (refer Section 6.2.3.1).

In December 2017, solid bowl centrifuges (SBC) systems were installed and commissioned at the Meandu Mine CHPP to undertake drying and thickening of the fine tailings stream to the extent that they would be able to be co-disposed with the coarse rejects as described in Section 6.2.2. Contingency tailings disposal will still be required during periods when the SBCs are under maintenance, or the tailings volume exceeds the operational capacity of the SBCs; however this is predicted to occur for less than 10% of normal operational time.

Tailings at Meandu Mine were initially deposited into K2 TSF, a specifically designed and constructed valley-fill structure built at the headwaters of Black Creek. Once mining ceased in the NWA pit, the opportunity to minimise residual void space at the mine was realised by using the NWA pit and Ramp 3 as TSFs. Ramp 3 was used intermittently between 1992 and 1996 during the transition of tailings deposition from K2 TSF to NWA TSF. Tailings were deposited sub-aqueously to minimise oxidation of entrained sulphides (notably pyrite) and settled to form a clayey silt of very soft consistency.

Historical rehabilitation of the NWA TSF consisted of initial backfilling the north-west arm of the void with a 5 m thick capping layer of rejects and by completing a high-face spoil dump around the southern margin in an arc joining the rejects dump on the west of the void to the excavated rock slope on the east of the void. The 5 m thick layer of rejects was advanced into the void to the south-east, with overburden/interburden spoil from the NWB, Central and West pits placed over the top of the rejects to a level that matched the surrounding spoil dumps. The depth of spoil over the rejects is approximately 40 m thick. The spoil dump in the southern arm was progressively advanced to the north towards the centre of the void. Due to the saturated nature of the tailings and overloading from the spoil, the tailings were displaced vertically by approximately 50 m vertically over the 3 years that back-filling occurred. A small volume of residual tailings was spread over the spoil to dry out before the final landform was constructed over the void. Limited information is available for Ramp 3 TSF; however, it is likely to have been rehabilitated in a similar manner to NWA TSF. On landform construction and rehabilitation of this area in 2015–2017, investigations confirmed that no tailings were within 6 m of the final landform surface.

6.2.2.2 Mixed plant rejects

Prior to 2017, the coarse rejects were stockpiled at the CHPP before haulage to dedicated coarse rejects dumps in the Rejects Storage Area (RSA) located in the North-West dump. Smaller volumes were deposited in Hitachi Hill, Ramp 5 dump, West dump, Western Haul Road dump and Central dump.

Installation of the SBCs has improved the handleability of the fine to ultra-fine tailings, allowing the majority of the CHPP waste stream to be co-loaded as mixed plant rejects (MPR) and transported by truck for disposal in rejects cells within the progressing lowwall spoil dumps. The MPR generated by this approach require less volume for storage on placement, minimising the potential for seepage and enabling a more flexible waste storage design.

As the MPR have been identified as PAF by geochemical testing (Section 6.1.3), a specific management procedure has been developed for the placement of MPR into mining voids at Meandu mine to minimise the risk of oxidation of the MPR and potential resultant AMD generation. The management and disposal procedure is summarised below.

Mine planning ensures sufficient dump space is allocated which meets recommended MPR disposal guidelines. This includes:

- the final mine rehabilitation profile to ensure MPR are not emplaced within 6 m of the final rehabilitation profile
- MPR are not dumped on the pit floor following coal recovery or below a minimum rejects relative level based on the final pit void profile and further that they are not emplaced in a wetting/drying zone
- MPR are placed within the pit footprint (i.e., avoid ex-pit/out of pit dumps) and encapsulated within in-pit dumps to prevent material being transported/washed into the pit void
- geotechnical and slope stability considerations of the dump to determine whether it is a suitable location for MPR emplacement. During the design phase this may also include reviewing the surrounding dumps, the type of waste material, haul roads and drainage points.

Mine planning engineers liaise with production personnel daily to assess progress and implementation of both waste dump designs and emplacement areas. Where MPR are to be placed near the final face of a dump, overflow bunds shall be constructed to ensure material does not spill within 6 m of the final rehabilitation surface. At least 5 m of suitable overburden capping material is to be placed over the top of the MPR placement area and 6 m where the placement area is within 6 m of the final landform.

Current Meandu Mine management procedures of limiting storage/exposure time of coarse reject materials at the reject stockpile prior to mixing to less than two weeks appears to be an effective way of controlling the risk of MPR oxidation and resultant acid generation. Cover requirements for the MPR are described in Section 6.1.6.5.

Classification of MPR prior to emplacement

Prior to transport relevant personnel visually assess moisture content of the MPR material being produced by the CHPP and at proposed tip head/dump location. Material is then classified as:

- Low Moisture (dry to moist) – material that is mostly coarse reject rock material and is able to be easily trucked to the dump and will retain integrity in dump/tip head and is suitable for co-disposal
- Moderate to High Moisture (“wet”) – material contains significant wet fines with some coarse rejects and is able to be contained by cells and trucked to MPR dump with minimal spillage; or

- Very High Moisture (“very wet”/“sloppy”) – material mainly consists of wet fines and is difficult to transport due to high moisture. Material not able to be contained by cells and flows out over flat dump areas.

Placement methods of these three materials is outlined below.

Emplacement of material by “co-disposing” (low moisture)

When MPR material is suitable for “co-disposal”, the dump is set up with maximum 10 m high tip heads. The material is dumped as a mixture of 1 MPR load to 3 overburden loads (ideally blasted, blocky rock). The mixture of 1 load of MPR to 3 loads of overburden is a minimum, more overburden loads are better. MPR should be distributed along the whole tip head and not concentrated in one spot (see preferred dump plan in Figure 6.16). The dump should advance over previous paddock dump material or dry/flat benches.

No MPR/rejects are to be placed on outside/exposed sides of dumps. The best results for co-disposal have previously been obtained from MPR material being placed on tip heads up to 10 m high on blocky, paddock dumped material with a greater than 1 to 5 ratio of MPR to overburden. This enables the MPR to drain and it is less likely for MPR to create a slip surface at the toe of the tip head dump.

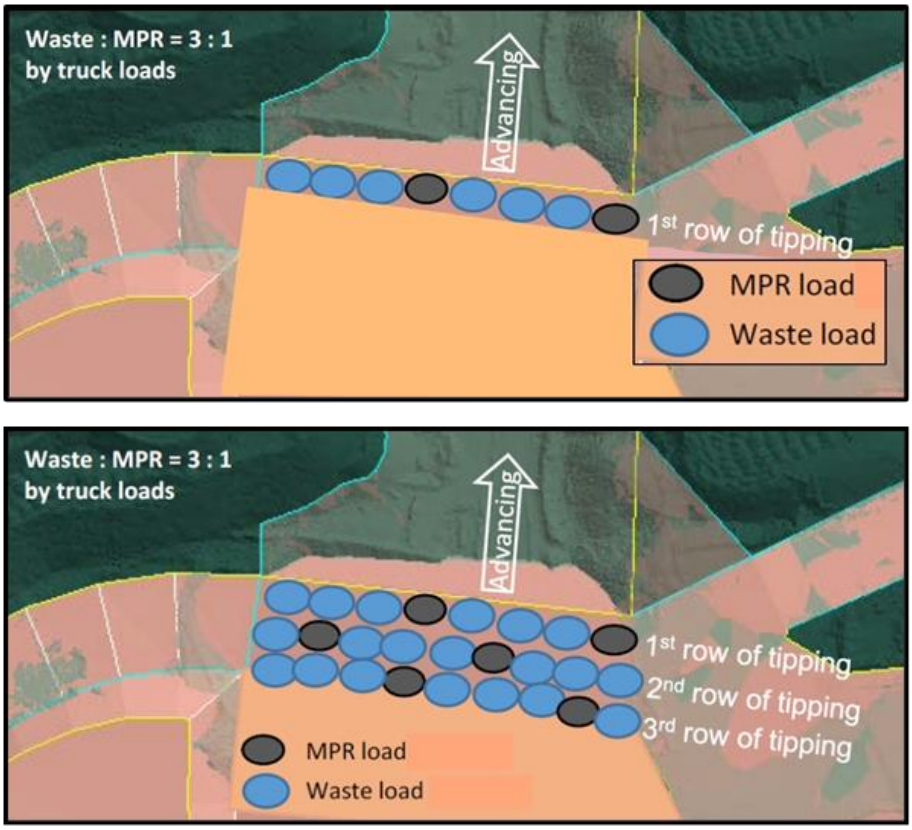


Figure 6.16 MPR Co-disposal dump pattern for minimum 3:1 ratio of waste to MPR

Emplacement of material in cells ("wet material")

MPR is placed in cells in the following configurations (See Figure 6.17 to Figure 6.20).

Alternatively, the MPR can be dumped out as paddock dump lifts with alternating paddock dump rows of overburden waste between the MPR material.

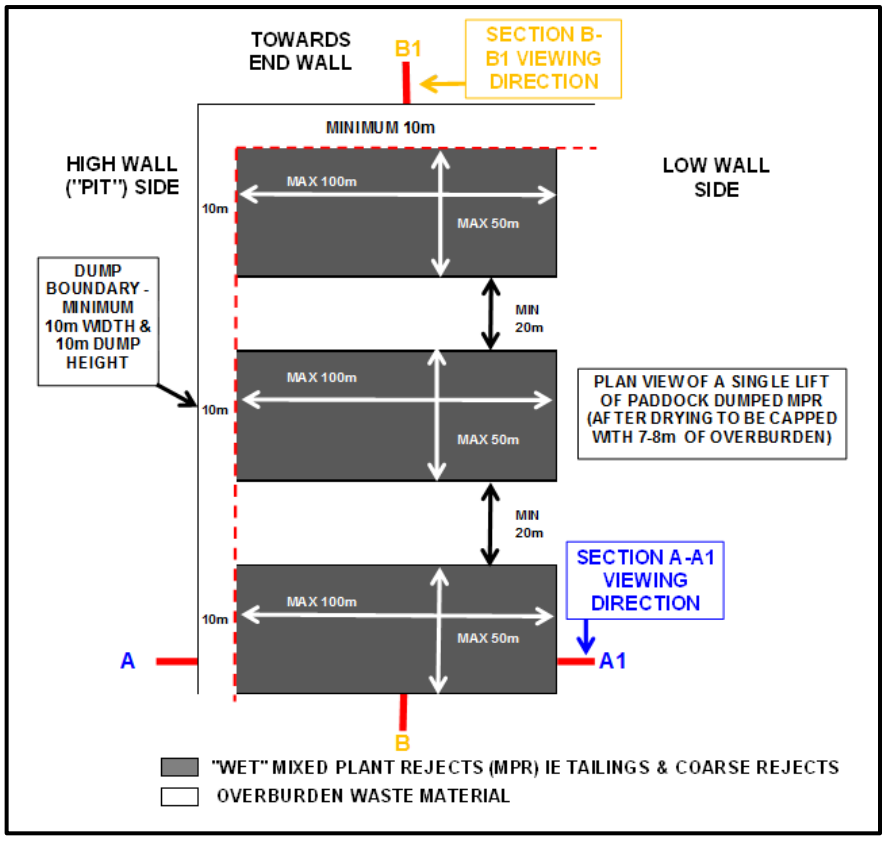


Figure 6.17 "Wet" MPR cell dump layout

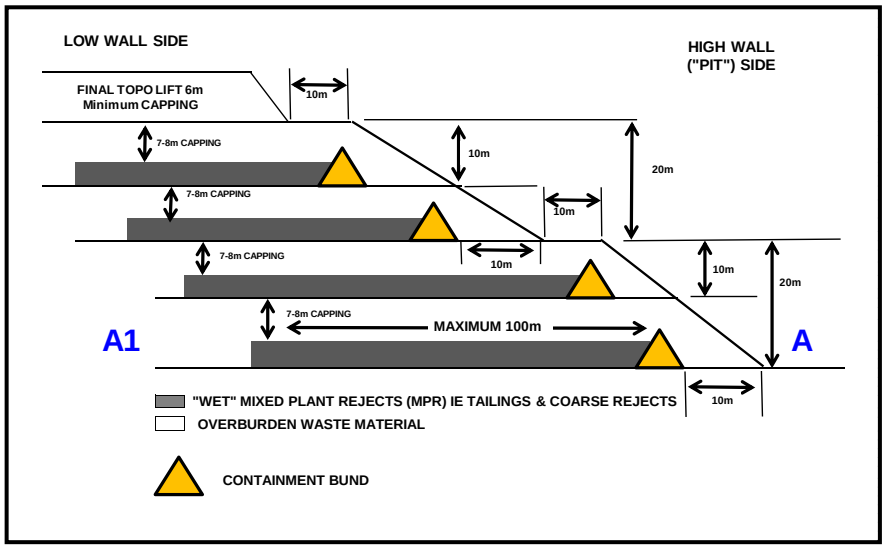


Figure 6.18 Cross section A – A1 of emplacement cell dump for "Wet" MPR.

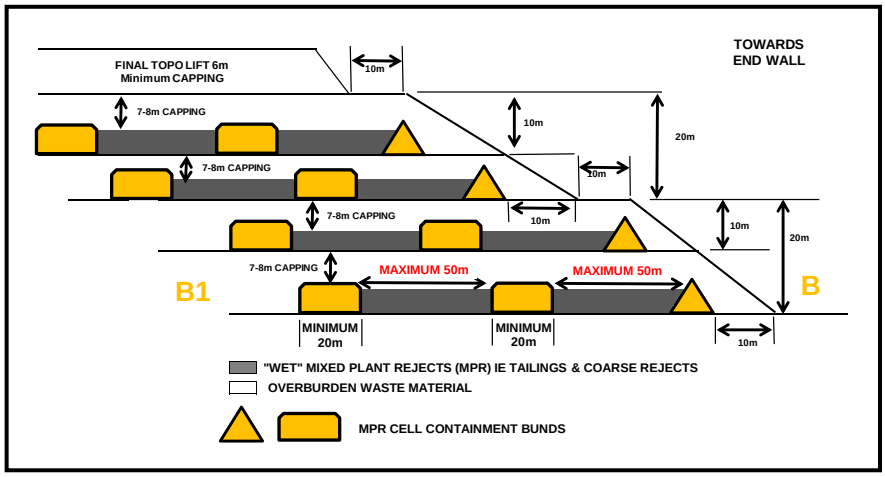


Figure 6.19 Cross section B – B1 of emplacement cell dump for “Wet” MPR



Figure 6.20 Example of MPR emplacement in cells at Central pit ~442RL looking south-west from northern end wall

Emplacement of material by "mud-slide" (high moisture – "sloppy")

When MPR material is assessed as unsuitable for "co-disposal" or cell emplacement due to the very wet nature of the material, a "mud slide" may need to be set-up (see Figure 6.21). The mud slide is to be contained within the in-pit spoil dump and not situated within 6 m of the final landform.



Figure 6.21 "Mud-slide" on ~447RL bench in Central pit

After emplacement of the MPR, no specific decommissioning or rehabilitation procedures are required and the MPR emplacements will be rehabilitated as per the cover design requirements detailed in Section 6.1.6.

6.2.2.3 Coal combustion products

Prior to 2009 all coal combustion products generated by the Tarong power stations were deposited outside of ML6674 into the Tarong Ash Dam within the Power Station Industrial Complex. The purchase of Meandu Mine by Stanwell in 2008 allowed the possibility of deposition of coal combustion products into exhausted mine voids rather than into the ash dam. Approval for coal combustion storage at Meandu Mine was originally granted under a Specific Use Beneficial Use Agreement (BUA) in 2009, with coal combustion product deposition into K2W pit commencing in November 2009. This Specific Use BUA had a positive environmental impact for both the mine and the power station as it provided additional back-fill material to minimise the residual void volume at Meandu Mine, whilst removing the need for an extension to the existing Tarong Ash Dam. The Tarong Ash Dam has consequently only been utilised for contingency coal combustion products deposition since 2009.

The commissioning of an ash thickening plant at Tarong Power Station in 2010 had the result that all ash pumped to Meandu Mine for deposition into K2W was a dense phase slurry (an ash thickening plant has been operating at Tarong North Power Station since the power station opened in 2002). The main advantage of dense phase coal combustion product disposal is that a more stable final landform is created that is more readily decommissioned and rehabilitated than a lean-phase deposited coal combustion product. Deposition of coal combustion products into the mine void also facilitates the harvesting of cenospheres from the ash surface for beneficial reuse.

Coal combustion products from the Tarong power stations are currently deposited as a dense phase slurry (~40% solids) in two joined mining voids at Meandu Mine – K2W and K2N (known collectively as K2W-N). Due to settling of this slurry in the K2W-N void after transportation from the power stations, a large body of water is formed on the surface of the void. This supernatant water is reclaimed from the K2W-N ASF and is currently pumped in a closed-loop system back to Tarong Ash Dam for recovery and re-use, in accordance with site procedures for Meandu mine and the Tarong power stations.

As discussed above, contingency tailings disposal into the K2W-N void occurs during periods when the SBCs are down. Modelling supporting the LOM Plan indicates that the contingency tailings will add 1–3% to the volume of ash stored in the void. Ash placement in the K2W-N void will continue until this storage facility reaches capacity (currently 518 mRL (crest level 520 mRL)). This is anticipated to be in approximately 2029 (depending on power station generation rates).

Following completion of ash and contingency tailing storage in K2W-N, ongoing ash and tailings will be pumped to K4S, which is scheduled for completion of mining in 2029. Appropriate design and consequence category assessments of K4S pit will be undertaken prior to commissioning. The manner in which ash transfer will occur is planned to remain as a pumped dense phase slurry via pipeline.

6.2.3 Material characterisation

6.2.3.1 Tailings

Tailings are finely ground wastes generated by the washing and flocculation processes at the CHPP. Tailings are also referred to as ultra-fine and fine rejects due to their particle size (<0.5 mm). The tailings comprise sandstone, siltstone, mudstone and inferior quality coal fines, and were historically pumped as a slurry to the TSFs.

Geochemically, the tailings at Meandu Mine are considered to be PAF; however, a combination of the addition of $Ca(OH)_2$ at the CHPP and the fine grain and low permeability of the tailings creates a significant lag time (>24 months) before the onset of acid production. The supernatant water quality from the TSFs support the conclusion that the tailings are unlikely to generate acid provided they remain saturated and/or oxygen ingress is limited (Appendix K – Meandu Mine PRC Plan Waste Characterisation Report (WSP, 2021b).

Geotechnically, the following attributes have been determined for the tailings at Meandu Mine (Sherwood Geotechnical and Research Services, 2020 and other mine monitoring data records):

Particle size distribution (PSD): Distributions indicate bimodal size distributions that vary with time depending on the source of coal mined, with northern and shallow coals having a greater fines loading than lower seams and southern coals. Results from 2021 are shown in Figure 6.22.

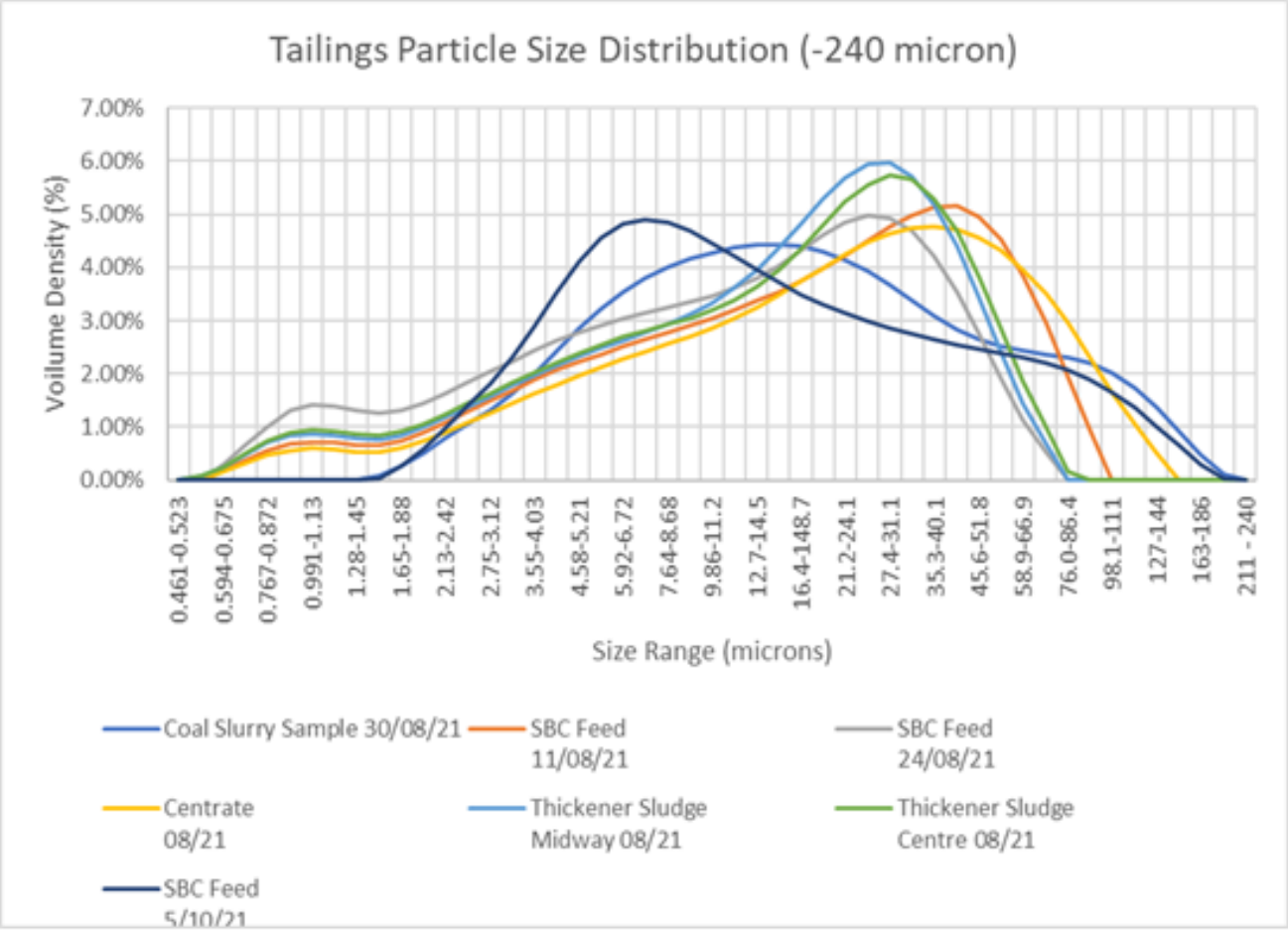


Figure 6.22 Meandu Mine Tailings PDS 2021 results

Cumulatively, 100% of coal fines have size -150 micron.

Specific Gravity (relative density): The range of density of tailings ranges from 1.50 to 1.89 t/m^3, which is typical of coal tailings in Queensland (Stanwell, 2022).

Atterberg limits: Atterberg limit testing conducted on two tailings samples returned liquid limits of 46–48% and plasticity indexes of 20–24. The tailings liquid limits are relatively high but similar to Rangal Coal Measure tailings, whereas the plasticity limits are categorised as highly plastic.

Moisture content and dry density profiles: Instrumented large column testing returned a gravimetric moisture content of 83.99%. The column achieved:

- average dry density of 0.551 t/m3 and void ratio of 2.54 after 5 months
- average dry density of 0.651 t/m3 and void ratio of 1.99 after 24 months; and
- average dry density of 0.677 t/m3 and void ratio of 1.86 after 33 months.

Settling testing: Testing of the instrumented column found that consolidation with settlement occurred predominantly after major rainfall events where dry coal tailings formed during desiccation collapse:

- settlements that occurred during the wet-dry periods were 17.7, 20.1, 144.2, 45.1 and 63.8 mm; and
- further settlement is expected to occur as during the last wet season of testing another 29.1 mm of settlement was measured (wet/dry cycle incomplete).

One slurry consolidometer test has been carried out on Meandu Mine tailings and the coefficient of consolidation is within the typical range of Queensland coal tailings, but the compression index was higher than typical; however, laboratory consolidation testing is very sensitive to sample preparation and results should only be used for indicative estimates of actual field performance.

Desiccation: The maximum unsaturated depths achieved during the wet-dry periods in the instrumented column were found to increase over time (150, 500, 700, 850 and 500 mm), that is expected to be due to better consolidation after weathering leading to shrinkage of pore size which in turn results in a stronger capillary force to uptake tailings water from deeper depth.

Additional in-situ testing of each TSF will be undertaken after tailings deposition has ceased and the tailings surface has crusted enough to support the test equipment; meanwhile assumed values were used for preliminary design as described in Section 6.2.4.1.

Shear strength: Tailings have minimal shear strength when initially discharged (being fluid) and strength is only gained over time as the deposit dewaters, consolidates and develops a drier surface crust, although the strength profile is affected by deposition practices and time. Meandu Mine tests returned shear strengths of ~25 kiloPascals (kPa) at 0–2 m depth and ~15 kPa at depths >2 m for the NWB TSF.

Permeability: Coefficients of permeability (k) for Meandu Mine tailings have been measured in three laboratory tests with results as follows:

- range k = $7e^{-10}$ m/s to $2e^{-7}$ m/s; and
- median k = $6e^{-9}$ m/s.

Coefficients of permeability for Meandu Mine tailings interpreted from cone penetration / dissipation testing program for NWB tailings storage were as follows:

- depth 10 m: k =$7e^{-9}$ m/s; and
- depth 20 m: k = $2e^{-9}$ m/s.

which are typical of intermediate plasticity clay or silt.

6.2.3.2 Mixed plant rejects

Geotechnical testing on the CHPP waste streams at Meandu Mine has focussed on the tailings slurry rather than the MPR as the solid nature of most MPR gives it geotechnical properties similar to the spoil in which it is emplaced. Available geotechnical information is discussed below.

The specific gravity (relative density) of dewatered tailings (SBC cake) from the SBC has been measured at 1.73–1.74 grams per cubic centimetre (g/cc), with a moisture content of approximately 25%.

Shear strength parameters for the MPR classifications (Sherwood Geotechnical and Research Services, 2020) are outlined in Table 6.19.

Table 6.19 Shear strength parameters for MPR classifications

Parameter	γ(kNm^{-3})	c' (kPa)	ϕ' (deg)
MPR Very high moisture (at placement)	18	liquid	0
MPR Moderate – High Moisture (at placement)	18	Sμ = 5	0
MPR Low moisture (at placement)	18	5	32
MPR Very high and Moderate – High Moisture (long-term)	20	10	28
MPR Low Moisture (long-term)	20	10	34

γ = weight; c' = effective cohesion; ϕ = effective friction angle

Permeability of the moderate – high and very high moisture MPR is 1e^{-7} m/s whereas the low moisture MPR have a slightly higher permeability of 1e^{-5} m/s.

6.2.3.3 Coal combustion products

Coal combustion products comprise the bottom or furnace ash remnant after burning the coal and air pollution control residues, which are the fine ashes precipitated from the flue gases and captured in the stack precipitators. The coal combustion products are transported from the power stations to the ash thickening plant as a wet slurry of 5–10% solid. The ash thickening plant dewaters the ash to approximately 40–55% solid, creating a dense phase slurry that is pumped to Meandu Mine for in-pit disposal (Stanwell 2020b). The coal combustion products mostly comprise fine ash with some fine gravel-sized sinter and coal fragments, plus cenospheres (small hollow silica balls), which float on the surface of water and can be periodically harvested and sold for beneficial reuse.

Geochemically, the coal combustion products are classified as NAF and will not generate acid through sulphide oxidation (Appendix K – Meandu Mine PRC Plan Waste Characterisation Report (WSP, 2021b). The actual acidity of the coal combustion products is neutralised during processing at the Tarong power stations through the addition of $Ca(OH)_2$. The coal combustion products appear to have the potential to generate a slightly saline "first flush" with elevated metals; however, the potential for ongoing SMD is considered low.

Geotechnically, the coal combustion products have the following attributes:

- *Shear strength: Effective cohesion of 0 kPa and effective friction angle of 25 degrees.*
- *Permeability: The coefficient of permeability for the sedimented coal combustion products (one sample) was measured as k = 1e^{-7}.*

6.2.4 Decommissioning and rehabilitation

6.2.4.1 Tailings storage facilities

Decommissioning and rehabilitation of NWB TSF and RD16 TSF (historical TSFs)

To avoid the technical and logistical issues that arose due to the saturated nature of the tailings when capping the NWA TSF, specific decommissioning and rehabilitation plans have been developed for NWB TSF and RD16 TSF, both of which have been decommissioned and are in the process of being rehabilitated. At the time of this submission, RD16 had been completed to milestone RM6, and the 2 m capping layer for NWB TSF had been commenced and was approximately 15% complete. RD16 TSF was located in a converted retention dam rather than in a mining void and is included in this discussion for completeness.

The overarching strategy for rehabilitation of the TSFs is to meet the EA condition of a safe, stable and non-polluting landform. These are addressed at a high level as follows:

- consolidation and settling have been considered
- contribution to seepage and controls implemented and to be maintained have been identified
- a free-draining (i.e. externally draining) final landform is proposed; and
- NAF material shall be used for initial cover (in contact with tailings) and for the cover layer to a minimum of 5.8 m thickness below the final topsoil layer (6 m total thickness of cover).

The first phase of rehabilitation of the TSFs is desiccation. This involves dewatering through self-weight consolidation and recovery of expelled water through pumping from a return water sump. A period of approximately 18 months is considered likely to be required to achieve suitable stability based on prior site experience; however specific timeframes will be subject to a number of factors including weather conditions, the volume and depth of tailings deposited and the dosing of chemicals (including flocculants) added to the tailings at the CHPP prior to deposition. RD16 was a relatively small volume, shallow TSF and desiccated relatively quickly. NWB TSF is of larger volume and variable thickness and required some 14 months of desiccation prior to in-situ geotechnical testing and a subsequent further short period until commencement of initial cover installation.

In-situ geotechnical testing will be undertaken at all TSFs after desiccation and prior to the commencement of initial cover installation to verify material strength is sufficient to support the required material and equipment. Testing and analysis with development of recommendations for capping has been completed at both RD16 TSF and NWB TSF.

The second phase of rehabilitation is the placement of initial cover material immediately above the tailings. As the spoil immediately over the tailings will potentially experience upward flow of water from the tailings during consolidation, this material needs to be NAF. Consistent with general spoil dump requirements, the outer 50 m horizontally will also be NAF. The cover material on RD16 TSF has had bulk material placed and, following a 12-month settlement period and importation of additional material to balance the settlement that occurred, undergone final profiling and rehabilitation works (to RM6). Initial cover installation of NWB TSF commenced in November 2021.

The challenge of placing the initial cover material over tailings is that the cover needs to be thick enough to spread the weight of the construction equipment (so that the resultant pressure is low enough to not fail the tailings), without being so thick that the weight of the cover material will fail (through the tailings). Stability analyses can be undertaken to check the geo-mechanical stability of various combinations of layer thickness and equipment weight; however, given the inherent variability of tailings throughout the NWB TSF, it is likely that at least in some areas performance will vary significantly from analysis. Consequently, construction must proceed on the understanding that the schedule and design may need to be revised during the process.

The tailings strength profile assumed for preliminary design at NWB TSF consisted of a surface layer 2 m thick with 25 kPa undrained shear strength, and 15 kPa undrained shear strength below that. Slope stability analysis found that a small dozer spreading a 3 m thick layer of spoil would have a FoS close to 1.5. Therefore, it is expected that the initial shallow cap will be placed using small equipment to limit tailings deformation, during 2021–2024, after which the capped surface will drain back to the site retention dam system. Based on geotechnical advice and experience capping the RD16 TSF, placement of the initial cap will potentially be staged to allow each section to rest and settle. Subsequent material up to final rehabilitation surface will by placed by mine production equipment, with material sourced from pit excavation, rehandled spoil material and/or MPR placement as appropriate.

Survey calculations indicates NWB TSF requires approximately 7,000,000 m^3 of material to install the initial cover and build the surface profile to the final landform height. A total of 250,000 m^3 of suitable NAF material has been identified for the initial cover layer sourced from the adjacent Hitachi Hill dump. The 2021 LOM Plan allocates spoil rehandle and overburden removed from the advance of K2E and potentially Central /Ramp 5 pits as the source of NAF material to make up the remaining volume in accordance with design.

Initial cover construction sequence

Following the cessation of deposition, an individual TSF Decommissioning and Rehabilitation Plan (DRP) will be developed for each individual TSF commissioned at Meandu Mine. Prior to desiccation and geotechnical testing, the DRP will be completed as a draft based on site knowledge and experience. The DRP will be updated to final once geotechnical testing results and subsequent analysis and recommendations are available. The geotechnical analysis and recommendations will include consideration of appropriate construction method, sequence and equipment, which will be incorporated into the DRP.

As an example, the following section discusses the planned construction equipment, method and sequence developed for the NWB TSF initial cover construction.

The planned NWB construction sequence for the initial cover layer of spoil is illustrated in Figure 6.23. Starting from the filter wall at the north, spoil will be stockpiled near the eastern end of the filter wall and a D6-LGP dozer will push the spoil onto the tailings in front of the filter wall up to the height of the filter wall crest. The spoil layer will be advanced across to the lowwall first and then southward down the TSF. As the cover layer is extended:

- the working face will stay aligned across the pit to minimise the length of the working face
- incident rainfall and water expressed from the tailings will be continually removed from the tailings surface using a mobile pump or highwall pump as required. A trench on the lowwall side of the tailings surface has been constructed to drain free water back to the northern sump, from where the water is pumped out as required

- once the active face moves away from the filter wall, spoil may be stockpiled on the constructed layer at a minimum setback and maximum height to be determined at detailed design. Such stockpiling must only be temporary and the spoil must be relocated to advance the first layer of cover with minimal delay. Capping activity to date has involved direct rehandle of material from Hitachi Hill dump and has not required stockpiling of the waste material
- as the active face approaches the southern end of the TSF the lowwall side should be swung around to enclose the dewatering sump and finally complete the cover layer.

During construction, the area must be inspected daily by a supervisor and any cracking or significant change in the tailings bow wave should be notified to a geotechnical engineer familiar with the decommissioning project.

Once the initial cover layer of NAF spoil has been placed over the tailings surface, and after a suitable period has passed to allow for settlement and repair, it may be possible to proceed as per normal dumping operations subject to observations of stability and further settlement. The subsequent dumping strategy will be confirmed by geotechnical analysis after the first layer is completed. The spoil will be dumped and spread to maintain a small fall toward the northern end so the rainfall drains away freely to the dewatering sump. The decant pond at the northern end of the TSF may be retained for some time as a sediment basin but will eventually also be backfilled to the final landform shape. As the spoil surface approaches the levels of the final landform, the areas of thickest tailings and spoil (at the south and south-east) may be over-dumped by a couple of metres to counterbalance predicted remaining consolidation settlement. A minimum of 6 m of NAF overburden/interburden will be emplaced beneath the final landform design surface.

It is anticipated that the landform will be completed to the end of bulk earthworks then allowed a period of potentially 24–36 months (a conservative timeframe compared to the 12 months required for the smaller scale RD16 TSF capping process) for consolidation settlement and maintenance as required. When topographic monitoring indicates that the remaining settlement is within a manageable range (nominally <0.3 m), the surface will be cut-and-filled to final design profile.

The area will then be rehabilitated in accordance with the final landform design as shown in Figure 6.24 and PMLU requirements as detailed in Section 6.1.6, including construction of contour drains and rock drains, topsoiling, ripping and seeding. If required, temporary surface protection may be provided through use of a grass or cover crop, during the period between bulk earthworks and topsoiling. The proposed final landform over NWB TSF is shown in Figure 6.24.

As shown in Figure 6.25, the depth of spoil required to achieve the final landform in the 2022 LOM Plan ranges from 10 m at the decant pond filter wall to 60 m against lowwall spoil at the south-western corner. With that depth of burial, in most respects, the tailings will not affect the condition or function of the rehabilitated landform, which will instead be subject to the same surface works and completion criteria as other rehabilitated spoil dumps.

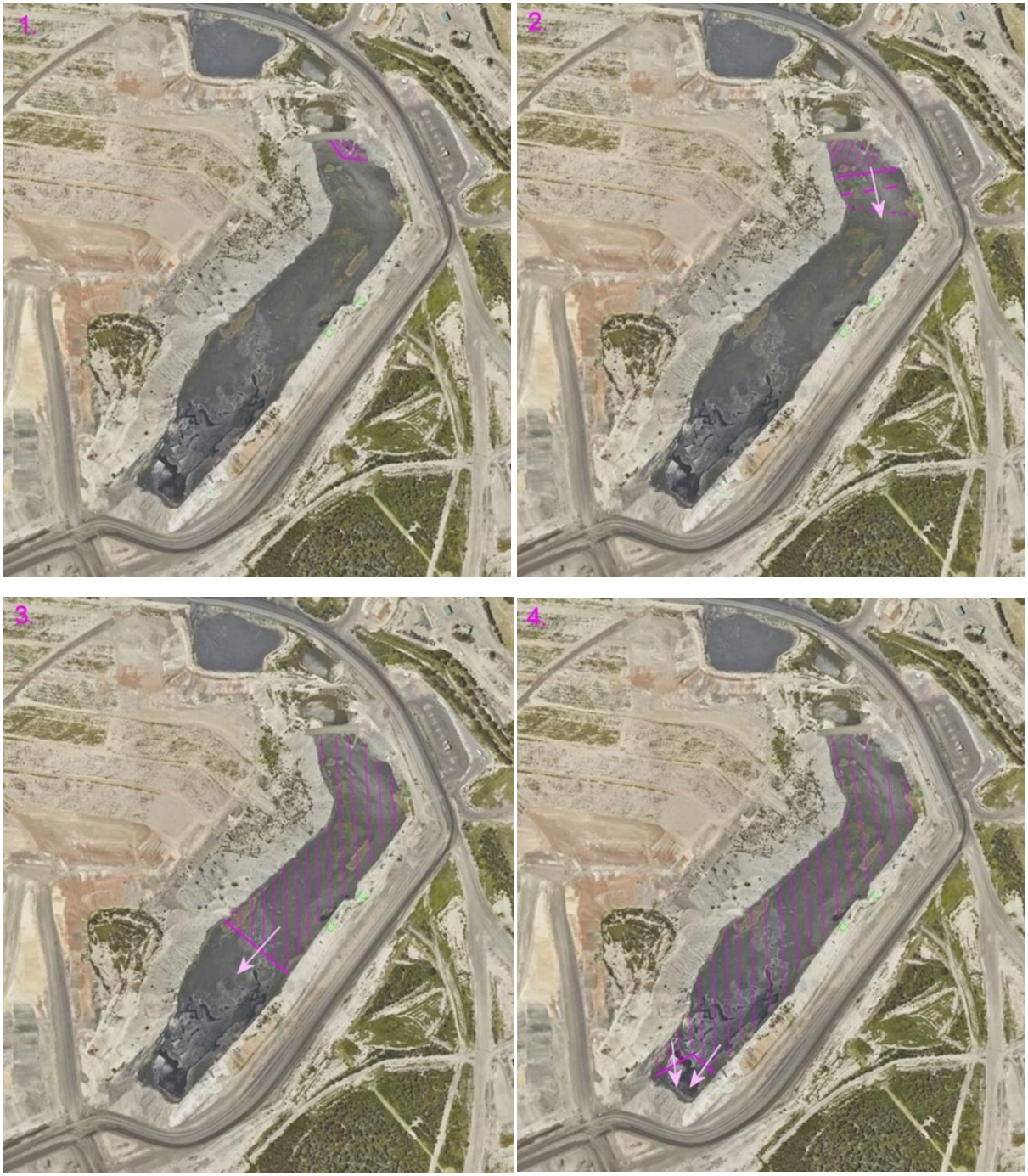


Figure 6.23 Construction progress for first cover layer on NWB TSF

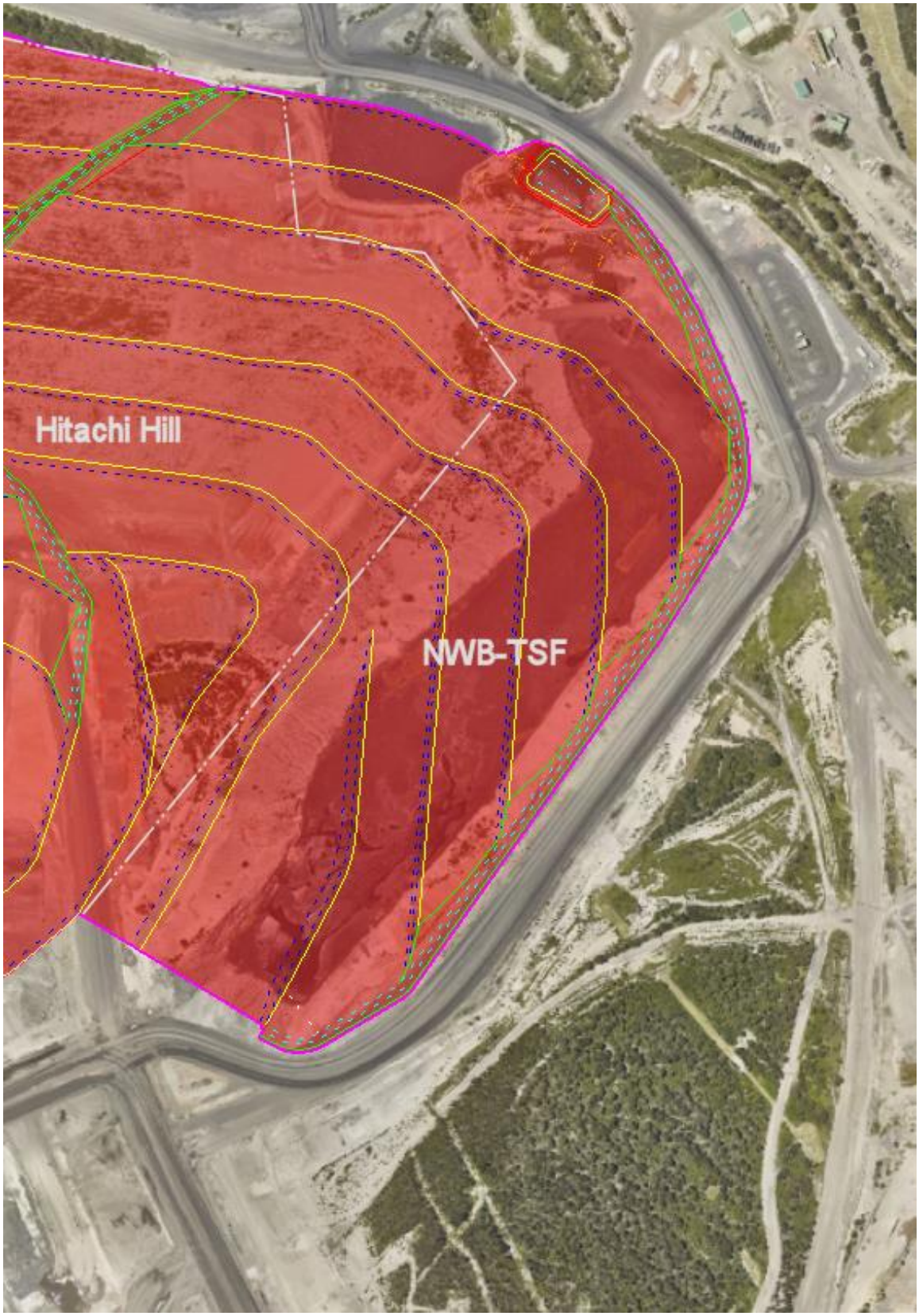


Figure 6.24 Proposed final landform over NWB TSF

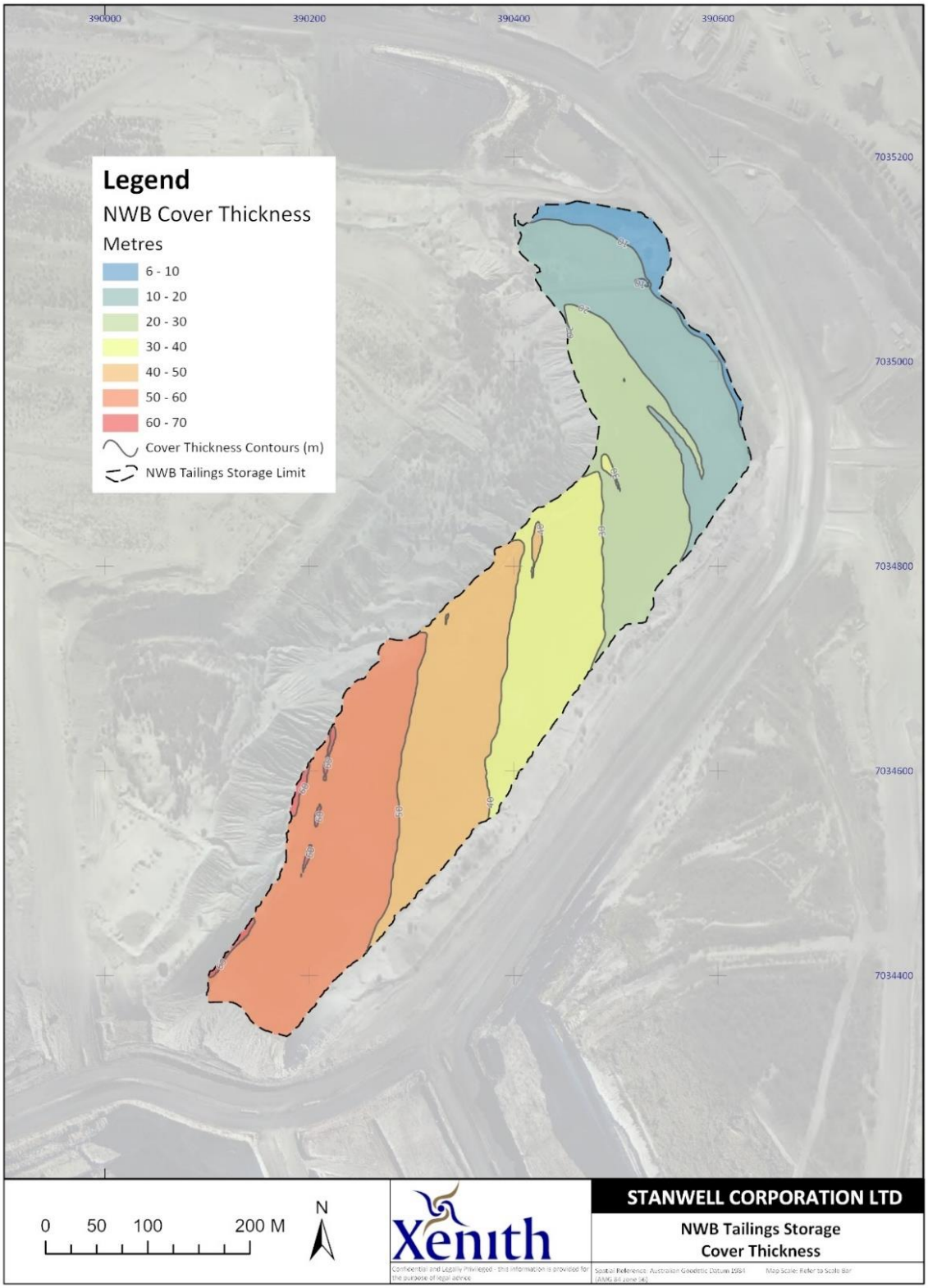


Figure 6.25 Depth of spoil over NWBTSF to achieve final landform

Active and future ash and tailings storages

With the installation of the SBCs at the CHPP wet tailings disposal will only be required for approximately 10% of the time. These tailings will be co-deposited with the coal combustion products in dedicated mine voids at K2W and then K4S. Ash deposition will continue in the K2W-N pit void and will then transition to K4S following both the transition of tailings deposition into the K4S facility and achievement of target ash fill level at K2W-N. The placement and decommissioning of tailings and ash storage facilities is discussed below.

Cover design and materials

Design of the cover system for the TSF's is discussed in Section 6.1.6.

6.2.4.2 Ash storage facilities

Rehabilitation strategy

Decommissioning and rehabilitation plan of the K2W-N void has been considered in the K2W-N design plan (including certified design drawings) in accordance with EA EPML00709113 conditions G8, G10 to G14 and H27 (Stanwell, 2022b). The decommissioning and rehabilitation plan will not be finalised until coal combustion product deposition has ceased and *in-situ* geotechnical testing conducted and analysis of results and recommendations for initial cover installation are finalised. Rehabilitation will comprise a period of desiccation/consolidation following by initial NAF cover installation and subsequent spoil lifts to a level in accordance with the final landform design, ensuring that the final cover will be free-draining (i.e. final surface constructed on a slope to minimise pondage). Decommissioning and rehabilitation of K4S post mine closure (~2037–2039) will be conducted in a similar manner.

Transition planning for ash deposition transfer from K2W-N to the K4S ASF will be incorporated into the decommissioning plan for the K2W-N ASF. Tailings deposition transfer to K4S will occur prior to the coal combustion products transfer. This will allow coal combustion products to continue to be pumped into the K2W-N facility for a period of approximately 12 months following cessation of tailings deposition, forming a layer over the tailings in K2W prior to capping. Testing has shown that the deposited coal combustion products are inherently stronger than the tailings and it is expected that this methodology will reduce potential deformation associated with the tailings and reduce capping duration, assisting to minimise the decommissioning and rehabilitation timeframe. Additional testing will be undertaken as coal combustion product and tailings levels increase and the proportions of the respective materials become more representative. In-situ geotechnical testing will be undertaken following cessation of coal combustion product deposition to determine suitable cover depths, suitable equipment and construction sequence and methodology.

Desiccation phase

Following cessation of coal combustion product disposal in the storage facilities, a period of desiccation (drying out/crusting) will be allowed. Once the desiccation period has finished and the surface has dried sufficiently to provide access, in-situ geotechnical testing will be undertaken and analysed to develop recommendations for an initial cover construction sequence and method including confirmation of suitable equipment. Previous experience gained at Meandu Mine in placing the temporary dust suppression layer over K2W indicates that a desiccation period of up to 18 months may be appropriate, and that shallow tiphead placement of the initial cover layer can be achieved using existing mine production equipment. The initial cover construction methodology will be refined for the K2W-N DRP based on outcomes of in-situ testing, with particular attention to the K2W area that is currently being used for tailings disposal and which will have a relatively thin ash cover thickness.

Landform design

The 2021 LOM Plan final landform design for the K2W-N void is shown on. It has been designed with the catchment divide toward the northern end of K2W at approximately 530 mRL and drainage channels reporting to the northern and south-western ends of the K2W-N backfilled void. As illustrated in Figure 6.26 the final depth of cover over K2W-N will range from 2 m at the northern end and 4 m at the southern end to 30 m on the western side adjacent to the K2W spoil dump.

Cover design and materials

Design of the cover system for the ASF's is discussed in Section 6.1.6.

6.2.5 Tailings design elements

As the tailings and coal combustion products are deposited as "flowable substances" the proposed use of exhausted mine voids (currently K2W-N and in future K4S) triggered the need for consequence category assessments on the storage facilities to determine whether they would be a regulated structure. Structures determined to have significant consequences for seepage scenarios must be designed with specific monitoring and mitigation measures. The assessments were conducted with the intent of determining whether potential seepage consequences could be minimised to prevent a significant categorisation.

These assessments were undertaken in 2018 for K2W-N (Henderson Geotech, 2018) and 2021 for K4S (Henderson Geotech, 2021). The category assessments focussed on seepage; however, the K2W-N assessment included consideration of overtopping and dam break due to the location and planned final height of K2W-N. Implications on the design elements of each facility are discussed separately below.

6.2.5.1 K2W-N

The seepage assessment of the K2W-N TSF established a "significant" consequence category. This was due to the assessment determining that releases to ground were likely through seepage to the north-west through the QW backfilled void.

As the K2W-N void had already been partially filled with coal combustion products before the introduction of regulatory requirements regarding lining of TSFs, it was not possible to back-engineer such structure(s). Hydrogeological investigations prior to the development of this PRC Plan (JBT 2018 and 2021) have identified that the Tarong bed lithologies generally have low hydraulic conductivities, which naturally limits seepage through the bedrock forming most of the pit walls on the north-east, east and southern sides of the void. Higher flow rates were predicted for the south-west and north-west/west walls due to modelled seepage through the weathered regolith to the south-west of the void and the spoil and alluvium to the north-west/west.

The potential of seepage from K2W-N to the north-west was recognised before the assessment and a seepage recovery sump was constructed in the QW backfilled spoil to act as a seepage collection system. Although potential seepage was identified from K2W-N, significant seepage was modelled to be captured by the QW sump or intercepted by Central pit.

Further studies since the consequence category assessment have led to a reconceptualisation of the area to the west of K2W-N and hydrogeological modelling by SLR (2022a), including contaminant particle tracking modelling, which showed that potential seepage from K2W-N is unlikely to reach the surface within 700 years post-closure. Further, the SLR modelling indicates that seepage from K2W-N will be towards the K4E final void, and in turn from K4E towards the K2E final void.

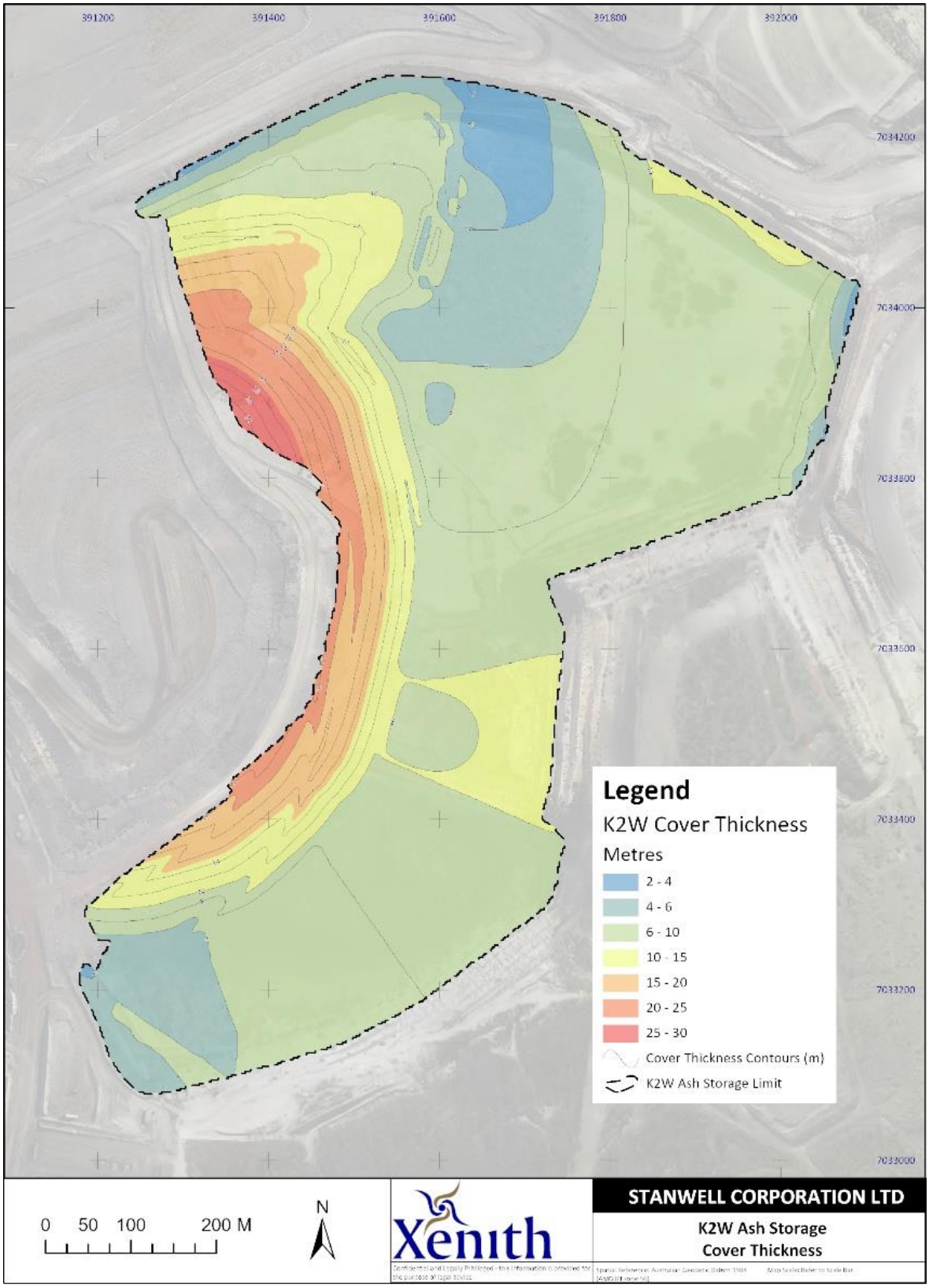


Figure 6.26 Depth of spoil over K2W-N ASF to achieve the final landform

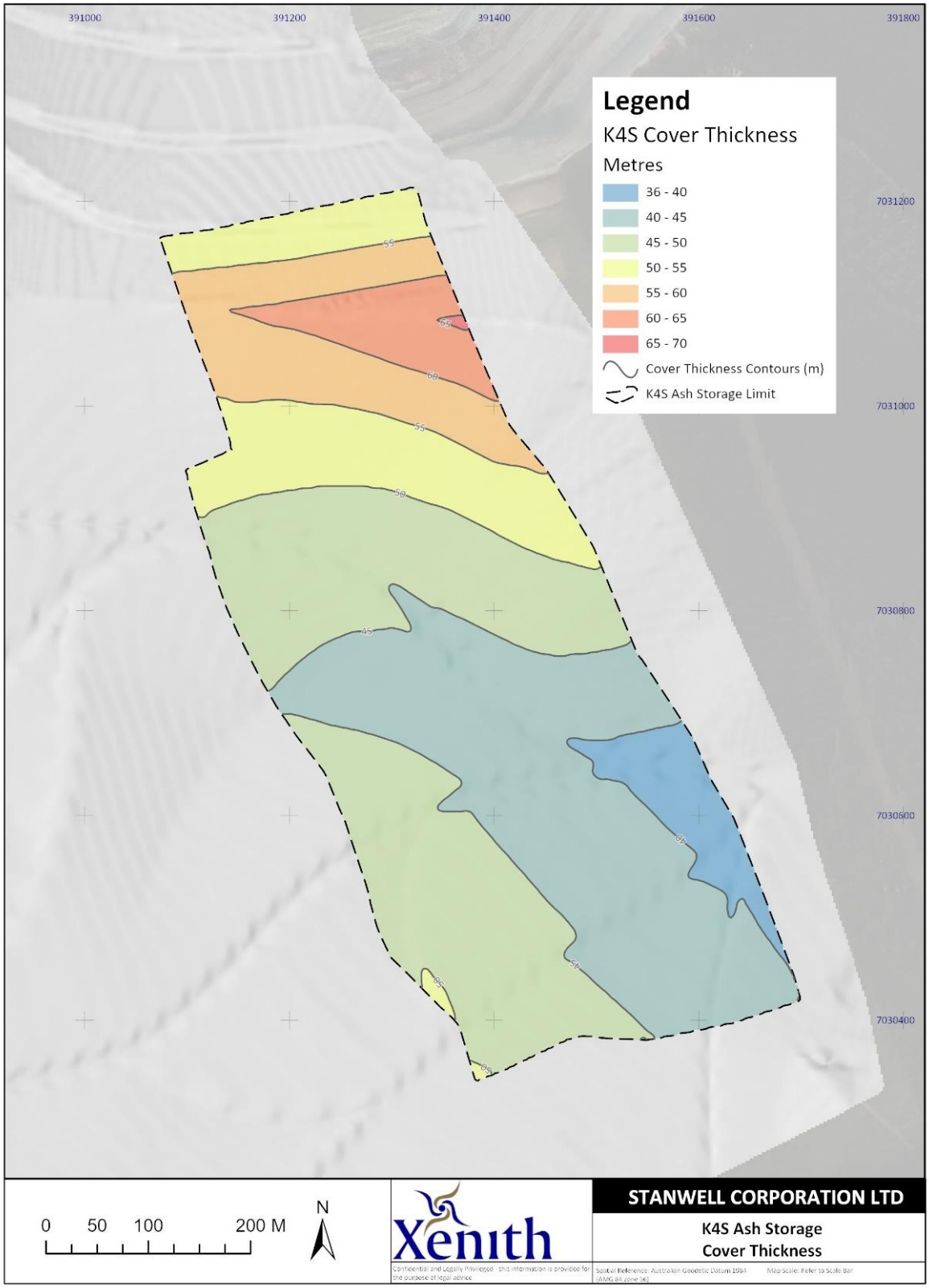


Figure 6.27 Depth of spoil cover over K4S ASF to achieve the final landform

A comprehensive groundwater bore network is in place in the vicinity of K2W-N (Section 6.1.1 and 8.2.4) and this is considered to provide adequate coverage to identify significant seepage from the void in this direction.

The in-pit nature of current and future tailings and coal combustion product storage acts as a proxy cellular storage design. Once K2W TSF reaches its design storage capacity future tailings and coal combustion product deposition will be into K4S, enabling the rehabilitation of K2W-N to commence. Ongoing rehabilitation of NWB TSF and RD16 TSF demonstrate that the in-pit disposal method successfully allows progressive rehabilitation of TSFs once the capacity of this facility has been reached and deposition discontinued.

The dam break consequence category was assessed as significant, due to the potential environmental impact associated with breach of the northern embankment causing cenospheres to affect Meandu Creek. The spillway design criteria is 1:1000 annual exceedance potential (AEP) and is fulfilled by the existing spillway in K2W-N. The engineered spillway is constructed in the south-east saddle embankment and can directly overflow towards K2E pit.

The overflow consequence category assessment determined the category as being low, therefore no design storage allowance or mandatory reporting level is necessary for K2W-N.

6.2.5.2 K4S

The consequence category assessment for K4S was limited to seepage because the operational and post-closure topography of K4S prevents overflow into operational areas or off-lease. The backfilled void will be encompassed on all walls by fresh Tarong beds, weathered Tarong beds and basalt. Geotechnical stability assessments have identified dam break as insufficiently likely to warrant assessment.

Seepage assessment of K4S concluded that seepage from the proposed K4S TSF would not have consequences sufficient to reach the threshold of Significant Consequence Category for any level of tailings/coal combustion product storage (Henderson Geotech, 2021). The modelled indicated likely seepage into the spoil that forms the lowwall on the west of the pit; however this seepage did not extend significantly into the underlying bedrock. Seepage in the weathered Tarong beds and basalt to a distance of 50–200 m over a period of 60 years in the highwall/endwalls of the final void was indicated; however, no surface expression was predicted from this seepage. These results are supported by the hydrogeological modelling conducted by SLR (2022b).

Because of the low permeability of the bedrock forming the walls of K4S pit, lining of the future TSF is not considered necessary as seepage is not expected to travel far or have any environmental impact. A network of groundwater bores situated around the final landform is proposed to act as a seepage detection system.

Due to the expected low volumes and limited extent of seepage from K4S, a seepage collection system is not considered necessary to protect the PMLUs and surrounding environmental values.

Due to the low consequence category of overflow from K4S, no design storage allowance or mandatory reporting level is required for the facility.

The void catchment is minimised by the LOM Plan, resulting in minimal runoff inflows, and freeboard heights to the lowest void wall above the TSF are sufficient such that an engineered spillway is unlikely to be required. Water level will be managed by pumping.

As K4S is planned as the last void to be used as a TSF in the LOM Plan, the rehabilitation of K4S will not commence until the completion of operations of the CHPP and Tarong power stations. Cessation of tailings and coal combustion product placement in K4S is planned for 2039, with rehabilitation to be completed by 2045, allowing for the desiccation and settling period and subsequent fill and reshaping.

6.3 Voids

PRC Plan Guideline (Section 3.6.3)

The information requirements of this domain are dependent on the nature of the proposed PMLU or NUMA for the void. For mine sites with voids, the rehabilitation planning part must include a void closure plan, which includes options for minimising final void area and volume; final void dimensions; pit wall geotechnical and geochemical stability, final slope angles, void hydrology, groundwater modelling, water balance and predicted long-term water quality.

A geotechnical report should focus on how the void will achieve post-closure slopes that will exhibit stability characteristics consistent with the planning and design of the post-closure mine void.

If floodwaters are likely to move over backfilled material, an assessment of the hydraulic properties must be conducted to assess whether instability may occur.

The rehabilitation and management strategies in the plan must include the supervision, verification and auditing of engineering works carried out to achieve the post-closure void landform, to ensure construction is consistent with the geotechnical design.

The rehabilitation and management strategy must also include confirmation that the post-closure landform demonstrates the level of stability as specified by the design.

6.3.1 Void closure plan

The Meandu Mine post-mining landform will contain two residual voids (K2E and K4E) allocated the PMLUs of Water Storage and Steep Rocky Ecosystem, the locations of which are shown on Figure 4.1.

WSP were commissioned by Stanwell to prepare a Void Closure Plan for the Meandu Mine 2021 LOM Plan in support of the development of this PRC Plan. The Meandu Mine PRC Plan Void Closure Plan (Appendix M) is purposed to evaluate options and identify the preferred configuration and final land uses of the voids created by open cut mining at Meandu Mine, including minimisation of final void depth, area and volumes, and to describe how rehabilitation of voids will be carried out to minimise potential environmental impacts and meet the legislative requirements relating to mine closure for land relating to ML6674.

The residual voids have been considered in the design of the post-mining landform as follows:

- maintain or optimise the location and geometry of the two final voids
- where possible, minimise size, depth and volume of final voids (refer Section 6.1.5.2)
- ensure drainage into the final voids is in alignment with the water storage requirements (i.e. is internally draining for surface water and groundwater)
- assess against the final highwall setback criteria, to avoid key assets/infrastructure between the FOS 1.5 setback line and pit crest and provide adequate standoff from the site boundary; and
- design final slopes in accordance with geotechnical recommendations to provide long-term geotechnical and erosional stability.

6.3.2 Void minimisation

The geometry and geology of the coal seams at Meandu Mine have allowed for significant void minimisation through back-filling of exhausted pits. On closure, the LOM Plan shows that 11 of the 13 voids created throughout the operation of the mine will be wholly backfilled and rehabilitated such that it contains similar features and slopes to the surrounding and pre-mining landscapes. The remaining 2 of the 13 voids developed through the mine life both receive substantial backfill, significantly reducing their depth, enabled through a strategy of stockpiling suitable spoil material above final landform design on the lowwall side of the final void location for subsequent dozer push or excavator and truck relocation in the years after cessation of coal mining operations. LOM planning has included strategies for reduction of final void sizes, including:

- reduce the size of K2E boxcut to reduce out of pit dumping and maximise in-pit dumping. This also results in reducing the volume to be reshaped to final landform
- achieve the coal combustion products placement strategy of K2W-N then confirm suitable LOM coal combustion product storage capacity in K4S
- pit optimisation to reduce final void footprint and volume
- step up the pit floor to the K4 seam in the last strip of K4E and K2E to reduce the depth of the final voids
- minimise overburden in advance to maximise in-pit placement of waste
- improve haulage efficiency for K2E out of pit hauls
- incorporate material mapping and selective material placement to achieve the final landform requirements that support the PMLU design and confirm viability of achieving this placement
- minimise closure movement and cost.

Waste streams used to backfill the pits (where licensed) comprise a combination of:

- overburden/interburden spoil
- coal combustion products
- tailings; and
- MPR (co-mingled dewatered tailings and coarse rejects).

Overburden/interburden spoil comprises the vast majority of material used to backfill the voids. Further information on the rehabilitation of the backfilled voids is provided in Sections 6.1.4, 6.1.5 and 6.1.6. As a result of the void minimisation since the preceding LOM Plan the extents and mix of PMLU s associated with the final voids (Steep Rocky Ecosystem, Water Storage, Native Ecosystem) have changed in comparison to the indicative PMLU allocation shown in the existing EA.

6.3.3 Final void dimensions

The surface area, maximum depth and volume of each residual void has been described previously in Section 6.1.5.2. It is noted that PMLU's have been allocated for the entirety of the residual void domains at the Meandu Mine (i.e. no NUMAs are being sought in this PRC Plan). The proposed PMLUs for the final voids are:

- Water Storage (including littoral zone for lowwalls)
- Steep Rocky Ecosystem – final highwalls; and
- Native Ecosystem and Beef Cattle Grazing – lowwall above Water Storage PMLU.

6.3.4 Final void pit wall stability

6.3.4.1 Final landform geometry

The final landform geometry of the Meandu Mine is described in Section 6.1.5, with this section concentrating on the landform design of the final void highwalls and lowwalls.

The lowwalls in the two final voids (K2E and K4E) will be formed of backfilled overburden/interburden and will be rehabilitated according to the general rehabilitation requirements for the PMLUs Native Ecosystem (K2E and K4E) and Beef Cattle Grazing (K4E only) and Water Storage (Littoral Zone).

6.3.4.2 Slope stability analysis

Slope stability analysis has been conducted on existing and final landforms at Meandu Mine to provide a geotechnical assessment of the safety of the existing landforms (excavated slopes and placed spoil dumps) and inform the final LOM Plan with regard to long-term stability of the proposed final landforms.

Analyses were done by calculating the FOS for the modelled slopes. FOS is essentially a ratio of the strength available to hold a slope in place divided by the stresses tending to move, or destabilise, the slope.
A minimum FOS of 1.5 has been adopted as the required long-term measure of stability, which represents a probability of failure of <0.1% (Henderson Geotech, 2020).

Highwalls

Geotechnical stability of the proposed final highwalls at Meandu Mine was assessed using limit equilibrium slope stability analysis for the range of materials and pit wall geometries described in the geological model and 2019 LOM Plan (Henderson Geotech, 2020). The stability criteria that were developed were then used to evaluate the proposed final highwalls for the 2021 LOM Plan.

Methodology and assumptions

Strength properties were collated for the various overburden and interburden materials encountered at Meandu Mine, derived from laboratory testing, back-analysis of slopes and operational experience. Material strength properties are listed in Henderson Geotech (2020). As active and future pits (K2E and K4E) have not yet reached their final void locations, no analyses was undertaken for specific actual final highwalls; instead stratigraphies for proposed wall locations were extracted from the geological model and existing operational wall geometries were applied over the range of configurations expected.

Groundwater levels in the model profiles were conservatively assumed to be at the base of weathering and a steady state finite element water pressure analysis was run for a typical highwall geometry to estimate the drawdown curve behind the void highwalls (Figure 6.28).

Limit equilibrium analyses were undertaken using the Slide™ V6.039 software package; the computational options are described in Henderson Geotech (2020). Six locations were selected along the final highwalls of K2E and K4E pits as shown on Figure 6.29, and final highwall geometries were created for each location in accordance with operational highwall designs (Section 6.3.4.1) and the Meandu Mine geological model. The cross-sections covered a wide range of overburden configurations, with lithological thicknesses varying from 0 to 90 m of residual soil, 10 to 120 m of weathered rock and 160 to 300 m pit depths.

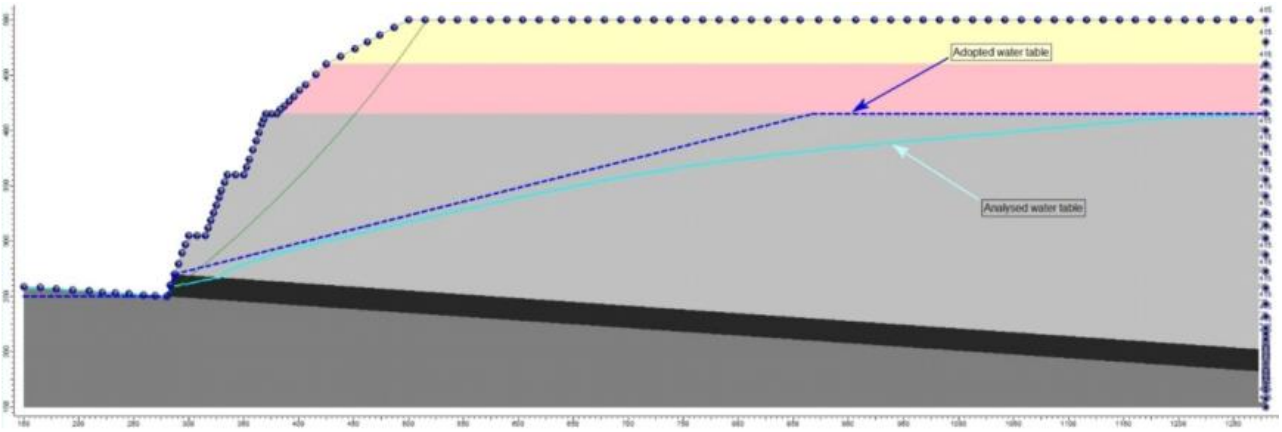


Figure 6.28 Stability analysis surface showing analysed water table and water table adopted for modelling (Henderson Geotech, 2020)

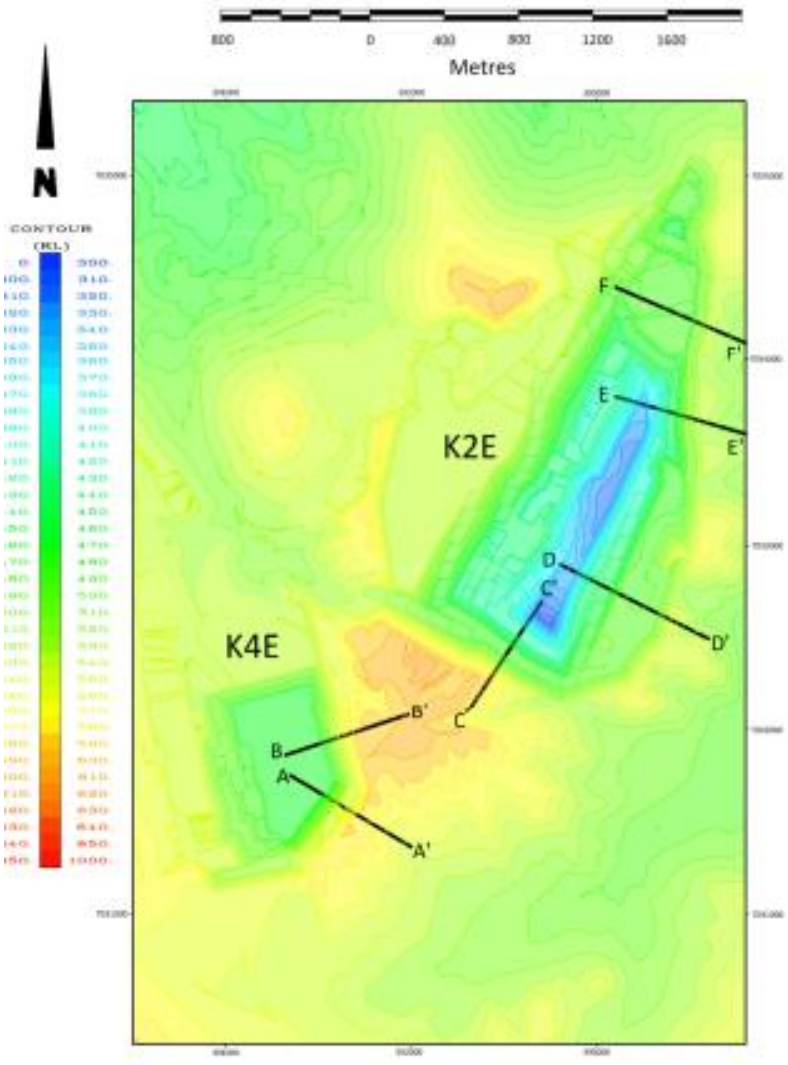


Figure 6.29 Meandu Mine final highwall sections used in geotechnical stability analysis

Results

The stability analyses found that the safety envelope that provided a FOS of 1.5 was driven by the depth of the final pit coupled with the depth of weathered overburden in the final wall. Set-backs from the pit toes to attain a FOS of 1.5 range from 176 to 516 m (Henderson Geotech, 2020). Selected results are shown as cross sections in Figure 6.30 and Figure 6.31, indicating a setback of 408 m from the toe in K4E pit and 211 m from the toe in K2E pit.

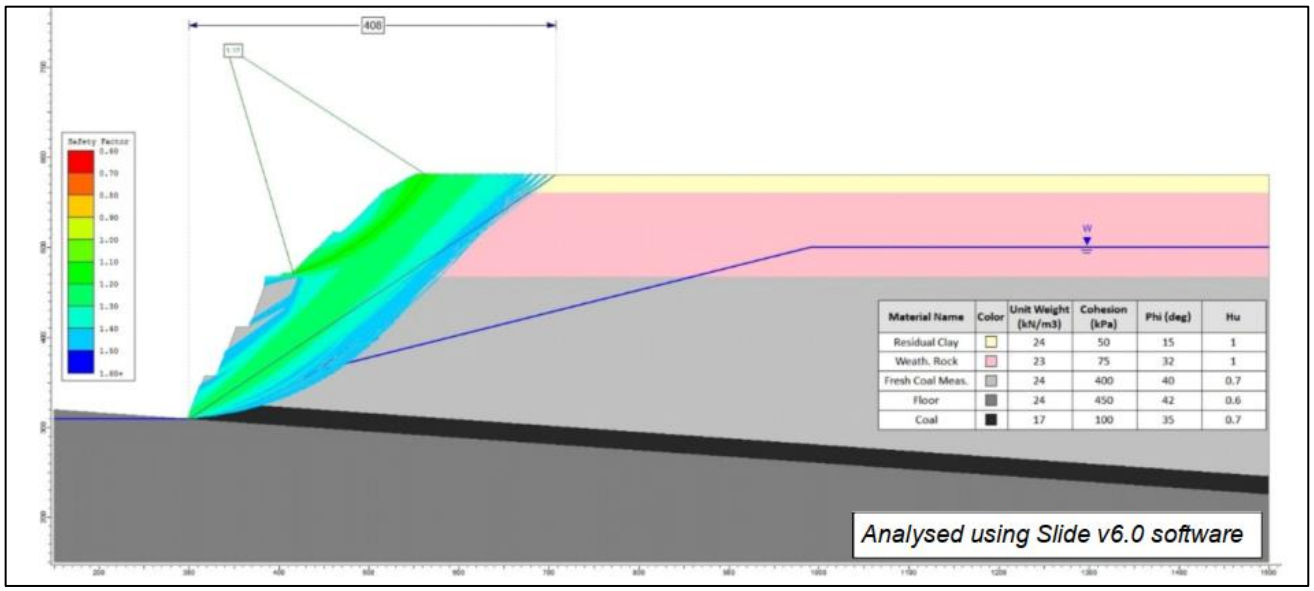


Figure 6.30 Slope stability analysis results for Section A, K4E final highwall

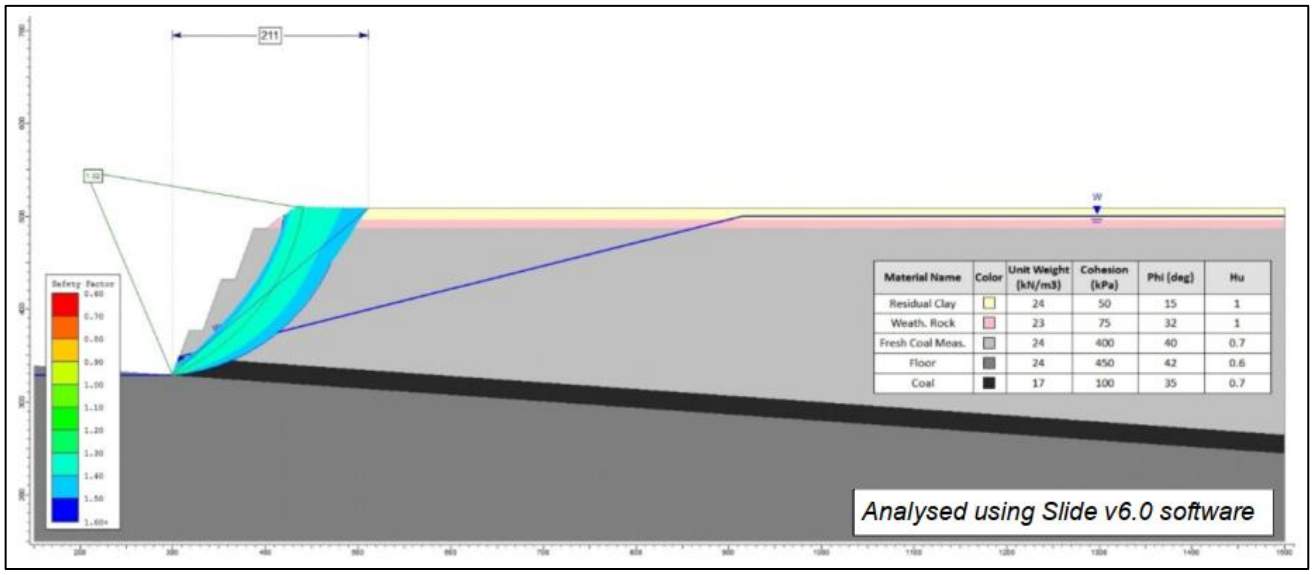


Figure 6.31 Slope stability analysis results for Section D, K2E final highwall

The FOS 1.5 setbacks are located 80–200 m behind the physical crest of the highest remaining bench in the final voids and represent the projected stable crest. Therefore, the boundary of the Steep Rocky Ecosystem PMLU footprint is assigned at the setback distance from the physical crest to ensure no third-party assets or significant environmental values are located within the setback encompassing potential slip failures with a FOS <1.5. A nominal 50 m buffer was applied between the Steep Rocky Ecosystem PMLU and surface rights area boundary as a contingency.

Statistical regressions were performed on the results and the output equations were adjusted to provide slightly conservative predictions for set back, as shown in Figure 6.32. The variables are illustrated on Figure 6.33.

Minimum set-back from wall toe: **S = maximum of (S3 / S2 + Wf *and* S1 + Wf + Ww)**

Where:

S3 = 2.7*Tm + 2.2*Tw + 1.5*Tf – 70

S2 = 4*Tm + 2.3*Tw + 9.8*Tm/Tw – 32

S1 = 5.1*Tm – 59

Tm = *thickness of Miocene sediments (residual soil and completely weathered rock)*

Tw = *thickness of highly and moderately weathered coal measure rocks*

Tf = *thickness of slightly weathered and fresh coal measure rocks within the wall profile*

Wf = *horizontal distance from the wall toe to the top of slightly weathered and fresh coal measure rocks on the wall face.*

Ww = *horizontal distance from the base to the top of highly and moderately weathered coal measure rocks on the wall face*

Figure 6.32 Final highwall minimum set-back calculations

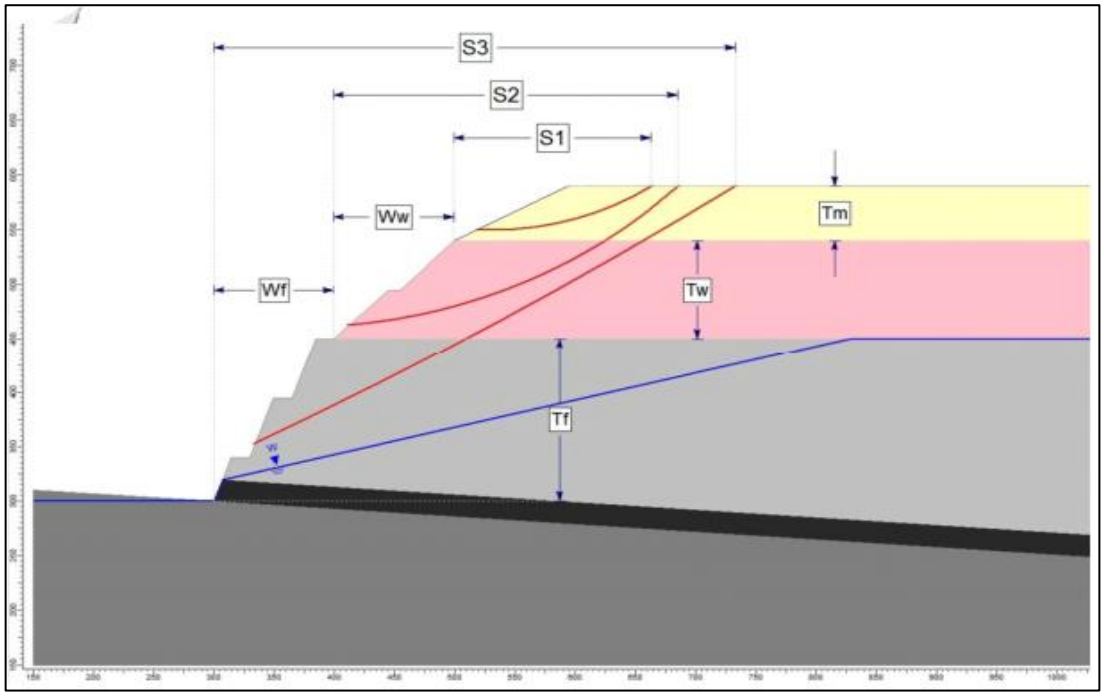


Figure 6.33 Definition of highwall stability parameters (Henderson Geotech, 2020 in WSP (2022b))

Setbacks from the final void highwalls have been calculated to meet the required FOS for the projected stable crest, with the Steep Rocky Ecosystem PMLU boundary defined by the setback distances and additional 50 m buffer. In some instances, the final highwall bench and lift design was latered to ensure the final highwall configuration achieved the required FOS at an acceptable offset distance from the surface rights area boundary.

Quality assurance checks were conducted on the final landform 2021 LOM pit shell by cutting cross-sections at various locations along the final walls (refer Figure 6.34 for locations) and undertaking manual calculation verification to address the final highwall geotechnical criteria described above. All locations comply or are within acceptable tolerance of design criteria for the purposes of PRC Plan planning and will be reviewed in detail at the time of development of each final highwall. This indicates that geotechnical stability will be achieved at the nominated projected crestline and adequate standoffs to key assets have been considered.

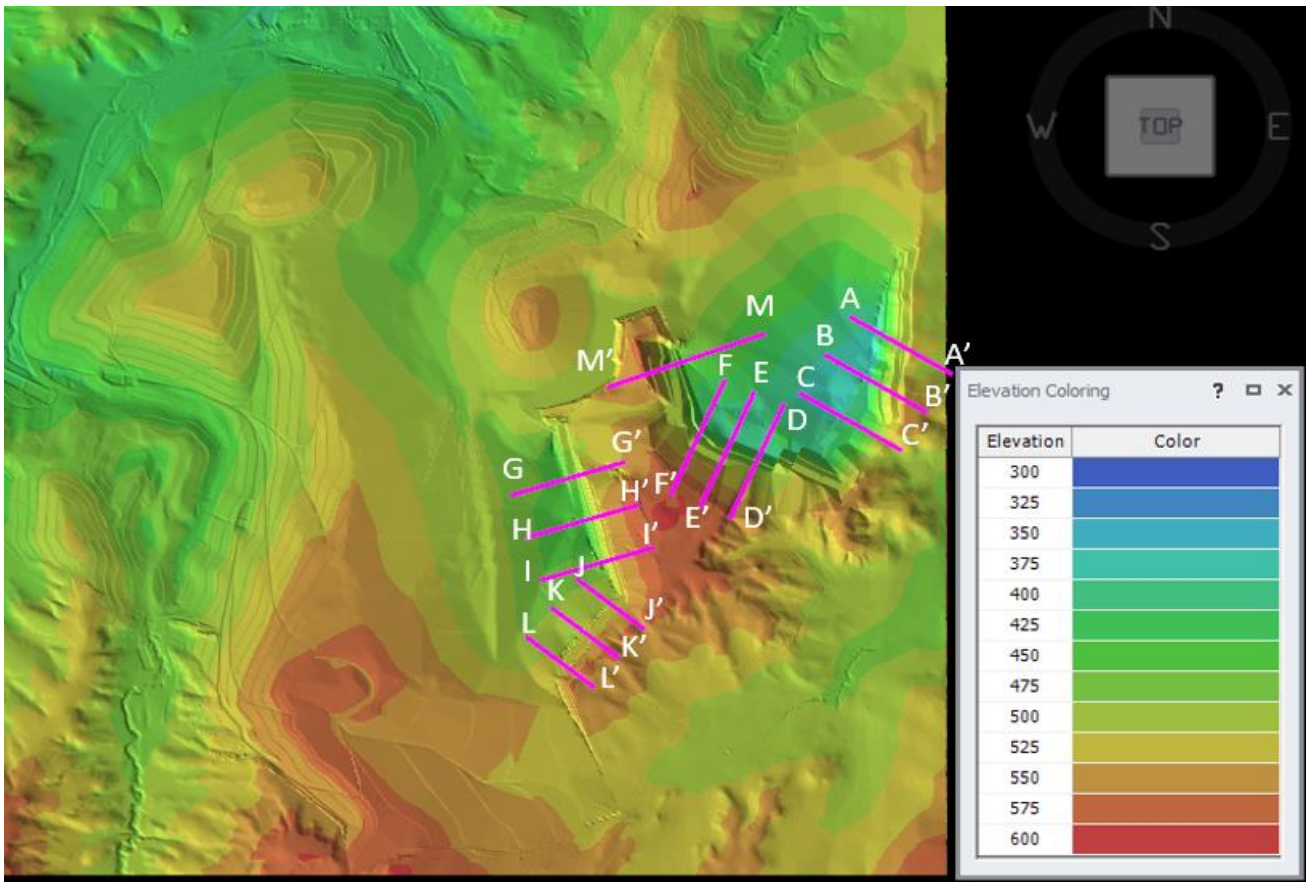


Figure 6.34 Meandu Mine final highwall stability analysis locations

Lowwalls

Where spoil piles are planned to remain as the lowwalls in final voids, factors additional to those considered for out-of-pit landforms need to be considered, such as pit slope, height of spoil keyed against the highwall and water table in the final void. Some of these have conflicting effects, for example water reduces the spoil strength bit the weight of water in the void also counteracts some of the destabilising weight of the spoil. Consequently, a worst-case scenario could not be confidently predicted in advance of analysis.

The methodology adopted was to vary the void water level with all other parameters held constant in order to determine the water level that produced the lowest FOS. This was then held constant while landform height was varied. Finally, using the worst combination of landform height and water level, floor dip and slope were varied separately. Maximum values for certain parameters were set at the design parameters for final rehabilitated landforms, as follows:

- maximum height of lowwall above final mined floor – 370 m or 300 m above spoil toe at highwall following reshaping
- maximum slope – 25%; and
- maximum pit floor dip – 9°.

Results

Results for void lowwall analyses are shown on Figure 6.35 and Figure 6.36. All modelled configurations for rehabilitated lowwall spoil slopes had FOS greater than 1.5. The most adverse water table was 100 m above the pit floor. Lowwall height only had an effect at lower heights. Floor dip also had a minimal effect, whereas landform slope had the most significant impact of FOS.

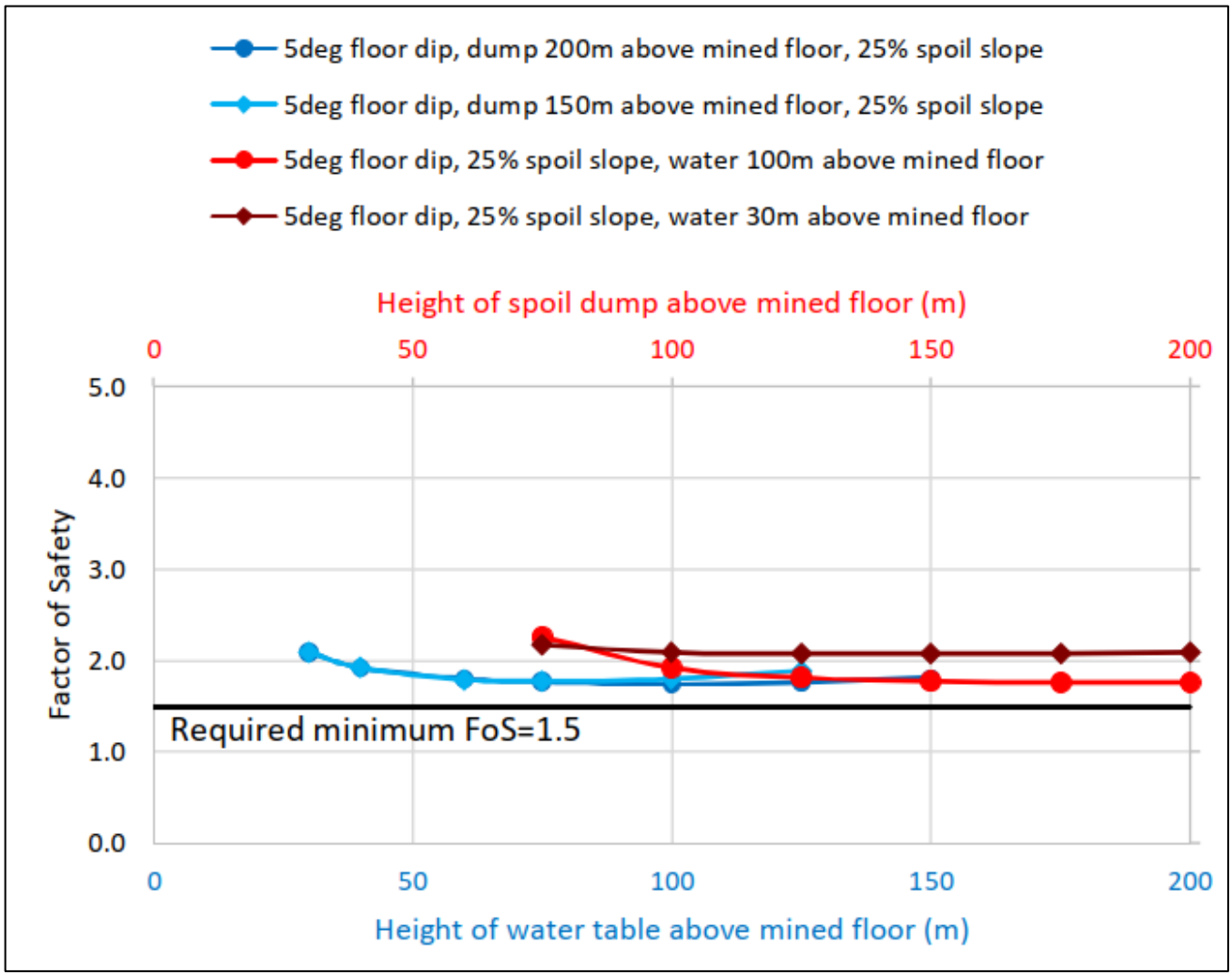


Figure 6.35 Effects of water table and spoil dump height on lowwall spoil stability

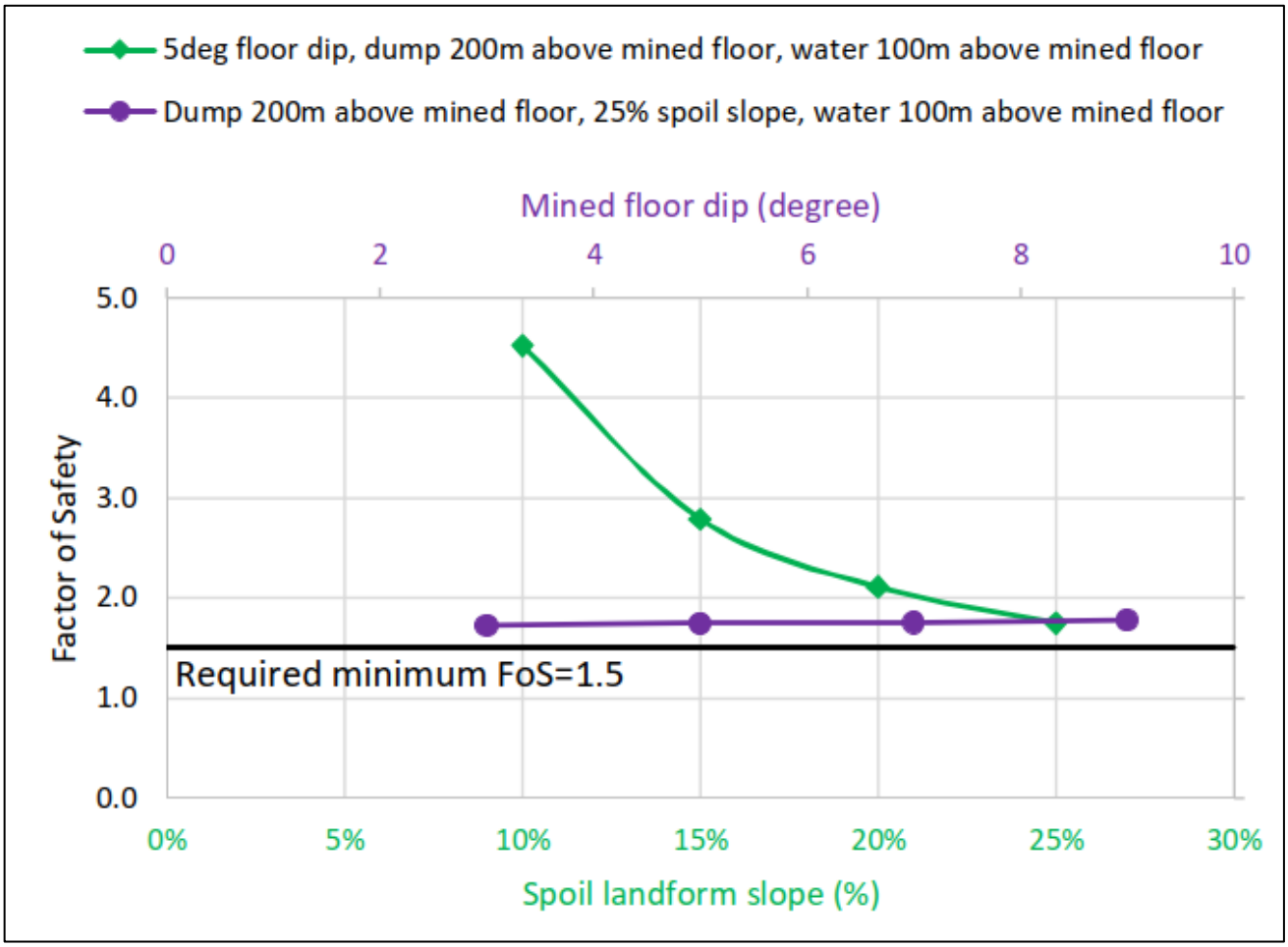


Figure 6.36 Effects of floor dip and slope angle on lowwall spoil stability.

Final landform designs have been proposed that meet the requirements of the PRC Plan Guideline for the PMLUs from a geotechnical perspective. Setbacks from the final void highwalls have been calculated to meet the required FOS for the projected stable crest, with the Steep Rocky Ecosystem PMLU boundary defined by the setback distances. Consequently, the volumes and characteristics of waste reflected in the LOM Plan are representative of final highwall design and volumes.

Based on the limit equilibrium analyses performed, the proposed final rehabilitated spoil landform designs exceed the minimum required FOS of ≥ 1.5 for long-term geotechnical stability in-pit and are therefore considered to meet the PMLU criteria.

6.3.5 Void hydrology

6.3.5.1 Geochemistry of final highwall

The current LOM Plan indicates that the K2E and K4E pits will become final residual voids that are likely to contain water beyond closure. There has been extensive static geochemical testing of material from the highwalls of these pits, collected from bore holes located near the final pit shells. The static testing verifies that at least two thirds of the samples, including some of the coal are NAF and that the majority of the PAF material is present in the coal (RGS, 2018 in WSP, 2021b). There is also an extensive history of water present in these pits, which verifies that the water bodies have retained circum-neutral pH and low to moderate salinity throughout the pit lives.

The water extraction tests on representative drill core material indicated low immediately available salinity or elevated metal concentrations in the overburden/interburden. Extractants from coal samples returned slightly acidic values (pH 4–5.8) with associated elevated concentrations of aluminium, cobalt, iron, manganese, nickel and zinc.

Kinetic leach data suggests that longer term drainage from the overburden/interburden is potentially highly variable, with some AMD, SMD and NMD potential. It should be noted that the material used in the column leach testing might not be representative of the greater rock mass at Meandu Mine and historical K2E and K4E pit water qualities over the life of the mine suggests that drainage and/or runoff from pit walls at Meandu Mine does not tend to be highly saline, acidic or metalliferous. Additional kinetic testing has been commenced as of September 2021 to provide more certainty on the likely long-term drainage water quality from the final pit highwalls.

Specific AMD management of the final highwalls is not expected to be required as geochemical testing suggests the relative volume of PAF material is insignificant at the scale of mining.

6.3.5.2 Voids in floodplains

As discussed in Section 6.1.2, the results of hydrologic and hydraulic modelling show that both the K2E and K4E voids are not subject to inundation due to flooding in Meandu or Rocky Creeks in any of the AEP events assessed, including the 0.1% AEP and PMF. The existing natural ridge forming the watershed between Rocky Creek and the voids is situated at approximately 50 m above the PMF flood level in Rocky Creek. The ridge line formed by the K4S back-filled void has an elevation approximately 60–80 m above the peak PMF flood level in Meandu Creek. The results also show that other features of the final landform including rehabilitated spoil dumps are very unlikely to be significantly affected by flooding in Meandu Creek.

Based on the results of the modelling there is no significant risk of ingress of flood waters to the final voids and the voids are not located on potential floodplains.

6.3.5.3 Long-term water balance

A water balance model (WBM) was developed by SLR (2022b) to assess the surface water system at Meandu Mine post-closure (refer Section 6.1.1.3 and Section 8.2 of Appendix I – Meandu Mine PRC Plan Groundwater Technical Report).

Five final void WBM scenarios were simulated to assess long-term water levels in the final voids:

- Base scenario – nil water extraction from either void – natural surface and groundwater recharge and evaporation only.
- Scenario 1 – limited stock water extraction from both voids: 2.08 Ml/y of stock water extracted from K2E and K4E final voids (total of 4.16 ML/y).
- Scenario 2 – maximum water extracted from K2E final void only. No extraction from K4E final void. 1 ML/day of water is extracted from K2E final void. Water is only extracted once the depth of stored water is at least 7 m and doesn't allow water depth the reduce past 5 m. This was designed as an 'upper limit' extraction scenario to test the viability of water in the future to support PMLUs other than Beef Cattle Grazing.
- Climate change Scenario 1 – model sensitivity to increase in rainfall depths: A sensitivity analysis to climate change assessed based on Scenario 1 with a 20% increase in rainfall.
- Climate change Scenario 2 – model sensitivity to decrease in rainfall depths: A sensitivity analysis to climate change assessed based on Scenario 1 with a 20% decrease in rainfall.

Results from Scenario 1 (Figure 6.37) show K2E final void water levels are expected to be in equilibrium at approximately 416 m Australian Height Datum (AHD) during median conditions which is approximately 36 m deep. During dry climatic conditions the levels are approximately 2 m lower whilst wet climatic conditions shows that the level is 2 m higher at 418 mAHD. This is approximately 100 m below the spillway level and the final void is not expected to overtop.

The final void water levels for K4E are expected to be in equilibrium at approximately 469 m AHD during median climatic conditions (Figure 6.38), which is approximately 20 m deep. Similar to the K2E results, the wet climatic condition water levels are approximately 2 m higher than median conditions at 471 m AHD whilst dry climatic conditions showed the final void water level sat 467 m AHD. This is approximately 30 m below the spillway level allowing significant capacity to prevent the final void from overtopping.

The results for the Base Scenario with no water extraction were similar to those from Scenario 1, with final void volumes increasing by up to 2% for K2E and 4.6% for K4E. This relatively small difference is attributed to the extraction volume in Scenario 1 being only a small fraction of the total inflow and evaporation rates. In addition, the evaporation rates in the Base Scenario were higher than Scenario 1 due to the increased surface area of water in the voids.

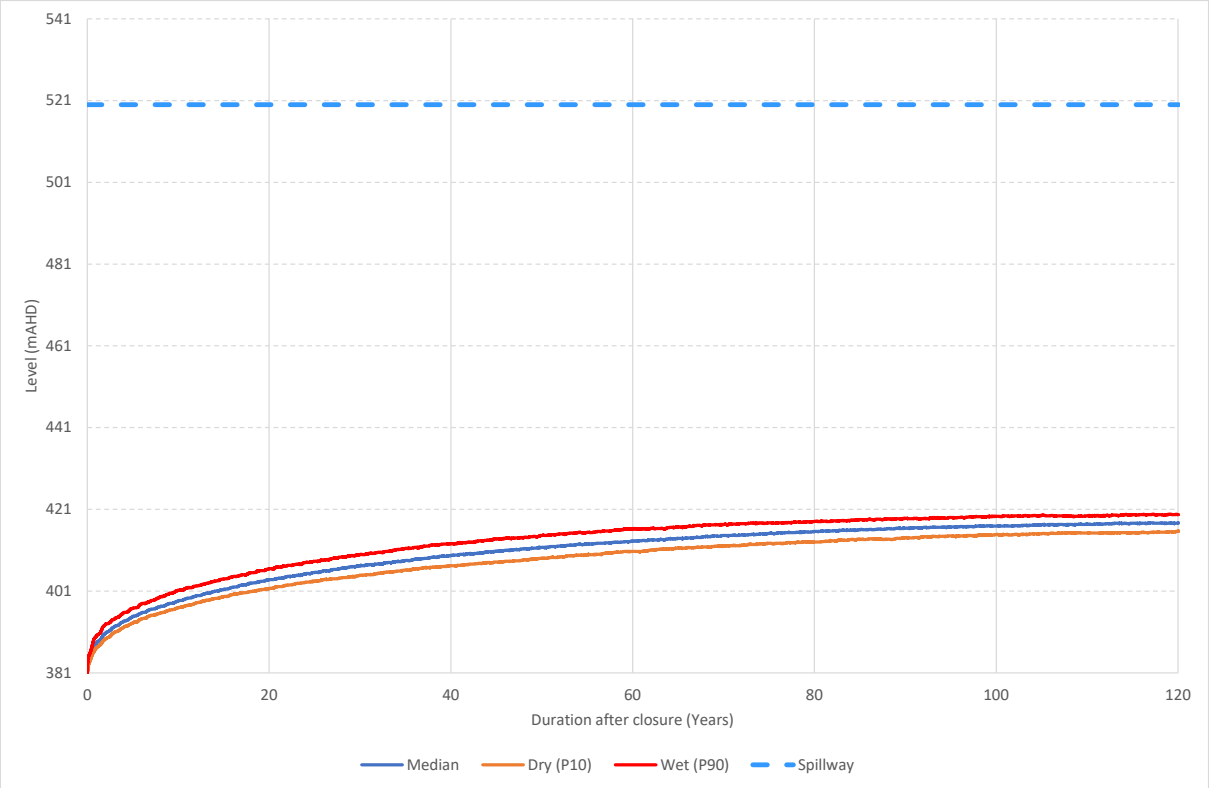


Figure 6.37 K2E Scenario 1 final void water levels

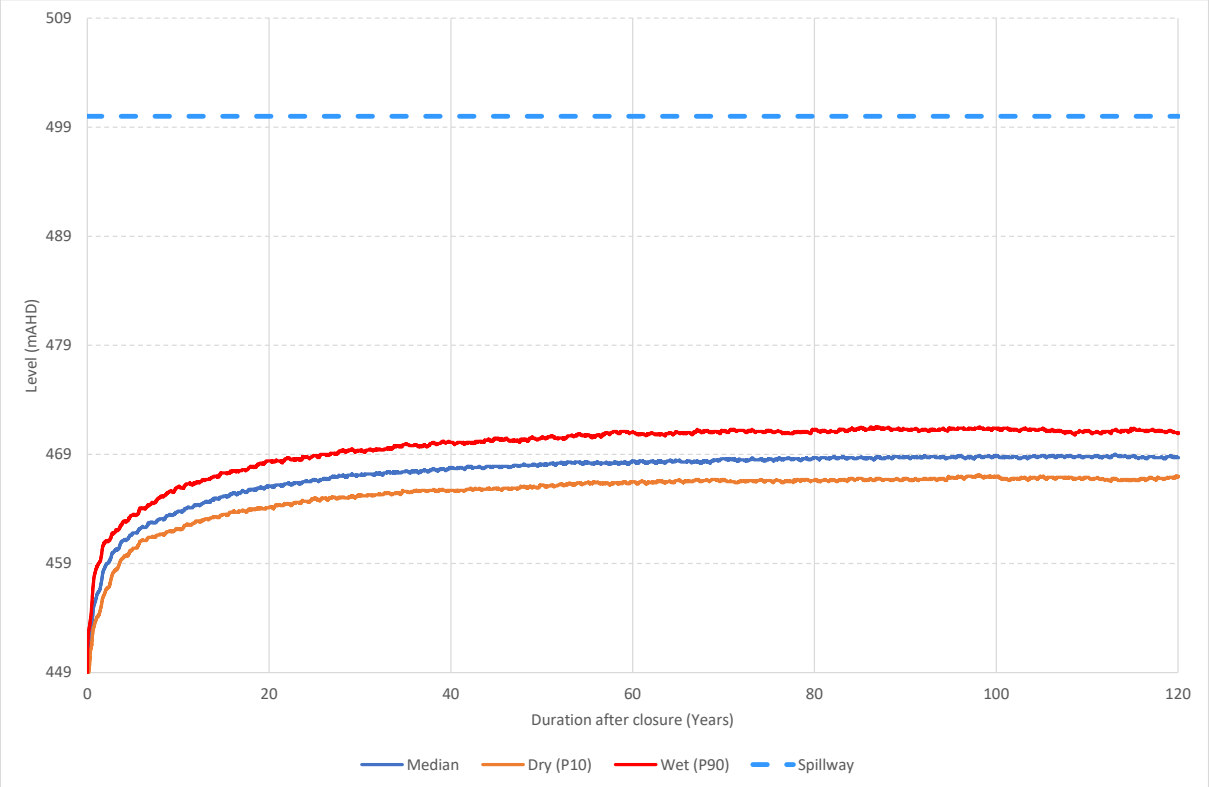


Figure 6.38 K4E Scenario 1 final void water levels

Scenario 2 for K2E resulted in much lower water levels in the final void stabilising at approximately 387 mAHD with a depth of 5–7 m during dry and wet climatic conditions, respectively. There was a negligible difference in the results for K4E in Scenario 2 compared with Scenario 1 due to the minimal impact of the water extraction in Scenario 1.

Climate Change Scenario 1 (20% increase in rainfall depth) resulted in final void water levels 15 m higher in K2E and 14 m higher in K4E compared with Scenario 1. This suggests that the results are sensitive to the 20% increase in rainfall although final voids maintained a low risk of overflow. Climate Change Scenario 2 (20% decrease in rainfall) resulted in water levels approximately 15 m and 8 m lower in K2E and K4E, respectively, with risk of overflow being very low.

The hydrological water balance model indicated water levels in both final voids were sensitive to the volume of water extracted and rainfall runoff; however, the risk of overflow of the voids was low for all scenarios. With the exception of Scenario 2, in which large volumes of stock water are extracted from K2E, water depths in the final voids equilibrate with water storage depths likely to be able to support Beef Cattle Grazing PMLU sustainably.

Numerical groundwater modelling was conducted which included aspects of final void surface and groundwater interactions, predicted changes to hydraulic heads, predicted cones of depression and projected inflows and outflows from the final voids. The modelling is discussed in detail in Section 6.1.1.2, with particulars relating to the final voids summarised in Section 9 of Appendix I – Meandu Mine PRC Plan Groundwater Technical Report.

In summary, the post-mining groundwater modelling predicts that the K2E final void will act as a sink receiving groundwater from approximately half of the mining area, including K4E final void, K4S and K2W-N backfilled voids used for coal combustion product and tailings storage, and part of Ramp 5 backfilled void. The results indicate that the risk of water stored in the final voids impacting on surrounding groundwater users is very low.

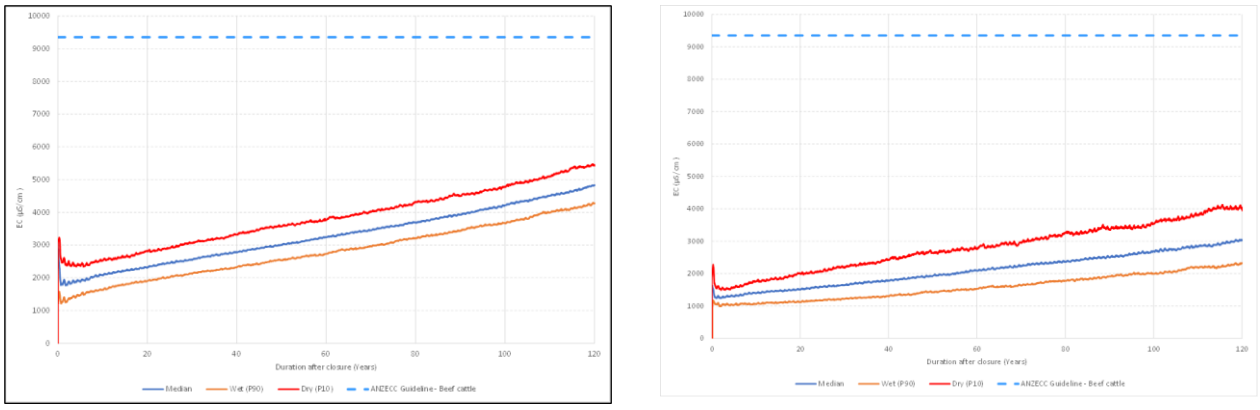
6.3.5.4 Hydrochemical modelling

As discussed in Section 6.1.1.4 contaminant transport modelling for the Meandu Mine was undertaken and run for Scenarios 1 and 2 as outlined in Section 6.3.5.3 above. The results of this modelling for the K2E and K4E final voids is presented below, with additional information provided in Section 10 of Appendix I – Meandu Mine PRC Plan Groundwater Technical Report.

Salinity

The predicted salinity in K2E final void over the modelled 120-year period for Scenario 1 is shown in Figure 6.39. The model shows that electrical conductivity (EC) levels increase up to 5,500 µS/cm. This is significantly below the criteria for Water Storage PMLU of 9,197 µS/cm (TDS of 5,000 mg/L ÷ 0.5436); suggesting that the water is of suitable quality for stock water demands for at least the 120 years modelled. The results for the Base Scenario showed a slightly more rapid increase in EC than Scenario 1.

It is noted that there is an ongoing slight upward trend in EC in Scenario 1 and the Base Scenario. This is understood to be due to the minimal clean/rehabilitated catchment runoff entering the void that can offset groundwater inflows and evaporation that increases the salinity. However, extrapolation of the trend shows that it is unlikely to breach the PMLU criteria for at least 200 years. The results for Scenario 2 showed a lower EC in the K2E void post-closure, stabilising at approximately 2,000 µS/cm, which is driven by the groundwater and surface water inflow ECs. This indicates that extraction of water from the void will prevent evapoconcentration and resultant increase of salinity.



K2E **K4E**

Figure 6.39 Scenario 1 EC in K2E and K4E final voids post-closure

The predicted EC in the K4E final void over the modelled 120 years for Scenario 1 is shown in Figure 6.39. The EC levels increase to up to approximately 4,000 µS/cm, which is lower than that modelled for K2E final void. This is significantly below the criteria for Water Storage PMLU, suggesting that the water is of suitable quality for stock water demands for at least 120 years. Similar to K2E results, there is an upward trend to the EC due to the minimal clean/rehabilitated catchment runoff entering the final void to offset evaporation that increases the EC. However, the trend shows that it is unlikely to breach the PMLU criteria for at least 400 years.

The results for the Base Scenario and Scenario 2 were very similar to the results for Scenario 1. This indicates the extraction of water for stock use modelled in Scenario 1 (2.08 ML/y) has very little impact on final void water qualities compared with no water extraction.

In the climate change scenario with an increase in rainfall of 20%, the EC of the K2E final void has an ongoing rising trend; however, the EC is only approximately 2,900 µS/cm after 120 years post-closure. This is a result of dilution by increased rainfall resulting in less evapoconcentration. The EC of the K4E final void in this scenario appears to stabilise at approximately 1,000 µS/cm after approximately 25 years post-closure. This is a result of dilution by increased rainfall from rehabilitated area resulting in less evapoconcentration.

The climate change scenario with a 20% decrease in rainfall resulted in a significant increase in K2E final void water EC, exceeding the Water Storage PMLU criteria within 100 years post-closure (Figure 6.40). The increase in salinity is a function of reduced rainfall depths and high evaporation rates. This is a pattern which is observed for regions with high evaporation rates and is exacerbated by the reduction in rainfall depths.

The climate change scenario with a 20% decrease in rainfall resulted in a significant increase in K4E final void water EC, exceeding the Water Storage PMLU criteria shortly after 100 years post-closure (Figure 6.40).

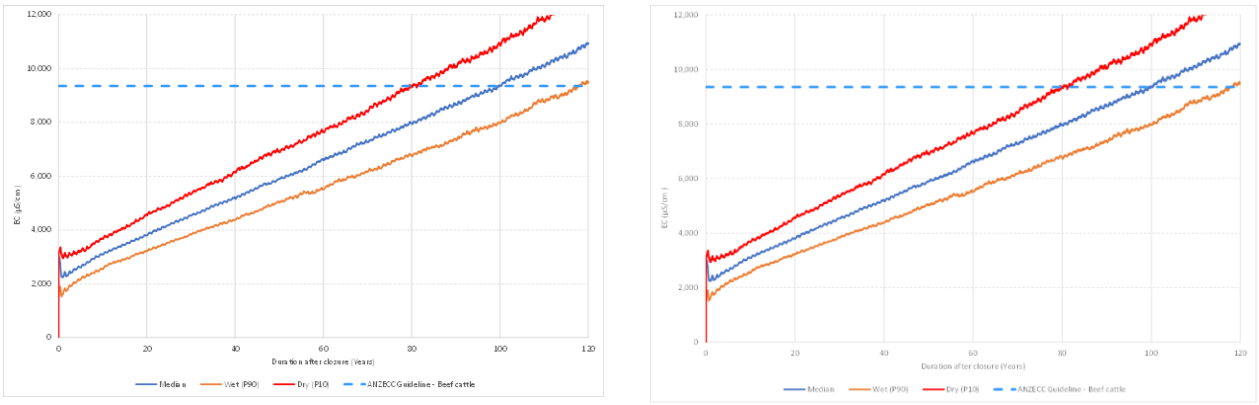


Figure 6.40 Climate change Scenario 2 EC in K2E and K4E voids post closure

Contaminants of concern

Predicted concentrations of potential contaminants of concern in the post-closure final void's surface waters are tabulated below in Table 6.20. The water quality results are presented showing the 10th, 50th and 90th percentile results for all predicted concentrations over the120 year simulation. Where relevant, the water quality criteria for Water Storage PMLU and ANZG livestock (beef cattle) drinking water (ANZG, 2018) are listed for comparison.

Table 6.20 Modelled contaminant concentrations in final voids at Meandu Mine

Potential Contaminant	K2E modelled concentration after 120 years (mg/L)			K4E modelled concentration after 120 years (mg/L)			Criteria	
	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile	PMLU criteria (mg/L)	ANZG Livestock drinking water Criteria (mg/L)
TDS	1,830	2,130	2,460	1,020	1,290	1,660	<5,000	–
Calcium	58.6	67.5	77.6	44.5	55.0	68.8	<1,000	–
Magnesium	109	126	145	67.6	83.2	102	<2,000	–
Nitrate	Not modelled as no groundwater data available						<400	-
Nitrite	Not modelled as no groundwater data available						<30	-
Sulfate	311	353	403	301	369	450	≤1,000	–
Cobalt	0.03	0.04	0.05	0	0	0	≤1	–
Nickel	0.04	0.04	0.05	0.05	0.06	0.08	≤1	–
Zinc	0.16	0.18	0.21	0.21	0.26	0.33	≤20	–

Potential Contaminant	K2E modelled concentration after 120 years (mg/L)			K4E modelled concentration after 120 years (mg/L)			Criteria	
Arsenic	0.001	0.001	0.002	0.0005	0.001	0.0015	<0.5	–
Boron	0.18	0.20	0.23	0.20	0.25	0.30	<5	–
Selenium	0.005	0.006	0.007	0	0	0	≤0.02	–
Molybdenum	0.002	0.002	0.002	0.004	0.005	0.006	<0.15	–
Fluoride	0.22	0.25	0.27	0.41	0.51	0.62	<2	–
Aluminium	1.09	1.26	1.45	0.57	0.69	0.84	–	<5
Beryllium	0.0004	0.0006	0.0007	0	0	0	–	Not determined
Cadmium	0.0002	0.0002	0.0002	0.0004	0.0005	0.0007	–	<0.01
Chromium	Not modelled as majority of surface water samples below detection limit						-	<1
Copper	0.008	0.009	Copper	0.008	0.009	Copper	–	0.008
Iron	20.1	23.8	27.8	0.38	0.49	0.64	–	Not sufficiently toxic
Lead	Not modelled as majority of surface water samples below detection limit						-	<0.1
Manganese	5.09	5.93	6.87	2.15	2.64	3.22	–	-Not sufficiently toxic
Mercury	Not modelled as majority of surface water samples below detection limit						-	<0.0001
Uranium	Not modelled as majority of surface water samples below detection limit						-	<0.2
Vanadium	0.011	0.012	0.014	0.019	0.023	0.028	–	Not determined

The results indicate that the concentrations for each analyte are not predicted to exceed the PMLU or ANZG water quality criteria, even at the 90th percentile. The final void water qualities are unlikely to contain contaminants of concern that will negatively impact on the PMLU of Water Storage for stock watering.

6.3.5.5 Stratification

Stratification modelling in the voids was considered to assess whether seasonal stratification occurs in the warmer months and the effect of annual mixing in the upper water column and lake turnover. The concern associated with stratification is the water quality which forms within the hypolimnion layer at depths below 20 m. During a lake turnover event, this water is fully mixed throughout the water column which can lead to a decline in water quality at the surface.

The modelling typically shows the change of water quality within the water column, typically with better quality freshwater at the surface. This modelling is helpful in understanding whether the better-quality water at the surface is appropriate to support a land-use, as well as quantifying the probability of a turnover event, and length of time where water quality may not be suitable for use.

The IWBM undertaken for the Meandu Mine (SLR (2022a) – Appendix I – Meandu Mine PRC Plan Groundwater Technical Report) showed that a completely mixed water column was not expected to exceed the Water Storage PMLU criteria for the TDS concentration of water used for watering stock. Therefore, it is considered that stratification modelling is not required to support the PMLU and has not been completed.

6.4 Underground mining

PRC Plan Guideline (Section 3.6.4)

For underground mining operations, the rehabilitation planning part must include:

- a geotechnical study
- an assessment of groundwater interactions and potential lowering of groundwater levels
- the development of a hydrogeological conceptual model
- subsidence analysis and modelling and a subsidence vegetation/habitat impact assessment
- consideration of how potential entries to underground workings will be sealed (i.e. through some form of capping or back filling)
- how surface ponding and cracking will be mitigated
- identification of post-closure stabilisation of underground workings in order to manage the potential for unplanned surface subsidence and unplanned ground collapse such as sinkholes and pot holing.

As there are no underground mining operations at the Meandu Mine, this section of the PRC Plan Guideline is not relevant.

6.5 Built infrastructure

PRC Plan Guideline (Section 3.6.5)

The administering authority's expectation of rehabilitation relating to built infrastructure is that it will be decommissioned, demolished, salvaged and/or disposed of unless it is being formally retained by the landholder to achieve an appropriate PMLU.

The rehabilitation planning part must include:

a identification of infrastructure that will be decommissioned and the methods for decommissioning
b a description of infrastructure that will remain post rehabilitation and the identification of ongoing maintenance requirements
c evidence of agreement for any infrastructure that will have ownership transferred.

6.5.1 Built Infrastructure introduction

As described in Table 2.20 the built infrastructure areas at the Meandu Mine comprise the following:

- infrastructure:
    - CHPP fixed plant, ROM and raw stockpiles
    - overland conveyor to Tarong power stations
    - administration and support services area
    - workshop/store area
    - gatehouse
    - tyreshop and Bucketshop; and
    - storage sheds associated with Dragline Shutdown Area
- support services:
    - power – incoming line
    - power – Site TX and switchboard, internal lines
    - raw water system
    - sewage farm
    - fuel farm and
    - explosive compound
- water management infrastructure (e.g. diversions, drains, dams and water storages).

Under schedule 4 of the EP Act, the lessee of a leasehold property granted under an Act is considered the owner, and therefore landholder, of that property. Under the *Lands Act 1994*, TEC Coal is the lessee of leasehold properties associated with the existing surface rights area and the K2E ASA within the resource tenure of ML6674. For the purposes of this PRC Plan and associated schedule TEC Coal is the owner and landholder.

6.5.1.1 Rehabilitated built infrastructure areas

Due to the ongoing and progressive nature of mining, the infrastructure areas will be required up to the cessation of mining activities (with some required for closure activities). Accordingly, TEC Coal will seek to decommission and rehabilitate all applicable areas consistent with this PRC Plan as soon as practicable.

A majority of the built infrastructure will be decommissioned, demolished and disposed of after the cessation of coal mining operations (FY2037). Other items are retained to support the completion of bulk waste movement to achieve final landform design (FY2041), and subsequently a subset of this infrastructure is required to support ongoing monitoring and maintenance of rehabilitation until achievement of RM9 for all PMLUs.

At the cessation of mining there are approximately 3 years of bulk reshaping to be undertaken to achieve the planned final landform for the Meandu Mine site. This work will be undertaken with a mining fleet similar to that utilised during the mining operations period of the Meandu Mine. Consequently, the demolition schedule removes the infrastructure associated with the mobile fleet and dragline maintenance after the completion of the bulk reshaping activities.

6.5.1.2 Retained infrastructure areas

No infrastructure is proposed as Landholder Retained Infrastructure, and accordingly there is no allocation of this PMLU in the Meandu Mine PRC Plan.

There are therefore no requirements under the *Mineral Resources Act 1989* to seek approvals for retained infrastructure from landholders or Government authorities.

In accordance with the Meandu PRC Plan Risk Assessment, freeholding of current leasehold lands held by the Department of Resources and DES (Parks) within the surface rights area is expected to proceed and to be finalised prior to EA and ML relinquishment. In conjunction with the lands already owned by Stanwell, this will result in all lands within the surface rights area being owned by Stanwell prior to EA and ML relinquishment.

6.5.1.3 Permanent infrastructure not related to mining

A number of items of infrastructure have been installed within the boundary of the ML by parties other than TEC Coal Pty Ltd and are owned, operated and maintained by these parties. They include:

- Powerlink high voltage transmission lines
- Gazetted and private roads or forestry tracks and creek crossings including:
    - Nobby Smith Way
    - Power Station Road
    - Ridge Road
    - Nanango-Neumgna Road
    - Sander Road
    - Tarong-Yarraman Road; and
    - Lewis Road.

The majority of these items lie within the area of the ML undisturbed by mining. None of this permanent infrastructure will be demolished and rehabilitated as part of the Meandu Mine PRC Plan as it is either not owned by TEC Coal Pty Ltd; is licensed under authorities other than the Meandu ML; is not mining related infrastructure; or has owners other than TEC Coal Pty Ltd.

Exceptions are Sander Road, Ridge Road and a section of the Tarong-Yarraman Road within the surface rights/K2E ASA, which will be closed and mined through as a result of mine plan pit progression, and subsequently rehabilitated and allocated a PMLU.

6.5.1.4 Permanent infrastructure as part of the Beef Cattle Grazing PMLU

Meandu Mine is currently accessed from the Nanango – Tarong Road via Nobby Smith Way, a gazetted public and sealed road which terminates at the boundary of the ML. Within the ML, a private road, inclusive of a crossing of Meandu Creek, provides connection from the end of Nobby Smith Way to the current mine administration and industrial area. As outlined in Section 6.5.1.3, this public road and associated easement will remain in place post mining. Retention will be to the benefit of the Beef Cattle Grazing PMLU and improvement to the associated land.

This road will be utilised for activities including:

- connectivity from the property to Nanango – Tarong Road (a gazetted stock route)
- general access to the property
- all weather semi-trailer size delivery of essential supplies and goods to support the property (e.g., supplies, weaner cattle, feed and fertiliser); and
- semi-trailer transport of fattened cattle off the property for sale.

To facilitate receipt and dispatch of cattle from the property, a cattle holding yard will be established within the northern end of the Beef Cattle Grazing PMLU in proximity to Nobby Smith Way.

Preservation of the private section of the road extending from the ML boundary to the mine infrastructure area will both benefit the Beef Cattle Grazing PMLU and improve the associated land. The road and Meandu creek crossing have been designed to relevant standards, are established, stable and well maintained. They are also appropriately located. Were they to instead be demolished and rehabilitated post mining, then they would need to be replaced to facilitate all weather access to the Beef Cattle Grazing PMLU, causing further disturbance to Meandu Creek and unnecessary expense.

The road will also be used to facilitate incidental access to the property for ongoing maintenance and inspection activities, for example, fire trail inspection and maintenance in the Native Ecosystem PMLU.

6.5.1.5 Essential management infrastructure for PMLUs

No items with potential to cause a material negative impact on the relevant PMLUs will be retained post closure.

6.5.1.6 Other constructed features

Minor items that form an essential part of safely operating and maintaining the PMLUs will be developed and maintained on site post closure. Examples of these features include:

- fire management, weed management and general access trails and the associated minor crossing points in gullies
- dams that are incorporated into the final landform design and are considered a part of the landform of the encompassing PMLU
- fencing (as required); and
- safety bunding and land shaping at the stable crest of the Steep Rocky Ecosystem areas which forms part of the landform design.

These items are essential to the development of the underlying PMLUs and by enabling the establishment of the relevant PMLU and the underlying stable landform, to the benefit of the community.

Pumps and water supply lines required for cattle watering, including header tank and troughs may be installed prior to or after the surrender of the EA and ML. Stock fencing will be constructed where required to define laneways, paddocks and to exclude stock from dams and lakes.

6.5.2 Identification of infrastructure that will be decommissioned

To facilitate accurate scheduling the built infrastructure was categorised into 5 broad groups (Demolition Areas) primarily based on the period in the rehabilitation sequence that they would be demolished, but also considering the geographic relationship of the infrastructure. The resulting areas groups are outlines in Table 6.21, with the general areas of categorisation shown in Figure 6.41 (excluding Area 6 as this is a general category for the smaller infrastructure items located across the surface rights area outside of the main infrastructure area).

Table 6.21 Built infrastructure demolition areas and description of timing / sequence

Demolition area	Description	Commencement of demolition sequence
1	Parking, gatehouse and administration	At end of rehabilitation and removal sequence after cessation of mining. The parking and gatehouse will be one of the last items in the demolition sequence to ensure safety and security during the decommissioning and rehabilitation process.
2	Main maintenance workshop and associated infrastructure and out-buildings	At end of main rehabilitation reshaping process and cessation of need to maintain the mobile fleets and dragline.
3	Coal handling and preparation plant and associated infrastructure and out-buildings	After the cessation of coal washing and clearing of all stockpiled ROM and RAW coal.
4	Dragline shutdown facilities and associated infrastructure and out-buildings	At end of main rehabilitation reshaping process and cessation of need to maintain the mobile fleets and dragline.
5	Explosives storage and mixing facilities	At the completion of all blasting associated with the reshaping and rehabilitation process.
6	Miscellaneous field-based items	As soon as is practicable and/or when no longer required for maintenance or monitoring activities.

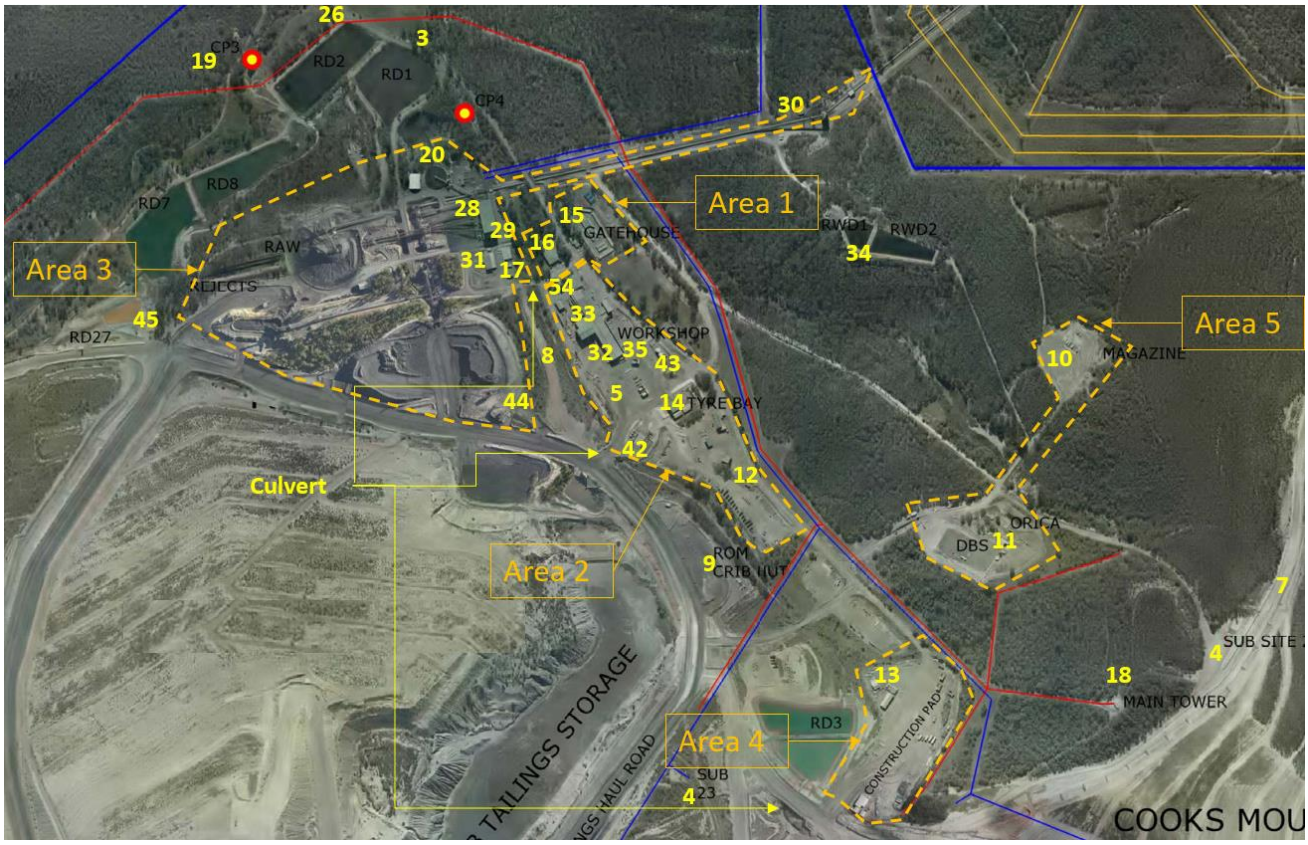


Figure 6.41 Map showing generic built infrastructure areas 1-5

The following sub-section contains a more detailed description of each Demolition Area.

6.5.2.1 Demolition areas

Area 1: Parking, gatehouse and administration

Area 1 covers the buildings and parking areas at the entry to the site. These facilities will be maintained until all other demolition and rehabilitation works on the site have been completed, giving a safe point of entry, nominated parking location for workers, and an office in which to continue the computer systems and planning/supervisory tasks required during the rehabilitation works. The administration building is located immediately adjacent to the gatehouse and carpark area and is the current location of the server and information technology systems.

Area 2: Main maintenance workshop

Area 2 includes the main mobile fleet workshop, the parts store, the maintenance planning office, the washdown facility, tyre changing bay, fuel storage tanks, the heavy metal work/bucket workshop and the associated hardstand areas. The workshops and associated facilities are required throughout the reshaping period of the rehabilitation after the cessation of coal mining to maintain the mobile fleet of excavators, trucks and ancillary gear undertaking the rehabilitation work.

Area 3: Coal handling and Preparation Plant (CHPP)

Area 3 is the CHPP and associated areas, including but not limited to the ROM stockpiles, RAW stockpile, Rejects Stockpile areas, the conveyor belt stacking and reclaiming system and the conveyor system that transports product coal to the Tarong power stations. This area will be decommissioned, demolished and removed from site once all the ROM and RAW coal has been passed through the CHPP following the cessation of coal mining.

Area 4: Dragline shutdown pad

Area 4 constitutes the dragline shutdown pad and the associated surrounding built infrastructure such as the shutdown offices and crib huts, multiple storage sheds and park-up areas. This area will be needed post the cessation of mining to continue to maintain the dragline during the bulk reshaping period of the rehabilitation and then decommission the dragline at the end of its useful life. The dragline will be decommissioned, deconstructed and removed from site. Once this task is completed the dragline shutdown pad and the associated built infrastructure will be demolished and removed from site.

Area 5: Explosives storage and mixing facilities

Area 5 is the explosives storage and mixing facilities that are located separate to the other major areas of built infrastructure at the mine. These facilities will be maintained and utilised during the bulk reshaping period of rehabilitation after the cessation of mining as various areas will require blasting during this period. Once the need for explosive treatment of rehabilitation areas ceases these areas will be decommissioned, demolished and removed from site.

Area 6: Miscellaneous field-based items

Area 6 is a generic grouping of the field-based items spread across the surface rights area and utilised to support either the mining and rehabilitation earthworks activities, or maintenance and monitoring of the water systems or rehabilitation process on the site. This includes items such as:

- communication systems
- crib-huts
- water monitoring systems for both groundwater and surface water
- pumping systems for dirty and clean water systems; and
- ash slurry and return water pipeline/pumps associated with the K4S ASF.

These items will be maintained until they are no longer required for maintenance or monitoring of the rehabilitation process.

6.5.3 Methods for decommissioning

A detailed schedule and scope of work for the demolition of all built infrastructure, and the dragline, has been generated for this PRC Plan. TEC Coal engaged a specialist demolition contractor, Liberty Industrial, to undertake this work.

All built infrastructure will be assessed by a suitably qualified and experienced person prior to any demolition. Removal of hazardous materials and disposal to an appropriately licensed waste facility will be explicitly included in the scope. A decommissioning checklist will be completed for each scope of work, and a failure to meet any of the checklist items will trigger remedial action or further investigation as appropriate. The detailed checklist will need to be finalised once the demolition contractor is appointed, but an example generic checklist that will form the basis of the process is shown in Table 6.22. The applicable rehabilitation milestone for the monitoring of progress and achievement of the built infrastructure removal is RM1.

Table 6.22 Generic checklist for demolition

Checklist item	Description
1	Induction and training on site
2	Work method statement developed
3	Management plans submitted
4	Subcontractor engagement
5	Approval to commence and site control granted
6	Fencing delineation and demarcation complete
7	Testing and inspection of service disconnections, de-energising, de-gassing and decommissioning
8	Verification of isolations (confirmation of air-gaps, etc.)
9	Make safe-works (propping, scaffolding, bracing, removal of excess fluids/gas)
10	Pre-weakening completed
11	Induced collapse
12	Concrete excavation
13	All demolished materials are processed and loaded out
14	All foundation works are completed and inspected
15	Final grading and site tidy up
16	Check all items have been removed from site
17	Remove all machinery and equipment
18	Client site walk and hand-back of site

The checklist for each area will include sufficient information to allow clear location of the area on a site map, the footprint (area) that has been decommissioned as well as the applicable dates and personnel.

6.5.3.1 Key demolition steps

CHPP and PLO bin areas

The major structures at Meandu Mine are large and complex and will be demolished only after structural engineering calculations and consultations have been undertaken.

The key sequence steps for decommissioning and removal of the built infrastructure are:

- conveyors will be mechanically demolished using appropriately sized excavators with shear attachments. The conveyors will be cut into sections and collapsed in a controlled drop zone. Alternatively, a cut and pull method may be suitable following detailed assessment during the site investigation and planning phase of the demolition works
- the thickeners are likely to be demolished using a top-down demolition approach, utilising an excavator with a shear attachment
- housing structures (e.g., the warehouse and control room and substations) will be demolished utilising a conventional mechanical demolition methodology as per the other structures on site
- the PLO and associated conveyor and structures will be mechanically demolished
- all structures, once brought down to the designated drop zone(s), will be further downsized with appropriate excavators until they are suitable for loading and removal from site using articulated dump trucks.

Key demolition steps – other built infrastructure

The other built infrastructure areas are planned for removal using conventional mechanical demolition methods. The key sequence steps for decommissioning and removal of the remaining built infrastructure are:

- structures will be cut and pulled to the ground utilising appropriately sized excavators with shear and grab attachments
- once the structures are located on the ground in the appropriate drop zone, the collapsed structures will be further downsized with appropriate excavators until they are suitable for loading and removal from site using articulated dump trucks
- concrete hardstands, plinths, and slabs will be demolished and excavators using excavators with hammer and bucket attachments
- access roads will be demolished with a grader
- any contaminated soil will be separated from uncontaminated soil. Contaminated soil will then be stockpiled and treated as per the steps detailed in Section 6.5.6; and
- all construction demolition waste will be transported and disposed off-site at facilities that are appropriate to receive the waste in question.

Key demolition steps – Dragline

The dragline is not technically part of the built infrastructure of the mine but is an item that is on such a scale that the decommissioning and removal of it from site at the cessation of its use is closer in alignment to the removal of built infrastructure than the other mobile equipment fleets on site.

The key sequence steps for decommissioning and removal of the Dragline are:

- removal of all greases, oils, fluids etc including those located in generators, motors and plants are removed and stored. All services to be de-energised and disconnected
- removal of all plant and equipment within the dragline house
- A-frame, mast and boom to be collapsed, potentially using cutting charges on the appropriate connection joints, as designed by a suitably qualified and experienced person, into a controlled drop zone. Alternatively, if appropriate, a cut and pull methodology may be utilised to demolish the A-frame
- the external house wall and tub will be mechanically demolished, inclusive of periodic degreasing as required
- the collapsed structure of the dragline will be further downsized with appropriate excavators until they are suitable for loading and removal from site using articulated dump trucks.

6.5.3.2 Demolition sequence

The demolition sequence explicitly considers the following:

- the timing of the landform reshaping and rehabilitation across the operational mine pits and the need for the built infrastructure to support these activities
- contingency for weather events of a severity that delay or prevent demolition activities for a period of time
- removing any built infrastructure as soon as is practicable after the cessation of mining
- contingency for the sourcing and transport to site of the key personnel and skills required to undertake the decommissioning, demolition and removal from site of the built infrastructure; and
- splitting the built infrastructure into different categories that reflect their useful life after the cessation of mining.

A detailed schedule for the demolition of the infrastructure was created from the above inputs (refer Table 6.23). This schedule includes a separate time allowance for each of the 5 main infrastructure groupings that apply to the main infrastructure area of the mine (Demolition Areas 1–5). This schedule underpins the timings shown in the PRC Schedule for the applicable rehabilitation areas. The rehabilitation milestone RM1 covers the removal of built infrastructure.

Table 6.23 Built infrastructure demolition sequence

Demolition area	Name	Demolition commences	Demolition timeframe
1	Parking, gatehouse and administration	2044	2 years
2	Main maintenance workshop and associated infrastructure and out-buildings	2042	2 years
3	Coal handling and preparation plant and associated infrastructure and out-buildings	2039	2 years
4	Dragline shutdown facilities and associated infrastructure and out-buildings	2042	2 years
5	Explosives storage and mixing facilities	2041	2 years
6	Miscellaneous field-based items	2038	10 years

Minor built infrastructure items necessary for the monitoring of rehabilitation

Several items of built infrastructure are necessary to continue in operation until the final certification of the site and surrender of the PRC Plan is actioned. These items include several groundwater monitoring bores, surface water monitoring points and sediment retention basins and dams that function to ensure appropriate water quality is achieved for discharges from the site during the period of rehabilitation establishment. For clarity:

- it is not intended for these items to prevent the remaining rehabilitation milestones from being achieved for the rehabilitation area in question; and
- the areas impacted by these items of infrastructure will be rehabilitated in accordance with the description of activities and criteria outlined in Section 6.5.3 of this PRC Plan.

These specific items have not been allocated to an individual RA as to do so would be functionally unworkable across the site and the framework of the PRC Plan, and it is judged unnecessary, given that the commitment to rehabilitation and the necessary planning to do so is included within the PRC Plan Schedule and the footprint of each of these monitoring and performance items is very small in the context of each RA within which they exist.

It is intended that the rehabilitation milestone RM1 applies to the following rehabilitation areas as shown in the PRC Plan Schedule:

- RA1 (Beef Cattle Grazing); and
- RA4 (Native Ecosystem).

6.5.4 Description of infrastructure that will remain post rehabilitation

Other than permanent or essential management infrastructure that will be incorporated into PMLUs, there is no other retained infrastructure proposed for Meandu Mine.

6.5.5 Identification of ongoing maintenance requirements

As there is no retained infrastructure, there are no ongoing maintenance requirements.

6.5.6 Management of residual contamination

The following specific areas within the infrastructure areas have been identified as potentially containing spillage or accumulation of hazardous substances that may result in contamination of the soil:

- PAF material beneath the coal/rejects stockpile areas excavated/hauled to PAF dumps
- explosives/ammonium nitrate storage areas
- hydrocarbon spills in proximity to the refuelling areas on the maintenance workshop hardstand and bulk fuel storage area; and
- chemical storage areas.

In 2021, a preliminary investigation was undertaken at Meandu Mine to investigate the potential for contamination from Per-and polyfluoroalkyl substances (PFAS). The investigation focussed on select areas on the mine lease where the use of fluorosurfactants (e.g., AFFFs) may have inadvertently caused contamination during fire-fighting training. The points of interest at Meandu Mine included assessment of water quality from select groundwater bores and surface waters of the Meandu Creek system. Results from the preliminary investigation concluded that there was no evidence of any such contamination. A second investigation has been planned to examine potential PFAS contamination in soils targeting the same select areas (where achievable) on the mine lease. Results from this study are expected by the end of CY2022. It is anticipated that no issues of contamination will arise from the soils investigation.

Prior to the decommissioning of the infrastructure areas a review of potential contamination associated with the site shall be undertaken as an initial National Environmental Protection (Assessment of Site Contamination) Measure 1999 (amended 2013) compliant desk-based preliminary site investigation (PSI). The PSI will identify Queensland Environmental Management Register, Contaminated Land Register and regulatory licences applying to the Meandu Mine lot/plans, site history, review of available site contamination reports/investigations and information related to chemical holdings such as waste management plans for hazardous waste.

A preliminary site contamination conceptual site model shall be generated from the PSI, considering water (ground and surface), sediment and soil from potential source areas and identify potential contamination impacts and exposed receptors through a source-pathway-receptor model.

The PSI will identify gaps in the existing site database and establish whether sufficient site contamination data exists to undertake a tier 1 risk assessment in order to determine whether remediation of contamination on site (if any) is required. If significant data gaps are identified, then a detailed site investigation(s) may be required to firm up the contamination data set, such as soil, groundwater and surface water sampling.

The site contamination data available will be used to develop remediation options assessments and/or remediation action plan(s) for areas of identified contamination if necessary.

Contaminated areas will be remediated with methodologies identified in the remediation options assessments, and verification testing undertaken as per rehabilitation milestone RM2.

Potential remediation strategies may include:

- excavation of the material immediately beneath coal/ rejects stockpile areas and disposal within mine plan scheduled PAF dump locations
- bioremediation of hydrocarbon-contaminated material in the site bioremediation facility
- in-situ bioremediation where assessed as appropriate; and
- decontamination of explosives/ammonium nitrate storage areas and chemical storage areas during the decommissioning and demolition process.

The presence of potentially contaminating mine waste in the final landform may mean that the relevant lot/plans remain on the Environmental Management Register under a contaminated Site Management Plan, which will be developed by a Suitably Qualified Contaminated Land Professional as defined in the EP Act (1994) and approved by a Queensland registered Contaminated Land Auditor. The Site Management Plan will be aligned to the success criteria for the PMLUs.

7 Risk assessment

Legislative requirements:

In accordance with section 126C(1)(f) of the EP Act, the rehabilitation planning part of the PRC plan must identify the risks of a stable condition for land described as a post-mining land use not being achieved, and how the applicant intends to manage or minimise the risks.

PRC Plan Guideline (Section 3.7)

As per section 126C(1)(j) of the EP Act, the administering authority considers it necessary for the proposed PRC plan to contain a risk assessment of all proposed NUMAs. The risk assessment must be carried out to identify the risks of the NUMA causing environmental harm and not being safe and structurally stable and detail how the applicant intends to manage and minimise the identified risks.

The AS ISO 31000:2018 Risk Management – Guidelines (Standards Australia, 2018) describes risk assessment as the overall process of risk identification, risk analysis, risk evaluation and risk treatment. Each of these aspects must be included in the risk assessment in the rehabilitation planning part.

Information requirements in this section apply to all applicants whether or not they are an existing EA holder. Existing holders may have the required information available from previously submitted plans/reports/applications that, if still valid, can be used in the PRC plan.

7.1 Risk assessment framework

A wholistic approach was taken to assessing both the risk of PMLU success for Meandu Mine and the overall risk to the delivery of the PRC Plan process. The risk assessment framework utilised is in accordance with AS/NZS ISO 31000:2018 Risk Management – guidelines.

In line with AS/NZS ISO 31000:2018 Risk Management – guidelines the following process was followed:

- scope definition
- risk assessment preparation
- risk identification
- risk analysis (risk ranking)
- risk evaluation
- risk treatment
- measure and review of short-term actions; and
- risk review and update.

Stanwell's Corporate Risk Assessment standard was utilised which is aligned with AS/NZS ISO 31000:2018 Risk Management – guidelines.

7.1.1 Meandu Mine PRC Plan risk assessment

The Meandu Mine PRC Plan risk assessment process was undertaken over an 18-month period, commencing in October 2020 and finishing in March 2022.

The process was designed to include the period in which supporting technical studies were conducted through to completion of PRC Plan, including iteration(s) and review to enable the inclusion of new findings from studies and any input from other associated activities including guidance from regular DES consultation on the Meandu Mine PRC Plan development.

The initial risk identification and assessment workshops in 2020 enabled both appropriate actions to be identified and the scoping of the technical studies required to support the PRC Plan. The resulting tasks were then tracked and reported against by the Meandu Mine PRC Plan Project team during the PRC Plan development.

At the conclusion of the technical study programs, the identified risks were re-assessed and any required additional treatments identified as necessary to achieve an acceptable residual risk were documented and included in a revised document.

A further iteration of the risk assessment process was then undertaken between January 2021 and January 2022 to address any new or developing concerns identified during, or by, the technical study program (and/or as a result of guidance from DES consultation). This iteration concluded by re-ranking all original and newly identified risks (inclusive of treatments implemented to this point in time) in order to assess residual risk. It also produced a list of the required treatment measures to achieve these residual risks for consultation within TEC Coal.

Details of the risk assessment process are outlined in Table 7.1.

Table 7.1 Major steps in the PRC Plan Risk Assessment Process for Meandu Mine

Step	Process	Timeframe	Detail
1	Risk Identification	October 2020 – December 2020	Preparation for, and undertaking, a 2-day workshop with 14 cross-functional attendees representing internal and external experts in ecology, mine planning, environmental compliance, business planning, revegetation and rehabilitation. Facilitated by Stanwell Corporate Risk and Compliance specialist(s).
2	Risk Analysis and Evaluation	January 2021 – February 2021	5 Workshops, 16 Attendees with experts covering: • strategic and business items • planning and long-term impacts • short-term execution • rehabilitation planning; and • community and engagement.

Step	Process	Timeframe	Detail
3	Risk Treatments	February 2021	Assignment of specific technical and business scopes of work to deliver actions identified in the risk assessment workshops (steps 1 and 2 above). Actions assigned and tracked in internal Stanwell compliance system by PRC Plan Project team.
4	Technical Studies	January 2021 – January 2022	Technical studies undertaken to support this PRC Plan submission and address identified areas of risk.
5	Updated Risk Summary and Identification	February 2022	Re-assessment of existing risk assessment and results of technical studies.
6	Risk Analysis and Evaluation	February 2022	Review of existing risk items and assessment of risks and concerns identified during /by technical studies. Ten (10) attendees representing internal and external rehabilitation, planning, water and geochemistry specialists. Facilitated by Stanwell Corporate Risk and Compliance specialist.
7	Risk Treatments	February 2022	Assessment and commitment to milestones and SMART criteria in the PRC Plan Schedule to ensure appropriate management of identified risks to PMLU success.

Further details about the risk identification process is provided in Section 7.2, the risk analysis process in Section 7.3 and the risk evaluations and treatments in Section 7.4. Table 7.6 shows the results of the qualitative risk assessment process including the committed risk treatments to achieve a suitable risk to the success of the PMLUs.

7.2 Risk identification

A complete set of risks was identified and addressed by running risk identification workshops comprising a broad range of participants with different expertise and experience. The identification process included a tour of the Meandu Mine site and presentations outlining the rehabilitation and planning processes. Participants included both internal and external experts in the fields of commercial analysis, rehabilitation planning, landform design, erosion assessment, water assessments, mine and business planning.

A second risk identification process was undertaken 12 months later following the completion of the majority of the technical studies that underpin the PRC Plan submission, and included consideration of consultation with DES. This ensured that any new concerns identified in the technical work were appropriately assessed and evaluated using the same process as the initial risk assessment. Experts in each of the technical areas were asked to identify areas of concern or risk pertaining to their scope of work, and where these were not adequately assessed in the initial process, they were included in the February 2022 re-assessment process. A generic risk of delays due to various causes was also considered.

7.3 Risk analysis

Risk comprises both the likelihood that something will occur and the consequence of it occurring. When combined in a qualitive ranking system, each risk can be ranked to assign its relative importance and priority for treatment.

To assist with the assessment and classification of risks, the Stanwell risk matrix shown in Table 7.2 was utilised. The matrix facilitates consideration of the category of likelihood against the category of consequence. Information about the Stanwell Risk standard likelihood categories is provided in Table 7.3, and the Consequence Categories in Table 7.4.

Table 7.2 Risk rating heat map used in the assessment and evaluation process

	Impact level				
Likelihood	**(1) Low**	**(2) Minor**	**(3) Moderate**	**(4) Major**	**(5) Severe**
Almost certain (A)	Medium (7)	Medium (14)	High (20)	Extreme (23)	Extreme (25)
Likely (B)	Low (6)	Medium (13)	High (19)	Extreme (22)	Extreme (24)
Possible (C)	Low (5)	Medium (12)	High (15)	High (18)	Extreme (21)
Unlikely (D)	Low (3)	Low (4)	Medium (9)	High (16)	High (17)
Rare (E)	Low (1)	Low (2)	Medium (8)	Medium (10)	Medium (11)

Table 7.3 Categories of likelihood used in the assessment and evaluation process

Likelihood	**Description**	
	Probability	**Frequency**
Almost certain (A)	>95%	The consequence will **almost certainly** occur within the timeframe of assessment.
Likely (B)	>70 to 95%	The consequence **will likely** occur within the timeframe of assessment.
Possible (C)	>30 to 70%	The consequence **may possibly** occur within the timeframe of assessment.
Unlikely (D)	>5 to 30%	The consequence is **unlikel**y to occur within the timeframe of assessment.
Rare (E)	≤5%	The consequence is **highly unlikely** to occur to occur within the timeframe of assessment.

Table 7.4 Categories of consequence used in the assessment and evaluation process

Impact level	Examples of category – Health and Safety, Environmental, Reputation and Culture, Compliance and Legal
Severe (5)	*Fatality* or *Serious Injury with permanent impairment* (as defined by the *Work Health Safety Act 2011* (Queensland)). Widespread contaminant release to air, water or land or noise emission where an area of high conservation value or special significance is affected. Results in irreversible environmental harm. Widespread impact and/or death of flora, fauna and/or species of interest or concern. Irreversible harm to significant Aboriginal area and/or significant Aboriginal object on authorised or unauthorised sites. Significant and recurring negative national and/or metropolitan media coverage relating to Stanwell's business activities. Widespread and/or continuous public criticism. Breach of legislative or regulatory obligation(s) for which there are significant fines and/or legal proceedings instituted by an external body or regulator. Multiple systemic and material compliance incidents or breaches.
Major (4)	*Serious Injury without permanent impairment* (as defined by the *Work Health Safety Act 2011* (Queensland)). Contaminant release to air, water or land or noise emission where an area of high conservation value or special significance is affected. Long-term remediation required. Localised impact and/or death of flora, fauna and/or species of interest or concern. Harm to significant Aboriginal area and/or significant Aboriginal object on unauthorised sites resulting in preventative remediation works. Negative national and/or metropolitan media coverage relating to Stanwell's business activities. Localised and/or short-term public criticism. Ongoing or repeated breach of legislative or regulatory obligation(s) for which there are major fines and/or investigations by an external body or regulator and/or enforceable undertaking issued or likely to be issued. Suspension of material licences, permits, approvals. Systemic material compliance incident or breach.

Impact level	Examples of category – Health and Safety, Environmental, Reputation and Culture, Compliance and Legal
Moderate (3)	Medical Treatment Injury (MTI) or Lost Time Injury (LTI) (that is, a Recordable Injury). Contaminant release to air, water, land or noise emission where a localised off-site area is affected. Short term remediation required. Unauthorised death and/or disturbance of flora, fauna and/or of a species of interest or concern. Negative regional media coverage relating to Stanwell's business activities. Public reaction contained at a local level. Breach, repeated breaches or ongoing breaches of legislative or regulatory obligation/s for which there are moderate fines issued or likely to be issued and/or administrative action taken by a regulator to prevent or rectify the breach/s (e.g. environmental evaluation). Multiple non-systemic compliance incidents or breaches. Intentional and/or repeated breach of Stanwell's Code of Conduct and/or underlying policy framework where there is no investigation and/or enforcement action by an external body.
Minor (2)	First Aid Case: Minor work-related injury or illness requiring first aid treatment (for example, removal of foreign bodies from wound or minor sprains and strains). Contaminant release to air, water or land or noise emission where an on-site area is affected. Minor remediation required. Injury to species of interest or concern. Unauthorised clearing or removal of flora and/or fauna (excluding species of interest). Little or no adverse media coverage in relation to Stanwell's business activities Breach of legislative or regulatory obligations(s), that requires notification to a regulator or external body and/or results in a minor fine and/or further action from a regulator (e.g. issuing of a warning notice, infringement notice or letter from a regulator). Complaint(s) received from the local community and/or concern expressed by local opinion leaders.
Low (1)	Report Only injuries/illnesses; No treatment has been provided as the result of the work-related event/injury or no event/injury has occurred, but treatment is sought to prevent an injury occurring (e.g. discomfort in shoulder, small 'surface splinters' or preventative eye washes). Contaminant release to air, water or land or noise emission within designed controls where there is localised site-based nuisance – on site area affected. Routine short-term controls required. Unauthorised and unintentional disturbance or entrapment of native fauna. Inquiries, questions and/or concerns from the local community. Immaterial and non-intentional breach of legislative or regulatory obligation(s) where a fine is unlikely; Notification to regulator not required. Questions by a regulator relating to a potential non-conformance or non-compliance with legislative or regulatory obligation(s) for which no further action is taken.

7.4 Risk evaluation/treatment

The risk evaluation and treatment (where deemed necessary to lower the residual risk ranking) was undertaken across the comprehensive list of risks developed during the risk identification processes.

The evaluation was undertaken within the framework of likelihood and consequence as outlined in Section 7.3, and considered the impact of any potential for delay, enhancement or acceleration of the PMLU success. The different sources for the risk, their potential consequence and their impacts (both positive and negative) were considered in the assessment process.

The risk treatment is summarised in Table 7.6, including the justification of the treatment(s) selected, the resource requirements, performance measures, the reporting and monitoring requirements as well as the timing and scheduling as applicable to the PRC Plan Schedule. The risks were identified and ordered to align with the nine rehabilitation milestones, with the additional topic of community and stakeholder consultation. Table 7.5 lists the nine rehabilitation milestones for ease of reference. For detail on these milestones and their associated criteria and SMART justification, refer to Table 9.2 in Section 9.

Table 7.5 Summary of rehabilitation milestones for ease of reference to risks

Milestone reference	Rehabilitation milestone
RM1	Infrastructure decommissioning and removal
RM2	Investigation and/or remediation of contaminated land
RM3	Installation of cover system over ash and tailings storage facilities
RM4	Landform development and reshaping
RM5	Surface preparation
RM6	Revegetation (all applicable PMLU's)
RM7	Achievement of initial surface requirements
RM8	Water quality at rehabilitated state
RM9	Achievement of PMLU

Management consultation regarding the acceptability of residual risks and proposed treatments based on Table 7.6 occurred in February 2022.

Table 7.6 PRC Plan risk assessment, evaluation and outcomes

Risk ID	Milestone	Risk description	Potential impact	Initial analysis	Initial ranking	Mitigation measures/risk treatment	Justification of treatment	Resource requirements	Performance measures and constraints	Reporting and monitoring requirements	Timing and scheduling	Residual analysis	Risk ranking
1	Stakeholder Engagement	**CULTURAL HERITAGE** Cultural heritage values not adequately considered in the development of the PRC Plan, or; Cultural heritage values unable to be resolved with the Traditional Owners.	• Reputational damage. • Significant compensation payments. • Legal costs. • Impact on follow-up return to country or other outcome. • Unresolved cultural heritage expectations at closure.	Possible Major	High (18)	• Proactive consultation with Traditional Owner representatives during development of PRC Plan. • Inclusion of Traditional Owner consultation in ongoing consultation per the PRC Plan Community consultation plan.	Ongoing and open consultation is the key to maintaining the working relationship with the traditional owners.	Personnel and adequate time for ongoing consultation and engagement. Funding commitment for staffing and time in the community engagement team.	Annual review by site management team. Sufficient annual budget to conduct required activities.	3 yearly audit requirements for the PRC Plan including stakeholder consultation register.	As detailed in the PRC Plan Community consultation plan.	Rare Major	Medium (10)
2	Stakeholder Engagement	**COMMUNITY ACCEPTANCE** Final land use is not accepted by local community	• Final land use benefits not realised. • Reputational damage. • Inability to surrender mining licence. • Significant rework to develop final land use.	Unlikely Moderate	Medium (9)	• Undertake evaluations on the economics of the proposed PMLU mix. • Understand the materials balance for the soil required and check that an economic area is achievable. • Continue to undertake community engagement as per the PRC Plan Community consultation plan. • Update corporate manuals as appropriate to ensure oversight of the PRC Plan and community engagement occurs at the appropriate strata levels within Stanwell.	Ongoing and open consultation is the key to maintaining the engagement and involvement of the community in the outcomes for the land once mining is complete.	Personnel and adequate time for ongoing consultation and engagement. Funding commitment for staffing and time in the community engagement team.	Annual review by site management team. Sufficient annual budget to conduct required activities.	3 yearly audit requirements for the PRC Plan including stakeholder consultation register.	As detailed in the community consultation plan.	Rare Major	Medium (10)
3	RM1 – Infrastructure decommission-ing and removal	**DELAY TO INFRASTRUCTURE REMOVAL** Infrastructure decommissioning and removal takes longer than is planned in the PRC Plan Schedule due to underestimation of the task, incorrect communication of scope to the decommissioning team, or shortage of specialist labour.	• Unable to meet PRC Schedule timeframes leading to non-compliance with the PRC Plan. • Commencement of RM2 delayed.	Unlikely Moderate	Medium (9)	• Internal review of PRC Plan Schedule to be undertaken in the first 3 months post AEMO 4 year notice of power station closure date. • Ongoing ERC process and regular submissions. • Ensure adequate wet weather/ productivity downside/ availability allowance in the landform reshaping/bulk moving required post closure (e.g. sufficient float in the activities that lead to trigger point of removing infrastructure). • Formal RFT process, including physical site visit of potential contractors, triggered to commence for closure reshaping activities and infrastructure removal once 4 year AEMO notice is submitted for power station closure. • Development of infrastructure demolition schedule and monthly tracking meetings as part of the contract oversight during execution.	The proposed actions provide sufficient time for detailed planning, and then early identifications of any deviation on projected timelines towards the milestones. This will allow sufficient time to assign additional resources and compensating activities to ensure the schedule remains on track.	Allocation of funding and time for project planning and then progress meetings during execution. Funding for supplementary works if required to address progress.	Criteria for RM1.	Monitoring requirements for RM1. Annual progress report for the PRC Plan 10th December each year.	Annual reporting to the Regulator by December 10th each year.	Rare Moderate	Medium (8)

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4	RM2 – Investigation and/or remediation of contaminated land	**DELAY TO REMEDIATION OF CONTAMINATED LAND** Previously unidentified contaminated land requiring investigation found during decommissioning activities/greater extent of work required than expected on known contaminated land.	• Contamination of ground/surface water and/or soil. • Unable to meet the PRC Schedule timeframes leading to non-compliance with the PRC Plan. • Additional cost required for remediation. • Delay to RM2.	Possible Minor	Medium (12)	• Stage 2 Hazardous materials investigation to be commenced no later than 3 months post submission of AEMO 4 year notice of power station closure. • Continued maintenance and update of the HAZMAT register, contaminated land register and GIS reference layer. • Assess known areas of contamination for extent and mitigation, update the contaminated land register and then continue to undertake annual monitoring of known areas of remediated contamination (e.g. decommissioned hydrocarbon dump, asbestos dump). • If required, Site Management Plan and site suitability statement to be finalised prior to closure.	The proposed activities ensure compliance with the EP Act and the conditions in the Meandu Mine EA.	Adequate funding and internal resources to commence, manage and undertake appropriate Stage 2 Hazmat work, ongoing monitoring and project management during the remediation project.	Criteria for RM2.	Hazardous materials register, GIS reference information, regular environmental reports. Annual progress report for the PRC Plan 10th December each year.	AEMO notice of closure. Monthly environmental reporting. Environmental Audits, incident register during project. PRC Plan submission and 3 yearly audit requirements for the PRC Plan. Annual reporting to the Regulator by December 10th each year.	Unlikely Minor	Low (4)
5	RM3 – Installation of Cover Systems over ash and tailings storage systems	**UNDERPERFORMANCE OF COVER SYSTEMS VS DESIGN** Cover system not appropriate leading to inappropriate infiltration (too much or too little) caused by inadequate design or QA/QC during construction and vegetation establishment.	• Excessive erosion leads to unplanned infiltration. • Incorrect vegetation causes damage to compacted layers leading to greater than designed infiltration. • Excessive infiltration leads to seepage of contaminated water. • Environmental impact to receiving environment.	Possible Minor	Medium (12)	• Engage specialists during the PRC Plan creation to define the cover system design and requirements. • Engage specialists as required for specific capping tasks e.g. Ash, TSF to provide site specific execution designs. • Undertake a change management process under the site change management procedure to ensure all requirements are included in the appropriate control manuals and site documentation. • Include cover QA/QC requirements in the PRC Plan and in cover/dump construction processes. • Ongoing monitoring of cover system performance through the groundwater bore levels and qualities.	The focus on pre-work in the lead up to the PRC Plan submission ensures that the key items for executing the PRC Plan are included in the Meandu Mine operational documents, with sufficient time in the schedule to allow for identification of any delays and or issues and assign additional resources as required.	Additional internal and external mine planning and rehabilitation resources during each LOM planning cycle. Labour and funding for shift, daily, and monthly operations level reporting on cover construction. Initial internal additional resources and time commitments to update the corporate processes and manuals.	PRC Plan rehabilitation planning document. Criteria for RM3.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan. ERC process.	PRC Plan submission and 3 yearly audit requirements for the PRC Plan. LOM planning process.	Unlikely Minor	Low (4)

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6	RM3-9	**DELAY TO POST-CLOSURE REHABILITATION AREAS** Potential delay to rehabilitation areas after cessation of mining operations – caused by change in oversight, inadequate supervision of contractors, loss of key personnel, extreme weather events or desiccation of ash storage facilities taking longer than estimated.	• Unable to meet PRC Schedule timeframes leading to non-compliance with the PRC Plan.	Unlikely Moderate	Medium (9)	• Allowance in the submitted PRC schedule timeframes for a) settling of the landform and b) contingency on construction and rehabilitation. • Time allowance for drying and desiccation of the K4S ASF to include a factor of safety of 1.5 on versus that achieved with the preceding K2W-N ash facility. • Time allowance for cover system settlement of the K4S ASF to include a factor of safety of 1.5 of the time applied to the generic spoil dumps across the rest of the site. • Formal Request For Tender (RFT) procurement process to be undertaken, including physical site visit, to select appropriate contractors to undertake the rehabilitation work.	By tying capping of the final ash/tailings storage facilities directly to the closure and cover of the current facility (to be closed approximately 10 years prior to cessation of mining) there is sufficient time (years) to identify and rectify any issues during the decommissioning and cover work, then adapt the findings to an altered procedure for the final cover system installation at the cessation of mining. Cover design by a suitably qualified person and a trial dust management capping have previously been installed as measures on ash storage facilities, proving the concept at the site.	Additional internal and external mine planning and rehabilitation resources during each LOM planning cycle. Labour and funding for shift, daily, and monthly operations level reporting on cover construction. Initial internal additional resources and time commitments to update the corporate processes and manuals. Technical and procurement time and resources for tender process.	PRC Plan rehabilitation planning document, PRC Schedule, annual reporting to DES by 10th December each year.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan. ERC process. Annual progress report for the PRC Plan 10th December each year.	Annual reporting to the Regulator by December 10th each year.	Rare Moderate	Medium (8)
7	RM4 – Landform	**FINAL LANDFORM** Land formation is unsuitable to support intended PMLU's due to erosion/subsidence/ microrelief/topography mis-match.	• PMLU success criteria not achieved. • Final land use is not accepted by land holders.	Unlikely Major	High (16)	• Creation of the PRC Plan landform design report as a central repository of design information. • Construction of all future rehabilitation landforms and shapes consistent with the requirements of the landform design report. • Review soil cover prior to PRC Plan to check that it can reduce the infiltration of water to the levels considered appropriate. • Assess the designed final landform shape using landform evolution software and adjust as necessary.	The focus on pre-work in the lead up to the PRC Plan submission ensures that all future work is completed fully appreciating all PMLU requirements, and recognises the considerable and consistent historic successful rehabilitation at Meandu Mine.	Design time, technical services time and personnel for ongoing design work and assessment. Funding, training and time allowance for supervision and monitoring during landform construction on a shift/daily basis.	Annual site review and rehabilitation audits as outlined in the site Environmental Management Plan (EMP).	PRC Plan submission. 3 yearly audit requirement for the PRC Plan.	PRC Plan submission and 3 yearly audit requirements for the PRC Plan. Annual inspections.	Rare Major	Medium (10)
8	RM4 – Landform	**FINAL HIGHWALL / STEEP ROCKY ECOSYTEM LANDFORM** Final Highwall Profile not certified by DES at closure due to lack of clarity on profile requirements.	• PMLU not certified as safe and stable. • Final land use not accepted by land holders. • Reshaping and disturbance of established rehabilitation to alter the highwall profile.	Unlikely Major	High (16)	• Undertake investigations into the strategic form and extents of the final highwall designs during the PRC Plan process, including where needed external experts w.r.t. geotechnical assessment, ecology, soil and highwall design. • Include final highwall information in the PRC Plan rehabilitation planning part and show the extents in the GIS submission associated with the PRC Plan Schedule. • Monitoring trial to be undertaken on the Steep Rocky Ecosystem PMLU as documented in the PRC Plan submission. • Include final highwall design requirements in Landform Design Report, and also in future LOM planning cycles.	Appropriate assessment and design of the highwall prior to their creation will prevent unnecessary re-work and impacts on established rehabilitation, and enables the creation of a design guideline and notes from the supporting technical investigations.	External consultants, commitment of internal resources to develop the criteria and specification for the final highwalls. Funding and staffing for ongoing data collection. Additional design time for future LOM planning cycles.	PRC Plan rehabilitation planning part.	Safe, stable, non-polluting and able to sustain the PMLU. Timeframe and reporting details as outlined in the trial section of the PRC Rehabilitation Planning document.	As per the PMLU trial detailed in the PRC Plan submission.	Rare Major	Medium (10)

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9	RM4 – Landform	**LANDFORM – NATIVE VEGETATION** Risk that design and land form profile/contours of native vegetation do not meet success criteria for PMLU.	• Poorly designed landforms/drains result in localised excessive erosion impacts necessitating reshaping/redesign/drain installation.	Possible Moderate	High (15)	• Creation of the new landform design report as a central repository of design information. • Construction of all future rehabilitation landforms and shapes consistent with the requirements of the landform design report. • Assess the designed final landform shape using landform evolution software and adjust as necessary.	Appropriate assessment and design of the Landform criteria and overall form will prevent unnecessary re-work and impacts on established rehabilitation, and recognises the considerable and consistent historic successful rehabilitation at Meandu Mine.	Design time, technical services time and personnel for ongoing design work and assessment. Budget, training and time allowance for supervision and monitoring during landform construction on a shift/daily basis.	Landform evolution modelling. PRC Plan submission requirements for Landform Design Report. Annual records of completed rehabilitation work	PRC Plan submission. 3 yearly audit requirement for the PRC Plan.	Submission. 3 yearly audit requirements for the PRC Plan. LOM planning process.	Unlikely Moderate	Medium (9)
10	RM4 – Landform	**RESIDUAL COAL SEAMS** Fire risk associated with residual coal seams [NOTE: This is seams above the Queen seam as the Queen seam will be covered by backfill].	• Environmental harm resulting from heating and potential subsidence. • Increased fire risk for adjoining rehabilitated areas.	Unlikely Moderate	Medium (9)	• Include the need to provide an appropriate cover system to exposed coal in the design of the final void highwall. • Include in the PRC Plan rehabilitation planning part A details on the need to cover of exposed coal seams in the final highwall.	Providing an engineering level of control for risk management is preferential to an administration or monitoring solution. With appropriate planning and forethought, the cover system can be installed as part of the final pit excavations, removing the risk of re-work.	Commitment of time and consultants during the PRC Plan process to detail requirements. Additional costs to achieve the cover requirements (additional labour and machine hours) during development of final highwalls.	PRC Plan rehabilitation planning document.	PRC Plan submission.	Submission. LOM planning process. Specific review prior to excavation of final highwall.	Rare Moderate	Medium (8)
11	RM4 – Landform	**LOM PLAN** LOM Plan changes which consequently impacts PCRP (e.g. inability to deliver the expected grazing land area).	• PRC Plan milestones not achieved. • Final PMLU does not meet requirements of agreed PRC Plan. • Reversion to Native Vegetation PMLU from Beef Cattle Grazing or other higher ecological/economic value PMLU. • Impact on community and stakeholder relationship if commitment is changed.	Rare Moderate	Medium (8)	• All LOM planning cycles to include express consideration of landform and achievement of PMLUs per the PRC Plan. • Carry out community engagement as per the PRC Plan Community consultation plan. • Update corporate manuals as appropriate to ensure oversight of the PRC Plan and community engagement occurs at the appropriate strata levels within Stanwell.	Inclusion of landform and PMLU outcomes in the regular LOM planning cycle ensures any change is incremental and well signposted prior to any impact on the short term (1-5 year) timeframe, leaving adequate time for an amendment process and community engagement.	Additional internal and external mine planning and rehabilitation resources during each LOM planning cycle. Initial internal additional resources and time commitments to update the corporate processes and manuals.	PRC Plan rehabilitation planning part A.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan. ERC process.	Submission. 3 yearly audit requirements for the PRC Plan. LOM planning process.	Rare Moderate	Medium (8)
12	RM4 – Landform	**NAF AVAILABILITY** Insufficient NAF material for upper 6m of dumps at all stages of the rehabilitation schedule.	• PMLU does not meet success criteria. • Unable to meet cover design requirements. • Environmental impact to receiving environment.	Unlikely Moderate	Medium (9)	• Mapping of material quantities and source/ destination scheduling in the LOM Plan underpinning the PRC Plan. • Tracking of material placement on a regular basis per operational procedures. • Inclusion of NAF and material quantities in all future LOM and annual mine planning cycles.	The focus on pre-work in the lead up to the PRC Plan submission ensures that the key items for executing the PRC Plan are included in the Meandu Mine operational documents, with sufficient time in the schedule to allow for identification of any delays and or issues and assign additional resources as required.	Allocation of funding and resources to undertake detailed geological mapping, LOM planning and then quantity scheduling during preparation of the PRC Plan submission. Time and labour to undertake tracking of material placement during operations. Ongoing additional time and resources during each LOM and annual planning cycle to complete material schedule and balance.	PRC Plan rehabilitation planning document. PRC Plan Schedule document and Rehabilitation Areas.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan. ERC process.	Submission. 3 yearly audit requirements for the PRC Plan. LOM planning process. Annual reporting to the Regulator by December 10th each year.	Rare Moderate	Medium (8)

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13	RM4 – Landform RM5 – Surface preparation	**BEEF CATTLE GRAZING DESIGN FAILURE** Rehabilitated land is unable to support Beef Cattle Grazing PMLU due to inappropriate construction technique (e.g. deep ripping causing hazard) OR Inappropriate soil/subsoil selection and placement.	• PMLU success criteria not achieved. • Final land use not accepted by land holders. • PMLU not certified by DES.	Possible Moderate	High (15)	• Beef Cattle Grazing management, construction and monitoring actions to be developed through consultation with industry expert(s) with requirements documented in a suitable reference document. • Develop signoff sheets and procedures for the construction of the grazing areas. • Grazing trial for subsoil and vegetative performance as described in the PRC Plan submission, and if economic threshold of pasture growth cannot be achieved, consider establishing Native Ecosystem as an alternate PMLU.	Inclusion of the trial as noted in the PRC Rehabilitation and Planning document ensures early confirmation of the process, or, sufficient time to adjust to achieve success.	Resources to establish early, maintain vegetation and slash as needed, then monitor and report on trial results. Additional training then time on a shift/daily/ weekly basis to ensure construction of landforms to appropriate requirements.	Trial reporting as outlined in the PRC Rehabilitation Planning Part.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan. Reporting as outlined in the trial section of the PRC Rehabilitation Planning Part.	Submission. 3 yearly audit requirements for the PRC Plan. Trial reporting requirements.	Rare Moderate	Medium (8)
14	RM4 – Landform RM5 – Surface preparation RM6 – Revegetation	**PRC PLAN MILESTONES NOT ACHIEVED** Risk of PRC Plan milestones not being achieved in the progress to RM7 and RM8 e.g. timely progress of progressive rehabilitation.	• Non-compliance with PRC Plan Schedule. • Regulator attention and penalties. • Reputation impact with stakeholders and community.	Possible Moderate	High (15)	• Include the relevant requirements of the PRC Plan and schedule in the site change management process. • Include the relevant requirements of the PRC Plan and schedule as metrics in the annual mine plan, budget and tracking process.	Inclusion of the PRC Planning Part and Schedule metrics in the Site Management System and EMS ensures that the requirements are addressed alongside the other operational constraints.	Additional time and resources in the annual planning, budgeting, monitoring processes. Initial commitment of time internally to undertake change management process under the site EMS and update the document management system.	Annual site inspections and rehabilitation audits as outlined in the site EMS. Audit requirements for the PRC Plan. ERC submission process.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan. ERC process.	ERC process intervals. 3 yearly audit requirements for the PRC Plan. Annual reporting to the Regulator by December 10th each year.	Rare Moderate	Medium (8)
15	RM5 – Surface Preparation	**SOIL QUALITY – ALL PMLU's** Soil is unsuitable to support PMLUs due to allocation of unsuitable material e.g. PAWC, nutrient levels, erosivity, inadequate post placement treatment.	• PMLU's not achieved. • Rehabilitated land does not meet PMLU success criteria. • Final land use is not accepted by land holders.	Unlikely Moderate	Medium (9)	• Clearly define in the PRC Plan the soil related success criteria for all PMLU's to ensure suitability. • Co-ordinate mine plan and PMLU requirements to ensure the correct soil type is available at the right time (e.g. If needed stockpiling different soil types as they become available during the LOM). • Map the soil and subsoil requirements for different PMLUs and match to waste material dumping schedule in the annual mine planning process and LOM planning cycle (as well as the PRC Plan submission).	The focus on pre-work in the lead up to the PRC Plan submission ensures that all future work is completed in full appreciation of all PMLU requirements, and recognises the considerable and consistent historic successful rehabilitation at Meandu Mine. Inclusion of assessment and execution requirements in the annual mine planning process ensures conformance.	Additional consulting and internal resourcing and time during creation of the PRC Plan submission. Ongoing additional monitoring and planning resources in the annual mine planning and operational processes.	Annual site inspections and rehabilitation audits as outlined in the site EMS. Audit requirements for the PRC Plan.	PRC Plan submission; 3 yearly audit requirement for the PRC Plan.	Annual inspections. Annual mine planning process. LOM planning cycle. 3 yearly audit requirements for the PRC Plan..	Rare Major	Medium (10)

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16	RM5 – Surface Preparation	**SOIL AVAILABILITY** Insufficient subsoil/topsoil of suitable quality available at appropriate times to complete the rehabilitation of the planned PMLU allocation as scheduled.	• PMLU does not meet success criteria. • Vegetation failure due to inappropriate subsoil/topsoil. • Excess erosion due to exposure of underlying materials or inappropriate material utilised as a substitute.	Possible Moderate	High (15)	• Assessing all subsoil and topsoil requirements for the PMLUs during the PRC Plan creation. • Mapping of material quantities and source/ destination scheduling in the LOM Plan underpinning the PRC Plan. • Inclusion of subsoil and topsoil material quantities in all future LOM and annual mine planning cycles. • Targeted program of further sampling as required to assess soil qualities and viability assignment to PMLUs.	The focus on pre-work in the lead up to the PRC Plan submission ensures that the key items for executing the PRC Plan are included in the Meandu Mine operational documents, with sufficient time in the schedule to allow for identification of any delays and or issues and assign additional resources as required.	Allocation of funding and resources to undertake detailed geological mapping, LOM planning and then quantity scheduling during preparation of the PRC Plan submission. Time and labour to undertake tracking of material placement during operations. Ongoing additional time and resources during each LOM and annual planning cycle.	PRC Plan rehabilitation planning document. PRC Plan Schedule document and Rehabilitation Areas.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan. ERC process.	Submission. 3 yearly audit requirements for the PRC Plan. LOM planning cycle. Annual reporting to the Regulator by December 10th each year.	Rare Moderate	Medium (8)
17	RM6 – Revegetation	**SUBMERGED NATIVE VEGETATION** Risk of rehabilitated native vegetation being inundated and suffering damage in areas adjoining the residual void water storage PMLU areas.	• Submerged native vegetation – causes damage to vegetation that requires replanting or alternative species mix. • Over investment in native vegetation PMLU areas.	Unlikely Moderate	Medium (9)	• Undertake detailed final void modelling as per the PRC Plan Guideline requirements to clearly define maximum water storage volumes prior to determining the native vegetation extent. • Investigate and apply an appropriate species mix consistent with the native vegetation and inundation requirements prior to PRC Plan submission adapted from the existing successfully applied Creek Diversion seed mix. **NOTE: Change in consequence justified due to definition of the mixing zone and application of specific vegetation mix to suit.**	The focus on pre-work in the lead up to the PRC Plan submission ensures that all future work is completed in full appreciation of all PMLU requirements.	Specialist consulting time and resources for modelling requirements, internal time and resources to identify appropriate margin treatment species. Additional time and seed mixes during the rehabilitation process to create the vegetation specific to the mixing zone.	PRC Plan rehabilitation planning document.	PRC Plan submission; 3 yearly audit requirement for the PRC Plan.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan.	Rare Minor	Low (2)
18	RM6 – Revegetation	**CLIMATE CHANGE** Climate change impacts the rehabilitated area. Future extreme weather events and their impact on the: Landform; Vegetation; Availability of labour and equipment.	• Impact on the ability of rehabilitation to survive and grow as required to meet the milestones in the PRC Plan. • Water may be less available to support PMLUs (through impact on water storage PMLU volumes). • Impact of vegetation growth and establishment during periods of limited rainfall, or after periods of extreme rainfall. • Erosion of landform structures due to extreme weather events.	Unlikely Moderate	Medium (9)	• Undertake assessment of climate change impacts on the species included in the current seed mix and adjust as necessary (e.g. drought tolerance). • Undertake review of the fire load and controlled burn strategy to ensure fuel loads are being appropriately managed. • Undertake landform evolution modelling of the proposed landform including potential impacts. • Evaluate likely climate change scenarios using CSIRO resources and include these in the final void (and other) water modelling simulations. • Include sufficient time in the timing for each Rehabilitation Area in the PRC Plan Schedule to allow for an additional weather impacts between mine plan indicating available footprint and achievement of the applicable initial rehabilitation milestone.	Climate change and including sufficient time in the PRC Plan Schedule are of critical importance to the robustness of the PRC Plan Schedule. The best available information has been utilised as input, and timings adjusted based on the extensive mining and landform construction experience of the assessment team.	Specialist consulting time and resources for modelling requirements, internal time and resources to undertake the risk assessment and time frames required.	PRC Plan rehabilitation planning document. PRC Plan Schedule document and Rehabilitation Areas. ERC submission(s). Annual rehabilitation monitoring.	PRC Plan submission; 3 yearly audit requirement for the PRC Plan. Annual rehabilitation monitoring report.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan.	Rare Moderate	Medium (8)

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19	RM6 – Revegetation	**VEGETATION FAILURE** Vegetation not successfully established due to failure of revegetation e.g. inappropriate seed mix, weed infestation, fire damage, inappropriate management.	• PMLU (Native Veg) does not meet success criteria. • PMLU Beef Cattle Grazing does not meet success criteria. • PMLU Creek Diversion does not meet success criteria. • Need to re-establish vegetation.	Unlikely Minor	Low (4)	• The rehabilitation monitoring and maintenance program (refer Section 8)and associated procedures will clearly outline the process to be followed for establishing and maintaining Vegetation across the applicable PMLUs to the level of quality required to meet the success criteria in the Meandu Mine EA once RM8 has been reached. • Regular rehabilitation monitoring and maintenance will continue on an annual basis.	The focus on pre-work in the lead up to the PRC Plan submission ensures that all future work is completed in full appreciation of all PMLU requirements, and recognises the considerable and consistent historic successful rehabilitation at Meandu Mine.	Resources time to move existing site procedures, documentation and studies over to the PRC Plan framework. Ongoing resources for fire management, monitoring and weed management throughout and after mining operations.	PRC Plan rehabilitation planning document. Annual site inspections and rehabilitation audits as outlined in the site EMS.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan. Annual reporting to the Regulator by December 10th each year.	Rare Minor	Low (2)
20	RM6 – Revegetation	**FAUNA** Fauna not specifically considered prior to the PRC Plan, risk that rehabilitated land is unable to adequately support fauna.	• Reputational impacts in the local community with those who have particular interest in the local fauna communities. • Reduction in PMLU bio-diversity (e.g. species abundance and variety, genetic diversity, species distribution). • Pest or non-typical fauna occupy rehabilitated land.	Unlikely Minor	Low (4)	• Species composition in the success criteria definition for the Native Ecosystem in the Meandu Mine EA are benchmarked on the local relevant Regional Ecosystems – e.g. are consistent with the species mix and diversity in the region that support the local fauna. • Maintain and adjust as needed the weed and feral pest management documents and procedures. • Design PMLU makeup for Beef Cattle Grazing (through shelter belts) and Native Ecosystem to maintain adequate connection throughout the footprint to form wildlife corridors. • Native Ecosystem PMLU within reasonable proximity of the water storage PMLU.	Native Ecosystem as outlined in the existing Meandu Mine EA success criteria to be transferred to the PRC Plan, are benchmarked on local R.E. which have demonstrated their ability to support the local fauna. Pest management has been undertaken since mining commenced.	Initial design and assessment time prior to PRC Plan submission with external specialist consultants and internal resources working on the PRC Plan. Ongoing resources (labour) to undertake rehabilitation monitoring and pest control.	PRC Plan rehabilitation planning document. Annual site inspections and rehabilitation audits as outlined in the site EMS.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan.	Rare Minor	Low (2)
21	RM6 – Revegetation	**VEGETATIVE FAILURE – STEEP ROCKY ECOSYSTEM** Baseline study has been a once off event in 2021, risk that the results are not representative.	• Inability to establish self-sustaining vegetative communities. • Need to re-establish vegetation on the highwalls and monitor etc for a longer than planned period (e.g. pushing out delivery of the PRC Plan milestones).	Possible Moderate	High (15)	• Undertake detailed investigation into the strategic form and extents of the final highwall designs during the PRC Plan process, including where needed external experts w.r.t ecology, soil. • Monitoring trial to be undertaken as per the PRC Plan submission to establish longitudinal data w.r.t. vegetation establishment across seasons, weather events, orientations (e.g. west/north). • Include in PRC Plan Schedule allowance for a time period when the final highwalls are exposed to compare their initial 1-5 year performance against the site-specific reference locations identified in the trial.	Appropriate assessment and design of the Steep Rocky Ecosystem PMLU specifications prior to their creation will prevent unnecessary re-work and impacts on established rehabilitation. Collating trial data across the immediate timeframe allows for sufficient time to identify any delays or concerns, and put in place remedial actions to ensure the PMLU is successful.	External consultants, commitment of internal resources to develop the criteria and specification for the PMLU vegetative requirements. Funding and staffing for ongoing data collection. Additional design time for future LOM planning cycles.	PRC Plan rehabilitation planning document. Trial reporting as detailed in the PRC Plan submission.	PRC Plan submission. ERC process. PMLU trial reporting as detailed in the PRC Plan submission.	As per the PMLU trial detailed in the PRC Plan submission.	Unlikely Minor	Low (4)
22	RM7 – Initial Surface Requirements	**CREEK DIVERSION** Inability to meet PMLU success criteria due to: landform degradation due to increased flows/velocities above design OR; Structures approved under previous legislative requirements not meeting current regulator viewpoint.	• Inability to certify the creek diversion. • Water quality impacts to downstream water (Meandu Creek Dam).	Possible Moderate	High (15)	• Adjust as needed the creek diversions up to and following the certification process. • Include creek diversion in the annual monitoring program and hydraulic assessments. • Monitor and manage creek diversion rehabilitation as per the monitoring details in the PRC Plan Section 8.	The treatment recognises the status of the current creek diversions, and commits to a proactive reporting and certification approach over the short term, well before any planned closure of the Meandu Mine.	Ongoing resources (labour) to undertake rehabilitation monitoring and pest control. Labour and equipment to undertake any necessary improvements and vegetation management for certification.	PRC Plan rehabilitation planning document. Annual site inspections and rehabilitation audits as outlined in the site EMS.	As detailed in the PRC Plan submission.	Submission of Certification. Annual rehabilitation monitoring program.	Unlikely Moderate	Medium (9)

Risk ID	Milestone	Risk description	Potential impact	Initial analysis	Initial ranking	Mitigation measures/risk treatment	Justification of treatment	Resource requirements	Performance measures and constraints	Reporting and monitoring requirements	Timing and scheduling	Residual analysis	Risk ranking
23	RM7 – Initial Surface Requirements	**QUALITY OF HISTORIC REHABILITATION** Suitability of historical rehabilitation actions undertaken by previous mine owners/operators.	• Inability to certify existing rehabilitation areas. • Redesign and rework of existing rehabilitation areas. • Significant cost to rework existing rehabilitation areas.	Possible Moderate	High (15)	• Submit an application for rehabilitation certification prior to PRC Plan submission [NOTE: Completed and Successful]. • Adjust rehabilitation monitoring and maintenance program (refer Section 8) with actions resulting from feedback from rehabilitation certification process to ensure remaining rehabilitation can be brought to certification standard (if needed). • Continue with ongoing annual inspections and maintenance of existing rehabilitation. **NOTE: Consequence changed as the action is to reduce the Risk Consequence**	Appropriate assessment by external consultants and DES representatives provides the clearest and most independent guidance on the rehabilitation standard and processes in place. Adjustment now to these processes for inclusion in the PRC Plan ensures all future work is to best practice, minimising any residual risk to PMLU success.	External consultants time, internal resources commitment to certification process, monitoring, updates to plans as needed. Ongoing funding for labour and equipment time to maintain and update as needed the creek diversion.	PRC Plan rehabilitation planning document. PRC Plan Schedule document and Rehabilitation Areas. Application for Rehabilitation Certification (completed).	As detailed in the PRC Plan Submission.	Annual rehabilitation monitoring program. Annual mine planning process.	Unlikely Minor	Low (4)
24	RM7 – Initial Surface Requirements	**PRC PLAN CHANGE MANAGEMENT** Change management for rehabilitation activities are not prioritised by management, leading to a failure to meet the surface requirements.	• Inability to deliver the PRC Plan Schedule, failure of nominated PMLUs. • Reputational damage.	Possible Moderate	High (15)	• Include the relevant requirements of the PRC Plan and schedule in the site change management process. • Include the relevant requirements of the PRC Plan Schedule milestones in the annual mine planning, budgeting and execution processes. • Update the EMP for Tarong/Meandu to include the relevant requirements of the PRC Plan Schedule actions.	The focus on pre-work in the lead up to the PRC Plan submission ensures that the key items for executing the PRC Plan are included in the Meandu Mine operational documents. Inclusion of assessment and execution requirements in the annual mine planning process ensures conformance.	Additional internal resourcing and time during creation of the PRC Plan submission. Ongoing additional monitoring and planning resources in the annual mine planning and operational processes.	Annual site inspections and rehabilitation audits as outlined in the site EMS. Audit requirements for the PRC Plan.	As detailed in the PRC Plan submission; 3 yearly audit requirement for the PRC Plan.	Annual rehabilitation monitoring program. Annual mine planning process. 3 yearly audit requirements for the PRC Plan..	Rare Moderate	Medium (8)
25	RM7 – Initial Surface Requirements	**WATER STORAGE ABILITY TO SUPPORT PMLUs** Suitability of water storage areas to support/compliment commercial beef cattle grazing PMLU due to quality of water.	• PMLU success criteria not met for both the water storage and beef cattle grazing PMLU. • PMLU not achieved or degraded. • Significant rework to develop final land use.	Unlikely Moderate	Medium (9)	• Undertake final void modelling (including water quality) as part of the PRC Plan preparation. • Ensure cattle do not have direct access to the void water to prevent fouling of water.	The focus on pre-work in the lead up to the PRC Plan submission ensures that the key items for executing the PRC Plan are included in the Meandu Mine operational documents.	Specialist consulting time and resources for modelling requirements, internal time and resources to undertake the risk assessment and time frames required.	PRC Plan rehabilitation planning document. PRC Plan Schedule document and Rehabilitation Areas. Commitment to managing water quality in final voids through reasonable extraction.	PRC Plan submission. Final void water quality monitoring.	3 yearly audit requirements for the PRC Plan..	Unlikely Moderate	Medium (9)
26	RM7 – Initial Surface Requirements	**FINAL LAND PRODUCTIVITY UNSUITED TO PMLU** Final land productivity of rehabilitated land is insufficient to support commercial PMLUs of Beef Cattle Grazing or Plantation Forestry.	• Final land use is not accepted by land holders. • Socio-economic benefits not realised. • PMLU success criteria not met.	Unlikely Moderate	Medium (9)	• All PMLUs subsoil/topsoil requirements included in PRC Plan submission development and in the rehabilitation monitoring and maintenance program (refer Section 8). • Consult with industry specialists to ensure an achievable, competent set of milestones and criteria is set for these PMLUs. • Grazing trial for subsoil and vegetative performance as described in the PRC Plan submission, and if economic threshold of pasture growth cannot be achieved, consider establishing Native Ecosystem as an alternate PMLU.	The focus on pre-work in the lead up to the PRC Plan submission ensures that the key items for executing the PRC Plan are included in the Meandu Mine operational documents.	Additional internal resourcing and time during creation of the PRC Plan submission including external specialist. Ongoing additional monitoring and planning resources in the annual mine planning and operational processes.	PRC Plan rehabilitation planning document. PRC Plan Schedule document and Rehabilitation Areas. Trial reporting as outline in the PRC Plan Rehabilitation planning Part.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan. Reporting as outlined in the trial section of the PRC Rehabilitation Planning Part.	PRC Plan Submission. 3 yearly audit requirements for the PRC Plan. Trial reporting requirements.	Unlikely Moderate	Medium (9)

Risk ID	Milestone	Risk description	Potential impact	Initial analysis	Initial ranking	Mitigation measures/risk treatment	Justification of treatment	Resource requirements	Performance measures and constraints	Reporting and monitoring requirements	Timing and scheduling	Residual analysis	Risk ranking
27	RM7 – Initial Surface Requirements	**FAILURE TO EXECUTE PRC PLAN** Activities to maintain compliance with PRC Plan are not prioritised during the medium – long-term due to incomplete documentation or resources.	• Delay in delivery of the PRC Plan – possible compliance breach as a result of missed milestones. • Delay or re-work required in order to deliver the proposed PMLU in the footprints outlined in the PRC Plan.	Unlikely Moderate	Medium (9)	• Ensure that the change management process includes all timeframes of both planning and execution. • Include annual community engagement for PRC Plan in ongoing business planning. • Update corporate manuals as appropriate to ensure oversight of the PRC Plan.	Inclusion of the PRC Planning Part and Schedule metrics in the Site Management System and EMS ensures that the requirements are addressed alongside the other operational constraints.	Initial commitment of time internally to undertake change management process under the site EMS and update the document management system. Additional time and resources in the annual planning, budgeting, monitoring processes.	Annual site inspections and rehabilitation audits as outlined in the site EMS. Audit requirements for the PRC Plan. ERC submission process. Tracking against PRC Schedule.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan. ERC process.	Annual mine planning process. ERC process intervals. 3 yearly audit requirements for the PRC Plan. Annual reporting to the Regulator by December 10th each year.	Rare Moderate	Medium (8)
28	RM8 – Rehabilitated state water quality	**GROUNDWATER SEEPAGE – NWBV – RSA1 CONTAMINANTS** Regional modelling has identified potential seepage associated with the NWBV at Bullgang corner and Ramp 7. The potential source of contaminants is the RSA1 dump and this risk addresses the decay and then potential seepage of these contaminants into the receiving environment.	• Environmental impact to receiving environment. • Unable to achieve PMLU success criteria. • Impact through accumulation of metals in Meandu Creek upstream of Meandu Creek Dam. • Salinity impact on Meandu Creek Dam as receiving environment. • Potential re-dissolution of metals and transport to Meandu Creek Dam. • Noting that 10 kl/day is in relative terms a very small flow,	Likely Moderate	High (19)	• Develop clear monitoring milestones for key analytes to confirm the water quality is on trend to have no detrimental relative impact to the receiving environment and include in the PRC Plan and PRC Plan Schedule. • Develop and include site-specific WQO for key indicators and analytes in the receiving environment to preserve aquatic ecosystem health. • If milestone water quality trends for the section of Meandu Creek adjacent to the NWBV are not achieved in the nominated near-term (closure +10 years) investigate options for and develop options to achieve suitable water quality and receiving environment outcomes, e.g. Wetland treatment, treatment of source material. • Continue monitoring of GW level and water quality in the NWBV during 1) pumping and periodic cessation of pumping 2) following completion of the NWB TSF capping system and generic bulk waste dump 3) during vegetation establishment to >50% coverage. • Periodic reassessment and calibration of the water models to assess the effectiveness of the cover system.	Ongoing monitoring and continuation of existing short term management actions continue through the operating period of Meandu Mine, improving the predictive capacity of the models before closure. Final capping and establishment of revegetation on the catchment area of the NWBV is included in the PRC Schedule and will be completed 5 years before closure, allowing sufficient time to monitor and develop contingency plans if required.	Funding and resources to continue short term management actions, monitoring and ongoing predictive modelling updates.	3 yearly updates to DES on water model calibration results.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan. ERC process; Monthly environmental reporting.	3 yearly water model calibration and updates.	Possible Minor	Medium (12)
29	RM8 – Rehabilitated state water quality	**GROUNDWATER SEEPAGE – QW SALINE PLUME** Regional modelling has identified the potential for saline seepage at Meandu Creek upstream of the Meandu Creek Dam with potential contamination from the unexplained saline plume upgradient from the DL Shutdown pad.	• Environmental impact to receiving environment. • Unable to achieve PMLU success criteria. • Existing modelling showed essentially no discernible contaminant reaches the creek (lots of interaction with other water flows).	Unlikely Minor	Low (4)	• Continue to monitor and review the historic and new (2021) groundwater bores for water quality and any migration. • Periodic reporting to DES of monitoring results following approval of the PRC Plan.	The initial work investigating the Queen West (QW) saline plume has shown that the plume is essentially stationary. Additional monitoring bores have already been installed and are active, reporting on less than a 5 year interval will not allow any meaningful movement to be measured. The modelling shows that there is no discernible impact on the receiving environment from this plume.	Funding and resources to continue environmental monitoring of the bores on a monthly basis.	5 yearly updates to DES on any observed changes in the monitored qualities and levels.	PRC Plan submission. 5 yearly updates on QW monitoring to DES. Monthly environmental reporting.	5 yearly intervals reporting to DES.	Unlikely Minor	Low (4)

Risk ID	Milestone	Risk description	Potential impact	Initial analysis	Initial ranking	Mitigation measures/risk treatment	Justification of treatment	Resource requirements	Performance measures and constraints	Reporting and monitoring requirements	Timing and scheduling	Residual analysis	Risk ranking
30	RM8 – Rehabilitated state water quality	**GROUNDWATER SEEPAGE – BLACK CREEK** Regional modelling has identified the potential for saline seepage in the Black Creek Gully with potential for contamination from an unexplained saline plume in the rehabilitated K2E Dump area. Potential expression in shallow water table on-site near RD17.	• Environmental impact to receiving environment. • Unable to achieve PMLU success criteria. • Scenario considers onsite expression at RD17.	Possible Minor	Medium (12)	• Additional monitoring bores to be installed by December 2024 to allow comparison of groundwater chemistry and investigation of source and migration of potential. • Undertake chemical signature comparison for the various sites and potential sources.	Immediate installation of further monitoring bores in the next 2 years allow adequate data to be collected 10-15 year+ prior to planned closure, allowing adequate time to establish if any further action is required, and if so include in an amended rehabilitation schedule.	Funding and resources to select appropriate locations and install monitoring bores and equipment. Funding and resources to undertake ongoing monitoring and analysis and comparison of the monitoring results.	Install additional monitoring bores by Dec 2024.	PRC Plan submission. Monthly environmental reporting.	Install additional monitoring bores by Dec 2024.	Unlikely Minor	Low (4)
31	RM9 – Achievement of Stable PMLU	**SAFETY OF FINAL HIGHWALLS** Unintentional health and safety risk associated with final land use of terraced void walls.	• Public safety incident. • Inability to surrender mining licence. • Final land use benefits not realised. • Significant rework to develop final land use.	Unlikely Severe	High (17)	• Assess final highwall form and include in the final void design and excavation plans. • Undertake detailed investigation into the strategic form and extents of the final highwall designs during the PRC Plan process, including where needed external experts w.r.t. geotechnical assessment, ecology, soil and highwall design. Engage external geotechnical and rehabilitation consultants to develop an appropriate design and have it independently reviewed.	Appropriate assessment and design of the highwall prior to their creation will prevent unnecessary re-work and impacts on established rehabilitation.	Allocation of funding and internal resources to setup and run an investigative project before PRC Plan submission, inclusive of external consultants and specialists. Commitment of internal resources to develop the criteria and specification for the final highwalls for documentation. Ongoing labour and time in each LOM planning cycle.	PRC Plan rehabilitation planning document. Landform design report.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan.	LOM planning process. 3 yearly audit requirements for the PRC Plan.	Rare Severe	Medium (11)
32	RM9 – Achievement of Stable PMLU	**QUALITY OF LANDHOLDER RETAINED INFRASTRUCTURE** New land holders unable to effectively use retained infrastructure.	• Final land use is not accepted by land holders. • PMLU is not achieved. • Socio-economic benefits not realised.	Possible Minor	Medium (12)	• No longer relevant. Following economic assessment and stakeholder consultation, no infrastructure will be retained other than that used as that critical to the resulting PMLU.	Refer to the main PRC Plan text addressing PMLUs.	Not applicable	Not applicable	Not applicable	Not applicable		
33	RM9 – Achievement of Stable PMLU	**INFRASTRUCTURE STRATEGY** Not keeping the right minor infrastructure for incorporation into the other PMLUs as essential management infrastructure.	• Infrastructure does not support final land use. • Socio-economic benefits not realised. • Higher infrastructure costs for new land holders.	Possible Minor	Medium (12)	• No landholder retained infrastructure. • Define the PMLUs needs as part of the development of the PRC Plan submission. Consult industry experts as needed to provide additional support and knowledge. • Engage with community stakeholders re the land use categories post mining.	The focus on pre-work in the lead up to the PRC Plan submission ensures that all future work is completed in full appreciation of all PMLU requirements.	Additional consulting and internal resourcing and time during creation of the PRC Plan submission.	PRC Plan rehabilitation planning document. Consider final needs in assessment prior to decommissioning.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan.	Unlikely Minor	Low (4)
34	RM9 – Achievement of Stable PMLU	**BEEF CATTLE GRAZING – WATER ACCESS** Access to water storage is insufficient, or inappropriate (e.g. cattle damage water supply).	• Final land use not accepted by land holders. • PMLU does not meet the success criteria.	Unlikely Minor	Low (4)	• Design Beef Cattle Grazing PMLU to ensure easy access to water sources. • Design Beef Cattle Grazing PMLU to include fences to keep cattle from fouling water sources. • Undertake water modelling scenarios that include use of water for cattle. • Include requirements in the PRC Plan submission.	The focus on pre-work in the lead up to the PRC Plan submission ensures that the key items for executing the PRC Plan are included in the Meandu Mine operational documents.	Allocation of funding and internal resources to setup and run a project to investigate and assess the requirements prior to PRC Plan submission. This includes time and funding allocation for additional consulting and internal resourcing.	PRC Plan rehabilitation planning document. PRC Plan Schedule document and Rehabilitation Areas.	PRC Plan submission.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan post construction of PMLU.	Rare Minor	Low (2)

Risk ID	Milestone	Risk description	Potential impact	Initial analysis	Initial ranking	Mitigation measures/risk treatment	Justification of treatment	Resource requirements	Performance measures and constraints	Reporting and monitoring requirements	Timing and scheduling	Residual analysis	Risk ranking
35	RM9 – Achievement of Stable PMLU	**WATER STORAGE – RUNNING DRY** Risk of rehabilitated water storage PMLU areas go dry and steep banks/depth are exposed if water is over-extracted.	• Water storage areas are unable to support other PMLU areas. • Final land use not achieved or degraded. • Socio-economic benefits not realised. • Higher land management costs.	Rare Minor	Low (2)	• Assess the post-mining uses for the water stored in the final voids and include this explicitly in the PRC Plan submission. • Assess the minimum and maximum extraction cases from the voids through water modelling, inclusive of the impact of climate change.	The focus on pre-work in the lead up to the PRC Plan submission ensures that the key items for executing the PRC Plan are included in the Meandu Mine operational documents.	Allocation of funding and internal resources to setup and run a project to investigate and assess the requirements prior to PRC Plan submission. This includes time and funding allocation for additional consulting and internal resourcing.	PRC Plan rehabilitation planning document.	PRC Plan submission.	PRC Plan submission. 3 yearly audit requirement for the PRC Plan post construction of PMLU.	Rare Minor	Low (2)

7.5 Rehabilitation trials

PRC Plan Guideline (Section 3.7.1)

In accordance with section 126C(1)(j) of the EP Act, if rehabilitation trials are planned, the rehabilitation planning part must state:

- the objective of the trial(s)
- the trial design including, but not limited to, the location, underlying land characteristics and potential issues
- the details of how the trial(s) will be carried out
- when the trial(s) will commence
- the duration of the trial(s)
- how the trial(s) will be assessed for success
- how the results of the trial(s) will be incorporated into rehabilitation strategies and the development of milestones, and
- where the trials have previously been carried out by the applicant.

The information requirements in this section will apply to all applicants, whether or not they are an existing EA holder, who have planned or commenced rehabilitation trials. Existing EA holders can provide details of any rehabilitation trials that have occurred prior to the submission of the proposed PRC plan.

Future rehabilitation trials are required and have been developed to support rehabilitation methodology and assist in milestone development at Meandu Mine for specific PMLUs. The following information relating to these trials is provided in accordance with section 126C(1)(j) of the EP Act and section 3.7.1 of the PRC Plan Guideline.

7.5.1 Basis of need for trials

The risk assessment carried out in Sections 7.2 to 7.4 identified that data gaps present a risk to the successful completion of two of the proposed PMLUs at Meandu Mine which are yet to be implemented, namely:

- Beef Cattle Grazing; and
- Steep Rocky Ecosystem.

Trials for other PMLUs were not identified as being required and justifications are provided in Section 7.5.3.

As a mitigating action, two monitoring trials as detailed in Table 7.7 have been developed in order to provide the data and confidence that specific aspect/s of the PMLU success criteria will be achieved.

While the Beef Cattle Grazing PMLU is not representative of a new land use within the local and surrounding area of Meandu Mine, no prior Meandu Mine rehabilitation has been undertaken in the planned footprint of this type of PMLU at Meandu Mine. The risk assessment (refer Table 7.6 – Risk ID 11, 13, 19, 20, 25, 26 and 34) identified the risk associated with the development and sustainability of pasture-land and grass species due to subsoil and topsoil selection to achieve target livestock carrying density.

A monitoring comparison trial of two different subsoil designs utilising available site materials to confirm the preferred makeup for the majority of the PMLU upper cover layer is proposed (see Table 7.7). Depending on results from the trial, subsequent selective waste placement within the Beef Cattle Grazing PMLU allocated polygon may then utilise one or a combination of both subsoil designs.

Steep Rocky Ecosystem is a new PMLU for rehabilitation at Meandu Mine. The risk assessment (refer Table 7.6 – Risk ID 8 and 21) identified the risk associated with vegetative failure including inability to establish self-sustaining vegetative communities and / or the need to re-establish vegetation on the highwalls and monitoring requirement for a longer than planned period. Therefore, appropriate assessment and design of the Steep Rocky Ecosystem PMLU specifications prior to their creation will prevent unnecessary re-work and impacts on established rehabilitation.

A trial will be undertaken in the form of monitoring of a number of exposed final benched pit highwalls that will form part of the final PMLU footprint as part of a longitudinal study to assess elements of native species ecosystem development (soil development, vegetation establishment and fauna development) (see Table 7.7). This trial will assess and support development of the methodology, timing and success of proposed rehabilitation practice, and may explore techniques to enhance substrate development. Collating trial data across the immediate timeframe allows for sufficient time to identify any delays or concerns and put in place remedial actions to ensure the PMLU is successful. The goal of this proposed trial is to extend the single time point of current monitoring (refer to Section 8) and create a longitudinal data set that can be used to create a trend that the final highwall progress can be measured against at the end of the LOM Plan.

7.5.2 Description of trials

A description of the future trials including all information required under section 3.7.1 of the PRC Plan Guideline is provided in Table 7.7.

Table 7.7 Future rehabilitation trials for Beef Cattle Grazing and Steep Rocky Ecosystem PMLUs at Meandu Mine

Requirement	Beef Cattle Grazing	Steep Rocky Ecosystem
Objective	To develop/verify the preferred sub-soil source material required to achieve Class 1, 2, or 3 requirements for beef cattle grazing, address land degradation and support an economically viable (weaner fattening) grazing operation.	To develop/verify rehabilitation success criteria and analogues site for final highwalls at Meandu Mine, that will achieve a self-sustaining Steep Rocky Ecosystem based on native species, containing biotic assemblages that populate and persist naturally in the wild, with similar climatic response to regional native assemblages and resilience in the face of environmental change.

Requirement	Beef Cattle Grazing	Steep Rocky Ecosystem
Trial Design • Location • Underlying land characteristics • Potential issues	Location: K4S lowwall spoil dump. Land characteristics: In-pit/out-of-pit spoil dump, comparison trial substrate to consist of: **a** minimum 5.5 m depth rehandled NAF spoil material overlain with 0.5 m topsoil and **b** minimum 5 m depth excavated NAF material, overlain with 0.8 m weathered basalt subsoil and 0.2 m basaltic topsoil. Other practices that may be considered: Periodic slashing frequency to simulate grazing until introduction of cattle in order to maintain pasture quality and enhance natural seeding and germination processes. Potential Issues: Insufficient PAWC or elevated salinity. Establishment of minimum reasonable area required prior for a representative trial means that several years may lapse between seeding some areas and trial commencement (creating a risk of deterioration). Species suitability/ establishment under site specific conditions.	Location: K2W highwall benches, and potentially K2E interim (currently developed within existing surface rights area) and SW13. Land characteristics: Excavated benches in Miocene and weathered/fresh Triassic material. Monitoring and compilation of longitudinal on-site analogue reference database indicating the development of parameters over time for use in assessment of milestone criteria for final highwalls developed towards end the LOM Plan. Potential Issues: geotechnical/ access issues, species selection and success of vegetation establishment. Variability of highwall material and access to appropriate range of material for suitable duration to conduct trial.
Commencement	2025	2024
Duration	Up to 5 years	Up to 5 years
Assessment for trial success	Persistent pasture grass mix under dryland grazing operation, to be simulated by periodic slashing of vegetation. Soil criteria achieves Class 1, 2 or 3 requirements.	Successful vegetation establishment that is persistent and provides sufficient data to allow creation of indicative timeframes for development and climatic response for on-site communities. Ecological function indicators on the right trajectory.

Requirement	Beef Cattle Grazing	Steep Rocky Ecosystem
Incorporation of results into rehabilitation strategies and milestones	Refinement/verification of species selection and material placement requirements to achieve success criteria. Timing for commencement of grazing following rehabilitation establishment and verification of sustainable stocking rates and production metrics.	Refinement of species selection and amelioration for different material types if required. Optimisation of highwall design including batter height/ bench width and drainage design for different materials. Establishment of remote monitoring program (verified against field monitoring results) and associated success criteria. Timing for achieving successful vegetation establishment on benches to inform rehabilitation schedule.
Previous trials	Not applicable.	K2E, K2W and SW highwalls (short duration monitoring trials)
Relevant supporting documents	Appendix L – Meandu Mine PRC Plan Revegetation Plan	

7.5.3 Justification for PMLUs with no need for trials

No further trials of Native Ecosystem PMLU are required because the majority of the rehabilitation that has occurred at Meandu Mine to date is Native Ecosystem and:

- there have been extensive prior trials and rehabilitation (631 ha) of Native Ecosystem to date
- in 2021, Progressive Rehabilitation Certification of 153 ha of Native Ecosystem rehabilitation (Appendix L – Meandu Mine PRC Plan Revegetation Plan) was achieved; and
- the existing rehabilitation and attendant monitoring confirms that this is a viable and achievable PMLU and that the rehabilitation objectives and proposed milestones can be met.

The Creek Diversion PMLU relates to historical creek diversions that have already been constructed at Meandu Mine. No new creek diversions or modifying major earthworks alterations are proposed for the remainder of the LOM. Any earthworks and repair would be limited to the extent that the original design is not altered and only for the purpose of maintaining stability. The historical creek diversions include:

- downstream diversion, 1986, approximately 970 m in length
- middle diversion, 1992, approximately 780 m in length; and
- upstream diversion, 2005, approximately 2,300 m in length.

The older (Downstream and Middle) creek diversions were approved in accordance with the requirements of the time, being the Mining Lease and the attendant creek diversion designs, with construction undertaken in accordance with design, and the more recent Upstream diversion work was conducted under permits held and design certification as required at the time. Construction and rehabilitation have been completed in accordance with the specific approved design and works have been inspected as certified as in compliance with design. It is therefore considered that no trial for this PMLU is required at Meandu Mine.

The planned footprint of the Plantation Forestry PMLU is populated with mature age plantation forestry established by the current plantation licence holder (HQPlantations) and an access road currently utilised for site activities that is planned to be used for forestry access post-closure. Meandu Mine proposes to preserve this area for future commercial harvesting operations after cessation of mining. The soil and subsoil are the existing in-situ material and meets or exceeds requirements of cover design for PMLU of Plantation Forestry. No or minimal disturbance is anticipated by mining activity (limited to cultural heritage clearance and/or exploration purposes). As such no trial in relation to Plantation Forestry is required.

The footprint of the planned Water Storage PMLU is located within the two final voids in the Meandu Mine final landform design. The primary concerns for final water storages relate to fluctuations in water level and water quality. There are a number of pit voids that have for short to long periods sat idle with sufficient time to collect water quality data which has been utilised in the consideration of final void water modelling. Final void water modelling (Appendix I – Meandu Mine PRC Plan Groundwater Technical Report) and a site integrated water balance model (Appendix I – Meandu Mine PRC Plan Groundwater Technical Report) have been evaluated, with routine monitoring (refer Section 8.2.4) now able to assess development against model. As there is sufficient existing data and a robust predictive model, no further trials are considered necessary.

No rehabilitation and trials will be required for the Landholder Retained Infrastructure PMLU as none is included in the PRC Plan.

8 Monitoring and maintenance

PRC Plan Guideline (Section 3.8)

Under section 126C(1)(j) of the EP Act, the administering authority considers monitoring and maintenance necessary to decide if the PRC plan is consistent with the requirements of the legislation. The rehabilitation planning part must contain a monitoring and maintenance program that identifies and describes the monitoring systems that will be carried out in order to demonstrate a milestone and milestone criteria have been achieved. The program must include, where relevant to the milestone and milestone criteria (but is not limited to):

- schedule of monitoring, reporting and review for each milestone
- description of methodologies and standards, which could include field-based assessments and the application of new remote sensing, GIS and other relevant emerging technologies
- monitoring that enables the repeatable collection of relevant statistically valid data
- monitoring using appropriate quality assurance and data management processes and systems
- regular analysis of site data including multi-year comparison trends and bench-marking against analogue/reference sites
- contingency strategies if monitoring data indicates milestone criteria are not being met
- post-closure monitoring to ensure milestone criteria has been demonstrated intent of monitoring reports, such as provision of results and key findings.

The information requirements in this section will apply to all applicants whether or not they are an existing EA holder. However, existing holders may already have the required information available from previously submitted plans/reports/applications that, if still valid, could be used in the PRC plan. If there has/is any monitoring or maintenance of areas already rehabilitated, details must be included in the PRC plan.

This section provides a summary of the monitoring and maintenance program proposed at Meandu Mine to demonstrate achievement of the RMs, as they relate to achieving PMLUs particularly to Native Ecosystem, Beef Cattle Grazing, Steep Rocky Ecosystem, Creek Diversion and Water Storage.

8.1 Monitoring and maintenance program

Rehabilitation condition at Meandu Mine has been comprehensively monitored over the past 25 years under the existing rehabilitation monitoring program. From 1995 to 2011 monitoring of rehabilitation was performed by The University of Queensland, in 2014 and 2015 by Queensland Herbarium, in 2017, 2018 and 2019 by Aurecon consultants, and most recently in 2020 and 2021 by WSP consultants, with the support of the Queensland Herbarium providing forest growth trajectory modelling. The monitoring events to date are only relevant to the Native Ecosystem PMLU as it is the only existing rehabilitated PMLU type at Meandu Mine.

The subsections herein describe the rehabilitation monitoring and maintenance programs implemented and proposed at the Meandu Mine. Consistent with the requirements of the PRC Plan Guideline and Section 126(C) of the EP Act, these sections describe how monitoring will be implemented to demonstrate progression of rehabilitation areas to achievement of rehabilitation milestones for each PMLUs. Each of the PMLUs at Meandu Mine will have different milestone criteria against which monitoring will occur and the development of

these criteria included several research and technical inputs. Appendix L – Meandu Mine PRC Plan Revegetation Plan is included to describe the rationale and technical considerations in developing these criteria.

Milestone criteria for existing Plantation Forestry PMLU are considered to have been achieved as this area is pre-existing (pre-mining) and will remain undisturbed through to the closure. The trees within this PMLU were established by the Plantation Licence holder prior to the area becoming part of the surface rights areas. No monitoring requirement is considered necessary for the Plantation Forestry PMLU since no new plantation is currently proposed within the surface rights area of mining lease (ML6674). Plantation Forestry is therefore not included in Table 8.1 or Table 8.2.

The upstream (south) creek diversion at Meandu Mine has been rehabilitated using a native revegetation approach and is currently undergoing monitoring, maintenance and intervention. The same approach will be applied to rehabilitate the downstream (central and north) creek diversions and the littoral zones located on the lowwall side of the final void, therefore the same monitoring and maintenance measures will be applicable to these areas.

Water monitoring will continue to take place in the Water Storage areas at Meandu Mine through to closure, some of which provide data that will be applicable to the final voids Water Storage PMLU. The milestone criteria for water quality are consistent with those specified in the current Meandu Mine EA and are outlined in RM9 in Table 9.2, Section 9.

A significant area of existing Native Ecosystem PMLU has substantially completed the applicable Rehabilitation Milestones (616.5 ha, 153 ha of which have been certified as completed). Further details are provided in Table 2.23.

A summary of the rehabilitation milestone monitoring requirements for each PMLU is provided in Table 8.1.

A summary of the monitoring activities that will be undertaken for each applicable PMLU against each Milestone is provided in Table 8.2. The relevant monitoring activities will be undertaken as appropriate for the Milestone status of each applicable rehabilitation area. The tables do not include criteria Landholder Retained infrastructure, as the PMLU is not utilised in this PRC Plan. Should any future amendment to the PRC Plan utilise Landholder Retained Infrastructure as a PMLU, the appropriate monitoring requirements will be developed and included in the amendment application.

Table 8.1 Rehabilitation milestone monitoring requirement for each PMLUs

PMLUs	RMs only require maintenance and intervention against milestone criteria	RMs require long-term monitoring and tracking against milestone criteria
Plantation Forestry	Milestone criteria for existing Plantation Forestry PMLU have all been achieved and no new plantation is currently proposed	
Creek Diversion	RM4 RM5 RM6	RM7 RM9
Water Storage (including littoral zones of final void lowwall side)	RM4 RM5 (for littoral zones) RM6 (for littoral zones)	RM7 RM9

PMLUs	RMs only require maintenance and intervention against milestone criteria	RMs require long-term monitoring and tracking against milestone criteria
Steep Rocky Ecosystem	RM4 RM6	RM7 RM9
Native Ecosystem Beef Cattle Grazing	RM1 RM2 RM3 RM4 RM5 RM6	RM7 RM8 RM9
Landholder Retained Infrastructure	No rehabilitation milestones to apply as there is no Landholder Retained Infrastructure in this PRC Plan.	

Table 8.2 Milestone criteria and proposed monitoring activities against each applicable PMLUs

PMLU against RM	Beef Cattle Grazing	Native Ecosystem	Steep Rocky Ecosystem	Creek Diversion	Water Storage
RM1: Infrastructure decommissioning and removal	**General milestone criteria:** **a** All services are disconnected. **b** All buildings demolished and removed. **c** Hardstands and roads (bitumen, blue metal, aggregate etc) are removed. **d** Infrastructure (pipelines, signage etc) are removed. **e** Any non-retained are decommissioned. **f** Machinery not required for rehabilitation removed off-site. **g** Any fences not needed for safety or security purposes are removed.				
	h The private road that is within the Beef Cattle Grazing PMLU and links the Beef Cattle Grazing PMLU to the end of (the local gazetted road) Nobby Smith Way remains in place to provide all weather vehicle access to the Beef Cattle Grazing PMLU.	No additional criteria	No additional criteria	No additional criteria	No additional criteria
	Monitoring and Maintenance activities: • Visual inspection and review of: Service termination records. • Decommissioning and removal of all built infrastructure listed in the PRC Plan and applicable ERC submission.				
RM2: Investigation and/or remediation of contaminated land	**General milestone criteria:** **a** Contaminated land investigations to be carried out by a suitably qualified person. **b** Removal and disposal, or appropriate treatment onsite, of any contaminated materials or soils. **c** Removal and disposal of plastic/ geofabric liners from dams/leach pads etc. **d** Carry out validation testing to confirm that the remediation/ removal has been completed.				

PMLU against RM	Beef Cattle Grazing	Native Ecosystem	Steep Rocky Ecosystem	Creek Diversion	Water Storage
	No additional criteria	No additional criteria	No additional criteria	No additional criteria	No additional criteria
	Monitoring and Maintenance activities: Certification as required by a suitably qualified person.				
RM3: Installation of cover system over coal combustion products, and tailings storage facilities	**General milestone criteria:** **a** Cover systems on tailings and coal combustion productions are designed and installed in such a way as to effectively minimise the infiltration of water into the tailings deposition area and the likelihood of any erosion occurring in the final cover system. **b** Cover systems on coal combustion products and tailings are designed by a suitably qualified and experienced person. **c** Coal combustion products and tailings storage areas have undergone an appropriate period of desiccation to allow safe and effective placement of the initial capping layer. **d** Coal combustion products are at least 2 m below and tailings at least 6 m below final landform surface. **e** Decommissioning report from a suitably qualified person confirming that the facility has been successfully capped, includes a layer to minimise the infiltration of water into the underlying material and, the capped surface levels provide effective drainage of surface runoff to mine drainage systems.				
	No additional criteria	No additional criteria	No additional criteria	No additional criteria	No additional criteria
	Monitoring and maintenance activities: • Field verification of construction process by relevant supervisors and technical team. • Practical completion report required from a suitably qualified and experienced person. • Visual inspection as required by a suitably qualified person of cover system during construction and following completion.				

PMLU against RM	Beef Cattle Grazing	Native Ecosystem	Steep Rocky Ecosystem	Creek Diversion	Water Storage
RM4: Landform development and reshaping	**General milestone criteria:** **a** Bulk earthworks achieve required landform mass balance – excluding allowance for access required for ongoing maintenance or required for PMLU purposes. **b** For all landforms constructed after 2016, the upper 6 m of material beneath the final landform surface is NAF. Mixed Plant Rejects (MPR) are located a minimum of 6 m beneath the final landform surface. **c** Subsoil material meets the criteria for the relevant PMLU. **d** Completed general reshaping achieves the overall landform slope. **e** Any designed waterways, drains and erosion and sediment control systems are installed. **f** Non-regulated dams not included as a feature of the final landform design for the PMLU have been filled. **g** Regulated dams / structures have been decommissioned and profiled according to the requirements of the decommissioning and rehabilitation plan for the structure developed by a suitably qualified and experienced person.				
	Additional PMLU specific criteria **h** Slopes are constructed such that the overall grade meets the following: • 80% of slopes are ≤ 15%, minor areas are up to a maximum of 25% • Factor of Safety ≥1.5 is achieved **i** Subsoil layer placed as part of the 6 m NAF dump cover is of suitable properties and of sufficient thickness to achieve Class 1, 2 or 3 land suitability criteria for beef cattle grazing as described in Table 6.10 of this PRC Plan.	**Additional PMLU specific criteria** **j** Slopes constructed such that the overall grade meets the following criteria: • The majority of slopes are ≤ 17%, minor areas are up to a maximum of 25% • Factor of Safety ≥1.5 is achieved	**Additional PMLU specific criteria** **k** Slopes constructed such that: • The landform provides a diversity of slopes, including a mix of predominately flat benches and batters up to 80 degrees, that create a varied environment for the future establishment of niche habitats. • Factor of Safety ≥1.5 is achieved at the projected stable crest.	**Additional PMLU specific criteria** **m** Landform is in accordance with conditions of the approved design plans.	**Additional PMLU specific criteria** **n** Slopes constructed such that: **o** Factor of Safety ≥1.5 is achieved

PMLU against RM	Beef Cattle Grazing	Native Ecosystem	Steep Rocky Ecosystem	Creek Diversion	Water Storage
			l Install a cover system on exposed residual coal seams where identified as appropriate by a suitably qualified person.		
	Monitoring and Maintenance activities: Quality assurance and controls on landform construction are in accordance with Section 6.1.5.7 of the PRC Plan and include: • approval of design plans by relevant operations and planning personnel • Field verification of construction process by relevant supervisors and technical team members • A survey of the final landform to confirm the overall slope requirements are achieved in accordance with the PMLU specific criteria.				
RM5: Surface preparation	**General milestone criteria:** **a** Remediate active erosion or subsidence as required prior to the application of topsoil. **b** Undertake testing of topsoil prior to spreading such that characterisation can be assessed and the topsoil identified to be suitable for the nominated PMLU. Where necessary, improvements to the soil such as amelioration or blending are to be undertaken to achieve the recommendations for the nominated PMLU. **c** Source, haul and spread topsoil of appropriate properties to a nominal depth of 0.2 m to the applicable footprint (e.g. not including rock armoured areas or constructed drains).				
	Additional PMLU specific criteria: **d** Post topsoil placement, the surface is to be contour ripped to a nominal depth of 0.3-0.5 m to aid in erosion control and vegetation root penetration where needed.	**Additional PMLU specific criteria:** **e** Post topsoil placement, the surface is to be contour ripped to a nominal depth of 0.3-0.9 m to aid in erosion control and vegetation root penetration where needed.	**Additional PMLU specific criteria:** No additional criteria. Note: no topsoil to be placed within the Steep Rocky Ecosystem PMLU [subject to outcomes of the rehabilitation trial].	No additional criteria	**Additional PMLU specific criteria:** For clarity, topsoil is to be placed only in the littoral zone[1]. The topsoiled area is to be contour ripped to a nominal depth of 0.3-0.9 m to aid in erosion control and vegetation root penetration where needed. [1] down to the higher of either (i) the lower RL of the modelled void water level fluctuation or (ii) the actual rebounded water level.

PMLU against RM	Beef Cattle Grazing	Native Ecosystem	Steep Rocky Ecosystem	Creek Diversion	Water Storage
	Monitoring and Maintenance activities: Quality assurance and controls on surface preparation in accordance with section 6.1.5.7 of this PRC Plan, with controls specific to RM5 including: • Testing of topsoil to ensure adequate characterisation and allocation to the appropriate PMLU and improvements are undertaken where required • A survey and/or assessment of the final landform to confirm topsoil is spread to the nominal depth • Survey reconciliation of topsoil register at the completion of works to ensure accurate tracking of available material.				
RM6: Revegetation	**General milestone criteria:** **a** Species selection is in accordance with the specific criteria for each PMLU **b** Species seeding rate and/or tubestock planting rate is in accordance with the requirements of the specific criteria for each PMLU.				
	Additional PMLU specific criteria: **c** Species selection and seeding rates comprise: • a mixture of annual and perennial pasture species • a high percentage of 3P grasses (palatable, productive and perennial) • inclusion of desirable forbs (e.g. legumes) • species that flower in different seasons • where assessed as necessary, achievement of an initial cover crop. **d** Light grazing, or slashing, to take place during the first summer / autumn season after the pasture seeds.	**Additional PMLU specific criteria:** **g** Species selection and seeding rates comprises a mixture of plant species similar to local regional ecosystems (RE), based on benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7.	No seeding rate requirements, apply, adjusted if necessary in line with the results of the Steep Rocky Ecosystem monitoring trial.	**Additional PMLU specific criteria:** **h** Vegetation is to be a mixture of plant species substantially reflecting on those found in local riparian regional ecosystem (RE 12.3.3), with species and seeding rates to be suitable for wet ground conditions or irregular inundation.	**Additional PMLU specific criteria:** **i** Species selection only applies to the littoral zone[1]. Vegetation is a mixture of plant species substantially reflecting those found in local riparian regional ecosystem (RE 12.3.3), with species and seeding rates suitable for wet ground conditions or irregular inundation. [1] down to the higher of either (i) the lower RL of the modelled void water level fluctuation or (ii) the actual rebounded water level.

PMLU against RM	Beef Cattle Grazing	Native Ecosystem	Steep Rocky Ecosystem	Creek Diversion	Water Storage
	e Species mix and seed rates is adjusted where necessary in line with the results of the Beef Cattle Grazing Trial. **f** Shelter belts of trees, with appropriate species selected from the Native ecosystem PMLU species mix to be in 50-100 m widths				
	Monitoring and maintenance activities: • Visual inspection. • First year grazing management.	**Monitoring and maintenance activities:** • Visual inspection • Seeder calibration and monitoring of applied seeding rates • Maintenance and intervention where required.	N/A	**Monitoring and maintenance activities:** • Visual inspection • Maintenance and intervention where required.	**Monitoring and maintenance activities:** • Visual inspection. • Maintenance and intervention where required.
RM7: Achievement of initial surface requirements	**General milestone criteria:** **a** Monitoring of vegetation to confirm that species growth and composition is appropriately progressing to meet requirements of the criteria for RM9. **b** Monitoring of landform condition to demonstrate that the land remains stable and non-polluting. **c** Intervention and remediation as required to maintain a trajectory that will achieve RM9. **d** Maintenance of any access required for monitoring and fire safety. **e** Installation of any required land improvements in accordance with the specific criteria for each PMLU.				

PMLU against RM	Beef Cattle Grazing	Native Ecosystem	Steep Rocky Ecosystem	Creek Diversion	Water Storage
	Additional PMLU specific criteria: **f** Regular light grazing/slashing is undertaken to encourage growth and continue self-seeding cycle. **g** Rapid assessment in year 1. Monitoring of land capability utilising dry season yield per hectare in years 3 and 5 and every 5 years thereafter. **h** Stock fencing is installed where required.	**Additional PMLU specific criteria:** **i** Rapid assessment in year 1. BioCondition assessment in years 3 and 5 and every 5 years thereafter. **j** Number of native species of native trees, shrubs and grasses equals or exceeds the RM9 criteria of 4, 6 and 4.	**Additional PMLU specific criteria:** **k** Presence of a mosaic of bare and vegetated land surfaces. **l** Presence of a variety of plant assemblages. **m** Plant assemblage structure consistent with that occurring on the trial sites	**Additional PMLU specific criteria:** **p** Records retained of as-built drawings and certification that creek diversions are operating in accordance with approved design and associated criteria. **q** Vegetation establishment and geotechnical stability assessed at years 1, 3 and 5, and every 5 years thereafter. Morphological stability assessed every 5 years.	**Additional PMLU specific criteria:** **r** Bi-annual water quality monitoring between years 1-10 with analysis by a NATA accredited laboratory. Analytes monitored are to include: TDS, Calcium, Magnesium, Nitrate, Nitrite, Sulfate, Cobalt, nickel, Zinc, Arsenic, Boron, Selenium, Molybdenum, Fluoride. **s** Vegetation establishment for the littoral zone (down to the lower reduced level of the modelled void water levels) assessed at years 1, 3 and 5, and every 5 years thereafter.
	Monitoring and maintenance activities: • Rapid assessment. • Visual inspection. • Land condition monitoring. • Pasture yield monitoring.	**Monitoring and maintenance activities:** • Rapid assessment. • BioCondition assessment. • Visual inspection. • Fauna observation. • Maintenance and intervention where required.	**Monitoring and maintenance activities:** • Trial bench condition monitoring. • Soil properties monitoring. • Vegetation field survey. • Remote sensing monitoring.	**Monitoring and maintenance activities:** • Vegetation field survey. • Morphological stability. • Geotechnical stability. • Surface erosion monitoring. • Local drainage monitoring.	**Monitoring and maintenance activities:** • Bi-annual water quality monitoring between years 1-10 with analysis by a NATA accredited laboratory.

PMLU against RM	Beef Cattle Grazing	Native Ecosystem	Steep Rocky Ecosystem	Creek Diversion	Water Storage
RM8: Water quality at rehabilitated state	**General milestone criteria:** For the relevant drainage areas upgradient of CP3: **a** Water quality in Meandu Creek shows progressive improvement over time, assessed annually at location CP3 and as indicated by the median concentration of the following analytes pH, Eh, EC, major Ions, Total Alkalinity / Total Acidity & Total Hardness, Fluoride, Ammonia, Nitrate, Nitrite, Copper, Mercury, Cobalt, Iron, Molybdenum, Aluminium, Arsenic, Cadmium, Chromium, Lead, Nickel, Zinc, Boron, Manganese, Selenium, Vanadium. Hardness corrections is applied to metals such as copper to measure acute toxicity to biota. **b** Aquatic ecology health monitoring is undertaken every 3 years in Meandu Creek between RD10 and RD1, and shows a progressive improvement, or is similar to, other ephemeral waterways in the region, with respect to the measurement of (i) aquatic habitat (through bioassessment score) (ii) riparian vegetation and (iii) diversity of macroinvertebrate communities. **c** Groundwater monitoring assessed annually in the NWBV using GW monitoring bores GW34, GW48, GW49 and GW75 (or suitable replacement bores in the NWBV area) demonstrates stable or improving median levels of the following analytes: EC, pH, TDS, Total Acidity / Total Alkalinity, Total hardness, major ions and metals/metalloids indicative of AMD or SMD. For the relevant drainage area upgradient of CP4 (QW): **d** Monitoring of movement and/or concentration of EC levels indicates a trend that salinity is not increasing and remains static to the extent that likelihood of future mobilisation towards the receiving environment (Meandu Creek) at existing concentrations is unlikely to cause any detrimental impact. For the relevant drainage area associated with location CP2 (BC): **e** Monitoring of movement and/or concentration of EC levels indicates a trend that salinity is not increasing and remains static to the extent that likelihood of future mobilisation towards the receiving environment (Meandu Creek) at existing concentrations is unlikely to cause any detrimental impact.				
	No additional criteria	No additional criteria	No additional criteria	No additional criteria	No additional criteria
	Monitoring and maintenance activities: Bi-annual water quality monitoring between years 1-10 with analysis by a NATA accredited laboratory.				

PMLU against RM	Beef Cattle Grazing	Native Ecosystem	Steep Rocky Ecosystem	Creek Diversion	Water Storage
RM9: Achievement of PMLU	**General milestone criteria:** **a** A hazard assessment by an appropriately qualified and experienced person is undertaken and concludes that safety hazards in the applicable PMLU are analogous to the hazards in equivalent land use sites in the surrounding unmined landscape [Note: Use of an equivalent land use site does not apply to the Steep Rocky Ecosystem or Water Storage PMLUs, however hazard assessments are required for both consistent with the PMLU specific criteria in this table]. **b** Indicators for runoff demonstrate the following suitable water quality parameters for EC and pH: pH: 5.5-9.0 (median) EC: <2037 µS/cm (median) [Note: does not apply to Water Storage PMLU or the undisturbed by mining Plantation Forestry PMLU]				
	c A land suitability assessment is undertaken by an appropriately qualified and experienced person using 'Regional Land Suitability Frameworks for Queensland (2013)', which confirms that grazing land meets either Class 1, 2 or 3 land suitability for grazing. **d** >50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 18%. **e** >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 18%.	**f** >50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 20%. **g** >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 20%. **h** Vegetation comprises a mixture of plant species similar to local regional ecosystems based on benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7. **i** Number of native species of native trees, shrubs and grasses equals or exceeds > 4, 6 and > 4 respectively. **j** Tree canopy cover is at least 20%	**k** A hazard assessment is undertaken by an appropriately qualified and experienced person, which confirms an acceptable residual hazard ranking is achieved. [Note: Comparison to an equivalent land use site is not required]	Note: For the hazard assessment the equivalent land use site in the surrounding landscape is creeks. **o** An assessment by an appropriately qualified and experienced person confirms that the creek diversion is functioning as designed and the performance and integrity of the watercourse diversion and/or adjacent watercourses is not threatened.	**q** A hazard assessment by an appropriately qualified person is undertaken and confirms that the water storages are designed and constructed such that they are safe for humans, stock and wildlife. [Note: Comparison to an equivalent land use site is not required] **r** Vegetation in the littoral zone is to be a mixture of plant species substantially reflecting those found in local riparian regional ecosystem (RE 12.3.3), with species to be suitable for wet ground conditions or irregular inundation.

PMLU against RM	Beef Cattle Grazing	Native Ecosystem	Steep Rocky Ecosystem	Creek Diversion	Water Storage
				p Vegetation is a mixture of plant species substantially reflecting those found in local riparian regional ecosystem (RE 12.3.3), with species suitable for wet ground conditions or irregular inundation.	**s** Water storages contain water of a suitable quality for native wildlife and/or livestock ingestion using the following indicators: TDS: <5,000 mg/L Calcium: ≤1,000 mg/L Magnesium: ≤2,000 mg/L Nitrate: ≤400 mg/L Nitrite: ≤30 mg/L Sulfate: ≤1,000 mg/L Cobalt: ≤1 mg/L Nickel: ≤1 mg/L Zinc: ≤20 mg/L Arsenic: ≤0.5 mg/L Boron: ≤5 mg/L Selenium: ≤0.02 mg/L Molybdenum: ≤0.15 mg/L Fluoride: ≤2 mg/L
	Monitoring and maintenance activities: • Rapid assessment. • Visual inspection. • Land condition monitoring. • Pasture yield monitoring. • Soil sampling.	**Monitoring and maintenance activities:** • BioCondition assessment. • Visual inspection. • Fauna observation. • Soil sampling. • Maintenance and intervention where required.	**Monitoring and maintenance activities:** • Soil properties monitoring. • Vegetation field survey. • Remote sensing monitoring. • Fauna observation. • Invertebrate monitoring.	**Monitoring and maintenance activities:** • Vegetation field survey. • Morphological stability. • Geotechnical stability. • Surface erosion monitoring. • Local drainage monitoring. • Water quality monitoring.	**Monitoring and maintenance activities:** • Bi-annual water quality monitoring between years 1-10 with analysis by a NATA accredited laboratory.

8.2 Rehabilitation monitoring methodologies

This section provides an instructional overview of the proposed monitoring programme including the parameters to be monitored in relevant to rehabilitation milestones and the assessment of monitoring outcomes.

8.2.1 Ecological and soil field surveys

The following rehabilitation monitoring activities are applicable to rehabilitation milestones for both Native Ecosystem PMLU, Beef Cattle Grazing PMLU, and Creek Diversion PMLU.

8.2.1.1 Rapid assessments

Rapid assessments are applicable to the Native Ecosystem and Beef Cattle Grazing PMLUs.

The assessments undertaken in the first year after establishment (refer Table 8.8 and Table 8.9) will be rapid assessments which focus on groundcover establishment and soil characteristics and stability. To achieve this, the assessment will commence with a random meander through the site recording species observed, taking note of groundcover patchiness and any erosion evident. Following this a representative location will be chosen that is towards the centre of the site to randomly throw a 1 x 1 metre quadrat in the four compass directions (north, east, south and west). The species will be recorded along with the groundcover percentage within these quadrats.

To determine if remediation activities are required in accordance with milestone criteria specified for each milestone, the results will be analysed in relation to the following outcomes:

- groundcover percentage
- species diversity should include all groundcover species within the seed mix applied during establishment
- no evidence of major erosion starting i.e., gullies or rills deeper than 100 mm
- evidence of recruitment of each vegetation category at the specified diversity.

8.2.1.2 Native Ecosystem BioCondition methodology

The following BioCondition assessment is only appliable to the Native Ecosystem PMLU. Refer to Section 8.2.2 and Section 8.2.4 respectively for Beef Cattle Grazing and Creek Diversion requirements.

The monitoring methodology after the first year is to establish permanent monitoring plots. The methodology presented here is that which was developed by the Queensland Herbarium using an adapted BioCondition methodology (Nelder & Ngugi, 2014; Nelder & Ngugi, 2017).

To establish a new monitoring plot the following methodology is used. If a plot is already established (i.e. is an existing rehabilitation site) the methodology will be the same except that the star picket will already be in place and the direction of the plot will already be known.

For the 50 m x 4 m plot:

- establish a new permanent plot by choosing a location to enter a star picket which is representative of the site. The number of new plots per rehabilitation area is dependent on the overall area of the rehabilitation site. Each site should have a minimum of two plots to account for natural variation and further plots should be installed at a ratio of 1 plot per 10 ha i.e., for an area 10 ha or less install 2 plots, 11–20 ha install 2 plots, 21–30 ha install 3 plots etc
- record the location of the star picket by GPS co-ordinate
- run out a 50 m tape, recording the bearing of the transect and the GPS location of the end point
- mark out 2 m either side of the 50 m tape with flagging tape to delineate the 50 m x 4 m plot
- record the canopy, sub-canopy and shrub cover by measuring that which overlaps the tape measure
- record the median canopy height (where applicable to the vegetation)
- record sub-canopy median height, if this stratum is present
- using a 1 m x 1 m quadrat, record the groundcover every 10 m along the tape (i.e., 10 m, 20 m, 30 m, 40 m and 50 m)
- record stem counts for each vegetation category
- record all trees and shrubs with a diameter at breast height (DBH) of >2 cm, noting all stems if plant is multi-stemmed; and
- measure the height of at least four dominant tree stems and permanently mark them for future assessments. Record GPS location of trees and distance along transect tape. If it is an existing plot, find the previously marked trees.

For the 50 m x 14 m plot:

- utilise the existing 50 m x 4 m plot and extend the sides to 7 m either side of the measuring tape
- record species richness of each life form. Actual species identification is not required (although is preferable), only the number of different species for each life form. Further information regarding the categorisation of each life form can be found in the BioCondition assessment manual (Eyre et al., 2015)
- record coarse woody debris (total length in metres for debris >50 cm length and >10 cm diameter); and
- record recruitment of dominant canopy species (i.e., juveniles emerging of canopy species).

Additional information to collect:

- for a new site which has not been monitored previously, collect a composite soil sample from the top 30 cm of soil. This should only include topsoil (i.e., no overburden, rock fragments etc.). This is to be sent to a laboratory or the Queensland Herbarium (if partnered for the rehabilitation assessment) for determining soil texture and water holding capacity; and
- other observations at the site which may be important to note such as soil erosion issues, any incidental fauna observations etc.

8.2.1.3 Visual inspections

Visual inspections are applicable to the Native Ecosystem, Beef Cattle Grazing, Steep Rocky Ecosystem, Creek Diversion and Water Storage PMLUs.

In addition to the above monitoring processes, regular visual inspections are also undertaken at the Meandu Mine to assist with determining if rehabilitation areas are progressing towards the rehabilitation milestones and success criteria. Visual inspections seek to rapidly identify an array of issues which may require further investigation, maintenance and/or intervention measures to ensure that areas continue to progress towards achieving rehabilitation milestones and success criteria.

Generally visual inspections seek to identify areas with:

- landform stability issues (e.g. graded bank failures and active gully erosion);
- poor vegetation establishment; and/or
- pest flora and fauna establishment.

8.2.1.4 Fauna observation

Fauna observation is applicable to the Native Ecosystem and Steep Rocky Ecosystem PMLUs.

Observations of any fauna species presence within or in the vicinity of the rehabilitation areas will be noted as part of rehabilitation monitoring. Where monitoring and management deems necessary, targeted fauna surveys will be developed and undertaken.

8.2.1.5 Soil sampling

Soil sampling is applicable to the Native Ecosystem, Beef Cattle Grazing, Steep Rocky Ecosystem and Creek Diversion PMLUs.

Soil sampling is undertaken at each new monitoring (transect) site. Methodologies on sampling from the *Australian Soil and Land Survey Field Notebook* (National Committee on Soil and Terrain, 2009) are used. Soil samples are taken from five locations along the transect (at 10 m intervals from within the bottom left-hand corner of the 1 x 1 m quadrats) from a maximum depth of 300 mm, dug with a hand trowel. The five samples are bulked within a labelled plastic zip lock bag prior to being transferred to the Queensland Herbarium to determine soil texture and water holding capacity.

Soil sampling for the Steep Rocky Ecosystem PMLU may be revised according to specific trial requirements and accessibility. The intent of monitoring for the Steep Rocky Ecosystem PMLU is to be monitoring the development of the substrate as noted in Section 8.2.3.

8.2.2 Additional Beef Cattle Grazing PMLU monitoring

This section describes the monitoring methodologies that are specifically developed for the Beef Cattle Grazing PMLU (refer to Appendix L – Meandu Mine PRC Plan Revegetation Plan).

8.2.2.1 First Year grazing management

Grazing management in the first year is critical to the establishment and long-term viability of sown pastures. There are two general approaches (DAF, 2022):

- no grazing until the pasture seeds
- lightly grazing once or twice during the first summer/autumn.

Light grazing is unlikely to be practicable while the Meandu Mine is operational and therefore will be replaced by slashing. Slashing should encourage the grasses to spread out and will reduce the build-up of too much growth that can smother young grasses and legumes. Allowing the pasture to seed in the first year is important for grasses that reproduce via seed only, rather than runners. Species such as Rhodes grass and others (e.g., creeping bluegrass – *Bothriochloa insculpta*) should fill in the gaps without seeding.

8.2.2.2 Land condition monitoring

Once established, land condition monitoring will be undertaken in rehabilitation used for the Beef Cattle Grazing PMLU. The objective of land condition monitoring is to determine the capacity of land to produce useful forage and is therefore, directly related to carrying capacity, livestock production and profitability (FutureBeef 2018). Land condition monitoring considers both soil and pasture condition and woody regrowth potential and classifies land into four broad categories as outlined in Table 8.3.

Table 8.3 Land condition classification

Condition category	Overview
A condition – good condition	• dominance of 3P (palatable, perennial and productive) pasture species; with little bare ground (<30%) • few weeds • no erosion and good soil surface condition; and • 100% long-term carrying capacity.
B condition – fair condition	• fewer 3P species, bare ground 30–50% • signs of previous erosion or potential erosion risk; and • 75% long-term carrying capacity.
C condition – poor condition	• large amounts of less favoured species, >50% bare ground • signs of previous erosion or current susceptibility to erosion is high; and • 45% long-term carrying capacity.
D condition – very poor condition	• lack of perennial grasses • severe erosion and scalding; and • less than 25% of long-term carrying capacity.

Grazing in rehabilitation should aim to maintain or improve land condition. Monitoring is qualitative and will be recorded and reported using the Stocktake Plus App (available at http://stocktakeplus.com.au/) or similar reporting tool. Land condition monitoring will be undertaken alongside pasture yield assessments for forage budgeting, or before and after rehabilitation grazing periods, or more frequently if desired.

8.2.2.3 Pasture yield monitoring

Pasture monitoring will be undertaken to determine the dry season yield per hectare to determine the potential safe stocking capacity that will avoid land degradation. This assessment method is based on collecting pasture samples from 0.5 m x 0.5 m quadrats along 50 m monitoring transect as follows:

- select five ground cover quadrat locations at random along each transect
- harvest the grass from each of the five 0.5 m x 0.5 m quadrats. The quadrat should be located adjacent to the centre line, noting if located to the left or right of the centre line and the distance along the centre line
- using shears, cut the herbage (grass & herbs) to within approximately 1 cm of the ground level and bag all the harvested material in a large labelled paper bag. Note that if there are large amounts of old dead herbage (typically grey in colour) it should be separated from the sample and discarded to prevent over estimation of the pasture mass
- determine the net (wet) weight of each sample (net weight = sample weight minus the bag weight)
- sub-sample each of the 'wet' sample quadrats. The subsample should be of mostly leafy material since this is mostly what cattle feed on. Incorporating stem material will result in potentially artificially high net weights
- measure the wet weight of each of the five sub-samples in grams
- oven dry the sub-sample (samples will be dried for 48 hours at approximately 70–80°C using a dehydrator)
- weigh the oven dried sub-sample (in grams)
- calculate dry matter percentage of the sub-sample
- use this dry matter percentage figure to determine the dry matter weight of each quadrat
- calculate the equivalent dry matter weight for each quadrat for one hectare (kg DM/ha); and
- determine dry season pasture budget to provide a guide for the appropriate stocking rate for the proposed light grazing land use (for an example see: *Dry season pasture budget: a guide for stocking rates* (FutureBeef, 2018)).

8.2.3 Additional Steep Rocky Ecosystem PMLU monitoring

This section describes the monitoring methodologies that are specifically developed for the Steep Rocky Ecosystem PMLU (refer to Appendix L – Meandu Mine PRC Plan Revegetation Plan).

8.2.3.1 Trial bench condition monitoring

Monitoring of trial benches (permanent belt transects or plots) describes the germination, establishment, maturation and long-term sustainability of plant species that colonise the trial site(s) by wind, birds, bats or other fauna.

The success criteria will be demonstrated by the trial results which will show statistics on occurrence of colonising species, and time sequence data on the species survival and growth.

8.2.3.2 Soil properties monitoring

Physical soil samples will be collected during field surveys. Monitoring of selected sites for basic soil properties will reveal the changes occurring in these substrates over time. These data will also show how the soil profile will evolve on rehabilitated sites. The soil samples will be assessed for colour, texture, pH, EC (conductivity), organic matter content, dispersion, exchangeable elements (Al, Na, Ca, Mg, K), soluble ions (Cl-, K+, NO3-, NH4+) and EDTA extractable elements (B, Cu, Fe, Mn, Mo, Zn) using standard CSBP methods.

Results of the soil properties monitoring will be used to predict the nature of flora and fauna that would colonise on the rehabilitated mine sites.

Further details for soil sampling, laboratory treatment and analysis and data analysis methodologies are included in Appendix L – Meandu Mine PRC Plan Revegetation Plan.

8.2.3.3 Vegetation, fauna and erosion monitoring

A combination of on-ground and remote monitoring will be required for the rehabilitation of Steep Rocky Ecosystem PMLU.

Field survey

Ground-truthing field survey will be undertaken to establish trends (including seasonal and climatic), determine/verify success criteria, provide comparison to analogue sites, confirm ecosystem functionality/ trends and support remote monitoring requirements.

At each monitoring site, photos will be taken, and land cover (including vegetation cover) will be determined. Plants will be collected, conserved as herbarium specimen, and identified to genus level where possible. In areas where safe access is not possible, remote photography utilising drone-based cameras may be utilised.

Desktop – remote sensing technique

Permanently marked monitoring sites will be monitored using repeat topography and via remote sensing (e.g. Lidar) to assess soil erosion rates. This monitoring will indicate if and where there may be a need for intervention and can support future design considerations.

Over whole of landscape, remote sensing assessment is proposed to detect change in foliage cover photosynthetic activity (estimated Foliage Projective Cover (FPC) and Normalised Difference Vegetation Index (NDVI)) seasonally. This will be particularly important for inaccessible areas of the void benches.

Monitoring reporting will be prepared describing rehabilitation success (including trends and trajectories), that will provide data on:

- plant assemblages – structure and composition (richness)
- phenology of monitored flora
- resilience of established vegetation to natural variables such as drought, heavy rains and bush fire
- habitation by larger fauna; and
- linkages established between rehabilitated sites and the surrounding undisturbed sites.

Fauna observation will be undertaken during the field visits and a method consistent with that applied to the Native Ecosystem PMLU (refer Section 8.2.1.4).

8.2.3.4 Invertebrate monitoring

Invertebrate fauna will be sampled using three techniques:

- sweeps of the vegetation with a handheld net (20 duplicate sweeps)
- manual intensive diurnal search (0.5 hr duration)
- manual sorting of leaf litter and associated duff layer (collected from a single 0.25 m^2 quadrat per site).

These techniques will be similar to those used during the previous sampling programs, in which the collected material from the sweep net was transferred to a plastic bag and flooded with 70% aqueous ethanol for transport to the laboratory for sorting. Invertebrates encountered during the intensive searches were placed in vials containing 70% aqueous ethanol. Litter samples were collected into plastic bags and sorted on the day of collection. Invertebrates were transferred to 70% aqueous ethanol in vials for future sorting.

In the laboratory collected samples were washed through a fine sieve (150 µm) and transferred into a sorting-trough with 70% ethanol for systematic searching with a stereomicroscope. Specimens encountered were classified to order (Naumann, 1991), counted and vouchered. Exceptions to the order-level classification were:

- Acarina (mites), Chilopoda (centipedes), and Diplopoda (millipedes) were classified to class-level only
- Hymenoptera was divided into family Formicidae (ants) and Other Hymenoptera (wasps and bees)
- Hemiptera was divided into suborder Heteroptera (true bugs) and Homoptera (phytophagous bugs); and
- Gastropods were classified to family.

To gain an indication of developing trophic structure amongst the invertebrate assemblages at each site invertebrate taxa likely to be dominated by relatively uniform feeding habits were classified as detritivores, herbivores, or predators (Houston and Melzer, 2018). Although Acarina (mites) include some predators, they are mostly detritivores. Formicidae (ants) and Diptera (flies) have a diverse array of feeding habits and are not included in this classification. Where it was possible to identify the family of the Coleoptera specimens they were included in the classification. Otherwise Coleoptera were excluded.

Monitoring reporting will be describing rehabilitation success (including trends and trajectories), that will provide data on:

- invertebrate composition and abundance
- ant functional groups
- linkages established between rehabilitated sites and the surrounding undisturbed sites.

Further details for invertebrate sampling, laboratory treatment and analysis and data analysis methodologies are included in Appendix L – Meandu Mine PRC Plan Revegetation Plan.

8.2.4 Additional Creek Diversion PMLU monitoring

This section describes the monitoring that has been developed for the Creek Diversion PMLU. It is based on the monitoring program included in the approved design plan for the upstream (south) diversion. An appropriate program will be developed for the two downstream (north and central) diversions, addressing similar objectives.

8.2.4.1 Vegetation establishment and sustainability

The objectives for vegetation establishment monitoring are to demonstrate:

- effective control of soil erosion through vegetation establishment
- a minimum ground cover of 50%
- vegetation species diversity that reflects existing riparian vegetation common to the catchment.

Methodologies similar to those used for the neighbouring Native Ecosystem PMLU will be utilised to assess vegetation establishment in the Creek Diversion PMLU, but will compare against the dominant riparian regional ecosystem in the catchment (RE 12.3.3).

8.2.4.2 Morphological stability

The specific objective of monitoring morphological stability is to demonstrate that the low flow channel of the diverted river is stable in plan form, and vertical profile, and that there are no significant areas of unstable floodplain and/or bank erosion/deposition.

Ground-based photographic monitoring will be undertaken to provide monitoring for the bed and bank conditions of the low-flow channel and flood bench surfaces:

- monitoring of plan form morphology with aerial photography (approximate 1:10,000 scale); and
- periodic surveys as required and comparison against “as-constructed” survey to identify potential erosion problems.

The general condition of the creek diversion will be monitored over time using appropriate industry standard methods (e.g. Index of Diversion Condition (IDC)).

8.2.4.3 Geotechnical stability

The monitoring of the Creek Diversion PMLU will include assessment of geotechnical stability including batter stability and surface settlements, particularly where these features could impact on overland flow and flood capacity of the diversion works, or potential to interfere with local surface water management systems:

- inspection of the surface of the diversion and banks; and
- measurement of slope areas if surface cracking or distress to the bank profile is observed.

8.2.4.4 Surface erosion monitoring

The purpose of surface erosion monitoring will be to confirm that the re-profiled surfaces are not generating excessive sediment-laden runoff, due to direct rainfall impact erosion or overland flow erosion from local runoff.

The primary areas of surface erosion monitoring will be:

- floodplain benches to assess the integrity of the revegetated cover
- overland flow paths; and
- exposed soils to identify uncontrolled gully and rill erosion which may require cover protection and/ or drainage modification.

Surface erosion monitoring will be undertaken at selected sites across the slopes of the creek diversion.

Visual monitoring of the surfaces of the diversion channel surfaces and overland drainage will be undertaken and recorded by photographic survey with frequency consistent with the vegetation monitoring. Evidence of fresh and/or on-going erosion will trigger more intensive erosion monitoring, including:

- establishment of reference transects to measure and photograph the spacing and depth of erosion gullies and measure their rate of development
- placement of reference control stakes in erosion gullies and measurement of the up-slope migration rates of head-cut erosion.

8.2.4.5 Local drainage monitoring

The objective of monitoring local drainage is to confirm that local channels are operating as designed and not contributing to instabilities in the rehabilitated bank landform or uncontrolled surface erosion. Visual inspection of the surface drainage works and local flow pattern will be undertaken periodically, in conjunction with rehabilitation monitoring and site dam/ drainage monitoring programs.

Key aspect of the inspections will be to identify:

- overtopping or piping breaching of the contour drains
- excessive sedimentation in the base of drainage channels which reduces the hydraulic capacity of the channel and can cause concentrated overflow and surface erosion of down-slope areas
- inadequate groundcover vegetation in the drainage channel sufficient to cause uncontrolled flow (increasing the potential for gully erosion)
- the integrity of rock-lined drains entering the diversion channel.

The locations of problems areas will be recorded with GPS and photographed for subsequent monitoring to confirm the adequacy of remedial works.

8.2.4.6 Water quality

Water quality in waterholes or storages downstream of the rehabilitated creek diversions will be monitored annually, to demonstrate that runoff water quality will achieve non-polluting success criteria as required by RM9 (c). This will be undertaken as part of the site water monitoring program.

8.2.5 Additional Water Storage PMLU monitoring

For consistency, the details on the monitoring requirements for the Water Storage PMLU are included with the other water monitoring items in the following Section 8.2.6 (Water monitoring).

8.2.6 Water monitoring

8.2.6.1 Proposed water monitoring objectives

Meandu Creek adjacent to Meandu Mine has been significantly modified through the creation of the dam downstream, and three diversions to facilitate mining operations. Meandu Creek adjacent to the Meandu Mine has been assigned a 'highly' disturbed aquatic ecosystem EV in the current Receiving Environment Monitoring Program (Stanwell, 2020). Mine rehabilitation and closure will be aimed at preventing or minimising adverse long-term environmental, physical, social and economic impacts, and to create a stable landform suitable for subsequent land uses. In accordance with this, and with the management intent of improvement outlined for highly disturbed aquatic ecosystems (ANZG, 2018), the overall objective post closure will be to restore the ecological value and function of waterways currently disturbed by mining activities. As such, following rehabilitation and closure of Meandu Mine, the objective is to progressively improve Meandu Creek adjacent to the mine from a 'heavily' disturbed aquatic ecosystem towards a 'moderately' disturbed aquatic ecosystem (Table 8.4).

Table 8.4 Existing and post closure Environmental Values for Meandu Creek adjacent to Meandu Mine

Environmental Value	Existing EVs	Post closure EVs
Aquatic ecosystems	Y, highly disturbed	Y, progressively improve from highly to moderately disturbed
Irrigation	NA	NA
Farm supply / use	NA	NA
Stock watering	NA	Y[1]
Aquaculture	NA	NA
Human consumer	NA	NA
Primary recreation	NA	NA
Visual appreciation	NA	NA
Drinking water	NA	NA
Industrial use	Y	NA
Cultural and spiritual values	NA	NA

NA – Environmental Value not applicable to the area

Y – Indicates applicable Environmental Value

1 – Beef cattle only

Given the objective for water quality post-mining is to progressively improve following rehabilitation and closure, a post-closure WQO range has been proposed for most parameters, that incorporates the existing water contaminant limits and release contaminant trigger investigation levels, and the default guideline values that are applicable to the post mining EVs. The proposed post-mining WQOs for parameters currently measured in the REMP are outlined in Table 8.5. Where the concentration of a parameter is below (except for pH) or within the WQO range, no further investigation will be triggered. However, where the concentration of a parameter is above the range (or below for pH), this will trigger further investigation in accordance with ANZG (2018).

Table 8.5 Proposed post closure Water Quality Objectives (WQO) for Meandu Creek adjacent to Meandu Mine

Parameter	Unit	Post closure WQO	Source[1]
pH	pH units	5.5–9.0	EA contaminant limit
Electrical conductivity*	mS/m	237–250 *	REMP WQO – EA contaminant limit *
Turbidity	NTU	25–1000	
Total dissolved solids	mg/L	4000	Stock water trigger value for beef cattle
Calcium	mg/L	1000	Stock water trigger value
Fluoride	mg/L	2	Stock water trigger value / REMP WQO
Sulfate	mg/L	545–1,000	REMP WQO – EA contaminant trigger investigation level
Ammonia	µg/L	900 – 1,430	ANZG 2018 (95% protection) – EA / ANZG 2018 (80% protection)
Nitrate	µg/L	2,400	REMP WQO – NIWA 2013 80% protection
Nitrite	µg/L	30,000	ANZG 2018 stock watering trigger value
Copper	µg/L	54 #	REMP / ESP (2019)
Mercury	µg/L	0.06–5.4	ANZG 2018 (95% protection) – EA / ANZG 2018 (80% protection)
Cobalt	µg/L	90	EA contaminant trigger investigation level / REMP WQO / DES (2017) Model Mining Conditions
Iron	µg/L	300	
Molybdenum	µg/L	34	
Aluminium	µg/L	55–150 (pH>6.5)	REMP / ANZG 2018 (95% protection) – EA / ANZG 2018 (80% protection)
Arsenic	µg/L	13-40	
Cadmium	µg/L	0.2–0.8 [L]	
Chromium	µg/L	1.0–40	

Parameter	Unit	Post closure WQO	Source[1]
Lead	µg/L	3.4–9.4	
Nickel	µg/L	11–17 L	
Zinc	µg/L	8–31 L	
Boron	µg/L	940–1,300	
Manganese	µg/L	1,900–3,600	
Selenium	µg/L	5–34	
Vanadium	µg/L	10	REMP WQO / DES 2017 Model Mining Conditions
Dissolved oxygen	% Sat	No WQO proposed, monitored to interpret other results	
Dissolved organic carbon	mg/L		
Temperature	°C		
Hardness (CaCO3)*	mg/L		
Potassium	mg/L		
Chloride	mg/L		
Sodium	mg/L		
Alkalinity	mg/L		
Nitrate + Nitrite (NOx)	µg/L		
Total Kjeldahl nitrogen	µg/L		
Total nitrogen	µg/L		
Filtered reactive phosphorous	µg/L		
Total phosphorous	µg/L		

1 Refer to Attachment A of the REMP (Stanwell, 2020) for further details on the source of WQOs

L Hardness modified calculations will be applied as appropriate and in accordance with DSITI 2017

Where DOC remains > 15 mg/L

* Site-specific WQO for EC in Meandu Creek adjacent to the mine may be considered based on biological survey results; refer to summaries of recent data provided in ESP (2022)

The overall management objective for Meandu Creek adjacent to the mine post-mine closure and rehabilitation will be to prevent or minimise adverse long-term environmental impacts and to create a stable waterway suitable for sustaining post-mining EVs. Specific objectives include:

- to achieve a water quality standard that is suitable to sustain the proposed post-mining EVs
- to progressively improve aquatic ecological value and function until it is on trend to move from a 'heavily' disturbed aquatic ecosystem to a 'moderately' disturbed aquatic ecosystem.

The restoration and maintenance of the main waterway early (through actions such as riparian revegetation) will improve water quality as well as ecological value and function and increase the resilience of the system.

Water quality

The draft post closure objectives have been developed based on the Australian Water Quality Management Framework, which includes ten main steps for managing water quality (Figure 8.1; ANZG, 2018).

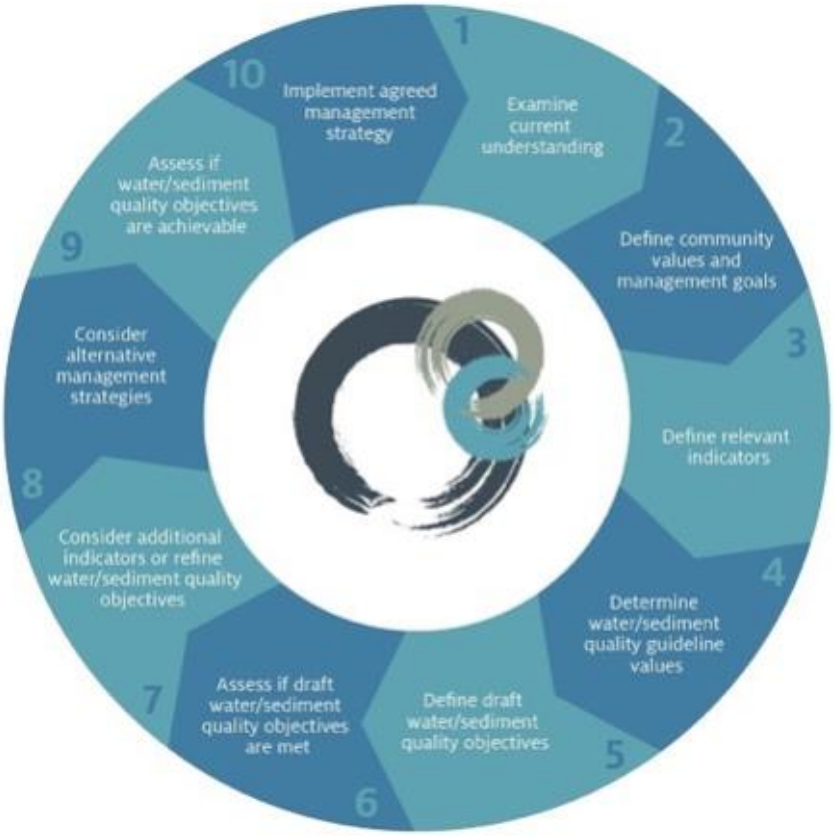

Figure 8.1 Australian Water Quality Management Framework (ANZG, 2018)

The first five steps of this process have been completed or are already proposed, as outlined in Table 8.6.

Table 8.6 Water quality management framework steps completed or proposed at Meandu Mine

Step	Comment
1	A conceptual model for Meandu Creek has been developed as part of the REMP (Attachment D) (Stanwell, 2020). Surface water and groundwater quality are monitoring as part of the EA and REMP to understand existing condition of Meandu Creek adjacent to the Meandu Mine. Biological (aquatic habitat, plants, macroinvertebrates and fish) monitoring to build on initial survey work undertaken in 2017 are planned for 2022 (May/June and September) to establish an understanding of the existing aquatic ecological condition and value of this reach.
2	Existing and post-mining EVs have been established (refer to Table 8.4).
3	Relevant indicators including water quality parameters are outlined in the REMP, as well as biological indicators (aquatic habitat, plants, macroinvertebrates and fish). Where appropriate these have been applied to the water quality objectives post closure for Meandu Creek as listed in Table 8.5.
4	Water quality guideline values that are relevant to Meandu Creek adjacent to the mine post-closure and rehabilitation have been reviewed.
5	Water quality objectives have been defined to sustain the post-closure EVs and objectives (refer to Table 8.5).

The remaining steps (6 to 10) are proposed to be assessed at 1 year, 2 years, 5 years and 10 years post mining, by seasonally (post-wet and pre-wet) sampling water quality at existing sites on Meandu Creek adjacent to the mine and in comparative areas. A summary of the proposed water quality assessment during each post-mining monitoring event is outlined in Figure 8.2. Following each post-mining event, Steps 1 to 5 as well as the monitoring program (e.g. indicators and frequency of sampling) will be reviewed (and updated if required) in accordance with the Water Quality Management Framework.

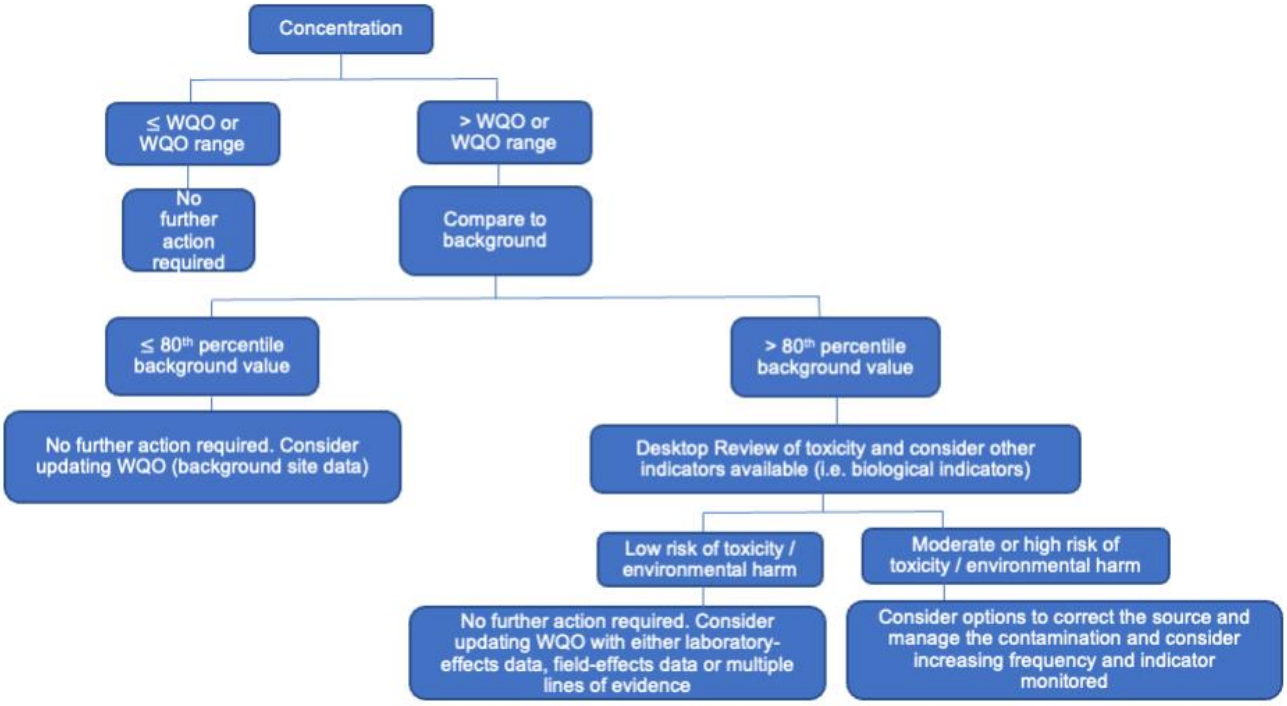

Figure 8.2 Proposed post-mining water quality assessment

Aquatic ecology

The overall objective for the aquatic ecology in Meandu Creek post closure and rehabilitation will be for the ecological value and function to improve towards or until similar to other ephemeral waterways in the region.

Similar to (and in conjunction with) water quality, this will be monitored and assessed at 1 year, 2 years, 5 years and 10 years post mining by seasonally (post-wet and pre-wet) sampling aquatic ecology and biological (macroinvertebrates indicators at existing sites on Meandu Creek adjacent to the mine and in comparative areas. Following each post-mining monitoring event, success against management objectives will be assessed as outlined in Table 8.7. If the management objectives have not been met, further actions to achieve the objectives will be considered and the monitoring program (e.g. frequency and indicators) will be reviewed.

Table 8.7 Measures for the management objective

Indicator	Measure
Aquatic habitat (e.g. bioassessment scores)	Trend shows improvement (i.e. increase in score over time) towards or until similar to other ephemeral waterways in the region.
Riparian vegetation	Trend shows improvement (i.e. increase in vegetation cover and canopy height; decrease in weed cover) towards or until similar to other ephemeral waterways in the region.
Biological (macroinvertebrates)	Trend shows improvement (i.e. indices increase over time) towards or within regional biological objective and/or until similar to communities in other ephemeral waterways in the region (i.e. statistically similar).

8.2.6.2 Surface water and pit void water monitoring methodology

Water samples will be collected in accordance with the latest version of the Administering Authority's *Monitoring and Sampling Manual* (DES 2018 or relevant updates) for water quality analysis.

- Surface water quality monitoring at PMLU areas – applicable to RM9:
  - indicators are to be analysed by a NATA-accredited laboratory.
- Water quality monitoring of water storage structures:
  - indicators are to be analysed by a NATA-accredited laboratory
  - results to be compared with the milestone criteria specified in RM9 for the Water Storage PMLU.
- Water quality monitoring or RM8:
  - indicators are to be analysed by a NATA-accredited laboratory
  - ultra trace analyses will be used for vanadium, selenium and chromium to allow comparison of results to the Water Quality Objectives.

8.2.6.3 Groundwater monitoring

Groundwater sampling is to be completed by a suitably competent person in accordance with the latest *Monitoring and Sampling Manual* (DES 2018). Groundwater monitoring will be undertaken at the established bore monitoring network in accordance with the current Meandu Mine Groundwater Monitoring Program which is included in the current Receiving Environment Monitoring Program (Stanwell, 2020).

8.3 Schedule of monitoring, reporting and review of each milestone

For water monitoring the methodologies and frequencies will be consistent all the way through. Schedule of monitoring for land to be rehabilitation to Native Ecosystem, Beef Cattle Grazing, Steep Rocky Ecosystem and Creek Diversion will vary based on the age and/or stage of the rehabilitation. The following subsections describe the proposed monitoring schedule for each of the three PMLUs.

8.3.1 Native Ecosystem PMLU

The Meandu Mine implements age-based rehabilitation monitoring methodologies with varying frequencies based on the method applied. The rehabilitation monitoring schedule for the rehabilitation of Native Ecosystem PMLU at Meandu Mine is provided in Table 8.8. Soil sampling may be undertaken in years 2 or 3 as appropriate.

Table 8.8 Monitoring schedule for Native Ecosystem rehabilitation

Years from seeding completion	Monitoring method				
	Rapid assessment	BioCondition assessment	Soil sampling	Fauna observation	Visual Inspection
1	✓	×	×	×	✓
Years 3, 5 and every 5 years hereon	×	✓	✓	✓	✓

8.3.2 Beef Cattle Grazing PMLU

Similar to the Native Ecosystem PMLU, rehabilitation monitoring methodologies with varying frequencies will be applied to the rehabilitation of Beef Cattle Grazing land. A preliminary rehabilitation monitoring schedule for the Beef Cattle Grazing PMLU at Meandu Mine is provided in Table 8.9. It is noted that a trial has been proposed for the Beef Cattle Grazing PMLU (refer Section 7.5) that aims to verify the material placement requirements to achieve the success criteria. The results from the trial will be used to:

- refine species selection; and
- provide guidance on the timing for commencement of grazing following rehabilitation establishment.

Depending on the trial results, the proposed monitoring schedule may be reviewed.

Table 8.9 Monitoring schedule for Beef Cattle Grazing rehabilitation

Years from seeding completion	Monitoring method					
	First year grazing management	Rapid assessment	Land condition monitoring	Pasture yield assessment	Visual inspection	Soil sampling
1	✓	✓	×	×	×	×
Years 3, 5 and every 5 years hereon	×	×	✓	✓	✓	✓

8.3.3 Steep Rocky Ecosystem PMLU

Table 8.10 provides the detail in regard to the monitoring method, frequency, area and measurements to be undertaken against each success criteria. The current proposed Steep Rocky Ecosystem PMLU monitoring at Meandu Mine implements a stage-based rehabilitation monitoring methodologies with varying frequencies based on the method applied (refer to Appendix L – Meandu Mine PRC Plan Revegetation Plan).

Rehabilitation trial has been proposed for the rehabilitation of Steep Rocky Ecosystem PMLU (refer Section 7.5. Timing for achieving successful vegetation establishment on benches to inform rehabilitation and monitoring schedule will be further elucidated from the trial results.

Table 8.10 Stage-based monitoring schedule for Steep Rocky Ecosystem rehabilitation

Stage	Monitoring method					
	Trial bench condition monitoring	Soil properties monitoring	Vegetation field survey monitoring	Remote sensing monitoring of vegetation and erosion	Fauna observation	Invertebrate monitoring
1 – Presence of a mosaic of bare and vegetated land surface	✓	✓	✓	✓	×	×
2 – Presence of a variety of plant assemblages	✓	✓	✓	✓	×	×
3 – Plant assemblage structure consistent with that occurring among nearby analogous examples	✓	✓	✓	✓	×	×
4 – Large fauna use steep rocky landscape for feeding, roosting and/or breeding	×	✓	✓	✓	✓	×
5 – Plant assemblages support an invertebrate assemblage with a structure and composition similar to that occurring in nearby analogous assemblages	×	✓	✓	✓	✓	✓
6 – Successful reproduction and soil seed bank establishment in plant assemblages	×	✓	✓	✓	✓	✓
7 – Seasonal changes in plant and invertebrate assemblages in a way that is consistent with that occurring among a range of nearby analogous assemblages	×	✓	✓	✓	✓	✓

Stage	Monitoring method					
	Trial bench condition monitoring	Soil properties monitoring	Vegetation field survey monitoring	Remote sensing monitoring of vegetation and erosion	Fauna observation	Invertebrate monitoring
8 – Responses to environmental stressors in plant and invertebrate assemblages is consistent with the range of change detected among nearby analogous assemblages	×	✓	✓	✓	✓	✓
9 – Facilitated species colonisation and establishment	×	✓	✓	✓	✓	✓

8.3.4 Creek Diversion PMLU

Table 8.11 provides rehabilitation monitoring frequencies for the different programs for the Creek Diversion PMLU.

Table 8.11 Monitoring schedule for Creek Diversion rehabilitation

Years from seeding completion	Monitoring method					
	Vegetation establishment	Morphological stability	Geotechnical stability	Surface erosion monitoring	Local drainage monitoring	Water monitoring
Years 1, 3 and every 5 years hereon	✓	×	✓	✓	✓	✓
Year 5 and every 5 years hereon	×	✓	×	×	×	×

8.3.5 Water monitoring

Table 8.12 provides rehabilitation monitoring frequencies for the different programs associated with the monitoring of water quality and aquatic ecosystem health consistent with the rehabilitation milestones.

Table 8.12 Schedule for monitoring of Water criteria

Years from completion	Monitoring method					
	RM8 Water Quality in Meandu Creek	RM8 Aquatic ecology health	RM8 GW monitoring in NWBV	RM8 QW monitoring of GW	RM8 BC monitoring of GW	RM9 Water Storage Criteria
Annual	✓	×	✓	✓	✓	✓
Every 3 years	×	✓	×	×	×	×

8.3.6 Reporting and review

8.3.6.1 Annual review

In accordance with sections 316IA and 316J of the EP Act, Stanwell is required to provide, within their annual review, an evaluation of the effectiveness of (Extract from section 316J[2] of the EP Act):

a *The actions taken in relation to each rehabilitation milestone or management milestone under the schedule; and*

b *The environmental management carried out under the schedule.*

The annual review must also state (Extract from section 316J[3] of the EP Act):

a *Whether any rehabilitation milestones or management milestones to be completed under the PRCP Schedule during the year have been met; and*

b *Whether the holder has complied with the conditions imposed on the PRCP Schedule.*

8.3.6.2 Annual Rehabilitation report

Stanwell currently undertakes annual rehabilitation monitoring of rehabilitation areas. Rehabilitation reports to date have included:

- assessment of the condition of rehabilitation sites against relevant benchmarks (e.g., requirements of EA EMPL00709113)
- predictive modelling of ecological condition over time
- commentary on sustainability and resilience of rehabilitation (e.g., growth trajectory assessment [as developed by the Queensland Herbarium]); and
- recommendations to undertake remedial action, intervention and/or maintenance, if required.

The annual rehabilitation report structure will be updated to include assessment of the condition of rehabilitation sites against the requirements of the PRC Plan and relevant rehabilitation milestones criteria outlined in (Section 9) for the designated PMLU.

8.3.6.3 Rehabilitation audit

In accordance with Part 12 Division 1 of the EP Act, a rehabilitation auditor must be commissioned by Stanwell to undertake an audit of the PRC Plan Schedule (i.e. a rehabilitation audit). Rehabilitation audits must be undertaken at defined intervals prescribed under the EP Act (i.e. the audit period) (extract from section 285 of the EP Act):

a *the 3-year period commencing from the day the schedule takes effect; and*

b *each 3-year period starting on day after the previous audit period ended.*

Within four months of the end of each audit period, the administering authority must be provided with the rehabilitation auditors report and accompanying declaration from the proponent. The rehabilitation auditors report must be in the approved form and include the following (extract from section 286 EP Act):

c *A statement about whether the holder has complied with the schedule during the audit period, including –*

- **i** *details of actions the holder has taken, or failed to take, in relation to the rehabilitation milestones and management milestones under the schedule; and*
- **ii** *whether the holder has complied, or failed to comply, with conditions imposed on the schedule; and*
- **iii** *whether information given to the administering authority under this Act about rehabilitation carried out under the schedule is accurate;*

d *An assessment of whether the post-mining land use for land subject of the schedule is likely to be achieved, having regard to the rehabilitation that has been and is to be carried out under the schedule;*

e *Recommendations about actions that the holder should take to ensure rehabilitation milestones and management milestones are achieved or conditions of the schedule are complied with;*

f *The other information the administering authority reasonably considers necessary to decide whether to take action to amend the schedule under part 6.*

The proponent declaration must state that all relevant information has been provided, and the proponent has not knowingly provided any false or misleading information to the auditor to undertake the audit.

Stanwell will comply with the requirements of the EP Act including any additional audits required by the administering authority under section 322 of the EP Act (i.e., audit notice).

8.4 Rehabilitation maintenance and intervention

If rehabilitation monitoring, annual rehabilitation reports, or rehabilitation audits identifies that rehabilitation areas are not progressing towards achieving rehabilitation milestones and success criteria, then rehabilitation maintenance and or intervention may be required.

Various maintenance and intervention methods (described below) are currently being trialled and/or undertaken by Stanwell to remediate rehabilitation areas which are not appropriately progressing to meet the relevant rehabilitation milestones and success criteria.

8.4.1 Landform stabilisation

Should rehabilitation monitoring identify defects or issues relating to erosion and landform stability, corrective actions (i.e., intervention and/or maintenance measures) will be implemented which may include, but are not limited to:

- cover material that fails characterisation QA/QC testing will require remediation through removal, replacement and re-testing
- areas of cover above the coal combustion products and tailings storage areas that do not conform to the required compaction and thickness criteria shall be repaired by additional compaction or addition of relevant material to deficient layer until minimum thicknesses are met
- non-conforming drainage channels or erosion control structures will be re-established to the required criteria
- any deviations from the final landform slope criteria will be assessed on a site-specific basis with respect to the risk presented by the deviation to ascertain the specific rectification requirements (if any) to minimise re-sculpting earthworks. A small area of deviation may be managed by erosion control or fast-tracked revegetation works negating any need for re-sculpting. Larger areas of deviation may require re-design and changes to the LOM Plan
- remediation of areas which have been subject to unacceptable degradation of drainage structures
- areas of active erosion may be backfilled or otherwise remediated and appropriate drainage channels re-established (as above).

8.4.2 Supplementary seeding

Supplementary seeding may be required in areas where rehabilitation monitoring identifies that the rehabilitation area is not appropriately progressing to achieve the rehabilitation milestones and success criteria.

The methodology for supplementary seeding (e.g., seed application rate/ha, species mix etc) will be determined specific to the rehabilitation area and on a case-by-case basis.

8.4.3 Pest flora and fauna controls

Should the results of regular monitoring identify the presence pest flora and/or pest fauna species at an unacceptable extent/level of occurrence (e.g. which impedes the ability for a rehabilitation area to achieve a rehabilitation milestone or success criteria) various site-specific controls may be implemented. These include:

- Pest Flora Controls:
    - identifying and mapping any areas of incursion
    - implementing a site-specific invasive plant treatment program in accordance with recommended practices
    - application of herbicides (if required) by a licensed pest control contractor in accordance with the *Agricultural Chemicals Distribution Control Act 1966* (ACDC Act) and manufacturer's directions
    - identification of environmentally sensitive areas (if present) and implementing specialised invasive plant control measures (e.g., riparian and ever green vine thicket areas)
    - undertaking follow-up inspections to ascertain effectiveness of the implemented treatment program; and
    - investigating the use, and monitor the effectiveness, of biological control agents.

- Pest Fauna Control:
    - identifying and mapping any areas of incursion
    - baiting and trapping measures in accordance with internal site management procedures (noting that optimum baiting occurs in May and October in conjunction with local/community programs)
    - recording and mapping areas where baiting and trapping occurs; and
    - if required, establishing surveillance cameras to more closely monitor control measure performance.

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Part B: Rehabilitation schedule

9 PRC Plan Schedule

9.1 Final site design

PRC Plan Guideline (Section 4.1)

Step 1. Final site design

The final site design must delineate the total area of the PRC plan as planned for surrender, including all proposed undisturbed areas (and their proposed uses identified as PMLUs), all proposed PMLUs and any proposed NUMAs.

The final site design is a map showing:

- the maximum disturbance footprint
- resource tenure boundaries
- PMLU(s) and NUMA(s) for the land within the resource tenure(s)
- flood plain extent.

The purpose of the final site design is to show the community what the site will look like post surrender.

The final site design for the Meandu Mine, including the maximum disturbance footprint, tenure boundaries, the PMLUs and the flood plain extent, is shown in Figure 9.1.

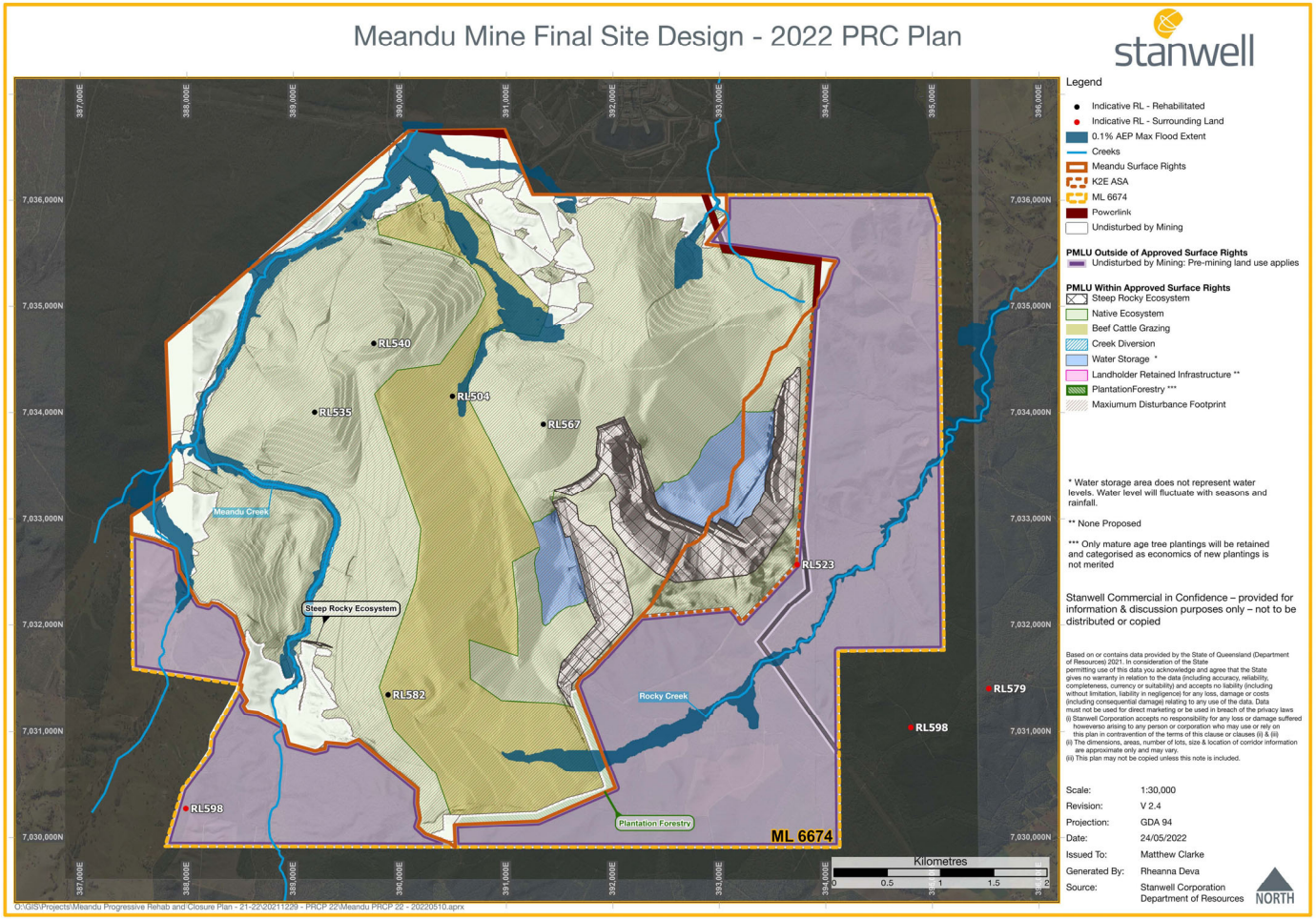


Figure 9.1 Meandu Mine final site design – 2022 PRC plan

9.2 Rehabilitation areas

PRC Plan Guideline (Section 4.1)

Step 2. Divide PMLU/NUMA into rehabilitation areas/improvement areas

PMLUs identified in the final site design must be broken down into rehabilitation areas, and NUMAs identified in the final site design must be broken down into improvement areas. A rehabilitation area is defined in the EP Regulation as an area of land in the PMLU to which a rehabilitation milestone for the post-mining use relates.

The purpose of breaking down the site into rehabilitation and improvement areas is to allow for progressive rehabilitation and closure of the site over the life of the mine. Only areas of disturbance need to be included in the rehabilitation areas/improvement areas.

Rehabilitation areas/improvement areas may only contain one primary PMLU/NUMA as the rehabilitation or management methodology will be different for different land outcomes.

The applicant must state in the proposed PRCP schedule the relevant activities within the rehabilitation/improvement area and the total area in hectares. The relevant activities must be consistent with the relevant activities identified in section 3.1 of this guideline.

Reference maps

References maps must be attached to the proposed PRCP schedule identifying the boundary of each rehabilitation area and improvement area. Reference maps may contain more than one rehabilitation area/improvement area and must be to a scale that allows for easy interpretation.

All maps must be prepared in accordance with the guideline ‘Spatial Information Submission’ (ESR/2018/4337).

PMLUs identified in the final site design have been divided into rehabilitation areas to allow for progressive rehabilitation and closure scheduling of the Meandu Mine site over the LOM Plan.

The Meandu Mine PRC Plan Schedule states the relevant activities within the rehabilitation/improvement areas and the total area in hectares.

The Meandu Mine rehabilitation areas are included as a plan in Section 9.6 Reference maps, Figure 9.2.

9.3 When land becomes available

PRC Plan Guideline (Section 4.1)

Step 3. Determine when land becomes available

In the proposed PRCP schedule, the applicant must state the year the rehabilitation area/improvement area is available for the commencement of rehabilitation/improvement. The identification and justification of when land becomes available, as required in the rehabilitation planning part of the PRC plan must be reflected in the proposed PRCP schedule.

For PMLUs, disturbed land is considered available for rehabilitation if the land is not being mined and will be required to be rehabilitated unless, as per section 126D(5) of the EP Act:

a the land is being used for operating infrastructure or machinery for mining, including, for example, a dam or water storage facility, or
b the land is identified in the proposed PRCP schedule or the application for an EA for relevant activities to which the schedule relates as containing a probable or proved ore reserve that is to be mined within 10 years after the land would otherwise have become available for rehabilitation, or
c the land is required for the mining of a probable or proved ore reserve mentioned in (b), or
d the land contains permanent infrastructure identified in the proposed PRCP schedule as remaining on the land for a PMLU.

If an applicant is proposing that certain land is unavailable for rehabilitation because land is being used for operating infrastructure or machinery or contains permanent infrastructure, then the applicant must provide sufficient evidence and justification to confirm compliance with the legislation.

The relevant activities at Meandu Mine that will define the sequence of rehabilitation are provided in Section 2.4. Table 2.22 in Section 2.4 also provides information on the duration of each activity from when the activity commences until it is available for rehabilitation.

9.4 Rehabilitation milestones/milestone criteria

PRC Plan Guideline (Section 4.1)

4.1 Steps for developing a PRCP schedule

Step 4. Develop relevant milestones

The applicant will develop appropriate rehabilitation or management milestones for each PMLU or NUMA as required in section 126D of the EP Act.

Rehabilitation milestones are required for all rehabilitation areas that have a PMLU as identified in step 2.

Rehabilitation milestones identify each significant event or step necessary to rehabilitate the land to a stable condition.

The administering authority has compiled a list of common milestones that it considers represent a "significant event or step" according to the above definitions. These are referred to as 'reference milestones' and are detailed in Appendix 3 – Reference milestones. Where relevant, milestones in this reference list should be adopted in the proposed PRCP schedule. Notwithstanding, this list is not intended to be exhaustive, and applicants should develop site-specific milestones where appropriate.

Milestones are legally enforceable commitments once the PRCP schedule is approved. Therefore, it is essential that milestones be written in a manner that delivers on SMART principles, meaning that they are:

- Specific—it is clear what must be done.
- Measurable—it must be possible to know when it has been achieved.
- Achievable—it is capable of being achieved.
- Reasonable/relevant—there is a clear connection between the milestone and the desired outcomes. The requirement is reasonable.
- Time Specific—it is clear when the milestone will be completed.

Step 5. Develop site-specific milestone criteria

Applicants are required to propose milestone criteria for each milestone. Milestone criteria, for management and rehabilitation milestones, means parameters that are measurable for achieving the milestone. Milestone criteria will be assessed to determine whether a rehabilitation or management milestone is achieved by the date stated in the PRCP schedule. The criteria must clearly demonstrate through SMART principles that the milestone has been successfully completed. Milestone criteria are used to demonstrate completion of progressive rehabilitation and improvement steps and events, however the milestone criteria for the final milestone will act as completion criteria for the achievement of either a PMLU or NUMA. The final milestone for each rehabilitation or improvement area must include milestone criteria for the area either achieving stable condition of the land for PMLUs or achieving sufficient improvement of the NUMAs.

For each PMLU, rehabilitation milestones must be supported by milestone criteria that:

a are appropriate for achieving the milestone
b facilitate achieving subsequent rehabilitation milestones.

PRC Plan Guideline (Section 4.1)

4.1 Steps for developing a PRCP schedule

Each mine site will have circumstances that are specific to that mine site that will be considered in the development of milestone criteria. Milestone criteria should provide quantitative indicators of progress towards achieving overall rehabilitation or closure objectives.

In accordance with the SMART principles outlined in step 4, milestone criteria help to ensure that successful completion of milestones is measurable. To ensure that this measurement is meaningful, the applicant must demonstrate in the rehabilitation planning part that:

- the selection of each criterion is justified, including how the relationship between the criteria and the milestone has been established (i.e. supported by reference to scientifically valid methodology)
- sufficient criteria are developed to adequately measure success in achieving a milestone (i.e. for water quality, relevant parameters are nominated)
- the criteria define outcomes that support the proposed PMLU and achieve stable condition, or best practice management for NUMAs
- the manner the criteria will be measured against is clear, scientifically justified, and meaningful
- the data relating to proposed criteria will be reviewed and analysed to establish progress towards and achievement of target outcomes.

The applicant may develop multiple criteria for a milestone as applicable, and criteria may be replicated across more than one milestone (e.g. to verify long-term success with an aspect of rehabilitation). As milestone criteria are site-specific, this guideline does not attempt to provide standardised milestone criteria.

Examples of milestone criteria are included in Appendix 2 (noting that these examples are not to be used as a standard for approval). It is expected that milestone criteria will be specific to each individual mine site. The rehabilitation or management objectives, proposed milestones, and rehabilitation or management methodology, which should be supported by information obtained through rehabilitation trials, will guide the development of relevant milestone criteria.

The proposed outcome of a particular criterion may vary significantly from site to site or even between rehabilitation and improvement areas within a single site depending on the nature of the disturbance and environmental factors (including environmental values of the receiving environment, climate, topography and soil characteristics). The applicant will be required to provide sufficient evidence to justify the selection of milestone criteria.

The Meandu Mine rehabilitation areas and relevant rehabilitation milestones are outlined in Table 9.1. These are illustrated in the reference map provided in Section 9.6.

The rehabilitation milestones and their associated milestone criteria along with the SMART (S – specific, M – measurable, A – achievable, R – reasonable/relevant, T – time specific) justification for Meandu Mine are shown in Table 9.2.

Table 9.1 Meandu Mine rehabilitation areas and relevant rehabilitation milestones

Rehabilitation milestone	PMLU								
	Beef Cattle Grazing			Native Ecosystem			Steep Rocky Ecosystem	Creek Diversion	Water Storage
	Rehabilitation Areas								
	RA1 (Infrastructure)	RA2 (General Mining Activity)	RA3 (Ash and Tailings Storage)	RA4 (Infrastructure)	RA5 (General mining activity)	RA6 (Ash and tailings storage)	RA7 (Excavated highwalls (general mining activity))	RA8 (Creek Diversion)	RA9 (Water Storage)
1 – Infrastructure decommissioning and removal	✓			✓					
2 – Investigation and/or remediation of contaminated land	✓			✓					
3 – Installation of cover system			✓			✓			
4 – Landform development and reshaping	✓	✓	✓	✓	✓	✓	✓	✓	✓
5 – Surface preparation	✓	✓	✓	✓	✓	✓		✓	✓
6 – Revegetation	✓	✓	✓	✓	✓	✓	✓	✓	✓
7 – Achievement of initial surface requirements	✓	✓	✓	✓	✓	✓	✓	✓	✓
8 – Water quality at rehabilitated state	✓			✓					
9 – Achievement of PMLU	✓	✓	✓	✓	✓	✓	✓	✓	✓
Total Area (ha)	**78.2**	**445.8**	**31.8**	**67.4**	**1447.4**	**79.5**	**204.0**	**19.0**	**107.4**

Table 9.2 Meandu Mine rehabilitation area milestones and milestone criteria

Milestone reference	Rehabilitation milestone	Milestone criteria
RM1	Infrastructure decommissioning and removal	**Generic milestone criteria that apply to all applicable PMLUs unless otherwise noted**: a) All services are disconnected. b) All buildings demolished and removed. c) Hardstands and roads (bitumen, blue metal, aggregate etc) are removed. d) Infrastructure (pipelines, signage etc) are removed. e) Any non-retained boreholes are decommissioned. f) Machinery not required for rehabilitation removed off-site. g) Any fences not needed for safety or security purposes are removed. **Additional PMLU specific criteria for Beef Cattle Grazing**: h) The private road that is within the Beef Cattle Grazing PMLU and links the Beef Cattle Grazing PMLU to the end of (the local gazetted road) Nobby Smith Way remains in place to provide all weather vehicle access to the Beef Cattle Grazing PMLU. Note: Landholder Retained Infrastructure is not utilised as a PMLU and therefore no criteria apply to that PMLU in this milestone or any of the following milestones.
RM2	Investigation and/or remediation of contaminated land	**Generic milestone criteria that apply to all applicable PMLUs unless noted otherwise:** a) Contaminated land investigations to be carried out by a suitably qualified person. b) Removal and disposal, or appropriate treatment onsite, of any contaminated materials or soils. c) Removal and disposal of plastic/geofabric liners from dams/leach pads etc. d) Carry out validation testing to confirm that the remediation/removal has been completed. NOTE: There are no additional PMLU specific criteria for RM2

Milestone reference	Rehabilitation milestone	Milestone criteria
RM3	Installation of cover system over coal combustion products, and tailings storage facilities	**Generic milestone criteria that apply to all applicable PMLUs unless noted otherwise:** a) Cover systems on tailings and coal combustion productions are designed in such a way as to effectively minimise the infiltration of water into the tailings deposition area and the likelihood of any erosion occurring in the final cover system. b) Cover systems on coal combustion products and tailings are designed by a suitably qualified and experienced person. c) Coal combustion products and tailings storage areas have undergone an appropriate period of desiccation to allow safe and effective placement of the initial capping layer. d) Coal combustion products are at least 2 m below and tailings at least 6 m below the designed final landform surface. e) Decommissioning report from a suitably qualified person confirming that the facility has been successfully capped, includes a layer to minimise the infiltration of water into the underlying material and, the capped surface levels provide effective drainage of surface runoff to mine drainage systems. NOTE: There are no additional PMLU specific criteria for RM3
RM4	Landform development and reshaping	**Generic milestone criteria that apply to all applicable PMLUs unless noted otherwise:** a) Bulk earthworks achieve required landform mass balance – excluding allowance for access required for ongoing maintenance or required for PMLU purposes. b) For all landforms constructed after 2016, the upper 6 m of material beneath the final landform surface is NAF. Mixed Plant Rejects (MPR) are located a minimum of 6 m beneath the final landform surface. c) Subsoil material meets the criteria for the relevant PMLU. d) Completed general reshaping achieves the overall landform slope. e) Any designed waterways, drains and erosion and sediment control systems are installed. f) Non-regulated dams not included as a feature of the final landform design for the PMLU have been filled. g) Regulated dams/structures have been decommissioned and profiled according to the requirements of the decommissioning and rehabilitation plan for the structure developed by a suitably qualified and experienced person.

Milestone reference	Rehabilitation milestone	Milestone criteria
		Additional PMLU specific criteria for Beef Cattle Grazing: h) Slopes are constructed such that the overall grade meets the following: • 80% of slopes are ≤ 15 %, minor areas are up to a maximum of 25% • Factor of Safety ≥1.5 is achieved. i) Subsoil layer placed as part of the 6 m NAF dump cover is of suitable properties and of sufficient thickness to achieve Class 1, 2 or 3 land suitability criteria for beef cattle grazing as described in Table 6.10 of the PRC Plan. **Additional PMLU specific criteria for Native Ecosystem:** j) Slopes constructed such that the overall grade meets the following criteria: • The majority of slopes are ≤ 17%, minor areas are up to a maximum of 25% • Factor of Safety ≥1.5 is achieved. **Additional PMLU specific criteria for Steep Rocky Ecosystem:** k) Slopes constructed such that: • The landform provides a diversity of slopes, including a mix of predominately flat benches and batters up to 80 degrees, that create a varied environment for the future establishment of niche habitats. • Factor of Safety ≥1.5 is achieved at the projected stable crest. l) Install a cover system on exposed residual coal seams where identified as appropriate by a suitably qualified person. **Additional PMLU specific criteria for Plantation Forestry:** Where pre-mining land surface remains and area is undisturbed by mining, no requirements. **Additional PMLU specific criteria for Creek Diversion:** m) Landform is in accordance with conditions of the approved design plans.

Milestone reference	Rehabilitation milestone	Milestone criteria
		Additional PMLU specific criteria for Water Storage: n) Slopes constructed such that: • Factor of Safety ≥1.5 is achieved.
RM5	Surface preparation	**Generic milestone criteria that apply to all applicable PMLUs unless noted otherwise:** a) Remediate active erosion or subsidence as required prior to the application of topsoil. b) Undertake testing of topsoil prior to spreading such that characterisation can be assessed and the topsoil identified to be suitable for the nominated PMLU. Where necessary, improvements to the soil such as amelioration or blending are to be undertaken to achieve the recommendations for the nominated PMLU. c) Source, haul and spread topsoil of appropriate properties to a nominal depth of 0.2m to the applicable footprint (e.g. not including rock armoured areas or constructed drains). **Additional PMLU specific criteria for Beef Cattle Grazing:** d) Post topsoil placement, the surface is to be contour ripped to a nominal depth of 0.3-0.5 m to aid in erosion control and vegetation root penetration where needed. **Additional PMLU specific criteria for Native Ecosystem:** e) Post topsoil placement, the surface is to be contour ripped to a nominal depth of 0.3-0.9 m to aid in erosion control and vegetation root penetration where needed. **Additional PMLU specific criteria for Steep Rocky Ecosystem:** Note: no topsoil to be placed within the Steep Rocky Ecosystem PMLU [subject to outcomes of the rehabilitation trial]. **Additional PMLU specific criteria for Plantation Forestry:** Where pre-mining land surface remains and area is undisturbed by mining, no requirements. **Additional PMLU specific criteria for Creek Diversion:** No additional criteria.

Milestone reference	Rehabilitation milestone	Milestone criteria
		Additional PMLU specific criteria for Water Storage: For clarity, topsoil is to be placed only in the littoral zone[1]. The topsoiled area is to be contour ripped to a nominal depth of 0.3-0.9 m to aid in erosion control and vegetation root penetration where needed. [1] down to the higher of either (i) the lower RL of the modelled void water level fluctuation or (ii) the actual rebounded water level.
RM6	Revegetation (all applicable PMLU's)	**Generic milestone criteria that apply to all applicable PMLUs unless noted otherwise:** a) Species selection is in accordance with the specific criteria for each PMLU. b) Species seeding rate and/or tubestock planting rate is in accordance with the requirements of the specific criteria for each PMLU. **Additional PMLU specific criteria for Beef Cattle Grazing:** c) Species selection and seeding rates comprise: • a mixture of annual and perennial pasture species • a high percentage of 3P grasses (palatable, productive and perennial) • inclusion of desirable forbs (e.g. legumes) • species that flower in different seasons • where assessed as necessary, achievement of an initial cover crop. d) Light grazing, or slashing, to take place during the first summer / autumn season after the pasture seeds. e) Species mix and seed rates is adjusted where necessary in line with the results of the Beef Cattle Grazing trial. f) Shelter belts of trees, with appropriate species selected from the Native ecosystem PMLU species mix, to be in 50-100 m widths. **Additional PMLU specific criteria for Native Ecosystem:** g) Species selection and seeding rates comprises a mixture of plant species similar to local regional ecosystems (RE), based on benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7. **Additional PMLU specific criteria for Steep Rocky Ecosystem:** No seeding rate requirements apply, adjusted, if necessary, in line with the results of the Steep Rocky Ecosystem monitoring trial.

Milestone reference	Rehabilitation milestone	Milestone criteria
		Additional PMLU specific criteria for Plantation Forestry: Where pre-mining land surface remains and area is undisturbed by mining, no requirements. **Additional PMLU specific criteria for Creek Diversion:** h) Vegetation is to be a mixture of plant species substantially reflecting on those found in local riparian regional ecosystem (RE 12.3.3), with species and seeding rates to be suitable for wet ground conditions or irregular inundation. **Additional PMLU specific criteria for Water Storage:** i) Species selection only applies to the littoral zone[1]. Vegetation is a mixture of plant species substantially reflecting those found in local riparian regional ecosystem (RE 12.3.3), with species and seeding rates suitable for wet ground conditions or irregular inundation. [1] down to the higher of either (i) the lower RL of the modelled void water level fluctuation or (ii) the actual rebounded water level.
RM7	Achievement of initial surface requirements	**Generic milestone criteria that apply to all applicable PMLUs unless noted otherwise:** a) Monitoring of vegetation to confirm that species growth and composition is appropriately progressing to meet requirements of the criteria for RM9. b) Monitoring of landform condition to demonstrate that the land remains stable and non-polluting. c) Intervention and remediation as required to maintain a trajectory that will achieve RM9. d) Maintenance of any access required for monitoring and fire safety. e) Installation of any required land improvements in accordance with the specific criteria for each PMLU. **Additional PMLU specific criteria for Beef Cattle Grazing:** f) Regular light grazing / slashing is undertaken to encourage growth and continue self-seeding cycle. g) Rapid assessment in year 1. Monitoring of land capability utilising dry season yield per hectare in years 3 and 5 and every 5 years thereafter. h) Stock fencing is installed where required.

Milestone reference	Rehabilitation milestone	Milestone criteria
		Additional PMLU specific criteria for Native Ecosystem: i) Rapid assessment in year 1. BioCondition assessment in years 3 and 5 and every 5 years thereafter. j) Number of native species of native trees, shrubs and grasses equals or exceeds the RM9 criteria of 4, 6 and 4. **Additional PMLU specific criteria for Steep Rocky Ecosystem:** k) Presence of a mosaic of bare and vegetated land surfaces. l) Presence of a variety of plant assemblages. m) Plant assemblage structure consistent with that occurring on the trial sites. **Additional PMLU specific criteria for Plantation Forestry:** Where pre-mining land surface remains and area is undisturbed by mining, no requirements. Otherwise: n) For Hoop Pine Plantations ≥ 150 trees per hectare. o) For Hardwood Plantation ≥ 100 trees per hectare. **Additional PMLU specific criteria for Creek Diversion:** p) Records retained of as-built drawings and certification that creek diversions are operating in accordance with approved design and associated criteria. q) Vegetation establishment and geotechnical stability assessed at years 1, 3 and 5, and every 5 years thereafter. Morphological stability assessed every 5 years. **Additional PMLU specific criteria for Water Storage:** r) Bi-annual water quality monitoring between years 1-10 with analysis by a NATA accredited laboratory. Analytes monitored are to include: TDS, Calcium, Magnesium, Nitrate, Nitrite, Sulfate, Cobalt, nickel, Zinc, Arsenic, Boron, Selenium, Molybdenum, Fluoride. s) Vegetation establishment for the littoral zone[1] assessed at years 1, 3 and 5, and every 5 years thereafter. [1] down to the higher of either (i) the lower RL of the modelled void water level fluctuation or (ii) the actual rebounded water level.

Milestone reference	Rehabilitation milestone	Milestone criteria
RM8	Water quality at rehabilitated state	**For the relevant drainage areas upgradient of CP3:** a) Water quality in Meandu Creek shows progressive improvement over time, assessed annually at location CP3 and as indicated by the median concentration of the following analytes pH, Eh, EC, major Ions, Total Alkalinity / Total Acidity & Total Hardness, Fluoride, Ammonia, Nitrate, Nitrite, Copper, Mercury, Cobalt, Iron, Molybdenum, Aluminium, Arsenic, Cadmium, Chromium, Lead, Nickel, Zinc, Boron, Manganese, Selenium, Vanadium. Hardness corrections is applied to metals such as copper to measure acute toxicity to biota. b) Aquatic ecology health monitoring is undertaken every 3 years in Meandu Creek between RD10 and RD1, and shows a progressive improvement, or is similar to, other ephemeral waterways in the region, with respect to the measurement of (i) aquatic habitat (through bioassessment score) (ii) riparian vegetation and (iii) diversity of macroinvertebrate communities. c) Groundwater monitoring assessed annually in the NWBV using GW monitoring bores GW34, GW48, GW49 and GW75 (or suitable replacement bores in the NWBV area) demonstrates stable or improving median levels of the following analytes: EC, pH, TDS, Total Acidity/ Total Alkalinity, Total hardness, major ions and metals/metalloids indicative of AMD or SMD. **For the relevant drainage area upgradient of CP4 (QW):** d) Monitoring of movement and/or concentration of EC levels indicates a trend that salinity is not increasing and remains static to the extent that likelihood of future mobilisation towards the receiving environment (Meandu Creek) at existing concentrations is unlikely to cause any detrimental impact. **For the relevant drainage area associated with location CP2 (BC):** e) Monitoring of movement and/or concentration of EC levels indicates a trend that salinity is not increasing and remains static to the extent that likelihood of future mobilisation towards the receiving environment (Meandu Creek) at existing concentrations is unlikely to cause any detrimental impact.
RM9	Achievement of PMLU	**Generic milestone criteria that apply to all applicable PMLUs unless noted otherwise:** a) A hazard assessment by an appropriately qualified and experienced person is undertaken and concludes that safety hazards in the applicable PMLU are analogous to the hazards in equivalent land use sites in the surrounding unmined landscape Note: Use of an equivalent land use site does not apply to the Steep Rocky Ecosystem or Water Storage PMLUs, however hazard assessments are required for both, consistent with the PMLU specific criteria in this table.

Milestone reference	Rehabilitation milestone	Milestone criteria
		b) Indicators for runoff demonstrate the following suitable water quality parameters for EC and pH: • pH: 5.5-9.0 (median) • EC: <2037 µS/cm (median) Note: does not apply to Water Storage PMLU or the undisturbed by mining Plantation Forestry PMLU. **Additional PMLU specific criteria for Beef Cattle Grazing:** c) A land suitability assessment is undertaken by an appropriately qualified and experienced person using 'Regional Land Suitability Frameworks for Queensland (2013)', which confirms that grazing land meets either Class 1, 2 or 3 land suitability for grazing. d) >50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 18%. e) >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 18%. **Additional PMLU specific criteria for Native Ecosystem:** f) >50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 20%. g) >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 20%. h) Vegetation comprises a mixture of plant species similar to local regional ecosystems based on benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7. i) Number of native species of native trees, shrubs and grasses equals or exceeds 4, 6 and 4 respectively. j) Tree canopy cover is at least 20% **Additional PMLU specific criteria for Steep Rocky Ecosystem:** k) A hazard assessment is undertaken by an appropriately qualified and experienced person, which confirms an acceptable residual hazard ranking is achieved. Note: Comparison to an equivalent land use site is not required

Milestone reference	Rehabilitation milestone	Milestone criteria
		Additional PMLU specific criteria for Plantation Forestry: Where pre-mining land surface remains and area is undisturbed by mining, no requirements. Otherwise: l) A land suitability assessment is undertaken by an appropriately qualified and experienced person using 'Regional Land Suitability Frameworks for Queensland (2013)', which confirms that plantation land meets either Class 1, 2 or 3 land suitability for plantations. m) For Hoop Pine Plantations ≥ 150 trees per hectare. n) For Hardwood Plantation ≥ 100 trees per hectare. **Additional PMLU specific criteria for Creek Diversion:** Note: For the hazard assessment the equivalent land use site in the surrounding landscape is creeks. o) An assessment by an appropriately qualified and experienced person confirms that the creek diversion is functioning as designed and the performance and integrity of the watercourse diversion and/or adjacent watercourses is not threatened. p) Vegetation is a mixture of plant species substantially reflecting those found in local riparian regional ecosystem (RE 12.3.3), with species suitable for wet ground conditions or irregular inundation. **Additional PMLU specific criteria for Water Storage:** q) A hazard assessment by an appropriately qualified person is undertaken and confirms that the water storages are designed and constructed such that they are safe for humans, stock and wildlife. [Note: Comparison to an equivalent land use site is not required] Vegetation in the littoral zone is to be a mixture of plant species substantially reflecting those found in local riparian regional ecosystem (RE 12.3.3), with species to be suitable for wet ground conditions or irregular inundation. r) Water storages contain water of a suitable quality for native wildlife and/or livestock ingestion using the following indicators: TDS: <5,000 mg/L, Calcium: ≤1,000 mg/L, Magnesium: ≤2,000 mg/L, Nitrate: ≤400 mg/L, Nitrite: ≤30 mg/L, Sulfate: ≤1,000 mg/L, Cobalt: ≤1 mg/L, Nickel: ≤1 mg/L, Zinc: ≤20 mg/L, Arsenic: ≤0.5 mg/L, Boron: ≤5 mg/L, Selenium: ≤0.02 mg/L, Molybdenum: ≤0.15 mg/L, Fluoride: ≤2 mg/L

9.5 Non-use management area milestones

Not applicable to the Meandu Mine as there are no NUMAs.

9.6 Reference maps

The Meandu Mine reference map showing the rehabilitation areas is included as Figure 9.2.

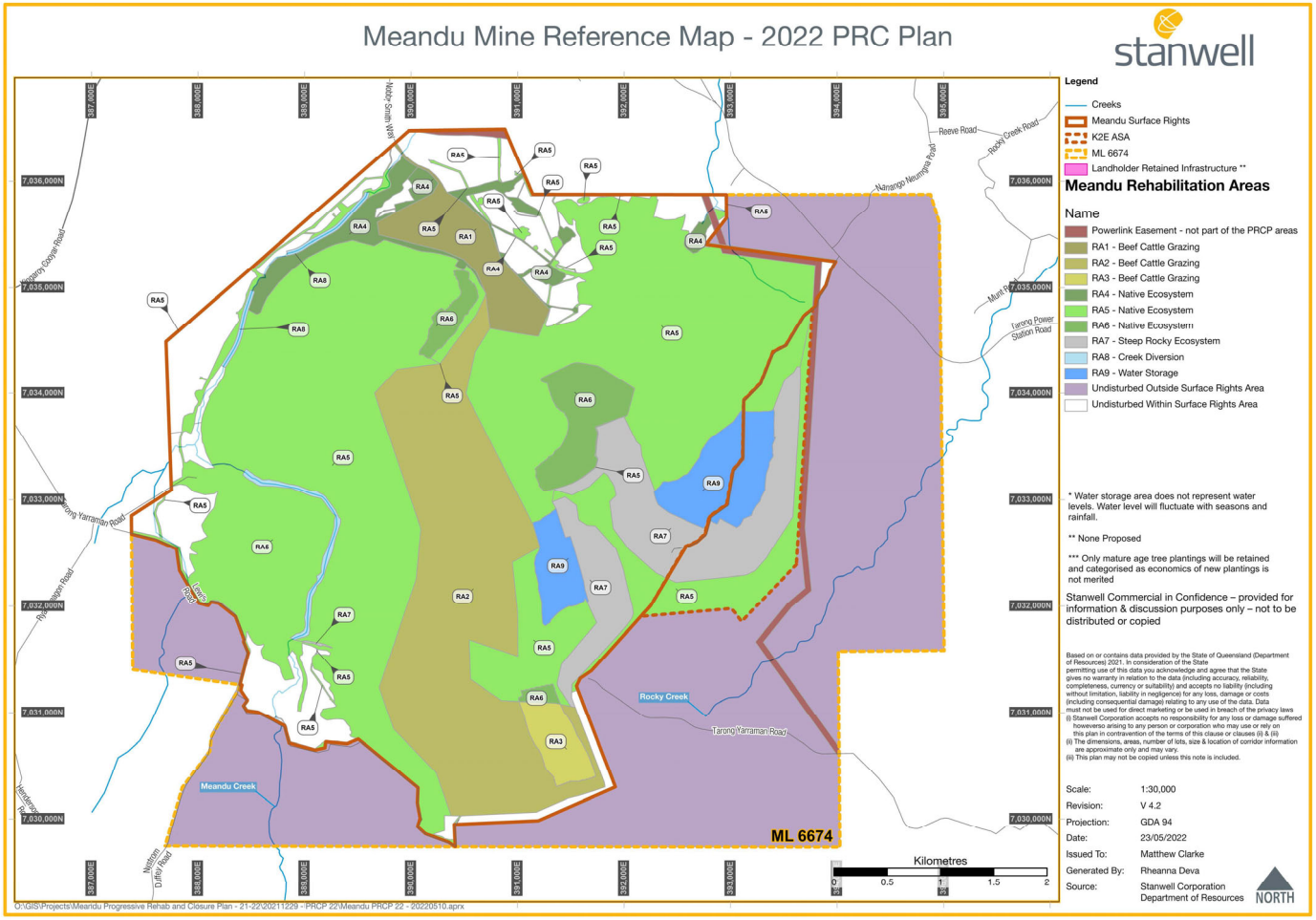


Figure 9.2 Meandu Mine rehabilitation area – 2022 PRCP

9.7 Schedule

PRC Plan Guideline (Section 4.1)

4.1 Steps for developing a PRCP schedule

Step 6. Propose when the first milestone must commence

For rehabilitation areas, applicants and the administering authority must have regard to land being rehabilitated 'as soon as practicable' when developing or assessing the rehabilitation milestones within a proposed PRCP schedule.

The EP Regulation states that the first rehabilitation milestone for a rehabilitation area will start as soon as practicable after the land in the area becomes available for rehabilitation by, for example, starting within 6 months after the area becomes available for rehabilitation.

The applicant must state in the PRCP schedule the date the first milestone must commence.

PRC Plan Guideline (Section 4.1)

4.1 Steps for developing a PRCP schedule

Step 7. Propose timing for when each milestone will be completed

The completion date is the date by which each milestone must be completed. Milestone completion dates will be nominated by the applicant in their proposed PRCP schedule.

Where insufficient evidence or justification regarding a proposed completion date is provided, the administering authority may impose an alternative completion date (see section 2.5 of this guideline).

Milestones will have a completion date of the 10 December of the calendar year nominated by the applicant. Therefore, the annual reporting period for all sites across Queensland will be the same day (10 December) to allow consistent reporting on a state-wide basis.

The EP Act states that the PRCP schedule must provide for each rehabilitation milestone to be achieved as soon as practicable after the land becomes available for rehabilitation.

Considerations for determining when rehabilitation or improvement can be achieved 'as soon as practicable' include, but are not limited to:

- the size of the area to be rehabilitated or improved
- the complexity of the rehabilitation or improvement methods
- the suitability of weather seasonality for the rehabilitation or improvement.

The availability of resources or equipment is not considered a factor for delaying when land must be rehabilitated or improved. It is the expectation of the administering authority that rehabilitation and improvement of the land is planned and, therefore, equipment and resources are appropriately allocated.

Timing impacts due to undesirable weather will need to be considered in the risk assessment in the rehabilitation planning part of the PRC plan and will be incorporated into the development of the proposed completion dates. Undesirable weather will not be considered a valid reason for milestones not being achieved by the completion date.

The completion date of the last milestone is intended to be when the land as a whole has reached stable condition or sufficient improvement. The completion date of the last milestone must have regard to any time frames agreed to during consultation with the community about the PRC plan.

The PRC Plan Schedule (Table 9.3 to Table 9.11) is based on the land being rehabilitated as soon as practicable after the land becomes available as required under section 126D(4) of the EP Act.

The proposed PRC Plan Schedule is provided on the following pages.

Table 9.3 Meandu Mine PRC Plan Schedule – RA1: Beef Cattle Grazing

Rehabilitation area	RA1 – Beef Cattle Grazing						
Relevant activities	Infrastructure						
Total size of rehabilitation area (ha)	78.15						
Commencement of first milestone RM1	2043						
PMLU	Beef Cattle Grazing						
Date area is available						10 Dec 2042	
Cumulative area available (ha)						78.15	
	Milestone completed by						
	10 Dec 2021	10 Dec 2026	10 Dec 2031	10 Dec 2036	10 Dec 2041	10 Dec 2046	10 Dec 2051
Milestone Reference	**Cumulative area achieved (ha)**						
RM1						78.15	78.15
RM2						78.15	78.15
RM4						78.15	78.15
RM5						78.15	78.15
RM6						78.15	78.15
RM7							78.15
RM8							78.15
RM9							78.15

Table 9.4 Meandu Mine PRC Plan Schedule – RA2: Beef Cattle Grazing

Rehabilitation area	**RA2 – Beef Cattle Grazing**						
Relevant activities	General mining activity						
Total size of rehabilitation area (ha)	445.83						
Commencement of first milestone RM4	2029						
PMLU	Beef Cattle Grazing						
Date area is available			10 Dec 2029	10 Dec 2034	10 Dec 2039	10 Dec 2043	
Cumulative area available (ha)			118.87	167.75	348.6	445.83	
	Milestone completed by						
	10 Dec 2021	10 Dec 2026	10 Dec 2031	10 Dec 2036	10 Dec 2041	10 Dec 2046	10 Dec 2051
Milestone Reference	**Cumulative area achieved (ha)**						
RM4			118.87	167.75	348.6	445.83	445.83
RM5			104.87	155.75	336.6	445.83	445.83
RM6			104.87	155.75	336.6	445.83	445.83
RM7					21.55	104.87	445.83
RM9					21.55	104.87	445.83

Table 9.5 Meandu Mine PRC Plan Schedule – RA3: Beef Cattle Grazing

Rehabilitation area	RA3 – Beef Cattle Grazing						
Relevant activities	Ash and tailings storage						
Total size of rehabilitation area (ha)	31.84						
Commencement of first milestone RM3	2038						
PMLU	Beef Cattle Grazing						
Date area is available					10 Dec 2038		
Cumulative area available (ha)					31.84		
	Milestone completed by						
	10 Dec 2021	10 Dec 2026	10 Dec 2031	10 Dec 2036	10 Dec 2041	10 Dec 2046	10 Dec 2051
Milestone Reference	**Cumulative area achieved (ha)**						
RM3						31.84	31.84
RM4						31.84	31.84
RM5						31.84	31.84
RM6						31.84	31.84
RM7							31.84
RM9							31.84

Table 9.6 Meandu Mine PRC Plan Schedule – RA4: Native Ecosystem

Rehabilitation area	RA4 – Native Ecosystem						
Relevant activities	Infrastructure						
Total size of rehabilitation area (ha)	67.39						
Commencement of first milestone RM1	2043						
PMLU	Native Ecosystem						
Date area is available					10 Dec 2042		
Cumulative area available (ha)					67.39		
	Milestone completed by						
	10 Dec 2021	10 Dec 2026	10 Dec 2031	10 Dec 2036	10 Dec 2041	10 Dec 2046	10 Dec 2051
Milestone Reference	Cumulative area achieved (ha)						
RM1						67.39	67.39
RM2						67.39	67.39
RM4						67.39	67.39
RM5						67.39	67.39
RM6						67.39	67.39
RM7							67.39
RM8							67.39
RM9							67.39

Table 9.7 Meandu Mine PRC Plan Schedule- RA5: Native Ecosystem

Rehabilitation area	RA5 – Native Ecosystem						
Relevant activities	General mining activity						
Total size of rehabilitation area (ha)	1447.44						
Commencement of first milestone RM4	2021						
PMLU	Native Ecosystem						
Date area is available	10 Dec 2021	10 Dec 2024	10 Dec 2029	10 Dec 2034	10 Dec 2039	10 Dec 2042	
Cumulative area available (ha)	601.91	745.9	819.13	874.51	1224.01	1447.44	
	Milestone completed by						
	10 Dec 2021	10 Dec 2026	10 Dec 2031	10 Dec 2036	10 Dec 2041	10 Dec 2046	10 Dec 2051
Milestone Reference	**Cumulative area achieved (ha)**						
RM4	601.91	745.9	819.13	874.51	1224.01	1447.44	1447.44
RM5	601.91	721.66	813.68	869.5	1058.61	1447.44	1447.44
RM6	601.91	721.66	813.68	869.5	1058.61	1447.44	1447.44
RM7	152.83	213	344.51	494.51	721.66	813.68	1447.44
RM9	152.83	213	344.51	494.51	721.66	813.68	1447.44

Table 9.8 Meandu Mine PRC Plan Schedule – RA6: Native Ecosystem

Rehabilitation area	RA6 – Native Ecosystem						
Relevant activities	Ash and tailings storage						
Total size of rehabilitation area (ha)	79.49						
Commencement of first milestone RM3	2021						
PMLU	Native Ecosystem						
Date area is available		10 Dec 2021		10 Dec 2031		10 Dec 2038	
Cumulative area available (ha)		16.36		74.67		79.49	
	Milestone completed by						
	10 Dec 2021	10 Dec 2026	10 Dec 2031	10 Dec 2036	10 Dec 2041	10 Dec 2046	10 Dec 2051
Milestone Reference	**Cumulative area achieved (ha)**						
RM3		16.36	16.36	74.67	74.67	79.49	79.49
RM4			13.89	71.31	74.41	79.49	79.49
RM5			13.89	71.31	74.41	79.49	79.49
RM6			13.89	71.31	74.41	79.49	79.49
RM7					13.89	71.31	79.49
RM9					13.89	71.31	79.49

Table 9.9 Meandu Mine PRC Plan Schedule – RA7: Steep Rocky Ecosystem

Rehabilitation area	**RA7 – Steep Rocky Ecosystem**						
Relevant activities	Excavated highwalls (general mining activity)						
Total size of rehabilitation area (ha)	204.02						
Commencement of first milestone RM4	2021						
PMLU	Steep Rocky Ecosystem						
Date area is available	10 Dec 2021				10 Dec 2037		
Cumulative area available (ha)	0.42				204.02		
	Milestone completed by						
	10 Dec 2021	10 Dec 2026	10 Dec 2031	10 Dec 2036	10 Dec 2041	10 Dec 2046	10 Dec 2051
Milestone Reference	**Cumulative area achieved (ha)**						
RM4	0.42	0.42	0.42	0.42	204.02	204.02	204.02
RM6			0.42	0.42	204.02	204.02	204.02
RM7					0.42	0.42	204.02
RM9					0.42	0.42	204.02

Table 9.10 Meandu Mine PRC Plan Schedule – RA8: Creek Diversion

Rehabilitation area	RA8 – Creek Diversion						
Relevant activities	Meandu Creek Diversion - South, Central and North (general mining activity)						
Total size of rehabilitation area (ha)	18.98						
Commencement of first milestone RM3	2021						
PMLU	Creek Diversion						
Date area is available	10 Dec 2021			10 Dec 2033	10 Dec 2037		
Cumulative area available (ha)	11.35			14.82	18.98		
	Milestone completed by						
	10 Dec 2021	10 Dec 2026	10 Dec 2031	10 Dec 2036	10 Dec 2041	10 Dec 2046	10 Dec 2051
Milestone Reference	**Cumulative area achieved (ha)**						
RM4	11.35	11.35	11.35	14.82	18.98	18.98	18.98
RM5	11.35	11.35	11.35	14.82	18.98	18.98	18.98
RM6	11.35	11.35	11.35	14.82	18.98	18.98	18.98
RM7				11.35	11.35	11.35	18.98
RM9				11.35	11.35	11.35	18.98

Table 9.11 Meandu Mine PRC Plan Schedule – RA9: Water Storage

Rehabilitation area	RA9 – Water Storage						
Relevant activities	K2E final void, K4E final void (general mining activity)						
Total size of rehabilitation area (ha)	107.44						
Commencement of first milestone RM4	2038						
PMLU	Water Storage						
Date area is available					10 Dec 2038		
Cumulative area available (ha)					107.44		
	Milestone completed by						
	10 Dec 2021	10 Dec 2026	10 Dec 2031	10 Dec 2036	10 Dec 2041	10 Dec 2046	10 Dec 2051
Milestone Reference	**Cumulative area achieved (ha)**						
RM4					107.44	107.44	107.44
RM5					33.3	107.44	107.44
RM6					33.3	107.44	107.44
RM7							107.44
RM9							107.44

Part C: Appendices

Appendix A

Progressive Rehabilitation and Closure Transition Notice (31 August 2020)



Notice

Environmental Protection Act 1994

Progressive rehabilitation and closure plan transition notice

This statutory notice is issued by the administering authority[1] under section 754 of the Environmental Protection Act 1994 *to advise you that you must submit a proposed Progressive rehabilitation and closure plan (PRC plan).*

TEC Coal Pty Ltd
Level 2, 180 Ann Street
BRISBANE QLD 4000
Jayden.Flint@stanwell.com.au

Attention: Jayden Flint, A/Environmental Manager Operations South

Our reference: EPML00709113 / 101/0008031-001(E)

Transition Notice for a PRC plan

1 Environmental authority details

Environmental authority EPML00709113 dated 11 September 2019 issued to TEC Coal Pty Ltd.

Land description: ML6674

2 Required action

The holder(s) of environmental authority EPML00709113 must submit a proposed PRC plan that meets the requirements in sections 126C and 126D of the *Environmental Protection Act 1994,* pursuant to section 754 of the *Environmental Protection Act 1994*. The holder(s) must submit the proposed PRC plan to the administering authority, by **31 May 2022**.

3 Transitional provisions

Pursuant to the transitional provisions in section 754(3) of the *Environmental Protection Act 1994*, the holder(s) of the environmental authority is not required to comply with the requirements under section 126C(1)(g) or (h), or section 126D(2) or (3) of the *Environmental Protection Act 1994* if–

(a) an outcome for the land has been identified under a land outcome document; and

(b) the outcome for the land is the same as, or substantially similar to, the outcome for the land if it were a non-use management area under a PRCP schedule.

[1] The Department of Environment and Science is the administering authority under the *Environmental Protection Act 1994*.

Queensland Government

A land outcome document is defined under section 750 of the *Environmental Protection Act 1994*.

Section 126C(1)(g) or (h), or 126D(2) of the *Environmental Protection Act 1994* require reasons and evidence to be provided to support a proposed non-use management area.

Section 126D(3) of the *Environmental Protection Act 1994* provides for any void that is contained wholly or partly in a flood plain to be rehabilitated to a stable condition.

In accordance with section 754(4) of the *Environmental Protection Act 1994*, if a land outcome document does not state sufficient detail to identify either the location or area of the land to which the outcome relates, the proposed PRC plan must state–

(a) if the area is not identified — how the total area of the land to which the outcome relates will be minimised; and

(b) if the location is not identified — how the mining environmental authority holder will ensure the location of the land to which the outcome relates minimises risks to the environment.

4 Supporting information

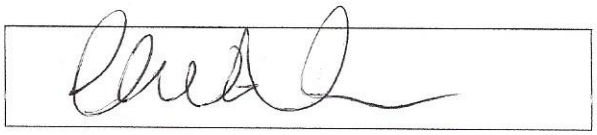
As detailed in section 2 of this notice, your PRC plan and associated PRCP schedule is required to address the relevant legislative requirements.

Please refer to the guideline Progressive Rehabilitation and Closure Plans (ESR/2019/4964) for more information about the requirements of the PRC plan and associate PRCP schedule, and the assessment process.

5 Consultation

The administering authority recommends that you request a pre-lodgement meeting to discuss the requirements of the proposed PRC plan in more detail. To request a pre-lodgement meeting, please completed and lodge the form 'Application for pre-lodgement services' (ESR/2015/1664) to arrange a meeting.

Should you have any questions in relation to this notice, please contact Bianca Voges-Haug, Team Leader, on telephone (07) 4987 9320.



Signature

31-08-2020

Date

Chris Wake
Department of Environment and Science
Delegate of the administering authority
Environmental Protection Act 1994

Enquiries:
Coal Business Centre
Department of Environment and Science
PO Box 3028, Emerald QLD 4720
Phone: (07) 4987 9320
Email: CRMining@ehp.qld.gov.au

Appendix B

Meandu Mine Environmental Authority (EA) EPML00709113 (12 January 2022)



Permit

Environmental Protection Act 1994

Environmental authority EPML00709113

This environmental authority is issued by the administering authority under Chapter 5 of the Environmental Protection Act 1994.

Environmental authority number: EPML00709113

Environmental authority takes effect on 12 January 2022

The anniversary date of this environmental authority is 15 November each year.

An annual return will be due each year on 01 April.

Environmental authority holder(s)

Name(s)	Registered address
TEC Coal Pty Ltd	Level 2, 180 Ann Street BRISBANE CITY QLD 4000 Australia

Environmentally relevant activity and location details

Environmentally relevant activity/activities	Location(s)
Ancillary 31 - Mineral processing 2: Processing, in a year, the following quantities of mineral products, other than coke (b) more than 100,000t	ML6674
Ancillary 63 - Sewage Treatment 1: Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of (b-i) more than 100 but not more than 1500EP if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme	ML6674
Ancillary 07 - Chemical Manufacturing 3: Manufacturing, in a year, a total of 200t or more of any of the following (d) explosives	ML6674

ABN 46 640 294 485

Queensland Government

Environmentally relevant activity/activities	Location(s)
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)	ML6674
Ancillary 62 - Resource recovery and transfer facility operation 1: Operating a facility for receiving and sorting, dismantling, baling or temporarily storing- (c) category 2 regulated waste	ML6674
Ancillary 60 - Waste disposal 1: Operating a facility for disposing of, in a year, the following quantity of waste mentioned in subsection (1)(a) (a) less than 50,000t	ML6674
Schedule 3 13: Mining black coal	ML6674

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.



Signature

12 January 2022

Date

Luke Johnston
Department of Environment and Science
Delegate of the administering authority
Environmental Protection Act 1994

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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)

Conditions of environmental authority

Schedule A: General	
Condition number	**Condition**
A1	**Scope of Approval** 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	In carrying out the mining activity authorised by this environmental authority, the holder of this environmental authority must comply with **Appendix 1 — Authorised disturbance areas** of this environmental authority.
A3	This environmental authority authorises the extraction of no more than **11.0 million tonnes** of run of mine (ROM) coal per annum.
A4	**Risk Management** 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* (ISO 31000:2009), or the latest edition of an Australian standard for risk management, to the extent relevant to environmental management.
A5	**Notification of Emergencies and Incidents** The holder of this environmental authority must notify the administering authority by written notification within **twenty-four (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.
A6	Within **ten (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.

A7	**Complaints** 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) the person responsible for resolving the complaint.
A8	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 **ten (10) business days** of completion of the investigation, or no later than **ten (10) business days** after the end of the timeframe nominated by the administering authority to undertake the investigation.
A9	**Monitoring** Except where specified otherwise in another condition of this environmental authority, all monitoring records or reports required by this environmental authority must be kept for a period of not less than **five (5) years**.
A10	The environmental authority holder is authorised to conduct exploration drilling and geophysical surveys within Yarraman State Forest to the east of the current surface rights of mining ML6674, within the area highlighted as "Approved Exploration Area" in **Appendix 1 — Authorised disturbance areas**, attached to this environmental authority.
A11	Exploration activities authorised by **Condition A10** must be conducted in accordance with all standard environmental conditions contained in the *Code of Environmental Compliance for Exploration and Mineral Development Projects*, with the exception of Condition 13, which is replaced by the following: *The holder of this environmental authority must not carry out activities in a category A Environmentally Sensitive Area. Activities involving machinery must not be carried out within 1 km of a category A Environmentally Sensitive Area.* *Exploration activities may be conducted on pre-existing roads, tracks, or cleared areas within Category B Environmentally Sensitive Areas provided that any associated disturbance (including that caused by access to and preparation of drill sites) is confined to these pre-existing tracks, roads or cleared areas, and that no native vegetation is removed or disturbed by the activities.*

A12	The holder of this environmental authority may burn vegetation cleared in the course of carrying out extraction activities provided the activity does not cause environmental nuisance or harm at any sensitive place or commercial place.
A13	**Waste Management Plan** A Waste Management Plan must be developed, implemented and reviewed, by a suitably qualified person(s), for all stages of mining activities and provided to the administering authority for review and comment by **30 March 2020,** and at intervals not exceeding **three (3) years** thereafter.
A14	Mine waste materials must be managed in accordance with the Waste Management Plan required by **Condition A13**.
A15	The Waste Management Plan required by **Condition A13** must include the following: (a) a description of the mining activities that may generate mine waste materials; (b) mine waste material management and control strategies such as: i. the types and amounts of wastes generated by the mining activities. ii. segregation of the wastes. iii. storage of the wastes. iv. disposal of the wastes. v. transport of the wastes. vi. monitoring and reporting matters concerning the wastes. (c) management of seepage and leachates during all phases of mining and closure; (d) the control of fugitive emissions to air; (e) a program of progressive sampling and characterisation to identify acid producing potential and metal concentrations of mine waste materials; (f) maintaining records of the relative locations of any other matter stored with the mine waste material disposal areas; (g) rehabilitation strategies of mine waste material storage and disposal areas; and (h) monitoring of rehabilitation, research and/or trials to verify the requirements and methods for decommissioning and final rehabilitation of tailings, including the prevention and management of acid mine drainage, erosion minimisation and establishment of vegetation cover.
A16	Within **twenty (20) business days** of receiving comments from the administering authority as per **Condition A13**, the Waste Management Plan must be updated to address the comments, amended to adopt any recommendations and re-submitted to the administering authority.

A17	**Coal Combustion Products Storage and Management** The holder of this environmental authority may store coal combustion products generated primarily from the combustion of pulverised black coal at the Tarong Power Station and Tarong North Power Station in voids defined in **Table A1 - Authorised coal combustion product storage locations** and **Appendix 2 - Meandu Mine Voids, Drainage System and Monitoring Network**.
A18	Coal combustion products stored in voids defined in **Table A1 - Authorised coal combustion product storage locations** and **Appendix 2 - Meandu Mine Voids, Drainage System and Monitoring Network** must comply with contaminant limits defined in **Table A2 - Maximum allowable leaching contaminant (TCLP) levels**.
A19	In addition to meeting the criteria in **Table A2 - Maximum allowable leaching contaminant (TCLP) levels**, the coal combustion products must not have any properties or contain any other contaminants at concentrations which may cause environmental harm.

Table A1 – Authorised coal combustion product storage locations

Void identification	Location
Central Pit	Refer to **Appendix 2 - Meandu Mine Voids, Drainage System and Monitoring Network**
King 4 South (K4S)	
King 2 West-North (K2W/N)	
King 4 East (K4E)	
King 2 East (K2E)	
Ramp 5	

Table A2 – Maximum allowable leaching contaminant (TCLP) levels

Contaminant	Maximum TCLP Value (mg/L)
Silver	0.5
Arsenic	0.5
Barium	10
Cadmium	0.05
Total Chromium	0.5
Copper	10
Nickel	0.5
Lead	0.5
Antimony	0.5
Thallium	0.1
Zinc	50
Selenium	0.1
Mercury	0.01

A21	Coal combustion products deposited and stored in a void identified in **Table A1 - Authorised coal combustion product storage locations** and **Appendix 2 - Meandu Mine Voids, Drainage System and Monitoring Network**, must be transferred or conveyed from the power station sites via an enclosed pipeline or other enclosed method of conveyance to prevent the release of a contaminant to the environment.

Schedule B: Air	
Condition number	**Condition**
B1	**Dust Nuisance** Subject to **Conditions B2** and **B3** of this environmental authority, the release of dust or particulate matter or both resulting from the mining activity must not cause an environmental nuisance, at any sensitive place.
B2	When requested by the administering authority, dust and particulate monitoring must be undertaken within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of the authorised officer) of environmental nuisance at any sensitive place, and the results must be notified within **fourteen (14) days** to the administering authority following completion of monitoring.
B3	If the environmental authority holder can provide evidence through monitoring that the following limits are not being exceeded, then the holder is not in breach of **Condition B1**: (a) dust deposition of 120 milligrams per square metre per day (measured as total insoluble solids), averaged over one month, when monitored in accordance with the most recent version of AS 3580.10.1 Methods for sampling and analysis of ambient air - Determination of particulates - Deposited matter - Gravimetric method; and (b) a concentration of particulate matter with an aerodynamic diameter of less than 10 micrometre (µm) (PM_{10}) suspended in the atmosphere of 50 micrograms per cubic metre over a 24-hour averaging time (excluding natural events such as bushfires and dust storm), at a sensitive place downwind of the operational land, when monitored in accordance with the most recent version of either, AS/NZS3580.9.3:2003; or AS3580.9.8:2008; or AS3580.9.11:2008.
B4	If monitoring indicates exceedance of the relevant limits in **Condition B3** of this environmental authority, then the environmental authority holder must: (a) address the complaint including the use of appropriate dispute resolution if required; or (b) immediately implement dust abatement measures so that emissions of dust from the activity do not result in further environmental nuisance.

Schedule C: Water	
Condition number	**Condition**
C1	**Contaminant release** Contaminants must not be released directly or indirectly to any waters as a result of the authorised mining activities, except as permitted under the conditions of this environmental authority.
C2	**Stormwater Management** With the exception of stormwater collected within voids defined in **Table A1 - Authorised coal combustion product storage locations**, all areas within the approved surface area of the mining lease must be designed so that any stormwater contaminated by mining activities is directed to, and managed in accordance with, the Meandu Mine Drainage System and Monitoring Network, to achieve compliance with **Condition C5**.
C3	Unless otherwise permitted under the conditions of this environmental authority, the release of mine affected water to waters must only occur from the release points specified in **Table C1 – Water monitoring locations and frequency**.
C4	**Release to waters** Mine affected water released in accordance with **Condition C3** must not exceed the limits stated in **Table C2 – Water contaminant limits**, when a release occurs and as measured at the release points specified in **Table C1 – Water monitoring locations and frequency**.
C5	The release of mine affected water from the release points must be monitored at the locations and frequency specified in **Table C1 – Water monitoring locations and frequency** for each quality characteristic specified in **Table C2 – Water contaminant limits**.
C6	In a 100-year ARI event the maximum limit for turbidity in **Table C2 - Water contaminant limits** will be the background level, as determined by the turbidity in Meandu Creek at a point upstream of the mining lease, plus 10% or 1000 NTU, whichever is the greater.
C7	For all discharges from **CP3** and **CP4** with an Electrical Conductivity greater than 2500µS/cm, but less than 2800µS/cm, a daily volume limit of 2.5ML/day applies.
C8	A result in excess of 9.0 for pH at **W3** is not considered a breach of **Condition C4** of this environmental authority if concurrent monitoring at release points **CP3** and **CP4** can demonstrate compliance with the maximum pH limit stated in **Table C2 – Water contaminant limits** for **W3** and the holder of this environmental authority can demonstrate that the pH at **W3** is not a result of mine activities.
C9	The release of mine affected water from the release points, **CP3** and **CP4** must be monitored on a monthly basis when a release occurs for each quality characteristic specified in **Table C3 - Release contaminant trigger investigation levels**.

C10	If water quality characteristics at a release point exceed any of the trigger levels specified in **Table C3 - Release contaminant trigger investigation levels** during a release event, the downstream results at W2 & W3 must also be compared to **Table C3 - Release contaminant trigger investigation levels** and: (a) where the trigger values are not exceeded at the downstream monitoring locations then no action is to be taken, or (b) where the downstream results exceed the trigger values specified in **Table C3 - Release contaminant trigger investigation levels,** for any quality characteristic, compare the results of the downstream site to the data from background monitoring sites and: 1) if the result is less than the background monitoring site data, then no action is to be taken, or 2) if the result is greater than the background monitoring site data, complete an investigation into the potential for environmental harm and provide a written report to the administering authority within 90 days of receiving the result, outlining: (i) details of the investigations carried out (ii) actions taken to prevent environmental harm. **Note:** Where an exceedance of a trigger level has occurred and is being investigated, in accordance with **Condition C10(b)(2)** of this condition, no further reporting is required for subsequent trigger events for that quality characteristic.

Table C1 – Water monitoring locations and frequency

Release and downstream monitoring	Location	Latitude (GDA94)	Longitude (GDA94)	Monitoring frequency
CP2^	Overflow from Retention Dam 17B on Black Creek	26º 47' 43.88" S	151º 55' 18.92" E	Continuous monitoring, except for periods of short duration (max **72 hours**) where maintenance or repair of monitoring equipment is carried out.
CP3^	Measuring weir on Meandu Creek	26º 47' 26.51" S	151º 53' 32.28" E	Continuous monitoring, except for periods of short duration (max **72 hours**) where maintenance or repair of monitoring equipment is carried out.
CP4^	Measuring weir on tributary of Meandu Creek	26º 47' 30.59" S	151º 53' 48.59" E	Continuous monitoring when a release occurs, except for periods of short duration (max **72 hours**) where maintenance or repair of monitoring equipment is carried out.
W3#	Downstream of the Meandu Creek Dam on Meandu Creek	26º 44' 46.32" S	151º 54' 36.72" E	Continuous monitoring: Except for periods of short duration (max **72 hours**) where maintenance or repair of monitoring equipment is carried out.
W2#	Downstream of the Meandu Creek Dam on Meandu Creek	26º 46' 23.16" S	151º 53' 45.24" E	To be monitored in accordance with **Conditions C10 and C17.**

Notes:

^ Monitoring and release point

Downstream monitoring location

Table C2 – Water contaminant limits

Parameter	Monitoring / Release Point	Units	24-hour average[1]
pH	W3, CP2, CP3 and CP4	pH Units	9.0
Turbidity	W3, CP2, CP3 and CP4	NTU	1000
Electrical Conductivity	CP2, CP3 and CP4	µS/cm	2500

1. 24 hr average must be calculated from 3pm to 3pm or as otherwise agreed to by the administering authority.

Table C3 - Release contaminant trigger investigation levels

Quality characteristic	Trigger levels (µg/L)	Comment on trigger level	Monitoring frequency
Aluminium	150	*For aquatic ecosystem protection, based on HD guideline (80% protection)*	Monthly when a release occurs at the release point.
Arsenic	140	*For aquatic ecosystem protection, based on HD guideline (80% protection)*	
Cadmium	0.8	*For aquatic ecosystem protection, based on HD guideline (80% protection)*	
Chromium VI	40	*For aquatic ecosystem protection, based on HD guideline (80% protection)*	
Copper[L]	2.5	*For aquatic ecosystem protection, based on HD guideline (80% protection)*	
Iron	300	*For aquatic ecosystem protection, based on low reliability guideline*	
Lead	9.4	*For aquatic ecosystem protection, based on HD guideline (80% protection)*	
Mercury	5.4	*For aquatic ecosystem protection, based on HD guideline (80% protection)*	
Nickel[L]	17	*ANZECC highly disturbed (80% protection) for aquatic ecosystems*	
Zinc[L]	31	*ANZECC highly disturbed (80% protection) for aquatic ecosystems*	
Boron	1300	*For aquatic ecosystem protection, based on HD guideline (80% protection)*	

Table C3 - Release contaminant trigger investigation levels

Quality characteristic	Trigger levels (μg/L)	Comment on trigger level	Monitoring frequency
Cobalt	90	*For aquatic ecosystem protection, based on low reliability guideline*	
Manganese[L]	3600	*ANZECC highly disturbed (80% protection) for aquatic ecosystems*	
Molybdenum	34	*For aquatic ecosystem protection, based on low reliability guideline*	
Selenium	34	*ANZECC highly disturbed (80% protection) for aquatic ecosystems*	
Fluoride (total)	2000	*Protection of livestock and short-term irrigation guideline*	
Sulphate (SO_4^{2-}) (mg/L)	1000 mg/L	*ANZECC Guideline (1000 mg/L)*	

1. *All metals and metalloids must be measured as total (unfiltered) and dissolved (filtered). Trigger levels for metal/metalloids apply if dissolved results exceed trigger.*
2. *The quality characteristics required to be monitored as per **Table C3 - Release contaminant trigger investigation levels,** can be reviewed once the results of two years monitoring data is available, or if sufficient data is available to adequately demonstrate negligible environmental risk, and it may be determined that a reduced monitoring frequency is appropriate or that certain quality characteristics can be removed from **Table C3 - Release contaminant trigger investigation levels,** by amendment.*
3. *HD – highly disturbed level of protection; guideline refers ANZECC & ARMCANZ (2000).*
4. *LOR (limit of reporting) – typical reporting for method stated. ICPMS/CV FIMS – analytical method required to achieve LOR.*
5. *L = Hardness modified calculations can be applied in accordance with DSITI, 2017*

C11	End of pipe release limits for process water and stormwater contaminated by mining activities must be monitored at the locations and frequencies defined in **Table C4 - End of pipe monitoring locations and frequency** and **Appendix 2 - Meandu Mine Voids, Drainage System and Monitoring Network** and comply with contaminant limits defined in **Table C5 - End of pipe release limits**.

Table C4 – End of pipe monitoring locations and frequency

Monitoring Point	Latitude (GDA 94)	Longitude (GDA94)	Monitoring frequency
RD2 – Overflow from Retention Dam 2	26º 47’ 29.69” S	151º 53’ 35.49” E	Quarterly

Table C5 – End of pipe release limits

Parameter	Units	Minimum	Maximum
Oil and Grease	mg/L	-	10

C12	All erosion and sediment control measures must be designed, implemented and maintained to minimise the release of sediment from the surface area of the mining lease.
C13	Mine water may be piped, trucked, conveyed or transferred by a means that does not contravene the conditions of this environmental authority.
C14	Mine affected water may be deposited into artificial water storage structures. This water may then be used on or at properties owned by the environmental authority holder or a third party with the agreement of the third party.
C15	**Receiving Environment Monitoring Program (REMP)** A Receiving Environment Monitoring Program must be developed, implemented and reviewed, by a suitably qualified person(s) for all stages of the authorised mining activity and provided to the administering authority for review and comment by **30 March 2020**, and every two (2) years thereafter.

C16	The REMP, required by **Condition C15**, must: a) identify and describe any potential adverse impacts to surface water environmental values, quality and flows due to the authorised mining activity; b) described methods utilised to monitor the effects of the mine on the receiving environment periodically (under natural flow conditions) and while mine affected water is being discharged from the site; c) describe any sensitive receiving waters or environmental values downstream of the authorised mining activity that will potentially be affected by an authorised release of mine affected water; d) include monitoring of key Acid Mine Drainage (AMD) indicators (Manganese, Nickel and Zinc) at monitoring points CP3, W2 & W3 specified in **Table C1 - Water monitoring locations and frequency;** e) be designed to facilitate assessment of key AMD indicators (Manganese, Nickel and Zinc) at monitoring points CP3, W2 & W3 (against ANZG for highly disturbed (80% protection) aquatic ecosystems); f) describe the background reference water quality; g) describe the condition of downstream water quality compared against water quality objectives; and h) describe the suitability of current discharge limits to protect downstream environmental values. For the purposes of the REMP, the receiving environment is the downstream monitoring locations shown in **Table C1 – Water monitoring locations and frequency**.
C17	Within **twenty (20) business days** of receiving comments from the administering authority, as required by **Condition C15**, the REMP must be updated to address the comments and submitted to the administering authority.
C18	A report outlining the findings of the REMP, including all monitoring results and interpretations in accordance with **Conditions C15 and C16** must be prepared annually and submitted to the administering authority with each annual return.

C19	**Annual Water Monitoring Reporting** The following information must be recorded in relation to all water monitoring required under the conditions of this environmental authority and submitted to the administering authority in the specified format with each annual return: a) the date on which the sample was taken; b) the time at which the sample was taken; c) the monitoring point at which the sample was taken; d) the measured or estimated daily quantity of mine affected water released from all release points; e) the release flow rate at the time of sampling for each release point; f) the results of all monitoring and details of any exceedances of the conditions of this environmental authority; and g) water quality monitoring data must be provided to the administering authority in the specified electronic format upon request.

Schedule D: Groundwater	
Condition number	**Condition**
D1	**Contaminant release** The holder of this environmental authority must not release contaminants to groundwater.
D2	**Monitoring and reporting** All determinations of groundwater quality and biological monitoring must be performed by a suitably qualified person.
D3	The holder of the environmental authority must implement a groundwater monitoring program which has been developed by a suitably qualified person. The program must be able to detect a significant change to ground water quality values and standing water levels (consistent with the current suitability of the groundwater for domestic and agricultural use) due to activities that are part of this mining project.
D4	The holder of the environmental authority must report the results and analysis of groundwater monitoring to the administering authority on request.
D5	Groundwater affected by the mining activities must be monitored at compliance bores within the nominated geologies and minimum frequencies defined in **Table D1 – Groundwater monitoring locations and frequency** and displayed in **Appendix 4 – Groundwater monitoring locations.**

D6	If the groundwater contaminant trigger levels defined in **Table D2 – Groundwater contaminant trigger levels** are exceeded, then the environmental authority holder must complete an investigation into the potential for environmental harm and notify the administering authority within **twenty-eight (28) days** of receiving the analysis results. An action plan to mitigate potential harm must be developed by a suitably qualified person.

Table D1 – Groundwater monitoring locations and frequency

Geology	Bore Number	Coordinates (AGD84)		Minimum Monitoring Frequency
		Easting	Northing	
Meandu Creek Alluvium	GW39	389931	7036197	Quarterly
Coal Measures – Ace Seam	N/A	N/A	N/A	
Coal Measures – King Seam	GW45_s	393707	7031395	
Coal Measures – King Seam	GW46_s	394330	7033546	
Coal Measures – Queen Seam	GW45_d,	393707	7031395	
Coal Measures – Queen Seam	GW46_d	394328	7033544	
Coal Measures – Queen Seam	GW63_d	393974	7032350	
Coal Seams below Queen Seam	GW86	7035561	7035561	
Coal Seams below Queen Seam	GW87_d	388025	7034138	

Table D2 – Groundwater contaminant trigger levels

Monitoring Site			GW39	GW45_s	GW46_s	GW45_d	GW46_d	GW63_d	GW86[3]	GW87_d[3]
Parameter	**Limit Type**	**Unit**								
pH	Range	pH Unit	5.5-9.5							
EC	Max	µS/cm	3400	6220						
Sulphate	Max	mg/L	Interpretation only[2]	244						
Fluoride[1]	Max	mg/L	2							
Aluminium[1]	Max	mg/L	0.08							
Arsenic[1]	Max	mg/L	0.042							
Boron[1]	Max	mg/L	0.68							
Cobalt[1]	Max	mg/L	0.1							
Lead[1]	Max	mg/L	0.154							
Manganese[1]	Max	mg/L	2.5							
Molybdenum[1]	Max	Mg/L	0.05							
Nickel[1]	Max	mg/L	0.12							
Selenium[1]	Max	mg/L	0.018							
Vanadium[1]	Max	mg/L	0.5							
Zinc[1]	Max	mg/L	0.138							

Notes:

[1] All metals/metalloids to be measured as total (unfiltered) and dissolved (filtered). Trigger levels for metals/metalloids apply if dissolved results exceed trigger.

[2] No trigger level proposed for Meandu Creek alluvium at GW39 due to influence of Meandu Creek Dam on sulphate concentration at this site.

[3] GW01 & GW11 must continue to be monitored for 12 months following the installation of GW86 and GW87 but are not subject to groundwater contamination trigger levels.

The assessment approach for trigger levels may be based on a two-tiered approach (DSITI, 2017), which includes:
Tier 1 – Assessment of a rolling median of 8 consecutive samples compared to the 80th percentile of the data.
Tier 2 – Three consecutive exceedances above the 95th percentile of the data set.

D7	An annual groundwater report must be submitted to the administering authority with each annual return. The report must include: (a) the results and interpretation of the groundwater monitoring program; (b) a review of the suitability of the groundwater network; and (c) recommendations or improvements to the groundwater network, including whether additional monitoring locations are required.
D8	**Bore Construction and Maintenance and Decommissioning** The construction, maintenance and management of groundwater bores (including background and compliance groundwater monitoring bores) must be undertaken in a manner that prevents or minimises impacts to the environment and ensures the integrity of the bores to obtain accurate monitoring. Construction and decommissioning must be in accordance with the "Minimum Construction Standard for Water Bores in Australia".
D9	Groundwater levels when measured at the monitoring locations specified in **Table D1 - Groundwater monitoring locations and frequency** must not exceed the groundwater level trigger level thresholds specified in **Table D3 - Groundwater level monitoring** below. **Note:** Trigger level threshold only applies if changes in water level are assessed to be related to mining activities, but not related to climatic variation and other non-mining related factors.
D10	**Exceedance Investigation** If quality characteristics of groundwater from compliance bores identified in **Table D1 - Groundwater monitoring locations and frequency** exceed any of the trigger levels stated in **Table D2 - Groundwater contaminant trigger levels** or exceed any of the groundwater level trigger threshold stated in **Table D3 - Groundwater level monitoring**, the holder of this environmental authority must compare the compliance monitoring bore results to the reference bore results and complete an investigation in accordance with the ANZECC and ARMCANZ 2000.

Table D3 – Groundwater level monitoring

Monitoring Location	Trigger Level Threshold
Shallow Tertiary/Quaternary Units	2m/year
Triassic coal seams (King Seam and Queen Seam, excluding Ace Seam)	5m/year

Schedule E: Acoustic	
Condition number	**Condition**
E1	**Noise Nuisance** Notwithstanding any other conditions of this environmental authority, noise from activities must not cause an environmental nuisance at any noise sensitive place or any commercial place.
E2	**Noise nuisance from mining operations (other than blasting)** When requested by the administering authority in writing, noise monitoring must be undertaken within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of an authorised officer) of environmental nuisance at any sensitive place, and the results must be notified within **fourteen (14) days** to the administering authority following completion of monitoring. Noise monitoring must include: (a) background noise level; (b) LA max, adj, 15 mins or where they can be justified as appropriate, LA 10, adj, 15 mins and LA 1, adj, 15 mins ; (c) the level and frequency of occurrence of impulsive or tonal noise; (d) atmospheric conditions including wind speed and direction; (e) effects due to extraneous factors such as traffic noise; and (f) location, date and time of recording.
E3	**Nuisance from Vibration and Airblast Overpressure** Vibration and/or airblast overpressure from the mining activity must not cause an environmental nuisance, at any sensitive place.
E4	**Airblast Overpressure and Ground-borne Vibration Nuisance** 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 E1 – Blasting noise limits** to be exceeded at a sensitive place or commercial place.

Table E1 – Blasting noise limits

Blasting Noise Limits	Sensitive or Commercial Blasting Noise Limits Place Limits	
	7am to 6pm	**6pm to 7am**
Ground vibration peak particle velocity	Houses and low-rise residential buildings and commercial buildings not included below – 4 out of 5 shots not to exceed 5mm/s and a maximum of 10mm/s for any blast	No blasting to occur
	Commercial and industrial buildings or structures of reinforced concrete or steel construction – 4 out of 5 shots not to exceed 10mm/s and a maximum of 15mm/s for any blast	
Airblast overpressure	115dB (80th percentile)	No blasting to occur
	120dB (maximum)	

E5	When requested by the administering authority, vibration and/or airblast overpressure monitoring must be undertaken within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of the authorised officer) of environmental nuisance at any sensitive place, and the results must be notified within **fourteen (14) days** to the administering authority following completion of monitoring.
E6	If the environmental authority holder can provide evidence through monitoring that the limits defined in **Table E1— Blasting noise limits** are not being exceeded, then the holder is not in breach of **Condition E4**. Monitoring must include: (a) Location of the blast(s) within the mining area (including which bench level); and (b) Atmospheric conditions including temperature, relative humidity and wind speed and direction; and location, date and time of recording.
E7	If monitoring indicates exceedance of the relevant limits in **Table E1 – Blasting noise limits,** then the environmental authority holder must: (a) Address the complaint including the use of appropriate dispute resolution if required; or (b) Immediately implement vibration and/or airblast overpressure abatement measures so that vibration and/or airblast overpressure from the activity does not result in further environmental nuisance.

Schedule G: Land	
Condition number	**Condition**
G1	**Progressive rehabilitation** Progressive rehabilitation must commence within 12 months of the disturbance activities ending.
G2	**Rehabilitation Management Plan and Rehabilitation Monitoring Program** The environmental authority holder must prepare and implement a Rehabilitation Management Plan and Rehabilitation Monitoring Program by **30 October 2021**. Copies of the Rehabilitation Management Plan and Rehabilitation Monitoring Program must be provided to the administering authority upon request, which must be within **fourteen (14) days** of the request (or an otherwise agreed timeframe).
G3	All areas disturbed by mining activities must be progressively rehabilitated to achieve: (a) A landform for final land uses that are: (i) safe to humans and wildlife (ii) non-polluting (iii) stable; and (iv) able to sustain the final land use; and (b) The final land use and rehabilitation success criteria are in **Appendix 5 - Final land use and rehabilitation success criteria for landforms** and indicative locations of final land uses are shown in **Appendix 5 – Final land uses and indicative locations**. (c) If the water storage in residual void and Steep Rocky Ecosystem landform shown in **Appendix 5 – Final land uses and indicative locations** that is associated with the future K2E mine extension is not approved by **18 December 2025**, it must be removed from **Appendix 5 – Final land uses and indicative locations.**
G4	The holder of this environmental authority must take all reasonable and practicable measures to minimise the area of land, including spoil areas, with post mined land slopes of greater than 17%.
G5	**Rehabilitation Outcomes** Areas that are to be progressively rehabilitated to a final land use, as required by **Condition G3** of this environmental authority must be rehabilitated using the rehabilitation criteria defined in **Appendix 5 - Final land use and rehabilitation success criteria for landforms.**

G6	**Residual Void and Highwall/Low Wall Outcome** The **two (2)** residual voids including highwall and low wall shown in **Appendix 5 – Final land uses and indicative locations**, must comply with the following outcomes: (a) Residual voids including highwall and low wall must not cause any serious environmental harm to land, surface waters or any known groundwater source, other than the environmental harm constituted by the existence of the residual void including highwall and low wall itself, and subject to any other condition within this environmental authority; (b) Residual voids must have a final land uses as steep rocky ecosystem and water storages.
G7	**Twelve (12) months** prior to the establishment of a residual void on the mining lease the holder of this environmental authority must complete an investigation into the residual void and submit a report to the administering authority proposing acceptance criteria, including: (a) Proposed landform design criteria for the competent and incompetent slopes; (b) The proposed surface area of the void; and (c) Proposals to meet the requirements of **Condition G6.**
G8	**Deep drainage (seepage)** Deep drainage (seepage) from the **domain** is non-polluting to recognised groundwater sources as assessed by an appropriately qualified person.
G9	**Tailings Deposition Areas** When the deposition of tailings to an area ceases, the holder of this environmental authority must install a final cover system to the tailings dam which effectively minimises: (a) Infiltration of water into the tailings deposition area; and (b) The likelihood of any erosion occurring to the final cover system.
G10	**Acid Rock Drainage Management** Measures must be implemented to prevent hazardous leachate being directly or indirectly released or likely to be released as a result of the activity to any ground water or water course.
G11	**Final Cover** When deposition of coal combustion products into voids defined in **Table A1 – Authorised coal combustion product storage locations** ceases, unless otherwise agreed to by the relevant landowner, any relevant land manager and the administering authority, the holder of this environmental authority must install a final cover system over the coal combustion products following sufficient time for ash consolidation and desiccation.
G12	The final capping system over coal combustion products in the voids defined in **Table A1 – Authorised coal combustion product storage locations** must be at least 2m deep and must include an upper layer of earthen material that is capable of sustaining plant growth and must be designed and maintained to minimise erosion occurring to either the final capping system or the coal combustion products in the void.

G13	Materials used in the construction of the capping layer over the coal combustion products in the voids defined in **Table A1 – Authorised coal combustion product storage locations** must achieve an in-situ permeability which is sufficiently low and / or be sufficient thickness so as to minimise infiltration of water into the landform.
G14	Reject disposal areas must be covered by a minimum of 6 (six) meters capping designed in accordance with criteria determined by a suitably qualified and experienced person.
G15	Reject disposal areas capped in accordance with **Condition G14** must include an upper layer of earthen material designed and maintained to sustain plant growth.

Schedule H: Regulated Structures	
Condition number	**Condition**
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) 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).*
H4	**Design and Construction of a Regulated Structure** **Conditions H5 to H9** inclusive do not apply to existing structures. **Note:** Construction of a dam includes modification of an existing structure—refer to the definitions.
H5	All regulated structures must be designed by, and constructed 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).* **Note:** Certification of design and construction may be undertaken by different persons.
H6	Construction of a regulated structure is prohibited unless: (a) the holder has submitted a consequence category assessment report and certification to the administering authority; and (b) the design, design plan and the associated operating procedures has been certified by a suitably qualified and experienced person 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; (ii) Wall failure due to erosion by floodwaters arising from any watercourse or drainage line; and (iii) For regulated dams that are dams associated with a failure to contain — seepage: have the floor and sides of the dam designed and constructed to prevent or minimise the passage of the wetting front and any entrained contaminants through either the floor or sides of the dam during the operational life of the dam and for any period of decommissioning and rehabilitation of the dam.
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; and (b) Construction of the regulated structure is in accordance with the design plan.

H10	**Operation of a Regulated Structure** Operation of a regulated structure, except for an existing structure, is prohibited unless the holder has submitted to the administering authority: (a) one paper copy and one electronic copy of the design plan and certification of the 'design plan' in accordance with **Condition H5**; (b) a set of 'as constructed' drawings and specifications; (c) certification of those 'as constructed drawings and specifications' in accordance with **Condition H9**; (d) 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; (e) the requirements of this authority relating to the construction of the regulated structure have been met; (f) the holder has entered the details required under this authority, into a Register of Regulated Structures; and (g) there is a current operational plan for the regulated structures.
H11	For existing structures that are regulated structures: (a) Where the existing structure that is a regulated structure is to be managed as part of an integrated containment system for the purpose of sharing the DSA volume across the system, the holder must submit to the administering authority by **2 February 2016** a copy of the certified system design plan including that structure; and (b) There must be a current operational plan for the existing structures.
H12	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.
H13	**Mandatory Reporting Level** **Conditions H14** to **H17** inclusive only apply to Regulated Structures which have not been certified as low consequence category for 'failure to contain — overtopping'.
H14	The Mandatory Reporting Level (the MRL) must be marked on a regulated dam in such a way that during routine inspections of that dam, it is clearly observable.
H15	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.
H16	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.

H17	The holder must record any changes to the MRL in the Register of Regulated Structures.
H18	**Design Storage Allowance** 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.
H19	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).
H20	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.
H21	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.
H22	**Annual Inspection Report** Each regulated structure must be inspected each calendar year by a suitably qualified and experienced person.
H23	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.
H24	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)*.
H25	The holder must within **twenty (20) business days** of receipt of the annual inspection report, provide to the administering authority: (a) the recommendations section of the annual inspection report; and (b) if applicable, any actions being taken in response to those recommendations; and (c) 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 **ten (10) business days** of receipt of the request.

H26	**Transfer Arrangements** 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.
H27	**Decommissioning and Rehabilitation** Dams must not be abandoned but be either: (a) Decommissioned and rehabilitated to achieve compliance with **Condition H28**; or (b) Be left in-situ for a beneficial use(s) provided that: (a) it no longer contains contaminants that will migrate into the environment; (b) it contains water of a quality that is demonstrated to be suitable for its intended beneficial use(s); and (c) 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).
H28	Before surrendering this environmental authority, the site must be rehabilitated to achieve a sustainable, safe, stable, non-polluting landform in accordance with the conditions contained in **Schedule G: Land** of this environmental authority.
H29	**Register of Regulated Structures** A Register of Regulated Structures must be established and maintained by the holder for each regulated structure.
H30	The holder must provisionally enter the required information in the Register of Regulated Structures when a design plan for a regulated dam is submitted to the administering authority.
H31	The holder must make a final entry of the required information in the Register of Regulated Structures once compliance with **Conditions H10** and **H11** has been achieved.
H32	All entries in the Register of Regulated Structures must be approved by the chief executive officer for the holder of this authority, or their delegate, as being accurate and correct.
H33	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 Structures, in the electronic format required by the administering authority.
H34	**Transitional Arrangements** All existing structures that have not been assessed in accordance with either the Manual or the former *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams* must be assessed and certified in accordance with the Manual by **2 August 2015**.

H35	All existing structures must subsequently comply with the timetable for any further assessments in accordance with the Manual specified in **Table H1 - Transitional hydraulic performance requirements for existing structures**, depending on the consequence category for each existing structure assessed in the most recent previous certification for that structure.
H36	**Table H1 - Transitional hydraulic performance requirements for existing structures** ceases to apply for a structure once any of the following events has occurred: (a) It has been brought into compliance with the hydraulic performance criteria applicable to the structure under the Manual; (b) It has been decommissioned; or (c) It has been certified as no longer being assessed as a regulated structure.
H37	Certification of the transitional assessment required by **Conditions H35** and **H36** as applicable must be provided to the administering authority by **2 August 2015**.

Table H1 – Transitional hydraulic performance requirements for existing structures

Transition period required for existing structures to achieve the requirements of the Manual for Assessing Consequence Categories and Hydraulic Performance of Dams			
Compliance with criteria	**High**	**Significant**	**Low**
>90% and a history of good compliance performance in last 5 years	No transition required	No transition required	No transitional conditions apply. Review consequence assessment every 7 years.
>70%-≤90%	Within 7 years, unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	Within 10 years, unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	No transitional conditions apply. Review consequence assessment every 7 years.
>50-≤70%	Within 5 years unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	Within 7 years unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	Review consequence assessment every 7 years.
≤50%	Within 5 years or as per compliance requirements (e.g., TEP timing)	Within 5 years or as per compliance requirements (e.g., TEP timing)	Review consequence assessment every 5 years

Schedule I: Offset Requirements	
Condition number	**Condition**
I1	Significant residual impacts to prescribed environmental matters are not authorised under this environmental authority or the Environmental Offsets Act 2014 unless the impact(s) is specified in Table I1 - Significant residual impacts to prescribed environmental matters.
I2	An environmental offset made in accordance with the Environmental Offsets Act 2014 and Queensland Environmental Offsets Policy, as amended from time to time, must be undertaken for the maximum extent of impact to each prescribed environmental matter authorised in Table I1 - Significant residual impacts to prescribed environmental matters.

Table I1 - Significant residual impacts to prescribed environmental matters		
Prescribed environmental matter	**Location of impact**	**Maximum extent of impact**
REGULATED VEGETATION		
Endangered regional ecosystem – RE 12.5.13c – semi-evergreen vine thicket	Lot 289 on FTY1859 Refer Appendix 6 of this EA Permit (WSP Figure 9.3) of e.g., maps/figures, coordinates, lot(s) on plan(s), resource authorities or project areas.	16.7 ha
Essential habitat (not in an urban area) for vulnerable wildlife – RE 12.5.13c - *Turnix melanogaster* (Black-breasted Button-quail)	Lot 289 on FTY1859 Refer Appendix 6 of this EA Permit (WSP Figure 9.3)	16.7 ha
PROTECTED WILDLIFE HABITAT		
Habitat for an animal that is vulnerable wildlife – RE12.11.11 (Least Concern) - *Turnix melanogaster* (Black-breasted Button-quail)	Lot 289 on FTY1859 Refer Appendix 6 of this EA Permit (WSP Figure 9.3)	1 ha

Definitions

Key terms and/or phrases bolded in this environmental authority are defined in this section. 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.

'accepted engineering standard' a design completed or certified by a RPEQ or Certified Professional in Erosion and Sediment Control (CPESC).

''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.

'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); and

(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.

'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.

'**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.

‘**cenospheres**’ means inert, hollow, essentially thin-walled glass spheres of approximately 10-350 microns having a typical density of 0.4-0.8g/cm3, comprised largely of silica and alumina and filled with air and/or gasses which are formed from coal combustion ash when in a molten state.

'**certified**', with respect to watercourse diversions, means assessed and approved by a suitably qualified and experienced person. In relation to 'as constructed' drawings and specifications, the certification must be by the suitably qualified person who supervised the construction of the watercourse diversion, or re-establishment of the watercourse.

'**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)).

'**certifying**', '**certify**' or '**certified**' have a corresponding meaning as 'certification'.

'**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.

‘**coal combustion products**’ means fly ash, furnace bottom ash or cenosphere(s) resulting from the burning of coal within coal fired power stations and coal fired boilers where at least 90% of the fuel source is coal and up to 10% of the fuel source can be biomass material (e.g. wood chip, biosolids), and where no other source of fuel is mixed other than petroleum based gas or liquid fuel for ignition support.

'**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.

'**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).*

'**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.

'**construction**' or '**constructed**', in relation to watercourse diversions, is the process of building, or modifying an existing diversion, but does not include investigations and testing necessary for the purpose of preparing a design plan.

'**contaminant**' — a contaminant can be:

(a) a gas, liquid or solid; or

(b) an odour; or

(c) an organism (whether alive or dead), including a virus; or

(d) energy, including noise, heat, radioactivity and electromagnetic radiation; or

(e) a combination of contaminants.

'**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 setting out how all identified consequence scenarios are addressed in the planned design and operation of a regulated structure.

'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.

'**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; or

(f) releasing of contaminants into the soil or underlying geological strata.

However, the following areas are not included when calculating areas of 'disturbance':

(iii) areas off lease (e.g. roads or tracks which provide access to the mining lease);

(iv) areas previously disturbed which have achieved the rehabilitation outcomes;

(v) 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);

(vi) 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; or

(vii) disturbance that pre-existed the grant of the tenure.

'domain' means all listed final land uses noted in Appendix 5.

'**EC**' means electrical conductivity.

'**effluent**' treated wastewater 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.

'existing structure' means a structure that prior to **2 February 2015** meets any or both of the following, a structure:

a) with a design that is in accordance with the Manual for Assessing Hazard Categories and Hydraulic Performance of Dams and that is considerably in progress; and

b) that is under considerable construction or that is constructed.

'**equilibrium**': A state where 'balance' is achieved despite changing variables.

'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.

'**fly ash**' means solid material extracted from the flue gasses of the boilers at the power station sites produced primarily from the combustion of coal, consisting essentially of the oxides of silicon, aluminium, iron and some calcium of which particle sizes range from less than 1µm (micrometre) to 200µm and are irregular to spherical in shape.

'**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:

(iii) geomorphic and vegetation assessment of the existing watercourse;

(iv) hydrologic conditions of the existing watercourse;

(v) the proposed watercourse diversion route; and

(vi) 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.

‘**furnace bottom ash**’ means the agglomerated particles formed at the bottom of the furnaces at the power station sites. Bottom ash is typically grey to black in colour, is quite angular, and has a porous surface structure.

'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' (EM635)*.

'**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 detailed on page 1 of this environmental authority.

'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)*.

'**m**' means metres.

'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.

'**measures**' includes any measures to prevent or minimise environmental impacts of the mining activity such as bunds, silt fences, diversion drains, capping, and containment systems.

'mine affected water':

(a) means the following types of water:

(i) pit water, tailings dam water, processing plant water;

(ii) water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the *Environmental Protection Regulation 2008* if it had not formed part of the mining activity;

(a) rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated, excluding rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed in accordance with the standards and requirements of an Erosion and Sediment Control Plan to manage such runoff, provided that this water has not been mixed with pit water, tailings dam water, processing plant water or workshop water;

(b) groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated;

(c) groundwater from the mine's dewatering activities; or

(d) a mix of mine affected water (under any of paragraphs i)-v) and other water;

(b) does not include surface water runoff which, to the extent that it has been in contact with areas disturbed by mining activities that have not yet been completely rehabilitated, has only been in contact with:

(i) land that has been rehabilitated to a stable landform and either capped or revegetated in accordance with the acceptance criteria set out in the environmental authority but only still awaiting maintenance and monitoring of the rehabilitation over a specified period of time to demonstrate rehabilitation success; or

(ii) land that has partially been rehabilitated and monitoring demonstrates the relevant part of the landform with which the water has been in contact does not cause environmental harm to waters or groundwater, for example:

(a) areas that are been capped and have monitoring data demonstrating hazardous material adequately contained with the site;

(b) evidence provided through monitoring that the relevant surface water would have met the water quality parameters for mine affected water release limits in this environmental authority, if those parameters had been applicable to the surface water runoff, or

(a) both.

‘**mine waste material’** includes, but is not limited to:

(a) Tailings;

(b) Coal Combustion Products;

(c) Coal Rejects; and

(d) Waste Rock.

'**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 nature.

'non-polluting' means having no adverse impacts upon the receiving environment.

'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.

'**power station sites**' means Tarong Power Station and Tarong North Power Station, Tarong-Maidenwell Road, via Nanango Qld 4615.

'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.

'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) a watercourse;

(b) groundwater; or

(c) an area of land that is not specified as "surface rights areas" in **Appendix 1 Authorised disturbance areas** of this environmental authority.

'receiving waters' means the waters into which this environmental authority authorises releases of mine affected water.

'Register of Regulated Structures' includes:

- date of entry in the register;
- name of the dam, its purpose and intended/actual contents;
- the consequence category of the dam as assessed using the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635);
- 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;
- name and qualifications of the suitably qualified and experienced person who certified the design plan and 'as constructed' drawings;
- 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);

(e) Mandatory reporting level (metres AHD);

- the design plan title and reference relevant to the dam;
- the date construction was certified as compliant with the design plan;
- the name and details of the suitably qualified and experienced person who certified that the constructed dam was compliant with the design plan;
- details of the composition and construction of any liner;
- the system for the detection of any leakage through the floor and sides of the dam;
- 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;
- dates when recommendations and actions arising from the annual inspection were provided to the administering authority;
- dam water quality as obtained from any monitoring required under this authority as at **1 November** of each year.

`**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.

'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**' the process of reshaping and revegetating land to restore it to a stable landform.

'release event' means a surface water discharge from mine affected water storages or contaminated areas on the licensed place.

'release of a contaminant' into the environment, includes-

(a) to deposit, discharge, emit or disturb a contaminant;

(b) to cause or allow the contaminant to be deposited, discharged, emitted or disturbed;

(c) to fail to prevent the contaminant from being deposited, discharged, emitted or disturbed;

(d) to allow the contaminant to escape; and

(e) to fail to prevent the contaminant from escaping.

'**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.

'Resource activity' is an activity that involves—

1. a geothermal activity;
2. a GHG storage activity;
3. a mining activity; or
4. a petroleum activity.

'**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.

[1] Not including a species declared under the Land Protection (Pest and Stock Route Management) Regulation 2003 as a category class 1 pest, category class 2 pest or category class 3 pest.

'**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.

'Scheme fund' means the scheme fund established under the *Mineral and Energy Resources (Financial Provisioning) Act 2018*, section 24.

'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;

b) a motel, hotel or hostel;

c) an educational institution;

d) a medical centre or hospital;

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.

Note: The definition of 'sensitive place' and 'commercial place' is based on Schedule 1 of EPP Noise. That is, a sensitive place is inside or outside on a dwelling, library and educational institution, childcare or kindergarten, school or playground, hospital, surgery or other medical institution, commercial and retail activity, protected area or an area identified under a conservation plan under Nature Conservation Act 1992 as a critical habitat or an area of major interest, marine park under Marine Parks Act 2004, park or garden that is outside of the mining lease and open to the public for the use other than for sport or organised entertainment. A commercial place is inside or outside a commercial or retail activity.

A mining camp (i.e., accommodation and ancillary facilities for mine employees or contractors or both, associated with the mine the subject of the environmental authority) is not a sensitive place for that mine or mining project, whether or not the mining camp is located within a mining tenement that is part of the mining project the subject of the environmental authority. For example, the mining camp might be located on neighbouring land owned or leased by the same company as one of the holders of the environmental authority for the mining project, or a related company. Accommodation for mine employees or contractors is a sensitive place if the land is held by a mining company or related company, and if occupation is restricted to

the employees, contractors and their families for the particular mine or mines which are held by the same company or a related company.

Accommodation for mine employees or contractors is a sensitive place if the land is held by a mining company or related company, and if occupation is restricted to the employees, contractors and their families for the particular mine or mines which are held by the same company or a related company.

For example, a township (occupied by the mine employees, contractors and their families for multiple mines that are held by different companies) would be a sensitive place, even if part or all of the township is constructed on land owned by one or more of the companies.

'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' means a person who is a Registered Professional Engineer of Queensland under the provisions of the Professional Engineers Act 2002, who has an appropriate level of expertise in the structures, geomechanics, hydrology, hydraulics and environmental impact of watercourse diversions.

*An **appropriate level of expertise** includes:*

(a) demonstrable competency, experience and expertise in:

(i) investigation, design or construction of watercourses diversions;

(ii) operation and maintenance of watercourse diversions;

(iii) geomechanics with particular emphasis on channel equilibrium, geology and geochemistry;

(iv) hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology;

(v) hydraulics with particular reference to sediment transport and deposition and erosion control;

(vi) hydrogeology with particular reference to seepage and groundwater; and

(f) solute transport processes and monitoring thereof, or

(b) sufficient knowledge and experience to certify that where the suitably qualified and experienced person has relied on advice and information provided by other persons with relevant expertise:*

(i) they consider it reasonable to rely on that advice and information; and

(ii) the expert providing the advice and information has knowledge, competency, suitable experience and demonstrated expertise in the matters related to watercourse diversions.

***Persons with relevant expertise** include:*

(a) Geomorphologist: person who has demonstrated competency and relevant experience in stream geomorphology and watercourse diversions.

(b) Geotechnical Expert: person who has demonstrated competency and relevant experience in geotechnical assessment of soil characteristics suitable for watercourse diversions.

(c) Vegetation Expert: person who has demonstrated competency and relevant experience in the identification, role and function of vegetation with watercourses and adjoining floodplains, and has

demonstrated competency and relevant experience in revegetation of watercourse diversions and adjoining floodplains.

(d) Groundwater Expert: person who has demonstrated competency and relevant experience in groundwater systems.

(e) Surface Water Expert: person who has demonstrated competency and relevant experience in hydrology.

(f) Engineer: person who is a Registered Professional Engineer of Queensland (RPEQ) under the provisions of the Professional Persons Act 2002 or has similar qualifications under a respected professional registration association, and has demonstrated competency and relevant experience in design and construction of watercourse diversions.

(g) Soils Expert: person who has demonstrated competency and relevant experience in soil classification including the physical, chemical and hydrologic analysis of soil.

'suitably qualified person' in relation to environmental matters means a person who:

(a) is a member of an organisation listed in Schedule 14 of the EP Regulations 2019; and

(b) holds certification as an environmental practitioner (e.g. Certified Environmental Practitioner, (CEnvP) under the CEnvP Scheme) or,

(c) has professional qualifications, training, skills and 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.

'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.

'TCLP' means Toxicity Characteristic Leaching Procedure and is test described in the most recent version of the United States Environmental Protection Agency's Test Methods for Evaluation Solid Waste, Physical/Chemical Methods.

'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*.

'µS/cm' means micro siemens per centimetre.

'**void**' means any constructed, open excavation in the ground.

'**water**' is defined under Schedule 4 of the *Water Act 2000*.

'water year' means the 12-month period from **1 July to 30 June**.

'**watercourse**' has the same meaning given in the *Water Act 2000*.

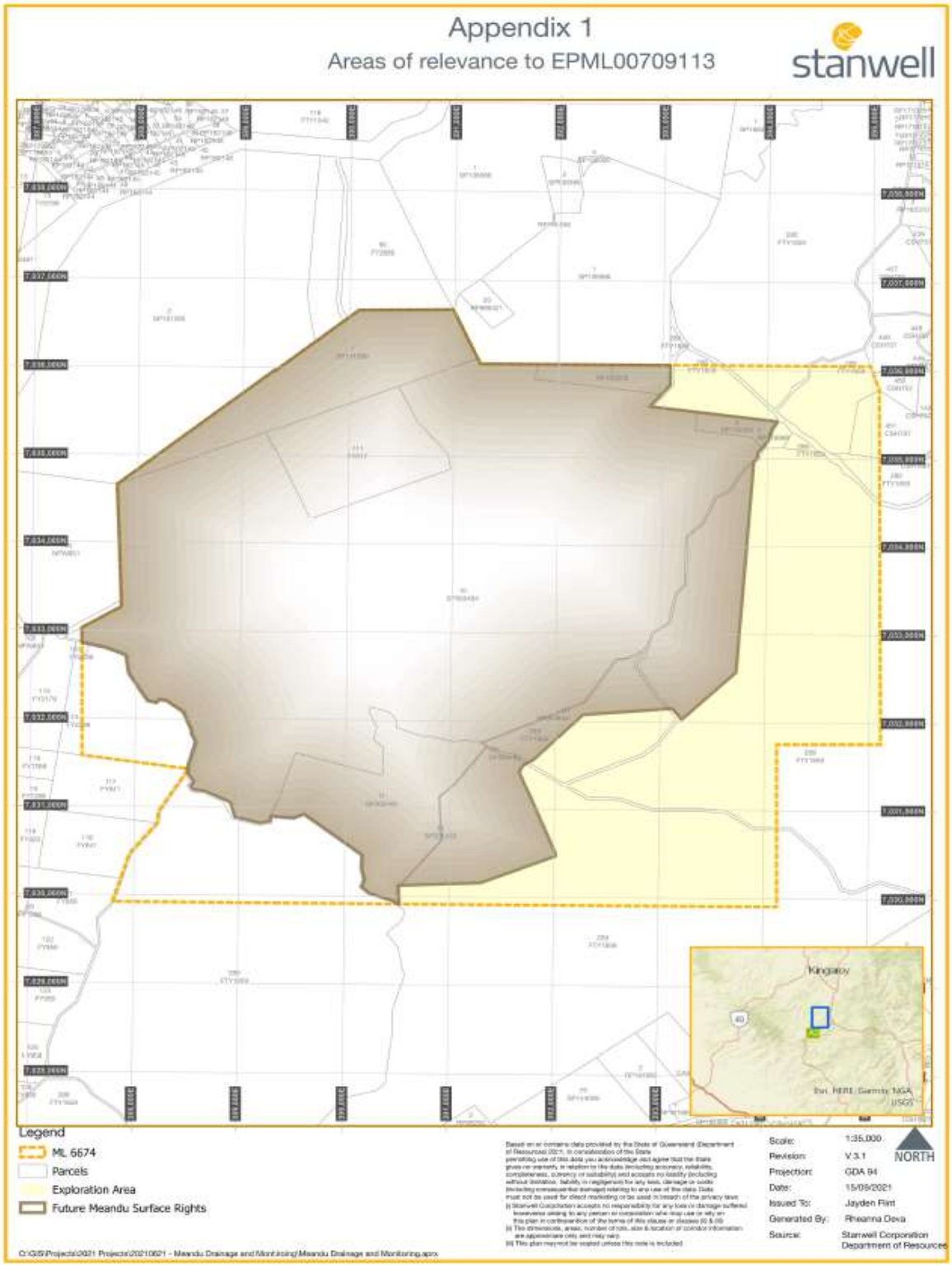
'water quality' means the chemical, physical and biological condition of water.

'**waters**' includes river, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, unconfined natural or artificial watercourse, bed and bank of any waters, dams, non-tidal or tidal waters (including the sea), storm water channel, storm water drain, and groundwater and any part thereof.

'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.

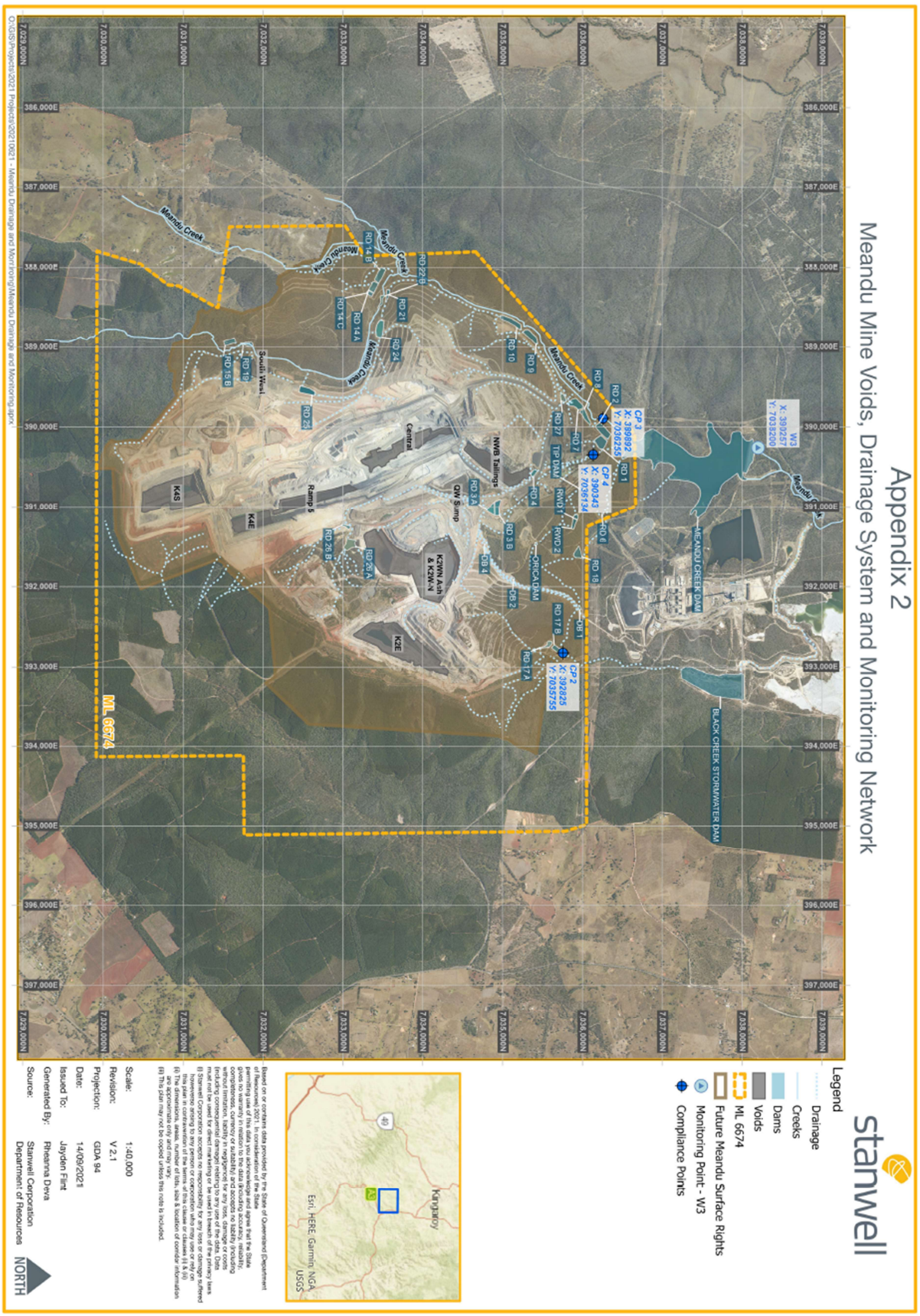
Appendices

Appendix 1 – Authorised disturbance areas[1]

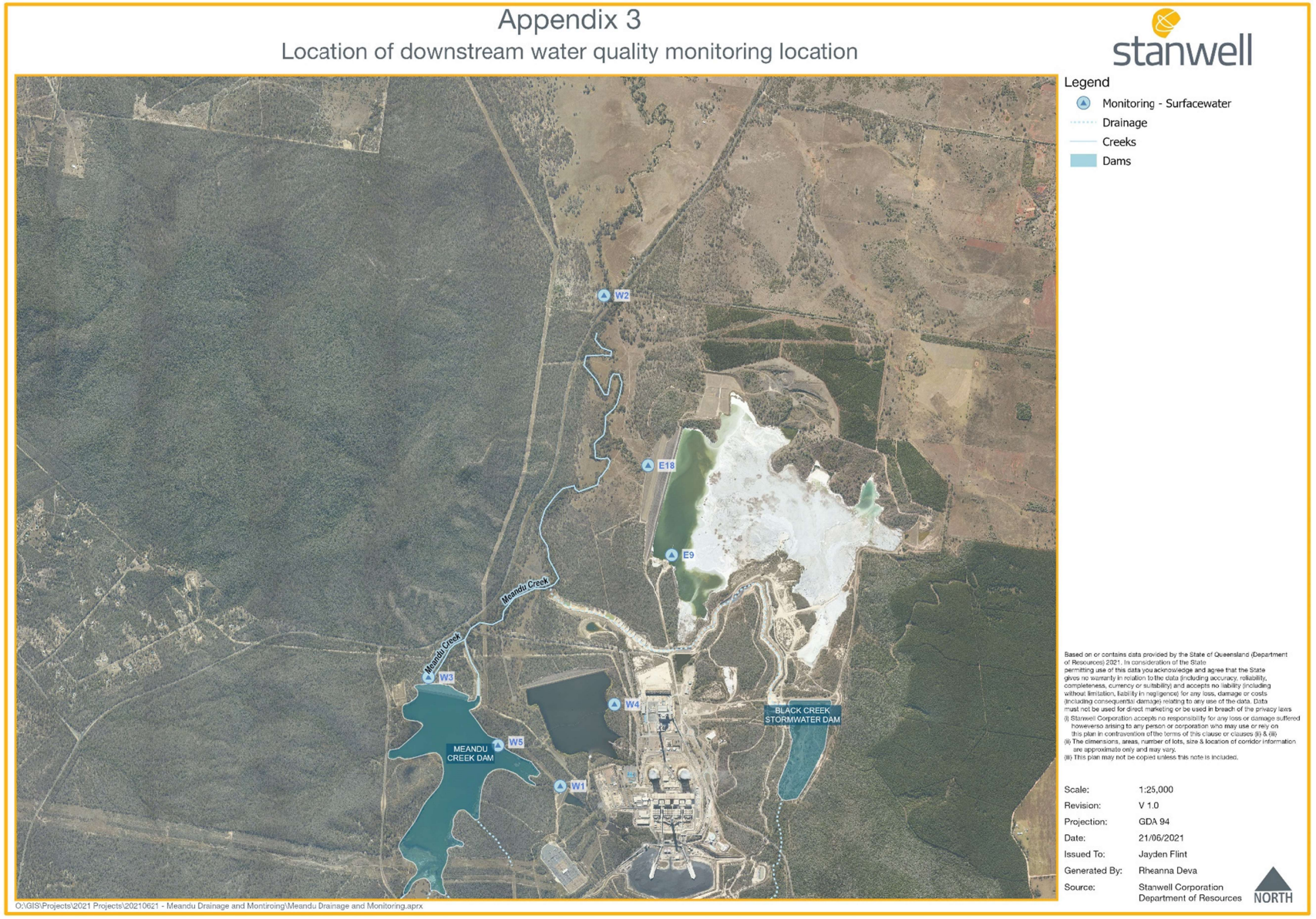


[1] Note: K2E Additional Surface Area is indicative only and has not yet been approved by Department of Resources

Appendix 2 – Meandu Mine Voids, Drainage System and Monitoring Network)



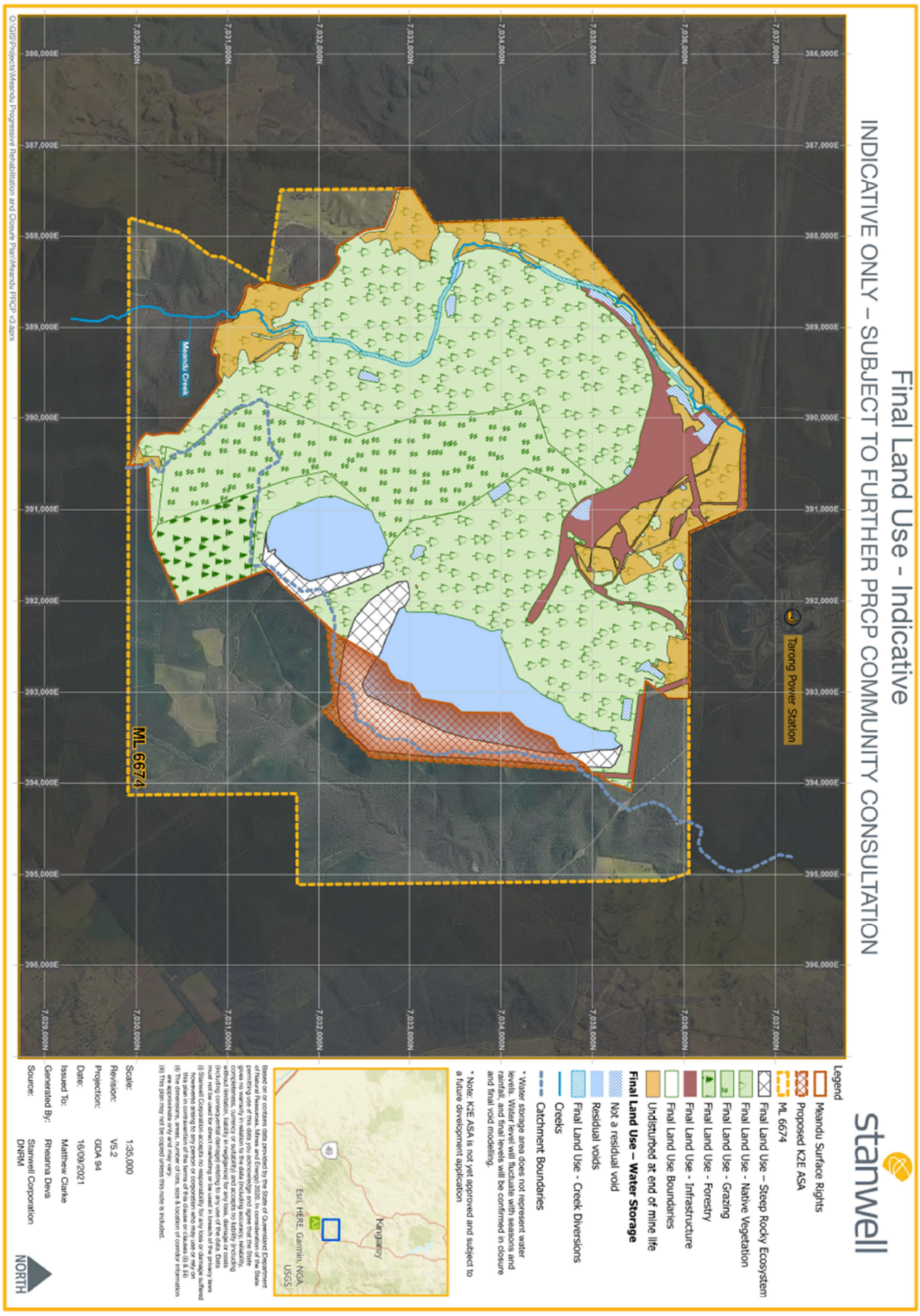
Appendix 3 – Location of downstream water quality monitoring locations (W2 &W3)



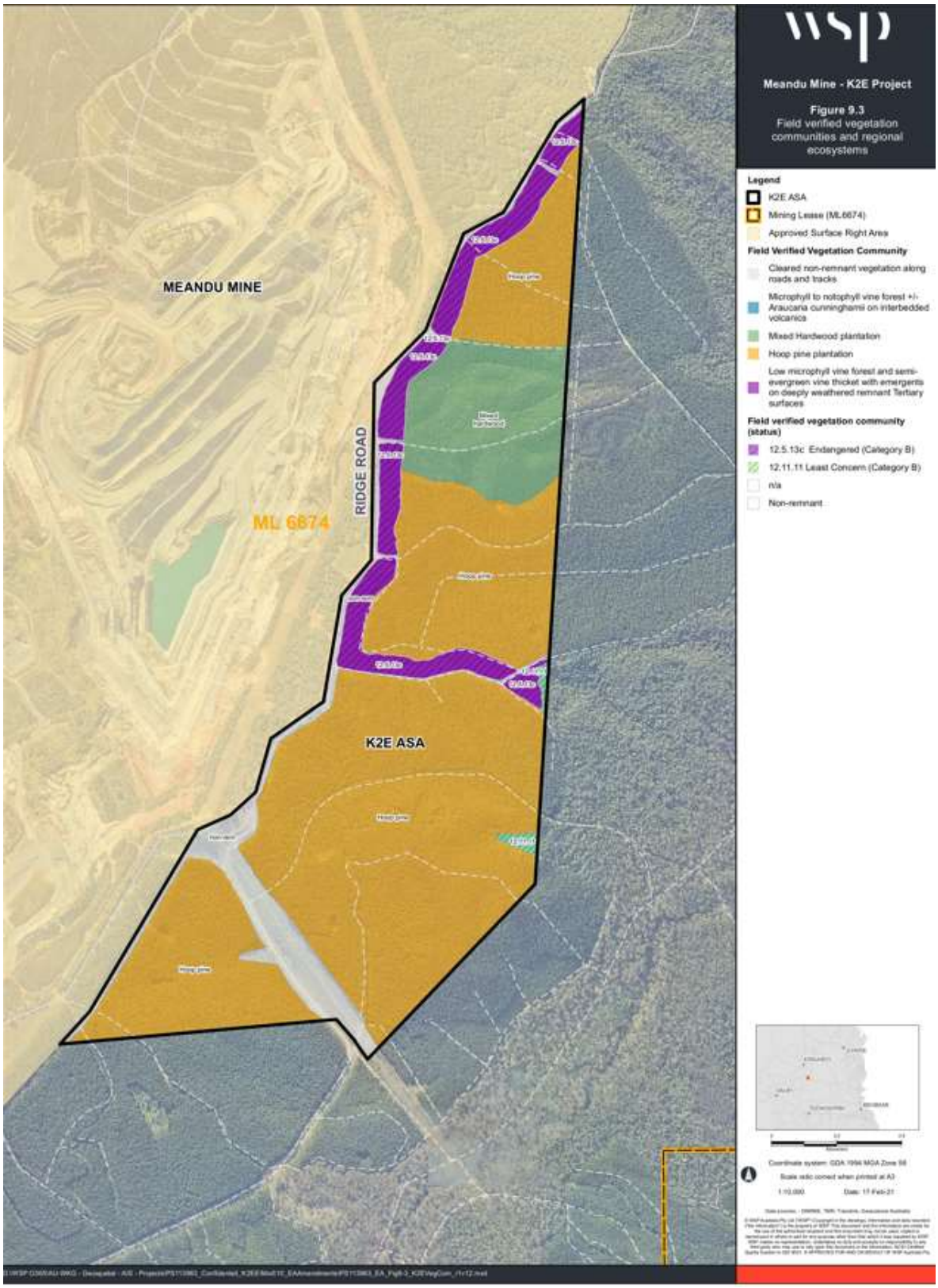
Appendix 4 – Groundwater monitoring locations.



Appendix 5 – Final land uses and indicative locations



Appendix 6: Significant residual impact area (refer EA Table I1)



Appendix 7 - Final land use and rehabilitation success criteria for landforms

FINAL LAND USE	GOAL	OBJECTIVE	INDICATOR	CRITERIA
Native Ecosystem[2]	Safe to humans and wildlife	Safety hazards in rehabilitation are analogous to local regional ecosystems in surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the native ecosystem must have no significant difference to hazards in local regional ecosystems in surrounding unmined landscape.
	Stable	Rehabilitation is geotechnically stable in the long term.	Factor of safety	≥1.5
		Rehabilitation ensures soil surface condition is erosionally stable.	Groundcover to be established and persistent.	>50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 20%. >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 20%.
	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5-9.0 (median) EC: <2037 µS/cm (median)

[2] Plant species composition of the low wall part of the residual void and the water equilibrium level will be decided by a geotechnical assessment.

	Able to sustain an agreed final land use	Vegetation to comprise a mixture of plant species like local regional ecosystems based on benchmarks for RE 12.9 -10.7; 12.9 -10.18 and 12.11.7[2]	Establishment of native ecosystems to resemble a mixture of benchmarks for RE 12.9 -10.7; 12.9 -10.18 and 12.11.7[3].	A. Native plant species richness: - Trees ≥4 count - Shrubs ≥6 count - Grass ≥4 count B. Cover: - Tree canopy cover is at least 20%
Creek diversion	Safe to humans and wildlife	The diversion has been constructed and is operating safely.	Designed and certified, with monitoring of operation by appropriately qualified and experienced person.	Records retained of as-built drawings and certification that creek diversions are operating in accordance with approved design and associated criteria.
		Safety hazards in rehabilitation are analogous to creeks in surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the creek diversions have no significant difference to hazards in creeks in surrounding unmined landscape.
	Stable	Creek diversions are both geotechnically and erosionally stable.	Stability assessed by an appropriately qualified and experienced person.	The assessment shows that the creek diversion is functioning as designed and the integrity of the watercourse diversion and/or adjoining watercourses is not threatened.
	Non-polluting	Diversions do not impact the environmental values of the receiving environment.	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5-9.0 (median) EC: <2037 µS/cm (median)

[3] Neldner, V. and Ngugi, M. (2012) *Assessment of BioCondition scores for three to twenty-year-old regeneration at Meandu Mine*, Southeast Queensland. Queensland Herbarium, Department of Science, Information Technology, Innovation and the Arts, Brisbane.

	Able to sustain an agreed final land use	Creek diversions are functioning as intended.	Assessment by an appropriately qualified and experienced person.	The assessment shows that the creek diversion is functioning as designed and the performance of the watercourse diversion and/or adjoining watercourses is not threatened.
Beef Cattle Grazing	Safe to humans and wildlife	Safety hazards in rehabilitation are analogous to grazing land in the surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the grazing land to have no significant difference to hazards in grazing land in the surrounding unmined landscape.
	Stable	Rehabilitation is geotechnically stable in the long term.	Factor of safety	≥1.5
			Minimal slope greater than 15%	80% of Slopes ≤ 15%. Minor areas up to a maximum of 25% to achieve tie-in with surrounding areas.
		Rehabilitation ensures soil surface condition is erosionally stable.	Groundcover to be established and persistent.	>50% established and persistent groundcover for all slopes less than or equal to 18%. >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 18%.
	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5-9.0 (median) EC: <2037 µS/cm (median)

	Able to sustain an agreed final land use	Rehabilitation is suitable for sustainable beef cattle grazing.	Land suitability assessment by appropriately qualified and experienced person using 'Regional Land Suitability Frameworks for Queensland' (DNRM & DSITIA 2013)[4].	Grazing land to meet Class 1, 2 or 3 land suitability for grazing.
Plantation Forestry	Safe to humans and wildlife	Safety hazards in rehabilitation are analogous to plantations in the surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the plantations to have no significant difference to hazards in plantations in the surrounding unmined landscape.
	Stable	Rehabilitation is geotechnically stable in the long term.	Factor of safety	≥1.5
		Rehabilitation ensures soil surface condition is erosionally stable.	Groundcover to be established and persistent.	>50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 20%. >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 20%.

[4] DNRM & DSITIA (2013) *Regional Land Suitability Frameworks for Queensland,* Queensland Government (Department of Science, Information Technology and Innovation and Department of Natural Resources and Mines), Brisbane, Queensland.

	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5-9.0 (median) EC: <2037 µS/cm (median)
	Able to sustain an agreed final land use	Rehabilitation is suitable for sustainable plantation forestry.	Land suitability assessment by appropriately qualified and experienced person using 'Regional Land Suitability Frameworks for Queensland' (DNRM & DSITIA 2013)[3].	Plantation land to meet Class 1, 2 or 3 land suitability for plantations. For Hoop Pine Plantations greater than or equal to 150 trees per hectare. For Hardwood Plantation greater than or equal to 100 trees per hectare.
Water Storage	Safe to humans, stock and wildlife	Safety hazards are managed for humans, stock and wildlife.	Hazard assessment by an appropriately qualified and experienced person.	Design requirements are determined to ensure water storage is safe for humans, stock and wildlife.
	Stable	Rehabilitation is geotechnically stable in the long term.	Factor of Safety	>1.5
	Able to sustain an agreed final land use	Able to sustain an agreed final land use.	Water storages contain water of a suitable quality for native wildlife and/or livestock ingestion, measured using the indicators of TDS, Calcium, Magnesium, Nitrate, Sulfate, Cobalt, Nickel, Zinc, Arsenic, Boron, Selenium, Molybdenum and Fluoride.	Total Dissolved Solids: <5,000 mg/L Calcium: ≤1,000 mg/L Magnesium: ≤2,000 mg/L Nitrate: ≤400 mg/L Nitrite: ≤30 mg/L Sulfate: ≤1,000 mg/L Cobalt: ≤1 mg/L

				Nickel: ≤1 mg/L Zinc: ≤20 mg/L Arsenic: ≤0.5 mg/L Boron: ≤5 mg/L Selenium: ≤0.02 mg/L Molybdenum: ≤0.15 mg/L Fluoride: ≤2 mg/L
Landholder Retained Infrastructure	Safe to humans and wildlife	Safety hazards accepted by landholder.	Legally binding agreement	Agreement executed by both parties.
		Safety hazards in rehabilitation are analogous to surrounding unmined landscape with the same infrastructure.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the landholder retained infrastructure to have no significant difference to hazards in the same infrastructure in surrounding unmined landscape.
	Stable	Landholder accepts condition of infrastructure, including its structural integrity.	Legally binding agreement	Agreement executed by both parties
	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5-9.0 (median) EC: <2037 µS/cm (median)
	Able to sustain an agreed final land use	Landholder formally accepts infrastructure for his/her ongoing beneficial use.	Legally binding agreement	Agreement executed by both parties.

Steep Rocky Ecosystem	Safe to humans and wildlife	Safety hazards are managed for humans and wildlife now and in the foreseeable future	Hazard assessment by an appropriately qualified and experienced person.	Acceptable residual hazard ranking achieved.
	Stable	The landforms are geotechnically and erosionally stable.	Factor of Safety	>1.5 assessed at the projected stable crest.
	Non-polluting	Rainfall runoff from rehabilitation protects stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5-9.0 (median) EC: <2037 µS/cm (median)
	Able to sustain an agreed final land use	Landform that creates native fauna and flora habitat, while still being stable and safe.	Creation of a safe, stable and non-polluting landform that supports flora and fauna habitat.	The landform provides a diversity of slopes including mix of predominately flat benches and batters up to 80 degrees that create a varied environment for the future establishment of niche habitats.
		Vegetation on benches to provide an appropriate environmental outcome and be based on a species composition that ensures geotechnical stability of the benches is not compromised.	A species composition that ensures geotechnical stability of the benches is not compromised.	Native plant species richness per appropriate ecosystem outcome, adjusted to meet geotechnical stability requirements.

END OF ENVIRONMENTAL AUTHORITY

Appendix C

Pre-lodgement engagement with DES



Appendix C: Pre-lodgement engagement with DES

The following pre-lodgement engagement has been held between TEC Coal and DES:

- Pre-lodgement discussion meeting held with DES - 7 March 2022
- Pre-lodgement of spatial data with DES - 18 March 2022
- Pre-lodgement feedback received on spatial data from DES - 23 March 2022
- Pre-lodgement feedback received from DES - 8 April 2022
- Pre-lodgement feedback discussion meeting with DES held - 13 April 2022

Appendix D

Meandu Mine Plan of Operations (January 2019 – December 2020)



Plan of Operations January 2019 – December 2020
Mining Lease ML6674
Environmental Authority EPML00709113
Document Number ASM-MINE-PLAN-17

This document applies to the following sites:

All Sites	☐				
Rockhampton Office	☐	Brisbane Office	☐	Stanwell PS	☐
Kareeya PS	☐	Swanbank PS	☐	Koombooloomba PS	☐
Mica Creek PS	☐	Barron Gorge PS	☐	Mackay Gas Turbine	☐
Tarong North PS	☐	Tarong PS	☐	Meandu Mine	☒

Authorisation for original submission:

AUTHOR	REVIEWER	APPROVAL	DATE
Steve Jensen	Paul Veivers	Jacob Orbell	18/12/2018

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List of Attachments

Attachment 1	Meandu Mine Financial Assurance Calculator January 2019
Attachment 2	Meandu Mine Financial Assurance Calculator December 2019
Attachment 3	Meandu Mine Financial Assurance Calculator December 2020
Attachment 4	Meandu Mine Rehabilitation Cost Rate Confirmation - Downer EDI Mining
Attachment 5	Meandu Mine Demolition Report
Attachment 6	Cost Estimates for Closure Studies V5
Attachment 7	Stanwell Annual Report 2017/18 (web address)
Attachment 8	TEC Coal Financial Discount Declaration ESR-2015-1822
Attachment 9	TEC Coal 2019-2020 Plan of Operations Compliance Statement Final

1. Purpose

The purpose of this Plan of Operations is to:

- Describe all proposed mining activities that will be undertaken at Meandu Mine during the period 1 January 2019 to 31 December 2020;
- List the action programs (proposed and in place) that manage ongoing compliance with the conditions of Environmental Authority (EA) EPML00709113 throughout the period of this Plan;
- Propose a rehabilitation program for land significantly disturbed during the Plan period, including rehabilitation areas and projects that will be undertaken; and
- Calculate the Financial Assurance for Meandu Mine required during the Plan period.

This Plan of Operations has been prepared in accordance with the Department of Environment and Science (DES) Guidelines EM583 *Preparing a plan of operations and audit statement for level 1 mining projects* and ESR-2015-1758 *Financial assurance under the Environmental Protection Act 1994*.

2. Scope

Meandu Mine is an open-cut coal mine that is operated for the purpose of supplying black thermal coal to the adjacent Tarong (TPS) and Tarong North (TNPS) Power Stations. In addition to the mining operation Meandu Mine includes one coal handling and preparation plant (CHPP), where mined coal is screened, washed and transported to the power stations via overland conveyor.

Meandu Mine currently operates within a surface rights area covering 2,638.4 hectares, within Mining Lease (ML) 6674 that has a total area of 4267 hectares.

The current long-term plan is for mining operations to continue at Meandu Mine through until 2037.

2.1 Term of this Plan of Operations

The period of this Plan of Operations is from 1 January 2019 to 31 December 2020.

2.2 Project Name and Location

Meandu Mine is located in Queensland's South Burnett district, approximately 150 km north-west of Brisbane, 14 km south-west of Nanango and 1.5 km to the south of the Tarong and Tarong North Power Stations (see Figure 1).



Figure 1: Project Locality

2.3 Holder of the Environmental Authority

The Meandu Mine EA is held by TEC Coal Pty Ltd (TEC), a wholly owned subsidiary of Stanwell Corporation Limited (SCL). Stanwell Corporation (then Tarong Energy) purchased the mine in 2008 from Rio Tinto Coal Australia (RTCA), who had previously owned and operated the mine since 1983.

Stanwell Corporation owns and operates the neighbouring TPS and TNPS.

2.4 Tenements Associated with this Plan of Operations

This Plan of Operations applies to ML 6674. The underlying properties which are impacted by activities on the operational area of the mining lease are included in Table 1.

Table 1: Tenure Summary

Mining Lease	Expiry Date	Tenure Holder/ Applicant Name	Surface Area Primary Land Tenure	Surface Area Secondary Land Tenure	Nature and extent of all activities to be carried out on operational land
ML 6674	28/02/2023	TEC Coal Pty Ltd	Lot 10 on FY2980	Lot A on AP17150	Areas cleared, areas with topsoil stripped & stockpiled, mine pits, in pit spoil dumps, out of pit spoil dumps, spoil undergoing rehabilitation, mine ramps, haul roads, access roads, water management works including stream diversions, coarse and fine rejects storage facilities, raw coal stockpiles, coal preparation plant
			Lot 111 on FY817	Lot C on RP194488	
			Lot 1 on SP181280	Lot A on RP194488	
			Lot 11 on SP280476	Lot B on RP194488	
			Lot 2 on RP169258	Lot E on RP194487	
			Lot 3 on RP176969	Lot F on RP194487	
			Lot 289 on FTY1859	Lot H on RP194486	
			Temporarily closed road sections of Ridge Road, Tarong Yarraman Road and Unnamed Road	Lot G on RP194486	
				Lot BB on SP110163	
				Lot D on CP826323	
				Lot C on RP194488	

Figure 2 shows the boundary of ML 6674, the operational area (surface rights area) of Meandu Mine (including the 2016 Surface Rights Extension (SRE)) and tenements within ML 6674. Exploration drilling operations may be undertaken at times within ML 6674 to the east of the current surface rights area, as shown by the yellow-hatched area in Figure 2.

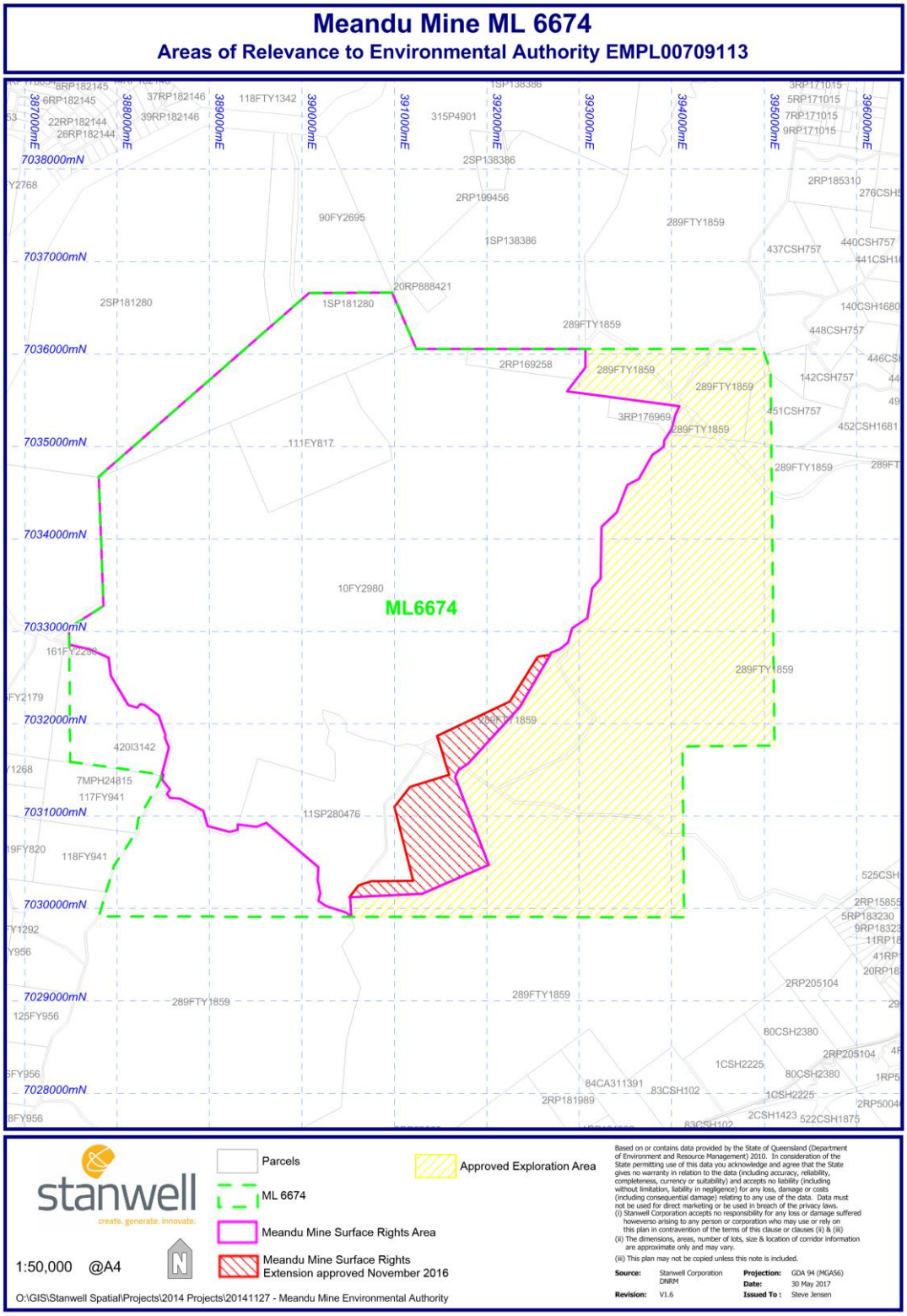


Figure 2: Meandu Mine Lease Boundary and Surface Rights Area

2.5 Environmentally Relevant Activities and Notifiable Activities

Environmentally Relevant Activities (ERAs) applicable to ML 6674 are listed in Meandu Mine's EA and summarised in Table 2. Notifiable activities (as described under Schedule 3 of the *Environmental Protection Act 1994*) which will be carried out at Meandu Mine during the term of this Plan of Operations are detailed in Table 3.

Table 2: Environmentally Relevant Activities

Environmentally Relevant Activity	Location
Environmental Protection Regulation 2008, Schedule 2A ERA 13 Mining black coal ***Environmental Protection Regulation 2008, Schedule 2*** ERA 7 Chemical manufacturing – Threshold 3 manufacturing, in a year, a total of 200t or more of any of the following – (d) explosives. ERA 8 Chemical storage – Threshold 3 storing more than 500m3 of chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous goods class 3. ERA 31 Mineral processing – Threshold 2 processing, in a year, the following quantities of mineral products, other than coke – (b) more than 100,000t. ERA 56 Regulated waste storage - receiving and storing regulated waste. ERA 60 Waste disposal – Threshold 1 operating a facility for disposing of, in a year, the following quantity of waste – (a) less than 50,000t. ERA 63 Sewage treatment – Threshold 1 operating sewage treatment works, other than no-release works, with a total daily peak design capacity of – (b) more than 100 but not more than 1500EP – (i) if treated effluent is discharged through an infiltration trench or irrigation scheme.	ML6674

Table 3: Notifiable Activities

Notifiable Activity	Description
1	Abrasive blasting—carrying out abrasive blast cleaning (other than cleaning carried out in fully enclosed booths) or disposing of abrasive blasting material.
6	Chemical manufacture or formulation—manufacturing, blending, mixing or formulating chemicals if— (a) the chemicals are designated dangerous goods under the dangerous goods code; and (b) the facility used to manufacture, blend, mix or formulate the chemicals has a design production capacity of more than 1t per week.
7	Chemical storage (other than petroleum products or oil under item 29), storing more than 10t of chemicals (other than compressed or liquefied gases) that are dangerous goods under the dangerous goods code.

Notifiable Activity	Description
14	Engine reconditioning works—carrying out engine reconditioning work at a place where more than 500L of any of the following are stored— (a) halogenated and non-halogenated hydrocarbon solvents; (b) dangerous goods in class 6.1 under the dangerous goods code; (c) industrial degreasing solutions.
15	Explosives Production or Storage —operating an explosives factory under the *Explosives Act 1999*
20	Landfill, disposing of waste (excluding inert construction and demolition waste).
23	Metal treatment or coating—treating or coating metal including, for example, anodising, galvanising, pickling, electroplating, heat treatment using cyanide compounds and spray painting using more than 5L of paint per week (other than spray painting within a fully enclosed booth).
24	Mine wastes: (a) Storing hazardous mine or exploration wastes, including, for example tailings dams, overburden or waste rock dumps containing hazardous contaminants; or (b) Exploring for, or mining or processing, minerals in a way that exposes faces, or releases groundwater, containing hazardous contaminants.
29	Petroleum product or oil storage, storing petroleum products or oil: (a) In underground tanks with more than 200L capacity; or (b) In above ground tanks with: (i) For petroleum products or oil in class 3 in packaging groups 1 and 2 of the dangerous goods code—more than 2,500L capacity; or (ii) For petroleum products or oil in class 3 in packaging groups 3 of the dangerous goods code—more than 5,000L capacity; or (iii) For petroleum products that are combustible liquids in class C1 or C2 in Australian Standard AS 1940, 'The storage and handling of flammable and combustible liquids' published by Standards Australia—more than 25,000L capacity.
33	Scrap yards—operating a scrap yard including automotive dismantling or wrecking yard or scrap metal yard

3. Commitments Summary

Table 4 provides a summary of environmental projects and commitments that are scheduled for this Plan of Operations period.

Table 4: Commitments Summary

Aspect	Commitment
General	The recommendations contained in the Acid and Metalliferous Drainage (AMD) Environmental Investigation Report will be implemented during the term of this Plan of Operations.
Air	A temporary dust suppression layer over the ash in King 2 West pit will be maintained until it is either inundated by the rising ash stored in King 2 North or buried by contingency tailings disposal.
	A new air (dust), noise and vibration monitoring network (ANVS) was installed at selected sites around Meandu Mine prior to commencement of this Plan. The network will provide Meandu Mine with the ability to monitor dust and noise emissions from site and allow operations to respond to complaints.
Water	Desilting of a number of sediment dams during this plan period is expected to occur should sediment accumulate at a rate that would compromise the dam's effectiveness during the plan period.
	Water management in the Surface Rights Extension area will occur by: • Minimising disturbance for mining activities immediately prior to active mining being undertaken, and • Re-grading mine-impacted areas within the SRE so runoff drains back to the active pit, as soon as practicable following disturbance.
Groundwater	The evaluation and installation of additional groundwater monitoring bores will be undertaken as required at or around Meandu Mine.
	Licenced water bore drillers will be engaged to install any new groundwater monitoring bores and decommission any that are to be removed.
Noise and vibration	Air blast and vibration impacts from the mining operations will be monitored using the air, noise and vibration monitoring network, to demonstrate compliance with EA criteria.

Aspect	Commitment
Waste	The supernatant water level in the North-West B tailings storage facility (NWB-TSF) will be maintained at or below 443.0 mRL unless subsequent assessment determines that this level should be altered. Deposition of tailings in NWB-TSF will cease by the end of calendar year 2019.
	During late 2017, solid bowl centrifuges were installed in the CHPP to enable dry disposal of tailings. A minimum 40% tailings (by dry weight) will be dewatered, mixed with coarse rejects and trucked to disposal sites within the inpit spoil dumps.
	The NWB-TSF and RD16-TSF will be retained for emergency tailings disposal should the centrifuges be by-passed during breakdowns or for maintenance or repairs during the Plan period. Tailings disposal into NWB-TSF will cease by the end of 2019. A decommissioning and rehabilitation plan has been developed for the NWB-TSF. A similar Plan will be developed for the RD16-TSF. Subsequent ongoing contingency tailings disposal will be into the K2W-N ash storage, pending approval.
	Redesign and modifications to the bunding for the tailings pipeline will be undertaken to ensure any potential spill would report to the dirty water drainage system.
Land	During the two-year Plan period, TEC will rehabilitate a minimum of 58ha of mining related disturbances.
	Maintenance works will be undertaken in some established rehabilitation areas to improve species diversity and density and/or to address any identified erosion or other issues that may impact on the performance of these areas to meet agreed completion criteria.
	Topsoil will be stockpiled to a maximum height of: • 5 m for freshly stripped topsoil • The lessor of 10 m or the existing height for relocated topsoil stockpiles
	Active rejects dumping locations will be mapped and a suitable capping methodology for each location will be determined. Active coarse rejects and tailings storage facilities will be capped with a minimum 6m of non-acid forming (NAF) overburden material during the rehabilitation process unless subsequent assessment determines that this cover depth should be altered.
	Major material types suitable for rehabilitation will be defined and a material balance for integration into Meandu's geological model will be developed.

Aspect	Commitment
Regulated structures	Construction of the K2W-N ash/tailings storage facility to 520RL embankment will progress during the Plan period.
	An RPEQ geotechnical engineer will undertake annual geotechnical inspections and assess any activities which impact on the operation of the K2W-N ash/tailings storage facility and QW Sump.

4. Nature and Extent of Mining Activities on ML6674

Mining activities at Meandu Mine during the term of this Plan of Operations will involve:

- Exploration drilling
- Clearing of vegetation
- Stripping and stockpiling of topsoil from disturbance areas
- Drilling and blasting
- Overburden removal using truck and shovel, dragline, dozers and scrapers
- Coal mining and transport
- Coal processing
- Coarse and fine reject disposal
- Disposal of ash from coal combustion at power stations
- Onsite disposal of waste tyres
- Maintenance of water management structures including sediment controls
- Dump construction and reshaping
- Rehabilitation of disturbed land

4.1 Coal Mining

4.1.1 Exploration Drilling

Exploration drilling and related activities are undertaken periodically at Meandu to better define the coal resource. Approval was granted to conduct exploration drilling within ML6674 to the east of the current Surface Rights area to identify potential additional reserves for future mining. A comprehensive exploration drilling program has been conducted since 2009 to further refine knowledge of the resource along the south and east boundaries and to increase mine plan accuracy. Exploration drilling occurs in accordance with approval granted by the Queensland Department of Natural Resources and Mines.

Exploration borehole sites are predominantly located on existing forestry tracks with a small number located within the plantation timber areas, as agreed with the plantation holder HQ Plantations, which are then progressively rehabilitated.

No exploration activities are planned to occur within ML6674 to the east of the current Surface Rights area during this Plan period.

4.1.2 Clearing of Vegetation

Vegetation is routinely cleared in advance of mining operations within the surface rights area. This will occur primarily in advance of the active pits in Central, Ramp 5, K4E and K4S. Central and Ramp 5 pit progression will require clearing of older established rehabilitation and remnant vegetation, while K4E and K4S pit progression will require clearing of remnant vegetation and previously-harvested pine plantation areas.

At K4E and K4S, the cleared and stripped area will be re-graded to drain back to the active pit, minimising the risk of uncontrolled runoff from the disturbed area from leaving site. As mining progresses towards the east these sediment control structures will be progressively removed and replaced as required.

Cleared vegetation is either:

- Stockpiled and burnt prior to topsoil stripping, to reduce fire fuel load and allow ash to be incorporated into the topsoil, or
- Utilised in rehabilitation areas, to provide fauna habitat and soil surface protection.

The 2016 surface rights extension area had previously been harvested of the pine plantation occupying the area and was designated ‘Undisturbed’ upon transfer to the surface rights area. This area has since been culturally cleared and has been re-classified as ‘Cleared’.

Some remnant vegetation is required to be cleared in the King 4 area prior to and during this Plan period to allow construction of a new drainage channel upstream of RD25. This will provide clean water / mine water separation and allow rehabilitation in the K4S catchment to progress. Some remnant vegetation clearing may occur in the boundary pit area for a powerline relocation.

4.1.3 Stripping and Stockpiling Topsoil

Topsoil will be stripped to an appropriate depth and either directly placed onto re-contoured landforms or stockpiled for use later during rehabilitation. Topsoil is managed in accordance with site procedures to minimise impact to the topsoil resource.

Topsoil stockpiles formed from freshly-stripped topsoil will be limited to heights of 5m, to assist with retaining the seed bank and soil structure. This height was determined to be suitable to limit anaerobic oxidation, through an analysis of the soil types at Meandu and comparison with criteria in ACARP Report C9029. Due to area limitations, relocated stockpiles may be formed higher than 5m but will not exceed the height of the original stockpile. Stockpiles are formed on either in-situ ground or on spoil dumps.

Topsoil stockpiles are strategically placed to avoid future pit and dump progression that may require their relocation, whilst positioning them as close as practicable to the rehabilitation area on which they will later be spread. Stockpiled topsoil volumes and locations are recorded in the site topsoil register and locations are shown in Figure 3.



Figure 3: Topsoil Stockpile Locations

4.1.4 Drill and Blast

Explosives are used to assist removal of overburden and mining of coal. Explosive product is selected for each shot to minimise (and where possible remove) the occurrence of fume. Common explosives used on-site are ANFO, Heavy ANFO and Emulsion which is mixed on-site and loaded down the blast pattern drill holes. Storage of explosives is in accordance with Explosives Production or Storage - operating an explosives factory under the *Explosives Act 1999* and per license #0409758 granted by the Queensland Government Department of Mines and Energy. Explosive storage facilities are shown in Figure 4.

The designs and practices used throughout the mine emphasise the minimisation of vibration and fly-rock whilst maintaining productivity. The ANVS network includes a number of blast monitors to measure blast related ground vibration and overpressure. Blast monitoring is also carried out when blasting in King 2 East (not planned until 2023) to ensure vibration measured at the Powerlink transmission pylons located adjacent to the mine surface rights is within limits required for Powerlink structures.

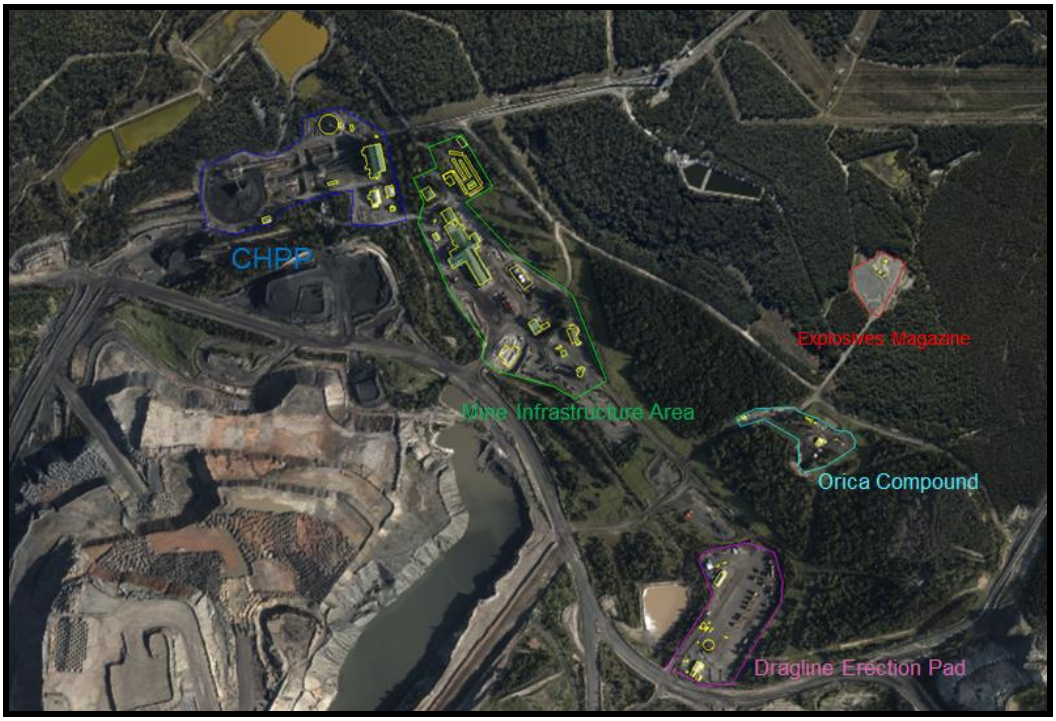


Figure 4: Explosives Storage, CHPP and Coal Conveyor Locations

4.1.5 Waste Rock Removal

Waste rock material removed in advance of coal mining is comprised of:

- Overburden, which is located above the upper coal seam,
- Interburden, which is located between adjacent coal seams,
- Coal roof, coal floor and coal partings, which is located adjacent to coal seams, or
- Spoil material, which has previously been dumped and is rehandled to provide access to the targeted coal seam.

Interburden is competent material which is drilled and blasted to allow efficient handling by equipment, while overburden can be either free dig material or drilled and blasted. The majority of overburden (over 90%) is blasted.

Waste rock material will be moved by dragline and excavator/ haul truck fleets to inpit or ex-pit overburden dumps, appropriate to the mine plan and mining location.

Overburden and interburden is primarily NAF. In-pit coal roof, coal floor and coal partings are assumed to be potentially acid forming (PAF). Rejects are assumed to be PAF or PAF low capacity (PAF-LC) and tailings are assumed to be NAF or PAF-LC.

Material identified as PAF is subject to strict dump location criteria; it must be located at minimum 6m depth from the final landform design surface (and where possible, is located at a greater depth than 6m). The material placement and cover requirements will be reviewed as additional information becomes available from the material characterisation program.

Mining operations in the period of this Plan will advance the existing Central, Ramp 5, King 4 East (K4E) and King 4 South (K4S) pits. King 2 East (K2E) pit is not planned to be mined until 2023, when operations in this area are scheduled to resume, subject to future approvals associated with the proposed eastern extension to this pit.

Figure 5 shows the planned clearing and active pits over the period of this Plan, while Figure 6 shows proposed pit progression out to 2037. Exact clearing boundaries may be refined during detailed mine planning, but will remain within the disturbance schedule quantities specified in Table 7 in Section 6.1.3.



Figure 5: 2019-2020 Active Pits (Red) and Proposed Clearing (Blue)

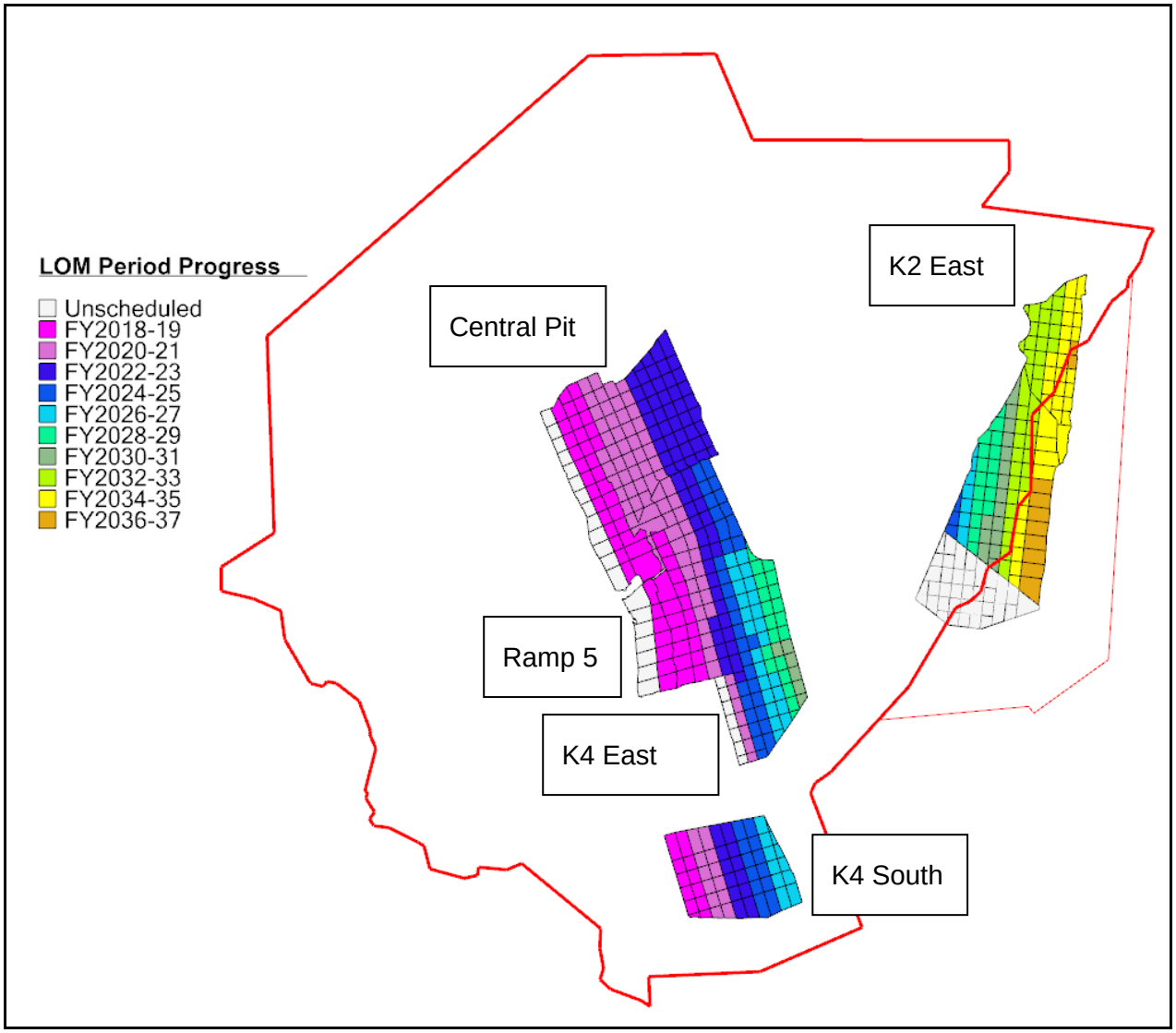


Figure 6: Life of Mine Plan Pit Progression FY2018-19 to FY2036-37

4.2 Processing

4.2.1 Coal Mining and Transport

Coal from the Ace, King and Queen seams will be mined by excavators in the previously nominated pits. Coal production is directly linked to demand from TPS and TNPS and varies on a monthly basis depending on delivery requirements for the power stations.

Coal will be transported to Run of Mine (ROM) stockpiles or the ROM bin at the CHPP in rear dump trucks. The CHPP processes include screening, crushing and washing using gravity separation, to achieve product coal ash content specifications. Product coal will then be transported via a 1.5 km overland conveyor to the Tarong Power Stations.

Haul roads, stockpiles and conveyors are watered during operation in order to minimise the generation of nuisance dust from transport of coal and overburden.

4.2.2 Coal Handling Preparation Plant

ROM coal is sized in primary and secondary breakers, during which raw coal is separated from breaker rejects. During the CHPP process, raw coal is separated into coal and non-coal materials using a washing and flocculent method. The resultant product coal is sent to the TPS and TNPS. The locations of the CHPP processing plant and conveyors are depicted in Figure 4.

Meandu Mine coal production is dependent on TPS generation requirements and will not exceed 11.0 million ROM tonnes per year.

Coarse rejects are co-mingled with dewatered fine rejects and hauled to in-pit rejects dumps.

4.2.3 Coarse and Fine Rejects

Fine rejects (coal tailings) are thickened and treated with $Ca(OH)_2$ to attain a broadly neutral pH in the CHPP thickener and pumped in slurry form to solid bowl centrifuges, where they are dewatered to the required moisture content for transport. Dewatered fine rejects are co-mingled with coarse rejects and the resulting Mixed Plant Rejects (MPR) stockpiled at the CHPP before being trucked to the rejects dump locations shown in Figure 7. Water that is recovered from the solid bowl centrifuges will be recycled back through the CHPP system.

MPR are dumped within mine inpit spoil dumps, either within shallow cells that are progressively covered with overburden material, or co-mingled with spoil in a tiphead configuration. Optimisation of the MPR dumping strategy will occur during the term of this Plan and investigations assessing the benefit of co-mingling rejects with other mine materials will continue to reduce AMD potential of the resultant blend. Rejects will be placed minimum 6m below final landform surface, capped with a NAF spoil cover system and rehabilitated as per EA requirements and the Meandu Mine Rehabilitation Plan.

Geochemical assessment has verified that both coarse and fine rejects can range in quality from NAF to PAF, depending on the source of the coal. The rejects are generally treated as PAF from a material handling and placement perspective.

Coal tailings have historically been pumped as slurry of circum-neutral pH directly to the RD16 Tailings Storage Facility (RD16-TSF) or North-West B Tailings Storage Facility (NWB-TSF), previously the NorthWest B mine pit. Figure 7 shows the location of these TSFs. The NWB-TSF or RD16-TSF may be used intermittently during the period of this Plan, when bypass of the solid bowl centrifuges is required for maintenance purposes. Tailings deposition into NWB-TSF will cease prior to the end of 2019. Deposition into RD16-TSF may continue during 2020, if required.

Decant water from the TSFs is reclaimed and pumped into the mine drainage system, where it passes through a series of retention dams to assist with the settling of sediment and coal fines. This water is reclaimed from RD2 and re-used through the CHPP, minimising raw water use.

During the period of this Plan, it is planned that contingency tailings disposal will occur into the K2W-N ash storage, as per the following sequence:

- initially into a tailings cell to be constructed in the K2W portion of the facility as shown in Figure 7 (for the duration of this Plan period)
    - ash and tailings materials will remain separated

  - tailings supernatant will continue to be pumped to the mine drainage system and ash supernatant will be pumped to the TPS ash dam

- once the ash level exceeds the K2W tailings cell crest level, the ash and tailings streams will be co-mingled with slurry deposition from separate pipes
  - the ash and tailings supernatant waters will be combined and pumped back to the TPS ash dam
  - depending on water quality, suitability for reuse and regulatory approvals (if required), the combined ash and tailings supernatant waters may also be re-used at Meandu.

A decommissioning and rehabilitation plan for NWB-TSF has been developed. A similar plan will be developed for RD16-TSF during the term of this Plan. Once decommissioned, these TSFs will undergo a period of desiccation (drying out and consolidation) prior to commencement of capping. The desiccation period may extend beyond the period of this Plan.

Coarse and fine rejects and associated infrastructure (including decommissioning) will be managed as per commitments in ***Appendix A: Action Program***, to enable compliance with EA conditions and minimise the risk of environmental harm.

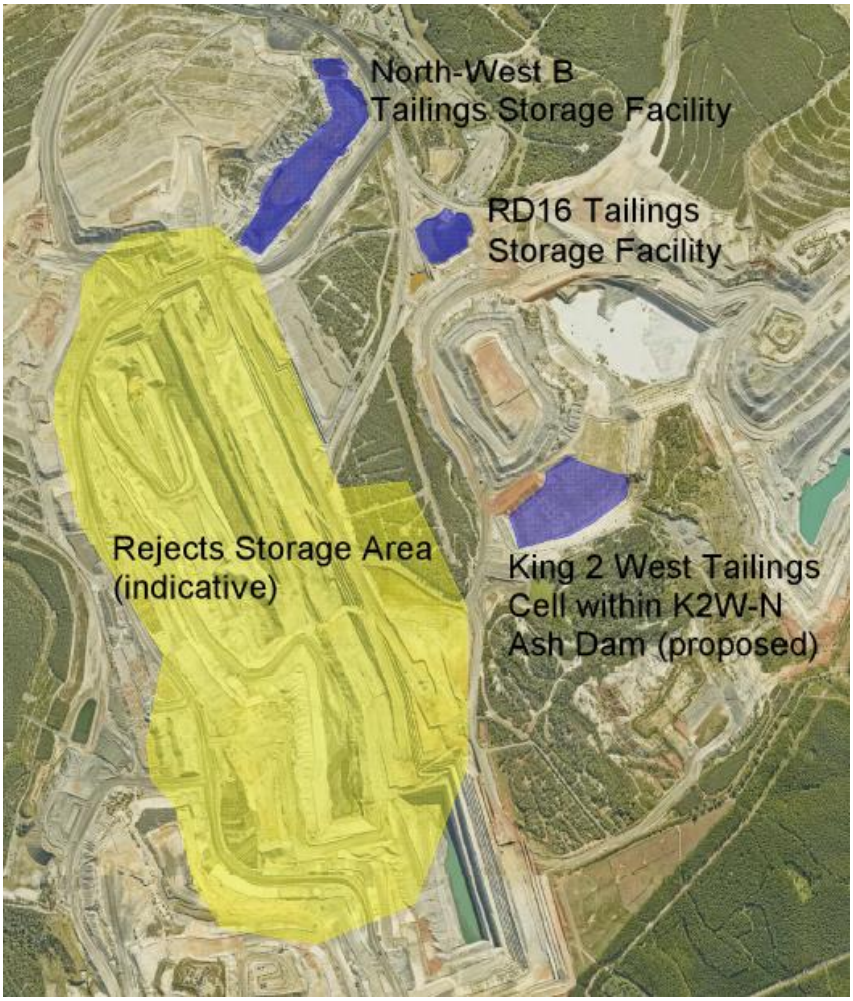


Figure 7: Tailings and Mixed Plant Rejects Storage and Disposal

4.2.4 Ash Storage

Fly-ash is produced during the coal combustion process at the power stations as a by-product of power generation. Dense-phase ash slurry has been pumped from TPS and TNPS to Meandu Mine for disposal in disused mine voids since 2009 under *Beneficial Use Approval (BUA) ENBU00736008* which was subsequently replaced *by End of Waste (EoW) Approval ENEW07312817.*

Ash was initially deposited into King 2 West (K2W) void with approval for ash deposition in the combined King 2 West-North (K2W-N) ash storage obtained in January 2012. This was based on the *King 2 West Ash Void Stage 2 Above Ground Design Plan and Certification* and associated documentation.

Mining in King 2 North (K2N) was completed in FY15 after which the K2N void was prepared to receive ash. The ash slurry pipelines were diverted from K2W to K2N during FY16, allowing ash deposition to occur directly into K2N.

During the period of this Plan, construction of the K2W-N ash storage facility will progress, that will involve:

- raising the K2W-N embankment to an interim level of RL505m and ultimately RL520m with a spillway that will report to the adjacent K2E pit,
- construction of the Queen West (QW) seepage collection sump (QW Sump), and
- certification and operation of the K2W-N storage and the QW Sump as Regulated Structures prior to storage levels in the facility reaching the current approved level of RL484m.

Supernatant water is reclaimed from the K2W-N Ash Storage and pumped in a closed-loop system back to TPS ash dam for recovery and re-use. Depending on water quality, water collected in the QW sump will be pumped to the mine drainage system or pumped back to the TPS ash dam. Once the ash and tailings streams are co-disposed in K2W-N storage, the combined ash-tailings supernatant waters will be pumped back to the TPS ash dam. These supernatant waters may also be re-used at Meandu, depending on water quality, suitability for reuse and regulatory approvals (if required).

Ash deposition into the K2W-N ash storage will continue during the term of this Plan of Operations, in accordance with the EA, EOW approval and the approved and certified ash storage design plans. Ash quantities are dependent on TPS generation rates, coal quality and proportion of ash sent to Meandu. The EoW approval is due to expire in September 2019. Ongoing ash storage may then be managed as part of the Environmental Authority or under a proposed EoW Code, subject to the approval of the administering authority.

Bunding and drainage systems have been installed along the ash pipeline route and catch dams constructed downgradient from each emergency dump valve along the ash pipeline, to contain any ash spill in the event of pipeline breach. Associated infrastructure for ash disposal, such as the pipeline and access road, return water and stormwater pumps, and catchment dams will be maintained as required.

Regular inspections and routine maintenance will be carried out to monitor the system. Operational and maintenance procedures for the ash and return water pipeline are in place in collaboration with TPS. In addition to regular site inspections by the site geologist and Open Cut Examiner, an independent RPEQ geotechnical engineer undertakes annual geotechnical inspections and assesses any activities or situations with the potential to impact on the operation of the K2W-N ash storage.

A spoil layer has been placed over the western portion of the K2W side of the ash storage to assist with dust suppression and will be in place until ash in the K2W-N facility increases above this level. This temporary layer does not represent a final cap and therefore has not been designed to meet those specifications. Contingency tailings disposal will occur into a cell on the capped K2W portion of the ash storage during the term of this Plan.

Cenospheres are a by-product of the coal combustion process and are entrained in the ash slurry and liberated from the material once the slurry has been deposited in the void. Cenospheres are small, hollow, silica balls that float on the water's surface. They are marketable due to their heat-resistant properties. Cenospheres may be harvested from K2W-N facility during the term of this Plan in accordance with *EoW Approval Number ENEW07312817,* the proposed E0W Code or under the EA, subject to the approval of the administering authority.

Dust suppression mechanisms that will be used to minimise dust transmission during this Plan period include the dust suppression layer on the western portion of the K2W ash area and the use of sprinklers or water trucks if required.

Figure 8: shows the location of the K2W-N ash storage facility and the indicative alignments of the ash slurry and return water pipelines on Meandu Mine. These pipelines will be relocated over time during the construction of the K2W 520RL ash dam and to assist with the beaching profile within the dam.



Figure 8: King 2 West-North Ash Storage Facility and Associated Infrastructure

4.3 Maintenance Activities

Ongoing maintenance of infrastructure and fixed and mobile plant will occur during the period of this Plan. Maintenance activities on mobile plant will predominantly take place in the workshop, however, periodic field maintenance will be required for the dragline and some other plant.

A new heavy vehicle washbay facility was recently constructed at the workshop, which includes treatment systems to treat washdown effluent. Mobile equipment is washed down at this washdown facility prior to maintenance being undertaken.

Tool box talks are conducted under a training schedule to provide maintenance and operations personnel an understanding of the management of spills and environmental incidents that may occur during maintenance practices. Ongoing maintenance on the CHPP and other site infrastructure will be undertaken as required.

4.3.1 Abrasive Blasting

The maintenance of major plant such as the coal preparation plant and mining equipment periodically involves abrasive blasting prior to repainting. This occurs at different times throughout the year in accordance with operating procedures in place at Meandu Mine. The product used in the abrasive blasting process is inert. Abrasive blast rejects will be contained and tested to determine the most appropriate method of disposal.

4.3.2 Fuels and Chemicals

Bulk storage of diesel, other hydrocarbon products and reagents are maintained onsite. These products are used in the operation of heavy vehicles, mining equipment, explosives and in the CHPP process. No change to these facilities is planned during this Plan period.

All flammable and combustible liquids will be contained in a manner that prevents environmental harm and maintained in accordance with Section 5.9 of AS 1940. Regular inspections of the fuel farm and associated infrastructure will confirm this. Any spillage of fuel or chemicals will be contained and cleaned up according to site procedures. Training on spill management is carried out with the site personnel within the training schedule each year.

4.4 General Activities

4.4.1 Environmental Management

SCL has contracted mining contractor Downer EDi Mining Pty Ltd (Downer) to provide mining services at Meandu Mine, that includes environmental management and development, maintenance and implementation of systems to maintain compliance with the site's environmental authority. Downer employs an Environmental Superintendent, Environmental Specialist, Environmental Advisors and an Environmental Graduate to oversee all aspects of the site's environmental management.

In addition, SCL employ an Environmental Manager (covering a number of Stanwell sites) and Environmental Engineer to oversee operations and ensure Downer compliance with site environmental obligations and SCL corporate environment policies.

Meandu Mine has an Environmental Management System (EMS) that is maintained by Downer and includes policies, management plans, procedures and controls, that describe potential impacts and environmental controls that are in place to enable compliance with conditions of the EA.

Downer is presently contracted to provide mining services up to 30 June 2020. For the July – December 2020 period the provider of the above mining services is still to be determined through a tender process.

The following sections describe key environmental management initiatives, which will continue to be undertaken by Meandu Mine during the plan period.

4.4.2 Risk Management

Meandu Mine utilises a risk management system which is consistent with the content of ISO 31000:2009 and encompasses environmental risk management. Risk management principles are integrated into the Environmental Management System and the Health and Safety Management System.

Internal audits and ongoing third-party surveillance audits are utilised to verify that the systems are implemented and functioning appropriately. A number of Internal and surveillance Audits were conducted in 2016 to 2018. Further audits are planned to occur during the term of this Plan.

4.4.3 Waste Management Activities

The Waste Management Plan describes the management, segregation and disposal procedures for waste streams generated onsite. Within the Waste Management Plan an emphasis is placed on reduce, reuse, and recycle in conjunction with proper separation of waste types.

All regulated waste is managed under the waste tracking system as per the *Environmental Protection Act 1994.* Recyclable and industrial rubbish are managed in accordance with the Waste Management Procedure.

Tyres that have come to the end of their useful life are stockpiled temporarily, then either used in civil construction works on site or disposed of in the mine area as per the Waste Management Plan and DES guidelines. Records are kept at site of what, when and where used tyres have been disposed in spoil dump.

Lubricants and solvents are used on or in the equipment on the mine. Waste lubricants and solvents are collected before being transported off-site for recycling, reuse or disposal by a licensed waste contractor. They are managed under the regulated waste tracking system.

Timber pallets that cannot be reused by the supply company and some packaging materials are taken to a designated area on-site to be burnt during fire training exercises. This maintains and improves fire-fighting skills of the Emergency Response Team and other site personnel.

4.4.4 Air Quality

Dust abatement measures include use of water trucks for dust suppression, sprinkler systems at the CHPP, applying speed limits on equipment used on site, avoidance of certain activities during windy conditions and progressive rehabilitation. A new water fill point is in place at RD26 with construction completed during FY17. This fill point is centrally located for the future mining operations which reduces water truck travel time and improves the effectiveness of dust suppression. Upgrades have occurred during the previous Plan period to the (separate) ROM fill point, which included construction of an additional tank to reduce delay time for water trucks.

Dust monitoring will be undertaken in accordance with the requirements of the EA. Any complaints received in relation to dust will be investigated according to the site complaint review process and if required, monitoring undertaken in accordance with the site dust monitoring procedure.

Meandu Mine has an Air, Noise and Vibration System (ANVS) in place, which consists of five monitoring stations located around and within the surface rights area, representative of different clusters of identified sensitive receptors adjacent to the mine. The ANVS is intended to monitor, analyse and aid in controlling potential hazards or emissions from mining operations, by allowing operations to respond to threshold triggers. Data collected by the system will be used to aid discussions with the surrounding community.

4.4.5 Noise and Vibration

Any complaints received in relation to noise, will be investigated according to the site complaint review process. Noise and blast vibration and overpressure monitoring will be undertaken at the request of the administering authority in relation to complaints, in accordance with EA conditions.

All equipment is regularly maintained to enable efficient operation so that unnecessary noise is not impacting sensitive receptors outside the mine area.

New procedures have been implemented to minimise noise transmission to the areas surrounding the mine. These include the adoption of a 'silent horn' system on the truck fleet, redirection of the audible alarms on the CHPP and reallocation of track dozers from northern dump locations during weather conditions that are known to facilitate noise transmission.

Data collected from the ANVS will be used to develop trigger levels for site operational purposes.

4.4.6 Water Management

A comprehensive drainage and retention system exists at Meandu Mine covering the operational and industrial areas, CHPP, workshops and the warehouse, as shown in Figure 9. This system is maintained and upgraded to preserve the separation of clean and dirty water, maximise water recycling and minimise the need to discharge water from the mine area.

The existing network of drains, pipelines and retention dams currently in place will continue to be actively managed and maintained to meet water quality objectives and compliance with EA conditions.

A clean water diversion drain is planned to be constructed in the K4S area to direct runoff from the surrounding catchment around the proposed K4S pit footprint. Areas disturbed for mining activities within this SRE will be regraded so runoff from these areas drains back to the K4E and K4S pit catchments or existing mine retention dams.

Retention Dam RD25 has been constructed to provide sediment control for the future catchment of King 4 rehabilitation areas. In the short term, RD25 will receive pit water from Central, K4E and K4S pits, and will be used to supply water to the King 4 water fill point for dust suppression.

Life of Mine planning has identified that partially backfilled final voids will remain at K2E and K4E as part of the final landform. The final land use for these voids will be as water storages. It is likely that some water will accumulate in these voids and will be of suitable quality for stock watering or irrigation (e.g. pasture or plantation establishment).

Construction of new drainage channels upstream of RD25 will progress during this Plan period, to provide clean water / dirty water separation and divert runoff from future rehabilitated slopes to RD25. Once this drainage channel is constructed, the SW void will be backfilled, profiled and rehabilitated.

RD26 was completed early FY17 and receives runoff from the Boundary dump catchment and pumped flows from K2E pit. It was constructed ahead of Central pit progression that removed RD23. The new Boundary water fill point (Sparrows Nest Fill Point) sources its water from RD26.

RD27 was constructed during FY18 and collects water expressing from the toe of the North-West (NW) spoil dump, that is then lime-treated and pumped to other dams or directed to site facilities for re-use.

During FY18, the existing RD16 was modified for use as tailings storage (the RD16-TSF) that meant construction of a replacement sediment dam was required. Work has commenced on modifying the existing RD3, by increasing its storage capacity and splitting it into two separate dams (RD3A and RD3B). Construction will be completed during the period of this Plan. Planning has commenced for the design of a new retention dam in the Central-Ramp 5 area. Construction of this dam may commence during the term of this Plan.

Review of the pumping system will be carried out during the period of this Plan to effectively manage sediment loads and maximise reuse of mine-affected and process water.

Water infrastructure inspections as well as surface and groundwater monitoring activities will continue in accordance with the EA and action plan outlined in this document. A NATA accredited laboratory is used to measure quality limits as required. Mine water monitoring data is recorded in the Mine's water quality database.

Automated monitoring sensors and networks are used to monitor water quality at compliance points. The sensors are calibrated quarterly. Daily monitoring of water quality at compliance points occur as required by the EA and as described in the action program and monitoring program in this Plan. Additional automated stations have been installed in key storage dams to improve monitoring capability.

Retention dams will be de-silted as required with the removed sediment placed within mine void or tailings void sub-catchments. Dams are prioritised according to effective capacity, location within the catchment and future activities to be undertaken within each catchment (including progressive rehabilitation). The Mine Water Management Plan will be updated during the period of this Plan.

Figure 9 shows the existing water management network including recent improvements.

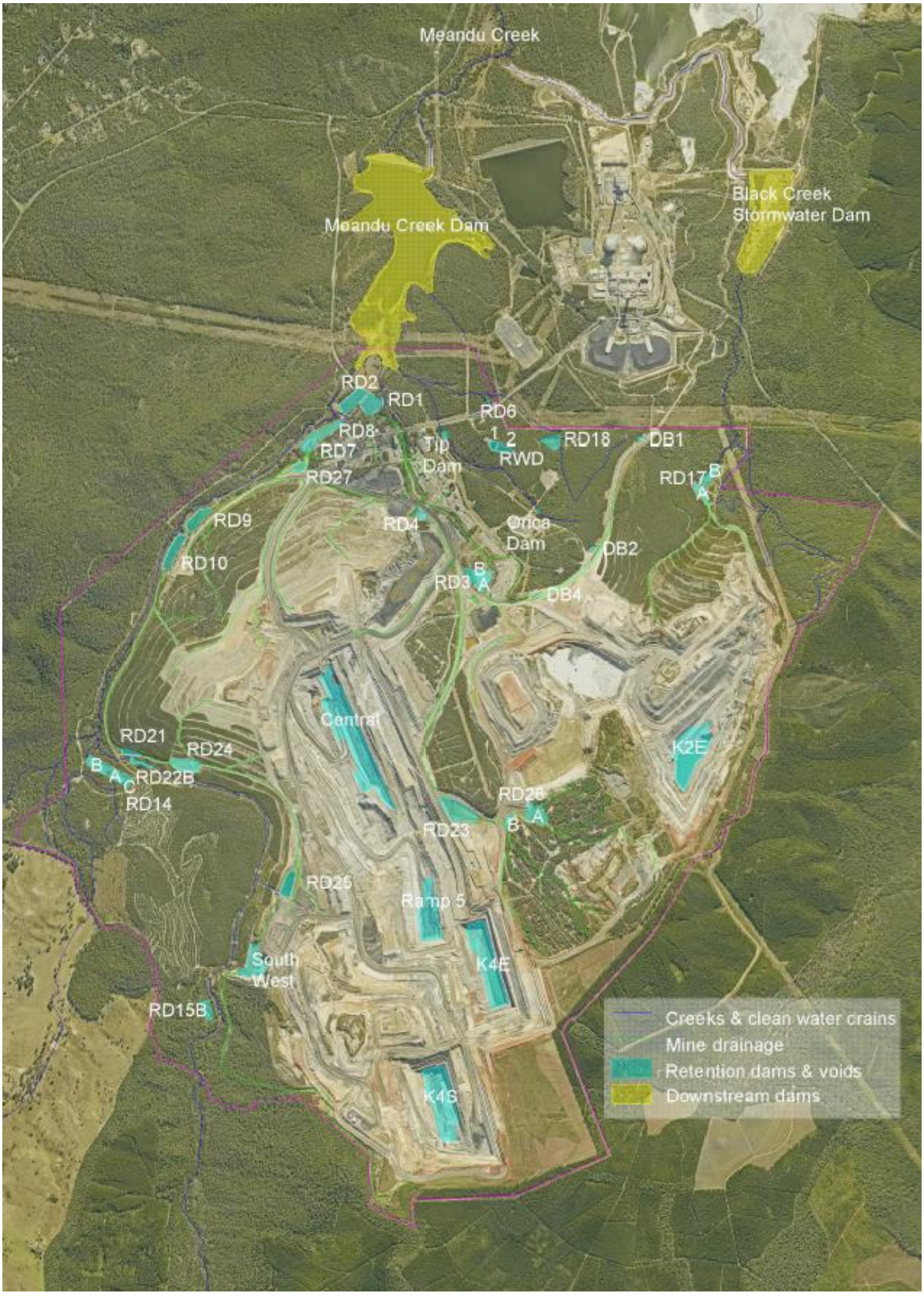


Figure 9: Water Drainage Channels & Retention Dams

4.4.7 Mine Impacted Water Management

During 2015, Acid and Metalliferous Drainage (AMD) had been identified onsite and was expressing as surface seepage from the NW back-filed pit. The AMD can have acid, neutral or mildly alkaline pH and varying concentrations of salts, metals and metalloids.

AMD reports to Ramp 7 along the toe of the NW Dump and to Bullgang Drain at the toe of Hitachi Hill. The seepage is mildly acidic along the toe of the NW Dump and in Bullgang Drain. Both seeps contain salts and some elevated metals.

It is suspected that the source of the seepage is mine impacted water (MIW) that has filled the NW back-filled pit void over the life of mine and that has now reached pre-mining topographic low points.

Short-term engineering works and a series of technical studies were undertaken to evaluate the source, cause and extent and potential environmental impact of the MIW.

Specific measures have been implemented to identify and address potential issues associated with the seepage including:

- Expanding parameters and surface water/ groundwater sites that are sampled, to establish trends and provide early identification of conditions with potential to impact water quality;
- Identifying a single suite of analytes to be analysed at Meandu Mine and TPS on surface and groundwater samples from all monitoring sites to allow modelling in an integrated surface water model;
- Undertaking a groundwater study to:
    - Evaluate and report on existing water levels within Meandu Mine;
    - Review existing monitoring network and identify locations for additional monitoring bores in areas of concern; and
    - Evaluate potential for installing dewatering bores, to dewater MIW from the backfilled pits over the Life of Mine (LOM);
- Undertaking geophysics surveys to investigate the presence of potential seepage pathways across Meandu Mine, including an initial land-based survey and a broader aerial survey;
- Redesigning the final landform in the NW back-filled pit area to improve the capping, drainage and rehabilitation outcomes from previous design options. The revised drainage design for Hitachi Hill maximises surface water runoff;
- Accelerating the program of reshaping and progressively rehabilitating Hitachi Hill in order to reduce infiltration into the NW back-filled pit;
- Undertaking mapping of life of mine rejects and tailings storage locations within Meandu Mine's 3D Digital Terrain Model (DTM) to improve the understanding of potential sources of AMD;
- Production of 3D DTMs of NW back-filled pit to evaluate environmental aspects;
- Sampling and analysis from the surface of a 4.5 ha area of re-profiled rejects on Hitachi Hill, which verified that the samples had neutral pH and low EC;
- Completion of major geochemical characterisation programs;

- Installation of automated water quality monitoring in key storages;
- Commissioning of MIW (lime dosing) treatment at RD7 (since replaced by treatment at RD27 – see below);
- Construction of under-drainage in Hitachi Hill, to contain and direct MIW to RD7 after construction of the Hitachi Hill final landform;
- Construction of RD27 to intercept the MIW seepage from the toe of the NW Reject Dump and in Bullgang Drain for lime treatment of the MIW in RD27 via the construction of a lime dosing plant;
- Following treatment, water is pumped from RD27 to other site dams (e.g. RD26) or directed to site water fill points for re-use.

Consolidated sludge resulting from the lime dosing operation has been recovered during RD7 desilting works in 2018 and placed with MPR in the rejects dump.

Subsequent to the submission of the AMD Environmental Investigation Report (EIR) to DES in September 2018, the following management actions have been or will be implemented during this Plan period in accordance with the recommendations made in the EIR:

- Operation of the NW dewatering bores commencing in CY 2019;
- Continued operation of the lime dosing plant at RD27.
- Treated MIW at RD27 will be directed to water fill points or to RD26.

4.4.8 Creek Diversions

Three creek diversions have been constructed within the Meandu's surface rights area since mining commenced. These works were undertaken as follows:

- 1985-1986: 1.0 km diversion of Meandu Creek through competent material, with RD7 constructed within the original drainage channel;
- 1991-1992: 0.8 km diversion of Meandu Creek through competent material, with RD10 constructed within the original drainage channel;
- 2000-2005: 2.4 km diversion of Meandu Creek through backfilled spoil, which was approved and constructed under Water Licence 102005 (expiry date May 2020) to allow coal mining to occur through the south-west area.

The 1985-1986 and 1991-1992 diversions are currently classified as Infrastructure within the Financial Assurance calculations.

Rehabilitation of the 2000-2005 Meandu Creek diversion has been undertaken according to detailed engineering design and revegetated according to success criteria specified in the EA. These areas have been classified as being rehabilitated for the respective years in which they were seeded.

Sediment dam RD22 was originally constructed at the downstream end of the diversion to provide sediment control during the construction works. It will remain in place until ongoing monitoring shows that the rehabilitated landform is stable and vegetation cover successful.

An application for renewal of Water Licence 102005 will be will be made prior to its expiry during this Plan period.

4.4.9 Groundwater Management

A comprehensive groundwater monitoring bore network currently exists at and around Meandu Mine. This includes bores located at strategic points downstream of mine operations and the ash disposal facility as well as background bores designed to detect any potential impacts further afield. Bores are monitored quarterly by an independent contractor and samples analysed by a NATA-accredited laboratory. An independent annual review of groundwater monitoring data is undertaken to identify any changes and assess potential impacts to the groundwater resource.

The groundwater monitoring network is included in Figure 10. The network includes bores within Ace, King and Queen coal seams, alluvial aquifers on Meandu Creek and Black Creek, and within backfilled pits. Construction and decommissioning of groundwater monitoring bores will be undertaken by licenced water bore drillers.

In accordance with EA conditions D5 and D6 and Tables D1 and D2, the following bores are currently being monitored within the respective aquifers:

Meandu Creek Alluvium	GW39
Coal Measures – King Seam	GW45s, GW46s
Coal Measures – Queen Seam	GW45d, GW46d, GW63d
Coal Seams below Queen Seam	GW01, GW11

A number of groundwater bores are likely to be removed by mining operations over time. If required, these will be replaced in consultation with a RPEQ groundwater expert.

A number of groundwater monitoring bores have been proposed in the vicinity of the K2W-N ash storage to monitor for potential impacts of seepage from the ash storage on surrounding groundwater. These bores will be constructed during this Plan period.

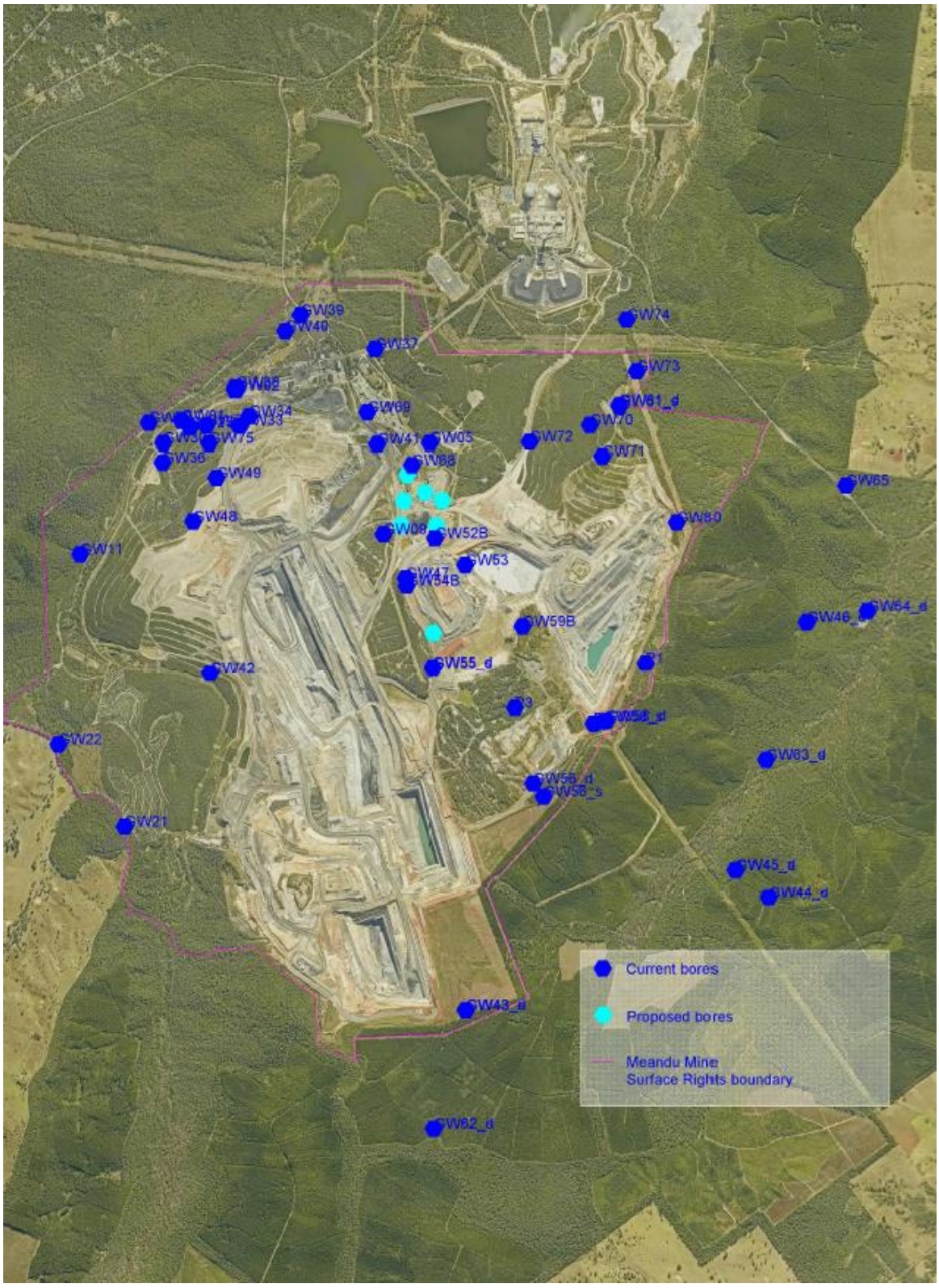


Figure 10: Groundwater Monitoring Network

4.4.10 Sewage Management

A sewage treatment plant (STP) is operated on the Meandu Mine site, consisting of aerated primary and secondary treatment chambers with sludge return and chlorine treatment of effluent from the secondary treatment chamber. Effluent from the plant is piped from the pump-out chamber of the STP directly to the TPS sewage effluent dam. Sludge from the STP is dewatered in drying beds, after which dried sludge is removed as required for burial in the reject dump.

The STP is operated and maintained to ensure the treated sewage effluent is of a quality which is appropriate for reuse at TPS, with regular performance monitoring to ensure plant is operating efficiently. The delivery pipeline is inspected on a regular basis. An overflow pond is located within the STP compound, which has capacity to contain up to 5 days of effluent generation to counter any potential plant breakdown or malfunction.

5. Regulated Dams

A transitional consequence category assessment was conducted and certified for all existing water structures at Meandu Mine prior to this Plan. At that time, the assessment showed that no structures were in the high or significant categories. The certification of the transitional assessment was provided to the administering authority in accordance with Condition (H37) of the EA.

When new structures are designed or where there is a change to the design, purpose or nature of contents stored in an existing structure, re-assessment of the consequence category for that structure will be undertaken and certified by a suitably qualified and experienced person. If identified as a Regulated Structure, the required documentation will be submitted to the administering authority as per Meandu's EA and relevant DES guidelines, and details recorded in the site Regulated Dam Register.

Consequence category assessments have been undertaken for RD25, RD26 and RD27 and it was determined that these dams were in the Low category. A new ash pipeline detention basin (DB4) was completed in 2018. Construction of RD3A&B will be completed during this Plan period. Consequence category assessments undertaken for these dams prior to detailed design determined them to be in the Low category..

Consequence category assessments of the K2W-N Ash Storage 520mRL Embankment Raise and QW Sump were undertaken in CY17 prior to their detailed design, and it was determined that these structures would be in the Significant category. A revised consequence category assessment of the K2W-N Ash Storage 520mRL Embankment Raise was undertaken during CY18 to consider the introduction of tailings into the facility. This assessment showed that no change to the consequence category was required and re-confirmed that the structure is in the Significant category. Relevant controls will be included in the certified design plans for the structures and will be included in the Operational Plans.

The certified design plan for these facilities includes an interim design at the 505mRL embankment level, final design at the 520mRL embankment level and the QW sump, each component of which will be certified as construction is completed. These facilities are planned to be completed and operational during the term of this Plan. They will be managed as Regulated Structures once the storage level in K2N exceeds the 484mRL, below which the consequence category has been assessed as Low.

6. Rehabilitation

The rehabilitation process involves regrading and contouring the spoil to the design slope of final landforms recommended in the EA, followed by vegetation establishment. This is assisted by the strategic use of topsoil, which has been stripped ahead of the overburden removal.

Rehabilitation activities to be undertaken during the term of this Plan of Operations include:

Landform Preparation

Reshaping will be performed by dozers and scrapers to achieve the final landform. Preparation includes shaping the slope to achieve specifications outlined in the EA, contour bank construction and drain shaping. Final landform slopes are generally designed less than 17%, with minor areas up to a maximum of 25% to achieve tie-in with surrounding areas. The average overall slope is generally 14%. Minimum specifications for drainage structures are site-specific and determined through hydrologic and hydraulic assessment. The main objective is landform stability, which may include the removal of drainage structures (e.g. contour banks) at some stage.

Contour banks will be aligned with the contours on either side of the area to ensure correct drainage and are generally 1m high with a back slope of 17%.

Erosion Control

Contour banks slow the water sufficiently to allow for penetration to assist with vegetation growth. The distance between contour banks is outlined in the EA for different slopes and is generally no more than 70m. A fall of approximately 1% will allow for delivery of water from the rehabilitation areas to the drains. Drain specifications are dependent on drain alignment and catchment. If required, drains will be lined with basalt rock (generally +150-500mm), rock sheeting or rock checks as appropriate for the conditions.

Topsoil Placement

Topsoil shall be sourced using direct-placed topsoil removed from cleared areas in advance of mining operations or recovery from existing topsoil stockpiles at Meandu Mine. Topsoil will be spread to a depth of approximately 200mm after landform preparation but as close as possible to ripping/ seeding operations to minimise erosion risk.

Ripping and Seeding

Ripping of the area will be performed post-topsoiling and pre-seeding (or in conjunction with seeding) to aid in erosion control and assist with root and moisture penetration. The furrows that are created will help slow runoff water flow and increase infiltration, in addition to encouraging short term seed germination and long term strong root development. Ripping will occur to a depth range of approximately +300-500mm.

6.1 Rehabilitation Program

During ongoing mining operations spoil dumps will be progressively rehabilitated to meet EA requirements. A total of 58ha of rehabilitation will be undertaken during the two-year term of this Plan. This may include one or more areas across the King 2 East, North-West, Central, West and/or King 4 spoil dumps.

The vegetation established will be primarily native eucalypt-acacia woodland. Meandu Mine is currently investigating the optimum species composition and diversity to achieve long term sustainability.

The topsoil spreading depth is determined based on available topsoil stockpiled on-site and the disturbed area that requires topsoil for rehabilitation to occur. An annual reconciliation of topsoil resources is undertaken as mining progresses and topsoil recovery and usage occurs, during which the spreading depth is reviewed and the Rehabilitation Program updated accordingly. Table 5 summarises the results from the reconciliation conducted in November 2018.

Table 5: Topsoil Reconciliation (November 2018)

Stockpiled topsoil volume	3.50 million m^3
Disturbed area including pits*	1,417 Ha
Disturbed area excluding pits*	1,128 Ha
Coverage at 200mm spreading depth	1,752 Ha

* excludes 'Rehabilitation' and 'Topsoiled' categories

Relevant information regarding rehabilitation activities (e.g. dates, areas, topsoil depth and quality, seed mix) will be kept for quality control and to allow optimisation of rehabilitation methods. The Rehabilitation Program will assist with future planning and with past successes being incorporated into current rehabilitation techniques.

6.1.1 Current Rehabilitation

Rehabilitation areas completed during recent years are summarised in Table 7 and shown on Figure 12.

Rehabilitation monitoring is undertaken every 2 years by external contractors. The most recent monitoring was performed in June 2017, with the next round of rehabilitation monitoring scheduled for 2019.

During the term of this Plan, remedial works will continue in the SW rehabilitation areas to improve species diversity.

SCL is currently investigating alternate rehabilitation completion criteria. It would appear that the criteria listed in EA EPML00709113 Schedule G Table 2 "Species composition and acceptance criteria" were developed for rehabilitation at a point in time (e.g. 5 years of age) and should not have been applied to all rehabilitation areas regardless of age.

SCL is considering the use of BioCondition benchmarks for regional ecosystem (RE) condition assessment, Southeast Queensland as the basis for developing completion criteria. The data and process required for the development of benchmarks is described in Eyre et.al (2011b). The development of a benchmark for the Meandu mine rehabilitation is described in Neldner and Ngugi (2012), and provided below. The species and structure of the Meandu benchmark (representing a self-sustaining Eucalypt woodland) was based on the surrounding native vegetation types (three Res: 12.9-10.7, 12.9-10.18 and 12.11.7), while not being specific to any particular RE. As a result, the benchmark was defined by the average structure and species composition of the amalgam of the three locally common regional ecosystems.

Table 6: Benchmark for Meandu Mine Rehabilitation

Benchmark Item	Score
Recruitment of dominant canopy species (%)	100%
Native plant species richness:	
Tree:	*7*
Shrub:	*11*
Grass:	*9*
Forbs and other:	*11*
Tree canopy median height (m):	20.6
Tree canopy cover (%):	36
Tree sub-canopy median height (m):	10
Tree sub-canopy cover (%):	12
Large eucalypt tree dbh threshold (cm):	47
Number of large eucalypt trees per hectare:	51
Large non-eucalypt tree dbh threshold (cm):	Not specified
Number of large non-eucalypt trees per hectare:	Not specified
Typical tree species: *Eucalyptus crebra, Angophora leiocarpa, E. tereticornis, E. longirostrata, Corymbia intermedia*	
Native shrub cover (%):	16
Typical shrub species: *Acacia blakei, A. leiocalyx, Jacksonia scoparia, A. disparrima* subsp*. disparrima, Dodonaea triangularis, Alphitonia excelsa, Cassinia laevis*	
Ground cover (%):	
Native perennial grass cover (%):	*21*
Organic litter cover (%):	*57*
Typical ground cover species: *Cymbopogon refractus, Cyanthillium cinereum, Cheilanthes sieberi, Aristida gracilipes, Desmodium rhytidophyllum, Glycine tabacina, Themeda triandra*	
Non-native plant cover (%):	0
Eyre, T.J., Kelly, A.L., and Nelder, V.J. (2011). Method for the Establishment and Survey of Reference Sites for BioCondition. Version 2.0. Department of	

Benchmark Item	Score
Environment and Resource management (DERM)< Biodiversity and Ecological Sciences Unit, Brisbane. Neldner, V.J. and Ngugi, M.R. (2012), Assessment of BioCondition scores for three to twenty year old regeneration at Meandu Mine, Southeast Queensland. Queensland Herbarium, Department of Science, Information Technology, Innovation, and the Arts, Brisbane.	

Rehabilitation Completion Criteria, subject to administering authority approval, may then look like:

- achieve >50% of a native ecosystem canopy cover,
- >70% of median height,
- with a mix of 5 tree and shrub species present in canopy.

6.1.2 Rehabilitation Trials

The Meandu Mine EA allows for alternative rehabilitation criteria to that specified in Schedule G Table 1, as agreed between Stanwell and the administering authority. Stanwell is currently conducting research into alternative final land uses as part of its mine closure planning, including the potential for mine spoil to support the establishment of Pongamia plantations and the productivity of commercial hardwood timber species. Rehabilitation trials are being implemented according to Plans developed for each trial, which include details on objectives, design methodology and monitoring.

A 3-year research program commenced in 2013, to investigate the potential for mine spoil to support the establishment of Pongamia plantations. The seeds from the Pongamia tree have potential as a feedstock for biofuel production. Two sites totalling 1.6 ha have been established, including sites on re-contoured mine spoil and a control site on cleared land with a “natural” soil profile. The trial period was completed in 2016. These trials plots are still in place and further assessments may be undertaken during this Plan period.

Commercial hardwood timber trial plots totalling 2.3 ha were established in 2013, on profiled mine spoil in K2E. The trial will compare and evaluate the effectiveness of different techniques, including planting of commercial tree seedlings, and direct seeding and thinning to optimum density.

Maintenance and monitoring of hardwood timber trial sites will continue during the term of this Plan.

SCL plans to investigate alternate final land uses during this Plan period, including pasture establishment, grazing and the feasibility of hoop pine establishment on rehabilitated mine spoil.

6.1.3 Final Landform Design

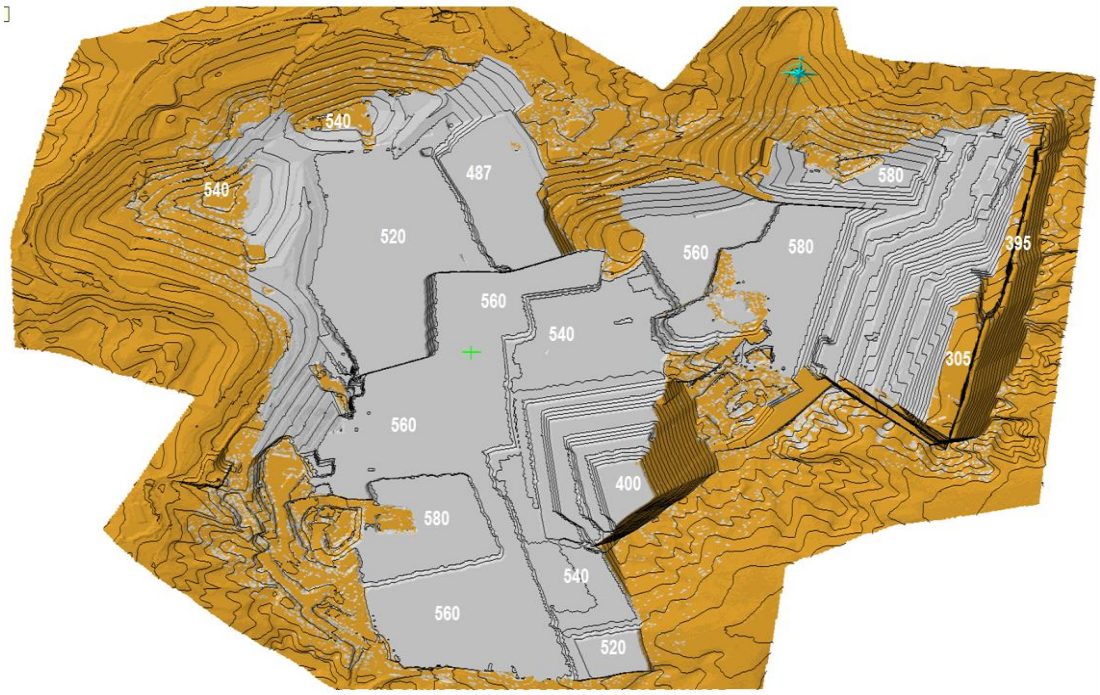
SCL took ownership of Meandu Mine in February 2008. Prior to this point RTCA planned to close the mine in December 2010. SCL plans to extend the life of Meandu Mine with the current mine plan showing closure in 2037.

A revised Life of Mine (LOM) Plan for Meandu Mine was approved in October 2013, which provided preliminary dump and final landform designs. These designs have been

optimised to improve the final landform and dump surfaces and include options for the continued deposition of ash from TPS into storage facilities at Meandu Mine.

During the 2017-208 period the LOM Plan was significantly updated and included detailed landform and drainage design. The updated indicative final landform design is shown in Figure 11.

The final landform designs will continue to be refined as mine plans are optimised and environmental and final void investigations progress.



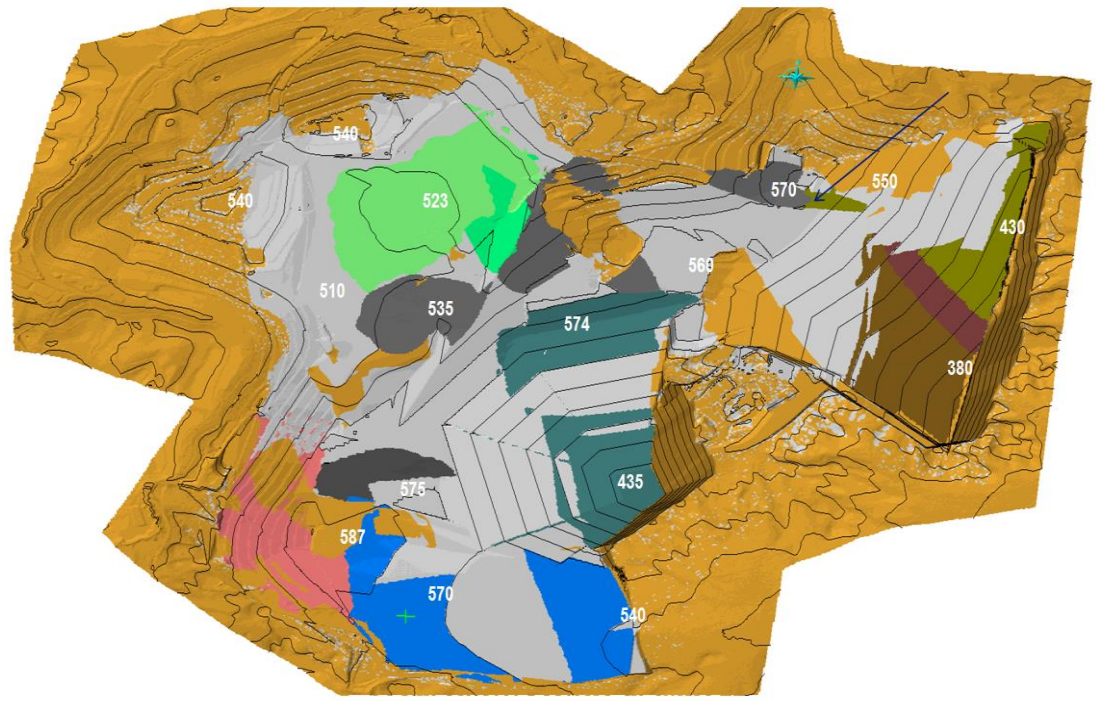


Figure 11: Meandu Mine – As Dumped and Final Landform from 2018 Feasibility Study

6.1.4 Residual Voids

Final landform planning has identified final voids as the Post Mining Land Use (PMLU) as per the *Mineral and Energy Resources (Financial Provisioning) Act 2018* for the final mining pits at K2E and K4E. These voids will be partially backfilled as there is insufficient material available at the end of mine life to backfill them completely. The final land use for these voids will be water storages. The low wall spoil surface will be profiled into the void at slopes specified for spoil areas, with permanent access (roads) designed into the landform to allow future access to the water body that may accumulate in them. It is expected that the water quality will be suitable for wildlife habitat, stock water or to irrigate plantation areas that may form the final land use on adjacent level areas of the final landform.

6.1.5 Total Disturbance Summary

The disturbance categories described in **Table 7** have been used in the calculations for Financial Assurance for Meandu Mine.

Table 7: Disturbance Categories

Disturbance Category		Description
Undisturbed		Area(s) with the Surface Rights Area (SRA) of ML6674 that have not been disturbed by mining related activities.
Cleared		An area that has been cleared of trees and shrubs and not further disturbed for mining activities, including areas that have been culturally surveyed and not stripped of topsoil.
Powerlink		Cleared area(s) associated with the Powerlink easement.
Stripped topsoil		An area on natural ground that has been cleared and stripped of topsoil.
Active Pits		An area of open pit in natural ground including ramps. Excludes areas within pit catchments that consist of spoil placement. Includes final/residual voids at the end of mine life that may not be completely backfilled and suitable as a water storage.
Overburden & Spoil	Expit	Spoil dumps that have been formed outside of the current mined void boundary, with an existing or future requirement for further spoil placement.
	Inpit	Spoil dumps that have been formed within the footprint of the current mined void, with an existing or future requirement for further spoil placement. Includes pit low walls and previously rehabilitated areas that are being re-excavated.
	Rejects	Areas of previously backfilled pits or ramps that are currently used for rejects disposal areas. These areas will be covered with a minimum 6m of spoil material to form the final landform.
Tailings		An area that is covered or will potentially be filled/covered by tailings/ash.
Infrastructure		Areas of land disturbed for haul roads, hardstand areas, buildings, drains, water bores, easements, transmission lines, coal stockpile areas and retention dams. Costs associated with decommissioning mine infrastructure (i.e. CHPP, workshops, ROM, offices and buildings) are included as a lump sum amount based on third party quote from Liberty. Includes contaminated land investigation and remediation.
Rehabilitation	Recontoured	An area of land that has been contoured to final grade ready for placement of topsoil. Areas of acidic or saline material that require encapsulation or covering with inert material have not be included in this category. Includes previously rehabilitated areas that have been cleared and stripped in advance of the active pit.
	Topsoiled but not seeded	An area of land that is currently undergoing rehabilitation and has been recontoured with a sufficient depth of topsoil placed on it. Includes topsoil stockpiles formed on land of final grade, and previously rehabilitated areas that have been cleared but not stripped in advance of the active pit.
	Seeded	An area of land that has been ripped and seeded, regardless of whether seeding has been successful. Includes Rehabilitation Trial areas.
	< 3 years	An area of land that has been re-contoured, topsoiled, ripped and seeded and vegetation has successfully established. Rehabilitation less than 3 years old that may still require some maintenance works (e.g. erosion repairs), excluding it from the established rehabilitated category.
	Established	Rehabilitation areas older than 3 years that should no longer require maintenance works and only require monitoring and pest management activities to be undertaken.
Exploration rehabilitation		Costs associated with removal of borehole casing and rehabilitation of exploration drill sites on the mining lease but outside the Surface Rights area.

Table 8 provides the planned change in area for each disturbance category during the term of the Plan of Operations.

Figure 12,

Figure 13 and Figure 14 provide a comparison of disturbance areas at January 2019, January 2020 and at the end of the Plan period, December 2020. Disturbance areas are determined from the combination of aerial survey dated 22/09/2018 and reconciliation based on survey pick-up and mine planning up to 1/01/2019, 31/12/2019 and 31/12/2020, respectively.

Table 8: Schedule of Disturbance

Description	Jan-2019 Actual	Dec-2019 Projected	Dec-2020 Projected	Projection Comments
Total Lease Area	4267.0	4267.0	4267.0	
A = Total Surface Rights Area (A=B+C+D)	2636.5	2636.5	2636.5	
B = Undisturbed	483.7	454.5	454.5	Clearing in advance of K4E-Central-Ramp 5 pits and for K4S rehabilitation works.
C = Cleared	167.6	105.2	105.2	K4E-K4S pit progress into cleared areas. Includes Powerlink easement.
D = Total area of significant disturbance	1985.6	2077.1	2077.2	
Stripped topsoil	0.0	32.9	33.3	Topsoil is stripped immediately prior to other disturbance.
Active pit	289.8	306.7	302.8	Advancement and re-alignment of Central-Ramp 5-K4E pits and advancement of K4S pit.
Waste rock - expit	92.7	98.0	86.3	Variation through plan period with K4S rehab works.
Waste rock - inpit	479.3	522.3	469.3	Variation through plan period with progress of rehab works in K2W and K4S.
Rejects	43.1	34.5	34.4	MPR cells progressively covered and moved with dump progression.
Tailings	86.8	86.3	86.2	K2W-N ash storage facility and NWB & RD16 tailings storage facilities.
Infrastructure	351.6	330.3	311.4	Decrease due to pit progression.
Recontoured	0.0	11.2	82.1	Includes established rehab areas cleared for re-mining. Increase due to scheduled rehab works and clearing in advance of Central pit.
Topsoiled	82.3	77.4	76.9	Includes topsoil stockpiles.
Seeded	3.9	3.9	3.9	Includes rehabilitation trial areas.
Rehabilitation – Yr 0	24.5	38.0	19.8	Refers to rehabilitation completed within 1 year prior to the

Description	Jan-2019 Actual	Dec-2019 Projected	Dec-2020 Projected	Projection Comments
				corresponding date.
Rehabilitation – Yr 1	46.0	24.5	38.0	Refers to rehabilitation completed within 2 years prior to the corresponding date.
Rehabilitation – Yr 2	37.4	46.0	24.5	Refers to rehabilitation completed within 3 years prior to the corresponding date.
Established rehabilitation	447.7	464.7	507.7	King 1 and QW rehab cleared for Central pit progression.
Exploration rehabilitation	0.4	0.4	0.4	Each borehole site covers approximately 0.04 ha.

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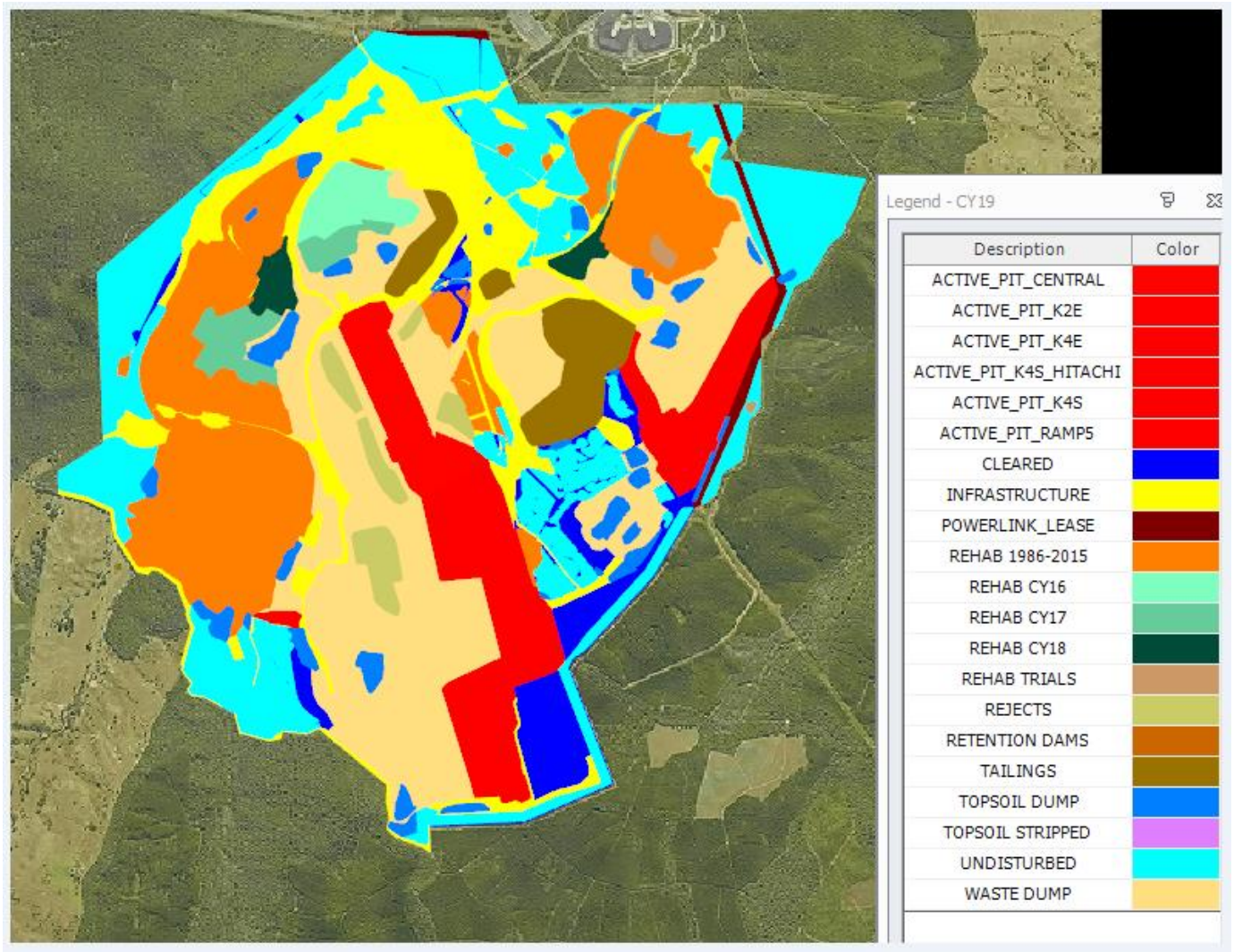

Figure 12: **Meandu Mine Disturbance Areas at January 2019**

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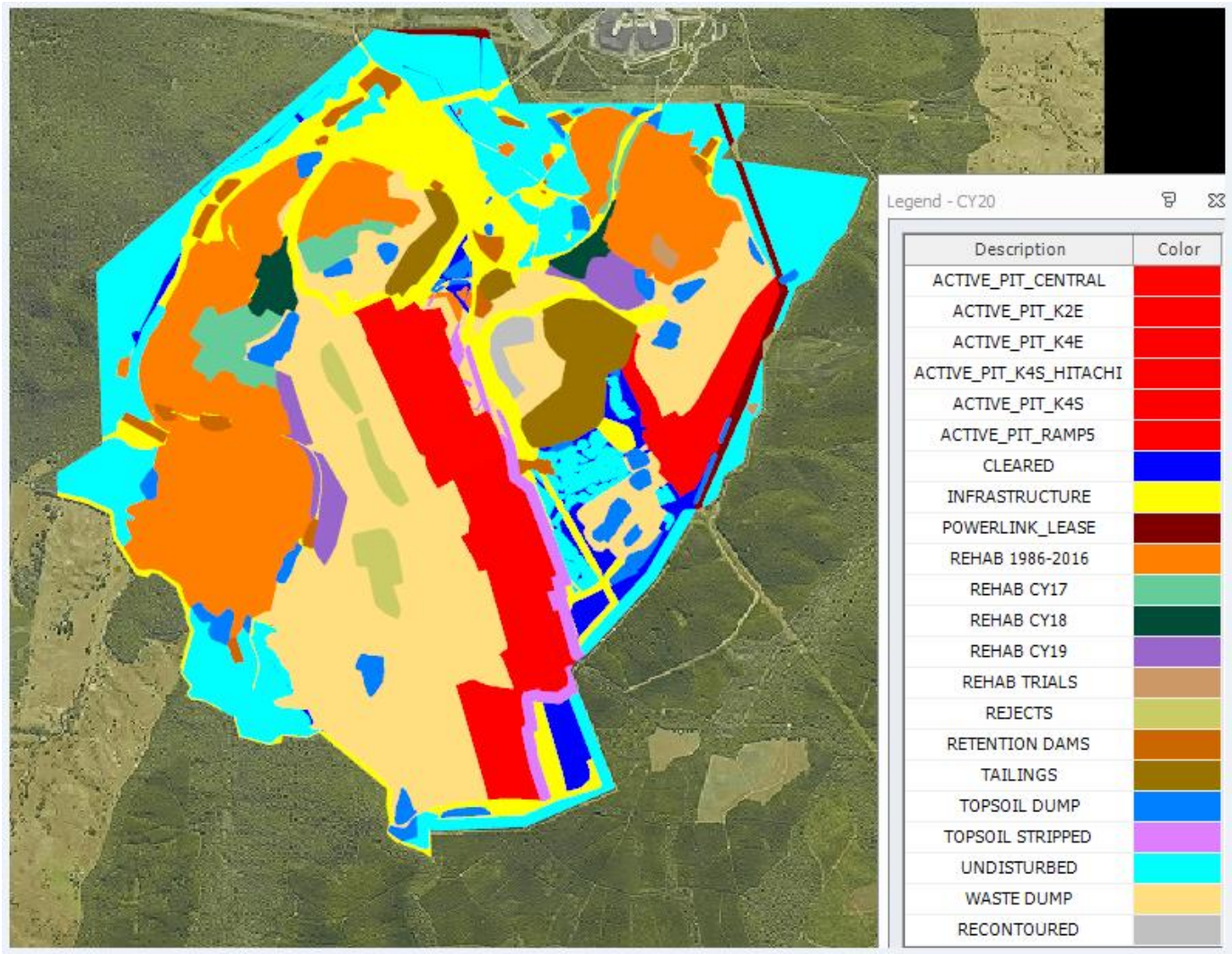

Figure 13: Meandu Mine Disturbance Areas at December 2019

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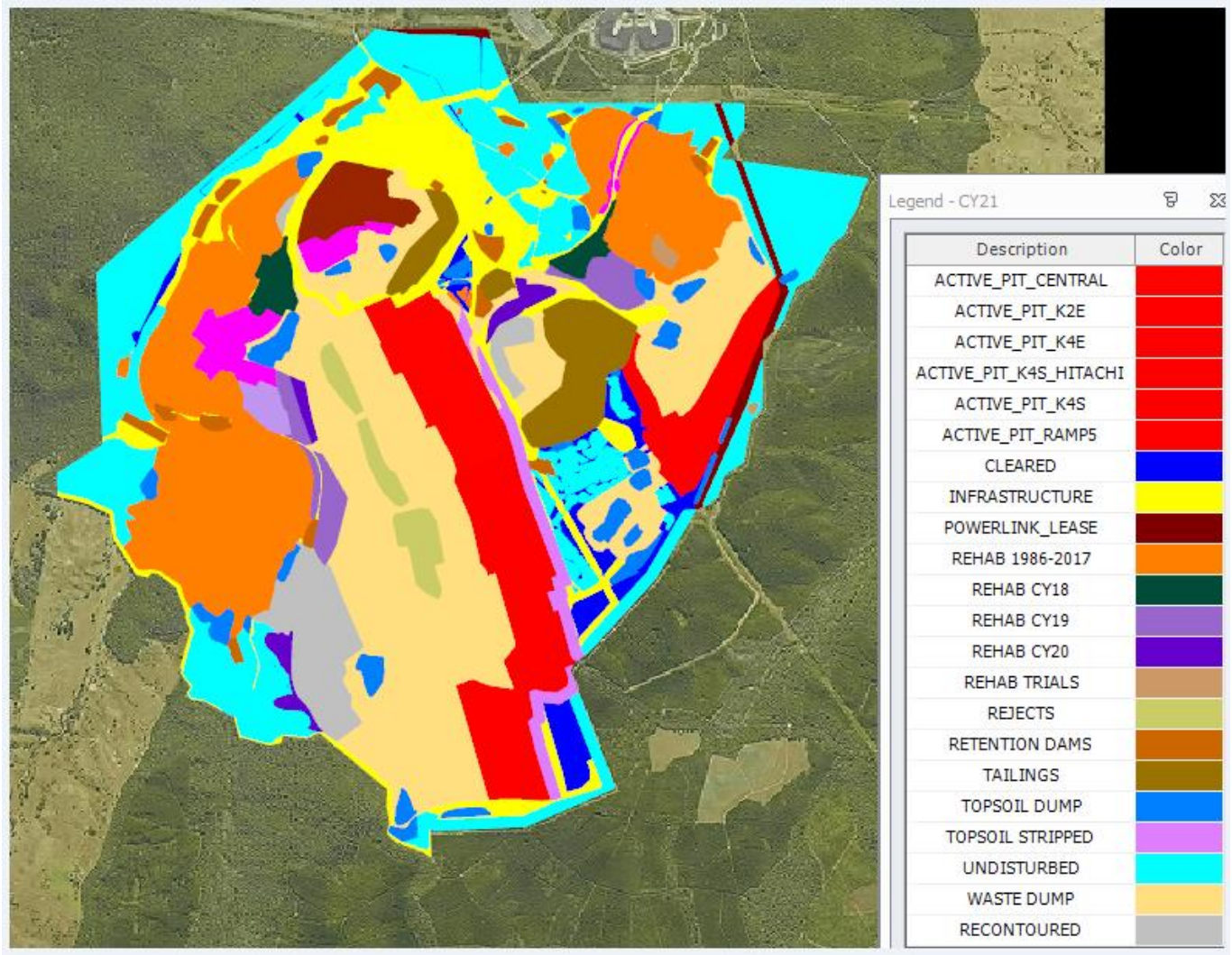

Figure 14: Meandu Mine Disturbance Areas at December 2020

6.2 Rehabilitation Costs

Meandu Mine rehabilitation costs have been calculated for January 2019 (start of the Plan period), December 2019 and December 2020 (end of the Plan period) using ESR/2015/1824 *Mining financial assurance calculator* V 3.00, according to instructions in ESR/2015/1823 *User Guide – Mining and petroleum and gas financial assurance calculators* (refer to ***Attachment 1: Meandu Mine Financial Assurance Calculator January 2019, Attachment 2: Meandu Mine Financial Assurance Calculator December 2019*** and ***Attachment 3: Meandu Mine Financial Assurance Calculator December 2020***). Accordingly, the following statement is included as required under the Terms and Conditions for use of the Calculator:

> *Rehabilitation costs in Table 9 have been derived with a software tool used with the permission of the State of Queensland, URS Australia Pty Ltd and Windaf Pty Ltd trading as GSS Environmental. Neither the State of Queensland, URS Australia Pty Ltd or Windaf Pty Ltd trading as GSS Environmental has evaluated the manner of use of the software tool nor the validity of the original data treated by the software tool and therefore give no warranty as to its accuracy, completeness, currency or suitability for any particular purpose.*

Rehabilitation costs are calculated based on requirements to achieve the final landform specified in Meandu's EA, and include bulk re-shaping of voids and dumps, topsoil placement, revegetation and specialised drainage works. Material quantities and disturbance areas have been determined as at June 2019 and entered into the Calculator.

Calculations assume actual site rates based on first principles (including overheads and contractor's margin) for material moved by truck and excavator and dozer push, and no use of the dragline. ***Attachment 4: Meandu Mine Rehabilitation Cost Rate Confirmation - Downer EDI Mining*** contains a statement from Meandu Mine operator Downer EDI Mining, confirming currency of the rates used in the Calculators. The alternate rates provided are indicative of wet hire rates, and include equipment ownership costs, mobilisation and demobilisation, labour, contractor's margin/ overheads and fuel costs.

Dump batters and pit low wall slopes are designed to achieve an overall slope of approximately 14%. This profile provides a 17% slope between contour banks and rock drains, with minor areas up to the maximum allowable grade of 25% to achieve tie-in with surrounding landform. Inpit dumps are formed within the footprint of the mined void, while expit dumps have been formed outside the footprint of the mined void.

Pit highwalls are to be left in a stable condition. It has been assumed that competent rock material will remain at 37° (the natural angle of repose), the upper weathered strata in K4E is battered to 28°, weaker materials such as upper weathered strata in K4S have been battered to 25° and highwall drainage installed where required to minimise erosion potential.

Costs associated with decommissioning infrastructure have been estimated based on an independent study by Liberty Industrial (refer ***Attachment 5: Meandu Mine Demolition Report).*** The report presents a worse case scenario as some of the infrastructure may not be decommissioned depending on the proposed Post Mining Land Use (PMLU) for these infrastructure areas. TEC intends to retain the majority of retention dams as clean water structures post-mining. Certain other infrastructure may be retained (powerlines, sheds and slabs, pumping infrastructure, access roads, etc), bores may be retained, all to support the proposed PMLU and management of this infrastructure will be consistent with the general rehabilitation goals (i.e. safe, stable, non-polluting and able to sustain the PMLU.

Contaminated land remediation costs (if required) have been included in the Infrastructure domain costs using rates in the Calculator. Costs for preparation of site investigation reports and rehabilitation plans are detailed in ***Attachment 6: Cost estimates for closure studies v5 (Part 1)*** and included as a lump sum amount in the Calculator.

The 1985-1986 and 1991-1992 Meandu Creek diversions are assumed to be compromised water courses and have been allocated the corresponding default rehabilitation costs. Water treatment costs are included to treat seepage water expressing from the toe of NW dump. Provision has been made to perform major remediation on the existing rehabilitation in the NW area using default unit rates. The actual extent of the works (if any) will be determined from environmental monitoring of the area that is being undertaken.

Rehabilitation trial areas have been included in the “Seeded” disturbance category. This accounts for the possibility that supplementary seeding may need to occur to ensure rehabilitation meets the native ecosystem success criteria in the EA, should trials be unsuccessful.

Default rates for general maintenance of established rehabilitation areas (including weed and pest management, re-seeding, amelioration and minor repair) have been applied to all existing rehabilitation areas.

Rehabilitation of exploration borehole sites is undertaken as per Stanwell procedure *ASM-MINE-STD-05 Mining operations rehabilitation of drill sites*, which meets or exceeds the departmental standard as required.

Table 9 provides the rehabilitation liability summary from the financial Assurance calculator.

Table 9: Rehabilitation Costs

Domain	Rehabilitation Liability Jan-2019	Rehabilitation Liability Jan-2020	Rehabilitation Liability Dec-2020
Domain 1: Infrastructure	$14,738,242	$13,913,799	$14,336,397
Domain 2: Tailings Storage Facilities (1)	$2,532,569	$2,557,850	$2,529,784
Domain 2: Tailings Storage Facilities (2)	$10,268,931	$10,268,931	$10,268,931
Domain 2: Tailings Storage Facilities (3)	$827,442	$827,442	$827,442
Domain 3: Overburden & Waste Dumps (1)	$18,479,655	$19,429,890	$19,112,025
Domain 3: Overburden & Waste Dumps (2)	$65,240,281	$60,831,092	$63,672,724
Domain 3: Overburden & Waste Dumps (3)	$34,751,198	$29,493,236	$29,493,236
Domain 4: Water Management	$7,798,630	$7,798,630	$7,798,630
Domain 5: Pits (1)	$2,896,182	$3,284,828	$3,164,792
Domain 5: Pits (2)	$3,972,294	$4,149.986	$4,763,369
Domain 5: Pits (3)	$2,492,082	$2,499,572	$2,499,572
Domain 6: Other Management Issues	$2,805,140	$3,271,785	$3,699,614
Subtotal	**$166,802,645**	**$158,327,041**	**$162,166,515**
Contingencies			
Project Management (10%)	$16,680,265	$15,832,704	$16,216,652
Environmental Maintenance and Monitoring (5%)	$8,340,132	$7,916,352	$8,108,326
Subtotal	**$25,020,397**	**$23,749,056**	**$24,324,977**
Total Rehabilitation Liability (excl. GST)	**$191,823,042**	**$182,076,098**	**$186,491,492**

6.3 Financial Assurance

The financial assurance has been calculated using the year in which maximum liability is incurred. Thus, the required financial assurance is the total rehabilitation liability calculated for January 2019 (being the maximum assessed amount within the plan period) as shown in Table 10.

Table 10: Financial Assurance Summary

Description	Amount
Maximum FA during the Plan Period (January 2019)	$191,823,042
Available Discounts claimed: 20% (financial standing and tailings management strategies)	-$38,364,608
Net FA required for Plan period	$153,458,434
Current FA in place	$170,585,730
Additional FA required	**-$17,127,296**

TEC Coal is eligible for the selected discount on account of:

- Financial Standing
  - Stanwell Corporation Limited (including its subsidiary TEC Coal Pty Ltd) is audited annually as required by accounting standards, by the Queensland Audit Office (refer ***Attachment 7: Stanwell Annual Report* 2016/17)**
  - A declaration from TEC Coal (EM1266) confirming financial standing and adequate rehabilitation budget provision has been completed and is submitted with this Plan (refer ***Attachment 8: TEC Coal Financial Discount Declaration EM1266***)
- Waste Management
  - TEC Coal has commissioned solid bowl centrifuges at the CHPP to dewater tailings, that allows them to be co-mingled with coarse rejects and hauled to designated areas within spoil dumps
  - This initiative has reduced the quantity of tailings being pumped to the tailings storage facilities by at least 40%.

TEC Coal has elected to take a conservative position and maintain the existing financial assurance bond of $170,585,730 rather than seek its return and replacement with a new financial assurance bond for the lower amount of $153,458,434.

This Plan of Operations has been audited by an independent third-party auditor. This involved an evaluation of the site's environmental performance over the previous Plan period and assessment of the current Plan to ensure it complies with EA conditions and other regulatory requirements. The Compliance Statement is included as ***Attachment 9: TEC Coal Plan of Operations Compliance Statement***.

7. Actions

Appendix A: Action Program states how the site will comply with the conditions of the Environmental Authority during the term of this Plan. The structure of the action plan follows the sequence of schedules and conditions in the EA, listing the relevant control strategies and actions which will be undertaken during the term of this Plan. **Appendix B** refers to the monitoring activities to be undertaken during the course of this Plan to comply with the EA.

8. Revision History

Rev. No.	Rev. Date	Revision Description	Author	Reviewer	Approval
0	24/10/2013	Initial issue	S Jensen	R Baldock	D Brooks
-	31/10/2013	Reference to SCL and Downer document numbers			
1.0	28/05/2015	FY16 issue	S Jensen	D Brooks	J Orbell
1.1	20/08/2015	FY16 submission 2	S Jensen	J Orbell	S Ewart
2.0	1/06/2016	FY17-FY18 issue	S Jensen	M Clarke	D Franklin
2.1	30/05/2017	FY17-FY18 amendment	S Jensen	G Walsh	J Orbell
3.0	1/03/2018	April 2018 to June 2019	S Jensen	J Orbell	D Redman
4.0	14/12/2018	January 2019 to December 2020	S Jensen	P Veivers	J Orbell

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9. Appendices

9.1 Appendix A: Action Program

Condition	Legal Obligation	Control Strategy	Actions
Schedule A - General			
Scope of Approval			
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.	Mining operations will be conducted in accordance with conditions of the Environmental Authority EPML00709113, *Environmental Protection Act 1994* and relevant environmental legislation.	Mining operations will be conducted in accordance with this plan of operations and EA conditions.
A2	In carrying out the mining activity authorised by this environmental authority, the holder of this environmental authority must comply with **Appendix 1 – Authorised disturbance areas** of this environmental authority.	Mining operations will only be conducted in authorised disturbance areas as per Appendix 1 of the EA. This plan of operations has been prepared in accordance with the requirements of this condition.	Mining operations will be conducted in accordance with this plan of operations and EA conditions.
A3	This environmental authority authorises the extraction of no more than **11.0 million tonnes** of run of mine (ROM) coal per annum.	No more than 11 million tonnes of run of mine (ROM) coal will be extracted annually.	During the period of this Plan of operations, the planned extraction quantity of ROM Coal will be less than 11 Mtpa.
Financial Assurance			
A4	The activity must not be carried out until the environmental authority holder has given financial assurance to the administering authority as security for compliance with this environmental authority and any costs or expenses, or likely costs or expenses, mentioned in section 298 of the *Environmental Protection Act 1994*.	Submit the financial assurance in the amount and form required by the administering authority.	The amount of financial assurance has been calculated based on the DEHP Guideline **ESR-2015-1758 Financial assurance under the Environmental Protection Act 1994,** Schedule of Rehabilitation in this plan of operations as shown in **Table 8**. The amount will be submitted in an acceptable form when requested by the administering authority.
A5	The amount of financial assurance must be reviewed by the holder of this environmental authority when a plan of operations is amended or replaced or the authority is amended.	The financial assurance will be reviewed in association with any amendments to this plan of operations or amendments to the Environmental Authority.	This replacement Plan of Operations includes a review of the financial assurance required as included in **Attachment 1**, **Attachment 2** and **Attachment 3.**
Risk Management			
A6	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.	The site implements a risk management system which is consistent with the content of ISO31000:2009 and encompasses environmental risk management. Risk management principles are integrated into the Environmental Management System (EMS), and Health and Safety Management System (HSMS) which is consistent with OHSAS 18000:2007 and AS/NZS 4801:2001.	Continue operation of risk management system which is consistent with the content of ISO 31000:2009. Maintain EMS and HSMS during the term of this plan.
Notification of Emergencies, Incidents and Exceptions			
A7	The holder of this environmental authority must notify the administering authority by written notification **within twenty-four (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.	Notify the administering authority within 24 hours of becoming aware of an emergency or incident that results in the release of a contaminant that is not accordance or reasonably expected to be in accordance with the conditions of the Environmental Authority.	Notify the administering authority of emergencies and incidents that result in the release of contaminants not authorised under the Environmental Authority, within the required timeframe. All notifiable environmental incidents and emergencies will be recorded in the site's incident reporting system (INX) and managed in accordance with the site incident reporting and investigation procedure.
A8	Within **ten (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.	Investigate all incidents or emergencies and provide written advice and the information stipulated in this condition to the administering authority within either 10 business days of the incident or emergency or the receipt of monitoring results.	Administering authority will be provided with written advice regarding the investigation of an emergency or incident within 10 business days of the initial notification. All notifiable environmental incidents and emergencies will be recorded in the site's incident reporting system (INX) and managed in accordance with the site incident reporting and investigation procedure.
Complaints			
A9	The holder of this environmental authority must record all environmental complaints received about the mining activities including: i) name, address and contact number for of the complainant; ii) time and date of complaint; iii) reasons for the complaint; iv) investigations undertaken;	All environmental complaints and associated investigation details will be recorded in the sites complaints register and incident management system (INX).	All complaints will be investigated and management strategies implemented to address legitimate complaints.

Condition	Legal Obligation	Control Strategy	Actions
	v) conclusions formed; vi) actions taken to resolve the complaint; vii) any abatement measures implemented; and viii) the person responsible for resolving the complaint.		
A10	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 **ten (10) business days** of completion of the investigation, or no later than **ten (10) business days** after the end of the timeframe nominated by the administering authority to undertake the investigation.	Conduct relevant monitoring within a reasonable and practicable timeframe nominated by the administering authority to investigate a complaint.	Respond within a reasonable timeframe nominated by the administering authority to investigate a compliant of environmental harm.
Monitoring			
A11	Except where specified otherwise in another condition of this environmental authority, all monitoring records or reports required by this environmental authority must be kept for a period of not less than **five (5) years**.	Record all monitoring results and records required under EA conditions and retain records for a minimum of 5 years. Maintain monitoring data in the site's Environmental Data Management System (EDMS), Plant Information Management System (PIMS) or Central Filing System (CFS).	All environmental monitoring results will be recorded and kept as per the site document control and records system. Specific data relating to the EA will be recorded and stored within the EDMS, PIMS or CFS for a minimum of 5 years.
A12	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 (2) 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 condition **H34**, the time specified in that condition; or 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.	Ensure that changes to relevant standards, policies or guidelines relating to mining operations are identified and management strategies implemented to manage the relevant change. Legal updates are monitored and provided to relevant site personnel by Stanwell Corporate.	Review relevant site management documentation to reflect the legislative changes.
Drilling Outside the Surface Rights Area			
A13	The environmental authority holder may drill up to **eight (8)** exploratory bores outside of the surface rights area of ML6674, within Category B Environmentally Sensitive Areas located on the south-western corner of this tenement.	The number of exploration bores to be drilled outside of the surface rights area of ML6674 within Category B Environmentally Sensitive Areas located on the south-western corner of the tenement, will be restricted to eight (8) bores.	Six (6) exploration bores have been drilled within Category B Environmentally Sensitive Areas on the south-western corner of the tenement to date. No Exploration drilling is planned to occur in this area during the period of this plan of operations.
A14	The environmental authority holder is authorised to conduct exploration drilling and geophysical surveys within Yarraman State Forest to the east of the current surface rights of mining ML6674, within the area highlighted as “Approved Exploration Area” in **Appendix 1 – Authorised disturbance areas**, attached to this environmental authority.	Exploration drilling will occur within areas identified as "Approved Exploration Area" in Appendix 1 of the EA.	No exploration drilling is currently planned to occur within ML6674 to east of current surface rights area during the period of this plan of operations, within the "Approved Exploration Area" in Appendix 1 of the EA. However, this may change during the course of this Plan period.

Condition	Legal Obligation	Control Strategy	Actions
A15	Exploration activities authorised by conditions **A13** and **A14** must be conducted in accordance with all standard environmental conditions contained in the Code of Environmental Compliance for Exploration and Mineral Development Projects, with the exception of condition 13, which is replaced by the following: *The holder of this environmental authority must not carry out activities in a category A Environmentally Sensitive Area. Activities involving machinery must not be carried out within 1km of a category A Environmentally Sensitive Area.* *Exploration activities may be conducted on pre-existing roads, tracks, or cleared areas within Category B Environmentally Sensitive Areas provided that any associated disturbance (including that caused by access to and preparation of drill sites) is confined to these pre-existing tracks, roads or cleared areas, and that no native vegetation is removed or disturbed by the activities.*	Exploration activities outside the surface rights area shall be conducted in accordance with the *Code of Environmental Compliance for Exploration and Mineral Development Projects.*	Undertake all exploration activities within the "Approved Exploration Area" in accordance with the *Code of Environmental Compliance for Exploration and Mineral Development Project*s and revised wording for condition 13, as included in the EA. Any drilling within Category B areas will be restricted to pre-existing forestry tracks within this area, with no disturbance to native vegetation. Outside of Category A or B areas, drilling will occur within plantation timber areas as agreed with the plantation licence holder, HQ Plantations.
Waste Management			
A16	The holder of this environmental authority may burn vegetation cleared in the course of carrying out extraction activities provided the activity does not cause environmental nuisance or harm at any sensitive place or commercial place.	Site procedures are maintained under the Project Management Plan that includes controls to minimise impacts from land disturbance activities (including burning of cleared vegetation). Fire permits are obtained prior to burning of cleared vegetation.	Burning will only be undertaken when suitable weather conditions prevail. Permit to Light Fire will be obtained for all burns. Burns will be conducted in accordance with the conditions of the permit.
A17	Tailings must be managed in accordance with procedures contained within the current plan of operations. These procedures must include provisions for:		
	a) containment of tailings;	Solid bowl centrifuges have been installed at the CHPP to dewater coal tailings to allow fine rejects to be co-mingled with coarse rejects. Existing or additional tailings storage facilities will be used to provide contingency tailings storage during periods of bypass.	Solid bowl centrifuges have been installed at the CHPP to dewater tailings to allow co-mingling and disposal with coarse rejects. The resultant mixed plant rejects (MPR) will be hauled to nominated rejects dumps. The NWB-TSF and/or RD16-TSF will be used to provide contingency tailings storage durring periods when bypass of the centrifuges is required. Contingency tailings disposal into the K2W-N ash storage will commence during this plan period. Tailing deposition in NWB-TSF will cease prior to the end of 2019. Tailings deposition to RD16-TSF may continue beyond 2019. Investigations into and optimisation of tailings/ rejects storage methodology will continue.
	b) the management of seepage and leachates both during operation and the foreseeable future;	Investigations into potential for seepage from tailings storage facilities will be conducted (including modelling where appropriate), should conditions change or new storage facilities be considered for tailings disposal. A surface and groundwater bore monitoring program will be conducted to identify potential acid mine drainage (AMD). Groundwater and surface water monitoring will be conducted for early identification of potential seepage and leachate issues. Investigations will be triggered and actions implemented if monitoring identifies seepage/ leachate is occurring. Catchment areas reporting to tailings storage areas will be minimised. Once decommissioned, the landform over tailings deposition areas will be designed and profiled to shed rather than pond water on the rehab surface.	The site Water Management System is designed to prevent contaminants from being released to any groundwater or watercourse, in the event that hazardous leachate is generated. The ground and surface water monitoring program (designed by a appropriately qualified person) will continue during the term of this Plan, which monitors surface water and groundwater quality (including AMD parameters) at selected locations. Investigations will be undertaken if seepage(s) were identified, recommendations from which will be used as a basis for future actions. The AMD Environmental Evaluation was finalised and the Environmental Investigation Report was submitted to the administering authority in September 2018. At the time of submission of this Plan of Operations, additional information requested by the Administering Authority is being collected by TEC. The landform above the decommissioned NWA tailings storage area has been designed and constructed to allow surface runoff to be removed from the area. The seepage potential of the RD16-TSF has been assessed as Low consequence by an independent suitably qualified person. The QW sump has been constructed to intercept seepage from the K2W-N ash storage. Ongoing analysis of dewatered tailings, rejects and spoil material will be undertaken to determine leachate potential and optimise disposal/ dumping strategy.

Condition	Legal Obligation	Control Strategy	Actions
	c) the control of fugitive emissions to air;	Tailings were previously deposited as thickened slurry. Pipehead flocculation has occurred in NWB-TSF and RD16-TSF to increase in-situ density of the tailings and assist with tailings drying and return water recovery, resulting in beaching of the tailings above water level. The pipehead flocculation assisted with coagulation of fine particles and significantly reduces fugitive emissions to air. Once tailings deposition in each TSF has ceased and sufficient drying and consolidation has occurred, a minimum 6m capping layer will be installed and the area rehabilitated as per requirements in Schedule G.	Secondary pipehead flocculation of tailings has resulted in tailings beaching in some areas above water level. While tailings are damp during active deposition, limited potential exists for contact between tailings and air. Once the deposited tailings have dried, it is expected that the secondary flocculation will reduce risk of dust and fugitive emissions to air. Solid bowl centrifuges are now operational and tailings are being disposed of with coarse rejects, fugitive emissions will be managed by utilising dust control measures in place for dumps. Contingency tailings disposal will continue to occur when the solid bowl centrifuges are off line or not able to process 100% of the tailings stream. If operating parameters change, a risk assessment will be undertaken to consider the impacts and address potential issues.
	d) a program of progressive sampling and characterisation to identify acid producing potential and metal concentrations of tailings;	Mine material characterisation investigations have been undertaken in 2007 and 2016 that indicate tailings at Meandu Mine are typically non-acid forming but have potential to leach sulphate and some metals. Tailings samples will be collected each week by CHPP, composited each month and sent to ALS for geochemical assessment. Samples of tailings slurry, dewatered tailings, rejects and spoil material will be analysed to determine leachate potential and improve disposal/ dumping strategy. Water quality and water level in tailings voids and surrounding water within backfilled voids will be monitored.	Mine material characterisation investigations have been undertaken in 2007 and 2016, which indicate tailings at Meandu Mine are typically non-acid forming. Sampling and analysis of dewatered tailings, rejects and spoil material will be undertaken to determine leachate potential and improve disposal/ dumping strategy.
	e) maintaining records of the relative locations of any other waste stored within the tailings;	Consolidated sludge produced as a result of operating the lime dosing plant in RD7, RD27 or other dams may be stored with the tailings or with mixed plant rejects (MPR). Records of this or any other waste disposed of with tailings will be maintained.	The locations and quantities of consolidated sludge from the lime dosing plants at RD7 and RD27 that are either stored with the tailings or with mixed plant rejects (MPR) will be recorded.
	f) rehabilitation strategies; and	Once the final landform of the current tailings areas are achieved after capping with at least 6m of overburden material, the areas will be topsoiled, ripped and seeded as per requirements in Schedule G. Similar rehabilitation methods will be used for future rejects storage areas, including those with co-mingled coarse and fine rejects material. Investigations into co-mingled material properties will continue to optimise rehabilitation strategies.	Decommissioning and rehabilitation of the NWB-TSF and RD16-TSF is planned to commence during the period of this plan of operations. A decommissioning and rehabilitation plan has been developed for NWB-TSF and will be developed for R16-TSF during this Plan period. Following the planned cessation of tailings in NWB-TSF by the end of 2019, rehabilitation of this TSF will commence with a period of dessication and consolidation. Development of a rehabilitation strategy for co-mingled rejects material will progress during this Plan period, incorporating results from the material characterisation program.
	g) monitoring of rehabilitation, research and/or trials to verify the requirements and methods for decommissioning and final rehabilitation of tailings, including the prevention and management of acid mine drainage, erosion minimisation and establishment of vegetation cover.	Rehabilitation success will be monitored as part of the site's periodic rehab monitoring program, and remediation works scheduled if required. Tailings supernatant water and groundwater surrounding the TSF will be monitored as part of the site's monitoring program. Placement methodology and performance of the landform above NWA-TSF will be assessed and learnings incorporated into the decommissioning and rehabilitation plan for NWB-TSF.	Treatment of the tailings while it was being deposited (secondary flocculation) was implemented in NWB-TSF and RD16-TSF to increase structural integrity of the tailings material and reduce potential for deformation during capping. Tailings supernatant water and groundwater surrounding the NWB void will be monitored as part of the site's monitoring program. The landform above NWA-TSF (in particular drainage structures) will be monitored to determine whether settling or consolidation has occurred. During the period of dessication and consolidation at NWB-TSF during the latter part of the Plan period, it is likely that a number of penetration and shear strength tests will be undertaken on the insitu tailings surface material to determine when the first layer of capping can commence.
Schedule B - Air			
Dust Nuisance			

Condition	Legal Obligation	Control Strategy	Actions
B1	Subject to conditions **B2** and **B3** of this environmental authority, the release of dust or particulate matter or both resulting from the mining activity must not cause an environmental nuisance, at any sensitive place.	The site's progressive rehabilitation program will provide significant benefits in reducing dust generation by establishing a dense vegetation cover in what would otherwise be elevated, exposed mine spoil subject to windage effect. Limit the speed of all traffic on the mine site to 60km/h. Water active haul roads and other unsealed roads during peak usage times. Minimise dust and particulate matter released from the mining activities by: a) watering of unsealed roads, b) dust suppression sprays, c) avoidance of topsoil stripping and spreading during windy conditions.	The dust management program will be maintained during the term of the Plan of Operations to ensure that the mining activities do not cause an environmental nuisance. Where required, air quality sampling will be conducted in accordance with AS 3580 and the site dust monitoring procedure. Operation of dust suppression sprays at the K2W-N ash void. A temporary suppression layer will be maintained over the ash in King 2 West pit until contingency tailings deposition into a cell on top of this layer occurs.
B2	When requested by the administering authority, dust and particulate monitoring must be undertaken within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of the authorised officer) of environmental nuisance at any sensitive place, and the results must be notified within **fourteen (14) days** to the administering authority following completion of monitoring.	Investigate any legitimate incident of dust complaint and examine means to resolve the issue with the complainant. Maintain a complaints register.	Respond within a reasonable timeframe, nominated by the administering authority, to complaints with a dust monitoring program. The monitoring point(s) will be located as close as practicable to the location of the complainant. All complaints will be recorded in the sites complaint register and managed via the sites incident management system (INX).
B3	If the environmental authority holder can provide evidence through monitoring that the following limits are not being exceeded then the holder is not in breach of condition **B1**: a) dust deposition of 120 milligrams per square metre per day (measured as total insoluble solids), averaged over one month, when monitored in accordance with the most recent version of *AS 3580.10.1 Methods for sampling and analysis of ambient air - Determination of particulates - Deposited matter - Gravimetric method*; and b) a concentration of particulate matter with an aerodynamic diameter of less than 10 micrometre (µm) (PM_{10}) suspended in the atmosphere of 150 micrograms per cubic metre over a 24 hour averaging time, at a sensitive place downwind of the operational land, when monitored in accordance with: i) Particulate matter - Determination of suspended particulate PM_{10} high-volume sampler with size-selective inlet - Gravimetric method, when monitored in accordance with *AS 3580.9.6 Methods for sampling and analysis of ambient air - Determination of suspended particulate matter - PM (sub) 10 high volume sampler with size-selective inlet - Gravimetric method*; or ii) Any alternative method of sampling PM_{10}, which may be permitted by the 'Air Quality Sampling Manual' as published by the administering authority. *NOTE: The environmental authority holder must propose which monitoring method is appropriate in accordance with condition B3 a) or B3 b), or both.*	Undertaken monitoring program in response to compliant.	Report results of monitoring program to the administering authority
B4	If monitoring indicates exceedance of the relevant limits in condition **B3** of this environmental authority, then the environmental authority holder must: a) address the complaint including the use of appropriate dispute resolution if required; or b) immediately implement dust abatement measures so that emissions of dust from the activity do not result in further environmental nuisance.	Investigate any legitimate incident of dust complaint and examine means to resolve the issue with the complainant. A complaints register will be maintained and contain information on the nature of the complaint, the identity of the Complainant and any actions taken by the Mine to resolve the issue with the Complainant.	Dust abatement measures have been installed and any complaints handled expeditiously. If relevant monitoring indicates exceedances of conditions in B3, additional dust abatement measures will be developed and implemented within a reasonable timeframe in consultation with the administering authority.
Schedule C - Water			
Contaminant Release			

Condition	Legal Obligation	Control Strategy	Actions
C1	Except as authorised by condition **C5** of this authority, there must be no release of contaminants to waters.	Meandu Mine has maintained a comprehensive water quality monitoring program that has been continuous from the outset of mine development.	Design areas of new mining disturbance within the approved surface area of the mining lease so that stormwater contaminated by mining activities is directed to, and managed in accordance with, the Meandu Mine Drainage System, to achieve compliance with Condition C5. The existing drainage system will be maintained and upgraded as required.
Stormwater Management			
C2	With the exception of stormwater collected within the King 2 West Void, all areas within the approved surface area of the mining lease must be designed so that any stormwater contaminated by mining activities is directed to, and managed in accordance with, the Meandu Mine Drainage System and Monitoring Network, to achieve compliance with condition **C5**.	A mine water management system was installed from the outset of mining. The system is modified as required to accommodate planned mine progression and rehabilitation. This is recorded in the Meandu Mine Drainage System map that is reviewed annually and incorporated within the Plan of Operations and the Water Management Plan.	Design all areas of new mining disturbance within the approved surface area of the mining lease so that any stormwater contaminated by mining activities is directed to, and managed in accordance with, the Meandu Mine Drainage System, to achieve compliance with Condition C5.
C3	Suitable banks and / or diversion drains must be installed and maintained to prevent stormwater runoff from entering the King 2 West Void and coming into contact with ash. All banks or bunds that are relied upon for the integrity of King 2 West Void shall be designed to an accepted engineering standard.	The mine water management system has been modified to accommodate the King 2 West-North (K2W-N) Ash Void and prevent stormwater runoff from entering the void. Banks and bunds constructed as part of the water management around the K2W-N void shall be assessed as required.	Banks and diversion drains required to prevent stormwater runoff from entering the K2W-N void will be designed and constructed to accepted engineering standards and maintained during the term of this plan of operations.
C4	A suitable stormwater and leachate collection system must be installed and maintained within the King 2 West Void to enable excess liquid to be removed from the void as required to ensure compliance with the conditions of this environmental authority.	A stormwater and leachate collection system will be maintained within the K2W-N void, to allow excess liquid to be removed from the void. This will consist of pumping from the supernatant pond in K2W-N and/or from the QW seepage collection sump.	A suitable stormwater and leachate collection system will be maintained in and surrounding the K2W-N void during the term of this Plan of Operations. Any changes to the collection system will be assessed and certified by a suitably qualified person and operation of the system recorded in the K2W-N Operations Plan. Supernatant water will be recovered from the K2W-N facility and pumped back to TPS or re-used at Meandu, depending on water quality and suitability for reuse. Water collected in the QW sump will either be pumped to the supernatant pond in K2W-N for return to the TPS ash dam, or to the mine drainage system (depending on water quality).
Release to Waters			
C5	Receiving waters affected by the release of process water or stormwater contaminated by the mining activities or both must be monitored at the locations and frequencies defined in **Table C1 - Water monitoring locations and frequency** and **Appendix 2 - Meandu Mine Drainage System and Monitoring Network** and comply with the contaminant limits defined in **Table C2** - **Water contaminant limits.**	Meandu Mine has maintained a comprehensive water quality monitoring program from the outset of mine development. The site records water quality values at compliance points using an in-stream probe, logging and automated telemetry system. Real time readout of water quality parameters is recorded on a daily basis. In this way water quality is recorded and available for inspection on request by the administering authority. The system allows the site to respond to changing conditions in a timely fashion. An additional automated monitoring system has been installed to monitor water quality in key storages that report to compliance point CP3.	Receiving waters will be monitored at the locations and frequencies in Schedule C - Table C1 to demonstrate compliance with the contaminant limits in Schedule C - Table C2, as detailed in the environmental monitoring program in this Plan of Operations. Monitoring will comply with requirements in the DES Monitoring and Sampling Manual. Water quality and release quantity at compliance points will be measured daily using data collected from the automated monitoring network, except for periods of short duration where maintenance or repair of monitoring equipment is being undertaken. Water quality in key storages reporting to CP3 will be monitored, to allow internal water transfers to occur and preventative action to be taken to maintain compliance with condition C5. The pump-back system from RD17B to RD1 will be maintained, and activated, if required, to maintain compliance at CP2.
C6	End of pipe release limits for process water and stormwater contaminated by mining activities must be monitored at the locations and frequencies defined in **Table C3 - End of pipe monitoring locations and frequency** and **Appendix 2 - Meandu Mine Drainage System and Monitoring Network** and comply with contaminant limits defined in **Table C4 - End of pipe release limits.**	Meandu Mine has maintained a comprehensive water quality monitoring program that includes monitoring for oil and grease at RD2. Water quality is recorded and available for inspection on request by the administering authority. RD1 captures runoff generated in and around the industrial area, including equipment workshops, large hardstand areas and the coal preparation plant. The workshop and wash-down areas are serviced by an oil capture and separation system, which ensures oil spills cannot enter the site drainage system. A floating boom is in place on the spillway of RD1 before it reaches RD2 to capture any oil and grease.	RD2 will be monitored at the spillway for oil and grease on a quarterly basis to demonstrate compliance with Schedule C – Table C4. A permanent floating oil boom will be maintained across the spillway of RD1. If a hydrocarbon spill were to occur upstream of RD1, this boom will reduce surface oils from escaping into RD2 and possibly being released into Meandu Creek. Emergency spill response equipment is maintained in close proximity to RD1 and RD2 and will be implemented in the event of a spill. The oily water separation system at the heavy vehicle washbay will be monitored and maintained to ensure optimal efficiency and reduce the risk of contaminated water being released to RD1.

Condition	Legal Obligation	Control Strategy	Actions
C7	All reasonable and practicable erosion protection measures and sediment control measures must be implemented and maintained to minimise the release of sediment from the surface area of the mining lease.	A mine water management system was installed from the outset of mining. The system is modified as required to accommodate planned new mining and rehabilitation areas. Erosion protection and sediment control measures will be implemented and maintained to minimise sediment release from the surface area, including regular desilting of sediment dams. The site is served by several identifiable and separate drainage systems, comprising more than 20 retention dams, some of which are fitted with manually operated release valves. The western boundary of the surface rights area contains a dirty water drain separate from Meandu Creek, which reports to RD2 via a series of sediment dams before being released from site. Progressive rehabilitation is undertaken to reduce erosion and sedimentation of these areas.	All run-off water from disturbed areas will be intercepted and diverted to retention dams via the Meandu Mine Drainage System. Maintenance will be undertaken on the erosion control structures as required. Retention Dams will be assessed and desilted as required. The volume of sediment removed will be recorded. Progressive rehabilitation works will occur in some or all of the King 2 East, King 2 West, North-West, Central, West and/or King 4 spoil dumps during the period of this Plan. As the mine progresses, additions to the water management system will be made prior to the commencement of mining in the area affected.
Schedule D - Groundwater			
Contaminant Release			
D1	The holder of this environmental authority must not release contaminants to groundwater.	A groundwater monitoring program will be implemented to demonstrate compliance with this condition. Additional groundwater level and groundwater quality bores were installed in 2016 to qualify the potential for the release of contaminants from mined voids to groundwater.	Groundwater monitoring will be conducted in accordance with the monitoring program in this plan of operations and as required by EA conditions. Should any groundwater bores be removed, these will be replaced, if required, in consultation with a RPEQ groundwater consultant.
Monitoring and Reporting			
D2	All determinations of groundwater quality and biological monitoring must be performed by an appropriately qualified person.	Groundwater quality and biological monitoring will be conducted by appropriately qualified person.	Monitoring will be conducted by qualified persons and analysis carried out by an accredited laboratory. These results are analysed annually by a suitably qualified and experienced person and a report prepared on the interpretation of these results.
D3	The holder of the environmental authority must implement a groundwater monitoring program which has been developed by a suitably qualified person. The program must be able to detect a significant change to ground water quality values and standing water levels (consistent with the current suitability of the groundwater for domestic and agricultural use) due to activities that are part of this mining project.	A groundwater monitoring program designed by a suitably qualified and experienced person has been implemented at Meandu, including quarterly monitoring to identify changes to water quality and standing water levels. Results will be analysed annually by a suitably qualified and experience person and a report prepared on the interpretation of these results.	The site groundwater monitoring program which has been designed by a suitably qualified and experience person, will continue during the period of this plan of operations. Monitoring will be conducted by qualified person and analysis carried out by an accredited laboratory. An annual review and assessment of changes to groundwater quality and standing levels will be undertaken.
D4	The holder of the environmental authority must report the results and analysis of groundwater monitoring to the administering authority on request.	Groundwater monitoring results are analysed annually by a suitably qualified and experienced person. Results will be provided to the administering authority upon request.	Monitoring results will be provided to the administering authority within a reasonable timeframe upon request.
D5	Groundwater affected by the mining activities must be monitored at compliance bores within the nominated geologies and minimum frequencies defined in **Table D1 - Groundwater monitoring locations and frequency.**	Groundwater monitoring will be conducted in accordance with Table D1.	Groundwater bores will be monitored at the locations and frequencies required in Table D1. A minimum of one monitoring event per quarter will be undertaken by a qualified person and analysis carried out by an accredited laboratory.
D6	If the groundwater contaminant trigger levels defined in **Table D2 - Groundwater contaminant trigger levels** are exceeded then the environmental authority holder must complete an investigation into the potential for environmental harm and notify the administering authority within **twenty-eight (28) days** of receiving the analysis results. An action plan to mitigate potential harm must be developed by a suitably qualified person.	Complete an investigation into the potential for environmental harm if groundwater contaminant trigger levels are exceeded. Advise administering authority of results within 28 days of receiving the analysis.	Groundwater at the relevant compliance bores listed in table D1 will be sampled for contaminants listed in Table D2. If significant changes in groundwater quality are detected in the annual assessment, an investigation will be undertaken to determine the potential for environmental harm caused by the change. Recommendations within the report will be implemented if determined to be appropriate.
Determining Contaminant Trigger Level			
D7	An annual groundwater report must be submitted to the administering authority with each annual return. The report must include: a) the results and interpretation of the groundwater monitoring program; b) a review of the suitability of the groundwater network; and c) recommendations or improvements to the groundwater network, including whether additional monitoring locations are required.	Undertake quarterly groundwater monitoring ensuring the bores specified on Table D1 are monitored. Engage a suitably qualified groundwater expert to undertake the annual review.	A suitably qualified and experienced groundwater monitoring contractor (currently 4T Consulting) shall undertake the quarterly groundwater monitoring program include the bores listed in Table D1. A suitably qualified groundwater expert (currently John Bradley) shall be engaged to undertake the annual review and complete the annual groundwater report for submission with the Annual Return.
Bore Management			

Condition	Legal Obligation	Control Strategy	Actions
D8	The construction, maintenance and management of groundwater bores (including background and compliance groundwater monitoring bores) must be undertaken in a manner that prevents or minimises impacts to the environment and ensures the integrity of the bores to obtain accurate monitoring. Construction and decommissioning must be in accordance with the “Minimum Construction Standard for Water Bores in Australia”.	A groundwater monitoring bore network will be designed by a suitably qualified person. Construction and decommissioning will be undertaken in accordance with the "Minimum Construction Standard for Water Bores in Australia."	Groundwater monitoring bores will be constructed, maintained and decommissioned according to the required standards. Licenced water bore drillers will be engaged to install new groundwater monitoring bores and decommission any that need to be removed.
D9	Groundwater levels when measured at the monitoring locations specified in **Table D1 - Groundwater monitoring locations and frequency** must not exceed the groundwater level trigger change thresholds specified in **Table D3 - Groundwater level monitoring** below.	Conduct a groundwater monitoring program for bores identified in Table D1 to demonstrate that the groundwater level trigger threshold as identified in Table D3 are not exceeded.	A suitably qualified groundwater expert (currently John Bradley) shall be engaged to review the results of the monitoring program and determine whether any groundwater level trigger change thresholds have been exceeded.
Exceedance Investigation			
D10	If quality characteristics of groundwater from compliance bores identified in **Table D1 - Groundwater monitoring locations and frequency** exceed any of the trigger levels stated in **Table D2 - Groundwater contaminant trigger levels** or exceed any of the groundwater level trigger threshold stated in **Table D3 - Groundwater level monitoring**, the holder of this environmental authority must compare the compliance monitoring bore results to the reference bore results and complete an investigation in accordance with the ANZECC and ARMCANZ 2000.	Where monitoring of groundwater compliance bores listed in Table D1 indicates an exceedance of trigger levels listed in Tables D2 and D3, these results will be compared to the background reference bores and an investigation conducted.	If an exceedance of trigger levels in Tables D2 or D3 were identified, an investigation will be completed as required, in accordance with the ANZECC and ARMCANZ 2000.
Condition	**Legal Obligation**	**Control Strategy**	**Actions**
Schedule E – Noise			
Noise Nuisance			
E1	Notwithstanding any other conditions of this environmental authority, noise from activities must not cause an environmental nuisance at any noise sensitive place or any commercial place.	Noise and vibration from blasting operations is managed by limiting the timing of blasting to Monday to Saturday from 7am to 6pm. All reasonable and practicable measures are taken to avoid blasting on Sundays or public holidays. Surrounding neighbours are notified of blasts 24 hours prior to the blast. This neighbour contact list is held and maintained by the Drill and Blast Engineer. Noise monitoring is carried out periodically in areas surrounding the mine.	All new equipment bought onto site will be tested to ensure compliance with safety regulations for noise levels on equipment of the relevant size. Any new equipment and materials shall comply in design, construction and performance with the current issue of the relevant company and Australian Standards and/or Guidelines. In their absence, they shall comply with relevant International Standards together with the requirements of competent authorities having jurisdiction over all or part of their manufacture, installation and operation. Noise level exposure tests shall be undertaken in respect of both the machine Operator and the Bystander position in accordance with AS 2012.1 and 2012.2. The vibration produced by the normal operation of this equipment is required to comply with statutory duty of care obligations such that an individual’s health is not harmed. Vibration shall be damped via cab isolation mechanisms and a seat suspension system. Noise control strategies such as earth barriers and haul road siting will continue to be utilised. Machinery will be maintained to ensure that exhaust devices remain effective. When bringing new equipment on site, whole-body vibration level exposure tests shall be undertaken in accordance with AS 2670 or ISO 2631.
Noise Nuisance - Mining Operations (other than blasting)			

Condition	Legal Obligation	Control Strategy	Actions
E2	When requested by the administering authority in writing, noise monitoring must be undertaken within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of an authorised officer) of environmental nuisance at any sensitive place, and the results must be notified within **fourteen (14)** days to the administering authority following completion of monitoring. Noise Monitoring must include: a) background noise level; b) LA max, adj, 15 mins or where they can be justified as appropriate, LA 10, adj, 15 mins and LA 1, adj, 15 mins ; c) the level and frequency of occurrence of impulsive or tonal noise; d) atmospheric conditions including wind speed and direction; e) effects due to extraneous factors such as traffic noise; and f) location, date and time of recording.	Conduct noise monitoring within a reasonable and practicable timeframe nominated by the administering authority to investigate a noise complaint at a sensitive place.	Any legitimate noise complaints will be investigated within a reasonable and practicable timeframe or that nominated by the administering authority. A noise monitoring program will be implemented with the monitoring point located closest to the location of the complaint. The monitoring point(s) will target the parameters required and be located as close as practicable to the location of the complainant. Results will be forwarded to the administering authority within 14 days. Complaints will be recorded in the sites complaints register and incident management system (INX).
Nuisance from Vibration and Airblast Overpressure			
E3	Vibration and/or airblast overpressure from the mining activity must not cause an environmental nuisance, at any sensitive place.	Noise and vibration from blasting operations is managed by limiting the timing of blasting to Monday to Saturday from 7am to 6pm. All reasonable and practicable measures are taken to avoid blasting on Sundays or public holidays. Surrounding neighbours are notified of blasts 24 hours prior to the blast. This neighbour contact list is held and maintained by the Drill and Blast Engineer.	Upon request from the administering authority in accordance with condition E5, vibration and/or airblast overpressure monitoring will be undertaken.
Airblast Overpressure and Ground Borne Vibration Nuisance			
E4	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 E1 - Blasting noise limits** to be exceeded at a sensitive place or commercial place.	Noise and vibration from blasting operations is managed by limiting the timing of blasting to Monday to Saturday from 7am to 6pm. All reasonable and practicable measures are taken to avoid blasting on Sundays or public holidays. Surrounding neighbours are notified of blasts 24 hours prior to the blast. This neighbour contact list is held and maintained by the Drill and Blast Engineer. Noise monitoring is carried out periodically in areas surrounding the mine. Vibration and airblast overpressure monitoring is carried out within the boundary of the surface rights area.	Blasting will only be carried out between 7.00am and 6.00pm, Monday to Saturday, where ever practicable, during the term of this Plan.
E5	When requested by the administering authority, vibration and/or airblast overpressure monitoring must be undertaken within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of the authorised officer) of environmental nuisance at any sensitive place, and the results must be notified within **fourteen (14) days** to the administering authority following completion of monitoring.	Conduct vibration and airblast overpressure monitoring within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaints.	Vibration and/or overpressure monitoring will be undertaken within a reasonable timeframe nominated by the administering authority in response to complaints. The monitoring point will be located closest to the location of the complaint. Results will be forwarded to the administering authority within 14 days.
E6	If the environmental authority holder can provide evidence through monitoring that the limits defined in **Table E1 – Blasting noise limits** are not being exceeded then the holder is not in breach of condition **E4.** Monitoring must include: a) location of the blast(s) within the mining area (including which bench level); and b) atmospheric conditions including temperature, relative humidity and wind speed and direction; and location, date and time of recording.	Noise monitoring is carried out periodically in areas surrounding the mine. Vibration and airblast overpressure monitoring is carried out within the boundary of the surface rights area.	Any vibration and/or airblast overpressure monitoring required to investigate a complaint will include measurement of the relevant parameters specified in the EA.
E7	If monitoring indicates exceedance of the relevant limits in **Table E1 – Blasting noise limits** then the environmental authority holder must: a) address the complaint including the use of appropriate dispute resolution if required; or b) immediately implement vibration and/or airblast overpressure abatement measures so that vibration and/or airblast overpressure from the activity does not result in further environmental nuisance.	If monitoring is required in response to a complaint and results exceed the limits specified, Meandu Mine will: • Record details of and investigate complaints, and communicate effectively with complainant or the administering authority (if complaint is received through the administering authority), or • Implement vibration and/or overblast abatement measures for the next blast or a number of blasts (depending on the investigation results) and measure the effectiveness of those measures through the monitoring.	If monitoring in response to a complaint indicates exceedances of the relevant limits in the EA, the appropriate complaint resolution process will be implemented and/or appropriate abatement measures implemented to avoid further environmental nuisance. If required, dispute resolution with the complainant will be utilised.

Condition	Legal Obligation	Control Strategy	Actions
Schedule G - Land			
G1	All areas significantly disturbed by mining activities after **15 November 2002** must be rehabilitated to achieve: a) a landform that is: a. safe to humans and wildlife b. non-polluting c. stable; and d. able to sustain the post-mining land use; and b) where the disturbance type is listed in **Schedule G - Table 1 Final land use and landform criteria**, the final land use description and landform criteria in this table, unless otherwise agreed to between the landowners, any relevant land managers (e.g. Forestry Plantation Queensland) and the administering authority.	Rehabilitation of disturbed land (spoil dumps) will involve re-profiling to meet the following design grade and drainage requirements: • Maximum slope of 17% for general spoil dump rehab; • Slopes greater than 17% but less than 25% are restricted to isolated areas; • Contour banks separated by a maximum of 70 metres; • Overall rehabilitation profiles are typically at grade 15% or less; • Maximum spoil height on site limited to 600mRL to reduce the aesthetic impact on the surrounding landscape. The landform designs of spoil dumps are based on the optimal cut and fill volumes to achieve the desired grades. The pattern of spoil peaks and valleys may be retained to manage runoff and minimise cut and fill activity. Selective handling of material will occur to reduce the potential that material used for rehabilitation contributes to acid or saline drainage. Monitoring of surface water and water in backfilled voids will continue to determine final void water quality and runoff quality from rehabilitated surfaces. Topsoil will be managed to minimise impact to topsoil quality and structure. Newly formed stockpiles will be limited to heights of 5m, to assist with retaining the seed bank and soil structure. Relocated stockpiles may be formed at heights exceeding 3m if necessary, but not more than the height of the original stockpile (up to a maximum of 10m). After re-profiling, topsoil will be respread before seeding with native species to achieve a self-sustaining native bushland post-mining outcome. This process is designed to achieve a landform that is safe to humans and wildlife, non-polluting, stable, absent of active rill and gully erosion, and able to sustain the post-mining land-use. Where the proposed final land use is not included within Table G1, prior agreement will be sought with the administering authority.	Land progressively rehabilitated during the term of this Plan will be assessed against the EA completion criteria. Areas planned to be rehabilitated during the period of this plan include areas within some or all of the King 2 East, King 2 West, North-West, Central, West and/or King 4 spoil dumps. Topsoil will be managed to minimise impact to the resource, including allowable stockpile heights. Topsoil reconciliation will occur annually and spreading depths determined based on available topsoil volumes (spreading depths will be included in the Rehabilitation Program). Rehabilitation areas will be monitored biannually to ensure it is on the right trajectory to achieve the requirements stipulated in the EA. If monitoring determines that erosion is active, remediation works will be scheduled to repair the erosion. Active erosion areas will be regraded sufficiently to allow vegetation cover to stabilise the affected area and/or stabilised with suitable surface protection material. Sediment loads removed from retention dams during maintenance operations will be assessed to assist in determining soil loss from corresponding catchments. Some areas of existing rehabilitation will be disturbed with the extension of the mine life. The development of a Mine Material Management Plan (MMMP) and a Progressive Rehabilitation and Closure Plan (PRCP) will progress during the term of this Plan, as information becomes available from the exploration drilling program and Life of Mine studies. The majority of spoil dump areas will be reshaped to a slope of <17% with maximum erosion control structure spacing of 70 metres. These erosion control structures may be removed once the landform has been assessed as stable. Where possible, basalt material will be segregated as it is mined for use as rip-rap (rock mulch or drainage protection) in rehabilitation areas. An agreement is in place with the administering authority for some rehabilitation trial areas on-site.
G2	Notwithstanding condition **G1** of this environmental authority, spoil areas rehabilitated **prior to 15 November 2002** must be maintained to achieve: a) a self-sustaining native ecosystem; b) a stable landform; and c) absence of active rill and gully erosion.	Spoil areas rehabilitated prior to 15 November 2002 will be monitored and maintained if necessary to ensure they achieve: • a self-sustaining native ecosystem; • a stable landform; and • absence of active rill and gully erosion.	Rehabilitation areas will be monitored biannually (every 2 years) to confirm it is on the right trajectory to achieve these requirements, including areas rehabilitated prior to 2002. If monitoring determines that erosion is active, remediation works will be scheduled to repair the erosion or some areas may be reseeded to improve species density/ diversity. Sediment loads removed from retention dams during maintenance operations will be assessed to determine soil loss from corresponding catchments. Some areas of existing rehabilitation will be disturbed with the extension of the mine life.
G3	The holder of this environmental authority must take all reasonable and practicable measures to minimise the area of land, including spoil areas referred to in **Schedule G - Table 1 Final land use and landform criteria**, with post mined land slopes of greater than 17%.	All reasonable and practicable measures will be taken to minimise the area of land with post-mined slopes >17%. General spoil dump (including pit low wall) rehabilitation design parameters include maximum 17% grade on rehab surfaces, with an average of <15% when including contour banks at 70m spacing. Minor areas (>17% and <25% slope) will be included to tie-in rehab profiles with the surrounding landform. Pit highwalls to remain at end of mine life will be minimised, and geotechnically assessed and made safe prior to relinquishment.	Spoil dumps will be designed at maximum 17% slope. Minor areas will be designed between 17% and 25%, to allow tie-in with the surrounding landform. Pit highwalls to remain at end of mine life will be minimised. High-walls will be re-graded to achieve a stable slope, which will vary depending on material competency.
G4	Progressive rehabilitation must commence within **12 months** of areas becoming available within the operational land.	Rehabilitation progresses according to the mine plan and availability of equipment. The rehabilitation process commences within one year of an area becoming available for rehabilitation (that is, coal resource is mined and the area is no longer required for spoil placement or infrastructure).	As disturbed areas become available for rehabilitation during the term of this Plan of Operations, these areas will be progressively rehabilitated.
Native Ecosystem Outcome			

Condition	Legal Obligation	Control Strategy	Actions
G5	Areas that are to be progressively rehabilitated to a native ecosystem, as required by condition G1 of this environmental authority, must comply with the following outcomes; a) a self-sustaining native ecosystem has been established and species composition and distribution meets the acceptance criteria defined in **Schedule G - Table 2 Species composition and acceptance criteria;** b) all areas disturbed by mining activities must be rehabilitated to the landform design criteria defined in **Schedule G - Table 1 Final land use and landform criteria;** and c) landforms are stable with no visible active rill and gully erosion.	Following re-profiling to design criteria in Table G1 and other earthworks activities (including topsoil spreading), rehab areas will be seeded with species selected to achieve the density/ diversity criteria specified in Table G2. The species seed mix is constantly being reviewed to achieve optimum results; species used include those that have historically performed well at the mine, and new species which improves diversity. Rehabilitation areas will be monitored and if necessary, maintained so that they are stable with no visible active rill and gully erosion.	Land progressively rehabilitated during the term of this Plan will be monitored to determine whether areas are on the right trajectory to satisfy these success criteria. TEC will embank on a process to amend the rehabilitation success criteria in Schedule G Table 2 during this Plan period by way an an EA amendment application. TEC will then seek progressive rehabilitation certification for some rehabilitation areas. Some areas of existing rehabilitation will be disturbed in the future in accordance with the extension of the mine life. Rehabilitation areas will be monitored biannually to confirm it is on the right trajectory to achieve the requirements stipulated in the EA. If required, works will be scheduled to remediate affected areas, including supplement seeding and/ or regrading of active erosion sites to allow vegetation cover to stabilise the affected area.
Residual Void Outcome			
G6	Residual voids must comply with the following outcomes: a) residual voids must not cause any serious environmental harm to land, surface waters or any recognised ground water aquifer, other than the environmental harm constituted by the existence of the residual void itself, and subject to any other condition within this environmental authority	Conditions and potential impacts surrounding proposed residual voids (whether they be open pits or backfilled voids containing tailings, ash, rejects or spoil) will be assessed to avoid any serious environmental harm to land, surface waters or any recognised ground water aquifer, other than the environmental harm constituted by the existence of the residual void itself.	It has been identified from LOM planning that final voids will be established for mining pits K2E and K4E, the post-mining land use for which will be water storage. No residual voids will be created during the term of this plan. Where voids are to be left as water storages at the end of mine life and where geotechnical stability is evident, remaining high-walls will be protected from inflow with a diversion bank where required (1:100 design) topped with large rocks to reduce vehicular access. The site will undertake earthworks to ensure highwall geotechnical stability is achieved. This may involve selective highwall blasting or backfilling to reduce grade to angle of repose, battering weaker tertiary materials to a lower grade and/or partial backfilling of the void to reduce highwall elevation. The crest of each pit will be assessed and battered down between 10m-20m using a dozer fleet to prevent crest failure. The crest area of each pit will be stripped of topsoil and earth works completed to reduce the water flow into the pit void. After drainage is installed the area will have topsoil applied, ripped and seeded and a 2m bund installed. Ramps leading into the voids may be retained for monitoring purposes, access to the water resource and safe exit of void in emergency, and/or treated as per the low-wall.
G7	Twelve months prior to the establishment of a final void on the mining lease the holder of this environmental authority must complete an investigation into the residual void and submit a report to the administering authority proposing acceptance criteria, including: a) proposed landform design criteria for the competent and incompetent slopes; b) the proposed surface area of the void; and c) proposals to meet the requirements of condition **G6.**	An investigation will be completed which addresses the required aspects of the residual void and a report submitted to the administering authority, 12 months prior to the establishment of a final void	No residual voids will be created during the term of this Plan. LOM planning options inclusive of final void evaluation will be evaluated throughout 2019 and 2020. A final LOM final void plan will be produced and included within the Progressive Rehabilitation and Closure Plan (PRCP).
Tailings Deposition Areas			
G8	When the deposition of tailings to an area ceases, the holder of this environmental authority must install a final cover system to the tailings dam which effectively minimises: a) infiltration of water into the tailings deposition area; and b) the likelihood of any erosion occurring to the final cover system.	Following decommissioning of each tailings storage facility, the landform over tailings deposition areas will be designed and profiled to increase surface runoff and minimise ponding, to reduce potential for infiltration. Capping will have a depth of at least 6m of suitable material. The need for a soil cover system that effectively minimises infiltration of water into the tailings is dependent on the geochemical and hydraulic properties of the tailings and the material that contains the tailings. Once the final landform of the current tailings pit is achieved, the area will be topsoiled, ripped and seeded as per the EA requirements. Similar rehabilitation methods will be used for future tailings storages.	Tailings disposal into the NWB-TSF will cease by the end of 2019. Decommissioning of this TSF will commence with a period of desiccation (drying out) prior to commencement of capping. The landform above the decommissioned NWA-TSF has been designed to remove runoff and minimise ponding, to reduce infiltration into the underlying tailings. Potential for erosion will be reduced through installation of rock-lined rehab drains, designing drains and contour banks at appropriate grades, staged cover construction to increase consolidation of the landform before final rehab, and selecting suitable rehabilitation material. Capping material has been selected to meet specifications for rehabilitation and included in the NWB-TSF Decommissioning and Rehabilitation Plan.
Acid Rock Drainage Management			

Condition	Legal Obligation	Control Strategy	Actions
G9	All reasonable and practicable measures must be implemented to prevent hazardous leachate being directly or indirectly released or likely to be released as a result of the activity to any ground water or water course.	In 2015 Meandu became aware of the potential for acid or neutral drainage that has the potential to contain salts and metals (collectively referred to as AMD) at site. Material characterisation will continue to identify PAF material and selective handling implemented to reduce risk of AMD being produced. A surface and groundwater bore monitoring program will be conducted to identify potential acid mine drainage.	Mined materials (ash, tailings, rejects, overburden and interburden and soil) will be characterised and classified into defined material classes. This will be included in the Mine Material Management Plan. A Water Management Plan has been prepared and is regularly reviewed and updated. The site water management system includes pump and pipe infrastructure and the dam and drainage network. The water management system is designed to minimise risk of contaminants from being released to any groundwater or surface water off the ML. Automated monitoring for pH, EC, turbidity and water level was installed in 2015 and will be used to detect elevated contaminant levels in storages and used as triggers to initiate internal water transfers. RD27 has been constructed to collect seepage expressing from the toe of NW dump. A lime dosing plant is operated to treat MIW in RD27. Water is then pumped to RD26, and/or to water fill points. A ground and surface water monitoring program has been implemented which includes quarterly sampling from groundwater bores, selected retention dams and waterbodies along Meandu Creek. Data will be reviewed by a suitably qualified person to determine potential impacts to groundwater or surface water. Details are included in the Water Management Plan.
Rehabilitation of the King 2 West Void			
G10	The Rehabilitation Program for the King 2 West void must include, but may not be limited to: a) details of the proposed post-ash placement land use(s); b) a plan showing the final landform design on cessation of the ash placement trial; c) details of the rehabilitation objectives, success indicators and completion criteria that will be used to achieve the criteria specified in condition **G1;** d) a description of rehabilitation management techniques incorporating works and monitoring programs and timetables; and e) keeping appropriate records or rehabilitation measures to monitor rehabilitation progress and success. *Note: if the proposed final/and use for the King 2 West Void is native ecosystem, the requirements stipulated in condition **G5** will apply.*	The Rehabilitation Program for K2W-N ash void will address the requirements of this condition.	The final landform and rehabilitation plan that is currently proposed for K2W-N ash void following its decommissioning is included in the King 2 West Ash Storage Stage 2 Above Ground Design Plan & Certification. Options for future ash storage in the K2W-N facility beyond the current certified design are currently being assessed and any revised design will include re-evaluation of the Rehabilitation Program for K2W-N ash storage facility. Ash deposition into K2W-N will not cease during the term of this Plan, thus no final rehabilitation will be required in this plan of operations document.
Final Cover			
G11	When deposition of ash into the King 2 West void ceases, the holder of this environmental authority must install a final cover system over the ash.	A minimum 2m cover of inert capping material of sufficiently low permeability will be installed upon cessation of ash deposition in K2W-N void.	Ash deposition will not cease during the term of this Plan, thus no final cover system will be required. A temporary dust suppression layer has been installed over the K2W portion of the K2W-N void.
G12	The final capping system over the ash in the King 2 West void must be at least 2m deep, and must include an upper layer of earthen material that is capable of sustaining plant growth, and be designed and maintained to minimise erosion occurring to either the final capping system or the placed ash.	A minimum 2m cover of inert capping material of sufficiently low permeability will be installed upon cessation of ash deposition in K2W-N void. Topsoil will be spread prior to seeding.	Ash deposition will not cease during the term of this Plan, thus no final cover system will be required.
G13	Materials used in the construction of the capping layer over the ash in the King 2 West void must achieve an in situ permeability with is sufficiently low and / or be sufficient thickness so as to minimise infiltration of water into the landform.	A minimum 2m cover of inert capping material of sufficiently low permeability will be installed upon cessation of ash deposition in K2W-N void.	Ash deposition will not cease during the term of this Plan, thus no final cover system will be required. The temporary dust suppression layer installed over the K2W portion of the K2W-N void has not be assessed against the requirements of this condition, as it will not be the final cover.
G14	Sufficient monitoring of parameters affecting the sustainability of the final capping system (e.g. soil loss) on the King 2 West void must be undertaken to enable the environmental authority holder to demonstrate the sustainability of the final capping system.	Monitoring will occur as required to ensure the final capping layer is sustainable	Ash deposition will not cease during the term of this Plan, thus no final cover system will be required.
Schedule H - Regulated Structures			

Condition	Legal Obligation	Control Strategy	Actions
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) prior to any change in its purpose or the nature of its stored contents.	A suitably qualified and experienced person will be engaged to assess the consequence category of any structure as per the conditions of this EA in accordance with the Manual for *Assessing Consequence Categories and Hydraulic Performance of Structures (EM635),* as required.	New dams or any dams whose purpose or nature of their contents change, will be assessed in accordance with EM635 prior to design and construction by a suitably qualified and experienced person. Consequence category assessments have been conducted for RD21, RD24, RD25, RD26, RD27, RD16-TSF, DB4 (ash pipeline detention basin) and RD3A&B (the replacement dam for RD16), all of which are classified as Low consequence category. The K2W-N 505RL/520RL ash storage facility and QW sump have been assessed prior to detailed design and it was determined that these storages will be in the Significant category once constructed and operated. The K2W-N ash storage facility was subsequently re-assessed to consider storage of tailings and ash within the facility. It was determined that the consenquence catergory would remain as Significant due to this change in the nature of the stored contents in K2W-N facility.
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.	A consequence assessment report and certification will be prepared for each structure assessed.	A consequence assessment reports and certifications have been prepared for RD21, RD24, RD25, RD26, RD27, RD16-TSF, DB4, RD3A&B, K2W-N ash-tailings storage facility and QW sump. Consequence assessment reports and certifications will be prepared for any future structures that are assessed.
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).*	Certification will be obtained from a suitably qualified and experienced person in accordance with the requirements of the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635).*	Certification will be provided by the person who undertook the assessment, in the form set out in EM635.
Design and Construction of a Regulated Structure			
H4	Conditions **H5** to **H9** inclusive do not apply to existing structures. *Note: Construction of a dam includes modification of an existing structure-refer to the definition.*		
H5	All regulated structures must be designed by, and constructed 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).* *Note: Certification of design and construction may be undertaken by different persons.*	Any regulated structures will be designed by and constructed under the supervision of a suitably qualified and experienced person.	The K2W-N ash storage 520RL embankment raise and QW sump (both Regulated Structures) have been designed by and are being constructed under supervision of a suitably qualified and experienced person.
H6	Construction of a regulated structure is prohibited unless: a) the holder has submitted a consequence category assessment report and certification to the administering authority; and b) it 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.	Construction of regulated structures will not commence unless the relevant consequence category assessment report and certification has been submitted to the administering authority.	The consequence assessment report and certification for the K2WN ash storage 505RL/520RL embankment raise and QW sump was submitted to the administering authority 21/12/2017. Consequence assessment reports and certifications will be prepared for any future structures that are planned and submitted as required.
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.	Certification will be provided by the person overseeing the design plan of any regulated structure, in the form required in EM635. Certification will be recorded in the site Regulated Dams/Levees register as required.	Certification will be provided by the person overseeing the design plan of any regulated structure in the form required in EM635. This includes the K2WN ash storage 505RL/520RL embankment raise and QW sump during the period of this Plan. Certification will be recorded in the site Regulated Dams/Levees register as required.
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: a. floodwaters from entering the regulated dam from any watercourse or drainage line; and b. wall failure due to erosion by floodwaters arising from any watercourse or drainage line; and	Regulated structures will be designed and constructed in accordance with EM635 and requirements of the EA	Any regulated structures will be designed by and constructed under the supervision of a suitably qualified and experienced person, in accordance with EM635 and requirements of the EA. Structures will be design and controls implemented with consideration for regulatory requirements.

Condition	Legal Obligation	Control Strategy	Actions
	c) for regulated dams that are dams associated with a failure to contain - seepage: have the floor and sides of the dam designed and constructed to prevent or minimise the passage of the wetting front and any entrained contaminants through either the floor or sides of the dam during the operational life of the dam and for any period of decommissioning and rehabilitation of the dam.		
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; and b) construction of the regulated structure is in accordance with the design plan.	The suitably qualified and experienced person supervising construction of any regulated structure will provide adequate information to enable certification by a suitably qualified and experienced person in the required form upon completion of works, which will be submitted to the administering authority	On completion of construction of each of the K2WN 505RL/520RL ash storage embankment raise and QW sump structures, the suitably qualified and experienced person supervising construction will certify the structures as per requirements. Certification will be submitted to the administering authority.
	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: a. one paper copy and one electronic copy of the design plan and certification of the 'design plan' in accordance with condition **H5** b. a set of 'as constructed' drawings and specifications; c. certification of those 'as constructed drawings and specifications' in accordance with condition **H9;** d. 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; e. the requirements of this authority relating to the construction of the regulated structure have been met; f. the holder has entered the details required under this authority, into a Register of Regulated Structures; and g. there is a current operational plan for the regulated structures.	Prior to operating any new regulated structure, the required documentation will be submitted to the administering authority.	The required documentation will be submitted to administering authority, prior to operating any new regulated structure (including the K2W-N 505RL/520RL ash storage facility above the current approved level of 484RL or the QW sump).
H11	For existing structures that are regulated structures: a) where the existing structure that is a regulated structure is to be managed as part of an integrated containment system for the purpose of sharing the DSA volume across the system, the holder must submit to the administering authority by **2 February 2016** a copy of the certified system design plan including that structure; and b) there must be a current operational plan for the existing structures.	Existing regulated structures will be managed according to a certified design plan (to be submitted to the administering authority by 2 February 2016) and current operations plan.	A transitional consequence category assessment of existing structures has been undertaken, certified and submitted to the administering authority prior to the due date. The assessment concluded that there are no regulated structures on-site at Meandu.
H12	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.	Regulated structures will be managed according to a certified design plan, certified "as constructed" drawings and the current operations plan.	Once they become regulated, the K2W-N 505RL/520RL ash storage facility and QW sump will be managed according to a certified design plan, certified "as constructed" drawings and the current operations plan.
Mandatory Reporting Level			
H13	Conditions **H14** to **H17** inclusive only apply to Regulated Structures which have not been certified as low consequence category for 'failure to contain - overtopping'.		The K2W-N 505RL/520RL ash storage facility and QW sump have been certified as low consequence category for 'failure to contain - overtopping'.
H14	The Mandatory Reporting Level (the MRL) must be marked on a regulated dam in such a way that during routine inspections of that dam, it is clearly observable.	The MRL for any regulated dams will be marked in a way that is clearly visible	No regulated structures relevant to this condition are planned to be operated during the term of this Plan. However, should this occur, the MRL for any regulated dams will be marked in a way that is clearly visible

Condition	Legal Obligation	Control Strategy	Actions
H15	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.	The administering authority will be notified within 48 hours if monitoring of the water level in regulated structures indicates that the MRL will be reached.	No regulated structures relevant to this condition are planned to be operated during the term of this Plan. However, should this occur, the administering authority will be notified within 48 hours if monitoring of the water level in regulated structures indicates that the MRL will be reached
H16	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.	If monitoring indicates that the MRL within regulated structures is reached, actions will be taken to prevent any discharge from occurring.	If applicable, actions will be taken to prevent any discharge from occurring should monitoring indicate that the MRL within regulated structures is reached
H17	The holder must record any changes to the MRL in the Register of Regulated Structures.	A Register of Regulated Structures will be maintained, including records of changes to the MRL of regulated structures	4868-SE-REG1002 Meandu Mine Regulated Dam Register is maintained and will be updated when changes to MRL have been certified.
Design Storage Allowance			
H18	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.	The performance of each regulated dam will be assessed based on actual observations prior to 1 July each year.	The performance of each regulated dam will be assessed based on actual observations prior to 1 July each year
H19	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 Allowance (DSA) volume for the dam (or network of linked containment systems).	Ensure adequate storage is available in each regulated dam as of 1 November each year, to meet DSA requirements for the dam	Adequate storage will be made available in each regulated dam as of 1 November each year, to meet DSA requirements for regulated dams
H20	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.	The administering authority will be notified within 48 hours if monitoring of the water level in each regulated structure indicates that there is not sufficient storage to meet the DSA volume on the 1 November of the year.	If applicable, the administering authority will be notified within 48 hours if monitoring of the water level in each regulated structure indicates that there is not sufficient storage to meet the DSA volume on the 1 November of the year.
H21	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.	Regular inspections of any regulated structures will be undertaken. If monitoring indicates that any regulated structure will not have the available storage to meet the DSA volume on the 1 November of any year, actions will be taken to prevent any discharge from occurring.	Undertake inspections and actions to comply with DSA volume requirements, where required.
Annual Inspection Report			
H22	Each regulated structure must be inspected each calendar year by a suitably qualified and experienced person.	Each regulated structure will be inspected annually by a suitably qualified and experienced person.	Annual inspections will be undertaken of each regulated structure.
H23	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.	Annual inspections will include assessment of condition and adequacy of all components of each regulated structure. A report will be prepared by the person undertaking the inspection, which will include any recommended actions to maintain integrity of the structure.	Annual inspections will be undertaken of each regulated structure and a report will be prepared by the person undertaking the inspection, which will include any recommended actions to maintain integrity of the structure.
H24	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).*	Annual inspection reports for regulated structures will be certified by a suitably qualified and experienced person in accordance with requirements in EM635.	Annual inspection reports for regulated structures will be certified by a suitably qualified and experienced person.
H25	The holder must: a) within **20 business days** of receipt of the annual inspection report, provide to the administering authority: a. the recommendations section of the annual inspection report; and b. 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** of receipt of the request.	The "Recommendations" section of the annual inspection report, actions implemented and, if requested, the full annual inspection report will be submitted to the administering authority in accordance with conditions of this EA.	Any actions or recommendations from the annual inspection report will be provided to the administering authority within 20 business days, as required. If requested by the administering authority, the full annual inspection report will be submitted to the administering authority, if requested.

Condition	Legal Obligation	Control Strategy	Actions
Transfer Arrangements			
H26	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.	Records including all reports, documentation and certifications relating to regulated structures will be maintained and provided to a new holder on transfer of the authority.	All records including reports, documentation and certifications will be stored on the sites Central Filing System and document management system. These documents will be provided to a new holder of the environmental authority upon transfer.
Decommissioning and Rehabilitation			
H27	Dams must not be abandoned but be either: a) decommissioned and rehabilitated to achieve compliance with condition H28; or b) be left in-situ for a beneficial use(s) provided that: a. it no longer contains contaminants that will migrate into the environment; and b. it contains water of a quality that is demonstrated to be suitable for its intended beneficial use(s); and c. the administering authority, the holder of the environmental authority and the landholder agree in writing that the dam will be used by the landholder the cessation of the environmentally relevant activity(ies).	Dams and voids are to be either decommissioned and rehabilitated or left in-situ and made safe and non-polluting	All dams and voids will be either left in-situ and made safe and non-polluting or rehabilitated, as per site's environmental authority conditions. No dams or voids will be decommissioned and rehabilitated during the term of this Plan.
H28	Before surrendering this environmental authority the site must be rehabilitated to achieve a sustainable, safe, stable, non-polluting landform in accordance with the conditions contained **Schedule G: Land** of this environmental authority.	The site will be rehabilitated to achieve a sustainable, safe, stable, non-polluting landform in accordance with Schedule G: Land prior to surrendering this EA. If dams are to remain as water storages, they will satisfy requirements of Condition H27. If dams are to be decommissioned, the final landform will comply with general site landform and rehab requirements: • landform re-profiled to meet design grade and drainage requirements; • 17% slopes with specific, isolated areas up to 25%; • contour banks separated by maximum of 70 metres); • topsoil spreading at pre-determined depth; • seeding with native species to achieve self-sustaining native bushland post-mining outcome	If dams are to be decommissioned, they will be rehabilitated to meet compliance with native woodland criteria specified in this EA. Ongoing monitoring will occur (including geotechnical stability and water quality) to confirm the landform is sustainable, safe, stable and non-polluting prior to relinquishment.
Register of Regulated Structures			
H29	A Register of Regulated Structures must be established and maintained by the holder for regulated structure.	Register of regulated structures will be maintained.	4868-SE-REG1002 Meandu Mine Regulated Dam Register is maintained in Meandu Mine's Central Filing System and updated as required.
H30	The holder must provisionally enter the required information in the Register of Regulated Structures when a design plan for a regulated dam is submitted to the administering authority.	The regulated dam register will be maintained and updated when a design plan for a regulated dam is submitted to the administering authority.	4868-SE-REG1002 Meandu Mine Regulated Dam Register will be updated when the "as constructed" design plans for K2W-N 505RL/520RL ash storage facility and QW sump are submitted to the administering authority.
H31	The holder must make a final entry of the required information in the Register of Regulated Structures once compliance with condition **H10** and **H11** has been achieved.	A final entry will be made in the Register of Regulated Structures once compliance with condition H10 and H11 has been achieved	If applicable, a final entry will be made in 4868-SE-REG1002 Meandu Mine Regulated Dam Register once compliance with condition H10 and H11 has been achieved
H32	All entries in the Register of Regulated Structures must be approved by the chief executive officer for the holder of this authority, or their delegate, as being accurate and correct.	All entries in the Register of Regulated Structures will be approved by the CEO for the holder of this EA or their delegate	Any entries in 4868-SE-REG1002 Meandu Mine Regulated Dam Register will be approved by the EA holder's CEO or their delegate
H33	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 Structures, in the electronic format required by the administering authority.	Submit a copy of the Register of Regulated Structures to the administering authority with the annual return	A copy of 4868-SE-REG1002 Meandu Mine Regulated Dam Register will be submitted to the administering authority with the annual return.
Transitional Arrangements			

Condition	Legal Obligation	Control Strategy	Actions
H34	All existing structures that have not been assessed in accordance with either the Manual or the former *Manual for Assessing Hazard Categories* and *Hydraulic Performance of Dams* must be assessed and certified in accordance with the Manual by **2 August 2015.**	Ensure all existing structures are assessed in accordance with EM635 by 2 August 2015	All existing structures were assessed and certified in accordance with EM635 prior to the due date.
H35	All existing structures must subsequently comply with the timetable for any further assessments in accordance with the Manual specified in Table **H1: Transitional hydraulic performance requirements for existing structures,** depending on the consequence category for each existing structure assessed in the most recent previous certification for that structure.	Re-assessment of structures to occur in accordance with timeframes specified in Table H1 of the EA	No existing structures will require re-assessment during the period of this Plan
H36	**Table H1: Transitional hydraulic performance requirements for existing structures** ceases to apply for a structure once any of the following events has occurred: a) it has been brought into compliance with the hydraulic performance criteria applicable to the structure under the Manual; or **b)** it has been decommissioned; or **c)** it has been certified as no longer being assessed as a regulated structure.		No existing structures were identified as regulated structures as part of the transitional assessment.
H37	Certification of the transitional assessment required by **H35** and **H36** (as applicable) must be provided to the administering authority by **2 August 2015**.	Certification of transitional assessments will be submitted to the administering authority by 2 August 2015.	The certification of the transitional assessment of existing structures has been submitted to the administering authority prior to the due date.

9.2 Appendix B: Monitoring Program

Monitoring Type	Aim	Methods	Schedule
WATER			
Discharge quality	To monitor discharge water quality for compliance with Environmental Authority	Sampling and analysis	Measurements for compliance with EA Condition C5 are undertaken daily for pH, EC and Turbidity at CP1, CP2 and CP3 and EC at CP4. Calculation of 24 hour average for reporting to WATERS. Quarterly sampling and analysis of surface water samples released from site at CP2, CP3 and CP4. As required monitoring for discharges, dams and creeks.
Flow	For use in and calibration of ISWM	Data collection via automated monitoring network	Automated data collection
RD2 Overflow	To monitor for oils and greases	Sampling and analysis	Quarterly grab sample at RD2 spillway
Pit Water	To monitor for changes in quality	Sampling and analysis	Quarterly grab sample where possible
Groundwater - compliance bores	To monitor water quality and standing water level in given aquifers for compliance with EA	Depth measurement, grab sample and analysis	Quarterly monitoring Annual Review
Groundwater – site bores	To monitor and detect changes in standing water level and quality	Depth measurement, grab sample and analysis	Quarterly monitoring
Groundwater – piezometer bores	To monitor standing water level	Data collection using VWP	Quarterly monitoring
TAILINGS			
Tailings - supernatant water in TSFs	To monitor and record quantity and quality of free standing water in the void, to assess acid producing potential and metal concentrations of tailings	Sampling and analysis	Annual & Quarterly - surface water Quarterly - groundwater
LAND			
Erosion	To monitor embankment stability and detect failures in water infrastructure	Routine dam and drainage inspections	6-monthly inspections
Erosion and Sedimentation	To quantify soil loss from catchments above CP3 and CP2	Record volume of bedload sediment removed from retention dams during maintenance of dams. Use turbidity data to quantify volume of suspended sediment moved from site	Annual
Topsoil	To monitor and map topsoil stockpile locations and volumes	Ground surveys of new and utilised stockpiles	Annual reconciliation
Disturbance	To map distribution of disturbance types and rehabilitation	Aerial and ground survey interpretation	Annual reconciliation
Rehabilitation	To monitor rehabilitated areas for compliance with the EA	Vegetation assessment of selected areas	Rehabilitation monitoring conducted biennially
AIR			
Dust Levels	To record dust levels off lease	Sampling and analysis	As required for compliance with the EA
NOISE			
Noise Levels	To record noise levels off lease	Refer to the EA	As required for compliance with the EA
VIBRATION and AIRBLAST OVERPRESSURE			
Blast Vibration and Airblast Overpressure	To record vibration and airblast overpressure levels off lease	Refer to the EA	As required for compliance with the EA
K2E Blast Vibration Levels	To record vibration levels from K2E blasts at Powerlink structures	Blast monitors installed at K2E Powerlink structures for K2E blasts	As required for K2E blasts

10 Attachments

Attachment 1	Meandu Mine Financial Assurance Calculator January 2019
Attachment 2	Meandu Mine Financial Assurance Calculator December 2019
Attachment 3	Meandu Mine Financial Assurance Calculator December 2020
Attachment 4	Meandu Mine Rehabilitation Cost Rate Confirmation - Downer EDI Mining
Attachment 5	Meandu Mine Demolition Report
Attachment 6	Cost Estimates for Closure Studies V5
Attachment 7	Stanwell Annual Report 2017/18
Attachment 8	TEC Coal Financial Discount Declaration ESR-2015-1822
Attachment 9	TEC Coal 2019-2020 Plan of Operations Compliance Statement Final

Appendix E

Meandu Mine Waste Management Plan




Together we create energy solutions
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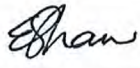
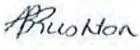
zero harm today

REV	DATE	DETAILS
A	11 March 2020	Draft for Stanwell review
B	26 March 2020	Final draft
C	28 July 2020	Final

	NAME	POSITION	DATE	SIGNATURE
Prepared by:	Emily Shaw	Environmental Planner (WSP)	28 July 2020	
	Allison Rushton	Principal Environmental Scientist (WSP)	28 July 2020	
Reviewed by:	Jayden Flint	Act. Environmental Manager Operations South	29 July 2020	
	Helen Jones	Technical Executive (Contaminated Land Management) (WSP)	28 July 2020	
Approved by:	Jacob Orbell	General Manager Mining	29 July 2020	

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ABBREVIATIONS

AEMO	Australian Energy Market Operator
AFFF	Aqueous fire-fighting foam
AMD	Acid and Metalliferous Drainage
ANC	Acid neutralising capacity: A measure of a sample's maximum potential ability to neutralise acid.
ANFO	Ammonium nitrate and fuel oil
AS	Australian Standards
BUA	Beneficial Use Agreement
CCPs	Coal Combustion Products
CHPP	Coal handling and preparation plant
CI	Continuous Improvement
DES	Department of Environment and Science
Downer	Downer EDI Mining Pty Ltd
EA	Environmental Authority
EP Act	*Environmental Protection Act 1994*
EP Regulation	*Environmental Protection Regulation 2019*
EMR	Environmental Management Register
EMS	Environmental Management System
ERA	Environmentally Relevant Activity
ERC	Estimated rehabilitation cost
FY	Financial year
GET	Ground Engaging Tools
ha	hectares
HID	High Intensity Discharge
IBCs	Intermediate bulk containers
IMS	Integrated Management System
K2N	King 2 North
K2W	King 2 West
K2W-N	King 2 West – North

Kbcm	‘000 bank cubic metres
K4E	King 4 East
K4S	King 4 South
km	Kilometres
L	Litres
LOM	Life of Mine
ML	Mining lease
Mm	Millimetres
mRL	Reduced level in metres
Mtpa	Million tonnes per annum
NAF	Non-acid forming: Geochemical classification criterion for a sample that will not generate acid conditions.
NWB TSF	North West B Tailings Storage Facility
PAF	Potentially acid forming: Geochemical classification criterion for a sample that has the potential to generate acid conditions.
PFAS	Per- and poly-fluoroalkyl substances
PMP	Project Management Plan
QW	Queen West
RD16 TSF	RD16 Tailings Storage Facility
RL	Reduced level: Relative to mean sea level as distinct from depths to water
ROM	Run of Mine: Coal as it comes from the mine prior to screening or processing.
RSA	Rejects storage area
RTCA	Rio Tinto Coal Australia
Tarong power stations	Tarong and Tarong North power stations
TCLP	Toxicity Characteristic Leaching Procedure
TEC	TEC Coal Pty Ltd
TSF	Tailings storage facility
WRR Act	*Waste Reduction and Recycling Act 2011*

1 INTRODUCTION

Meandu Mine is an open cut coal mining operation located in Queensland's South Burnett region. The nearest town to the mine site is Yarraman, which is located approximately 6 km south south-east from approved mining activities. The mine occupies an area of 4,267 hectares (ha) and has been operational since 1983.

Meandu Mine currently has five working pits and is capable of supplying the adjacent Tarong and Tarong North power stations (Tarong power stations) with up to 7 million product tonnes of coal per year. When the mine was first established it was estimated that there was enough coal to supply the Tarong power stations for up to 25 years. Through exploration programs and geological modelling TEC Coal Pty Ltd (TEC) has subsequently determined that there remains sufficient economically viable coal at Meandu Mine to meet TEC's long-term needs for both the Tarong power stations. Mining continues to use open pit techniques which are considered the most appropriate for resource recovery with consideration to seam geometry and strip ratio.

1.1 PURPOSE

The operation and eventual decommissioning stages of Meandu Mine has and will result in the generation of a series of waste streams and products. If not managed and disposed of appropriately, waste has the potential to cause adverse environmental harm and impact social values, including human health. Waste avoidance and reduction in line with the requirements set out under the *Waste Reduction and Recycling Act 2011* (WRR Act) is an integral part of the waste management framework at Meandu Mine.

This Waste Management Plan has been prepared to satisfy both legal and social obligations to minimise and appropriately manage waste generated at the Meandu Mine. The mine performance is regulated by an Environmental Authority (EA) EPML00709113.

1.2 TARGET AND OBJECTIVES

This Waste Management Plan, when implemented, will aim to achieve the following outcomes for Meandu Mine:

- Comply with waste legislation and regulations, including site specific regulations as set out by relevant administering authorities.
- Continual improvement for minimising the generation of waste.
- Maximise recycling, reuse and other strategies to reduce the volume of waste sent to landfill.

1.3 SCOPE OF THE WASTE MANAGEMENT PLAN

This Waste Management Plan provides an overarching framework to manage waste generated at Meandu Mine. The Waste Management Plan aims to identify and provide appropriate waste management measures to reduce the risk of causing environmental harm that may arise from improper management of waste and maximise the potential for waste avoidance and minimisation activities at the mine.

The scope of this Waste Management Plan is to:

- identify and describe what mining activities generate (certain) waste materials
- identify roles and responsibilities for implementing this Waste Management Plan
- provide waste management and control strategies, including:
  - type and volumes of waste

  - waste segregation
  - waste storage
  - waste disposal
  - transport of waste
  - monitoring and reporting
- identify the management of seepage and leachate during all phases of mining and closure
- identify controls for fugitive emissions to air
- summarise a program of progressive sampling and characterisation of mine waste materials for acid producing potential and potential metals/metalloid production
- identify rehabilitation strategies for mine waste material storage and disposal areas, including monitoring to verify methods for decommissioning and rehabilitation
- demonstrate how current waste generation and disposal methods align with the waste management hierarchy of waste avoidance and reduction and set provision for future improvement opportunities
- identify monitoring, data management and reporting procedures as required during the life of the mine.

This Waste Management Plan is to be implemented by all mine site personnel, including subcontractors, responsible for carrying out works throughout all life of mine (LOM) stages, including exploration, extraction, production, decommissioning and rehabilitation. Roles and responsibilities are outlined in Section 1.6.

1.4 REVIEW OF THIS WASTE MANAGEMENT PLAN

In accordance with the EA conditions, this Waste Management Plan will be reviewed, updated and provided to the administering authority at **intervals not exceeding three (3) years**, or prior in the event of any significant changes to the management and/or disposal of waste at Meandu Mine or any significant changes to legislative requirements. Examples of changes at Meandu Mine that would trigger a review of this Waste Management Plan include:

- major change to storage or disposal methods
- any relevant amendments to the EA.

The administering authority at the time this Waste Management Plan was prepared is the Department of Environment and Science (DES).

1.5 DESCRIPTION OF WASTE

The term *waste* is defined under the *Environmental Protection Act 1994* (EP Act) as follows:

Waste includes anything, other than an end of waste resource, that is –

a) left over, or an unwanted by-product, from an industrial, commercial domestic or other activity; or

b) surplus to the industrial, commercial, domestic or other activity generating the waste.

As defined in the WRR Act, all waste generated by the mine is classified as commercial and industrial waste. For the purposes of this Waste Management Plan, wastes from the Meandu Mine have been classified into the following waste categories:

- **General waste**
- **Regulated waste**
- **Mined waste material:**

- Waste Rock
- Tailings and Coal Rejects
- Coal Combustion Products.

1.6 ROLES AND RESPONSIBILITIES

There are two entities at Meandu Mine that have responsibility for ensuring compliance with EA EPML00709113. These are TEC and Downer EDI Mining Pty Ltd (Downer).

TEC is a wholly owned subsidiary of Stanwell and is the holder of the Meandu Mine EA EPML00709113. Downer is contracted by TEC to provide mining services at Meandu Mine, which includes environmental management and development, maintenance and implementation of systems to maintain compliance with the site's EA. Downer was appointed operator of Meandu Mine on 1 January 2013. Downer has been reappointed as mine contractor of Meandu Mine under a new five year contract with TEC, which commenced in July 2020.

The roles and responsibilities relevant to this plan are outlined in Table 1.1.

Table 1.1 Roles and responsibilities

ROLE	COMPANY NAME	RESPONSIBILITIES
General Manager Mining	TEC Coal Pty Ltd	Responsible for compliance with EA EPML00709113.
Project Manager	Downer	Responsible for implementing this Waste Management Plan and education of staff.
Environmental Superintendent	Downer	The Environmental Superintendent is required to ensure the mine maintains compliance requirements and obligations under the EP Act and EA EPML00709113. — Review and amend the Waste Management Plan in accordance with the sites document management system requirements or in the event of changes to legislation or site operations. — Periodically review site operations to assess waste management improvement opportunities. — Ensure that waste transport certificates are forwarded to DES within the required timeframes. — Maintain records of waste types and quantity's either removed or disposed of on-site including the completion of Monthly Waste Generation and Disposal Inventory Form (8512-DM-SE-F61) and Tyre Disposal Form (8512-DM-PL-F139). — Ensure that appropriate waste storage facilities (e.g. bins and signs) are available on site in conjunction with Infrastructure Supervisor. — Maintain waste agents' agreements with relevant waste transporter. — Coordinate the removal of waste from site in conjunction with Infrastructure Supervisor.
Infrastructure Supervisor	Downer	— Ensure waste transport certificate and dockets are forwarded to the Environmental Advisor.

ROLE	COMPANY NAME	RESPONSIBILITIES
		— Supervise waste transport contractors while operating on site. — Management of bins and waste storage areas, including monitoring and inspection of bins and relocation of bins around site as required.
Waste Management Representatives	Downer	— Ensure waste transport certificates are completed for regulated trackable waste that is not covered under an agent's agreement. — Ensure copies of the waste transport certificates are filed in the Central Filing System.
All mine workers	All	— Ensure all wastes are disposed of in accordance with this Waste Management Plan.

1.7 SUITABLY QUALIFIED PERSONS

A suitably qualified person, as defined under section 564 of the EP Act, means a person who has qualifications and experience relevant to performing the function. Table 1.2 outlines the qualifications and experience of the persons involved in the preparation, review and implementation of this Waste Management Plan.

Table 1.2 Experience and qualifications of persons involved in preparation, review and implementation of this Waste Management Plan

NAME	ORGANISATION	POSITION	QUALIFICATIONS	YEARS OF EXPERIENCE
Prepared / reviewed by				
Allison Rushton (Author)	WSP Australia Pty Ltd	Principal Environmental Scientist	Bachelor of Economics (Honours); Graduate Diploma Environmental Science; Certified Environmental Practitioner	24
Emily Shaw (Author)	WSP Australia Pty Ltd	Environmental Planner	Bachelor of Urban and Environmental Planning (Honours)	5
Helen Jones (Reviewer)	WSP Australia Pty Ltd	Technical Executive (Contaminated Land Management), Principal Waste Practitioner	Bachelor of Science Honours in Engineering Geology, University of Greenwich, London, completed in 1996 Chartered Wastes Manager (Chartered Institute of Waste Management UK) Member EIANZ Suitably Qualified Person under Chapter 7 Part 8 of the EP Act.	23

NAME	ORGANISATION	POSITION	QUALIFICATIONS	YEARS OF EXPERIENCE
Jayden Flint (Reviewer)	Stanwell Corporation Limited	Act. Environmental Manager Operations South	Bachelor of Science and Bachelor of Environmental Engineering (Honours); Graduate Certification of Business	9
Implemented by				
Merilyn Barnes	Downer	Environmental Superintendent	Bachelor Applied Science (Conservation & Park Management)	25+
Josh Burke	Downer	Site Senior Executive – Project Manager	Site Senior Executive Legislation Exam (SSE)	16
Jacob Orbell	Stanwell Corporation Limited	General Manager Mining	Bachelor of Engineering - Mining	20
Updated by				
TBC at time of update				

2 SITE LOCALITY AND OPERATION OVERVIEW

2.1 MEANDU MINE

Meandu Mine is located in Queensland's South Burnett region, approximately 150 kilometres (km) north west of Brisbane, 14 km south-west of Nanango and 1.5 km to the south of the Tarong power stations. The nearest town to the mine site is Yarraman, which is located approximately 6 km south south-east from approved mining activities.

Meandu Mine is an open-cut coal mine that is operated for the purpose of supplying black thermal coal to the adjacent Tarong power stations. Meandu Mine has been supplying coal to the Tarong Power Station since 1983 and the Tarong North Power Station since 2003. During the period 1983 to 2007, Rio Tinto Coal Australia (RTCA) owned and operated the mine. TEC purchased Meandu Mine in 2008. The long-term plan is for mining operations to continue at Meandu Mine through until at least 2037.

Meandu Mine currently operates within a surface rights area covering 2,636.5 ha, within Mining Lease (ML) 6674 that has a total area of 4,267 ha.

In addition to the mining operation, Meandu Mine includes one coal handling and preparation plant (CHPP), where mined coal is screened, washed and transported to the power stations via overland conveyor. This Waste Management Plan applies to activities carried out within the Meandu Mine Authorised Disturbance Area (surface rights area), as shown in Appendix 1 of the EA EPML00709113, and illustrated in Figure 2.1.

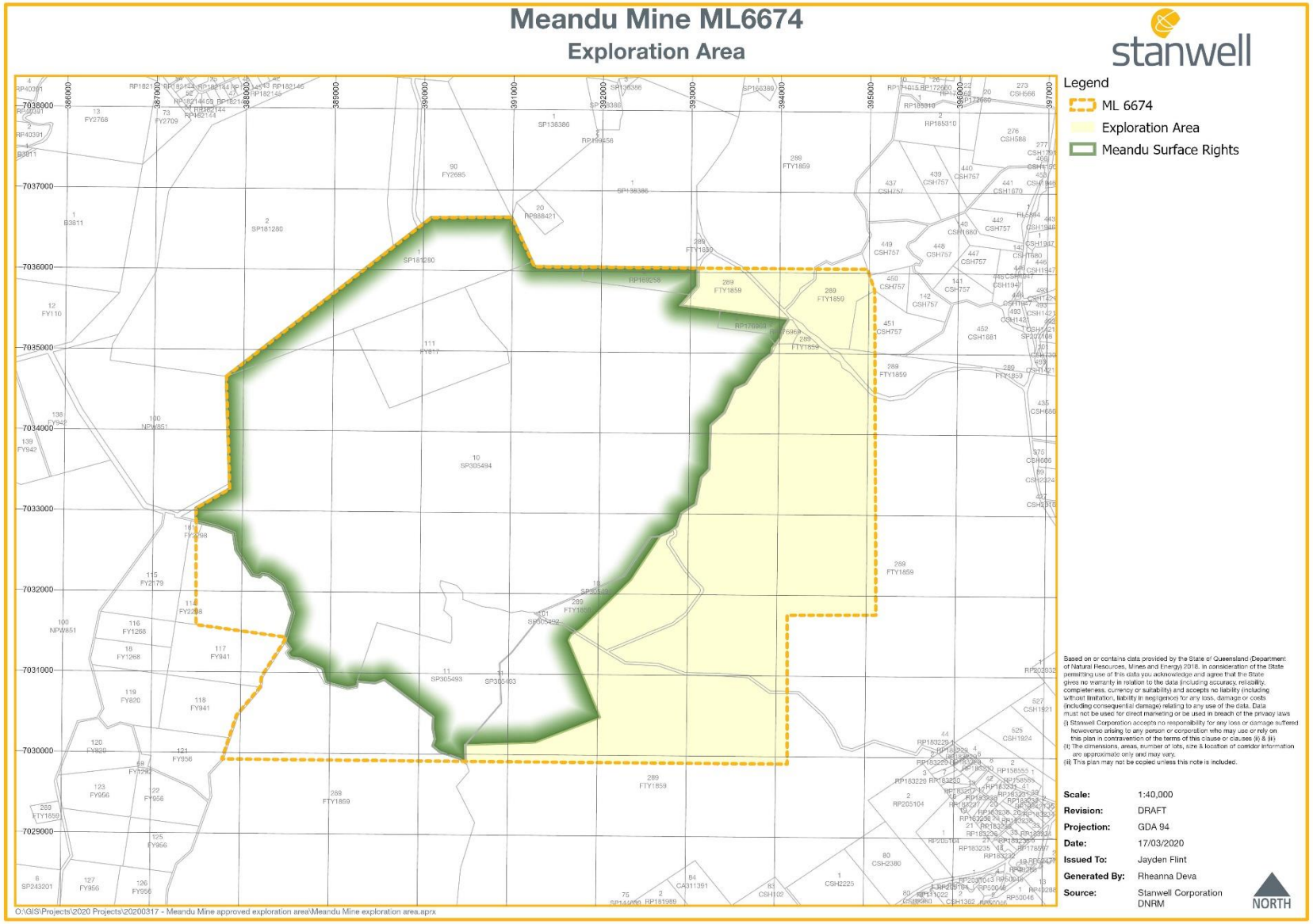


Figure 2.1 Meandu Mine Authorised Disturbance Area

2.2 OVERVIEW OF MEANDU MINE OPERATIONS

Mining activities at Meandu Mine involve:

- exploration drilling
- clearing of vegetation
- stripping and stockpiling of topsoil from disturbance areas
- drilling and blasting
- waste rock removal using truck and excavator, dragline, dozers and scrapers
- coal mining and transport
- coal processing
- coarse and fine reject disposal
- storage of ash from coal combustion at the Tarong power stations
- onsite disposal of waste tyres
- generation and management of mine water (e.g. treatment, reuse etc.)
- maintenance of water management structures including sediment controls
- dump construction and reshaping
- rehabilitation of disturbed land.

An overview of these activities is provided in the following sections.

2.2.1 CONSTRUCTION AND DEMOLITION

Typical activities that could be labelled "construction" include new sedimentation dams, communication tower installations and erection of new buildings. Demolition activities would be associated with decommissioning site infrastructure. No major construction or decommissioning activities are currently planned. When required these activities are managed under discrete management plans that assess all risks from that activity which would include aspects that cover waste generation, handling and disposal. These activities would seek to align to existing site management practices unless risk assessment dictates these activities to be managed differently.

2.2.2 MINING ACTIVITIES

2.2.2.1 EXPLORATION DRILLING

Exploration drilling and related activities are undertaken periodically at Meandu Mine to better define the coal resource. Approval was granted by the Queensland Department of Natural Resources and Mines to conduct exploration drilling within ML6674 to the east of the current surface rights area to identify potential additional reserves for future mining.

A comprehensive exploration drilling program has been conducted since 2009 to further refine knowledge of the resource along the south and east boundaries and to increase mine plan accuracy. Exploration borehole sites are predominantly located on existing forestry tracks with a small number located within the plantation timber areas, as agreed with the plantation holder HQPlantations, which are then progressively rehabilitated.

Additional exploration drilling will be undertaken as needed to deliver the required geological definition to support the operation.

2.2.2.2 CLEARING OF VEGETATION

Vegetation is routinely cleared in advance of mining operations within the surface rights area. This will occur primarily in advance of the active pits. Central and Ramp 5 pit progression will require clearing of older established rehabilitation and remnant vegetation, while K4E and K4S pit progression will require clearing of remnant vegetation and previously-harvested pine plantation areas.

Cleared vegetation is either:

- stockpiled and burnt prior to topsoil stripping, to reduce fire fuel load and allow ash to be incorporated into the topsoil
- utilised in rehabilitation areas, to provide fauna habitat and soil surface protection.

2.2.2.3 STRIPPING AND STOCKPILING TOPSOIL

Topsoil is stripped to an appropriate depth and either directly placed onto re-contoured landforms or stockpiled for later use during rehabilitation. Topsoil is managed in accordance with the Topsoil Handling Procedure (8512-SE-P1010) to minimise impact to the topsoil resource. Stockpiled topsoil volumes and locations are recorded in the site Topsoil Stockpile Register (8512-SE-F1021).

2.2.2.4 DRILL AND BLAST

Explosives are used to assist removal of overburden and mining of coal. Explosive product is selected for each shot to minimise (and where possible remove) the occurrence of fumes. Common explosives used on-site are ammonium nitrate and fuel oil (ANFO), Heavy ANFO and Emulsion which is mixed on-site and loaded down the blast pattern drill holes. Storage of explosives is in accordance with Explosives Production or Storage - operating an explosives factory under the *Explosives Act 1999* and per license #0409758 granted by the Queensland Government Department of Mines and Energy.

2.2.2.5 WASTE ROCK REMOVAL

Waste rock material removed in advance of coal mining is comprised of:

- overburden, which is located above the upper coal seam
- interburden, which is located between adjacent coal seams
- coal roof, coal floor and coal partings, which is located adjacent to coal seams
- spoil material, overburden that has previously been dumped and is rehandled to provide access to the targeted coal seam.

Interburden is competent material which is drilled and blasted to allow efficient handling by equipment, while overburden can be either free dig material or drilled and blasted. The majority of overburden (over 90%) is blasted.

Waste rock material is moved by dragline and excavator/ haul truck fleets to in-pit or ex-pit overburden dumps, appropriate to the mine plan and mining location.

2.2.3 PROCESSING

2.2.3.1 COAL MINING AND TRANSPORT

Coal from the Ace, King and Queen seams is mined by excavators. Coal is transported to Run of Mine (ROM) stockpiles or the ROM bin at the CHPP in rear dump trucks. The CHPP processes include screening, crushing and washing using gravity separation, to achieve product coal ash content specifications. Product coal is then transported via a 1.5 km overland conveyor to the Tarong power stations.

2.2.3.2 COAL HANDING AND PREPARATION PLANT

ROM coal is sized in primary and secondary breakers, during which raw coal is separated from breaker rejects. During the CHPP process, raw coal is separated into coal and non-coal materials using a washing and flocculent method. The resultant product coal is sent to the Tarong power stations. Coarse rejects are co-mingled with dewatered fine rejects and hauled to in-pit rejects dumps.

Meandu Mine coal production is dependent on generation requirements of the Tarong power stations and will not exceed 11.0 million ROM tonnes per annum (Mtpa).

2.2.4 MAINTENANCE ACTIVITIES

Ongoing maintenance of infrastructure and fixed and mobile plant occurs at the Meandu Mine. Maintenance activities on mobile plant predominantly take place in the workshop; however, periodic field maintenance is required for the dragline and some other plant.

A heavy vehicle washbay operates at the workshop, which includes treatment systems to treat washdown effluent. Mobile equipment is washed down at this washdown facility prior to maintenance being undertaken.

Ongoing maintenance on the CHPP and other site infrastructure is undertaken as required.

2.2.4.1 ABRASIVE BLASTING

The maintenance of major plant such as the coal preparation plant and mining equipment periodically involves abrasive blasting prior to repainting. This occurs at different times throughout the year in accordance with operating procedures in place at Meandu Mine (Abrasive Blasting Procedure (8512-SE-P1002) and Abrasive Blasting, High Pressure, Chemical and Mechanical Cleaning (8512-SE-SOP16)). The product used in the abrasive blasting process is inert. Abrasive blast rejects are contained and removed from site as regulated waste.

2.2.4.2 FUELS AND CHEMICALS

Bulk storage of diesel, other hydrocarbon products and reagents are maintained onsite. These products are used in the operation of heavy vehicles, mining equipment, explosives and in the CHPP process.

All flammable and combustible liquids are contained in a manner that prevents environmental harm and maintained in accordance with Section 5.9 of Australian Standards (AS) 1940:2017 *The storage and handling of flammable and combustible liquids*. Regular inspections of the fuel farm and associated infrastructure are undertaken to confirm this.

2.2.5 LANDFORM AND REHABILITATION

Spoil dumps are progressively rehabilitated during ongoing mining operations. The rehabilitation process involves regrading and contouring the spoil to the design slope of final landforms, followed by vegetation establishment. This is assisted by the strategic use of topsoil, which has been stripped ahead of the overburden removal.

Rehabilitation activities include:

- **Landform preparation**: Reshaping is performed by dozers and scrapers to achieve the final landform.
- **Erosion control**: Rehabilitation at Meandu Mine is designed to minimise erosion. Where needed, contour banks slow the water sufficiently to allow for penetration to assist with vegetation growth.
- **Topsoil placement**: Topsoil is sourced using direct-placed topsoil removed from cleared areas in advance of mining operations or recovery from existing topsoil stockpiles at Meandu Mine.
- **Ripping and seeding**: Ripping of the area is performed post-topsoiling and pre-seeding (or in conjunction with seeding) to aid in erosion control and assist with root and moisture penetration.

An overview of steps undertaken for rehabilitation activities at the Meandu Mine is summarised in Table 2.1.

Table 2.1 Rehabilitation steps

REHABILITATION STEP	ACTIVITY	INDICATIVE TIMEFRAME
Required volume of excavated material (spoil) is deposited in the area to be rehabilitated	Some overburden is moved by a walking dragline and dumped directly into the adjacent mined out strip. Excavators are used to mine the upper layers of overburden. The excavated overburden is placed into rear tip trucks and carted to in-pit and out-of-pit spoil dumps and dumped to nominated levels to ensure there is sufficient spoil volume to form the final landforms detailed in the LOM plan.	Ongoing each year. All material is classified for suitability and classed as near surface (non-acid forming or NAF) or deeper (potentially acid forming or PAF).
Dozer profiling of bulk landform	Dozers profile the dumped spoil to the final profile and establish contours and drainage systems.	12-month period after an area is no longer active and is not required for the remaining mine life (e.g. final bulk dump profile is achieved).
Drain establishment	Where required by site specific design – basalt rock placement and detailed shaping takes place.	2 months (this occurs within the 12-month period of the dozer profiling step above).
Topsoil placement	Topsoil is recovered from stockpiles or from areas in advance of mining. Topsoil spreading is undertaken with scrapers and small dozers to a design thickness of 200 mm.	Two months following completion of the dozer profile. Each year this is organised to occur prior to the wet season.
Ripping, seeding and soil enrichment	The topsoiled surface is contour ripped to a depth of 0.3-0.5 m with small dozers to aid in erosion control, root penetration and moisture infiltration. Seed and fertiliser are applied in a single pass in conjunction with contour ripping.	One month.
Rehabilitation monitoring and maintenance	Monitoring (based on bio-condition assessments) is undertaken by external consultants. Inspections of established rehabilitation is undertaken by site personnel. Where maintenance is required, this is undertaken as part of the annual rehabilitation program under the supervision of the site environment team.	Ongoing on an annual basis.

3 LEGAL REQUIREMENTS

Applicable legislation, regulations and policies enacted by the Commonwealth, State and Local Governments relating to waste management is described in the following sections.

3.1 ENVIRONMENTAL AUTHORITY

Under the EP Act, Meandu Mine must comply with waste related conditions, specifically conditions A17 – A19, as shown in Table 3.1. This table demonstrates how this Waste Management Plan complies with these EA Conditions.

Table 3.1 Compliance with EA EPML0070913 Waste related conditions

EA CONDITION NUMBER	REQUIREMENT	RESPONSE / CROSS REFERENCE TO WASTE MANAGEMENT PLAN
A17	A Waste Management Plan must be developed, implemented and reviewed by a suitably qualified person(s) for all stages of mining activities and provided to the administering authority for review and comment by **30 March 2020**, and at intervals not exceeding **three (3) years** thereafter.	Refer to Section 1.7 (Suitably Qualified Persons) for details on the authors, reviewers and implementers of this Waste Management Plan. Refer to Section 1.4 (Review of this Waste Management Plan) for review frequency and submission to DES.
A18	Mine waste materials must be managed in accordance with the Waste Management Plan required by Condition A17.	Refer to the following sections of the Waste Management Plan for the management of mine waste materials: – Section 5 (Waste Rock) – Section 6 (Tailings and Coal Rejects) – Section 7 (Coal Combustion Products (Ash)). The management of non-mine waste materials is provided in: – Section 0 (General Waste) – Section 0 (Regulated Waste).
A19	The Waste Management Plan required by Condition A17 must include the following: – a description of the mining activities that may generate mine waste materials.	Refer to Section 2.2 (Overview of Mining Operations)
	– mine waste material management and control strategies such as: — the type and amounts of wastes generated by mining activities	Refer to the following sections of the Waste Management Plan: – Section 0 (General Waste) – Section 0 (Regulated Waste) – Section 5 (Waste Rock)

EA CONDITION NUMBER	REQUIREMENT	RESPONSE / CROSS REFERENCE TO WASTE MANAGEMENT PLAN
	— segregation of the wastes — storage of the wastes — disposal of the wastes — transport of the wastes — monitoring and reporting matters concerning the wastes	— Section 6 (Tailings and Coal Rejects) — Section 7 (Coal Combustion Products (Ash)).
	— management of seepage and leachate during all phases of mining and closure	Refer to the following sections of the Waste Management Plan: — Waste Rock: Section 5.1.5 (Control of Seepage and Leachate) — Tailings and Coal Rejects: Section 6.5 (Control of Seepage and Leachate) — Coal Combustion Products (Ash): Section 7.5 (Control of Seepage and Leachate).
	— the control of fugitive emissions to air	Refer to the following sections of the Waste Management Plan: — Waste Rock: Section 5.1.6 (Control of Fugitive Air Emissions) — Tailings and Coal Rejects: Section 6.6 (Control of Fugitive Air Emissions) — Coal Combustion Products (Ash): Section 7.6 (Control of Fugitive Air Emissions).
	— a program of progressive sampling and characterisation to identify acid producing potential and metal concentrations of mine waste materials	Refer to Section 4.5.1 (Waste Characterisation Program).
	— maintaining records of the relative locations of any other matter stored within the mine waste material disposal areas	Refer to the following sections of the Waste Management Plan: — Waste Rock: Section 5.1.1 (Relevant site procedures) — Tailings and Coal Rejects: Section 6.1.1 (Relevant site procedures) — Coal Combustion Products: Section 0 (Relevant site procedures) — Tyre Disposal: Section 4.4.1 (Relevant site procedures).
	— rehabilitation strategies of mine waste material storage and disposal areas	Refer to the following sections of the Waste Management Plan: — Waste Rock: Section 5.1.7 (Decommissioning and rehabilitation)

EA CONDITION NUMBER	REQUIREMENT	RESPONSE / CROSS REFERENCE TO WASTE MANAGEMENT PLAN
		— Tailings and Coal Rejects: Section 6.8 (Decommissioning and rehabilitation) — Coal Combustion Products (Ash): Section 7.7 (Decommissioning and rehabilitation).
	— monitoring of rehabilitation, research and/or trials to verify the requirements and methods for decommissioning and final rehabilitation of tailings, including the prevention and management of acid mine drainage, erosion minimisation and establishment of vegetation cover.	Refer to the following sections of the Waste Management Plan: — Waste Rock: Section 5.1.8 (Monitoring and maintenance) — Tailings and Coal Rejects: Section 6.8 (Monitoring and maintenance) — Coal Combustion Products (Ash): Section 7.8 (Sampling, monitoring and maintenance).

3.1.1 NOTIFIABLE ACTIVITIES

TEC has a duty to notify for activities that have the potential to cause land contamination under section 320 of the EP Act. Notification to the administering authority is required where any of the following occur:

- Notify within 24 hours of becoming aware of an event that is not authorised or a change in condition involving contaminants:
  - that is causing or could involve serious or material environmental harm
  - on land that has previously been listed on the Environmental Management Register (EMR) on the basis of a notifiable activity
- Notify within 20 business days of becoming aware of a notifiable activity that either has or is being conducted.

The notifiable activities (as listed under Schedule 3 of the EP Act), which will be carried out at Meandu Mine during the life of the mine, are shown in Table 3.2.

Table 3.2 Notifiable activities

NOTIFIABLE ACTIVITY	DESCRIPTION
1	**Abrasive blasting—**carrying out abrasive blast cleaning (other than cleaning carried out in fully enclosed booths) or disposing of abrasive blasting material.
6	**Chemical manufacture or formulation**—manufacturing, blending, mixing or formulating chemicals if— — the chemicals are designated dangerous goods under the dangerous goods code; and — the facility used to manufacture, blend, mix or formulate the chemicals has a design production capacity of more than 1 t per week.
7	**Chemical storage** (other than petroleum products or oil under item 29)—storing more than 10 t of chemicals (other than compressed or liquefied gases) that are dangerous goods under the dangerous goods code.

NOTIFIABLE ACTIVITY	DESCRIPTION
14	**Engine reconditioning works**—carrying out engine reconditioning work at a place where more than 500 Litres (L) of any of the following are stored— — halogenated and non-halogenated hydrocarbon solvents — dangerous goods in class 6.1 under the dangerous goods code — industrial degreasing solutions.
15	**Explosives production or storage**—operating an explosives factory under the *Explosives Act 1999*.
20	**Landfill**—disposing of waste (excluding inert construction and demolition waste).
23	**Metal treatment or coating**—treating or coating metal including, for example, anodising, galvanising, pickling, electroplating, heat treatment using cyanide compounds and spray painting using more than 5 L of paint per week (other than spray painting within a fully enclosed booth).
24	**Mine wastes**— — storing hazardous mine or exploration wastes, including, for example, tailings dams, overburden or waste rock dumps containing hazardous contaminants; or — exploring for, or mining or processing, minerals in a way that exposes faces, or releases groundwater, containing hazardous contaminants.
29	**Petroleum product or oil storage**—storing petroleum products or oil— — in underground tanks with more than 200 L capacity; or — in above ground tanks with— a) for petroleum products or oil in class 3 in packaging groups 1 and 2 of the dangerous goods code—more than 2500 L capacity; or b) for petroleum products or oil in class 3 in packaging groups 3 of the dangerous goods code—more than 5000 L capacity; or c) for petroleum products that are combustible liquids in class C1 or C2 in Australian Standard AS 1940,'The storage and handling of flammable and combustible liquids' published by Standards Australia—more than 25 000 L capacity.
33	**Scrap yards—**operating a scrap yard including automotive dismantling or wrecking yard or scrap metal yard.

3.2 RELEVANT GUIDELINES AND POLICIES

3.2.1 COMMONWEALTH

This Waste Management Plan has been prepared with consideration of the Commonwealth legislation and policies shown in Table 3.3.

Table 3.3 List of applicable Commonwealth legislation and policies related to waste

ACT / POLICY	PURPOSE / INTENT	IMPLEMENTATION OPPORTUNITIES
National Waste Policy: Less Waste, More Resources 2018	The National Waste Policy provides a national framework for waste and resource recovery in Australia. It outlines roles and responsibilities for collective action by businesses, governments, communities and individuals.	Opportunity to apply the circular economy principles of the National Waste Policy, as listed below: — avoid waste — improve resource recovery — increase use of recycled material and build demand and markets for recycled products — better manage material flows to benefit human health, the environment and the economy — improve information to support innovation, guide investment and enable informed consumer decisions.
National Environment Protection Measure *(Movement of Controlled Waste between States and Territories)*	The National Environment Protection Measures provides a national framework for developing and integrating State and Territory systems for the management of the movement of controlled wastes between States and Territories originating from commercial, trade, industrial or business activities. The desired environmental outcome is to minimise the potential for adverse impacts associated with the movement of controlled waste on the environment and human health.	Possible means for achieving the desired environmental outcome is listed under Part 3 of the National Environment Protection Measure, and include: — licensing and mutual recognition — prior notification and consignment authorisations — waste tracking — obligations — maintenance of records — furnishing of information to Council.

3.2.2 STATE

This Waste Management Plan has been prepared with consideration of the Queensland legislation and policies outlined in Table 3.4.

Table 3.4 List of applicable Queensland legislation and policies related to waste

ACT / POLICY	PURPOSE / INTENT	IMPLEMENTATION OPPORTUNITIES
EP Act	Part of the EP Act aims to reduce waste and ensure all waste is managed to not cause impact to health or environmental harm. The EP Act requires waste management, including waste prevention and minimisation.	Mandatory responsibility to comply with EA waste conditions (EPML00709113) (refer to Section 3.1 for further details). Mandatory duty to notify under Chapter 7, Part 1 of the EP Act (refer to Section 3.1.1 for further details). Mandatory general environmental duty under section 319 (1) of the EP Act.
Environmental Protection Regulation 2019 (EP Regulation)	**Regulated waste** Introduces a new risk-based waste classification framework. Regulated waste is to be classified as either: — Category 1 regulated waste (highest risk) — Category 2 regulated waste (moderate risk); or — Not-regulated waste / general waste (lowest risk).	Mandatory responsibility for waste generators to classify waste into a risk-based category by either: — adopting default waste category listed in Schedule 9 of the EP Regulation — organising sampling and testing of waste by an appropriately qualified person in accordance with section 43 of the EP Regulation (known as a tested waste). Mandatory responsibility for waste tracking in accordance with Schedule 11 of the EP Regulations.
	Waste Environmentally Relevant Activity (ERA) Framework Introduces a new schedule of waste-related ERAs.	Mandatory responsibility to comply with EA waste conditions (EPML00709113). Waste-related ERA regulated under the EA include: – ERA 56: Regulated waste storage - receiving and storing regulated waste – ERA 60: Waste disposal – Threshold 1 operating a facility for disposing of, in a year, the following quantities of waste – (a) less than 50,000 t.
WRR Act	**End of Waste Framework** The legislation establishes a new framework to modernise waste management and resource recovery practices in Queensland. It will promote waste avoidance and reduction and encourage resource recovery and efficiency.	Opportunity to adopt: — End of Waste Framework (Chapter 8 of the EP Act).

ACT / POLICY	PURPOSE / INTENT	IMPLEMENTATION OPPORTUNITIES
	Waste Levy The legislation imposes a levy on waste delivered to a liable waste disposal site within levy zones (including South Burnett and Toowoomba). Waste disposed within the levy zone, or waste that originates in the levy zone or interstate and is disposed of in the non-levy zone will be liable for the levy. The waste levy will apply to general waste streams - municipal solid waste, commercial and industrial waste, and construction and demolition waste. The levy also applies to regulated (or hazardous) waste.	Mandatory requirement for: — waste levy.
Waste Management and Resource Recovery Strategy for Queensland 2019	The strategy provides the framework to help deliver coordinated, long-term and sustained growth for the recycling and resource recovery sector while reducing the amount of waste produced and ultimately disposed of, by promoting more sustainable waste management practices for business, industry and households.	Opportunity to adopt: — waste management hierarchy — circular economy principles.

3.2.3 LOCAL GOVERNMENT

Meandu Mine is located across both Toowoomba Regional Council and South Burnett Regional Council local government areas. Local governments are required to address the strategic planning for waste reduction and recycling provisions under Chapter 6 of the WRR Act. This Waste Management Plan has been prepared with consideration of the local strategies shown in Table 3.5.

Table 3.5 List of applicable local government strategies related to waste

STRATEGY	PURPOSE / INTENT	IMPLEMENTATION OPPORTUNITIES
Toowoomba Region Waste Management Strategy 2017	The Strategy addresses the management of priority wastes, as required under Queensland's WRR Act. The purpose of the Strategy is to achieve the objectives outlined in the Queensland Waste Management and Resource Recovery Strategy 2019.	Ensure waste disposal aligns with this strategy, including disposal at authorised locations.
South Burnett Waste Management Plan 2015-2022	This Strategy includes provision to address the higher order waste hierarchy principles of Waste Avoidance, Waste Reduction and Reuse, while also concentrating on waste collection, treatment, resource recovery and disposal.	Ensure waste disposal aligns with this strategy, including disposal at authorised locations.

3.3 ENVIRONMENTAL MANAGEMENT SYSTEM

Stanwell's Environment Policy (ENV-POL-01) outlines the organisation's commitments in relation to environmental performance. The policy provides a framework for decision making and action, through the establishment of environmental objectives and targets. It also documents the roles and responsibilities for environmental management across the business.

Stanwell's Environmental Management System (EMS) defines how the Stanwell Environmental Policy is implemented across Stanwell through a systematic framework focused on the management of environmental compliance obligations and risk. Meandu Mine operates under the Downer EMS with touch points into the Stanwell EMS to key elements including the Environmental Policy, Event Management Compliance and environmental compliance obligations management.

The Downer EMS provides a framework for environmental practices across Meandu Mine operations. The framework is based on best practice standards and aligned to:

- ISO14001 Environmental Management Systems
- ISO9001 Quality Management Systems
- AS/NZS 4801 Safety Management Systems
- OHSAS 18001 Occupational Health and Safety Management Systems.

This Waste Management Plan supports the waste management component of Downers EMS and supports Stanwell's overarching EMS and Environmental Sustainability Policy. In particular, this Waste Management Plan provides guidance for site personnel to ensure activities at Meandu Mine are undertaken in accordance with legal requirements and align with the overarching EMS framework.

3.4 RELATIONSHIP WITH OTHER DOCUMENTATION

This Waste Management Plan is a high-level document in a hierarchy of documentation for waste management at Meandu Mine. It is not intended to capture all details of waste management, but rather provide background information and context for waste management. Specific details around waste management are captured in relevant site plans and procedures as referenced throughout this Waste Management Plan.

Figure 3.1 shows how this document is part of the Meandu Mine EMS; which is a hierarchy of documentation managed through the Downer Integrated Management System (IMS) and accessed under the Meandu Mine Project Management Plan (PMP). A number of subordinate documents addressing waste management that includes procedures, work instructions and inspection forms are available on the Meandu Mine PMP and are reference in this document. A list of related documents is provided in Section 12.

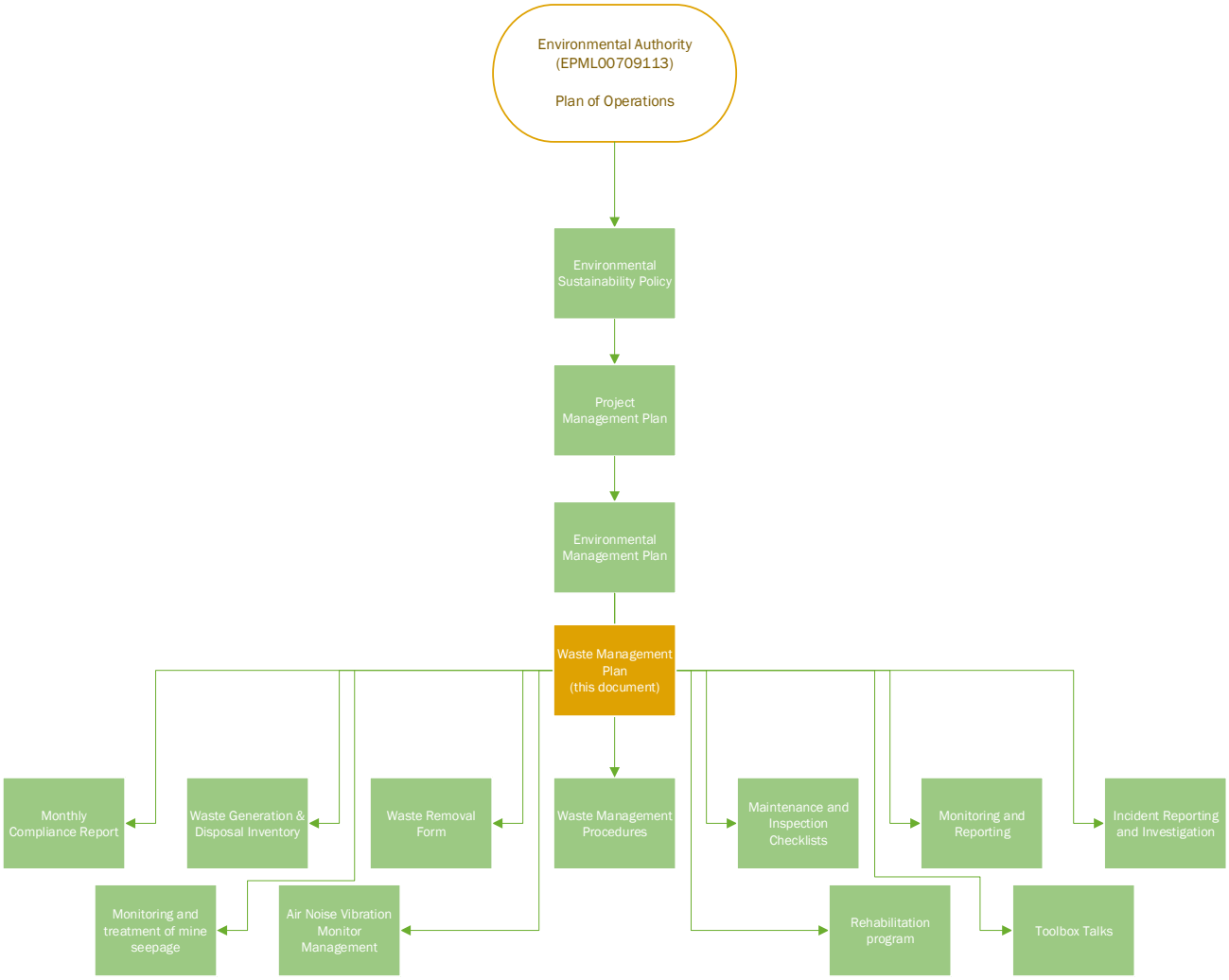


Figure 3.1 Waste Management Plan relationship with Meandu Mine PMP

3.5 COMMITMENTS

As stated in the Environmental Sustainability Policy, TEC are committed to (amongst other things):

- compliance with all site environmental approvals and other relevant environmental obligations
- optimising the use of raw materials and generation efficiency in order to maximise value and minimise the impact of our operations
- developing and reporting of measurable environmental objectives and targets that drive continuous environmental performance improvement.

With respect to waste management at the Meandu Mine, TEC has committed to:

- designing out or minimising waste generation as far as economically practical
- the continued implementation, monitoring and improvement of waste recycling initiatives including consideration of recovery avenues as beneficial markets emerge
- collection of monthly waste volumes for general and regulated waste data over the 2020-21 financial year and the setting of targets for the following year to achieve a reduction in waste being disposed of to landfill
- Continuous Improvement (CI) projects to increase efficiencies

- continued improvements to the tailings dewatering processes
- greater facilitation of water reuse options
- review mixed plant rejects cell cover depths
- development of an ash offtake facility.

Specifics details around these commitments are provided in Sections 8 and 9.

4 WASTE MANAGEMENT AND CONTROL STRATEGIES

4.1 WASTE MANAGEMENT HIERARCHY

Meandu Mine applies a sustainable approach to waste management. This approach involves adopting the waste hierarchy of waste avoidance and reduction in line with the requirements set out under the WRR Act. The waste hierarchy is shown in Figure 4.1.

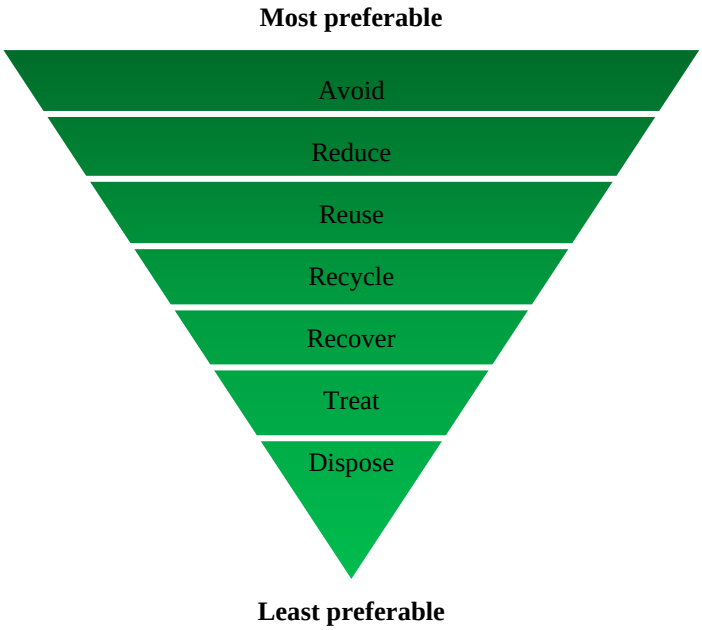


Figure 4.1 Waste and resource management hierarchy (WRR Act, Queensland Government)

A summary of the waste streams, current and future disposal methods and waste reduction initiatives/improvements is provided in the following sections.

4.2 WASTE STREAMS

The commercial and industrial waste stream from the Meandu Mine comprises:

- General waste
- Regulated waste
- Mine waste materials.

Waste materials produced from operations at Meandu Mine, and disposed of or stored on-site, includes:

- Waste Rock
- Tailings and Coal Rejects
- Coal Combustion Products.

While waste is generated from all the major mining areas and infrastructure at the mine site, mined waste rock and tailings and coal rejects represent the greatest volumes of waste generated on site.

Coal Combustion Products (CCPs) are produced during the coal combustion process at the power stations as a by-product of burning coal for power generation. Ongoing storage facilities for coal combustion products are critical to the ongoing operation of the Tarong power stations, and by extension, Meandu Mine. Coal combustion products from the Tarong power stations are currently stored in two (joined) mine voids at Meandu Mine; known as K2W and K2N (known collectively as K2W-N). Approval for coal combustion products (or ash) storage at Meandu Mine was originally granted under Beneficial Use Agreement (BUA) ENBU00736008 in 2009, then under an End of Waste Agreement and more recently incorporated into conditions within EA EPML00709113 (conditions A21-A24). As requested by DES, effective 13 February 2020, Tarong power stations have entered into a third-party agreement with TEC, approving the transfer of coal combustion products (and mine affected water) between sites.

A summary of each of these waste streams is shown in Table 4.1. Further details are provided in the following sections.

Table 4.1 Meandu Mine waste streams overview

WASTE	INDICATIVE ANNUAL VOLUME	GENERATION	DISPOSAL/STORAGE
General waste	2,500 m^3	On site through offices, stores, workshop, CHPP, lunchrooms and crib facilities.	Collected by contractor and disposed to landfill.
Recyclable	720 m^3	On site through offices, stores, workshop, CHPP, lunchrooms and crib facilities.	Collected by contractor for recycling.
Regulated waste	Refer to Section 0 for details.		
Waste rock	35,000 kbcm (FY2020)	Free-dig or blasted material moved in advance of coal mining.	Moved by dragline or truck and shovel to in-pit/ out-of-pit dumps, appropriate to mine plan and material characterisation.
Contingency Tailings	149 k tonnes (FY2020)	Fine rejects from CHPP coal processing that bypass the solid bowl centrifuges when down for maintenance.	Pumped as slurry to dedicated Tailings Storage Facility.
Mixed plant rejects	1,621 k tonnes (FY2020)	Blending of coarse rejects and dewatered tailings generated from coal processing at the CHPP.	Haulage to dedicated in-pit rejects cells.
Coal combustion products	1.35 Mt	By-product of coal combustion process that is captured from flue gases using precipitators.	Pumped as slurry to dedicated ash storage facilities (currently K2W-N).

4.3 GENERAL WASTE

General waste is not defined as regulated waste under legislation. General waste may derive from commercial or domestic sources and may include non-regulate wastes that are recyclable.

The types of general wastes generated at Meandu Mine are outlined in Table 4.2, along with current disposal practices. Practices that minimise wastes in accordance with waste management hierarchy are also identified. Meandu Mine uses plastic bins around site in all work areas. All bins have lids or are tagged out of service. The skip bins are cleaned and maintained by the primary contractor for general, recycling and regulated waste.

Table 4.2 Types of general waste

WASTE	CURRENT STORAGE PRACTICES	CURRENT DISPOSAL PRACTICES
Aerosol cans (empty)	General garbage bins in crib huts and around buildings, green wheelie bins in workshops and large general waste bins within the industrial area.	Disposed in general waste.
Aluminium foil	Recycle bins in crib huts or yellow-lid wheelie bins when foil is clean (not contaminated with food). If contaminated, then to go in general waste bins.	Collected for recycling (comingled).
Batteries (alkaline or ni-cad)	Small battery boxes. Transferred to the 120L wheelie bin stored in Environmental Lab.	Collected for recycling (specialised).
Cardboard	Recycle bins in crib huts, yellow-lid wheelie bins, or large recycle bins located around site.	Collected for recycling (comingled).
Concrete (wet from washing out trucks)	n/a	Disposed with rejects.
Concrete (dry waste)	n/a	Disposed with rejects.
Conveyor belt	CHPP storage shed	Sold for reuse.
Conveyor rollers	General waste	Collected for disposal.
Explosive / blast packaging	Bins for explosive waste packaging are located at the laydown area.	Collected for disposal and recycling.
Fire extinguishers (empty)	Stored behind CHPP. Note this does not include PFAS fire extinguishers (refer to Table 4.4).	Collected for recycling (specialised).
Fire hoses	Metal fittings removed if possible, for scrap steel. Hoses into 15 m^3 rubber skip located behind CHPP.	Collected for disposal.
General refuse	General garbage bins in crib huts and around buildings, green wheelie bins in workshops and large general waste bins within the industrial area.	Collected for disposal.

WASTE	CURRENT STORAGE PRACTICES	CURRENT DISPOSAL PRACTICES
Green waste	Cleared and grubbed material pushed up into windrows to be burnt. Vegetation to be mulched or pushed to the edge of the work zone if in limited quantities. Vegetation in Hoop Pine areas are mulched and used for erosion and sedimentation controls.	Cleared and grubbed material is burnt prior to topsoil stripping, to reduce fire fuel load and allow ash, char and nutrients to be incorporated into and collected with the topsoil. Suitable logs are used in rehabilitation areas, to assist with providing fauna habitat and soil surface protection.
Paint (dry and empty containers)	Drums or containers with paint residue to be let dry out to form solid mass or add paint hardener to ensure set, then containers can be placed in general waste bins.	Collected for disposal or reprocessing.
Paper	Place paper in recycle bins beside photocopiers, crib rooms or recycle bins.	Collected for recycling (comingled).
Plastic containers; aluminium cans; glass containers	Place in the recycling bins located in crib rooms or large recycle bins around site.	Collected for recycling (comingled).
Printer and toner cartridges	Printer recycles boxes located at some printers around site.	Collected for recycling (specialised).
Rubber	General waste bins for small volumes or 15 m^3 skips at CHPP for larger quantities. See notes on conveyor belts.	Collected for disposal.
Scrap metal (low grade)	Scrap metal bins located around workshops and main skips at laydown area.	Collected for recycling (specialised).
Scrap metal (high grade)	Dragline rope stored at pile lay down area on western haulroad. Dump chains stored at Bucket shop. Ground Engaging Tools (GET) placed in general scrap metal bins around workshops.	Collected for recycling (specialised).
Solvents (parts washers)	Parts washer at individual workshops.	Collected for recycling (specialised).
Steel cans	Place in recycling bins located in crib huts, yellow-lid wheelie bins or large recycle bins.	Collected for recycling (specialised).
Timber part boxes / pallets	Timber boxes and pine pallets to be stored behind main bathhouse.	Reused on site.

Future initiatives to reduce general waste are discussed further in Sections 8 and 9.

4.4 REGULATED WASTE

4.4.1 RELEVANT SITE PROCEDURES

The relevant site procedures for regulated waste are shown in Table 4.3.

Table 4.3 Relevant site procedures relating to the storage and disposal of regulated waste

DOCUMENT TYPE	TITLE	REFERENCE	PURPOSE OF DOCUMENT
Procedures	Regulated Waste Management Procedure	8512-SE-P1019	Provides details on the requirements for the disposal of regulated trackable waste from Meandu Mine.
	Disposal of Tyres Procedure	8512-DM-PL-P15	Procedure for managing the disposal of tyres at Meandu Mine.
	Abrasive Blasting Procedure	8512-SE-P1002	Procedure for managing abrasive blasting including management of abrasive blasting wastes.
	Bioremediation Area Management Procedure	8512-SE-P1005	Outlines the responsibilities and guidelines for the establishment and management of the bioremediation area including control of contaminated soils, managing plots and removal of clean soil.
	Sewage Treatment Plant	8512-SE-P1008	Describes the requirements for the efficient operation of the Sewage Treatment Plant, including inspections, breakdown procedures, responsibilities and health and safety requirements.
Standard Operating Procedure	Using Hazardous Substances	8512-SE-SOP5	Procedure for use of hazardous substances onsite including potential environmental impact and waste disposal.
	Abrasive Blasting, High Pressure, Chemical and Mechanical Cleaning	8512-SE-SOP16	To identify, assess and control hazards associated with abrasive blasting; and high pressure, chemical and mechanical cleaning at Meandu Mine, including trigger level determination for regulated waste and disposal of rejects.
Forms	Tyre Disposal Record	8512-DM-PL-F139	Identifies the tyre size, date of inspection, and disposal location record for earthmoving tyres.
	Sewage Treatment Plant Daily Maintenance Check	8512-SE-F1018	Identifies the daily maintenance checks at the Sewage Treatment Plant including visual checks, cleaning accumulated soils and checking parts.
	Washbays, Fuel Farm and Oily Waste Pit Daily Check	8512-SE-F1022	Identifies the daily checks for the truck wash and oily waste pit, including checking parts and removing rubbish.

DOCUMENT TYPE	TITLE	REFERENCE	PURPOSE OF DOCUMENT
	Bioremediation Area Activity Inspection Checklist	8512-SE-F1023	List of items to check during bioremediation area inspections.
Data recording and storage	Monthly waste generation and disposal inventory	8512-DM-SE-F61	Records wastes generated and disposed of, including the type of waste, area the waste is generated, quantity of waste, disposal technique, disposal agency and any reference/invoice numbers.
	Meandu Register of Project Files	4648-DM-SE-F5	Identifies the location of waste records.
	Tyre Disposal Record	4868-DM-PL-F139	Identifies the tyre size, date of inspection, and disposal location record for earthmoving tyres. All earthmoving tyres shall be tracked through Otracom via their unique serial number. Records reviewed at a minimum monthly basis to verify earthmoving tyres are located in their correct status.

4.4.2 TYPES OF REGULATED WASTE

Regulated waste requires specific handling and disposal due to their potential to cause harm to humans and/or the environment. Some regulated wastes are classified as trackable whereby a Waste Transport Certificate is required under legislation to identify the type and quantity of waste being carried and to track its transport and disposal.

The types of regulated wastes generated at Meandu Mine are shown in Table 4.4. Storage of regulated waste is undertaken in designated locations and within suitable storage containers to minimise the risk of causing environmental harm, this is undertaken to accumulate sufficient quantity or volume of material prior to disposal. Recycling or reprocessing of regulated waste for beneficial use is the preferred method of disposal. Disposal to a licensed regulated facility is completed as a last resort.

Table 4.4 Types of regulated waste

WASTE	INDICATIVE ANNUAL VOLUME	CURRENT STORAGE PRACTICES	CURRENT DISPOSAL PRACTICES
Abrasive blasting residue	Ad Hoc	Blasting residue collected should be placed in enclosed drums or waste skips.	Waste is removed from site and disposed to licenced landfill.
Asbestos	Ad hoc 1 m^3 removed over previous 24 months	205 litre poly drum located at radioactive storage facility. Where larger volumes are being generated handling, storage and disposal will be in accordance with Standard operating procedure Managing Gases, Spray Painting and Asbestos (8512-SE_SOP). Material must be triple wrapped in black builders plastic.	Disposed of at licenced landfill.

WASTE	INDICATIVE ANNUAL VOLUME	CURRENT STORAGE PRACTICES	CURRENT DISPOSAL PRACTICES
Batteries (lead acid)	8.5 tonnes (2018-19 average)	Place in the battery storage containers located on the northern side of the main workshop. Once full batteries then relocated to laydown area.	Collected for recycling. Removed approximately every quarter.
Batteries (lithium ion)	Included in Batteries (lead acid)	Small battery boxes located around site which are transferred to the 120 L wheelie bin stored in Environmental Lab.	Collected for recycling.
CCA Timber	Ad Hoc	Case by case basis. Contact Environmental Officer or Infrastructure Supervisor.	Disposed of at licenced landfill.
Chemical containers – empty	See Combined Hydrocarbon Waste	Storage requirement dependent on substance to be removed. Refer to MSDS.	Collected for processing / disposal.
Chemical waste	See Combined Hydrocarbon Waste	Storage requirement dependent on substance to be removed. Refer to MSDS.	Collected for processing / disposal.
Coolant (used)	2300 L (2018-19 average)	Waste coolant stored in 1000 L IBC's at end of workshop slab.	Collected for recycling. Removed once per year.
Dragline grease (Black jack)	See Combined Hydrocarbon Waste	Stored in 1.5 m^3 bins or 205 L drums at Bucket Shop.	Collected for disposal.
Empty drums (contents unknown)	See Combined Hydrocarbon Waste	Drums to be stored on bunded pallets at laydown area.	Collected for disposal.
Empty drums (hydrocarbons)	Volume contained within recycling	Drums used for hydrocarbon storage should be emptied into the waste oil tank at fuel farm and then drained into waste oil bin at laydown area. Empty drums to be stored at laydown area opposite Franna Crane shed.	Collected for recycling.
Fire Fighting Foams (including Per-and poly-fluoroalkyl substances (PFAS) materials)	Ad Hoc	Hydrocarbon storage area.	Collected for disposal at approved facility. AFFF was phased out from use on-site in June 2019. Managed in accordance with DES Environmental Management of Firefighting Foam Policy 2016.

WASTE	INDICATIVE ANNUAL VOLUME	CURRENT STORAGE PRACTICES	CURRENT DISPOSAL PRACTICES
Fluorescent tubes (High Intensity Discharge (HID) lighting)	Ad Hoc	Dedicated bins are located inside the main workshop opposite staircase to planning office.	Collected for recycling.
Grease (spillage from grease cylinders at end of workshop for filling service trucks)	See Combined Hydrocarbon Waste	Oily rags and absorbent bins.	Collected for disposal.
Combined Hydrocarbon Waste	189 m^3 (2018-19 average)	As per individual descriptions.	Collected for disposal, frequency monthly-bimonthly.
IBC's (empty)	Ad Hoc	Stored at laydown area.	Collected for disposal. Suitable IBCs collected for reuse/recycling.
Kleensweep (used)	See Combined Hydrocarbon Waste	Oily rags and absorbents bins.	Collected for disposal.
Megadure Ceramic Part A&B (empty containers)	Ad Hoc	205 litre drums at FPM.	Collected for treatment and disposal
Megapoxy Part A & B (empty containers)	Ad Hoc	205 litre drums at FPM.	Collected for treatment and disposal.
Medical waste	Ad Hoc	Medical waste is collected in the Yellow "Clinical Waste" containers which are located at the gatehouse.	Collected for disposal.
Oil (waste)	390 kL (2018-19 average)	Waste Oil Tank – Fuel Farm capacity 22,500 L.	Collected for recycling, disposed monthly.
Oil filters	See Combined Hydrocarbon Waste	Filters to be drained and crushed where possible and placed in 1.5 m^3 skips at workshops.	Collected for disposal at licensed landfill.
Oil absorbents and oily rags	See Combined Hydrocarbon Waste	1.5 m^3 bins or blue hydrocarbon wheelie bins located at workshops and fuel farm.	Collected for disposal at licensed landfill.
Oily water	See waste oil	All liquid potentially contaminated by oil is passed three triple interceptors or oil/water separator with the oil only fraction being collected and removed from site.	Oil fraction collected for recycling.

WASTE	INDICATIVE ANNUAL VOLUME	CURRENT STORAGE PRACTICES	CURRENT DISPOSAL PRACTICES
Paint (wet)	Ad Hoc	Wet paint to be stored on bunded pallets at warehouse.	Collected for disposal or reprocessing.
Pesticides (empty containers)	Ad Hoc	Larcaba Shed (located SE end of dragline erection pad).	Responsibility of contractor to remove from site.
Pesticides	Ad Hoc	Larcaba Shed (located SE end of dragline erection pad).	Responsibility of contractor to remove from site.
Radioactive materials	Ad Hoc	Contact Radiation Safety Officer prior to proposed movement of radioactive gauges to ensure the correct requirements are carried out. A radioactive storage shed is located on Meandu Mine in the vicinity of the raw water dams however this facility is generally not used as the contractor (RTI) normally transports any material off as soon as it is removed from equipment.	Collected and shipped back to USA for disposal.
Soil (contaminated with hydrocarbons)	2392 tonnes (2018-19 average)	Contaminated soil is to be taken to the bioremediation area for treatment. Very small amounts of contaminated soil can be placed in oily rags and absorbents bins.	Treated in bioremediation area to reduce hydrocarbon contaminants. Once treated, material is relocated to spoil dump areas. Disposal frequency dictated by sump, washdown and spill clean up, generally new material every 2-3 months.
Transformer oil	See Waste Oil	Oil to be removed by contractor undertaking works on transformers or stored in containers for disposal.	Removed from site by licensed waste management contractor.
Tyres	260 tonnes (2018-19 average)	Tyres are stored at tyre storage area in accordance with DES's Operation Policy: Mining disposal and storage of scrap tyres at mine sites (ESR/2016/2380, 5 December 2014). A 10 m firebreak radius around the tyre storage area is implemented.	Disposed of in pits in accordance with DES's Operation Policy: Mining disposal and storage of scrap tyres at mine sites (ESR/2016/2380, 5 December 2014). Quantity and coordinates of the disposal location(s) are recorded as outlined in section 4.4.1. Disposal frequency dictated by machine utilisation and hours, general one disposal per year.
Sewerage treatment plant sludge	Ad Hoc Only undertaken when full	Sewage Treatment Plant	Dewatered in a drying bed and then disposed of in the mixed plant rejects dumps. Leachate from drying beds is directed to a small non-release retention pond for evaporation and ground absorption.

WASTE	INDICATIVE ANNUAL VOLUME	CURRENT STORAGE PRACTICES	CURRENT DISPOSAL PRACTICES
			Treated sewage water is chlorinated and pumped via a 3-inch poly-pipe to the Tarong Power Station sewage effluent dam for use on site.

4.4.3 WASTE MANAGEMENT LAY DOWN AREAS

Waste material is segregated and stored onsite within designated areas to allow the accumulation of enough material to economically dispose or recycle. The main storage location is within proximity of the main workshop and industrial area, as shown in Figure 4.2. This area is not subject to flooding and is located within proximity to major waste generation areas.

4.4.4 TRANSPORT OF REGULATED WASTE

The EP Regulation allows for written agreements known as Waste Agents Agreement to be made between the waste generator and the waste transporter or receiver. Under this agreement the waste generator appoints an 'agent' to act on their behalf to meet relevant waste tracking obligations. There are a number of waste agent's agreements in-place at Meandu Mine whereby waste tracking documentation is completed and submitted to DES by the waste transporter on behalf of the waste generator – Meandu Mine. These Waste Agent Agreements are outlined in Regulated Waste Management Procedure (8512-SE-P1019).

4.4.5 CONTROL OF SEEPAGE AND LEACHATE

Regulated waste materials are appropriately stored in designated storage areas (including 1.5 m and 3 m skip bins with lids or drums) and removed regularly from site. All waste storage areas are inspected weekly by the Infrastructure Department and monthly by DES. Any storage containers such as skips that do not have appropriate lids or have any corrosion are tagged out of service and removed from site by the waste contractor and the skips are replaced. Spare skips and plastic bins are kept on site for change out of any tagged out bins.

Any waste type with the potential to leak and generate seepage is stored in bins or within bunded storage areas. All heavy greases are double bagged before disposal in hydrocarbon skips. Meandu Mine also reports all hydrocarbon spills and leaks to the Environment Department through the Downer Event Management System (INX).

Wastes storage areas on-site are not subject to flooding.

4.4.6 CONTROL OF FUGITIVE EMISSIONS TO AIR

Regulated wastes are regularly removed from site for treatment, recycling or disposal offsite at appropriated licensed facilities. All waste is contained in bins with lids. Any bins with damaged lids are tagged out and replaced by spare stocks maintained on site. Air emissions from regulated wastes stored during this time are not expected to generate materialistic emissions.

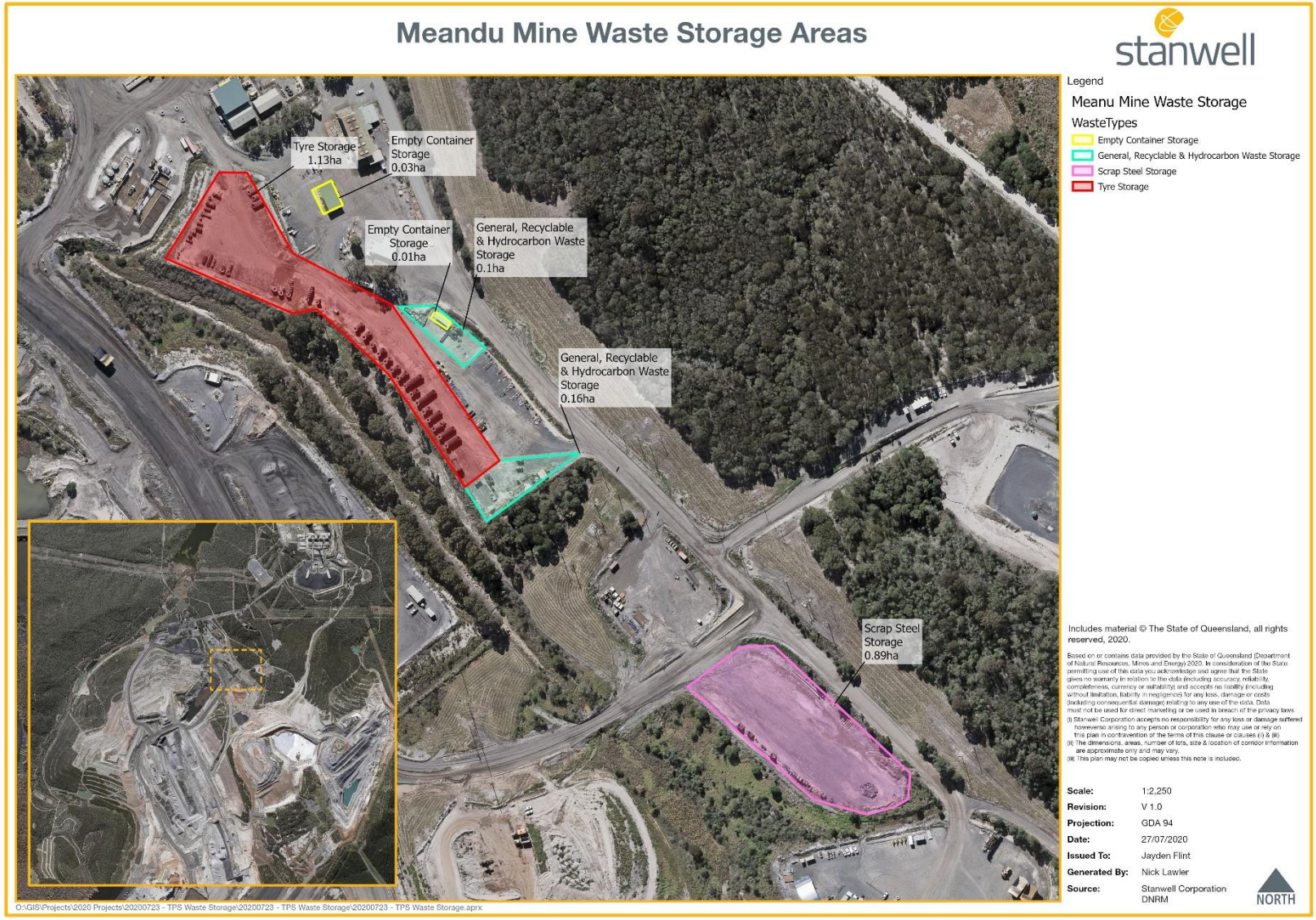


Figure 4.2 Meandu Mine Waste Storage Areas

4.5 MINED WASTE MATERIALS

Mined waste materials produced from operations at the Meandu Mine and disposed or stored of on-site includes:

- Waste Rock
- Tailings and Coal Rejects
- Coal Combustion Products (Ash) – waste material piped from the Tarong power stations to the K2W-N pit voids.

While waste is generated from all the major mining areas and infrastructure at the mine site, mined waste rock and waste from the CHPP (tailings and coarse rejects) represent the greatest volumes of waste generated. This is likely to remain the case for the life of the mine.

4.5.1 WASTE CHARACTERISATION PROGRAM

Understanding the material characteristics of mined waste materials is an important requirement to inform disposal strategies and ensure that the generation of acid metalliferous drainage is reduced to as low a level as possible. Since 1990, a number of studies have been undertaken relating to the geochemical characterisation of materials from the Meandu Mine. These have involved both static and kinetic leach column testing of overburden, interburden and process wastes such as rejects, tailings and ash as well as mine lithological units.

The majority of geochemical sampling at Meandu Mine has comprised targeted programs aimed at identifying acid and metalliferous drainage (AMD) occurrences in pit lakes (AGCWC 1993a) or in seepage from the North West Backfilled Pit (AGCWC 1993b, 1994, 1996, EGi 2006, 2007, 2016). As extensive geochemical characterisation was required to investigate the source of the observed AMD seepage at Rejects Storage Area 1 (RSA1) in 2016 (EGi 2016, RGS 2018, WSP 2018), a systematic geochemical sampling program was commenced at the mine at the same time to provide geochemical characterisation of future waste material and existing waste dumps (EG1 2016, RGS 2018).

The majority of samples collected for the systematic geochemical sampling program were open hole rotary chip samples (811 samples, including composites), supplemented by a further 309 diamond drill core samples (EGi 2016, RGS 2018). The bore holes were mainly drilled through *in-situ* formation in the forward mine planning area, with samples of overburden, interburden and coal collected; however, a number of bores were drilled through existing waste dumps to provide samples of older spoil, rejects and tailings. Additional samples of historic spoil, rejects and tailings were collected from test pits and grab samples from waste dump and tailings storage facility (TSF) surfaces. Representative samples of current process wastes (CPP, tailings and rejects) were collected directly from the waste stream at the point of production (CHPP and power station) over a period of 12 – 14 months.

The sampling strategy for the drilling program aimed to screen the entire mine stratigraphy for acid potential, identify horizons of concern and look for correlations between holes that indicate continuity. Drill chip samples were generally collected at 1 m intervals, although some longer sample intervals from the spoil dump bore holes were required due to poor recovery. In the laboratory approximately one third of the drill chip were composited. Composite intervals ranged from 1 m to 5 m and averaged 2 m. Drill core samples were collected at intervals of 0.5 to 1.8 m, averaging 1 m.

The most recent mined waste material classification results from the waste characterisation program are summarised in Table 4.5.

Table 4.5 Summary of mined waste classification results from waste characterisation program

WASTE MATERIAL	RESULTS
Lithology	— All non-organic lithologies returned a non-acid forming (NAF) classification based on average acid neutralising capacity (ANC) and Total Sulfur values. Statistically all non-organic lithologies have sufficient samples to establish that they are NAF on average at 95% confidence interval. — Of the organic lithologies, Coal, Coal Undifferentiated, Coal Weathered, Stony Coal and Lignite, are potentially acid forming (PAF) on average and on all individual samples. Carbonaceous Mudstone returns an uncertain (AMIRA, 2002) classification on average but requires more sampling. Carbonaceous Siltstone is NAF on average but requires further sampling.
Overburden units	— All overburden units return a NAF classification on average. — The overburden being stratigraphically above the coal-bearing formations, should not contain significant amounts of organic lithologies. — However, some areas within the overburden display contiguous organic lithology material which is possibly transported (i.e. area of conglomerate – sandstone). — Several high total sulfur PAF samples of lignite are also present within the overburden. Once these lignite lithology samples are excluded, none of the overburden units contain PAF samples apart from two samples of shale which are in direct contact with the uppermost coal seam.
Interburden units	— Each interburden unit contains one or two dominant non-organic lithologies but each may also contain small to moderate amounts of organic lithologies. — Of the three units defined none are PAF on based on average total sulfur and ANC, although they contain between 3% and 16% of PAF samples (by sample count). — Significant portions of the interburden is classified as UC (between 13% and 30% by AMD sample count).
Spoil (excluding rejects)	— Appears to be comparable to overburden within the forward mining planning area in terms of Total Sulfur and ANC.
Coarse rejects	— PAF classification on average.
Tailings	— PAF classification on average.
Ash	— NAF classification on average.

An environmental investigation into AMD at the mine in 2018 determined that the most probable cause of historic and ongoing AMD events from North West Backfilled Pit was oxidation of sulfide minerals and subsequent leaching of AMD weathering products from the reject storage. Kinetic leach column testing has confirmed that fresh coarse reject material is acid producing when allowed to oxidise, the fine grade rejects, tailings and ash maintains neutral pH.

Current management procedures in place at the Meandu Mine to control the risk of acidic drainage generation include:

- Limiting storage/exposure time of coarse reject materials at the reject stockpile to less than two weeks.
- Incorporating of fine-grade rejects and dewatered tailings, whereby pore voids within the coarse rejects will be filled with highly plastic low permeability tailings limiting oxidation and permeability. The combined reject and tailings

stream (mixed plant rejects) are placed into the spoil dumps and progressively co-mingled or encapsulated with overburden and interburden.

- PAF waste units identified in the highwall during mining will be segregated and placed at least 6 m under the final landform and covered by NAF material.

To improve the reliability of the overburden model so that PAF units can be identified ahead of mining and managed appropriately, drilling, sampling and analysis of mined material is ongoing. Sampling requirements for mine material characterisation are planned into the site drilling program. Ahead of mining, characterisation testing is undertaken on a representative subset of overburden chip samples, with individual samples being representative of the various rock types intersected and their relative degree of weathering.

Field sampling programs are undertaken in line with Procedure Geochemical Sampling (8512-OC-P1003), which provides the sampling instructions for:

- Bulk drill hole cuttings
- Twin chip tray
- Core sampling
- Pit/grab stockpile, bulk sampling
- Water sampling.

Geologically logged drilling is undertaken at a scale of approximately 80 m x 80 m to obtain seam structure and lithological definition. Cored drilling is undertaken at a scale of approximately 300 m x 300 m targeting the overburden sequence to obtain samples for geochemical and physical analysis. Geological logging has an enhanced focus on identification of organic lithologies at a resolution of 20 cm in open drilling and 1 cm in core drilling. While current data suggests that the classification for interbuden unit is uncertain, they are conservatively classed as PAF in the model. Future programs may seek to fine tune this classification.

The handling, storage and analysis of field samples is undertaken in line with Procedure Geochemical Sampling (8512-OC-P1003), which stipulates the timeframes for storage, labelling of samples and suitable storage locations along with the minimum requirements on the communication protocols to the laboratory, such as type of analysis, number or samples, labelling and timing expectations.

Characterisation of material for rehabilitation suitability is undertaken based on progressive drilling and sampling programs. Results from material characterisation programs are reviewed for rehabilitation suitability in terms of physical and geochemical properties, from which trigger levels are derived and re-assessed as new data becomes available. Key aspects used to determine rehabilitation suitability include erosion potential (relating to texture and dispersion potential), water holding capacity, nutrient levels and acid generating potential.

Material characterisation outcomes are incorporated into the geological model where appropriate, with rehabilitation suitability generally aligning with lithological units. This is then used as the basis for LOM plan as well as short to mid-term scheduling and material placement within the landform.

Sampling of rejects, tailings and ash streams is also ongoing for basic geochemical test parameters to ensure the geochemical nature of the mine waste is tracked over time.

Disposal of mined material is undertaken in accordance with the requirements of Procedure Material Movement – Mine Planning (8512-OC-P1004), which requires material type to be known ahead of dumping and matched to suitable disposal locations. In determining suitable disposal locations reference document Meandu Mine – Material Design Parameters (8512-OC-R1028) is used to guide how specific material should be disposed of, with PAF material being deposited at least 6 m below the final landform. This document is updated on an annual basis or as more material characterisation information becomes available.

5 WASTE ROCK

5.1 OVERVIEW

5.1.1 RELEVANT SITE PROCEDURES

Relevant site plans and procedures relating to the storage and disposal of waste rock are shown in Table 5.1. These plans and procedures are aimed at ensuring that the material characterisation of waste rock materials is understood to ensure that generation of AMD is reduced to as low a level as possible, and to limit the impact to the receiving environment.

Table 5.1 Relevant site procedures relating to the storage and disposal of waste rock

DOCUMENT TYPE	TITLE	REFERENCE	PURPOSE OF DOCUMENT
Management plans	AMD Mine Planning Management Plan	8512-OC-PLA1001	Provides a clear management structure for the handling of AMD Material at Meandu Mine.
Procedures	Material Movement – Mine Planning	8512-OC-P1004	Procedure for the management of Acid Saline and Metalliferous Drainage when undertaking mine planning activities.
	Geoscience AMD	8512-OC-P1002	Procedure for the management of Acid Saline and Metalliferous Drainage when undertaking geological activities.
Reference document	Meandu Mine – Material Design Parameters	8512-OC-R1028	Identifies the design parameters for handling of PAF / NAF pit and dump profiles for the Meandu Mine to be used to ensure best practice final landforms are built at the mine with respect to available site material.
	Dust Management Plan	8512-SE-PLA1015	Provides overview of the potential impacts and response plan to dust generated at Meandu Mine.
	Erosion and Sediment Control Plan	8512-SE-1012	Documents processes and strategies in place to minimise erosion and contain eroded sediment at Meandu Mine.
Forms, data recording and storage	Geoscience AMD	8512-OC-P1002	Outlines the data collection, integrity and security requirements for samples and data. Currently data is contained in both AcQuire and GDB. This document also stipulates how the data records are to be used to inform the monthly and annual recording and reporting of NAF and PAF inspections.

In accordance with Procedure Material Movement – Mine Planning (8512-OC-P1004), classification of the material being excavated and disposed is recorded on plans. The Material Movement – Mine Planning Procedure also outlines monthly and annual reporting requirements associated with these dig and dump plans which includes, material classification, location information including coordinates (including reduced level (RL)) that bound the area of activity and summary polygons representing the extent, roof and floor of dig and dump locations. Monthly and annual records of samples and associated purpose are also maintained in accordance with Procedure Geoscience – AMD (8512-OC-P1002).

5.1.2 WASTE ROCK VOLUME MINIMISATION

TEC approaches the Mine Waste Rock volumes at the highest level of the waste hierarchy, utilising the "Avoid" and "Reduce" steps. To achieve this TEC has executed an extensive and ongoing planning program to avoid mining unnecessary regions of the deposit and reducing to a minimum the quantity of waste rock moved in sourcing the coal fuel for the Tarong power stations. In 2013, 2014, 2016, 2017 and 2019 detailed LOM Plans were undertaken, evaluating the coal resource for the best strategy to deliver the required fuel volumes to the associated power stations. Demand for power generation from Tarong power stations is modelled quarterly and annually, with extensive reporting to the Australian Energy Market Operator (AEMO). Multiple legislative and demand scenarios are incorporated in each iteration of the fuel modelling, which is undertaken incorporating the full Stanwell portfolio of generation assets.

These plans have resulted in a reduction in planned waste rock movement per tonne of coal delivered. The LOM plan will continue to be regularly updated and improved in a three-year cycle and any reduction in planned waste movements will be translated into the mine quantities.

5.1.3 WASTE ROCK PREDICTED VOLUMES

Table 5.2 shows the expected volumes of waste rock material to be produced over the 2020, 2021 and 2022 financial years.

Table 5.2 Waste rock expected volumes

MATERIAL TYPE	FY2020	FY2021	FY2022
Total prime (prime kbcm)	34,817	30,594	33,783
Topsoil (kbcm)	197	90	20
Prime waste (kbcm)	34,621	30,504	33,763

Sufficient area is available to emplace this waste rock material within the approved area of the mine in accordance with the Project Approval, and current Plan of Operations, which will be replaced by the Progressive Rehabilitation and Closure Plan in late 2020.

5.1.4 DISPOSAL ACTIVITIES

Waste rock material is moved by dragline and excavator/ haul truck fleets to in-pit or out-of-pit overburden dumps, appropriate to the mine plan and mining location. The final landform is constructed in accordance with the approved Plan of Operations (based on the LOM Plan) and in accordance with the requirements of EA EPML00709113.

Material identified as PAF is subject to strict dump location criteria. That is, it must be located at minimum 6 m depth from the final landform design surface (and where possible, is located at a greater depth than 6 m). The material placement and cover requirements are continually reviewed as additional information becomes available from the material characterisation program (refer Section 4.5.1). The LOM Plan confirms that there is sufficient volume of NAF material to provide adequate cover and compliance.

5.1.5 CONTROL OF SEEPAGE AND LEACHATE

Control measures are in place to manage seepage and leachate from the mine landforms. In particular, the site Water Management System is designed to prevent contaminants from being released to any groundwater or watercourse, in the event that leachate is generated. A ground and surface water monitoring program (designed by an appropriately qualified person) is in place which monitors surface water and groundwater quality (including AMD parameters) at selected locations. This program includes daily, monthly, quarterly and/or annual monitoring and review of tailings dams, retention dams, pits, Meandu Creek, groundwater bores and seepage areas to ensure compliance with EA EPML00709113. This includes the planned installation, maintenance and calibration of real time data monitoring of compliance points.

Other control measures include:

- controlled movement of retention dam water to allow out of specification water to be diluted to maintain compliance at water discharge locations
- construction and operation of RD27 and associated Lime Dosing Plant in order to improve water quality prior to discharge offsite
- construction of additional retention dams and water infrastructure as required in order to contain seepage and re-use a greater amount of water, where possible
- progressive rehabilitation to reduce surface water infiltration
- specialist consultants engaged to assist with short, medium and long-term solutions and required investigations to address any AMD issues
- surveys and studies completed in order to map and risk assess existing and potential acid mine drainage issues across the mine
- mine waste characterisation program result which inform mined waste handling practices.

5.1.6 CONTROL OF FUGITIVE AIR EMISSIONS

Fugitive air emissions from mine landforms are managed in accordance with the site Dust Management Program. This program is maintained and implemented at the Meandu Mine to ensure that mining activities do not cause an environmental nuisance.

Dust and particulate matter released from mining activities is minimised by:

- watering of unsealed roads
- dust suppression sprays
- avoidance of certain activities, such as blasting, during windy conditions,
- progressive rehabilitation.

Where required, dust monitoring is undertaken in accordance with the requirements of EA EPML00709113 and the site Dust Management Plan (8215-SE-PLA1015).

5.1.7 DECOMMISSIONING AND REHABILITATION

Spoil dumps are progressive rehabilitated during ongoing mining operations in accordance with the Plan of Operations and as outlined in Section 2.2.5.

In accordance with condition G1 of EA EPML00709113, all areas significantly disturbed by mining activities must be rehabilitated to achieve a landform that is:

a) Safe to humans and wildlife

b) Non-polluting

c) Stable

d) Able to sustain the post-mining land use.

Rehabilitation planning is undertaken at a strategic level to ensure that a minimum of re-work is required. This minimises both the impact on the landform and the amount of equipment effort required to achieve the rehabilitation.

At the LOM plan level, a sequence of disturbance, mining, dumping and then rehabilitation is identified. This is then developed in more detail in the shorter-term plans, reaching execution point each year to achieve the areas nominated under the relevant plan of operations (or the estimated rehabilitation cost (ERC) plan once active). Rehabilitation is undertaken progressively as required by the EA and EP Act.

At a tactical level the waste dumps are designed and dumped to be consistent in volume with the final design volume, minimising the equipment time and emissions (dust, fugitive and equipment based) to achieve the final erosional and geotechnically stable landform with topsoil and seed in place.

Material with high erosion risk is placed to avoid surface exposure and material that is unlikely to support vegetation growth is not placed within the upper root zone, unless appropriate remediation or controls have been implemented. This may include amelioration, addition of fertiliser, lowering the design slope for a particular area, or blending of materials, as appropriate.

Drainage structures on rehabilitated spoil dumps are designed in accordance with the site Erosion and Sediment Control Plan, that considers catchment flows and resulting flow velocity, scour potential, construction material, construction methodology and rock placement requirements. Deep ripping is undertaken prior to or in conjunction with direct seeding. This assists in reducing overland flow, reduces erosion potential and improves water retention to assist germination.

5.1.8 MONITORING AND MAINTENANCE

Tracking of material placement is undertaken to demonstrate that PAF material has been placed in the appropriate location within the final landform profile. Annual reconciliations are completed to confirm PAF material disposal locations. Profiling of the final landform is undertaken with use of GPS-equipped equipment and progressive surveys to verify that the final landform is compliant with design, prior to final rehabilitation works.

Post-seeding, the rehabilitated area will be assessed as per the site Land Rehabilitation Inspection Checklist (8512-SE-F1125) to ensure it meets the relevant quality criteria as stated in Schedule G of EA EPML00709113. The final landforms will be included as part of the site rehabilitation monitoring program which will be used to determine success in terms of erosion, stability, groundcover and vegetation development.

This program is described in the Plan of Operations, and the site Environmental Monitoring and Inspection Program (Downer EDI 2017).

If during the rehabilitation monitoring period, any major cracking or differential settlement is observed, a geotechnical engineer will be engaged to assess the landform and recommend remedial works.

The aim of the ongoing monitoring and maintenance program is to move the rehabilitation towards a self-maintaining state that is able to be progressively certified as completed rehabilitation. Data collected is analysed and used to improve the future design and execution of rehabilitation at Meandu Mine.

6 TAILINGS AND COAL REJECTS

6.1 OVERVIEW

This section covers storage and disposal of tailings, coarse rejects and mixed plant rejects. In addition to conditions A17-A19 regarding waste management, disposal of tailings and rejects is also regulated by conditions G8, G13 and G14 of EA EPML00709113 as shown in Table 6.1.

Table 6.1 EA EPML0070913 - reject requirements

CONDITION NUMBER	REQUIREMENTS
G8	**Tailings Deposition Areas** When the deposition of tailings into an area ceases, the holder of this environmental authority must install a final cover system to the tailings dam which effectively minimises: a) infiltration of water in to the tailings deposition area b) the likelihood of any erosion occurring to the final cover system.
G13	Reject disposal areas must be covered by a minimum of 6 (six) metres capping designed in accordance with criteria determined by a suitably qualified and experienced person.
G14	Reject disposal areas capped in accordance with **Condition G13** must include an upper layer of earthen material design and maintained to sustain plant growth.

6.1.1 RELEVANT SITE PROCEDURES

Relevant site procedures relating to the storage and disposal of tailings and mixed plant rejects are outlined in Table 6.2.

Table 6.2 Relevant site procedures relating to the storage and disposal of tailings and mixed plant rejects

DOCUMENT TYPE	TITLE	REFERENCE	PURPOSE OF DOCUMENT
Management plans	AMD Mine Planning Management Plan	8512-OC-PLA1001	Provides a clear management structure for the handling of AMD Material at Meandu Mine.
	North West B Tailings Storage (NWB TSF) Facility Decommissioning and Rehabilitation Plan	-	Describes the strategies and works that will be implemented to transform the NWB TSF into a safe, stable, non-polluting landform consistent with the over-arching rehabilitation objectives and plans for Meandu Mine.
	RD16 Tailings Storage Facility (TSF) Decommissioning and Rehabilitation Plan	8512-SE-PLA1025	Outlines strategies and works that will be implemented to transform the RD16 TSF into a safe, stable and non-polluting landform consistent with the overarching rehabilitation objectives and plans for Meandu Mine.

DOCUMENT TYPE	TITLE	REFERENCE	PURPOSE OF DOCUMENT
Procedures	Tailings Storage Facility (TSF) and Pipeline	8512-SE-P1009	Outlines the operational requirements of the TSF, tailings pipelines, retention dams and associated pumping equipment, including procedure for current and future tailings disposal requirements.
	Material Movement – Mine Planning	8512-OC-P1004	Procedure for the management of Acid Saline and Metalliferous Drainage when undertaking mine planning activities.
	Geoscience AMD	8512-OC-P1002	Procedure for the management of Acid Saline and Metalliferous Drainage when undertaking geological activities.
	Geochemical Sampling	8512-OC-P1003	Procedure for ensuring consistency and best practice when geochemical data is collected, including sampling methodology, handling and storage.
Work instruction	Placement of Mixed Plant Rejects	8512-OC-WI1020	Work instructions for mixed plant rejects during the dump design phase, classification and emplacement phase.
Reference information	Meandu Mine – Material Design Parameters	8512-OC-R1028	Identifies the design parameters for handling of PAF / NAF pit and dump profiles for the Meandu Mine to be used to ensure best practice final landforms are built at the mine with respect to available site material.
Forms, data recording and storage	Geoscience AMD	8512-OC-P1002	Outlines the data collection, integrity and security requirements for samples and data. Currently data is contained in both AcQuire and GDB. This document also stipulates how the data records are to be used to inform the monthly and annual recording and reporting of NAF and PAF inspections.

As with waste rock, information regarding mixed plant rejects disposal is recorded and reported in accordance with the requirements of Procedure Material Movement – Mine Planning (8512-OC-P1004) and Procedure Geoscience – AMD (8512-OC-P1002).

6.2 TAILINGS AND COAL REJECTS MINIMISATION

TEC embraces the need to reduce the quantity of tailings and coal rejects. Minimising tailings and coal rejects is a key driver to effective operations at Meandu Mine. Multiple projects have been undertaken, and will continue to be undertaken, to improve the yield of the coal washed at the Meandu Mine CHPP (yield being the ratio of product coal to ROM (feed) coal). Increased yield directly reduces the quantity of tailings and coal rejects being produced.

The following projects have been completed since 2014 with the aim of improving yield and reducing the quantity of tailings and coal rejects:

- fines spiral circuit upgrade
- coarse and fine Jig rebuild
- installation of weightometers and online quality and quantity measurement systems at input and output points of the CHPP
- coal wash algorithm analysis and development of improved wash curves.

The improvement of mine site wide yield on coal mined continues to be of strategic importance to TEC. Future trials could investigate recovery, re-processing and/or reuse of tailings.

The installation of solid bowl centrifuges at the CHPP in late 2017 has enabled dry disposal of tailings. A minimum 40% tailings (by dry weight) will be dewatered, mixed with course rejects and trucked to disposal sites within the inpit spoil dumps. Refer to Section 6.4.1.

6.3 TYPES AND VOLUMES

During the CHPP process, raw coal is separated into coal and non-coal materials using a washing and flocculent method. The CHPP consists of 2 coarse jigs (13-75 mm) and 2 small jigs (0-13 mm) which rely on air water pulsation to cause separation. The resultant product coal is sent to the Tarong power stations.

Ultra-fine, high ash slimes are bled out of the process water circuits and gravitate to the tailings thickener via the thickener feed launder. These tailings are thickened and treated with $Ca(OH)_2$ to attain a broadly neutral pH in the CHPP thickener and pumped in slurry form to solid bowl centrifuges, where they are dewatered to the required moisture content for transport. Tailings disposed from the thickener may contain contaminants including metals/metalloids and dissolved salts, such as sulfates, chloride, major cations and as identified in Section 4.5.1, along with coarse rejects, are treated as PAF materials. To limit oxidation and permeability, dewatered tailings are co-mingled with coarse rejects and the resulting mixed plant rejects stockpiled at the CHPP before being trucked to the rejects dump locations where they are progressively co-mingled or encapsulated with overburden and interburden. Ongoing sampling of tailings for basic geochemical test parameters occurs to ensure that the geochemical nature of mine waste is tracked over time. Water that is recovered from the solid bowl centrifuges is recycled back through the CHPP system.

Contingency tailings disposal (wet tailings) will continue to occur when the solid bowl centrifuges are offline or not able to process 100% of the tailings stream. This will occur via pumping the slurry from the thickener to the K2W tailings cell.

Until the end of 2019, wet tailings slurry was pumped to the NWB TSF. This facility is now undergoing a period of desiccation (drying out/crusting) will in preparation for capping and rehabilitation.

6.3.1 COAL WASTE PREDICTED VOLUMES

Table 6.3 shows the expected volumes of coal waste to be produced over the 2020, 2021 and 2022 financial years (FY). Future volumes may vary depending on the burn rates in the future for the Tarong power stations.

Table 6.3 Coal waste volumes

MATERIAL TYPE	FY2020	FY2021	FY2022
Raw coal mined (k tonnes)	7,184	7,312	7,898
Total rejects (k tonnes)	1,770	1,816	2,198
Hauled (co-disposal) (k tonnes)	1,621	1,684	2,066
Pumped tailings dam (contingency) (k tonnes)	149	131	132

6.4 STORAGE AND DISPOSAL

6.4.1 TAILINGS

During December 2017, solid bowl centrifuge systems were installed and commissioned at the Meandu Mine CHPP to dewater coal tailings to a moisture content allowing them to be co-mingled with coarse rejects. Both coarse and fine rejects (mixed plant rejects) are then hauled to dedicated reject dumps within the Meandu mining operation. The water that is recovered from the solid bowl centrifuges is recycled back through the CHPP system, minimising raw water use at the mine.

Prior to dewatering using solid bowl centrifuges, tailing were deposited in the NWB TSF and RD16 TSF as a dense phase slurry. The RD16 TSF has now been capped and is awaiting settlement of the landform prior to final rehabilitation works. The NWB TSF will be decommissioned and rehabilitated over the next 2 to 5 years (refer Section 6.8).

6.4.1.1 CONTINGENCY TAILINGS DISPOSAL

Contingency tailings disposal is required during periods when the solid bowl centrifuges are down. Contingency tailings disposal into the K2W-N void commenced in early 2020. The process for contingency tailings disposal in the K2W-N is outlined below.

In order to maintain stability of the ash dam wall, contingency tailings deposition will be managed so that the tailings do not come into contact with the embankment as follows:

- construct tailings cell on K2W dust suppression layer using material already in place
- deposit ash (dense phase slurry) via multiple discharge piping system and beach away from K2W embankment/spoil
- ash will inundate and cover tailings when the level exceeds the tailings cell crest level
- when that occurs, ash deposition will be managed so that tailings are locked against the south-west corner of K2W and continually encased by the ash.

Tailings disposition into a cell on the capped K2W ash dam away from the RL520 ash dam wall is planned followed by staged co-disposal with coal combustion products in line with the process illustrated in Figure 6.1.

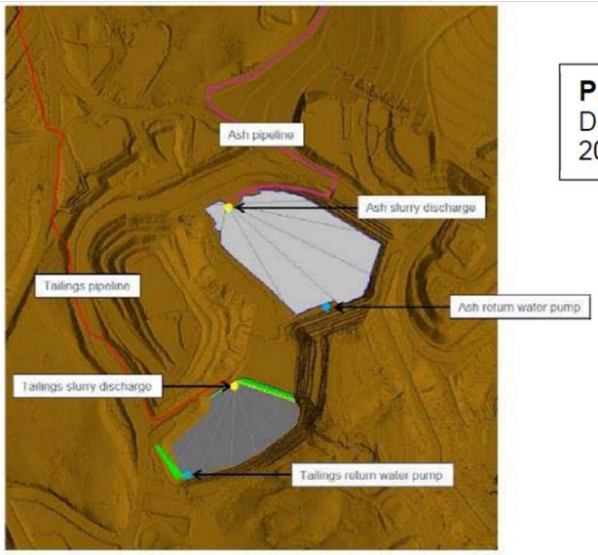
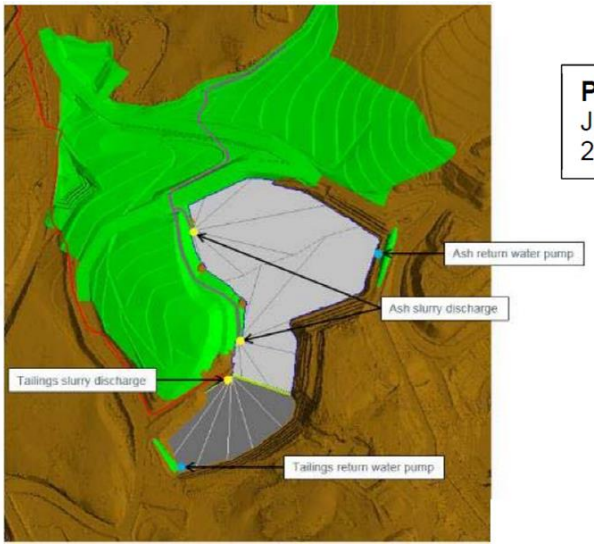
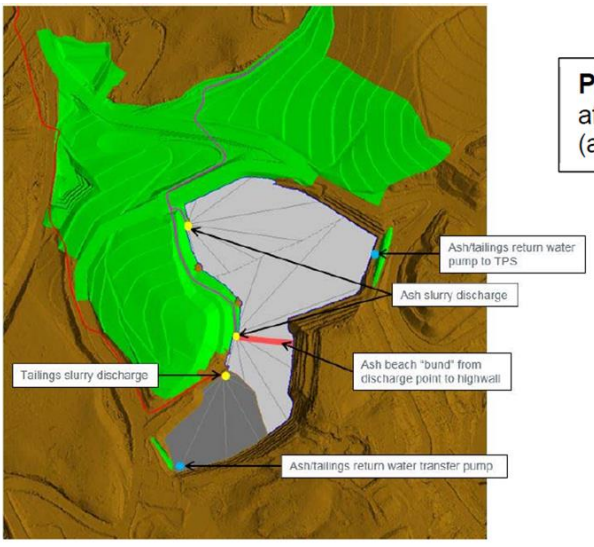
	**Phase 1: K2W-N Initial Ash (CCP) discharge with tailing deposition into a cell on the capped K2W ash**
	**Phase 2: Co-disposal of tailings with ash (CCPs) in K2W-N – staging with ash covering cell**
	**Phase 3: Co-disposal of tailings with ash (CCPs) in K2W-N – staging with ash covering cell**

Figure 6.1 Phases of staged co-disposal of tailings in K2W-N ash dam

Supernatant water at K2W-N will be managed as follows:

- Prior to ash covering the initial tailings cell, ash supernatant water will be returned to the ash dam at the Tarong power stations and tailings supernatant water will either be pumped to the Meandu Mine water management system, or to the Tarong ash dam
- After ash covers the tailings cell, supernatant water streams will be combined, and the combined supernatant water will be pumped to the Tarong power stations or directed to Meandu Mine's water management system. TEC will identify location to flexibly pump water to the destination where it provides most benefit (i.e. supernatant from ash or tailings could be pumped to either Tarong power stations or Meandu Mine storages depending on water quality and demand).

6.4.2 MIXED PLANT REJECTS

The environmental investigation completed in 2018 determined that the most probable cause of historic and ongoing AMD events from North West Backfilled Pit was oxidation of sulfide minerals and subsequent leaching of AMD weathering products from the reject storage. As such, rejects material placement focuses on:

- limiting storage exposure time of coarse reject materials
- combining rejects and tailings streams
- placement of reject materials at least 6 m beneath the final landform profile.

The mixed plant rejects dump/storage areas will be contained in the active mine dump areas.

Placement of mixed plant rejects in the rejects storage area is undertaken in accordance with the process outlined in Placement of Mixed Plant Rejects Procedure (8512-OC-WI1020).

In determining mixed plant rejects dump locations, geotechnical and slope stability considerations are taken into consideration to determine whether it is a suitable location for mixed plant rejects emplacement. During the design phase this may also include reviewing the surrounding dumps, the type of waste material, haul roads and drainage points.

Prior to emplacement, Mining Engineers / Supervisors / Operators are required to visually assess moisture content of the mixed plant rejects material being produced by the CHPP and at proposed tip head / dump location. The material is then classified as:

- **Low Moisture** (dry to moist) – material that is mostly coarse reject rock material and is able to be easily trucked to the dump and will retain integrity in dump / tip head and is suitable for co-disposal.
- **Moderate to High Moisture** ("wet") – material contains significant wet fines with some coarse rejects and is able to be contained by cells and trucked to mixed plant rejects dump with minimal spillage.
- **Very High Moisture** ("very wet" / "sloppy") – material not suitable for emplacement within cells will require a tiphead will need to be established, following formulation of a risk assessment (JHA) that considers geotechnical and environmental controls.

This classification determines the appropriate disposal process as described in the Placement of Mixed Plant Rejects Procedure (8512-OC-WI1020).

Future trials may investigate alternate methodology for tailings dewatering, co-mingling of rejects and tailings streams or transportation methods.

6.5 CONTROL OF LEACHATE AND SEEPAGE

The current Meandu Mine management procedures of limiting storage/exposure time of coarse reject materials at the reject stockpile to less than two weeks, has been an effective way of controlling the risk of acidic drainage generation. The potential for sulphide oxidation is further reduced through the incorporation of fine-grade rejects and tailings, whereby pore voids within the coarse rejects are filled with highly plastic low permeability tailings limiting oxidation and permeability. The combined reject and tailings stream are placed into the spoil dumps and progressively co-mingled or encapsulated with overburden and interburden and placed at least 6 m under the final landform and covered by NAF material and rehabilitated as per EA EPML00709113 requirements and the Meandu Mine Rehabilitation Plan (8512-SE-PLA1022).

Seepage is occurring from the toe of the North West Back-filled Pit area, that is associated with historical coarse rejects emplacement areas. RD27 has been constructed to intercept this seepage, which is then lime-dosed and re-used onsite. Dewatering bores are installed within the North West Backfilled Pit area with water pumped back to RD27, these are designed to reduce the water level with the back-filled pit to a point where seepage is reduced or eliminated.

The NWB TSF no longer receives pumped tailings slurry and will undergo capping over the next 2-5 years. During this time, the supernatant water collection sump at the northern end of NWB TSF will be maintained to assist with drawdown of water from within the tailings. The NWB TSF is hydraulically linked to the North West Backfilled Pit via spoil fill. Pore pressures released from the tailings during capping may permeate through this spoil and will be managed via the RD27 interception system.

6.6 CONTROL OF FUGITIVE AIR EMISSIONS

6.6.1 CONTINGENCY TAILINGS

Contingency tailings disposal in the ash disposal areas occurs as a slurry, which is either covered by ongoing ash disposal activities or forms a crust upon drying that minimises dust lift off.

6.6.2 MIXED PLANT REJECTS

Fine waste from the solid bowl centrifuges is mixed with coarse rejects and trucked to in-pit disposal areas. The material has high moisture content when placed and is then capped with overburden material within a few weeks. The potential exposure of mixed plant rejects to air-borne fugitive dust emissions is limited.

Fugitive emissions are managed by utilising dust control measures in place for dumps described in Section 4.1.3.3.

6.7 SAMPLING AND MONITORING

Sampling and monitoring of tailings and mixed plant rejects are summarised in Table 6.4.

Table 6.4 Sampling and monitoring of tailings and mixed plant rejects

PHASE / WASTE MATERIAL	SAMPLING / MONITORING
During operations	
NWB TSF and RD16 TSF	— Monthly monitoring of water levels in the facilities will continue until tailings have been capped.
Contingency tailings	— Groundwater monitoring to determine potential impacts to groundwater due to seepage from the K2W-N ash facility (refer Section 7.5).

PHASE / WASTE MATERIAL	SAMPLING / MONITORING
Mixed plant rejects	— Monthly CHPP rejects sampling — Survey of emplacement areas.
Post-capping / decommissioning	
NWB TSF and RD16 TSF	— Detailed in the respective Decommissioning and Rehabilitation Plans (refer Section 6.8).
Contingency tailings	— As detailed in Decommissioning and Rehabilitation of the K2W-N Ash Void (refer Section 7.7).
Mixed plant rejects	— Environmental monitoring as per EA conditions (groundwater, surface water) — Rehabilitation monitoring program.

6.8 DECOMMISSIONING AND REHABILITATION

6.8.1 TAILINGS STORAGE FACILITIES

In accordance with Condition G8 of the EA (EPML00709113), the NWB TSF and RD16 TSF will be capped with a NAF material to form the initial layer that is in contact with the tailings, and at least 6 m of the final landform surface to minimise infiltration of water and the likelihood of any erosion occurring to the final cover system. Rehabilitation of these tailings storage facilities will occur in accordance with:

- NWB TSF Decommissioning and Rehabilitation Plan.
- RD16 TSF Decommissioning and Rehabilitation Plan.

The RD16 TSF has been decommissioned and capped as of mid-2020. The covering material has been placed to final landform balance and is awaiting settlement of the landform prior to undertaking final profiling and rehabilitation works. Additional material may need to be imported based on settlement that can occur.

Capping of the NWB TSF will commence with a period of desiccation and consolidation. Tailings deposition in NWB TSF ceased in CY2019 and the surface has dried considerably due to dry weather and intermittent tailings deposition. It is planned that in-situ geotechnical testing will be undertaken during FY2021 to verify material strength and to develop a detailed capping methodology.

It is expected that the initial shallow cap will be placed using small equipment to limit tailings deformation, during CY2021-23, after which the capped surface will drain back to the site retention dam system. Based on geotechnical advice and experience capping the RD16 TSF, placement of the initial cap will potentially be staged to allow each section to rest and settle. Subsequent material up to final rehabilitation surface will by placed by mine production equipment, with material sourced from pit excavation or rehandled spoil material as appropriate.

6.8.2 CONTINGENCY TAILINGS

Contingency tailings disposal will occur in conjunction with coal combustion products disposal in K2W-N (refer Section 6.4.1). Decommissioning and rehabilitation of this and other future coal combustion products disposal facilities with contingency tailings co-disposal is covered in the Section 7.

6.8.3 MIXED PLANT REJECTS

At the mixed plant rejects emplacement areas (when not within 6 m of the final landform surface) cells are progressively capped with at least 5 m of overburden/interburden. Where mixed plant rejects are placed 6 m from the final landform surface, the 6 m capping will consist of NAF material. The areas will be topsoiled, ripped and seeded as per requirements in Schedule G of EA EPML00709113 and in accordance with the rehabilitation management practices as per current Plan of Operations and future Progressive Rehabilitation and Closure Plan:

- Incorporation into final landform design
- Drainage works (graded banks and rock waterways)
- Topsoil placement (200 mm)
- Contour ripping and seeding
- Ongoing maintenance and monitoring.

Investigations into co-mingled material properties will continue to optimise rehabilitation strategies. Future trials and investigations may refine co-mingling and placement methodologies, identify opportunities for co-mingling with other materials (spoil or ash), review capping requirements and optimise mixed plant reject cell placement within the landform.

6.9 MONITORING AND MAINTENANCE

6.9.1 DURING LANDFORM CONSTRUCTION

For the NWB TSF the rate and volume of seepage exiting the north-western corner of North West Backfilled Pit will continue to be monitored through decommissioning and rehabilitation of the NWB TSF. Management controls will be maintained at least until the seepage rate becomes negligible. The water level in North West Backfilled Pit and dewatering bore pump rates will be monitored to track effectiveness of this control. Results from monitoring will be fed back into the site water balance model.

The current groundwater monitoring bore network includes bores designed to monitor potential impacts from current and historical tailings storage facilities. The annual groundwater reviews undertaken onsite re-assesses the bore network to determine its continued adequacy to identify and monitor potential contamination risks. Potential issues or recommendations arising from the annual groundwater review will be investigated and actions scheduled for implementation as required.

Prior to undertaking final rehabilitation works, the landform above the capped tailings will be monitored to determine sufficient settlement has been achieved. It is anticipated that due to the staged plan for capping NWB TSF (as with RD16 TSF), the pore pressures within the tailings will dissipate and consolidate considerably as capping is placed and the landform is constructed. Monitoring of the “as-deposited” and profiled landform will involve evaluation of periodic surveys to determine settlement is within allowable limits, prior to undertaking final rehabilitation works.

6.9.2 AFTER COMPLETION OF REHABILITATION

Post-seeding, the rehabilitated area will be assessed as per the site Land Rehabilitation Inspection Checklist (8512-SE-F1125) to ensure it meets the relevant quality criteria as stated in Schedule G of the EA. The final landforms for the NWB TSF and RD16 TSF will be included as part of the site rehabilitation monitoring program which will be used to determine success in terms of erosion, stability, groundcover and vegetation development. This program is described in the site Environmental Monitoring and Inspection Program (Downer EDI, 2017) Annual rehabilitation monitoring is undertaken in accordance with the Meandu Mine Rehabilitation Monitoring Programme.

If during the rehabilitation monitoring period, any major cracking or differential settlement is observed, a geotechnical engineer will be engaged to assess the landform and recommend remedial works.

7 COAL COMBUSTION PRODUCTS (ASH)

7.1 OVERVIEW

This section covers current and future storage of coal combustion products from the Tarong power stations in identified mine voids. Ongoing storage facilities for coal combustion products are critical to the ongoing operation of the Tarong power stations, and by extension, Meandu Mine. Coal combustion products from the Tarong power stations are currently stored in two joined mining voids at Meandu Mine – K2W and K2N (known collectively as K2W-N).

Approval for coal combustion products (or ash) storage at Meandu Mine was originally granted under Beneficial Use Agreement (BUA) ENBU00736008 and an approved End of Waste Agreement (ENWE07312817). The End of Waste approval expired in September 2019 and since then, coal combustion products storage is now managed as part of the EA (conditions A21- A24) (refer Table 7.1 to Table 7.3). As stated previously, the transfer of CCPs (and water) between the Tarong power stations and Meandu Mine takes place through a third-party agreement; effective 13 February 2020.

For the purposes of waste management of coal combustion products the terms; disposal and storage, are used interchangeably as Stanwell recognises the potential for beneficial reuse into the future, specifically in the cement industry or other uses which comply with the End of Waste Code for Coal Combustion Products.

Stanwell is investigating the potential to co-fire biosolids with coal as a viable long-term renewable fuel source. Stanwell has undertaken extensive testing of the fuel source, completing laboratory scale burn trials on a scaled version of the Tarong boilers at an ALS testing facility (NATA accredited). Initial results are encouraging however further consideration, testing and analysis of ash (base case), and then combined with biosolid is needed to demonstrate that the resultant ash material is not materially changed as a result of the addition of biosolids. Further consideration on the potential for Per – and Poly-Fluoroalkyl Substances (PFAS) including its precursors in both solid and leachable form is also needed to support this assessment. Maintaining the current operating philosophy of the plant is critical in that transferring all ash to the mining voids while plant is available ensures the remaining volume in the Ash Dam at Tarong power station is preserved. Following this further assessment an EA amendment to align coal combustion product definitions between the Tarong power stations and Meandu Mine EA's is expected to occur prior to commencement of any site trials.

Table 7.1 EA EPML0070913 – Coal combustion products requirements

EA CONDITION NUMBER	REQUIREMENTS
A21	**Coal Combustion Products Storage and Management** The holder of this environmental authority may store coal combustion products generated by the burning of coal at the Tarong Power Station and Tarong North Power Station in voids defined in **Table A1 – Authorised coal combustion product storage locations**, and **Appendix 2 – Meandu Mine Voids, Drainage System and Monitoring Network**.
A22	Coal combustion products stored in voids defined in Table A1 – Authorised coal combustion product storage locations, and Appendix 2 – Meandu Mine Voids, Drainage System and Monitoring Network must comply with contaminant limits defined in **Table A2 – Maximum Allowable Leaching Contaminant (TCLP – Toxicity Characteristic Leaching Procedure) levels.**
A23	In addition to meeting the criteria in **Table A2 – Maximum Allowable Leaching Contaminant (TCLP) levels,** the coal combustion products must not have any properties or contain any other contaminants at concentrations which may cause environmental harm

EA CONDITION NUMBER	REQUIREMENTS
A24	Coal combustion products deposited and stored in a void identified in **Table A1 – Authorised coal combustion product storage locations**, and **Appendix 2 – Meandu Mine Voids, Drainage System and Monitoring Network**, must be transferred or conveyed from the power station sites via an enclosed pipeline or other enclosed method of conveyance to prevent the release of a contaminant to the environment.
G10	**Final Cover** When deposition of coal combustion products into voids defined in **Table A1 – Authorised coal combustion product storage locations** ceases, unless otherwise agreed to by the relevant landowner, any relevant land manager and the administering authority, the holder of this environmental authority must install a final cover system over the coal combustion products following sufficient time for ash consolidation and desiccation.
G11	The final capping system over coal combustion products in the voids defined in **Table A1 – Authorised coal combustion product storage locations** must be at least 2 m deep and must include an upper layer of earthen material that is capable of sustaining plant growth, and must be designed and maintained to minimise erosion occurring to either the final capping system or the coal combustion products in the void.
G12	Materials used in the construction of the capping layer over the coal combustion products in the voids defined in **Table A1 – Authorised coal combustion product storage locations** must achieve an in-situ permeability which is sufficiently low and / or be sufficient thickness so as to minimise infiltration of water into the landform.

Table 7.2 Table A1 – Authorised coal combustion product storage locations

VOID IDENTIFICATION	LOCATION
Central Pit	Refer to Appendix 2 – Meandu Mine Voids, Drainage System and Monitoring Network.
King 4 South (K4S)	
King 2 West – North (K2W/N)	
King 4 East (K4E)	
King 2 East (K2E)	
Ramp 5	

Table 7.3 Table A2 – Maximum allowable leaching contaminant (TCLP) levels

CONTAMINANT	MAXIMUM TCLP VALUE (mg/L)
Silver	0.5
Arsenic	0.5
Barium	10
Cadmium	0.05
Total chromium	0.5
Copper	10

CONTAMINANT	MAXIMUM TCLP VALUE (mg/L)
Nickel	0.5
Lead	0.5
Antimony	0.5
Thallium	0.1
Zinc	50
Selenium	0.1
Mercury	0.01

7.1.1 RELEVANT SITE PROCEDURES

The relevant site procedures for coal combustion products are shown in Table 7.4.

Table 7.4 Relevant site procedures relating to the storage and disposal of regulated waste

DOCUMENT TYPE	TITLE	REFERENCE	PURPOSE OF DOCUMENT
Procedures	Meandu Mine – Coal Combustion Products – Disposal Management Plan	-	To comply with EA conditions A17-A19, G10-G12 and H27-H28. Relates to current and future storage of coal combustion products in identified mine voids.
	King 2 West Ash Void and Ash Pipeline Procedure	8512-SE-P1004	Includes instructions for taking ash samples and dispatching samples for laboratory analysis. Water samples in the void are taken and analysed on a monthly basis.
	K2WN Ash Storage 520 mRL Crest Raise Operational Plan		Operational Plan for Ash Storage Facilities.
	K2WN Ash Storage 520 mRL Crest Raise Construction Certification Report		Certified design report for Ash Storage Facilities.
Forms, data recording and storage	Monthly King 2 West Ash Pipeline, Sediment Dam and Drain Inspection Checklist	8512-SE-F1063	Checklist of ash pipeline, bunds and dams.
	Meandu Mine Site Dam Register	8512-SE-F1062	Includes records of water levels, capacity and water classification as well as controlled discharge, overflows and pumping locations.

7.2 COAL COMBUSTION PRODUCTS VOLUME MINIMISATION

Approximately 10% of the Tarong power stations coal combustion products are collected and sold as useable products under contractual arrangements between Stanwell and ash off-takers. Stanwell is proactively exploring initiatives to significantly increase the proportion of coal combustion products that are sold for beneficial reuse. A new offtake facility is currently under construction and is planned to be commissioned in 2021. The new facility will increase the coal combustion reuse by approximately 400,000 tonnes per annum.

Cenospheres are a by-product of the coal combustion process and are entrained in the ash slurry and liberated from the material once the slurry has been deposited in the void. Cenospheres are small, hollow, silica balls that float on the surface of water. They are marketable due to their heat-resistant properties. Cenospheres are periodically harvested from the K2W-N ash storage facility for beneficial reuse, further reducing the volume of coal combustion products stored at Meandu Mine.

Future trials may be undertaken to investigate the beneficial re-use of ash for remediation, water management and rehabilitation of other mine materials. The piezometric properties of ash may assist with creating a low permeability barrier to seal particular materials or areas. The physical properties of ash may assist with amelioration of heavy clays or improve water retention within more permeable materials.

7.3 TYPES AND VOLUMES

Fly-ash is produced during the coal combustion process at the Tarong power stations as a by-product of power generation. Fly-ash is captured from flue gases using precipitators. Ongoing storage facilities for coal combustion products (which are a by-product of burning coal) are critical to the ongoing operation of the Tarong power stations, and by extension, Meandu Mine.

Total annual production of ash generated across the Tarong site varies from year to year. This variability is attributed to a number of factors, including fluctuations in Tarong's operations due to electricity market demand, the chemical composition of the coal burnt and the impact of overhauls and forced outages of the generating units. For example, with Tarong power stations operating at an annual average capacity factor of 70% and a 28% ash content of the coal, approximately 1.35 Mtpa of coal combustion products is generated. The volumes of coal combustion products produced and disposed between January 2017 and January 2020 are provided in Table 7.5.

Table 7.5 Coal combustion products volumes produced and disposal volumes

MONTH	ASH PRODUCED FROM TARONG POWER STATION 15810 OPERATIONS REPORT (MTPA)	TOTAL CCP SALES FROM CCP OFFTAKE DATABASE	ASH TO SITE STORAGE (MTPA)	% ASH SOLD FOR BENEFICIAL USE
Jan-17	100,462	9,164.48	91,297.52	9.1
Feb-17	96,337	10,384.46	85,952.54	10.8
Mar-17	107,869	12,415.60	95,453.40	11.5
Apr-17	116,531	8,558.28	107,972.72	7.3
May-17	115,145	11,877.82	103,267.18	10.3
Jun-17	110,029	9,780.69	100,248.31	8.9
Jul-17	110,029	10,284.62	99,744.38	9.3

MONTH	ASH PRODUCED FROM TARONG POWER STATION 15810 OPERATIONS REPORT (MTPA)	TOTAL CCP SALES FROM CCP OFFTAKE DATABASE	ASH TO SITE STORAGE (MTPA)	% ASH SOLD FOR BENEFICIAL USE
Aug-17	122,394	13,451.28	108,942.72	11.0
Sep-17	117,827	14,327.54	103,499.46	12.2
Oct-17	116,991	16,156.80	100,834.20	13.8
Nov-17	122,627	19,765.90	102,861.10	16.1
Dec-17	133,104	11,320.57	121,783.43	8.5
Jan-18	125,877	11,903.20	113,973.80	9.5
Feb-18	104,613	12,167.78	92,445.22	11.6
Mar-18	101,639	12,303.40	89,335.60	12.1
Apr-18	110,442	9,084.69	101,357.31	8.2
May-18	97,533	5,421.06	92,111.94	5.6
Jun-18	122,135	10,238.68	111,896.80	8.4
Jul-18	130,805	12,987.54	117,817.46	9.9
Aug-18	131,077	13,419.63	117,657.37	10.2
Sep-18	143,979	11,897.53	132,081.47	8.3
Oct-18	110,364	11,883.97	98,480.03	10.8
Nov-18	110,634	9,964.11	100,669.89	9.0
Dec-18	117,901	9,579.06	108,321.94	8.1
Jan-19	129,775	8,965.42	120,809.58	6.9
Feb-19	124,560	9,770.13	114,789.87	7.8
Mar-19	127,229	9,222.22	118,006.78	7.2
Apr-19	107,674	8,582.01	99,091.99	8.0
May-19	118,493	9,407.55	109,085.45	7.9
Jun-19	113,185	6,890.00	106,295.00	6.1
Jul-19	134,363	8,926.98	125,436.02	6.6
Aug-19	130,907	11,278.21	119,628.79	8.6
Sep-19	122,817	8,221.69	114,595.31	6.7
Oct-19	122,650	9,686.52	112,963.48	7.9
Nov-19	122,771	7,921.68	114,849.32	6.5
Dec-19	122,871	6,155.51	116,715.49	5.0
Jan-20	122,821	5,218.56	117,602.44	4.2

7.4 STORAGE AND DISPOSAL

7.4.1 CURRENT DISPOSAL

Coal combustion products from the Tarong power stations are currently stored in two joined mining voids at Meandu Mine – K2W and K2N (known collectively as K2W-N). An ash pipeline has been constructed to transport the coal combustion products in the form of, a slurry, from the TPS and TNPS to Meandu Mine. Due to settling of this slurry in the K2W-N void after transportation from the power stations, a large body of water is formed on the surface of the void. This supernatant water is reclaimed from the K2W-N Ash Storage and pumped in a closed-loop system back to Tarong power stations ash dam for recovery and re-use, in accordance with Condition C15 of the Environmental Authority.

As discussed in Section 6.4.1.1, contingency tailings disposal into the K2W-N void occurs during periods when the solid bowl centrifuges are down. Contingency tailings are transported to the K2W-N void via a pipeline.

Cenospheres may be harvested from K2W-N facility and removed from site for beneficial reuse in accordance with End of Waste Code for Coal Combustion Products Approval Number ENEW07359717, subject to the approval of the administering authority.

Disposal and management of ash in the K2W-N is undertaken in accordance with the requirements of the the certified design plan and operations plan (see section 7.1.1). The facility has been designed and constructed with a spillway that reports back to the K2E pit, reducing risk of offsite contamination due to overland flow.

Ash placement in the K2W-N void will continue until this storage facility reaches capacity (currently 518 mRL (crest level 520 mRL)). This is anticipated to be in approximately 2028 (depending on power station generation rates).

The Queens West (QW) Sump is a designed seepage collection sump downstream of K2W-N. Seepage is pumped back into K2W-N.

7.4.2 REGULATED STRUCTURES

Because the ash storage is contained within a regulated structure, specific inspection and reporting procedures are already in place in accordance with existing EA Conditions H10, H12 and H22 to H25.

The certified design report (incorporating the 520 mRL crest and tailings disposal) outlines the current plans for decommissioning of the void/ash storage facility. This structure will remain as a regulated structure until decommissioning works have been certified as satisfactorily completed.

The K2W-N void and the QW Sump will remain regulated structures after capacity is reached and until it is fully decommissioned. Spillway functionality will be maintained during the post-ash deposition period until completion of capping and re-shaping works, including final capped landform surface drainage. Inspection and reporting requirements for the regulated structure will be continued in accordance with the design report, operational plan, consequence category assessment and relevant EA conditions until the regulated structure has been certified to be effectively decommissioned.

7.4.3 FUTURE DISPOSAL

Following completion of ash and contingency tailing storage in K2W-N, placement of ash and tailings in a void within the Central Pit or another suitable area will then be undertaken. Appropriate design and consequence category assessments of Central Pit will be undertaken in due course. The manner in which ash transfer will occur may be as a dense phase slurry, as currently occurs, or by taking dredged ash from the Tarong ash dam, by truck or slurry, to the Meandu voids to increase the capacity of the Tarong ash dam.

It is anticipated that for future storage facilities, ash and tailings may be deposited within separate portions of the same larger void area, as per the current arrangement with the K2W-N storage facility.

TEC are constructing a new offtake facility that will be commissioned at Tarong power stations in early 2021. The ash offtake facility would enable Tarong power stations to reduce its waste and support the development of sustainable

products. Once the ash offtake facility is up and running, it will significantly reduce the amount of ash stored onsite and provide another source of fly ash for beneficial use. Stanwell will own the new offtake facility and Boral will operate and manage the ash offtake from it.

7.5 CONTROL OF LEACHATE AND SEEPAGE

Part of the ash storage containment is formed by depositing spoil backfill. Seepage of groundwater from the ash storage will also displace groundwater within the backfill spoil. The ponded supernatant water level in the K2W-N facility will be kept sufficiently low to avoid water ponding against the K2W-N northern embankment. Ash slurry discharge will be managed so ash beaches away from fill material (low wall spoil and northern embankment) and the supernatant pond will be maintained at the south-east end of K2N that is against the pit highwall. This is to minimise the potential for seepage through fill material.

Seepage within the spoil will be collected and managed using the QW Sump, which has been constructed on the northwest corner of the K2W dump. QW sump will be operational as part of the certified K2W-N void/ash storage design to intercept seepage reporting to QW backfilled pit.

The K2W-N ash storage facility is part of a larger complex of three interconnected mine pits: the K2W and K2N pits that are being used for ash storage, and the QW pit that has been previously backfilled with spoil. The QW Sump has been established in association with the K2W-N ash storage, at the original ramp into QW pit that represents the lowest natural ground level surrounding the K2W-K2N-QW complex.

The intent of QW Sump is to intercept seepage that may permeate through spoil within these back-filled pits. The water level in QW Sump is monitored and maintained at a level sufficiently below natural ground level and is subject to assessment during annual regulated structure inspections. This seepage collected in QW Sump will be pumped back to K2W-N void.

7.6 CONTROL OF FUGITIVE AIR EMISSIONS

Following the temporary cessation of ash disposal in the K2W void, a dust suppression layer consisting of mine spoil was place over the deposited ash to prevent dust lift off. This spoil layer will be in place until ash in the K2W-N facility increases above this level. This temporary layer does not represent a final cap and therefore has not been designed to meet those specifications.

Active ash disposal in the northern section of K2W-N has not had any signification fugitive dust emissions due to the moisture content of the deposited ash and the body of decant water over a significant portion of the deposited ash.

Following cessation of ash disposal, the period of desiccation is likely to have a high potential for fugitive dust emissions. Dust suppression mechanisms that will be used to minimise dust transmission during this phase will include:

- placement of a dust suppression layer
- install water sprays over the area
- apply chemical sealant to the surface.

The determination of dust control measure will be made prior to cessation of ash disposal.

7.7 DECOMMISSIONING AND REHABILITATION

7.7.1 REHABILITATION STRATEGY

A decommissioning and rehabilitation plan will be prepared for the K2W-N void/ash storage in accordance with EA EPML00709113 conditions G8, G10 to G14 and H27 and will address the following:

- desiccation phase (if required)
- cover materials identification (suitability, NAF, low permeability)
- construction design:
  - geo-mechanical analysis
  - verification testing
- final cover system
- capping depth:
  - planned construction sequence
  - first spoil layer
  - subsequent dumping to final landform
- landform surface drainage
- topsoiling
- final rehabilitation works (ripping and seeding)
- monitoring and maintenance.

In summary, rehabilitation will comprise a period of desiccation/consolidation following by capping with spoil to a level that fits in with the surrounding final landform and which will be free-draining (i.e. final surface constructed on a slope to prevent pondage).

This final surface will be topsoiled, ripped and seeded, in accordance with the final land-use plan, proposed for the area in the future Meandu Mine Progressive Rehabilitation and Closure Plan.

The transition to the next storage facility will be incorporated into the decommissioning plan for the K2W-N facility. It is planned that tailings deposition will be transferred to the next facility prior to the ash. This will allow ash to continue to be pumped into the facility and form a layer over the tailings in K2W prior to capping. Testing has shown that the deposited ash is inherently stronger than the tailings and it is expected that this methodology will reduce potential deformation associated with the tailings and reduce capping duration, assisting to minimise the decommissioning and rehabilitation timeframe. Additional testing will be undertaken as ash and tailings levels increase and the proportions of the respective materials become more representative. In-situ geotechnical testing will be undertaken following cessation of ash deposition to determine suitable capping depths and methodologies.

7.7.1.1 DESICCATION PHASE

Following cessation of ash disposal in the storage facility, a period of desiccation will be allowed for. Once the desiccation period has occurred and the surface has dried sufficiently to access, in-situ geotechnical testing will be undertaken to develop a suitable capping methodology. Previous experience placing the temporary dust suppression layer over K2W ash storage, indicates that a desiccation period of 18 months may be appropriate, and that shallow tiphead placement of the initial capping layer can be achieved using mine production equipment. This capping methodology will be refined based on outcomes of in-situ testing, particularly in the K2W area that is currently being used for tailings disposal.

7.7.1.2 COVER MATERIALS

NAF material will be used as an initial cover material and within a minimum 2 m of the final landform surface, with material potentially sourced from K2W spoil dump, K2E pit or possibly Ramp 5/ K4E.

7.7.1.3 LANDFORM DESIGN

The final landform design for the K2W-N void will be designed to the requirements of the K2W-N Ash Storage Operation Plan (December 2019).

The final landform has been designed with the catchment divide toward the northern end of K2W at approximately 540 mRL and drainage channels reporting to the northern and south-western ends of the K2W-N facility.

7.8 SAMPLING, MONITORING AND MAINTENANCE

7.8.1 DURING OPERATIONS

7.8.1.1 COAL COMBUSTION PRODUCTS SAMPLING

Regular sampling of the ash being deposited in K2W-N and cenospheres periodically harvested from it is undertaken. Water quality sampling of the K2W-N as dam is undertaken on a quarterly basis.

7.8.1.2 QW SUMP

Observations of the QW Sump pond shall be made and recorded at least once per month so that trends in seepage flowrate, water level, water chemistry, and pumping requirements can be demonstrated both prior to and after the ash storage level reaches 476 mRL.

Until such time as the observations and records described above enable alternative guidance, the maximum water level in the QW Sump pond shall not be permitted to rise by more than 5 m above the nominal "static" pond level of 458 mRL without immediately implementing a program of pumping to reduce the pond level with minimal delay.

Volumes of water pumped from QW Sump to K2W-N ash storage will be recorded.

Water quality sampling of the seepage collecting in the QW sump is undertaken on a monthly basis.

7.8.1.3 GROUNDWATER

Current groundwater monitoring conditions in the Meandu Mine EA EMPL00709113 adequately cover the assessment of potential impacts from ash storage in mine voids on downstream environmental values. Related context on these conditions is provided below.

Condition D3 requires a groundwater monitoring program to be implemented which is "able to detect a significant change to ground water quality values and standing water levels (consistent with the current suitability of the groundwater for domestic and agricultural use) due to activities that are part of this mining project".

Conditions D5 and D6 specify the locations and frequency of monitoring and the contaminant trigger limits for the groundwater monitoring program. The list of potential contaminants includes those contaminants typically associated with ash (i.e. pH, specific EC, boron, selenium, molybdenum, vanadium, sulphate and fluoride).

Further, Condition D7 requires:

An annual groundwater report must be submitted to the administering authority with each annual return. The report must include:

a. the results and interpretation of the groundwater monitoring program;
b. a review of the suitability of the groundwater network; and

c. recommendations or improvements to the groundwater network, including whether additional monitoring locations are required.

This annual report (completed by an appropriately qualified person as per Condition D2) will "identify the adequacy of the groundwater monitoring network to detect a significant change … due to mining activities (including storage of ash) and make recommendations for additional monitoring locations as required".

Conditions D6 and D10 also require an investigation to be completed into the potential for environmental harm if any exceedance of any contaminant trigger levels stated in EA Table D2 and an action plan to mitigate the potential harm (to be prepared by a suitably qualified person).

7.8.2 DURING FINAL LANDFORM CONSTRUCTION

At any time when spoil placement stops for more than three months, and when bulk earthworks are completed, minimum quarterly topographic surveys will be undertaken either by UAV or detailed ground survey. Change in elevation at selected points or sections will be plotted against time and the results will be used to decide when the predicted remaining settlement is small enough to proceed with final shaping.

During this monitoring period, if any erosion gullies deeper than 1m develop, they will be filled and the area upslope will be re-graded to prevent recurrence.

7.8.3 POST REHABILITATION PHASE

Post-seeding, the rehabilitated area will be assessed as per the site Land Rehabilitation Inspection Checklist (8512-SE_F1125) to ensure it meets the relevant quality criteria as stated in Schedule G of the Environmental Authority. The final landform will be included as part of the site rehabilitation monitoring program which will be used to determine success in terms of erosion, stability, groundcover and vegetation development. This program is described in the Plan of Operations.

If during the rehabilitation monitoring period, any major cracking or differential settlement is observed, a geotechnical engineer will be engaged to assess the landform and recommend remedial works.

8 FUTURE OPPORTUNITIES FOR WASTE MINIMISATION AND RESOURCE RECOVERY

Planning for future waste minimisation and resource recovery opportunities will ensure TEC continues to apply a sustainable approach to waste management. Previous and future waste reduction initiatives and improvement opportunities undertaken at the Meandu Mine are identified in Table 8.1. The implementation of these initiatives will further support the Commonwealth and Queensland Government waste management framework, as summarised in Section 0.

The most significant reduction in waste disposal onsite will be achieved by the installation and commissioning of the Ash Offtake facility at the Tarong power stations, which when operational from 2021 will achieve at least 20% reduction in coal combustion products being disposed within the mine void at Meandu Mine. This initiative is intended to remain in place for the life of the operation.

Table 8.1 Previous and future waste initiatives and improvements

WASTE	PREVIOUS WASTE REDUCTION INITIATIVES / IMPROVEMENTS	FUTURE WASTE REDUCTION INITIATIVES / IMPROVEMENTS
General waste (including recyclables)	Improvement of waste stream segregation and additional recycling facilities/infrastructure to encourage more recycling of materials. Toolbox training sessions to educate staff on types of general wastes that recyclable and encourage recycling of waste materials.	Continued implementation, monitoring and improvement of waste recycling initiatives including consideration of recovery avenues as beneficial reuse markets emerge. Segregation, cash for cans, battery recycling (D, AA, AAA).
Regulated waste	Toolbox training sessions to educate staff on regulated wastes streams and appropriate disposal as well as encourage recycling of recyclable regulated waste materials. AFFF phased out from site.	Continued implementation, monitoring and improvement of waste recycling initiatives including consideration of recovery avenues as beneficial reuse markets emerge. Investigate the potential to increase recycling rate of light vehicle tyres.
Waste rock	Minimise final voids. Ongoing material characterisation program, evaluation of geochemical/ physical properties and selective handling.	Continuous Improvement projects to increase efficiencies, that will reduce equipment hours to carry out the same job, reducing fuel usage, maintenance requirements, component replacement and waste generation. For example: – allocating additional material to dragline (reduced truck and shovel usage)

WASTE	PREVIOUS WASTE REDUCTION INITIATIVES / IMPROVEMENTS	FUTURE WASTE REDUCTION INITIATIVES / IMPROVEMENTS
		– installing short-cut ramps to reduce some long hauls – maximising truck payloads by implementing Argus system.
Mixed plant rejects	Fine coal centrifuges installed to improve coal recovery and reduce tailings quantities, solid bowl centrifuges installed to dewater tailings for co-disposal with coarse rejects. Water recovered from the solid bowl centrifuges is recycled back through the CHPP system, minimising raw water usage at the mine. Tailings supernatant water at K2W-N pumped to Meandu Mine water management system Refinement of placement methodology to reduce oxidation potential/ permeability of rejects.	Optimise tailings dewatering system thereby reducing solid bowl downtime and tailings needing to be pumped. Reuse tailings supernatant water through the ashing circuit if excess water is available, by pumping back to K2N to Tarong ash dam. Improvements to tailings dewatering processes resulting in dryer material/ less water in the blend/ reduced seepage risk/ reduced equipment hours to remove the material as trucks can be loaded to capacity. Floc trials to improve consistency of dewatered tailings. Review mixed plant rejects cell cover depths based on improvements to moisture content, that may allow available dump areas to be optimised and avoid long hauls for mixed plant rejects material.
Coal combustion products	Cenosphere harvesting for beneficial reuse. Supernatant water at K2N-W is returned to the Tarong power stations for reuse in ashing circuit. Minimise final voids.	To facilitate water reuse options, TEC are utilising onsite water modelling to identifying the benefits of pumping water to the destination where it provides most benefit for re-use. Ash offtake facility: Stanwell have entered into a contract for the design and construction of a new cement grade fly ash offtake facility at Tarong power stations. Once operational the facility will significantly reduce the amount of ash stored on site and provide another source of fly ash for beneficial use.

9 REVIEW AND AUDITS

Meandu Mine is committed to continually improving its environmental performance, to support initiative outlined in Section 8, and identify new opportunities. Data for monthly waste volumes for general and regulated waste will be collected over the 2020-21 financial year and set targets for the following year to achieve a reduction in waste being disposed of to landfill. This review is to be conducted in alignment with annual business planning cycles.

Waste contractor audits will be conducted during the term of this management plan to confirm waste being removed from site is being appropriately disposed at facilities licensed to receive the generated waste streams. Any actions or improvements identified in these audits will be implemented to ensure all legal requirements are being implemented.

10 NOTIFICATION, INVESTIGATION AND REPORTING OF INCIDENTS

All incidents and near misses will be reported immediately to the supervisor who will notify the Environmental Advisor. Site procedures for completing the requirements of **DM-SE-P2 Incident Reporting and Investigation** will be followed.

All reportable incident will be reported to the regulator by the Site Manager. Refer Section 3.1.1 for notifiable activities.

11 TRAINING AND COMPETENCY

Personnel who have accountabilities under the Waste Management Plan will receive training and be assessed in the relevant requirements of the Waste Management Plan and other associated site standards and procedures in accordance with the project training needs analysis. Training includes:

- Waste management toolbox presentation (8512-SE-TBT1005).

12 LIST OF RELATED DOCUMENTS

The list of related documents to this Waste Management Plan is provided in Table 12.1

Table 12.1 List of related documents for waste management from the Meandu Mine PMP

DOCUMENT NO.	DOCUMENT TITLE	DOCUMENT TYPE	PURPOSE
Environmental Management System			
AU001832-2	Downer Mining ISO 140001: 2004 (Environment) Certificate	Certification	Evidence of 14001 accreditation.
8512-DM-SE-F52	Special Conditions of Contract Safety and Environment	Form	Environmental requirements for contractors.
8512-DM-SE-PLA2	Environmental Management Plan	Plan	EMP for Meandu Site for all environmental aspects with cross reference to procedures.
8512-DM-SE-REG13	Environmental Aspects Register Open Cut Mining	Plan	Identification of aspects of mining at Meandu that have the potential to impact the environment.
DM-SE-P12	Environmental Risk Management	Procedure	Risk management (for all Downer Mining Operations).
DM-SE-P28	Environmental Compliance	Procedure	Management of environmental compliance (for all Downer Mining Operations).
Regulatory Approvals and Licences			
8512-SE-R1023	Environmental Authority (EA) EPML00709113	Government approval	Environmental approval for ML6674 – Meandu Coal Mine.
ASM-MINE-PLAN-17	Plan of Operations January 2019-December 2020	Plan	Describes proposed mining activities that will be undertaken at Meandu Mine during the period 1 January 2019 to 31 December 2020.
Plans, Reports, Technical Documents			

DOCUMENT NO.	DOCUMENT TITLE	DOCUMENT TYPE	PURPOSE
K2WN Ash Storage 520mRL Crest Raise Operational Plan	K2WN Ash Storage 520mRL Crest Raise Operational Plan	Plan	Operational Plan for Ash Storage Facilities.
K2WN Ash Storage 520mRL Crest Raise Construction Certification Report	K2WN Ash Storage 520mRL Crest Raise Construction Certification Report	Construction Report	Certified design report for Ash Storage Facilities.
8512-OC-PLA1001	AMD Mine Planning Management Plan	Management Plan	Provide a clear management structure for the handling of AMD Material at Meandu Mine.
	North West B Tailings Storage Facility Decommissioning and Rehabilitation Plan	Plan	Describes the strategies and works that will be implemented to transform the NWB TSF into a safe, stable, non-polluting landform consistent with the over-arching rehabilitation objectives and plans for Meandu Mine.
	RD16 TSF Decommissioning and Rehabilitation Plan	Plan	Outlines strategies and works that will be implemented to transform the RD16 TSF into a safe, stable and non-polluting landform consistent with the overarching rehabilitation objectives and plans for Meandu Mine.
Environmental Incident Management			
DM-SE-TBT21	Environmental Incident and Reporting Guideline	Guideline	Downer Mining Incident Management Guideline.
Monitoring Procedures, Inspections, Checklists			
8512-SE-P1018	Environmental Inspection Procedure	Procedure	Procedure for monitoring of all environmental aspects.
8512-SE-P1004	King 2 West Ash Void and Pipeline Procedure	Procedure	Includes instructions for taking ash samples and dispatching samples for laboratory analysis. Water samples in the void are taken and analysed on a monthly basis.

DOCUMENT NO.	DOCUMENT TITLE	DOCUMENT TYPE	PURPOSE
8512-SE-F1063	Monthly King 2 West Ash Pipeline, Sediment Dam and Drain Inspection Checklist	Checklist	Checklist of ash pipeline, bunds and dams.
8512-OC_P1004	Material Movement – Mining Planning Procedure	Procedure	Procedure for the management of Acid Saline and Metalliferous Drainage when undertaking mine planning activities.
8512-OC-P1002	Geoscience AMD	Procedure	Procedure for the management of Acid Saline and Metalliferous Drainage when undertaking geological activities.
8512-OC-P1003	Geochemical Sampling Procedure	Procedure	Procedure for ensuring consistency and best practice when geochemical data is collected, including sampling methodology, handling and storage.
8512-OC-WI1020	Placement of Mixed Plant Rejects	Work Instruction	Work instructions for mixed plant rejects during the dump design phase, classification and emplacement phase.
8512-SE-P1009	Tailings Storage Facility and Pipeline Procedure	Procedure	Outlines the operational requirements of the TSF, tailings pipelines, retention dams and associated pumping equipment, including annual sampling frequencies.
8512-DM-PL-P15	Disposal of Tyres Procedure	Procedure	Manage the disposal of tyres at Meandu Mine.
8512-SE-P1019	Regulated Waste Management Procedure	Procedure	Provides details on the requirements for the disposal of regulated trackable waste from Meandu Mine.
8512-DM-PL-F139	Tyre Disposal Record	Form	Procedure for managing the disposal of tyres at Meandu Mine.
DM-OC-(OC)-P362	Disposal of Explosives and Associated Waste		Procedure for disposal of explosives, etc.

DOCUMENT NO.	DOCUMENT TITLE	DOCUMENT TYPE	PURPOSE
8512-DM-SE-F61	Waste Generation and Disposal Inventory		Records wastes generated and disposed of, including the type of waste, area the waste is generated, quantity of waste, disposal technique, disposal agency and any reference/invoice numbers.
8512-SE-SOP16	Abrasive Blasting, High Pressure, Chemical and Mechanical Cleaning	Site operating procedure	To identify, assess and control hazards associated with abrasive blasting; and high pressure, chemical and mechanical cleaning at Meandu Mine, including trigger level determination for regulated waste and disposal of rejects.
8512-SE-P1002	Abrasive Blasting Procedure	Procedure	Procedure for managing abrasive blasting including management of abrasive blasting wastes.
8512-SE-WI1001	Removing ePoxy Waste from Site	Work Instruction	Instruction on process for removing ePoxy waste from site.
8512-SE-SOP5	Using Hazardous Substances	Site Operating Procedure	Procedure for use of hazardous substances onsite including potential environmental impact and waste disposal.
8512-SE-F1022	Washbays, Fuel Farm and Oily Waste Pit Daily Check	Form	Identifies the daily checks for the truck wash and oily waste pit, including checking parts and removing rubbish.
8512-SE-P1008	Sewage Treatment Plant	Procedure	Describes the requirements for the efficient operation of the Sewage Treatment Plant, including inspections, breakdown procedures, responsibilities and health and safety requirements.
8512-SE-F1018	Sewage Treatment Plant Daily Maintenance Check	Form	Identifies the daily maintenance checks at the Sewage Treatment Plant including visual checks, cleaning accumulated soils and checking parts.

DOCUMENT NO.	DOCUMENT TITLE	DOCUMENT TYPE	PURPOSE
8512-SE-P1005	Bioremediation Area Management Procedure	Procedure	Outlines the responsibilities and guidelines for the establishment and management of the bioremediation area including control of contaminated soils, managing plots and removal of clean soil.
8512-SE-F1023	Bioremediation Area Activity Inspection Checklist	Form	List of items to check during bioremediation area inspections.
8512-SE-SOP5	Managing Gases, Spray Painting and Asbestos	Standard Operating Procedure	Specify requirements for management of risks associated with managing gases, spray painting, spraying and other volatile substances and asbestos at Meandu Mine.

13 DEFINITIONS

Waste Rock	Waste rock Material such as soils, barren or uneconomic mineralised rock that surrounds a mineral or coal or body and must be removed in order to mine the ore. Generally referred to as overburden, interburden, interseam or spoil in coal mines.
Tailings and Coal Rejects	Washery waste from processing coal through the Coal Handling and Processing Plant (CHPP). In additional to coal material this waste also includes some waste rock material that having been through the coal processing process is required to be treated and managed differently to the waste rock described above.
Coal Combustion Products	Means fly ash, furnace bottom ash and cenospheres produced from the combustion of coal at the power station sites.
General waste	Means anything other than regulated waste.
Prime	Insitu overburden lying above the coal seam(s) prior to mining
Regulated waste	Means waste that constitutes, or is contaminated with, chemicals, cytotoxic drugs, human body parts, pharmaceutical products or radioactive substances.

Appendix F

Tarong Coal Project Draft Impact Assessment Study (Hollingsworth, 1979)



INVESTIGATOR COAL EXPLORATION PTY. LIMITED

TARONG COAL PROJECT

DRAFT IMPACT ASSESSMENT STUDY

Updating

"Pre-Investment Study of the Impact on the Environment of Open-Cut Coal Extraction at Tarong South", 1973

AUGUST 1979

prepared by:

PETER HOLLINGSWORTH & ASSOCIATED CONSULTANTS

in association with

SINCLAIR KNIGHT & PARTNERS PTY LTD

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Abbreviations

AADT	Annual Average Daily Traffic
ABC	Australian Broadcasting Commission
ABS	Australian Bureau of Statistics
A to P	Authority to Prospect
A.S.	Australian Standard
B.O.D.	Biological Oxygen Demand
^{o}C	Degrees Celsius
Company	Investigator Coal Exploration Pty. Limited
CRA	Conzinc Riotinto of Australia Limited
dB(A)	Noise level expressed in decibels using the "A" weighted network curves
Drg.	Drawing
ep	Equivalent Persons
GRIT	Generation of Regional Input Output Tables
gm	gram
ha	hectare
km	kilometre
k/h	kilometres per hour
kW	kilowatt
kWh	kilowatt hours
kV	kilovolt
ℓ	litre
ℓ/h	litres/hour
Mℓ	megalitres
Mℓ/a	megalitres per annum
MLA	Mining Lease Application
m	metre
mg	milligrams
mm	millimetre
MRD	Main Roads Department
MT	million tonnes
mty	million tonnes per year
MW	megawatt
N.P.&W.S.	National Parks and Wildlife Service
pH	A measure of acidity
pphm	parts per hundred million
ppm	parts per million
Q.A.T.B.	Queensland Ambulance Transport Brigade
Q.E.G.B.	Queensland Electricity Generating Board
Q.H.C.	Queensland Housing Commission
R.O.M.	Run of Mine
S.E.C.Q.	State Electricity Commission of Queensland
T.C.P.	Tarong Coal Project
t	tonnes
W.R.C.	Water Resources Commission
W.Q.C.	Water Quality Council
$\mu g/m^3$	micrograms per cubic metre

SECTION 1

Introduction

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1.0 INTRODUCTION

1.1 GENERAL

This document reports the findings of a modified Impact Assessment Study which has been undertaken in relation to the proposed Tarong Coal Project of Investigator Coal Exploration Pty. Limited, a fully owned subsidary of Conzinc Riotinto of Australia Limited (CRA).

This present report updates the previous environmental assessment of the Tarong Coal Project which was undertaken in 1973 and documented in a report titled: "Pre-Investment Study of the Impact on the Environment of Open-Cut Coal Extraction at Tarong South", Volumes 1 and 2.

1.2 STUDY OBJECTIVE

The principle objective of this current study was to essentially upgrade the former 1973 report and in so doing, to: *identify the likely interactions and to assess the consequential environmental impacts that could result from the implementation of the mine development proposal as currently envisaged by the Company.* These proposals are outlined briefly in Sub Section 1.4 below and described in some detail in Section 2 of the report.

The study was undertaken in response to the changes in environmental legislation which have occurred since 1973 and to assess the implication of the revised mine development programme.

1.3 PROJECT LOCATION AND REGIONAL SETTING

The proposed mining lease area is located within the local authority area of Nanango Shire. It is situated on the Shire's southern extremity and borders with Rosalie Shire, (refer Drg. No. E0351/1 - "Regional Location").

Nanango Shire is located in south east Queensland, some two hundred kilometres by road, north west of Brisbane. The Shire comprises an area of some 1,735 sq. km. of which approximately 7% is devoted to cultivation. The remainder of the shire, apart from urban areas, reserves and crown land is essentially used for grazing purposes.

The population of the Shire is currently 3,050. The only urban settlement of any significant size within the Shire is the township of Nanango. Other urban settlements in close proximity to the subject site are the towns of Yarraman and Cooyar, both of which are located within the adjacent Rosalie Shire. Kingaroy is the closest regional centre to the site, (refer Drg. No. E0351/2.).

1.4 BRIEF OUTLINE OF PROJECT

The aim of the Tarong Coal Project is to supply coal to the proposed Tarong Power Station which is to be located adjacent to the coal deposits. The projected output of the coal mine will increase from the power station's initial requirement of 1.0 MTY to 4.9 MTY when the station becomes fully operational in Year 6 of the development.

The current mine plan includes the eventual development of seven mining areas in which five coal seams will be mined. Mining will utilize conventional open cut mining methods involving a walking dragline for overburden removal and shovel and truck operations for coal loading and transportation from the pit areas to the coal preparation plant area. This plant area will later include a coal washing plant. Delivery of coal from the mine will be direct to the power station by a conveyor.

1.5 REPORT ORGANISATION

The contents of this Impact Assessment Report are set out in five sections. Following this introductory section, Section 2 - "The Proposed Project", describes the various elements of the Company's current proposal. Section 3 includes a description of the characteristics and conditions of the existing environment, both natural and man-made, for the proposed mining application lease area and its immediate surrounds. The fourth section of the report provides an evaluation of the anticipated impacts to existing environments from the intended implementation of the proposed project. The concluding section of the report summarises the main beneficial and detrimental consequences and also contains sections dealing with recommended environmental safeguards and governmental requirements applicable to the proposed mining development.

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The Proposed Project

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2.0 THE PROPOSED PROJECT

2.1 PROJECT BACKGROUND

In February 1978, the Queensland State Cabinet determined that a new thermal power station would be constructed at Tarong. This station would be a 1400 MW coal fired power station comprising four 350 MW generating units with the first unit to be commissioned in 1985. Thereafter, progressive commissioning of the remaining units would occur.

The coal supply for this power station will come from the adjacent Tarong South Coal deposits. An agreement will be negotiated between the Company and the State Electricity Commission of Queensland (SECQ) for the supply of coal to be consistent with the abovementioned progressive commissioning of generating units. At this point in time it is expected that the power station's coal requirements will be 1.0 MTY in year 1 of the station's operations, increasing to 4.9 MTY in year 6 when it is anticipated that the station will be at full planned capacity.

In order to meet these commitments, the Company currently proposes to mine the Tarong South coal deposits by open cut method. The development will also entail the construction and operation of a coal crushing and handling plant, a coal washing plant and other associated support and service facilities for the mine.

Exploration undertaken to date within A to P 235C, (held by the Company), has defined the following reserves:

(i) proven reserves - 287 MT (measured plus indicated 1st class)
(ii) inferred reserves > 100 MT

187 million tonnes of the proven reserves are located in the Tarong South deposits, the area relevant to the coal supply agreement. These reserves are adequate to meet the requirements for the life of the Tarong power station.

The individual development actions of the mine proposal are discussed in further detail in subsequent sub sections. The description has been limited to only that information which is necessary to undertake the environmental assessment. Technical engineering details have been avoided wherever possible. In some instances, the detailed engineering design has yet to be finalised and consequently some of the activities described in this section may be amended. However, the basic concept and principle design parameters are unlikely to alter. They are considered in terms of the following sequential phases of development:

(i) Pre-Construction Phase
(ii) Construction Phase
(iii) Regular Production Phase

2.2 DEVELOPMENT PROPOSALS AND PROGRAMME

The current mine plan covers the anticipated coal deliveries to the power station over the first twenty years of the project. This mine plan is outlined on Drg. No. E0351/5. It includes the eventual development of several mining areas in which five coal seams will be mined. The main areas to be mined as illustrated are:

North West
West
South West
King I
King II
King III
King IV

The Company proposes to mine the Tarong South coal deposits by conventional open cut mining methods utilizing a walking dragline for overburden removal and shovel and truck for coal loading and transportation from the open cut pits to the preparation plant area.

The coal produced during the initial 3 to 4 years of production will be of the required ash specification and will consequently not require washing. The initial benefication will be confined to crushing through a Bradford breaker. During subsequent years of production however, the coal will require washing and it is proposed to utilize a simple jig plant for this purpose. As illustrated on Drg. No. E0351/4, the mine's preparation plant area will be located in the extreme northern portion of the proposed mining lease area, immediately adjacent to the power station's south west boundary.

Administrative, support and service facilities for the mine will also be located in the vicinity of the preparation plant area. These facilities will include:

(i) Administrative Offices
(ii) Employee's Changeroom and Amenities
(iii) Maintenance Workshop
(iv) Warehouse
(v) Mine Laboratory
(vi) Fuel Storage
(vii) Mine Services

2.3 PRE-CONSTRUCTION PHASE

This phase has already commenced and includes all activities up to the commencement of the detailed design and construction of the various components of the overall mine development.

2.3.1 EXPLORATION AND SURVEY

The Company has undertaken a phased geological field mapping and drilling programme within the subject area and its immediate surrounds, which in the past were part of A to P 50C, 75C, 197C and subsequently 235 C. The drilling programme commenced in mid 1969.

Within the current A to P held by the Company, (No. 235C), exploration and survey work is continuing on the evaluation of the coal deposits.

2.3.2 BACKGROUND STUDIES

Other work and investigations are currently being directed towards the finalisation of such aspects as:

(i) an optimum mine plan, (including the selection of suitable mining equipment);
(ii) the final coal supply agreement;
(iii) the land acquisition programme;
(iv) the obtaining of a Mining Lease over the proposed mining area; and
(v) infrastructural and housing negotiations with various Government Departments and Local Authorities.

The main technical studies which are currently underway or proposed for this phase, include:

(i) geological studies on the coal reserve;
(ii) statistical studies of coal quality and coal handling characteristics;
(iii) rock mechanics evaluation of the deposit;
(iv) hydrological and groundwater evaluation of the deposit;
(v) civil, mechanical and electrical engineering studies;
(vi) aerial photography and topographical survey of the Tarong area; and
(vii) environmental monitoring programme to establish baseline data, (including water and air quality and visual aesthetics).

2.3.3 LAND ACQUISITION AND LEASE APPLICATION

Delineation of the northern boundary between the power station and the proposed mining lease area has been finalised and a mining lease application has been submitted. The Company is currently proceeding with the documentation and finalisation of the required land acquisition programme.

2.4 CONSTRUCTION PHASE

This phase will commence with the detailed design for the proposed development and lead through the on-site construction activities up to the commencement of regular coal deliveries to the power station. The construction phase comprises essentially two stages, viz:

(i) the initial construction and development of the mine site including the plant area, buildings and mine infrastructure; and
(ii) the later erection and construction of the mine washing plant.

Because of the long lead times applicable to the project, a detailed construction programme has not yet been finalized. The following sub sections outline the current preliminary programme for mine site construction activities.

2.4.1 SITE EARTHWORKS AND DRAINAGE

Construction of all facilities associated with the coal handling and preparation plant, mine site buildings, internal roads and tailings dams, (see Drg. No. E0351/4), will require the initial clearing of the existing vegetation cover. The total area requiring clearing is of the order of 800 ha. Clearing will also be required in an area away from the main plant area for the dragline construction and maintenance, (approximately 4 ha).

Level areas will be required for all mine buildings and plant items. Within the nominated plant area a designed balance of earthworks will be achieved by cuts and fills which will not exceed 5m in height. Stormwater drainage of these areas is not expected to be a problem.

To prevent stormwater runoff from entering the open cuts it is proposed to construct a series of open channels. These catch drains will follow roughly the contours around the high sides of the excavation to divert runoff water around each end of the pits. The size of the catch drains will be dictated by the size of the diverted catchment and the extent to which they can be made to follow the existing contours. Excavated material will probably be placed on the top of the low side of the channel to provide additional protection. Alternatively it may be used to construct the embankments for the settlement ponds.

2.4.2 PLANT AND BUILDING CONSTRUCTION

Mine plant and facilities consistent with the production of the annual tonnage of coal necessary to meet the coal delivery specification will be erected on site. The buildings to be erected have previously been mentioned in sub section 2.2.

2.4.3 CONSTRUCTION OF MINE INFRASTRUCTURE

(i) Power Supply

A construction power supply will be available for the power station programme well in advance of the mine construction requirements. Consequently it will not be necessary to provide temporary mobile power generation equipment for construction purposes at the mine site. Power will be required at the mine site from the outset of the Construction Phase. Peak loads are not expected to exceed 1 MW until the commissioning of the dragline. It is proposed to erect temporary reticulation followed by the building of a permanent supply at some later date in preference to erecting the permanent reticulation and initially energising at a lower voltage.

(ii) Water Supply

During the construction phase it is proposed to either exploit the reserves of groundwater which exist in the area or to obtain water from the Q.E.G.B. at the power station site. A small treatment plant will be installed to provide treated water for domestic use within the mine site.

(iii) Internal Roads

The area of the proposed coal mining lease will embrace a network of local connecting roads serving the present rural community. These roads are narrow, gravel surfaced and on poor alignment except for the one running north from the King I mining area, which is a 3.6 m wide bitumen sealed road. It is proposed that all existing roads will be closed so that public entry into the proposed lease area is restricted.

A network of specially constructed haul roads will be developed between the various mining areas and the mine preparation area. These haul roads which will be gravel surfaced, will be about 30 m wide and of reasonable grades to ensure rapid, safe and economic operations. The earthworks associated with these haul roads could be substantial in places with cuts and fills up to 5m in height. Exits from the pits will be by ramps on steep grades. The haul roads will terminate in a loop at the run of mine hopper. The location of the proposed haul roads is shown on Drg. No. E0351/5.

(iv) Communications

Telephone and telex services will initially be connected to the site office during the construction phase. Services will be progressively upgraded as permanent offices are constructed on site. The ultimate servicing of the mine site will include a PABX telephone system, telex facilities and a mobile radio service.

2.4.4 CONSTRUCTION WORKFORCE

The recruitment of construction labour is mainly the responsibility of the successful contractors who will import into the area the necessary skilled labour to execute the work. Employment opportunities will also be available to local labour.

The construction workforce for the mine is expected to peak at 440 persons during 1984.

It is planned that a second construction stage will occur during 1987/1988 when the washing section of the beneficiation plant is expected to be erected. The construction peak during the second stage will be approximately 150.

Table 2.1 shows the estimated construction workforce schedule.

TABLE 2.1

CONSTRUCTION WORKFORCE SCHEDULE

Year	Workforce
1982	60
1983	290
1984	440
1985	220
1987	150
1988	150

2.4.5 CONSTRUCTION WORKFORCE ACCOMMODATION

It is anticipated that the majority of the construction workforce will establish themselves in caravan parks located in the urban settlements surrounding the mine site. Negotiations are currently underway with the local authorities and relevant government departments concerned, in order to give immediate consideration to the accommodation of the construction workforce for both the mine and the power station. These aspects and associated factors are considered in further detail in Sub Section 4.3.3.

2.5 REGULAR PRODUCTION PHASE

As previously mentioned in Sub Section 2.1, the commencement of regular production of coal will coincide with year 1 of the power station's operations (1985). A schematic diagramme of the mining and preparation process is given in Drg. E0351/6.

2.5.1 CLEARING AND BURNING

The initial stage of the strip mining process involves the removal of vegetation from the area where the overburden is to be removed and deposited. The area involved for each nominated mining area will be of the following orders:

North West	240 ha
West	15 ha
South West	120 ha
King I	80 ha
King II	40 ha
King III	20 ha
King IV	120 ha

The vegetation will be dozed into windrows and burnt. The clearing will be undertaken in stages so as to limit the areas of bare ground before mining commences.

2.5.2 OVERBURDEN STRIPPING

The mining of each area will be carried out by excavation in strips, each approximately 100 m wide. The proposed strips and direction of workings are indicated on Drg. No. E0351/5. In general terms, the orientation of the strips approximates the direction of the contours.

After the clearing and burning of the vegetation, the topsoil will be removed by scraper and dozer operation and stockpiled off the excavated areas for subsequent reuse in the rehabilitation operations.

Prior to the commencement of excavation, the overburden will be drilled on a grid pattern using an electrically powered rotary rig and the material broken down with ammonium nitrate/fuel oil explosive. In general, charges will be fired once during the daylight shift. The loosened overburden material will then be removed by an electrically powered walking dragline of 45 m^3 capacity.

During this operation the dragline sits on the advancing end of the strip and excavates to the level of the coal seam by dumping overburden to one side. Thus a "high wall" which stands at an angle of 65° is created on the side yet to be mined. On the other side, the spoil heap spills down into the bottom of the pit at 38°. The height at which the spoil heap stands depends on the extent to which the overburden material bulks when excavated and the ratio of the depth of overburden to the depth of the coal. Also the height of the pile from the first strip will be higher than the others as there is no excavation in which to place it.

The relative depths of overburden and coal in each mining area are set out below:

	Overburden Depth Range	Coal Thickness
North West	15-35 m	3-15 m
West	15-60 m	3-13 m
South West	15-35 m	3-10 m
King I	15-60 m	3-29 m
King II	15-60 m	3-33 m
King III	15-40 m	3-17 m
King IV	15-50 m	3-21 m

After the last strip in each mining area is mined, a large open excavation will remain from which further mining could be carried out.

2.5.3 COAL EXTRACTION

After the removal of the overburden, the top surface of the coal seam will be cleared by dozer and then the coal will be drilled and blasted using a diesel powered rotary rig and ANFO explosive. Approximately one blast per daytime shift is anticipated.

A crawler mounted electric powered shovel will then be used to extract the coal from the shot coal pile and dump it into the haul trucks.

2.5.4 RAW COAL HANDLING

Coal will be hauled from the mining areas to the plant area in 109 tonne bottom dump off-highway vehicles. In peak periods, from 4 to 9 of these vehicles will be used depending upon the production rate.

Haulage will be along the specially constructed haul roads previously mentioned, (ref. Sub Section 2.4.3 (iii)). These roads will be graded and watered almost continuously to provide smooth dust free operations.

At the plant area the truck unloading station will consist of an elevated hopper of 380 tonne capacity. This will be large enough to allow simultaneous side-by-side bottom dumping by two trucks from a concrete roadway on top of the hopper.

Beneath the hopper, coal will be fed by a grizzly into an underground rotary breaker which will reduce the coal to the required size. Coarse rock oversize material will be rejected from the breaker. The broken coal will pass through the sizing plates of the breaker and will be collected on a conveyor installed in a tunnel beneath the crusher. The coal will be conveyed to the surface and onto the top of the raw coal stockpile through a vertical chute. The conveyor will be uncovered but protected by windshields.

The raw coal stockpile will be conical in shape, of 17,000 t capacity and will stand about 25 m high at 38° to the horizontal. Beneath the stockpile will be a tunnel and a reclaim conveyor which will deliver coal to the processing plant. In the early years this plant will consist of secondary crushers. A coal washing module will be constructed in 1987/1988.

2.5.5 CLEAN COAL HANDLING

It is currently planned to commission the washing section of the plant after 4 years of regular production during which time the coal mined will not require washing to meet the ash specifications. The washing plant proposed, will be the Simple Jig type with a rated capacity of 1700 tonnes of raw coal per hour.

Water for the process will be supplied to the recirculating tank from the storage reservoir, from the dewatering screen and from the settlement ponds. All undersized material will be pumped to the tailings dams.

The washed coal product will be conveyed to the washed coal stockpile which will be of similar size and shape to the raw coal stockpile. The material in this stockpile will however be smaller and the moisture content of the product will be up to 14%.

Product coal from the washed coal stockpile will be conveyed to a 200 t elevated surge bin. From here the coal will be chuted onto the main haul conveyor for direct delivery to the power station's coal stockpiles. This main haul conveyor will be covered.

2.5.6 MOBILE EQUIPMENT

The major items of mobile equipment for the mine have yet to be finalized. However the conceptual mobile equipment schedule for initial operations is set out in the following table.

TABLE 2.2

INITIAL MAJOR MOBILE EQUIPMENT SCHEDULE

Unit *	No.
Marion 8050 - 25 Dragline	1
Gardner Denver GD 130 Drill	1
Mayhew 1000 Coal Drill	1
P & H 1600 CH Coal Shovel	1
Wabco 120 CT Coal Truck	4
Amerind Anfo Truck	1
Cat D9H Dozer	4
Cat 988 Loader	1
Cat 631 D Scraper	2
Cat 16G Grader	1
Cat 631 Water Truck	1
Cat 824 R.T. Dozer	1
Michigan 475 B Loader	1
Lubrication and Fuel Truck	1
Field Service Truck	1
45 Passenger Bus	3
F100 Ambulance	1
90T Mobile Crane	1
5T Mobile Crane	1
10T Truck	1
5T Truck	1
1½T Truck	1
F100 Utilities	14
Falcon 500 Sedans	8
100T Low Loader	1

Source: Investigator Coal Exploration Pty. Limited, 1979

(* NOTE: The unit classification given is to indicate the size of equipment and the particular manufacturer's model quoted may not necessarily be that eventually acquired.)

2.5.7 REJECT AND WASTE DISPOSAL

Apart from the previously mentioned reject material pumped to the tailings dam from the preparation plant, there will be material rejected from the raw coal rotary breaker. This material will be discharged by a conveyor to the ground where it will be regularly loaded on to trucks and hauled back to the open cut spoil piles and dumped.

Tailings from the preparation plant will be pumped to the tailings dams where the sludge will settle out and the supernatent liquor will be returned to the plant for recycling in the washing process. These dams will be located in a local depression draining into Meandu Creek, as shown on Drg. No. E0351/4. The dams will be protected from ingress of stormwater by a catch drain which will divert runoff around them. As all the liquid entering the dams is returned to the washing plant for recycling, there will be no dam effluent discharge into Meandu Creek. Discharge will be made to one dam at a time so as to allow the sludge in the other dam to dry out. This sludge will eventually be trucked out and returned to the open cut pits for disposal.

Apart from the wastes produced in the coal preparation, the only other liquid effluent produced at the mine site will be from the water treatment plant and domestic sewage. The former may eventually reach Meandu Creek but the quantity involved will be very small.

Sewage disposal will be either by septic system or by an activated sludge package treatment plant. Effluent from the latter would be of the order of 36,000 ℓ/day and this would enter Meandu Creek. Its quality would be established by the Water Quality Council and this could be expected to be at least to 20 mg/ℓ B.O.D. and 30 mg/ℓ Suspended Solids.

2.5.8 MINE INFRASTRUCTURE

(i) Water Supply

The estimated peak operational requirement for the mine is 600 Mℓ/annum. It is currently proposed that this water will be supplied by Q.E.G.B. from the power station supply which will be drawing its operational water supply from the Boondooma Dam on the Boyne River near Proston. The final details of this water supply arrangement have yet to be finalized under the terms of the coal supply agreement between the Company and Q.E.G.B.

(ii) Power Supply

The power supply for the mine operations will be supplied directly from the Tarong Power Station to the mine switchboard at 66 kV. Reticulation within the mine area will be by 11 kV transmission lines from the switchyard to the pits and the handling and washing plant, where substations will step down the voltage as required.

The anticipated maximum annual power consumption is approximately 28 million kWh with a maximum half hour demand of 6900 kW.

(iii) Other Services

Details of other infrastructutal requirements have previously been stated. Refer to Sub Section 2.4.3 (iv) for communications and Sub Section 2.5.7 for liquid waste disposal.

2.5.9 REHABILITATION

The "Tender for the Supply of Coal" of 1st April, 1977, is based on the minimum rehabilitation of the mine workings and overburden dump areas after the coal has been extracted from each pit. This restoration will consist of the smoothing off of the tops of the spoil heaps and the replacement of the initially stockpiled top-soil over the smoothed heaps, by a dozer and scraper operation.

The final mined strip of each pit will remain an excavation which may eventually fill with water.

TABLE 2.3

OPERATIONAL WORKFORCE SCHEDULE

Workforce	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Operational																			
Imported			14	84	131	165	210	210	240	241	241	241	241	241	241	241	245	233	233
Local			6	32	51	64	81	81	94	94	94	94	94	94	94	94	95	91	91
Total Operational			20	116	182	229	291	291	334	335	335	335	335	335	335	335	340	324	324
Construction	60	290	440	220		150	150												
TOTAL WORKFORCE	60	290	460	336	182	379	441	291	334	335	335	335	335	335	335	335	340	324	324

It is understood that provision has been made for whatever level of restoration is required under any legislation either State or Federal proclaimed after the date of lodgement of the tender.

2.5.10 PERMANENT MINE WORKFORCE

The permanent workforce required for the operation of the mine is estimated to peak at 340 persons. It will be necessary to import into the district a large number of skilled personnel. However it is intended that the recruitment policy will give full consideration to the availability and suitability of the local population. For estimating purposes it has been assumed that approximately 28% of the permanent employees will be recruited locally. These workers will not require assistance with accommodation.

The operational workforce will commence in 1982 and build up gradually to almost full capacity by 1990. Consequently there will be some overlap with the construction and operational workforces, particularly during the construction of the washing plant in 1988 and 1989. The expected operational manpower schedule is shown in Table 2.3.

Table 2.4 provides an illustration of the range of workforce skills likely to be required by the proposed mine in a typical operation year.

TABLE 2.4

SKILLS OF OPERATIONAL WORKFORCE

Skill	No. of Workers
Staff	61
Mining	100
Engineering & Services	139
Administration	11
Preparation Plant	24
TOTAL	335

Source: Investigator Coal Exploration Pty. Limited

2.5.11 HOUSING

The Company proposes to construct 244 houses to accommodate the mine operational workforce. These houses will be of reasonable quality, timber framed and will be constructed in a number of configurations suitable for the Queensland climate. Further details of the Company's housing policy are given in Sub Section 4.3.3.

SECTION 3

The Existing Environment

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3.0 THE EXISTING ENVIRONMENT

3.1 GENERAL

This section of the report contains summary descriptions of the characteristics and conditions of the existing environment of the project area and its immediate surrounds. The depth of study undertaken varies with the particular environmental aspect being investigated. This is due to different levels of interaction between the environmental aspects and the various proposed development activities.

The descriptions of the existing environment are contained within the general groupings of:

(i) Natural Environment
(ii) Man-Made Environment

3.2 NATURAL ENVIRONMENT

3.2.1 GEOLOGY

(i) Regional Geology

A broad geological appraisal of the region in which the area for open cut mining is located, shows that the Upper Triassic Age Tarong Beds are almost completely surrounded by elevated blocks of basalt, metamorphosed sediments (metasediments), and granite. Tertiary Age basalt and sediments occur to the northwest and south of the coal deposit, forming the Stuart and Cooyar Ranges respectely. The western boundary is Permo-Triassic granite, and the eastern boundary Palaeozoic Age metasediments.

(ii) Local Geology

The proposed surface lease area occupies 4,000 ha of country in which the moderate relief is controlled by two main geological factors:

(a) Flat lying Tertiary Age basalt flows and associated sediments which form the subdued scarps of the Cooyar Range.

(b) Scattered remnants and wedges of coal measure sandstones and conglomerates which form isolated scarps in some parts and underlie most of the topographic highs.

An idealised geological column for the area is shown in Table 3.1.

TABLE 3.1

IDEALISED GEOLOGICAL COLUMN

Rock Unit	Thickness
Alluvium	0 - 15 m
Tertiary basalt, sediments and Laterite	0 - 110 m
Tarong Beds	250 - 350 m
Granite and Metasediment Basement	Unknown

The alluvium is mainly sand and gravel, which is restricted to Meandu Creek and its minor tributaries. These sediments may contain small amounts of groundwater.

The Tertiary basalt, associated sediments, and laterite, appear to the east, southeast and south, and give rise to the deep and lateritic soils. The basalt displays considerable variation in original thickness and subsequent lateritic weathering profile.

The Tarong Beds contain a typical coal measure sequence of inter-bedded conglomerate, sandstone, siltstone, mudstone, and coal. Eight main coal seams occur within the area. The porous sandstones and coal seams in the upper section of the coal measures generally tend to act as aquifers, and provide a small amount of water for local use.

The basement consists of granites belonging to the Permo-Triassic Boondooma Igneous Complex, and metasediments of the Palaeozoic Age Moronghi Creek Beds.

3.2.2 TOPOGRAPHY

The proposed mining lease area lies in the upper catchment of Meandu Creek, a minor part of the Burnett River System. This river flows to the South Pacific Ocean near Bundaberg. The land of the proposed mining lease area consists of part of the remnants of a once extensive plateau which has undergone minor structural movements, erosion, and weathering to produce a series of land surfaces of varying altitudes and elevations.

The average altitude of the area is approximately 480m. The area consists of gentle to moderately undulating hills of low relief characteristically with steep upper slopes and gentle summits and ridges. These hills are often spurs of the Cooyar Range (altitude 600M) lying in the east and to the south of the proposed lease area. Flat-lying basalt flows and the associated sediments form the generally subdued scarp of the Cooyar Range. Remnants of sandstones and conglomerates of the coal measures form isolated knobs and subdued hill scarps in the central area.

Extensive erosion has created narrow, mostly flat bottomed drainage valleys and reticulated flood plains which separate elevated surfaces and associated slopes. Along the north west boundary of the study area the flood plain of Meandu Creek broadly separates outcrops of the sandstones and conglomerate of the Tarong Beds.

3.2.3 SOILS AND EARTH RESOURCES

Soils which have developed on the proposed mining lease area vary in depth, texture and profile in accordance with topography. They generally become shallower and exhibit less pedological development with increasing degree of slope.

Soils on steep slopes formed on the finer sediments of the Tarong Beds are mostly shallow, medium to coarse textured, sandy and silty gravelly soils with rock outcrop occurring locally. Medium to fine textured sandy and silty clay soils occur on gentle slopes or level areas, however in all areas except alluvial surfaces soil horizons having pedological development are mainly very thin and overlie weathered rock materials of the Tarong Beds at shallow depth.

Soils developed on the coal measure conglomerates in areas of higher relief are generally medium to coarse textured grey or light brown sandy gravel or gravelly clay soils on footslopes, drainage floors and flatter areas. Rock outcrop with associated skeletal soils may occur on crests, steep slopes or locally elevated areas. On flat or gently concave inclined valley surfaces of low internal relief, soils are mostly transported medium to fine textured grey brown sandy and gravelly clay soils. However in some areas of low relief very shallow medium to coarse textured grey or light brown silty or clayey gravelly soils may occur particularly where depth to bedrock is shallow. These soils are of low fertility being deficient in nitrogen and phosphorous.

Soils derived from the tertiary basalt are primarily red earths. They are acid, friable, moderately fertile, relatively deep soils and on the slopes little differentiation into horizons is evident. On the hill tops, a less fertile, light textured, red soil overlies a moderately acidic and more fertile shallow B horizon.

Areas of Quaternary-Recent Alluvium although containing a variety of transported soils consist predominantly of deep, medium to fine textured brown or dark grey sandy and silty clay soils. These soils of alluvial origin are deep and fertile although of limited extent.

Earth resources on the proposed coal mining lease area are restricted to deposits of sand and gravel in Meandu Creek. No minerals or earth resources apart from coal and these construction materials are known to occur in the area.

3.2.4 SURFACE WATER

On a local scale, the proposed coal mining site lies within the catchment of Meandu Creek, a small ephemeral tributary of Barker Creek which flows north near the town of Nanango to the Burnett River. Meandu is a minor stream which flows only during the wet season (October-March). For the remainder of the year, this stream is composed of a series of wet areas and isolated waterholes covered with aquatic weeds.

No stream gauging has been carried out on this creek by the Water Resources Commission.

The catchment of Meandu Creek is about 163 square kilometres with approximately 98 square kilometres of this contributing to creek flow within the mining area. The creek rises at an elevation of approximately 610 metres in the Cooyar Range about 30 kilometres south west of Nanango and flows across gently undulating open countryside to its confluence with Barker Creek at an elevation of about 390 metres above mean sea level.

Meandu Creek and tributaries have been sampled throughout the proposed mining lease area for water quality criteria on a number of occasions since 1976 and on a weekly basis at five sample points when stream flow rates were sufficient from October 1978. A reasonably accurate base of quality parameters is being established.

The major points to note from the quality testing carried out to date are that the water is very slightly alkaline with reasonably high sodium and chloride content. The water has an unusually low suspended solids count and a typically high filterable residue from the surrounding farming area.

On a regional scale, two major surface water systems influence the study area and major towns in the vicinity. These are the south-north flowing Burnett River which enters the Pacific Ocean near Bundaberg and the north-south flowing system of the Brisbane River which enters Moreton Bay near Brisbane. The proposed lease area covers an area of approximately 4,000 hectares which extends over the Cooyar Range - the watershed of these two major river systems, ref. Drg. E0351/2. Kingaroy and Nanango (to the NW) lie within the catchments of the Burnett River while Yarraman and Blackbutt (to the SE) lie within the Brisbane River catchment.

The township of Nanango is situated on Sandy Creek, a small tributary of Barker Creek. At an altitude of 350 metres above mean sea level, the town does not have any serious flooding problems from bank overflow of its local streams. Sandy Creek, however, does cause some minor problems to the south east sectors of the town in storms greater than about 1 in 10 year frequency.

Cooyar Creek rises in the Cooyar Range south of Nanango. This is a tributary of the Brisbane River and is dammed at about 21 km to provide water for Nanango. This same stream also provides a water supply for Yarraman which is located on the creek further upstream where it is called Yarraman Creek.

Kingaroy is drained by Kingaroy Creek, a tributary of the Stuart River which, rising in the Bunya Mountains, is a major tributary of the Burnett River. Kingaroy has no major flooding problems from overbank flow of Kingaroy Creek.

A small creek and swampy area known as Tanduringie Swamp to the west of the proposed lease near the homestead of Tarong, was dammed some years ago to provide a domestic and stock supply for a local farmer. This resulting dam covers a surface area of about 5 ha and although reasonably shallow, provides a permanent source of water.

3.2.5 GROUNDWATER

(i) Regional

A regional groundwater assessment shows that only limited supplies of underground water are available. The water is contained within porous sedimentary rocks and fractures in igneous rocks. A total dissolved salt content of 1000-3000 ppm is to be expected.

(ii) Local

Within the proposed lease area there is a well developed tendency for the water table to parallel coal seams, particularly the thick ones, rather than the topography as would normally be expected. In some cases the water table lies within or just below the coal seam whilst in other places it follows the top of the coal, the seam forming the aquifer. There is also some evidence that the water table is perched where it lies close to the surface, for example under streams, at breaks of slope, and on flat hill top areas such as above the basalt of the Cooyar Range. Some of the perched water tables are also related to coarse sandstone infilling palaeo-stream channels within the coal measures. Seasonal groundwater level fluctuations appear to be less than 5 m over most of the area with some recharge from soilwater.

The water obtained from existing boreholes has a pH range of 3.5 -6.8. Local opinion indicates that the salt content of the water has increased over recent years. Recent estimates of total dissolved solid concentrations gave values ranging from 450 to 5260 ppm. Concentrations of some heavy metals in some water samples exceeded levels recommended for irrigation, livestock and domestic supplies. Suspended solids ranged from 0 to 27 mg/ℓ and consisted mainly of slowly settling iron stained particles, possible of organic origin. Supply for stock watering purposes is adequate.

3.2.6 CLIMATE

The Nanango area has a sub-humid moderate climate influenced by its inland locality and altitude. A weather recording station is located at Nanango

whilst a rainfall recording station at Maidenwell collects information on that parameter alone. Climatic and rainfall data are summarised in Tables 3.2 and 3.3. It should be noted that topography may strongly influence climate at particular localities and it may differ from Nanango's at points within the proposed lease area.

Temperature data for Nanango indicatesthat on an annual basis, the average daily temperature range is 14.5°C. The largest average daily range occurs during winter (eg. August: 16.9°C) and the smallest in summer (February: 11.1°C). The warmest months of the year are from November to February with average daily maximum temperatures exceeding 28°C. Temperatures above 32.2°C are recorded on around one day in every three during December and January whilst temperatures above 38°C occur only a few times each year.

During winter, mean daily maximum temperatures are around 20°C whilst mean daily minimum temperatures fall below 5°C, with July, the coldest month, having a value of 2.7°C. Frosts can be expected to occur on fine clear nights between mid autumn and mid spring on an average of 37 nights each year.

Rainfall at Nanango shows some seasonality. Summer months record more than twice the amount recorded during winter months. Maidenwell records significantly less annual rainfall on average (647 mm) than Nanango (805 mm). Rainfall of over 1000 mm can be expected at some localities on the ranges.

Evaporation generally exceeds rainfall in all months of the year. Humidities at 9 a.m. are generally lowest during spring and highest from May to July.

The average number of hours of sunshine per month varies from a minimum of 210 hours in June to a maximum of 270 hours in November. The cloudiest months of the year are on average January and March whilst least cloud is recorded during August.

Wind recorded at Nanango is usually from the north-east to south-east during the period October to April. These north-easterly winds tend to promote thunderstorms in the area as cloud builds up over the high ranges. There are around 30 thunder days per year.

During the period May to September winds blow from the south-west and occasionally strongly from the west.

Tropical cyclones generally lose intensity before reaching the area and affect it mainly as rain depressions.

TABLE 3.2

CLIMATIC DATA NANANGO

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Source
Temperature (°C)	Av. Daily Max.	30.3	28.4	27.8	25.7	22.4	20.1	19.3	21.4	22.9	26.4	29.0	29.5	25.3	a
	Av. Daily Min.	17.7	17.3	15.2	10.9	7.1	4.0	2.7	4.5	7.5	11.8	14.2	16.5	10.8	a
Rainfall (mm)	Mean	114	105	90	47	40	46	43	34	41	65	75	105	805	a
	Median	100	86	73	36	34	34	30	25	35	56	65	95	770	a
Raindays (No.)		10	10	10	7	6	5	5	5	5	7	7	9	86	a
Evaporation (mm)		168	140	140	114	89	64	71	89	114	165	173	208	1535	b
Relative Humidity %	9 a.m.	72	76	74	73	75	79	78	73	68	65	61	69	72	a
Cloud Cover Scale 0-8	9 a.m.	4.7	4.4	4.7	3.7	3.3	3.4	4.4	2.7	3.4	4.3	3.2	4.5		b
Sunshine (Hrs)		235	200	225	220	225	210	230	250	250	270	270	260	2845	b
Wind*	9 a.m.	E-SE	E-SE	E-SE	E-SE	E-SE	SE-SW	SE-SW	E-SW	E-SE& SW-NW	E-SE SW-NW	E-SE -NW	E-SE -NW		b

Source:
a. Bureau of Meterology (1975)
b. Hodge (1970)

* For Kingaroy Surface Wind Analysis refer Appendix E

TABLE 3.3

RAINFALL - MAIDENWELL

Month	J	F	M	A	M	J	J	A	S	O	N	D	Ann.
Rainfall (mm)	59	81	80	38	52	28	39	28	41	59	60	82	647

Source: Hodge (1970)

3.2.7 AIR QUALITY

The existing air quality over the minesite is generally good. During dry periods, dust of natural origin may be found in the air. Significant periods of smoke haze have been recorded by the Forestry Department at Yarraman. It is likely that the haze is caused by a combination of bushfires and airbourne dust.

With pre-mining exploration being carried out at the minesite, exploration tracks have been cleared, resulting in a higher incidence of dust particles from the movement of vehicles. Vegetation along the sides of these tracks and unsealed roads are covered with dust particles. This dust is generally swept from the leaves during periods of rain.

Being located in an area of low population density with little traffic and industrial activity, it is probable that existing concentrations of sulphur dioxide, oxides of nitrogen and carbon dioxide are very low and might be similar to those shown below which are regarded as typical of such regions.

sulphur dioxide	:	0.2 pphm
oxides of nitrogen	:	0.1 pphm
carbon dioxide	:	325 ppm

3.2.8 NOISE

The existing background noise levels within the study area are relatively low. Generally speaking, both day and night time levels are typical of rural environments. The low background noise levels, of the order of 25-35 dB(A), are occasionally increased by noise emitted by farm machinery and vehicular movement through the area. Wind in the trees and birds can also cause intermittent increases in noise levels.

Exploration drilling and the movement of men and equipment over the site has led to some increase in background noise levels. However these increases are short term and are not large enough to significantly affect the area's ambient noise levels.

3.2.9 FLORA

A vegetation survey of the proposed mining lease area at Tarong was undertaken. This investigation involved the interpretation of 1961 run black and white air photographs as well as a field survey of selected areas to verify boundaries and identify plant species.

Members of a survey party from the Government Herbarium were contacted regarding plant species present in the area. Vegetation descriptions and plant species lists produced for previous environmental studies in the area were also incorporated. The dominant vegetation types have been mapped on Drg. E0351/7.

Grazing, clearing and burning have severely modified much of the original vegetation occuring on land used for agricultural purposes. Clearing for agricultural uses has proceeded slowly since the 1961 run aerial photography and many previously cleared areas now support regenerating stands of forest. Land under Department of Forestry control has largely been cleared and planted to hoop pine plantation although there are fire breaks and some unplanted areas still supporting the original closed forest.

The vegetation of the proposed mining lease area consists of a number of types. These are eucalypt open forest, closed vine forest, plantation forest and grassland. A detailed flora list is given in Appendix A.

(i) Eucalyptus Open Forest

This forest type occurs as two main structural forms as well as a number of floristic types. The layered open forest consists of mainly *Eucalyptus crebra* associated with an under storey of vine forest species as well as lantana in the more disturbed areas. The ground layer in this type is fairly sparse although vine forest species tend to 'clump' allowing grasses in between. This type intergrades with closed vine forest, *E.crebra* often occuring as an emergent in the latter. The shrub layer is absent in poorer soils, particularly skeletal soils and in frost hollows. In these areas grasses such as kangaroo grass (*Themeda australis*), bladey grass (*Imperadum cylindricum*), red natal grass (*Rhynchelytrum repens*), *Aristida* sp and *Lomandra* sp are common.

This vegetation type is dominated by iron bark (*E.crebra*) on shallow ridge top soils. This species grades into a mixed community of iron bark, spotted gum (*E.maculata*) and sugar gum (*Angophora costata*) on the ridge slopes. Gum topped box (*E. moluccana*) also occurs on the slopes in some areas. In the north of the area poplar box (*E. populnea*) grows on slopes often in association with *E. moluccana*. A number of associations occur on lower slopes. Mixed blue gum (*E. tereticornis*), Broad-leaved apple (*Angophora subvelutina*) and bloodwood (*E. intermedia*) associate on some sites whilst on better soils the broad-leaved iron bark (*E. siderophloia*) and sugar gum (*A.costata*) occurs. Swamp mahogany (*E.robusta*) occurs on poorly drained areas.

There are approximately 840 hectares of this vegetation type in the area, mostly on freehold land.

(ii) Closed Vine Forest

This type of forest occurs along the higher slopes of the Cooyar Range as well as spurs and hill tops to the west. The vegetation type is restricted to the moderately fertile, acidic, friable red earths associated with Tertiary basalt flows. These soils have low to very low phosphate levels, however under natural vegetation the humus layer forms an important nutrient pool.

The closed vine forest grades into low closed vine forest on the ridge tops. These forest types are a dry form of complex notophyll vine forest, a semi evergreen vine thicket (bottle tree scrub) and Araucarian notophyll vine forest (Tracey, pers com.). Although the canopy is up to approximately 15 m in height, hoop pines (*Araucaria cunninghamii*), occasional bunya pines (*Araucaria bidwilli*) and narrow-leaved iron barks (*E. crebra*) are emergents growing considerably taller. Vine forest over storey species include crows ash (*Flindersia australis*), red ash (*Alphitoria excelsa*), white beech (*Gmelina leichhardtii*) and black bean (*Castanospermum australe*). This vegetation is characterised by the presence of many lianas as well as epiphytes in wetter areas. On drier sites, ground layer vegetation is limited to occasional tufts of grass and herbs.

Depauperate areas of closed vine forest remain in small isolated patches on agricultural lands and in places this type is regenerating. The Department of Forestry controls the largest areas of this vegetation type in the proposed lease area. Strips of this vegetation type form fire breaks and can be found in areas not yet planted for hoop pines such as in the north east and south west of the proposed lease area. These undistrubed areas are of conservation interest (Tracey, pers. com.).

This vegetation type covers approximately 570 ha of land, all the largest and least disturbed areas (77% of total) are in S.F. 289.

(iii) Plantation Forest

Hoop pine and some exotic *Pinus radiata* are grown in plantations on State Forest 289. Plantation is established by clear felling the original forest (the closed vine forest). The cleared vegetation is stacked and then burned. Seedling hoop pine are subsequently planted. *P. radiata* have been planted in some areas to protect the developing hoop pines from frost. Plantation areas develop from seedling hoop pines, with grasses and some young vine forest plants through to mature hoop pine forest with a vine forest understorey.

Some plantation areas have a softwood scrub fire break of about 40 m around the perimeter while in other areas this does not occur.

There are approximately 920 hectares of plantation all on Department of Forestry controlled land.

(iv) Grassland

This vegetation type is predominantly pasture land, with some areas of cultivation and farm houses and associated structures. The grasslands may support scattered eucalypts as well as areas of regenerating vine forest, acacias and weeds such as cotton bush (*Asclepias physocarpa*) and Lantana (*Lantana camara*).

Some land is cultivated for grain, oil seed or fodder crops. Summer crops may include peanuts, maize, sorghum and navy beans. Winter cereal crops may include wheat, barley and oats, while fodder crops grown include sorghum, millet, lucerne and cow peas. Soya beans, safflower, linseed, sunflower, cotton, pineapples, potatoes, *Setaria* and *Dubosia leichhardtii* are also occasionally grown.

This vegetation type covers approximately 1710 ha, the greatest area of any vegetation type found on the proposed mining lease area.

(v) Freshwater Vegetation

The proposed coal mining lease is located within the catchment of Meandu Creek, a small tributary of Barker Creek. This creek forms part of the Burnett River system. Meandu Creek flows only during the wetter summer months for the remainder of the year being a series of isolated water holes. The flora of this creek was sampled during March, 1973 at a site near the coal handling area and also two miles farther downstream. Other freshwater areas are the farm dams located in the area.

At the first site, the depth of the waterholes ranged from several millimetres to almost 2 m with a mean water depth of 0.5 m. The substratum was mud with isolated sandy patches. No surface flow was visible from these interconnected ponds and the water surface was covered with aquatic weeds.

The flora consisted of green and blue green algae, diatoms and several aquatic flowering plants. Stonewort (*Chara* sp) a more complex algae is restricted to pond margins whilst floating pond weed (*Potamogeton tricarinatus*) and *Najas graminea* cover the water surface. Isolated patches of swamp lily (*Ottelia ovalifolia*) occur amongst the other plants.

Meandu Creek at the second site was shaded by Open Eucalypt Forest as it flows over a substratum of red clayey mud with patches of sediment-covered pebbles. Flow was estimated at less than 1 m^3/sec.

The flora consisted of long filamentous streamers and mats of green and blue-green algae. No emergent vegetation or submerged aquatic plants were observed.

The Meandu waterholes constitute a biologically productive and diverse aquatic system. Biological productivity in terms of existing biomass (living matter) is very high; there is little water surface which is not covered by aquatic weed and its associated animal inhabitants.

The biological integrity of these waterholes is important because they serve as a reservoir of aquatic plants and animals in a relatively dry area. Within this small but dynamic community, aquatic organisms survive low stream flow conditions until they are re-dispersed following heavy seasonal rains.

Of the flora collected or known to be present in Meandu Creek none is of special scientific or conservation value, being common widely distributed groups.

3.2.10 FAUNA

The fauna of the proposed mining lease area has been surveyed to a limited extent during May, 1979. Department of Forestry biologists have studied fauna in nearby State Forest areas whilst fauna of the north west portion of S.F. 289 (a proposed National Park) has been studied during October, 1976 by the Wildlife Research Group (QLD). Data from all these sources has been used in compiling the species list given in Appendix A. Freshwater vertebrates and invertebrates as well as reptiles and bats of the area are the least extensively surveyed groups.

The native fauna of the area has been influenced since European settlement by clearing of vegetation for plantation forestry and for agricultural purposes, by fire and by the introduction of exotic animals. The overall pattern of habitat change as a result of these activities has been a reduction in the area of forest (both vine forest and open forest), a proportionate increase in the area of grassland and cultivation as well as the likely simplification of remaining eucalypt forest. Forest areas have become fragmented and the amount of forest/grassland ecotone has most likely increased, thus benefiting some species. These species often depend on the vine forest for shelter and nesting and utilize the grassland or adjacent agricultural lands for feeding.

Clearing of forested areas has resulted in the wider distribution of largely open country species such as the grey kangaroo, galah, sulphur crested cockatoo and black backed magpie. The open forest areas have also been invaded by introduced mammals such as cattle (*Bos taurus*), the hare (*Lepus europaeus*) and the fox (*Vulpes vulpes*) as well as birds like starlings (*Sturnus vulgaris*).

On the other hand the numbers and distribution of many vine forest and eucalypt forest species has been reduced. Open forest species have been most severely affected in that remaining habitats are degraded through disturbance.

The agricultural lands of the proposed mining area are not known to support populations of any rare or endangered species as vegetation in these areas is degraded. However species such as the rufous rat kangaroo (*Aepyprymnus rufescens*)which are likely to occur in the area are in need of further habitat reservation.

Areas of relatively undisturbed vine forest on State Forest 289 are reported (W. Fisher, pers. com.) to support populations of the uncommon Black-Breasted button quail (*Turnix melanogaster*).

The fauna associated with the waterholes at the first sampling site appears characteristic of that of a small pond. Invertebrates such as snails, caddisfly larvae, water boatmen, caterpillars and damsel fly nymphs are associated with the aquatic vegetation. The mollusc, *Sphaerium* sp, and dragonfly nymphs burrow in the mud while aquatic beetles live on the mud surface. Shrimps and fish such as the trout gudgeon and freshwater hardyhead also occured in this pond.

The invertebrate fauna of the second inspection site on Meandu Creek appears typical of that of a muddy bottom stream and consists primarily of burrowing forms and algal feeders. Amongst the former are oligochaete worms, dragonfly nymphs, burrowing mayflies and dipteran (true fly) larvae. Algal feeders include three types of snails. Amongst forms associated with pebbles are caddisflies and baetid mayflies. Detailed fauna lists appear in Appendix A.

The fauna of the Meandu Creek waterholes is relatively diverse and is an important reservoir of animals for redispersal into the creek system during the wetter part of the year.

Of the fauna collected or known to be present in Meandu Creek none is of special conservation value or scientific interest being relatively common and widespread. However, the lungfish (*Neoceratodus forsteri*) which is known to occur in the Burnett River system and may be present downstream of the site in Barker Creek is of special scientific and conservation interest as it is unique and of limited distribution.

3.3 MAN-MADE ENVIRONMENT

3.3.1 LAND USE

(i) Agriculture

The site is presently used for agricultural purposes, at varying intensities, which include two principle activities - beef production and cropping. No one land holding depends solely on one agricultural activity for its economic livelihood. A mix of agricultural activities is used, for example, beef and/or dairy cattle used to clear away crop residues.

Crops such as sorghum and corn are grown within the area. It is generally the river flats of the Meandu and Black Creek systems which are used for this purpose.

(ii) Forestry

Extensive areas within the site's immediate locality are used for forestry purposes, by the Queensland Forestry Department. The proposed mining lease area includes part of the Cooyar Range Forest (State Forest 289) on its eastern side (ref. Drg. E0351/4). This forest extends around the east, south and west of the site. It contains stands of rainforest, eucalypt forest and hoop pine plantations which have been managed for timber production since the 1930's. At the present time parts of the area have been logged with the forests now in the re-establishment phase of the 45-50 year production cycle. The main potential economic value of the forest now lies in its hoop pine plantations.

The area of S.F. 289 to the west of the site has not been cleared for plantation growth but is still covered with natural vegetation. There is a proposal that this area be declared a National Park (ref. Sub Section 3.3.3). To the north of the site State Forest 118 has also been essentially left in its natural state. No planting has been carried out to date as the forest is not regarded as a high quality area.

(iii) Mining

The proposed mining lease area is located within Authority to Prospect 235C held by CRA Exploration Pty. Ltd. (Ref. Drg. E0351/3). This A to P extends both north and south of the proposed mining lease area.

Apart from this A to P, the extent of mining activity within the sub-region is small. Several small leases for clay, sand and gravel extraction are current. Nanango itself is situated on a gold and mineral field but no significant workings are evident.

(iv) Urban Settlements

Nanango and Yarraman are the closest urban areas of any significance to the site. Nanango (1,111 persons) is situtated 16 road km north east of the site, and Yarraman (598 persons) is 7 km to

the east (via a Forestry Department road). Kingaroy (5,088 persons) is the region's major urban service and market centre and is located 38 km north of the site. The location of each of these centres is shown on Drg. E0351/2.

The site itself contains 9 rural residences and associated farm buildings. However only 5 of these are occupied permanently while 2 others are occupied occasionally. The occupancy of all portions of land within the site area is shown on Drg. E0351/8.

Most of the dwellings are relatively old but structurally sound although their external appearance suggests the need for maintenance in some cases. The quality of farm buildings ranges from good to very poor.

3.3.2 LAND TENURE

Details of the land tenure of the site are shown on Drg. E0351/8 . The majority of the land within the site is freehold although there are some leasehold tenures including Special Freehold Lease and Perpetual Lease Selection. The balance of the area lies within State Forest 289.

3.3.3 NATIONAL ESTATE

(i) Archaeology

An archaeological investigation of the proposed lease area has been undertaken by an archaeologist approved by the Department of Aboriginal and Island Affairs (Hill, 1979). A copy of the text of the investigation report is given in Appendix B.

The area lies adjacent to the boundary separating the aboriginal tribes of the Kaiabara and the Garumga. Generally speaking the inspected area yielded very few lithic artifacts (those recovered are listed in Appendix B), and, indeed, few other indications of past Aboriginal occupation. No examples of incised trees were located and no camp sites were discovered. Axe-grooving was limited to a single example.

(ii) National Park

An area of land as shown on Drg. E0351/3 comprising the western portion of State Forest 289, the Recreation and Water Reserve 163 on Tanduringie Creek containing the Coomba Waterhole and Falls, as well as adjacent freehold land has been listed as a proposed National Park.

Interested parties have made submissions to the National Parks and Wildlife Service (N.P. & W.S.) concerning the area. The Wildlife Research Group (1976) reports the vegetation of the area is typically open forest, low closed forest and small areas of tall closed forest. This group has recorded a diversity of

fauna in the area (see Appendix A). The N.P&W.S. have recommended the area be acquired as a National Park on the basis of the variety of relatively undistrubed forest types of regional significance, the rich and varied fauna and the recreational value of Coomba Waterhole and Falls. The area is surrounded by cleared freehold land and pine plantations. The area is reported to be of marginal interest to the Department of Forestry for hoop pine plantations due to the poor soils and excessive slope over much of the area. This department does not have any plans to clear the area for pine plantations.

Two declared National Parks are in the region - Bunya Mountains National Park (11,610 ha) located 30 km west of the site and the Palms National Park (12 ha) 10 km to the south.

3.3.4 TOWN PLANNING

The Shire of Nanango is currently preparing a Statutory Town Planning Scheme and associated Town Planning and Subdivision By Laws. The Plan is due to go on public exhibition in the immediate future. The open cut mining areas are proposed to be zoned as Extractive Industry. An Interim Development Control By-Law is currently in force, and will remain so until the new Town Plan is gazetted. Under such a By-Law virtually all development proposals must be submitted to Council for their consent before commencement of the project.

Council also has a further responsibility under Section 32A of The Local Government Act to safeguard the environment of the Shire. It thus has the power to require the submission of an Environmental Impact Study in relation to any proposed development within its area of jurisdiction, as and when it is deemed necessary.

3.3.5 TRANSPORTATION

Three forms of transportation are currently available for travel within the area - road, rail and air. Road and rail are by far the most easily accessible forms and the significant features are shown on Drg. E0351/2. Air transport is limited to private plane ownership and charter flights in light aircraft from the major townships.

(i) Road

To the west of the lease area is main road 429 known as the Nanango-Tarong Road which continues on to Maidenwell in a south west direction. This road is planned for upgrading progressively over the next 3 years from its present 3.7 metre seal to a 7.4 metre sealed pavement.

The first 2.6 kilometres of this road, from D'Aguilar Highway southwards to the mine site, is currently being upgraded with work being carried out by the Main Roads Department. Funding for this section is jointly by MRD and the Nanango Shire. The remainder of the road to the power station and mine site, approximately 10 kilometres, is being funded by the Q.E.G.B.

To either side of the proposed lease are located roads under control of the MRD. These are the D'Aguilar Highway (40C) to the east and secondary road 4191 - the Nanango-Brooklands road to the west.

The major access through the region is the D'Aguilar Highway. This highway can conveniently be discussed in sections being those links joining the major townships of the area.

(a) Yarraman to Nanango (D'Aguilar Highway)

Here the road is of high standard being a 2 lane 6.2 metre bitumen seal with design speed in excess of 100 kilometres per hour. All creek crossings - Rocky and Yarraman Creeks being the major ones - have been designed to accommodate 1 in 50 year storm events and consequently, there are no major long-term flood problems on the link.

(b) Nanango to Goomeri (Burnett Highway)

This link is of reasonable standard, being 5.6 metre bitumen seal throughout with the exception of the first 8 kilometres from Nanango which has only a 5 metre sealed strip. The major flooding problem on the route occurs at Glan Devon, however, this floodway is planned for upgrading within a 10 year programme.

(c) Nanango to Kingaroy (D'Aguilar Highway)

This road has mostly a high standard 6.8 metres wide sealed pavement with the exception of a section approximately 6 kilometres north of Nanango where the dual floodway system of Meandu Creek and Barker Creek is crossed. Here a 4.7 metre sealed pavement traverses the floodway on old timber bridges with low flood immunity. Both bridges are planned for immediate reconstruction. Tenders for this work have been called on the Barker Creek Crossing and the Meandu Creek crossing is to be called in the near future.

(d) South Nanango to Meandu Creek

The local authority road from South Nanango to Meandu Creek was not gauged during the last MRD traffic census of 1976. However the estimate of 50 vehicles per day, given by officers of the Nanango Shire Council indicates its low priority as a major interconnector road. In spite of this, the link is of reasonable standard being sealed at the eastern end near its junction with the D'Aguilar Highway and gravel surfaced for the remainder of its length to the junction with the Nanango Tarong Road.

The D'Aguilar Highway from Yarraman towards Brisbane is in various stages of development, but generally offers a high standard link between the two centres. Major improvements are in progress on the Brisbane Valley Highway due to the construction of the Wivenhoe Dam. At present, there are several sections south of Esk where temporary road diversions have been provided while roadworks upgrading is taking place.

The other main road link of interest to this study is that joining the centres of Kingaroy and Brooklands via Goodger (MRD 419). This road is in general a 5.4 metre wide sealed road but contains a couple of lengths of gravelled pavement totalling approximately 9 kilometres. The road is located in both the shires of Nanango and Kingaroy. Both sections of unsealed road lie in the Nanango Shire.

Nanango is also connected to Toowoomba via the New England Highway from Yarraman. This is a fully sealed road, under-trafficked at present.

Traffic counts were last conducted on these and other local roads in 1976 and at that stage, the use being made of the road network was well below the capacity of any of the individual links. The traffic count figures are shown in Table 3.4

TABLE 3.4

MAIN ROADS DEPARTMENT TRAFFIC COUNTS

Main Road	Link	AADT* 1976 (Two-way Flow)
D'Aguilar Highway (40C)	Yarraman-Nanango	1037 (16) **
	Nanango-Kingaroy	No counts taken
Burnett Highway (41A)	Nanango-Goomeri	498 (10)
Bunya Highway (45A,B)	Kingaroy-Wondai	1301 (19)
	Kingaroy-Dalby	563 (19)
	Wondai-Murgon	1463 (16)
Kingaroy-Cooyar Road (419)	Kingaroy-Goodger	360 (16)
	Goodger-Brooklands	209
Nanango-Tarong Rd. (429)	Near Kissing Cnr	234 (19)
Nanango-Brooklands Road (4191)	Near Nanango	128
New England Highway (22A)	Near Yarraman	706 (13)

*AADT - Annual Average Daily Traffic.
** 1037 - Passenger Vehicle Count.
(16) - Commercial Vehicle Count.

Existing travel distances and travel times from the mine site to the various major towns of the region are shown in Table 3.5. Times are based on an assessment of road condition, pavement width and existing traffic.

TABLE 3.5

EXISTING TRAVEL DISTANCES & TIMES

FROM TOWNS TO MINE SITE

Centre	Link	Distance (km)	Time (min) (Approx.)
Nanango	Nanango-Tarong Road (429)	17	13
Yarraman	a) D'Aguilar Hwy/South Nanango-Meandu Creek	18	17
	b) D'Aguilar Hwy/Nanango-Tarong (429)	27	23
Blackbutt	a) D'Aguilar Hwy/South Nanango-Meandu Creek	33	27
	b) D'Aguilar Hwy/Nanango-Tarong (429)	42	33
Kingaroy	a) Via Nanango	41	30
	b) Via Goodger	37	26
Brisbane	D'Aguilar Hwy	190	180

(ii) Rail

There are two rail lines influencing the district and although once a very popular and highly used form of transport through the area, the patronage has decreased to such an extent that now the service is infrequent and is provided mainly for livestock and goods transport.

(a) Brisbane Valley Line

This line terminates at Yarraman. Traffic on the line consists of 6 goods trains each week, 3 up and 3 down movements. Passenger movement is limited to a service which terminates at Toogoolawah. This service ceased operating through to Yarraman about 8 years ago. During grain harvest, large grain loads are transported from the region via this rail line, however, most goods services consist of light loadings of grain, timber and livestock with some local fruits and vegetables to the Brisbane market. Goods transported by train into the region on the rail line consist mainly of groceries, fruit and fuel.

(b) Gympie-Kingaroy Line

Rail service from Gympie to Kingaroy through Murgon operates at the rate of 14 trips per week, 7 up and 7 down movements. Train loads consist of a daily mixed train service each way which carries both goods and passengers as required, as well as separate goods service each way twice weekly. Goods carried are similar to those on the Brisbane Valley line except that peanut haulage in the season is an additional product.

Branch line services from Kingaroy originally extended to Tarong and to Nanango, however these were closed in 1964, and 1960 respectively due to uneconomic operations. The line profile and easement still exists but the tracks have been removed. While the line could be relaid if warranted, the design grading of 1 in 50 would cater only to passenger or light goods movement.

(iii) Air

Airfields exist at both Nanango and Kingaroy as well as some of the local farms in the region. A private charter service, South Burnett Aviation, operating from Kingaroy, provides a twice weekly passage to Brisbane.

The airstrip at Kingaroy is a 3rd level strip which can cater for aircraft with up to 10 passenger seats. This is of higher grade than the Nanango field; However, examination has been carried out by the Department of Transport for upgrading this strip from its present length of 850 metres to approximately 1050 metres so that a charter service can be provided.

3.3.6 INFRASTRUCTURE & PUBLIC UTILITIES

(i) Mine Site

The area covered by the proposed lease has the predominant land uses of forestry and farming, principally cattle grazing with some cultivation. As such, much of the land is uncleared and of low density use. A small number of homesteads are located within the area and the public utilities within the area are provided as a basic service to these homesteads. All roads are of low standard, unpaved and drained by open channel.

Power throughout the area is presently supplied from the state grid under control of the Wide Bay-Burnett Electricity Board.

Telecommunication is achieved by telephone operated through a manual exchange in Nanango.

Reticulated water supply to homesteads in the area is not achieved because of the obvious cost limitations in farming communities. Tank water supply, local homestead bores and farm dams provide the water required by these places for all domestic and animal needs.

Sanitation of the local homesteads is undertaken by septic or night soil facilities with the homeowners disposing of their own garbage and wastes.

All other infrastructure requirements and public utility services are met with by trips to the major towns of the region.

(ii) Nanango

The population of Nanango has declined in recent years to about 1100 persons. As a consequence of this decline, the utilization of infrastructure and public utilities existing within the town has decreased. The following infrastructure exists at Nanango:

(a) Vacant Homesites

There are approximately 640 vacant allotments existing within the town. Of these about 120 are subdivided and have both water and sewerage available.

(b) Water Supply

Present water supply for the town is drawn from Cooyar Creek at a dam situated about 400 metres downstream of the confluence with Oaky Creek. With a yield of 350 Megalitres the dam has a storage capacity of over two years supply for the present population of Nanango based on calculated average daily consumption of 350 litres per person.

Acreage developments near the town have tank water. Water treatment is achieved by conventional sand filtration and chlorination. Pumping from the dam to a 1.1 megalitre above ground reservoir overlooking the town occurs at the rate of 14l ℓ per second.

The design population for the water supply system is 2000 ep which allows a spare capacity of about 800 ep on the existing population.

Studies have been conducted into the upgrading of the supply by either increasing the existing Cooyar Dam or from subsequent bores located at Barker Flat near Barker Creek.

(c) Sewerage

The sewerage system of Nanango township has been designed to two standards. The mains laid throughout the town have a design capacity of 3000 equivalent persons (ep) which gives them a generous additional capacity. The treatment works, situated on Barker Flat and the pumping stations have been designed to a staged design population of 1600 with capacity to upgrade to an eventual 4000 ep.

Treatment is by way of Imhoff tanks and lagoons with the overflow going to Sandy Creek. Drying beds are provided for the sludge. No chlorination of the effluent occurs. Acreage developments in the area surrounding the town have septic or night soil services.

(d) Roadworks & Drainage

All main streets of the town are very wide with centre parking and have a full width seal and kerb and channelling with underground drainage. Not all streets are sealed, however, but the Council has an ongoing programme of drainage and street improvements. Most of the outlying roads are still gravel pavements with earth table drains.

(e) Waste Disposal

A Council tip is presently located on the Brooklands Road, however, this is reaching capacity and is planned for relocation within 6-8 months. Currently, a sanitation service is operated by a private firm under contract to the Council.

(f) Telecommunications

A manual exchange is located in town, however, an automatic exchange is programmed for installation. Telegram and postal services are available.

Two television stations - ABC and commercial are received from the Bunya Mountains transmittors.

(iii) Kingaroy

The current population of Kingaroy is approximately 5100 with about 8100 people living within the shire boundaries. It is estimated that approximately 50 building plans are approved by Council each year. The following infrastructure is provided within the town.

(a) Vacant Homesites

There are approximately 408 potential building allotments in the town with 235 of these fully serviced.

(b) Water Supply

Water for the town comes from Gordonbrook Dam situated on the Stuart River about 20 kilometres north west of Kingaroy. Capacity of the dam is 2500 megalitres which is sufficient to cater for a population of 10,000 on the present average daily consumption rates of 480 litres per person. Treatment and pumping capacity of the system is presently 106 litres per second. The treatment of water gives a good quality product using sedimentation, sand filtration, lime stabilization,and chlorination.

Service storage consists of six reservoirs throughout the town with an overall capacity of about 6.7 megalitres, equivalent to 10,000 ep. This gives an overall spare capacity of 5,000 population.

(c) Sewerage

Sewerage treatment at Kingaroy has a present capacity for 7,200 which yields a spare capacity for 2,100 persons. Treatment is by way of primary and secondary sedimentation and filtration. Sludge digestors and drying beds have been installed to treat the solid material while the effluent is lagooned for approximately 8 days before discharge via flood irrigation to Kingaroy Creek. Some effluent is used to irrigate Department of Primary Industries test crops. BOD rarely exceeds 5 mg/l.

Acreage blocks in Kingaroy are not sewered but have septic installations. There are also about 16 premises on a night soil service in the town.

(d) Roadworks & Drainage

Main streets in the town are wide, fully sealed with kerbside angle parking and kerb and channelling to underground drainage system. All existing residential streets are sealed with a majority having at least kerbing. There are two private coach services operating in the town with daily passages to Brisbane, Toowoomba and Gympie.

(e) Waste Disposal

The Council operates a sanitation service for solid wastes, by day labour, disposing of it at a local Council tip.

(f) Telecommunications

Automatic telephone exchange, a daily mail delivery service and other normal postal operations are provided within the town. Television, as for Nanango, is received from the Bunya Mountains transmittors. A radio station, 4SB, is also located within the town and broadcasts to most centres in the South Burnett region.

(iv) Yarraman

Yarraman is situated in the Rosalie Shire and unlike Nanango and Kingaroy, is not the major town of its shire. The main shire offices are located outside the shire at Toowoomba. The current population of Yarraman is approximately 600.

(a) Vacant Homesites

There are about 85 serviced allotments within the township which are either vacant or contain vacant dwellings.

(b) Water Supply

Water for the town is drawn from the Cooyar Creek Weir situated on the same supply creek as for the Nanango township. The weir has a capacity of 288 Mℓ which gives a spare capacity to the system of an equivalent 250 persons. The major constraint to the water supply is the small rising main (150 mm diameter) from the weir to the town reservoir.

Power failure at the weir pump station occurs an average once each year. The town reservoir is generally not large enough to span these power failure periods and some water shortages can occur.

Current treatment of water is only by chlorination. A more sophisticated plant utilizing sedimentation and filtration has been planned.

(c) Sewerage

The existing treatment system employed in the town uses sedimentation, filtration and lagooning before effluent is discharged to Cooyar Creek. Sludge is digested and diced. Standard of effluent to the creek system is quite high with an average BOD loading between 10 and 15 mg/l. This is a relatively high standard and although discharged into Cooyar Creek upstream of the Nanango water supply intake, stream assimilation can more than cope with the increase

in nutrient level. The spare capacity in the treatment works based on the current population of the town is about 200 equivalent persons.

(d) Roadworks and Drainage

All residential streets in the town are fully sealed, while kerbing and channelling is approximately 80 percent completed.

The township is located astride the D'Aguilar Highway and is provided with a regular coach service which passes through the town both northwards and southwards on a daily basis.

(e) Waste Disposal

A once weekly garbage collection service is provided by Council contractors. Disposal is at a local Council tip.

(v) Blackbutt

Blackbutt is situated on the D'Aguilar Highway some 14.5 kilometres towards Brisbane from Yarraman. The town is located in the Nanango Shire and has a population of approximately 420 people. The town has an infrastructure capacity greater than what can normally be expected from a town of its size.

(a) Vacant Homesites

Within the residential area of the town, there are approximately 110 vacant allotments. Some require extension of water and sewerage mains to be fully serviced.

(b) Water Supply

Taromeo Creek, a tributary of the Brisbane River and passing through the southern outskirts of the town, provides an adequate source of water for both Blackbutt and Benarkin, the next downline station. There is no storage weir on the creek, however, from Department of Local Government tests the flow in the creek throughout the year appears adequate to cater for the needs of both towns. The pumping station on the creek has a capacity of 9 litres per second and has an average use of 8 hours per day.

The town reservoir has a capacity of approximately 560,000 litres or 2.3 days supply based on the average use.

(c) Sewerage

The existing sewerage scheme extends a gravity fed system to all premises within the town and has allowance for an additional 110 allotments. The treatment plant has been designed for a population of 750.

(d) Roadworks

Most streets in the town are fully sealed with the main street a very wide divided road with a large median strip.

Blackbutt is situated on both the D'Aguilar Highway and the Brisbane Valley Railway Line. Daily coach services pass through the centre.

(e) Telecommunications

A manual telephone exchange is operational within the town and other normal postal services are available.

(vi) Cooyar

Cooyar is situated on the New England Highway and is 33km south of the mine site. The town is located in the Rosalie Shire and has a population of approximately 100 people.

(a) Vacant Homesites

The town has approximately 20 dwellings and there are thirty vacant allotments. Land in Cooyar is relatively cheap.

(b) Water Supply

Water is pumped from Black Creek to a reservoir where it is chlorinated. It is then reticulated to the dwellings in the town.

(c) Sewerage

Sewerage treatment is by means of septic tanks and absorption trenches.

(d) Roadworks

Approximately 90% of the streets in Cooyar are bitumen sealed.

3.3.7 POPULATION STRUCTURE

The two closest towns to the mine site are Nanango and Yarraman. However within the general region of influence Kingaroy serves as the major service centre. Two other towns of Blackbutt and Cooyar are nearby together with small communities at Maidenwell and Coolabunia. A locality name of Neumgna applies to the area within the proposed mining lease area.

Nanango (population 1,111) and Yarraman (population 598) exhibit population structures which are typical of small rural service communities in Queensland. Both centres, together with the region as a whole, have, with the exception of Kingaroy, been losing population in recent years. This has been due primarily to the migration of younger people to coastal and southern centres. It is anticipated that this population decline will continue unless a change in the area's economic base occurs thereby arresting or reversing the present emigratory trend.

Kingaroy is the only centre in the region exhibiting a positive population growth rate. This appears to be because it serves as the regional centre and has a relatively broad economic base. Details of the region's population and growth rate are given in Tables 3.6 and 3.7.

The age distribution of the region's population in comparison with the Queensland average exhibits a relative deficiency in the teenage and young adult age groupings and a relative abundance in the older age categories. Details are tabulated in Appendix C.

TABLE 3.6

POPULATION

Year	Nanango	Yarraman	Kingaroy	Cooyar	Blackbutt
1911	1,499	-	1,191	356	333
1921	1,237	459	1,441	277	511 (Crow's Nest & Nanango)
1933	1,025	-	2,330	282	338
1947	1,431	640	3,893	196	453
1954	1,353	840	4,464	256	464
1961	1,314	942	4,914	242	458
1966	1,300	681	5,080	124	485
1971	1,187	604	4,925	-	436
1976	1,111	598	5,088	-	422

TABLE 3.7

POPULATION GROWTH

	1971	1976	Average Annual Growth Rate (%)
Nanango Shire	3,244	2,961	-1.81
Nanango Urban Area	1,187	1,111	-1.35
Neumgna Locality*	235	201	-3.14
Yarraman Urban Area	604	598	-0.20
Kingaroy Urban Area	4,925	5,088	+0.65
Cooyar Locality	244	228	-1.40
Blackbutt Urban Area	436	422	-0.67

* Slight boundary change between 1971 & 1976 Census

3.3.8 ECONOMY

In the study of the local and regional economies, the local area has been defined as the Nanango and Kingaroy Shires, and the regional area as the Wide Bay-Burnett statistical division. Although the Nanango and Kingaroy Shires are within the Wide Bay-Burnett statistical division, it should be noted that the selection of Wide Bay-Burnett as the regional zone of impact is somewhat arbitrary since the Tarong area borders both the Darling Downs and Moreton statistical divisions. The problem of appropriate boundaries occurs in all regional studies, however for practicality this analysis relies on the regions as defined by the Co-ordinator-General's Department. Thus, the Wide Bay-Burnett region is examined in this report.

The economic structure of the local and regional economies can be analysed by examining the relative importance of industries in these areas. This information can then be contrasted with similar data for the State and National economies. Table C.8 in Appendix C indicates the relative importance of industries in Nanango plus Kingaroy, Wide Bay-Burnett, Queensland, and Australia. Data on industry outputs were derived from input-output tables for Wide Bay-Burnett, Queensland and Australia. No input-output table exists for the Nanango and Kingaroy Shires so recourse was made to employment by industry figures from the Population Census.

(i) State and Regional Economy

The economy of the Wide Bay-Burnett region is dominated by the manufacturing and agricultural sectors which account for 29% and 26% respectively of the region's total industry output. Building and construction, and wholesale-retail trade are the next most important industries, accounting for 11% and 9% respectively of regional output. Mining is currently the smallest of the region's industries.

In terms of aggregate structure, the Queensland economy exhibits some similarities to that of Wide Bay-Burnett, particularly with regard to the manufacturing, electricity, construction, and community services - entertainment sectors. The main difference between the two areas is with regard to the agricultural sector. In the Wide Bay-Burnett region agriculture accounts for 26% of the region's output, whereas, for Queensland, in contrast, agriculture accounts for only 12% of the State's output. Queensland thus exhibits the features of modern developed economies with emphasis on the secondary and tertiary sectors, while Wide Bay-Burnett is a simpler economy emphasising the primary and secondary sectors.

(ii) Local Economy

The region's labour force reflects the rural and service character of the area's basic economic pursuits. In the rural towns the percentage of population in the workforce varies from 34% to 38%. In the rural areas and in Kingaroy this percentage increases to the range 43% to 47%. Except for Cooyar, the percentage of males in the workforce is within the range 60% to 70%. Workforce details are given in Appendix C.

Unemployment figures for the region as a whole were not available. Appendix C lists recent unemployment statistics for the Toowoomba and Gympie Employment Regions. Each of these regions include part of the region of influence of the mine project. In these Regions the highest unemployment was recorded in the occupational groups of Clerical and Administrative, Semi-Skilled, Unskilled, and Service Occupations.

Generally speaking there has been a decline in the area's labour force over the past decade, the decline being most noticeable in the rural sector and following the overall decline in the region's population. The rural sector, however, remains the singularly most important employer which, with the exception of the Kingaroy urban area, provides employment for approximately 35% of the region's workforce. In the Kingaroy and Nanango urban areas the most significant employment is found in the wholesale/retail sector. Details of the industry of employed persons are given in Appendix C.

(iii) Input-Output Analysis

To enable the economic effect of the proposed project to be determined, the existing economy has been modelled on an input-output basis. Input-output economics involves dividing the economy to be studied into industrial groupings (sectors) and tracing out the transactions (dollar) flows between the sectors for a particular year. The tables make it possible to define the exact make-up of a particular economy and to show the inter-relationships that exist within that economy. For example, the value of industries in the mining, building and construction, and manufacturing sectors can be measured and tabulated. From these tables output, income and employment multipliers can be derived for each sector of the economy. The multipliers enable measurement of total increases in output, income and employment resulting from a given economic stimulus in a particular year.

Thus the input-output multipliers enable economists to predict the impact that a change in one sector will have on other sectors and the total economy.

The Australian Bureau of Statistics has prepared a 109 sector input-output table representing the Australian economy in 1968-69 (Australian Bureau of Statistics, 1977). A research team at the University of Queensland has prepared input-output tables for the ten statistical divisions and for the State of Queensland (Jensen et. al., 1977) for the year 1973-74. The research team developed techniques for producing input-output tables known as the Generation of Regional Input-Output Tables (GRIT) system. The GRIT tables for the Wide Bay-Burnett statistical division and the State of Queensland, plus the Australian table have been used in this study. A number of other studies have utilised the GRIT tables for impact assessment, including the Gladstone Study (Mandeville et. al., 1977) and the Oaky Creek Environmental Impact Statement (Peter Hollingsworth et. al. 1978).

For the construction phase of the project, the building and construction sector from the above-mentioned input-output tables have been used. For the operational phase, the coal mining sector has been assumed appropriate, except for Wide Bay-Burnett. Since this region does not contain an extensive open-cut coal mining industry, representative regional multipliers from the GRIT table for the neighboring Fitzroy region of Central Queensland have been utilised.

Table 3.8 shows the output, income and employment multipliers for Wide Bay-Burnett, Queensland and Australia for both the building and construction and coal mining sectors. However, it must be noted that although multipliers are designed to measure impacts relating to a particular year, the total multiplicative effects may not work themselves through the community for several years.

TABLE 3.8

INPUT-OUTPUT MULTIPLIERS

	Wide Bay-Burnett	Queensland	Australia
Building and Construction			
Output multiplier[1]	1.31	1.70	1.96
Income multiplier[2]	1.34	1.65	1.87
Employment multiplier[3]	1.40	1.69	1.88
Coal Mining			
Output multiplier[1]	1.22[4]	1.46	1.47
Income multiplier[2]	1.64[4]	2.20	1.35
Employment multiplier[3]	3.22[4]	3.07	

Source: Jensen, Mandeville & Karunaratne (1977)
Mandeville and Jensen (1978)

[1] Indicates the economy-wide multiplicative effects on output of a $1.00 change in output in the relevant sector.

[2] Indicates the economy-wide multiplicative effects on household income of a $1.00 change in household payments in the relevant sector.

[3] Indicates the economy-wide multiplicative effects on employment of a 1 employee change in the relevant sector.

[4] These multipliers apply to the Fitzroy Region.

3.3.9 COMMERCIAL AND INDUSTRIAL STRUCTURE

Appendix D details the present commercial and industrial structures of Nanango and Yarraman.

Kingaroy is the main service centre for the region and is the Local Government Administrative Centre for Kingaroy Shire. It contains some Commonwealth and State Government Agencies and has well developed Educational, Health and Recreational facilities. Significant scope exists for convenience and comparison shopping within the town.

Nanango's role is principally that of a small agricultural service town and the administrative centre of the Nanango Shire. This town consequently exhibits a relatively well developed commercial and industrial structure for its size. Yarraman, on the other hand, has only the economic base of the bacon factory and the Forestry Headquarters and associated sawmills. It has a relatively limited agricultural service catchment and generally caters for only the immediate day-to-day convenience needs of the residents. Further demand for goods and services is generally satisfied in Nanango, Kingaroy or Brisbane.

3.3.10 HOUSING

Housing structure within the region of influence consists primarily of single dwelling units. In the urban areas of Kingaroy, Nanango and Yarraman limited flat accommodation is available but these are very isolated in occurrence and amount to no more than 13% of the total housing provision in the case of Kingaroy, 8% for Nanango, and 7.5% for Yarraman. The percentage of vacant houses is of the order of 10-12% of the total dwelling stock in each of the urban localities. No indication of the state of repair or habitability of these unoccupied dwellings is available. The average number of persons occupying each private dwelling varies from 3.07 to 3.75.

Accommodation for the itinerant worker or traveller in Kingaroy can be found in any of the 5 hotels or 3 motels (a fourth motel is under construction). In addition there are 2 caravan parks within the town.

There are 3 hotels in Nanango providing 32 beds and two motels. Three caravan parks (116 van sites) are established and 3 other caravan park development applications have been received by the Council. In addition a new caravan park is being planned for Maidenwell.

At Yarraman 3 hotels provide a total of 27 beds. There is one motel in the town. There is one Council owned caravan park with 12 powered sites.

Motel and hotel accommodation is available at Blackbutt. There is one caravan park providing 10 sites.

3.3.11 COMMUNITY FACILITIES

(i) Education

A range of child day-care and pre-school, primary and secondary educational facilities are available in the urban centres in the region. Maidenwell however lacks any educational facilities. Facilities are provided primarily by the Education Department although some are provided by church or community organizations. The enrolments of pupils at each of these facilities are given in Table 3.8, below. Pre-school facilities at Yarraman and primary facilities at Kingaroy are currently not utilized to full capacity. However due to personal choice and population growth in the Taabinga area (immediately south of Kingaroy) this primary school is receiving increased enrolments rather than nearby Kingaroy Primary School. Other educational facilities are currently operating at or slightly below capacity.

Schools and classes for mildly intellectually handicapped children are available in Kingaroy where the Sub-Normal Children's Welfare Association also has a centre for moderately intellectually handicapped children. There are no schools for physically handicapped children the nearest facilities being at Brisbane and Toowoomba. A special education centre in Kingaroy provides psychological and vocational counselling and speech and occupational therapy.

The closest tertiary educational facilities are at Brisbane and Toowoomba.

TABLE 3.

SCHOOL ENROLMENTS, 1979

Town	Pre-School		Primary		Secondary		Special	
	Govt.	Non-Govt.	Govt.	Non-Govt.	Govt.	Non-Govt.	Govt.	Non-Govt.
Nanango	47	-	259	91+	201*	-	-	-
Yarraman	25	-	114	-	134**	-	-	-
Coolabunia	-	-	33	-	-	-	-	-
Kingaroy	50	NA	290	141+	517	134+	31	NA
Taabinga	50	-	365	-	-	-	-	-
Cooyar	-	-	43	-	-	-	-	-
Blackbutt	-	-	82	-	-	-	-	-

* Secondary Department providing for years 8 to 12 attached to Primary School
** Secondary Department providing for years 8 to 10 attached to Primary School
\+ Enrolments at Catholic Education Department Schools, 1978.
NA Not Available

SOURCE: Department of Education

(ii) Health

Nanango and Kingaroy both contain public hospital facilities. The Nanango Hospital has a 44 bed capacity, 4 of which are for maternity purposes. The Kingaroy Hospital has a 120 bed capacity with 20 maternity beds. The current occupancy level for the general beds at Kingaroy Hospital is 41% and for Nanango Hospital is 31%. Kingaroy also has a private hospital with a capacity of 36 beds. There is no hospital at Yarraman.

Apart from Government doctors, 5 private doctors practise in Kingaroy and a number of specialists make regular visits. There is a Diagnostic Centre providing X ray and pathology services. Nanango has one doctor in private practice who is also the part-time Medical Superintendent at the hospital. Another doctor visits the town at regular intervals. At Yarraman a doctor visits once each week.

A Government dental clinic is located at the Kingaroy General Hospital. In addition there are 3 private dentists and at least 1 Orthodontist makes regular visits. Nanango has one private dentist. Both Kingaroy and Nanango have Maternal and Child Welfare Clinics. The QATB has ambulance services at Kingaroy, Nanango and Yarraman with staff members of 6, 1 and 2 respectively.

(iii) Police

Except for Maidenwell each of the towns within the region of influence of the mine has a permanent police station. Maidenwell is located within the Yarraman Police Division. The following table indicates the present distribution of police officers in the region.

TABLE 3.

POLICE FACILITIES

Town	Police Station	Staff	Police Residences
Kingaroy	1	11*	2
Nanango	1	2	3*
Yarraman	1	2	1
Blackbutt	1	1	1

* Surplus residence in Nanango is occupied by the police officer from Kingaroy.

(iv) Community Facilities

The South Burnett Lutheran Rest Home is located in Kingaroy and presently houses 59 inmates with planning in hand for a 30 bed Nursing Home section. Also the Blue Nursing Service and Meals on Wheels operate in the town. The Sub-Normal Children's Welfare Association operates a school and workshop and has 2 residential units. Nanango Shire has recently completed 2 single aged persons home units in Nanango.

Kingaroy, Nanango and Yarraman have all got public meeting halls and church halls. Details of these and all other community facilities and organisations are listed in Appendix D.

(v) Recreational Facilities

Regional recreational facilities are located on the south-western boundary of the site's zone of influence. The Bunya Mountains National Park has an area of approximately 9900 ha. Apart from the splendor of its natural vegetation the park is noted for its waterfalls. The small Palms National Park (12 ha) north east of Cooyar provides short walking tracks through a piccabeen palm grove and picnic facilities.

Closer to the proposed power station site, there exists a number of potential recreational areas. The State Forests in the locality to date have not been utilised to any significant extent for recreational purposes, although they could provide a basis for increased recreational activity in the area should the need arise. The proposed National Park to the south west of the site is an area which has potential to cater for significant recreational demands.

Kingaroy, Nanango and Yarraman all support organised recreational facilities. Appendix D lists the facilities for each town.

3.3.12 AESTHETICS

The aesthetic values of the proposed site and the surrounding area are derived principally from the presence of the Cooyar Range and the pattern of agricultural development which has been superimposed on the natural landscape. The general locality, therefore, is a typical example of the rural landscape found over a large part of the region. The exception to this is the Cooyar Range which forms the skyline to the east of the proposed site, and forms a constant reference point when one is travelling through the area.

The landforms on or surrounding the site are typically undulating to broken in character. To the west of the Neumgna-Meandu Creek Road the land formation consists of a north-south orientated broken ridge with spurs falling rapidly to the road. To the east of the road the land is less broken. The ridge systems here are more undulating in character and contain the flood plains of two creek systems.

With the exception of State Forest 289, the existing vegetation in the locality is not distinctive in character, and has been disturbed by either selective felling for timber getting purposes, or cleared for agricultural purposes. The landform and the road pattern of the area provide many opportunities for panoramic views to be had over most of the locality. However, apart from the views afforded by the major dominant ridges, vistas are generally relatively restricted by the undulating topography and the remaining vegetative cover. This is especially true where the road system follows valley floors.

A significant variation to the natural landscape is provided by the State Forest to the east of the site. Here large plantations of hoop pine provide a dense green cover as the land slopes eastwards and away from the proposed mining area.

SECTION 4

Environmental Evaluation

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4.0 ENVIRONMENTAL EVALUATION

4.1 GENERAL

The impact assessment described in this section is based upon the potential environmental changes which are likely to result from the imposition of the proposed development as described in Section 2 upon the existing environment as summarised in Section 3. This analysis has been undertaken in terms of the natural environment and the man made environment.

Potential impacts in all four geographic areas of interest have been identified from a consideration of the proposed development actions as contained in Section 3.

The time scale of these impacts has been considered in the assessment. On the one hand, the proposed project will create some impacts which will be temporary in occurrence (e.g. those occasioned by some activities during the construction phase). However, it might be expected that certain other impacts will result in permanent changes, especially those resulting from the operation phase. Some impacts will be intermittent in occurrence, while others will be continuous. The other important point to note in this regard is that the proposed development will occur in stages over a long time period, perhaps as long as 15 to 20 years, and consequently, the magnitude of any resulting impacts may change with the passage of time and the creation of new technologies and movements in other variables.

The direct or indirect nature of the impacts has also been examined. In some instances a particular development activity may have a direct effect on some component of the existing environment, while in other circumstances the identified impacts may be consequential or have "flowed-on" from a more direct impact.

Wherever it has been applicable, the assessment has sought to distinguish the anticipated impacts in terms of their beneficial or detrimental nature. In all instances, however, this was only attempted where an objective conclusion could be reached.

4.2 IMPACTS ON THE NATURAL ENVIRONMENT

4.2.1 TERRAIN

Some localized topographical changes will result from the open cut mining process and associated infrastructure. Open cut mining will result in overburden spoil heaps appearing as a series of high ridges of unconsolidated soil and rock on what was previously a strongly undulating landform. These spoil heaps will be recontoured to a profile compatible with the original landform. As rehabilitation will be a progressive process, the overall impact of spoil heaps will be reduced. Furthermore, as up to 30 metres depth of coal will be removed, the final surface could in parts be lower than the original surface.

The proposed mining areas lie predominantly on soils developed on the Tarong Beds with some areas on Quaternary Alluvium and minor patches of conglomerate. The proposed plant area is on soils developed

from the conglomeratesand sandstones. The soils vary from shallow sandy or silty gravels on moderately steep slopes to sandy or silty clays or plastic clays on gently sloping land. These soils may suffer sheet or mild gully erosion, particularly where adjacent to drainage ways.

Significant erosion may occur if areas to be mined are not properly managed. However broad scale erosion is unlikely because clearing will be undertaken on a strip by strip basis immediately prior to the mining of each strip. Clearing will only occur between the cut-off drain and the mine high wall so that a minimum amount of surface runoff will be generated. Erosion may be further reduced by stabilization of disturbed areas through planting of pasture grasses. Some problems could also be encountered with weed growth and regeneration of tree species.

Progressive tree clearing in advance of each particular mining phase will be carried out. This would allow collection of seed for revegetation purposes and if grass cover was maintained, particularly on steeper slopes, then erosion would be reduced. Grass and topsoil stripping should be delayed until just prior to the commencement of overburden stripping.

The soil profile will also be disturbed during clearing and levelling of the preparation plant site, building of haul roads, pipeline construction and provision of tailings dams, drainage and diversion banks. These activities will result in some minor topographical changes. Soil erosion in these areas can be reduced by carrying out clearing and earthworks during the dry season (winter) and by avoiding unnecessary disturbance. Soil stabilization should be carried out on all disturbed areas. Grass stabilization of embankments and cuttings apart from reducing erosion would also improve the aesthetic appearance of otherwise bare surfaces.

Runoff likely to enter pit areas will be prevented from doing so by use of contour diversion banks. These banks will also be constructed around stockpile and plant areas to minimise contaminated drainage. Discharge from table drains, from pipes under roads and from contour diversion banks can cause severe localized erosion. To prevent this, consideration will be given to providing properly constructed grassed waterways of suitable gradient. Advice should be sought from officers of the Soil Conservation Branch, D.P.I. in this regard.

Cuttings and fills along roadways can erode badly. Cuttings require to be made to a reasonably stable slope and need topsoiling before revegetation can be effective. If the best fill material is left near the surface, the fill embankments should not require top soiling. Both cuttings and fill slopes can be seeded and mulched using a hydromulcher.

Power transmission line easements, access and inspection tracks as well as pipeline routes are other potential erosion problem areas. The Soil Conservation Branch of the D.P.I. has published notes on route clearing and management for the former.

Disturbance and clearing of gullies and stream banks should be avoided where possible. A buffer zone of intact creek bank vegetation will dampen the effects of erosion and increased runoff in the catchment.

To improve the stability of tailings dams and evaporation ponds compaction control as well as permeability testing and investigation of potential soil dispersion problems may be needed.

4.2.2 SURFACE WATER

(i) Silt Loading

During the pre-mining phase, operations such as stripping of vegetation, removal of overburden, construction of haul roads, and levelling of the plant site will alter the natural flow paths of stormwater runoff from the area. Levelling and removal of vegetation will lead to increased volumes of stormwater reaching the natural creek system of Meandu Creek and to a lesser extent Black Creek. However increased flow rates alone are not expected to be detrimental to stream biota as small streams in this area normally experience a wide range of flow rates due to fluctuating weather conditions.

Runoff water from cleared areas will contain a higher than normal silt loading which will lead to increased turbidity in the creek systems. Increased stream turbidity, particularly in these low flow creeks and small permanent pools, can reduce sunlight penetration, reduce the ability of aquatic plants to photosynthesise, and reduce the ability of the stream to assimilate pollution loads.

Although this siltation increase in Meandu Creek will be a major impact to the creek system itself, no major use is presently being made of the stream other than stock water and some irrigation water, and hence the impact of the pre-mining activities on the system is somewhat reduced.

Downstream of the proposed lease area, Meandu Creek enters Barker Creek, a possible future source of water supply to the township of Nanango. From the northern boundary of the lease area Meandu Creek travels about 20 kilometres to the Barker Creek flats, the possible source of water. Most of the silt loading attributable to the mining would be lost before this area was reached and should, therefore, have little impact on any planned treatment.

During the mining phase, the ongoing process of overburden stripping and stockpiling will continue the potential for increased sediment discharge to the creek systems. However much of the other pre-mining areas which were cleared and levelled would have stabilised. Consequently the quantities of sediment loads likely to be discharged should be significantly reduced.

(ii) Coal Fines & Acid Drainage

Runoff from hardstands, haul roads, plant area, stockpiles and mine pits will contain coal fines. Apart from causing discoloration, the coal itself does not appear to seriously affect the biological system and coal dust settling from the atmosphere or being washed into the freshwater system is not likely to cause significant biological effects.

Detrimental impacts may occur, however, from certain coal impurities such as pyritic sulphur which when mixed with water produces acids. Stormwater runoff and groundwater which drains into the mine pits could possibly be acidic due to oxidation of pyrite which may be present in the exposed coal seam. It appears that acid water may constitute a problem in certain areas of the Tarong coal field. Analysis of bore water samples taken in 1973 and 1976 shows a pH range from 3.5 to 6.8.

Raw coal analysis shows relatively low sulphur (0.17-0.76%) and pyrite (0.01-0.15%) concentrations in the coal. Often acid drainage may not occur until sulphur concentrations are in excess of 1%. Due to the inconclusive nature of the analysis of the potential for the formation of acid drainage, the recommended operating procedures given in (iii) below should be complied with to ensure that should acid drainage be formed it can be adequately treated and not discharged to the freshwater system.

Should accidental discharge of acid drainage to the freshwater system occur significant detrimental impacts to the creek fauna will occur. During the wet season it is likely to be diluted and the effects will not be as serious. During the dry season local runoff into the permanent pools may cause complete loss of freshwater life. However much of this pollutant will be flushed out in the next wet season. Any adverse effects on the water quality in this area will be carried further downstream into Barker's Creek where subsequent use of the water for stock watering, irrigation or as a future source of domestic water may be impaired.

(iii) Recommended Construction & Operating Procedures

(a) Haul Roads and Plant Area

All haul roads and other roads within the mining areas where coal is likely to be dropped, should be provided with an adequate stormwater collection system on either side of the roadway. This drainage water should be fanned out over suitably flat and grassy areas to reduce the water velocity and remove coal particles from suspension before discharge to streams is permitted. Runoff from the plant area should be fed via a drainage system into detention basins where fines will settle out before entering the natural creek system. In designing these basins consideration should be given to using the basins as a source of water for wetting down roads for dust control.

The philosophy behind these basins is two-fold:

: to provide a still water area where coal and other particle fines can settle out of suspension before entering the creek system, and

. to detain highly turbid drainage from entering a creek system that may be low in turbidity.

To this end, it is recommended that these detention basins be designed to retain runoff from the various areas for a minimum of a 24 hour duration, 1 in 5 year intensity storm. It could be expected that once the detention basins begin to overflow, it is likely that Meandu Creek will contain water with as a high a turbidity as the drainage water itself. Thus overflow of the basin embankment at this stage would have little additional detrimental impact.

As water is a costly and highly used resource in coal handling and preparation areas, it is possible that the excess water from the settling basins can be recovered and recycled as either raw water make-up or washdown water. Regular maintenance and cleaning of stormwater detention basins must be carried out.

Similar detention basins should be provided to intercept all runoff and washdown water from the plant and stockpile area. Runoff from these areas is likely to be particularly heavily laden with coal fines and adequate detention must be provided to all these fines to settle out before the effluent is discharged to the natural system. Periodically these basins should be cleaned to remove saleable product retained in the ponds and also to provide adequate detention capacity in the ponds.

(b) Pit Drainage

As discussed in (ii) above, it is not yet clear whether acid drainage is likely to be formed in the open cut pits. Should acid mine drainage become a problem as mining proceeds the following construction and operating procedures should be adopted.

Pit drainage should be pumped to shallow evaporation ponds upstream of the other detention basins previously discussed. These evaporation ponds should be sited as close to the top of the catchment as is economically and physically possible to prevent high volumes of runoff entering them. Surface water should be diverted away from these ponds and away from the mine pits themselves.

These evaporation ponds should be designed so that no discharge to the freshwater system is possible and any pit drainage pumped into them is lost by evaporation. The bases of these ponds should retain all discharged drainage and not permit soakage to groundwater aquifers. Groundwater monitoring bores would need to be established around the evaporation ponds to ensure that the aquifer quality does not deteriorate.

Should accidental failure occur, or overtopping during intense rainfall activity, the discharge should be channelled and directed to detention ponds further downstream i.e. those

containing process and wash waters from the coal handling and preparation areas. This system provides a series of detention basins with the most polluted liquid wastes being detained at the highest levels in the catchment so that, in order to reach the freshwater creek system, these discharges must overtop the greatest number of stilling basins.

All water retention structures and drainage discharges must conform to standards set by the Queensland Water Resources Commission and the Water Quality Control Council.

It is important that all discharges to the freshwater system are checked. Monitoring of the stream has already taken place to establish a base for water quality review. This monitoring should be maintained on a continuing regular basis to keep the stream's characteristics under review.

4.2.3 GROUNDWATER

As the water table within the proposed mining area generally parallels the coal seams, groundwater seepage into open cuts is likely to occur. This may cause a lowering of the water table in the area surrounding the mine and may affect the recharge potential of Meandu Creek. However any reduction in flow rate and volume is likely to be within the range normally experienced in this stream.

Dewatering of the mine pits may also affect the quality of the groundwater. As discussed in Sub Section 4.2.2 acid mine drainage may be formed. Should acidity become apparent during the mine's operation, the water should be pumped from the pit area as soon as possible into the evaporation basins. Seepage from these basins should be monitored so that if it appears that groundwater is being polluted by the seepage of the acid drainage through the floor of the evaporation basin, remedial measures can be undertaken.

Upon completion of mining operations the final cut will be left as a water impoundment. Water filling this impoundment is likely to be comprised of groundwater seepage and runoff water from the rehabilitated spoil piles. Surface water runoff into the pit is likely to raise the water level above that in the surrounding strata and result in recharge to groundwater. If this recharge water is of lower quality than surrounding groundwater supplies, then groundwater quality would be affected. This could affect supplies to groundwater users in the area. Furthermore increased recharge in a pit no longer in use may result in increased groundwater flow into other operating pits in the area, increasing the volume of acid drainage to be treated. Should remedial measures be required it may be necessary to consider sealing exposed porous strata and coal seams as well as placement of non pyritic overburden below the water table under the spoil piles. As groundwater from this aquifer contains moderate levels of dissolved solids and is generally only suitable for stock watering purposes, an increase in total dissolved solids would not affect its potential usefulness for domestic purposes.

Acid groundwater from mining pits is unlikely to percolate to Meandu Creek as the water table at the creek appears to be perched in the Quaternary alluvium and therefore separate from ground water associated with the coal seams. In the few pit areas where this alluvium is exposed, care should be taken to ensure that no recharge of acid drainage to this aquifer occurs. The perched water table associated with the quaternary alluvium may be polluted if accidental discharge of evaporation ponds or tailings ponds to the creek system occurs, especially during low stream flow conditions. This may affect aquifer water quality for down flow users and for potential domestic supply purposes.

During the construction phase it is proposed to obtain water supplies from underground sources. Full testing must be undertaken to determine the safe yield of the available aquifers. Care must be taken to ensure that the aquifer's recharge rate is not exceeded by the withdrawal rate otherwise depletion of the resource and loss of water supply to the surrounding pastoral users could result.

4.2.4 AIR QUALITY

(i) General

The proposed open cut mining operation and preparation plant will result in an increase in particulate fallout in the surrounding area. The amount of dust generated will depend on the nature of each source, the degree of handling, and the strength and direction of the prevailing winds (ref. Appendix E). In addition smoke will be generated by burning vegetation and gases will be emitted from engine exhausts and explosions.

(ii) Emissions

As discussed above three major emissions will be generated by the mining operation which are likely to affect air quality. These are dust, smoke, and gases. The sources of each of these emissions are discussed below.

(a) Dust

Site Clearing

During the initial site clearing and construction of the haul roads, drainage, and infrastructure facilities, a large number of bulldozers, scrapers, trucks and graders will be operating. It is expected that up to 4 tonnes/hour of dust could be raised by these vehicles. If a wind speed of 5m/sec blows across the site in such a direction that all the dust is contained within a 2 km strip, then the maximum concentration of site-oriented dust particles immediately downwind of the site would be of the order of 1 $\mu g/m^3$. It is likely that most particles would be deposited within 1 km of the site for normal wind conditions, in which case the average deposition rate at this fringe could be of the order of 100 $mg/m^2/day$.

Mobile Plant

Once site clearing and construction operations are completed, a significant number of haul trucks and other plant will be operating on site during mining operations. It is likely that this traffic could generate dust at a rate of up to 2.4 tonnes/hour if the roads are not watered. If the roads are watered regularly the dust generation could be reduced to approximately 1 tonne/hour. Without road watering these mobile dust generating sources could produce maximum ground level concentrations up to 0.6 $\mu g/m^3$ at the perimeter of the site and deposition rates of the order of 60 $mg/m^2/day$ in the 1 km wide strip fringing the site. These levels could be reduced to 0.25 $\mu g/m^3$ and 25 $mg/m^2/day$ if sufficient water is applied.

Stationary Plant

Two major stationary sources of dust will be the dragline and the rock drill. Dust will be generated when the dragline bucket digs the overburden and also when it is emptied over the overburden spoil pile. The quantity of dust generated by this operation could be of the order of 60 kg/hr. Drilling of overburden and coal for the placing of explosives could cause significant amounts of dust to be raised. This dust is commonly discharged upwards and on average could generate approximately 2 tonnes/hour.

Blasting

Blasting would be carried out regularly to break up overburden and coal preparatory to removal by dragline or coal shovel. As the top of the coal seam will be some distance from the surface, it is unlikely that blasting of the coal would cause significant amounts of coal dust to be carried away from the source. Blasting of overburden would occur about once per shift. It is unlikely that the amount of dust raised each time would exceed 0.5 tonne.

Exposed Surfaces

In preparation for mining, all of the pit areas are to be cleared of vegetation and stripped of overburden. When exposed to wind, considerable amounts of dust can be raised from these exposed areas. Overburden heaps are also sources of wind-generated dust. Dust from exposed surfaces can be reduced by carefully phasing the clearing and stripping in conjunction with the mining programme so that large areas of exposed ground are not left standing for long periods. Similarly, progressive overburden restoration closely following the mining operations, will minimise the amount of raw overburden exposed to wind action.

Preparation Plant

Coal dust can be generated in several areas of the preparation plant including the R.O.M. dump hoppers, screens and crushers, and conveyors. At the dump hoppers and the screens and crushers significant dust control can be achieved by water sprays. Conveyors should be equipped with wind shields to minimise wind entrainment, particularly when elevated. All transfer points should be enclosed or at least equipped with water sprays.

Stockpiles

Stacking of both the raw and washed coal stockpile will be by discharge from the end of a conveyor resulting in conical stockpiles. Coal could drop distances of up to 25 metres and this could generate coal dust, particularly at the raw coal stockpile. The fitting of a telescopic chute would eliminate much of the dust. Reclaim will be by reclaim tunnel and conveyor and is unlikely to produce significant amounts of dust.

Airflow over the stockpiles can pick up fine coal from the surface and spread the dust downwind. The "pick up" velocity for this to occur for various sized particles depends to a large extent on the coal moisture content. It has been shown (Djamhouz & Ghanein, 1974) that for particles in the size range 75 to 105 microns, the "pick up" velocity varies from 5m/sec for 0% moisture to 6.3 m/sec for 7.5% moisture. Consequently more wind-blown dust will be generated from the raw coal stockpile than from the washed coal stockpile. The workshop and administration buildings and other areas where personnel are located should not be located downwind (i.e. north west) of the stockpiles.

(b) Smoke

Smoke would be generated by the burning of stacks of timber cleared from the mining areas, the total area of which would be approximately 900 hectares. However burning will be undertaken on a strip by strip basis in accordance with the clearing programme. Consequently vegetation from only relatively small areas will be burnt at any particular time.

It is recommended that burning be undertaken when the wind is blowing away from habitated areas (for Kingaroy Surface Wind Analysis ref. Appendix E). Written notification should be given to the Air Pollution Control Council advising them of details of the proposed burning and all of their requirements should be complied with. Because smoke generation is only an infrequent event, it is not expected to cause any serious impacts.

(c) Gases

Engine Exhaust

Gases from engine exhausts will be emitted during both the construction and mining phases. The quantities emitted will be approximately the same for each phase. The mobile equipment used would be predominantly diesel-engine powered. There could be a total installed engine power of about 7,500 kW on site and it is expected that an average of 3,400 kW would operate concurrently during each working shift, consuming up to 1400 ℓ/hr of diesel fuel.

The predicted rate of discharge and maximum downwind concentrations at ground level for each of the pollutant gases contained in the exhausts are presented in Table 4.1 below;

TABLE 4.1

DIESEL EXHAUST GASES

Gas	Rate of Production (kg/hr)	Max. increase in Ground Level Conc. off Site
unburned hydrocarbons	19	32µg/m^3
carbon monoxide	20	33µg/m^3
carbon dioxide	2,200	3,700µg/m^3
nitrogen oxides	26	43µg/m^3

Burning Vegetation

Where vegetation is burnt, significant quantities of carbon dioxide and carbon monoxide are released. At the burning rates assumed above, maximum increases in ground level concentrations off site for carbon monoxide have been estimated as 250µg/m^3 and for carbon dioxide as 30mg/m^3.

(iii) Impacts

(a) Dust

It is expected that a total of 90 tonnes of coal and earth dust could be discharged into the atmosphere each day by the processes which would produce dust on the site. Dust losses from the coal handling plant and the rock drill would each contribute approximately one-third of the total from the site. This estimate assumes that watering of haul roads and dust control measures in the coal handling area are carried out. However, because the coal dust would seldom reach heights in excess of 30 metres above the ground, it is unlikely that significant amounts of dust would be carried more than 1 km from the perimeter of the site.

As the dust sources are spread about the site and have changing locations, it is difficult to estimate the probable pattern of dust deposition in the area surrounding the site. Available dust deposition measurements from other mining and quarrying sites indicate that average fallout rates of the order of 100 mg/m^2/day could be experienced 2 km from the source. The Queensland Air Pollution Control Council has indicated that levels in excess of 110 mg/m^2/day are likely to cause complaint. Consequently significant effects may be observed and complaints may be generated from rural residences within 2 km of the mining areas.

It has been suggested that dust collecting on vegetation may cause a reduction in photosynthetic activity and a loss of plant vitality. However, such dust as does collect on leaves is usually removed by the action of wind and rain. Similar mining activities which have been in operation for a long time in other areas do not seem to have affected nearby vegetation, and a similar experience can be expected for the Tarong mine.

(b) Smoke

Smoke concentrations resulting from burning stacks of cleared timber would be sufficient to cause smoke haze even when natural winds provide maximum ventilation. During stagnant atmospheric conditions, smoke concentrations could build up to serious levels and, under early morning temperature inversion conditions, the smoke haze would probably drift northwards along the creeks until the inversion broke up.

(c) Gases

The maximum ground level concentrations which are expected downwind of the site for the various gases produced during the mining operation are given in Table 4.2. These increases would be insufficient to cause the maximum levels recommended for occupational exposure to be exceeded or even approached.

TABLE 4.2

MAXIMUM EXPECTED GROUND LEVEL GAS CONCENTRATIONS

Gas	Max. Incr. in Concentration
Carbon monoxide	283 $\mu g/m^3$
Carbon dioxide	34,000 $\mu g/m^3$
Nitrogen oxides	43 $\mu g/m^3$
Unburnt hydrocarbons	32 $\mu g/m^3$

4.2.5 NOISE

(i) Sources

The principal operations associated with the proposed open cut mining which are significant noise sources are given in the following table:

TABLE 4.3

SIGNIFICANT NOISE SOURCES

Activity	Source
Removal of vegetation	A
Earthworks	A
Overburden removal	A,B,D
Coal extraction	A,B
Coal haulage	A
Coal preparation	D
Rehabilitation	A
Traffic	C

Symbol: A = Diesel powered mobile plant
B = Explosives
C = Private and commercial vehicles
D = Machinery and ancillary equipment

According to studies conducted with respect to similar mining operations, typical noise levels attributable to each of the above sources are estimated in Table 4.4.

TABLE 4.4

NOISE SOURCES AND SOUND PRESSURE LEVELS

Source	Level dB(A) at 50m
Diesel powered equipment	83
Explosives	105 (peak)
Private and commercial vehicles	65
Coal preparation machinery	70
Dragline	75

(ii) Noise Levels

It could be anticipated that the maximum prolonged continuous sound levels at the mine site would not rise above about 80 dB(A). Short duration elevations to about 105 dB(A) may occur when blasting takes place. At the preparation plant a continuous sound pressure level of 70 dB(A) can be expected while the peaks associated with haul trucks are likely to be of the order of 80 dB(A) while travelling at relatively low speeds. During the construction phase prolonged continuous sound levels of approximately 80 dB(A) can be expected from earthworks and from preparation plant and dragline erection.

Noise from the source of generation is propogated in free air equally in all directions and hence is attenuated in a hemispherical pattern as it spreads from the source. Modifications to the attenuation rate depend upon factors such as wind speed and direction, airborne dust particles (turbidity), humidity and temperature (including temperature inversions), and topographical features or man-made barriers and screens.

Noise level calculations and observations have been performed on similar mining operations and "line of sight" attenuations on both general mining noise and blasting noise have been calculated. These calculations have been made for calm conditions in a stable atmosphere without making allowances for topography, winds, temperature inversions etc. Nevertheless, for distances up to approximately 4 km from the site, these results are likely to be indicative of those which will actually be experienced. Beyond this distance interference from topographical features and atmospheric conditions is likely to be more significant.

TABLE 4.5

NOISE ATTENUATION WITH DISTANCE

Radius from Source	Mining & Construction dB(A)	Blasting dB(A)	Prep. Plant dB(A)
50m (source)	83	105	70
100m	77	99	64
750m	60	82	47
1km	57	79	44
2km	51	73	38
4km	45	67	32
6km	41	63	28
8km	31		
12km	26		

(iii) Noise Standards

Noise criteria for planning purposes have been established in Australian Standard A.S. 1055-1978 "Noise Assessment in Residential Areas". This code establishes calculated background sound levels for different areas containing residences. If the predicted sound level exceeds the codes background levels then the noise is likely to be annoying. Table 4.6 has been extracted from A.S. 1055-1978.

TABLE 4.6

CALCULATED BACKGROUND SOUND LEVELS FOR DIFFERENT AREAS CONTAINING RESIDENCES

Noise Area Category	Description of neighbourhood		Calculated background sound level $L_{bg.calc}$ dB(A)						
	For planning Purposes	For existing Situations	Monday to Friday				Weekends and public holidays		
			0600-0700	0700-1800	1800-2200	2200-0600	0700-1800	1800-2200	2200-0700
R1	Areas with negligible transportation	Areas with negligible transportation	35	45	35	30	40	35	30
R2	Areas with low density transportation	Areas with low density transportation	40	50	40	35	45	40	35
R3	Areas with some commerce or industry	Areas with medium density transportation	45	55	45	40	50	45	40
R4	Not Applicable	Areas with some commerce or industry or with dense transportation	50	60	50	45	55	50	45
R5	Not Applicable	Areas in commercial districts or bordering industrial districts of with very dense transportation	55	65	55	50	60	55	50
R6	Not Applicabble	Areas within predominantly industrial districts or with extremely dense transportation	60	70	60	55	65	60	55

Source: AS 1055-1978

In addition to the A.S.-1055 criteria, the Queensland Department of Local Government, Noise Abatement Division, have indicated that the noise levels given in Table 4.7 might be considered as presumptive limits until regulations under the Noise Abatement Act have been promulgated.

TABLE 4.7

BACKGROUND NOISE LEVELS GENERALLY CONSIDERED ACCEPTABLE

Zone	7 a.m. - 10 p.m. dBA	10 p.m. - 7 a.m. dBA
1. Rural and outer suburban areas with negligible transportation	35	25
2. Generally suburban areas with infrequent transportation	40	30
3. Generally suburban areas with medium density transport	45	35
4. Suburban areas with mixed commerce and industry or close to dense transportation	50	40
5. City or commercial areas or residential areas close to industry	55	45
6. Predominantly industrial areas	60	50

(Source: Noise Abatement Division, Department of Local Government)

Based on its present land use, the mine site can be classified as Noise Area R1 (from Table 4.6) and Zone 1 (from Table 4.7). It should be noted that A.S. 1055-1978 daytime (45 dB(A)) and night time (30 dB(A)) levels are higher than the Noise Abatement Division's daytime (35 dB(A)) and night time (25 dB(A)) levels.

Both Yarraman and Nanango would be classified as Noise Area R3 (Table 4.6) and Zone 3 (Table 4.7).

(iv) Noise Impacts beyond the Mine

The probability of noise to cause complaints from nearby residents has been assessed by comparing the estimated noise levels against those given in A.S. 1055-1978. If the estimated noise level exceeds the A.S. 1055-1978 level then complaints may be expected. However as stated in the code excesses of 5 dB(A) or less may be of marginal significance.

Table 4.8 shows the comparison and indicates the likelihood of complaints.

TABLE 4.8

PROBABLE NOISE EFFECTS

Community	Distance from Closest Mining Area (km)	A.S. 1055-1978 Standard (dB(A))		Mining & Construction Noise		Blasting Noise	
		Day	Night	Estimated Level dB(A)	Complaints Likely	Estimated Level dB(A)	Complaints Likely
Yarraman	7	55	40	40	no	62	yes (mainly night)
Nanango	16	55	40	33	no	55	no
Maidenwell	8	50	35	39	no	61	yes
Rural Residences	<4	45	30	>45	yes	67	yes
"	4-17	"	"	45-30	Occasionally (Night only)	67-54	yes
"	>17	"	"	<30	no	<54	no

Mining noise is only likely to cause complaints from rural residences within 4 km of the site, although some disturbance from night time operations may be noticeable up to 17 km from the mine. However at such a distance attenuation from intervening topography and vegetation is likely to significantly reduce the noise levels below those given in Table 4.8. Consequently the effects listed in the table can be considered as being conservative.

Noise from blasting will be much more noticeable than from mining and construction operations. It will be clearly audible at Maidenwell and the surrounding rural residences. Should night time blasting occur, it will be even more likely to cause complaints from these communities and also from Yarraman. However, this noise will be of very short duration and will only occur approximately once per shift. It is recommended that blasting be limited to daylight hours. Coal blasting is likely to occur at significant depths within the open cut. At such depths, noise attenuation would be high within the pit,significantly reducing the noise effects observed beyond the mine.

The predominant direction of the prevailing winds is from the south east. Consequently noise attenuation in the quadrant north west of the mine site can, in general, be expected to be less than that experienced in the other quadrants.

Noise and blasting vibrations are, in the first instance, likely to disturb animals, particularly mammals and birds. Observations from other noisy regions (e.g. airports, freeways) indicate that many animals learn to disregard noise and re-colonise areas from which they were earlier displaced. However some species may not be able to readjust and will move out of the area.

Additional noise is likely to be generated by the increased traffic on the regional road system (ref. Sub Section 4.3.10). This noise is likely to affect those rural residents which are adjacent to the major roads in the area.

(v) Impacts at the Mine

Within the minesites themselves, operators of plant and machinery may be subject to excessive noise which could produce hearing damage. An equivalent continuous level for an 8-hour working day of 85-90 dB(A) is considered to be the threshold of intensity likely to cause damage. Higher levels may be acceptable for shorter periods. Table 4.9 below provides noise levels associated with the operator position of plant and machinery is use on an existing open-cut mine.

TABLE 4.9

OPERATOR NOISE LEVELS FOR VARIOUS PLANT

Specific Machine or Function	Noise Level dB(A)
Cat. D9 G	99 - 101
Terex Dump Trucks (Loaded)	93 Reverse 101 3rd gear 98 6th gear

TABLE 4.9 (CONTD.)

Specific Machine or Function	Noise Level dB(A)
Unloaded	101 - 103 104 tipping
Mack Dump Trucks	84 - 88
Wabco 58 Dump Trucks	82 idle 83 - 87 pulling from cut 93 tipping
38 RB Shovel	93 - 94
Gardner - Denver Rock Drill	104 - 107

Source: National Safety Council of Australia, January, 1978.

Provision for ear protectors and/or sound proof cabins could be required for operators of similar plant and noise reduction barriers may be necessary to screen workers from excessively noisy areas at the site.

4.2.6 FLORA

Establishment of the open cut mines, plant areas and haul roads will necessitate the removal of existing vegetation. Trees will also need to be cleared from power line alignments. In all approximately 1510 ha of vegetation will be removed or alienated representing about 37% of the total vegetation within the proposed mining lease area. The actual areas of each vegetation type disturbed will depend on the location of haul roads and power lines. Approximate areas of each vegetation type to be cleared or alienated have been estimated and are given in Table 4.10. Grassland will be most severely affected in terms of area lost, while Eucalyptus open forest will be next most severely affected. In terms of conservation value none of the areas of vegetation to be removed are significant as these vegetation types all occur in surrounding areas. Disturbed Eucalyptus open forests and grasslands are extremely wide spread. Although closed vine forest of the type found in the proposed mining lease area is not well preserved (Specht et al 1974), (Tracey, pers. comm.), the small areas on freehold land to be disturbed are of limited conservation value. However, those areas of closed forest on State Forest 289 are much more valuable in terms of conservation and it is recommended that these areas not be disturbed.

TABLE 4.10

ESTIMATED AREAS OF VEGETATION TO BE REMOVED OR ALIENATED (ha)

Vegetation Type	Haul Roads, Services & Catchdrains	Plant Area	Mining and Spoil Dumps	Other Disturbed	Total
Eucalyptus open forest	25	25	250	445	745
Closed vine forest	15	0	30	10	55
Plantation	0	0	0	0	0
Grassland	35	0	400	275	710
Total	75	25	680	730	1510

The available revegetation options include to revegetate to grazing land, to plantation or to native vegetation. These options are still being considered. Provided seed sources are available close by or fresh topsoil containing viable seed is used, then regeneration of native species presently in the area may occur quite rapidly which ever option is decided on. Revegetation to grazing standard would result in areas of grassland with clumps of trees, comparable to that presently existing. A plantation forestry system would result in essentially even age, dense stands of trees with some associated understorey species. The associated species and the diversity would depend partly on the primary plantation species. Revegetation to a vegetation type originally found in the area would result in areas of open forest, with a grassy or shruby understorey and vine forest on more suitable fertile soils. If revegetation is properly undertaken, then long term detrimental impacts on the flora of the area should be minimised.

Apart from direct removal of vegetation a number of lesser impacts may occur. Runoff from the coal handling area and spoil piles may contain some solutes harmful to vegetation. As all effluents are to be directed into detention ponds and none discharged directly to the creek system these should not affect the freshwater flora. The very low sulphur content of the coal should reduce any likely problems associated with acid leachate formation.

In the event that accidental discharge of acid drainage to Meandu Creek occurs, significant detrimental impacts to the creek biota will occur. Damage to aquatic biota from acid drainage can be attributed to high concentrations of mineral acids, sulphate and iron ions as well as the deposition of a smothering blanket of precipitated iron salts on the stream bed.

The most serious impacts would occur if discharge took place during low stream flow conditions. Depending on the volume of discharge acid drainage could affect Meandu Creek and downstream to Barker Creek. Freshwater life would be severely affected at the point of discharge, with only the most tolerant species surviving. Effects on aquatic life and water quality would decrease downstream to a degree, depending on the dilution occuring. Pollutants would be flushed from the stream with increased stream flow during the wet season and freshwater organisms would be reintroduced from higher reaches and by water birds. The freshwater system would be more susceptible to invasion by exotic pond weeds when the original vegetation was affected by acid drainage.

An increase in silt loads in the creek system is expected to occur during the construction phase. Increased levels of suspended solids in creek waters would result in reduced sunlight penetration, reduced photosynthesis in plants, possible smothering of benthic organisms as well as reduced capacity of the stream for assimilating other pollutants. The effects could be expected to decrease downstream from the points of entry of turbid stormwater. Impacts on the freshwater biota from this source are expected to be temporary. The implementation of the recommended water management scheme (Sub Section 4.2.2) and erosion control measures (Sub Section 4.2.1) would reduce the concentrations of suspended solids in discharged stormwater, particularly during the mining phase. Parts of the freshwater stream affected by sedimentation and suspended solid concentrations are expected to be recolonized from upstream and by organisms introduced by water birds. The freshwater system has in the past assimilated sediment resulting from agricultural clearing and cultivation.

Salt concentrations in groundwater are generally too high for the water to be used for irrigation purposes. Extensive 'scalding' of vegetation has occured below an existing bore used for stock watering purposes. Groundwater should not be used for irrigation during rehabilitation unless salt concentrations are below 600 to 1000 ppm. Any seepage from tailings ponds and from the suggested evaporation ponds would be high in total dissolved solids and of low pH and could thus kill vegetation in areas below these ponds receiving the seepage. This could result in soil erosion problems in the areas.

Dust is a largely unavoidable problem associated with open cut mining activities and is generated from haul roads, coal and spoil stockpiles as well as from process areas. It tends to coat the vegetation in the immediate vicinity of the source. Little is known of the effects of dust on plants, however it is possible that it would interfere with photosynthesis in those plant parts covered. However, no long term effects in other mining areas have been observed. Dust is generally washed off plants by rain.

The population increase in the area could result in degradation of the vegetation at some recreational sites through an increase in their usage. The construction of haul roads and service access routes will expose soil to erosive processes as well as to invasion by weeds. Proper vegetation of these areas would be a suitable method of surface stabilization and weed control.

4.2.7 FAUNA

Mine development is likely to affect terrestrial fauna through the removal of habitats and through indirect disturbance as a result of mining and associated activities. The clearing preceding open-cut mining effectively transforms the wooded habitats to grassland habitats in much the same manner as agricultural clearing, but this grassland phase is only transient, due to the systematic encroachment of open-cut mining operations.

The removal and disturbance of vegetation for mining will result in:

(i) The complete loss of specialist habitat species occupying the habitats that will be removed.

(ii) Significant decreases in populations of generalist habitat species within the general development area.

(iii) Changes in the species structure of faunal populations in areas immediately adjacent to the development areas.

(iv) Invasion or increased abundance of generalist exotic and native species in any simplified vegetation.

The larger and more mobile species such as macropods and birds will be driven out by the commencement of clearing operations, and the smaller, slower types, such as some small mammals, unfledged birds, reptiles and amphibians may die, either by their inability to avoid the machines or by finding themselves in a hostile environment from which they are unable to escape. Some of the larger mobile species may also fail to survive. Despite their ability to reach apparently suitable refuges, these are likely to be stocked to capacity by competitors, in which case the intruders are unlikely to become established.

Initially mining operations and associated activities will keep more timid species out of nearby suitable habitats. However it is expected that habituation will occur (e.g. as at Brisbane Airport). Most of these species will return provided they are not hunted.

In the event that revegetation is to an agricultural landscape then the grassland and planted woodland areas could be expected to support generalist native and exotic species. If on the other hand revegetation were to a stage where natural vegetation successions would continue then, in time, a more diverse range of wildlife would be expected. Vegetation returning to something similar to vegetation natural to the area would support a similar fauna provided the original wildlife species were conserved in nearby areas and were able to recolonise.

Use of any cleared land suitable for hoop pine plantation would result in vegetation resembling grassland in the early stages developing to mature hoop pine with many vine forest species in the understorey.

Fauna appropriate to this vegetation could be expected to occur provided species were able to recolonise. Recolonisation depends not only on the species being present in nearby habitat but also on its mobility.

If the relatively undisturbed vegetation remaining on parts of the mining lease area is disturbed by activities associated with mining, then generalist exotic and native species of flora and hence fauna may invade or become more abundant in the disturbed areas.

The final cuts of the open cut mines will form water impoundments. These may in time become suitable environments for aquatic flora and fauna. These impoundments can be made much more productive by increasing the area of water less than about 1 metre in depth. If problems with acidic water are encountered, corrective treatment may need to be taken. Bartle and Riches (1978) indicate that lakes associated with open cut coal mines return to neutral pH in approximately 30-40 years without treatment.

Runoff from the coal washing and crushing area, stockpiles and spoil heaps may contain solutes and sediment loads harmful to animals and animal habitats such as established vegetation and the creek ecosystem. All effluents are to be directed into detention basins or evaporation ponds and none discharged directly into the creek system. Any seepage will be monitored. Pollution of Meandu Creek would have considerable effect on the species present there as well as downstream in Barker's Creek. The lungfish (*Neoceratodus forsteri*), probably occuring in Barker's Creek, is of particular concern because of its uniqueness, scientific interest and limited distribution. The platypus (*Ornithorhynchus anatinus*) also unique and of particular public and scientific interest is known to occur in Barker's Creek (Kehl, pers. comm.).

Transport corridors and bands of grassland under power lines may provide a barrier to the free movement of some animals. Some movement however should still occur while more mobile species will be relatively unaffected. It is expected that there will be conflicts with wildlife, particularly macropods and vehicular traffic. Macropods are often

attracted to the verges of sealed roads during dry periods. Rain shower runoff from bitumen surfaces and mowing of road verges encourages short green grass favoured by macropods.

The planting of a 300m wide belt of trees around the coal mining areas should provide additional habitat for wildlife in the area. The value of this area for wildlife conservation will depend on the range of food resources and nesting sites developed. Nesting sites such as hollow limbs (or a substitute) and the development of a scrub understorey would encourage a greater diversity of fauna than would trees with a grassy understorey. This belt of trees should provide some protection from noise and dust for surrounding areas and their wildlife.

Although it is not envisaged to surface mine the vine forest areas at present under Department of Forestry control, in view of their limited nature, the diverse range of fauna they support and their likely role as habitat for the rare Black-breasted button quail (*Turnix melanogaster)* it is recommended that disturbance of these areas should be avoided. As the north west portion of S.F. 289 is under proposal for a National Park consideration should be given in revegetation to providing for a land use more consistent with conservation purposes than the existing agricultural land use.

The habitats of many species will be dramatically affected by the proposed development, however because of the distribution of these species outside the development area, no individual species can be considered to be threatened. The revegetation option decided on will largely determine the value of revegetated lands for wildlife conservation. Several bodies of water will be available at the cessation of open cut mining for freshwater flora and fauna and associated bird life.

4.2.8 REHABILITATION

(i) Recontouring and Drainage

Overburden spoil piles formed of soil and rock removed by draglines during open-cut coal mining often repose at angles of 38°. Spoil piles at these steep angles are unstable in the long term tending to erode and slump. Recontouring of these spoil piles allows more effective revegetation and reduces soil erosion and hence siltation problems in water ways. Spoil piles are generally recontoured such that slopes are consistent with those of the natural topography. For the proposed mining area, these are generally 1 in 14 (4°) to 1 in 7 (8°) with maximum grades of 1 in 2.3 (22°) for short distances only. The plateau surfaces resulting after recontouring should be free draining and have a rolling topography with slopes around 1 in 10 (6°). Steep slopes require special stabilization methods.

To reduce the velocity of runoff water and increase water infiltration, soil conservation structures are recommended particularly where slopes are more than 150 metres in length. Slopes with concave faces tend to lose less soil than convex slopesof comparable average gradient as deposition occurs on the lower slopes of the former.

Water pondage areas incorporated into the system of soil conservation structures are useful for increasing water infiltration, reducing runoff and allowing suspended solids to settle out of stormwater. Problems have been encountered with pondage areas increasing water infiltration into still-working areas of the pit.

After mining is completed, the final cuts of the open cut pits will be left as water impoundments. In many areas spoil heaps are recontoured so that runoff drains into this impoundment via the revegetated disused haul roads. The slope of the last overburden spoil piles leading into the last cut may need to be reduced to prevent slumping due to saturation of their base. The high walls, composed of consolidated sediments would be more stable. However should runoff from unmined areas of the catchment be likely to run over the high walls then contour diversion banks could be used to divert runoff water around the cut and rehabilitation area or if desired, into the final cut via a low gradient grassed water way.

Acidity problems associated with waters in the final cuts should be reduced by the low sulphur nature of the coal. Problems may be further minimised by keeping pyritic spoils found in proximity to coal seams and any reject coal away from the water body and the surface of the recontoured spoil piles. Pyritic spoils and reject coal should also be kept above the water table. Liming or contact with alkaline spoils or organic matter will help to reduce acidity.

Any acidic discharge from the impoundment would need to be retained for evaporation or treatment to prevent pollution of other waters. Runoff from spoil piles prior to effective revegetation would also need to be routed through settling ponds before discharge or held in storage ponds outside the pit.

(ii) Topsoiling and Revegetation

The use of topsoil for revegetation purposes generally provides a medium more amenable to plant growth than untreated spoil. Topsoil would ideally be stripped to a depth of 100 mm or more (depending on the soil). Once rehabilitation is in progress, top soil should be moved straight from stripping to the revegetation area. The reduction or elimination of storage reduces death of soil-stored seed and nutrient losses. Satisfactory revegetation results have been obtained with a minimum of topsoil but with extra fertilizer and good quality overburden.

Revegetation may be to a grazing system or to a standard that natural vegetation successions proceed. A forestry system could also be considered. The final choice should consider soils, likely future land use and surrounding land uses.

To achieve a grazing potential for the recontoured land the area would need to be planted to pasture grasses with suitably located wind breaks and shelter belts planted with trees. If the natural vegetation alternative is chosen then a soil stabilization planting of grasses would be needed as well as appropriate plantings of forest pioneer tree and shrub species. The Department of Forestry regards poor soils of the proposed lease

area as being unsuitable for hoop pine plantations without heavy fertilization although the volcanic soils are suitable. Exotic pine species do poorly in the area due to problems of dessication.

Before revegetation commences, soil properties likely to limit plant growth need to be identified with a view to rectifying these. The soil pH may be adjusted by liming (also reducing toxicities) while excess soluble salts may be removed by leaching and nutrient deficiencies corrected by the use of fertilizers. Pot trials followed by field trials could be used to determine the most suitable pasture grass species and cost effective soil treatments.

Due to the availability of seed and costs, exotic pasture species are generally used. Pasture seed mixes usually consist of a legume, a grass species for quick cover as well as a number of other pasture species sown at from 5 to 8 times normal seeding rates. The species used and fertilizer requirements will depend on the type of topsoil used to cover the recontoured spoil piles. Pasture species such as Rhodes grass (*Chloris gayana*), Green panic (*Panicum maximum*), Kikuyu (*Pennisetum clandestinum*), Siratro and Couch grass may be useful on the 'forest' and 'scrub' soils encountered in the area.

The Department of Primary Industries office in Kingaroy should be contacted for more specific advice on pasture species and fertilizer requirements. Soils in the area are known to be deficient in nitrogen and phosphorous and to a lesser degree in calcium, sulphur, potash and the minor elements (Wilson et al 1974).

Soil preparation should be carried out using a chisel plough on a tractor. The unit should plough along the contour to allow increased water infiltration. Fertilizing can be done either from the air or using a ground operated spreader. Seeding is most successfulwhen done from the ground.

Steep batters such as occur near the final cut or where spoil piles are in close proximity to infrastructure may require hydromulching.

Clumps of trees for visual screening, wind breaks, to stabilize slopes and to improve the visual asthetics and amenity of the rural landscape should be considered. The 300 m wide belt of native trees to be established for 16 km around the whole proposed mine area will be effective in fulfilling this need. Local native species have been found to be most suitable for revegetation purposes at many other mining areas. This is likely to prove the case at the proposed mine area where local Angophoras, Eucalypts and Acacias will be used over the 12 km belt of trees requiring planting. This may provide an opportunity to select faster growing and more pest resistant species for use on rehabilitation areas. The local species occurring on soils of sedimentary origin will be most suitable. Vine forest species are largely restricted to the red volcanic soils and are likely to be less suitable for rehabilitation work unless nitrogen fertilizers are heavily applied.

The Department of Forestry at Yarraman raises hoop pine seedlings and a small number of other species for amenity plantings. Should the company wish to utilize tubed stock from this source then it is recommended that discussions with the local Forestry Officer be undertaken as soon as possible. Alternatively the Company could buy seedlings from another source or establish its own nursery. To minimise disturbance to surrounding areas seed could be collected from the mining path prior to clearing.

Areas in the process of revegetating should be fenced to exclude stock and should not be grazed until vegetation is well established. Monitoring of revegetated areas is necessary to identify areas where vegetation establishment has failed.

Overburden recontouring and rehabilitation should proceed progressively following mining, enabling the employment of a regular workforce, ensuring that untreated spoil heaps are exposed for a minimum time and allowing modification of rehabilitation procedures in the light of experience.

4.3 IMPACTS ON THE MAN-MADE ENVIRONMENT

4.3.1 GENERAL

Many of the changes to the man-made environment outlined in this Section result primarily as a consequence of the population influx which will be generated by the project. In view of this, it is initially proposed to examine the likely nature of this influx before proceeding to identify its flow-on effects. In determining a likely population distribution, consideration has been given to the proposed housing policies that the Company is likely to adopt for housing its mine employees. However, cognisance must also be taken of the distribution of the power station employees as the two projects are inextricably linked in regard to regional population increases.

4.3.2 POPULATION STRUCTURE

(i) Construction Phase

As discussed in Sub Section 2.4.4, the mine construction workforce will be employed between 1982 and 1985 and again, with the construction of the washing plant, in 1987 and 1988. The peak will be 440 in 1984. The power station construction workforce will be employed from 1979 to 1988, peaking at 1200 in 1984.

Because the power station workforce will have been established in the area for 4 years before the mine workforce is established in 1982, it is difficult to predict with any degree of accuracy where the mine workforce will live. It is likely that the power station workforce will have already established locational and accommodation standards and the Company will have to take cognisance of these when determining the accommodation distribution for its construction workforce.

To determine the likely distribution of the power station workforce, reference has been made to workforce and population distributions estimated by the Tarong Project Advisory Committee. This is an interdepartmental government committee which has been established to examine the population and infrastructure effects of the Tarong Project (including both the mine and the power station). This Committee has assumed that 60% of the power station workforce will be accommodated in single men's quarters, 25% in caravans, and 15% in houses or multiple dwellings.

As far as accommodation for mine workers is concerned, the Company's policy is that single men's quarters either for the permanent workforce or for the construction labour will not be established at the mine site. The recruitment of construction labour will be mainly the responsibility of the successful contractor who will import into the area the skilled labour necessary to execute the work. Because of the relatively small construction force involved, it is believed that individual contractors will be able to locate their workers in caravan parks.

situated in the nearby towns.

As the mine construction period will be divided into two sections, 1982-1985 and 1987-1988 four years will be the longest period the construction workers will require accommodation. It is assumed that 50% of the workers will be single. Because of the facilities available in the nearby towns, it is expected that most of the married workers will bring their families into the caravan parks. However, some workers are expected to commute to centres such as Brisbane and Toowoomba for weekends and holidays.

The distribution of the construction workforce occupying caravan parks will depend largely on the cost and standard of facilities available during the construction phase, and on the locational distribution of the power station workforce. If facilities are competitive, then a wide distribution may occur, although excessive travelling will, in most cases, be avoided.

Assuming that 50% of the workforce is married and living with their families (2.5 persons per family), and that 2 single workers are accommodated per caravan, a possible construction workforce distribution is given in Table 4.11 below.

TABLE 4.11

POSSIBLE CONSTRUCTION WORKFORCE/POPULATION DISTRIBUTION

	1982	1983	1984	1985	1987	1988
Workforce						
Total	60	290	440	220	150	150
Company houses for Supervisory Personnel	4	12	15	15	8	8
Workforce in Caravans	46	228	365	175	132	132
Workforce from Local population	10	50	60	30	10	10
Population						
Direct Population Increase	88	420	665	333	245	245
Distribution						
Population/Caravans						
Kingaroy	23/10*	135/60	169/75	102/45	84/37	84/37
Nanango	34/15	169/75	237/105	135/60	86/38	86/38
Yarraman	23/10	50/22	102/45	34/15	34/15	34/15
Blackbutt		32/14	59/26	27/12	21/9	21/9
Others			52/23			

* 23 people living in caravans
10 caravans required

(ii) Operational Phase

(a) Workforce and Population

The estimated workforce schedule for the mine's operation is given in Table 2.3. This workforce will total 334 by 1990 and will peak in 1998 at 340.

It is assumed that approximately 72% of the workforce will be imported into the area, and that 80% of these will be married. To estimate the order of magnitude of the population increase which may result from this development, it has been assumed that the family of each married worker averages 3.75 persons. Based on these assumptions, possible population increases from mine operations have been estimated in Table 4.12.

TABLE 4.12

POSSIBLE IMPORTED POPULATION

Year	Imported Workforce	Imported Population
1984	14	45
1985	84	269
1986	131	419
1987	165	528
1988	210	672
1989	210	672
1990	240	768
1991	241	771
1992	241	771
1993	241	771
1994	241	771
1995	241	771
1996	241	771
1997	241	771
1998	245	784
1999	233	746
2000	233	746

(b) Workforce Distribution

In the Company's tender to the State Electricity Commission of Queensland (S.E.C.Q.) for the supply of coal to the power station, provision was made for a total of 244 houses for the mine employees. This is approximately the estimated number of employees who would be required to be imported into the area (ref. Table 4.12). Assumptions in the tender specification were made on information available in 1977 and the bulk of the permanent workforce will be recruited some eight years later, in 1985. It will therefore be appreciated that the economic and employment conditions existing at the time of recruitment will have significance in final detailed planning.

Because some time remains before a final decision needs to be made on the population distribution, and because of the continuing negotiations on the matter and the decisions yet to be made, the Company has not adopted a definitive policy on the population and housing distribution of its operational personnel. In addition, as the power station employees will become established prior to those for the minesite, a pattern will be set with regard to housing type and distribution which the Company will have to consider.

The Company is currently considering the two following alternatives:

(1) To construct houses and make them available to employees, recruited from outside the district, on a subsidised rental basis. This approach is widely used in conjunction with mining projects throughout Australia and requires the mine operator to act as landlord accepting responsibility for rates, taxes and maintenance of the houses.

(2) To construct houses and have permanent employees purchase them. Because of the satisfactory level of facilities available in the surrounding towns and their relative proximity to Brisbane, Toowoomba and the Sunshine Coast, it is considered that home purchase is a feasible alternative. It is possible, however, than an incentive to purchase by employees would be required, and that this could take the form of an attractive financing arrangement.

The towns most likely to expand to accommodate the permanent workforce are Yarraman, Nanango and Kingaroy. Both Yarraman and Nanango are located within a short travelling distance to the minesite, while Kingaroy, although further distant, offers a wider range of community facilities than Nanango or Yarraman.

Should alternative (1) be selected, it is likely that the Company will construct all of its houses in Nanango. Nanango has been selected because of the suitable trade off between the level of facilities available in the town and the short distance to the minesite. The Company intends to construct 244 houses and to integrate them, as far as is practicable, into the existing residential areas, depending on the cost and availability of suitable building allotments.

Should alternative (2) be selected, it is likely that the Company will have to distribute its houses through the three towns of Nanango, Yarraman and Kingaroy. In order to encourage employees to purchase their own homes, it will be necessary to cater for some of the workers who will be willing to endure the longer travelling times from

Kingaroy to have the higher level of services available. On the other hand, others may prefer the small-town lifestyle such as Yarraman has to offer. For the purpose of this assessment, it has been assumed that the distribution of houses between the towns would follow that which has been adopted by the Tarong Project Advisory Committee for the power station employees. This distribution is as follows:-

Kingaroy	56%
Nanango	27%
Yarraman	17%

It is based on the population size of each of the towns, and hence, the level of services offered and the distance of each town from the site, and hence, the length of travel time required.

(c) Population Distribution

In estimating the distribution of the population increase generated by the mine workforce, the workforce distributions outlined in (b) above have been used. However, to estimate the total population likely to be generated by the project, the induced population needs to be considered. This is the population increase that will occur indirectly due to the increased demand for goods and services from the mine employees and their families. Based on previous studies of similar projects, an employment multiple of 1.2 has been used to estimate the induced workforce during the operational phase and 1.15 during the construction phase.

To derive the population likely to be generated by the proposed workforce, assumptions as to the likely population structure have to be made. These assumptions are summarised below:

TABLE 4.13

ASSUMED WORKFORCE CHARACTERISTICS

Characteristic	Construction Phase	Operational Phase
Married:Single	50:50	80:20
% Imported	See Table 4.11	72%
Population Multiplier	2.5	3.75
Employment Multiplier	1.15	1.20
Distribution	See Table 4.13	Alternative (1) Kingaroy 0% Nanango 100% Yarraman 0% Alternative (2) Kingaroy 56% Nanango 27% Yarraman 17%

Based on these assumptions and the alternative workforce distributions given in (b) above, the following possible imported population distribution can be deduced.

TABLE 4.14

POSSIBLE IMPORTED POPULATION DISTRIBUTION

MINE ONLY

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Alternative (1)																			
Kingaroy	26	155	194	112		97	97												
Nanango	39	194	327	478	502	733	905	806	922	925	925	925	925	925	925	925	941	895	895
Yarraman	26	57	117	39		39	39												
Blackbutt		37	68	31		24	24												
Others			60																
Alternative (2)																			
Kingaroy	26	155	224	297	282	452	549	452	516	518	518	518	518	518	518	518	526	501	501
Nanango	39	194	288	242	136	270	316	218	249	250	250	250	250	250	250	250	254	242	242
Yarraman	26	53	126	94	85	147	176	137	157	157	157	157	157	157	157	157	160	152	152
Blackbutt		37	68	31		24	24												
Others			60																

It should be noted that this distribution has been estimated merely to indicate the order of magnitude of the population increase due to the coal mine which might be expected in each of the surrounding towns. The actual distribution that will finally result will be a combination of many factors some of which cannot be confidently predicted at this point in time.

Although the above distribution indicates the possible population effects from the mine's construction and operation, it does not reflect the total population impact on each of the towns involved. To do this the population increase due to the power station's construction and operation must also be considered. Estimates of the power station workforce population and distribution have been made by the Tarong Project Advisory Committee. These estimates for the power station workforce and population have been combined with the estimates of the mine's workforce and population given in Table 4.14 to illustrate a likely imported population distribution from the total project (including mine, power station and induced population). Table 4.15 gives a typical distribution for 1984, the peak construction year, and 1992 a typical year during the operational phase.

TABLE 4.15

TYPICAL IMPORTED POPULATION DISTRIBUTION

MINE & POWER STATION

Community	1984 (Construction Phase)	1992 (Operational Phase)
Alternative (1)		
Kingaroy	1187	767
Nanango	1698	1573
Yarraman	590	287
Blackbutt	150	25
Others	87	8
Alternative (2)		
Kingaroy	1217	1285
Nanango	1659	898
Yarraman	599	444
Blackbutt	150	25
Others	87	8

(iii) Population Structure

During the peak of the construction phase in 1984, the total imported population from both the mine and power station could be of the order of 3700 (ref. Table 4.15). The typical family profile of the married construction phase worker is that of a married couple under 35 years of age with one or no children. The imposition of this type of family structure on the existing community will, for the period of the construction phase, significantly alter the orientation of the age/sex structure of the communities from one relatively lacking in the younger population groups to one biased in the other direction.

Once the population has stabilised during the operational phase, approximately 2650 people can be expected to be imported into the region. The age/sex structure of the incoming family unit during this phase is likely to have an older average age and an increased number of children. The addition of this permanent group to the existing population will reduce somewhat the temporary youthful profile expected as a result of the population influx during the construction phase. It is not expected, however, that this youthful bias will be reduced significantly. The end result will be a more rounded population profile than currently exists, with most age/sex groupings relatively well represented but with the overall structure retaining a youthful bias.

4.3.3 HOUSING STRUCTURE

(i) Construction Phase

During the construction phase the Company proposes that all of the construction workforce, with the exception of Company supervision staff, be accommodated in caravans located throughout the surrounding towns (ref. Sub Section 4.3.2(i)). Based on the distribution given in Table 4.11 and on the Advisory Committee's assumptions of the distribution of the power station construction workforce (ref. Sub Section 4.3.2(ii)), the number of caravan spaces required at each of the surrounding towns for both the power station and the mine construction workers can be estimated. For the peak year of 1984 the number of caravan spaces required is given in Table 4.16 below.

TABLE 4.16

REQUIRED CARAVAN SPACES - 1984

Town	Mine	Power Station	Total Required	Total Presently Available
Nanango	105	137	242	116
Kingaroy	75	91	166	111
Yarraman	45	45	90	12
Blackbutt	26	9	35	10
Maidenwell & Others	23	3	26	

It is clear, therefore, that a significant increase in the number of available caravan spaces in all of the towns will be required if the expected demand from the construction workers is to be met. Should sufficient spaces not be available when they are first required, substandard housing conditions will occur as workers set up in unserviced areas. This could lead to significant health and social problems and possible industrial action at the construction sites. However in the early planning stages

are 3 caravan parks for Nanango, 1 for Kingaroy and 1 for Maidenwell which will provide a further 640 sites. Should all of these sites be constructed as planned it is unlikely that significant problems would arise due to shortages of available caravan sites.

It should be noted that the above distribution estimates have been made merely as an indication of one possible level of demand for serviced sites that may be exerted in each of the relevant towns. The actual distribution that will finally result will be a combination of many factors which cannot be confidently predicted at this point in time.

(b) Operation Phase

Housing facilities in the surrounding towns will require substantial upgrading to accommodate the operational workforce and their families. As far as the mine employees are concerned, the Company proposes to undertake the required upgrading by constructing 244 houses. The type of house considered by the Company is similar to that constructed by other mining towns throughout Queensland. These houses are of reasonable quality, timber framed and are constructed in a number of configurations suitable to the Queensland climate. Several styles are contemplated to avoid repetition. For the purposes of classification there would be senior staff houses, 3 bedroom houses and 4 bedroom houses.

The number and timing of house construction is given in Table 4.17.

TABLE 4.17

HOUSE CONSTRUCTION SCHEDULE

House Type	1982	1983	1984	1985	1986	1987	1988	1989
Senior Staff House	-	1	6	8	8	8	10	10
4 Bedroom House	2	6	12	25	35	42	50	59
3 Bedroom House	6	19	38	75	105	128	150	175
Total	8	26	56	108	148	178	210	244

By comparing the total number of houses to be constructed against the expected imported operational workforce given in Table 4.12, it can be clearly seen that no accommodation shortfalls will occur. In fact from 1989 onwards, the full 244 houses may not be required. However this total gives a significant margin of safety should a higher proportion of the workers be married or fewer local residents be available for employment than have been assumed.

In addition to the houses supplied by the Company, it is possible that the Queensland Housing Commission may provide some. The number of houses to be provided will be determined by negotiation between the Company and the Housing Commission.

The Company will endeavour to mix the new houses as far as practicable, into existing residential areas, depending on the cost and availability of suitable building allotments. This will ensure that as far as possible, the mine employees will be integrated into the existing community rather than be imposed as a physically separate and possibly conflicting social group upon the existing residents. The opportunity for successful integration will be more readily available if distribution Alternative (2) is selected and the workforce is spread throughout the 3 towns of Kingaroy, Nanango and Yarraman, rather than concentrating them all in Nanango as is the case for Alternative (1).

The standard of housing to be provided has a significant bearing upon labour force stability. Past experience in other mining projects suggests that good housing standards head the list of worker preferences in this type of industrial operation. Thus to ensure that the more stable married worker is attracted and retained, it is important that good housing standards are maintained.

As discussed in Sub Section 4.3.2 (c), the mine workforce has been assumed to generate an induced employment multiplier of 1.2. Based on this assumption, during the operational phase an induced workforce of 48 can be expected to be required to cater for the demand for goods and services which the incoming population is likely to exert. New housing will be required for some of this workforce. It is anticipated that in response to this additional housing demand, private enterprise will construct the necessary facilities. If however this sector does not meet the demand or if there is some delay in construction so that houses are not available when required, some accommodation problems could arise.

In addition to the housing demand from the mine employees, permanent accommodation will be required in Nanango, Kingaroy and Yarraman for the power station workforce. The responsibility for this rests with Q.E.G.B. This incoming population will also generate an induced workforce which will have to compete in what is likely to be an overextended market for house construction or other permanent accommodation.

4.3.4 ECONOMIC IMPACTS

(i) Construction Phase

The total construction costs of the project has been estimated at $154 million. Table 4.18 indicates the proportion of construction costs to be spent in the various areas.

TABLE 4.18

CONSTRUCTION EXPENDITURE BY AREA

Area	Amount ($ million)	Per Cent
Wide Bay-Burnett	39	25%
Queensland (inc. W.B.B.)	89	58%
Australia (inc. Qld. & W.B.B.)	136	88%
Overseas	18	12%

As shown in Table 4.11 the construction workforce is expected to peak in 1984 at 440 persons. Assuming wage payments of approximately $20,000 per worker (1979 dollars) or $8.8 million, and assuming that construction expenditure in that year is in the proportion shown in Table 4.18, the impact of the construction phase on the economies of Wide Bay-Burnett, Queensland and Australia can be estimated from the multipliers shown in Table 3.8. Results of this analysis are given in Table 4.19. The output effect is a measure of the total industrial output generated by the project. The income effect is the total increase in wages and salaries within each of the relevant areas. The employment effect measures the total number of jobs, both direct and indirect to be generated by the project.

TABLE 4.19

MULTIPLIER EFFECTS OF THE CONSTRUCTION PHASE

	Wide Bay-Burnett	Queensland	Australia
Income Impact ($ million)	11.8	14.5	16.5
Employment Impact (jobs)	590	744	827
Output impact ($ million)	17	51	90

(ii) Operation Phase

In estimating the impact of the operational phase of the project, multipliers for the coal mining sector as given in Table 3.8 have been used. The analysis in this section relates to the year 1990, when the mine will be operating at full capacity of 4.9 million tonnes per annum.

In 1990 the operating labour force of the mine will be 334 persons (ref. Table 2.3), with a total wages bill of $6 million assuming wages and salaries of $18,000 per worker. The total impact of the Tarong mine on the economies of Wide Bay-Burnett, Queensland and Australia is indicated in Table 4.20. The

employment effects of the project are estimated at 1076 jobs in all three economies.

TABLE 4.20

MULTIPLIER EFFECTS OF THE OPERATING PHASE

	Wide Bay-Burnett	Queensland	Australia
Income impact ($ million)	9.8	13.2	13.2
Employment impact (jobs)	1076	1076	1076

(iii) Interpretation of Results

There are a number of factors that need to be considered when interpreting the impact results. These factors are discussed below. Most important though is the point that given the nature of the assumptions inherent in the analysis, the economic impacts indicated in Tables 4.19 and 4.20 should be interpreted as order of magnitude indications rather than precise predictions.

The years which the input-output table are based on have considerable implications for the interpretation of the results. The further are projects into the future, the less reliable are the results obtained. On these grounds the construction phase impacts indicated will be more reliable than the operating phase effects. In addition, since the Wide Bay-Burnett and Queensland multipliers pertain to 1973-74 and those for Australia pertain to 1968-69 (ref. Sub Section 3.3.8), we should expect that the employment multipliers calculated from these tables will tend to overestimate employment impacts pertaining to the 1980's and beyond. That is, all industries are becoming more capital intensive, with labour productivity increasing over time, and these dated employment multipliers will tend to overestimate employment effects.

Comparing the effects, it can be seen that the construction phase of the project will have a lesser employment input than the operating phase. Construction effects by their very nature are short run, and the lasting effect of the project will be during the operating phase as the Tarong mine assumes an operating pattern within the economy.

Generally speaking, as the size of the economy considered increases, the multiplier effects also increase. Larger areas exhibit greater inter-industry linkages as firms are able to obtain more of their input requirements from within the area. However, for coal mining, the national sector includes a substantial proportion of underground mining while coal mining in Queensland is mainly by open-cut methods. In

this instance the state employment and income multipliers will give a more reliable indication of the national effects than the multiplier from the national table. The regional employment multiplier for coal mining is also considered to provide a better estimate of State and National impacts than are the State and National multipliers. Consequently, the regional employment figure given in Table 4.20 is used also for the State and the Nation.

While the multiplier effects tend to be greater in an absolute sense as the size of area considered increases, the relative importance of impacts increases as the area considered decreases. The operating phase of the Tarong mine will increase the labour force of Nanango plus Kingaroy Shires by 24%, while the total increase to Wide Bay-Burnett regional employment will amount to 2.2%. When Queensland as a whole is considered, the operating phase of the mine will result in a total increase to the State employment of 0.15%. The economic structure of the local area and region will change dramatically, with mining assuming a much greater importance than that indicated in Table C.7 of Appendix C.

The existing inter-regional trade flows in Queensland indicate that most of the multiplier effects occurring in Queensland outside Wide Bay-Burnett will accrue to the Moreton region. This point is reinforced by the fact that the Tarong area borders the Moreton region. However, for the same reason, one would expect some effects to accrue to the Darling Downs region also.

The sub-regional patterns that will be established in response to demands arising from the mine's establishment and operation will substantially increase local trade turnover. It is estimated that during the project's operational phase, some 65% of the disposable household income is likely to be spent locally. This is expected to amount to approximately $3 million annually (based on present day wage rates and tax scales).

It should be noted that this analysis only considers 'backward linkages', i.e. impacts resulting from labour and other inputs to the mine itself. When 'forward linkages' are considered the mine will play a key indirect role in the future employment potential of the State. This will occur via the Tarong power station, as the electricity infrastructure will be made available to enable the State to continue to provide an attractive location for further large scale industrial developments.

4.3.5 SOCIAL INFRASTRUCTURAL FACILITIES

The population increase caused by the mine and power station projects will cause a significant increase in the demand for commercial and community facilities as well as government services such as educational and health facilities. In Nanango and Yarraman the level of service offered by the existing facilities is adequate for the current populations. However, the population increase resulting from the project will necessitate the expansion of some services and probably the establishment of new ones which could not be adequately supported by the area's present population base.

Kingaroy, on the other hand, has a comparatively high level of commercial and community facilities which is likely to be able to cater more readily for the demands of the incoming population. Nevertheless expansion of some of Kingaroy's facilities will inevitably result particularly as it will act as the regional centre for the other towns.

As many of the facilities required will be used to their maximum early in the operation (i.e. during the construction phase of the project) it is important that planning for the establishment of these facilities, as well as their construction, takes place in advance of the commencement of the project.

Deficiencies in the provision of such facilities will serve to aggravate some of the sociological problems which can accompany the imposition of one community-type upon another. The sociological adjustment process can be greatly helped and encouraged through the provision of cultural and recreational facilities, for example, the establishment of halls, clubs etc. where people can meet informally or in organised group activities assists in moving towards community integration. The basic aim here is the fulfilment of psychological needs, and to this end the provision of an adequate range of cultural and recreational facilities can play a major role. The lack of such facilities can lead to discontentment and eventually to higher rates of labour turnover.

(i) Community Facilities

The existing range of social and cultural clubs will need to be expanded to meet likely demands. This, however, should automatically occur with the influx of population if sufficient help and encouragement in terms of financial and material assistance if forthcoming at the Company level. It is anticipated that no problems or deficiencies should occur if the population can be sufficiently motivated, and if the necessary level of Company support is available.

It is probable that existing meeting places within the communities will need expansion to cater for the requirements of such clubs.

(ii) Commercial Facilities

The existing commercial facilities in Nanango and Yarraman cover the basic day-to-day convenience needs of their respective comm-

unities. An increase in the population of the two towns will generate a greater level of business activity than currently exists. The extent to which this increased business activity will generate a range of new businesses and services within these towns is difficult to assess, as no estimate is available as to their current levels of utilisation. It is probable that most existing businesses could greatly increase their trading capacity without needing to undergo physical expansion. However, in terms of comparison shopping goods (e.g. clothing and furniture) it is expected that several new establishments may be generated.

No major industrial undertakings are envisaged in association with either the mine or the power station. Expansion in this sector is expected to be limited to the maintenance and repair of machinery and equipment, the servicing of vehicles, and light engineering works.

Kingaroy is expected to serve as the major regional centre for the project population. Consequently increased commercial activity is likely not only from the population which settles in the town but also from the population which settles in Yarraman and Nanango. Kingaroy offers a higher level of comparison shopping than either of the other towns and it is likely that the imported pppulation would undertake regular shopping trips to Kingaroy.

(iii) Educational Facilities

Distribution of the combined mine and power station workforce between the towns of Kingaroy, Nanango and Yarraman will require the expansion of existing educational facilities and an increase in the need for teacher accommodation. Both of these are the responsibility of the Education Department. Based on the population assumptions given in Table 4.15 the expected number of incoming children in 1984 and 1992 have been deduced in Table 4.21. This table also allows for children of induced workers. It is expected that the age distribution of the children will be weighted heavily in favour of pre-school children, particularly for construction workers' families. Thus the heaviest demand particularly in the initial years of the project is seen to be for pre-school and primary facilities.

TABLE 4.21

ESTIMATED NUMBER OF INCOMING CHILDREN

Year	Mine		Power Station		Induced	Total
	Construction	Operation	Construction	Operation		
Peak Year 1984	94	20	228	152	74	568
Average Year 1992	-	337	-	410	112	859

Additional facilities in Nanango will need to be provided by expanding the existing pre-school and by building a separate high school, allowing the present secondary department attached to the primary school to be utilized for primary students. In Kingaroy and Yarraman existing institutions would need to be upgraded and expanded where required. As any increase in the number of enrolments at Nanango would necessitate the building of a new State High School, the Education Department has indicated that it would prefer to concentrate its expenditure in this town. It is recommended that the Education Department be given sufficient advance warning of a decision to locate the workforce to allow allocation of finance and building of the required facilities.

(iv) Health Facilities

The existing hospital at Nanango has a 44 bed capacity but at the moment has an occupancy rate of only 31%. Consequently the town's population could increase significantly before expansion of the existing hospital facilities would be required. Similarly Kingaroy's hospital with a current occupancy of 41% could accommodate a significant increase in patients before expansion would be necessary.

Depending on the final population distribution, the number of doctors in private practice in both Nanango and Yarraman (and possibly Kingaroy) will have to increase. Similarly some increase in dental facilities will be necessary. It is probable that a first-aid centre will be established on the project site and that this will be staffed by the Yarraman Q.A.T.B. This Q.A.T.B. centre will consequently require additional personnel.

(v) Police

The Tarong Project Advisory Committee has indicated that the Police Department estimates that, if supervision of construction workforce accommodation centres (camps or caravan parks) is equivalent to that exercised over camps established at Wivenhoe and Split-Yard Creek Dams, existing police staff should be adequate to meet the needs of the additional population. It may be necessary to provide an extra officer at Nanango and, if so, an officer will be transferred from Kingaroy.

(vi) Recreational Facilities

Virtually all of the commonly played sports have facilities in Kingaroy and Nanango while Yarraman has the basic facilities of football/cricket, tennis, basketball and lawn bowls. The number and standard of facilities at both Yarraman and Nanango will need to be increased significantly to cater for the incoming population. Kingaroy, too, may need upgrading of some of its recreational facilities. The level adopted for the provision of recreational facilities will have a bearing upon the eventual community structure in each of the small towns and their relative attractiveness to the potential new resident and his family.

On the regional scale, the Bunya Mountains National Park and to a limited extent the surrounding State Forests will be able to cater for many of the passive recreational demands of the increased population. It is likely that this increased population will generate additional demand for the dedication of the proposed National Park to the west of the minesite.

4.3.6 CHANGES IN SOCIAL STRUCTURE

The existing social structures of Nanango, Yarraman and the Tarong District, will be affected by the rapid increases in population and the changing employment structure accompanying the proposed development. Social tensions arising from conflicts due to different ideas, attitudes and lifestyles of the incoming population and strains of existing community facilities will inevitably result. The level of social tension which will eventuate will depend upon the extent social integration is encouraged in the community, and the degree of social facilities provided.

Social tensions on the part of the existing population are likely to be generated by the wage differentials between workers on the project and those employed elsewhere, the increased pressures upon existing urban services, and more particularly from the different lifestyles and attitudes of the incoming population. The existing quiet and relatively tranquil life of the community will be disrupted. Persons, especially those who have lived in the community for a larger part of their lives, will tend to resent the intrusion of the migratory population upon their way of life and the changes in community attitudes it embodies.

The social adjustment problems confronting the newcomer to the community are essentially related to the ease with which one can be assimilated into the community, and to the way in which the community can assist in fulfilling one's basic psychological needs. These needs - self esteem and self identification, a rewarding family life, a network of social relationships outside the house, political participation and identification with place - are usually much more difficult to realise in the smaller urban community.

Social integration will finally rest with both the existing community and the incoming population. Opportunities for integration can however be fostered to some degree by an efficient community public relations and news system, by the establishment or support of clubs and community groups which lead to personal contact and communication, and the involvement of the induced population in the daily affairs of the town. The importance of social infrastructural facilities in this regard should also be kept in mind, (ref. Sub Section 4.3.5).

Besidesthe adjustment problems discussed above, the mixing of the two population groups can assist in the establishment of a more diversified community, with a greater range of social interests and opportunities. For example, past experience has shown that permanent executive staff (in particular) rapidly adapt to the lifestyles of their new communities and often assume leading roles in community activities. Their experience in leadership and management techniques often leads to an enrichment of local community life. Similarly, the women seem capable of rapid absorption into local groups and the exchange of new ideas enables women's groups to become more active, and more socially rewarding.

On large construction projects such as this, problems do sometimes arise due to the high number of single workers engaged on the project, particularly during the construction phase. However the Company's policy of mixing the single population along with the married population within the general communities of the surrounding towns, should significantly lessen the potential for social conflict in this regard. It is generally recognised that significant benefit can be obtained by both the individual worker and the community when workers have relief from their working environment during their leisure hours.

4.3.7 LAND USE

The acquisition of land for the proposed mine will result in a change in land use from pastoral production to extractive industry. The area of land likely to be disturbed by mining is of the order of 1500 ha. Based on the land's existing average carrying capacity of 5 hectares per beast, this would represent a theoretical potential loss of 300 head of cattle. At the sub regional level the effect will not be excessive because the area of land involved is comparatively small and pastoral farming in the area is quite extensive. In addition, the displacement of cattle is expected to be only temporary to a degree, as the land disturbed by mining is to be progressively rehabilitated and returned to a state which will permit pastoral activities once the open cut mining is complete.

Although part of the lease application area covers part of State Forest 289, no disruption of the existing land use of the forest will occur. The forest land does contain significant quantities of deeply seated coal, but it is not intended to exploit any of these reserves within the initial design life of the mine. Should future conditions warrant mining in this area, it is likely that it would be underground mining rather than open cut.

Six of the lots which the Company has acquired or proposes to acquire for surface mining rights are currently permanently occupied (Portions 3, 72, 108, 111, 133 and 161). Commencement of mining operations will necessitate the eventual displacement of these landholders (except for Portion 161) as mining progresses. Two other portions (69 and 107) are occupied occasionally, but surface mining rights are only required for Portion 107. One other portion which is permanently occupied (106) will not be acquired and no significant disruption to existing land uses will occur.

4.3.8 LAND TENURE

The Company has acquired or proposes to acquire surface mining rights over all of the land within the proposed mining lease area with the exception of the following: S.F. 289, Portions 62, 69, 70, 106 and 114. It proposes to acquire all of Portion 3 ("Oakvale") including that part which is outside the mining lease application boundary. Two small Reserves (R573 and R456) have been rescinded and are now vacant crown land.

The land tenure arrangements for the housing of the mine workforce is yet to be determined. As discussed in Sub Section 4.3.2, the Company is considering either constructing the necessary houses itself and renting them to the employees or alternatively have employees purchase the houses themselves. Until it is known which alternative is to be adopted, the land tenure implications for the surrounding communities cannot be fully gauged.

4.3.9 TOWN PLANNING IMPLICATIONS

As discussed in Sub Section 3.3.4, the Shire of Nanango is currently preparing a Statutory Town Planning Scheme for the whole of the Shire. As the proposed open cut mining area is proposed to be zoned as Extractive Industry, no conflict with the proposed Plan will be occasioned by the mine development. Further, recent amendments to the Mining Act provide for mining as an "of right" use in the area of a mining lease, irrespective of the zone under any Town Planning Scheme.

The proposed Plan should cater for the expected population increase which will occur as a result of the project. Sufficient land in Nanango should be zoned for urban purposes to ensure that delays in accommodating the influx in population will be minimised. It is envisaged that with the establishment of town planning control, the problems and costs associated with unco-ordinated and haphazard development will be minimised.

In addition to Nanango, Kingaroy should also examine its Town Plan in the light of its expected population increase to ensure that sufficient land is available for urban purposes when it is required. To a lesser extent, the Rosalie Shire Council should ensure that adequate urban land is available in Yarraman to cater for the likely population increase. No Town Planning Scheme presently exists for Yarraman and development control is exercised through Council's subdivision by law. It is suggested the Rosalie Shire Council considers implementing a Town Planning Scheme for this area to ensure that unco-ordinated and inefficient development does not occur and that Council's infrastructure and maintenance costs are minimised.

4.3.10 TRANSPORTATION

(i) Road

(a) Minesite

It is likely that establishment of the mining operation will require the closure of almost all roads which currently run through the proposed mining lease area. However it is unlikely that the Cooyar Range road which runs north-south along the eastern side of the mining areas will need to be closed as no open pit areas cross it. In this way access to those properties over which the Company does not propose to obtain surface mining rights (ref. Sub Section 4.3.8) will be maintained.

All of the roads which are to be closed are secondary Shire roads and have been constructed only to serve the local landholders and carry negligible volumes of through traffic. As all of those landholders whose access will be eliminated by the road closures will be relocated out of the proposed lease area, no significant impacts are likely to occur from the road closure. Furthermore as major north-south through -roads pass both east and west of the proposed lease area, no serious interruptions to through traffic will occur.

A system of haul roads will be constructed throughout the lease area as described in Sub Section 2.4.3. The main spine haul road will in general follow an alignment similar to that of the main north/south road which currently runs through the area. It is inevitable that coal fines will be spilt on the haul roads during trucking operations. Regular road watering should be maintained to reduce dust emissions from the truck movements.

The particles of spilt coal, together with rubber from tyres and various greases and exhaust emissions, will give rise to a polluted runoff in time of storm flows from the roadway. It is important that haul road drainage not be channelled directly to natural water courses. Runoff should first be fanned out over suitably flat and grassy areas to reduce the water velocity and remove coal particles from suspension before discharge to streams is permitted (ref. Sub Section 4.2.2).

(b) Surrounding Road Network

To obtain an overview of the impact that the project's development might have on the surrounding road network, it is necessary to make some prediction of the amounts of traffic generated on these roads.

Because of the close association between the mine development and operation and the power station development and operation, it is essential that in assessing the impact on the road network, the increase in road traffic from both the power station and mine are noted.

In order to assess the effect of worker traffic travelling to and from the site, the construction and operational workforce figures given in Sub Section 4.3.2 have been analysed. This analysis was undertaken for the peak year of 1984 when the maximum number of workers will be travelling to the site. During this year the construction workers will be working one shift per day only. During the operational phase the transportation effects given below will be in excess of those expected, because the workers will be operating three shifts per day and peak traffic volumes will be spread throughout the day.

To estimate the likely increase in traffic arising from the influx of population into the region, the following assumptions have been made:

(i) The mining construction and operation phases are based on a single day shift.

(ii) The power station construction is based on a single day shift while operation is based on a 3 shift system.

(iii) One third of the mine operations workforce travel each day in a bus service provided by the Company.

(iv) A change of shift at the power station occurs in the morning when mine workers are arriving for their day work.

(v) Average workforce car occupancy is 2.1 workers.

(vi) Other trips from the surrounding towns are generated in patterns similar to normal trip making processes in similar rural communities.

For general predictions on the need or otherwise of upgrading the local and regional roads, the trip numbers generated were distributed among the various routes linking the major towns and the mine and power station.

Traffic from Kingaroy was assumed to approach the mine and power station via either the Kingaroy/Nanango road or the Kingaroy/Brooklands road. In assigning this traffic to either of these alternative routes, factors were applied relating the traffic directly to the road condition and inversely to the distance.

Traffic from Blackbutt and Yarraman was assumed to approach the mine and power station along either the Yarraman/Nanango/Tarong road or the Yarraman/South Nanango/Meandu Creek road in a proportion determined by similar factors.

The impact that the development may have on the road network can be considered by review of the estimated traffic increases. Based on these increases and the existing condition of the roads likely to be used, recommendations for upgrading the network links can be made. These have been summarised in Table 4.22.

Of the roads affected by the mine and power station developments, the link between the development site and Nanango will undoubtedly receive the heaviest traffic volumes and will necessitate the greatest amount of upgrading. The existing 3.7 metre pavement width should be widened to at least a 7 metre seal. Vertical re-alignment and upgrading to these standards is currently being carried out and with upgrading of one minor bridge crossing at Meandu Creek, a satisfactory standard should be achieved.

While the D'Aguilar Highway between Blackbutt and Kingaroy may receive increased traffic loadings of up to 100% of the existing use, the standard of road is such that it should be able to accommodate these increases without major upgrading works. The two stream crossings over Barker Creek just north of Nanango are currently being upgraded and with these a high quality link should be provided between Yarraman and Kingaroy. The link between Nanango and Yarraman, while being of adequate standard to provide a reliable service to the expected traffic increase, does contain some relatively high grades just north of Yarraman and a relatively narrow timber bridge south of Nanango which should be upgraded in the future.

Some minor vertical and horizontal re-alignment could be carried out on the section between Blackbutt and Yarraman and road widening by sealing shoulders and maintaining potholing in a few trouble spots could improve the standard of this section. However, in view of the small increase in traffic over the link this upgrading is probably not essential.

TABLE 4.22

ESTIMATED ROAD NETWORK IMPACTS

(Peak Year 1984)

Road Section	Link	Existing AADT[1]	Estimated % Peak Increase in use over Existing Morning Peak Period		Recommended Upgrading
40C D'Aguilar Highway	(i) Blackbutt-Yarraman	N.A.[2]	40[3]	(100)[4]	Minor upgrading necessary
	(ii) Yarraman-South Nanango	1036	25	(75)	No upgrading necessary
	(iii) Kingaroy-Nanango	N.A.	10	(70)	No upgrading necessary
South Nanango - Meandu Creek	(i) South Nanango-Meandu Creek	50	700	(3000)	Upgrading necessary
419 Kingaroy/Cooyar	(i) Kingaroy-Goodger	360	45	(170)	Several sections require upgrading
	(ii) Goodger-Brooklands	209	65	(400)	Several sections require upgrading
	(iii) Brooklands-Minesite	18	150	(600)	Upgrading necessary
427 Nanango/Tarong	(i) Nanango-Meandu Creek	234	300	(1000)	Upgrading necessary
	(ii) Meandu Creek-Site	126	400	(1400)	Upgrading necessary
	(iii) Maidenwell-Mine Site	137	100	(120)	Minor upgrading necessary
4191 Nanango-Brooklands	(i) Nanango-Brooklands	128	-	-	No upgrading necessary

1 Annual Average Daily Traffic 1976 Census
2 Not Available
3 40 - % increase over existing traffic due directly to mine workforce traffic
4 (100) - % increase over existing traffic due to both mine and power station workforce traffic

The higher increase in relative use of the link from South Nanango to Meandu Creek is due to the fact that the road is currently used merely as a local access road and therefore carries little through traffic. The increase of 700% in morning peak traffic indicates that approximately 85% of the workforce living at both Yarraman and Blackbutt may elect to cut across to the mine site from South Nanango, thus saving the additional 9 kilometres of high class but unnecessary travelling distance via the D'Aguilar Highway.

While this increase in traffic accounts for only a relatively small percentage of the total minesite workforce, the use made of the road will warrant its upgrading to at least a 7 metre pavement, sealed over the entire length.

The link between Kingaroy and the development sites via Goodger and Brooklands contains several sections of badly potholed and/or unpaved surfaces. It is likely that an increase in traffic volumes on this link will occur as it has a shorter travelling distance and more direct route to the site than the D'Aguilar Highway via Nanango. Hence the road should be fully sealed over its length. While the vertical alignment is generally adequate, horizontal alignment on several curves requires some modification but can probably be accommodated within the existing road reserves.

(ii) Rail

With no coal being transported out of the region (the power station being the only consumer) the rail line will not be extended from either Kingaroy or Yarraman to the mine site. The current use of the rail system is mainly for goods movements with some passenger transport from Kingaroy northwards and Toogoolowah southwards. It is expected that heavier use of the rail will be made for goods inflow to the major towns but both goods and passenger movements out from the region are unlikely to increase significantly.

Overall, impact on the rail system therefore should only be slight and could probably be accommodated by extra wagons per shuttle rather than the requirement of an extra service.

4.3.11 INFRASTRUCTURE AND PUBLIC UTILITIES

(i) Mine Site

(a) Roadworks and Drainage

All existing local roads covering the proposed lease area will be closed, prohibiting public entry (ref. Sub Section 4.3.10). A system of haul roads will be constructed for the transport of coal from the pits to the plant area.

Drainage from these roads will be by the existing system of earth formed table drains. During times of wet weather, it could be expected that a higher proportion of oil, grease and dust contaminated runoff than is currently produced, will enter the creek system from these roads. Coal dust from the haul roads will also provide a larger source of contamination of road runoff. It is recommended in Sub Section 4.2.2 that road runoff velocity be reduced to allow the coal to settle out before discharge is permitted to local streams.

(b) Water Supply

The mine's permanent water supply will be obtained directly from the power station. This should have no significant impacts over and above those which will occur if the water supply is to be used for the power station only.

During the construction phase it is possible that water supplies will be obtained from underground sources. Care must be taken to ensure that the aquifer's recharge rate is not exceeded by the withdrawal rate otherwise depletion of the resource and loss of water supply to the surrounding users could result.

(c) Waste Disposal

Sewage

It is proposed to establish either septic tanks or a package treatment plant for treatment of sewage generated in the plant area from shower blocks, dining areas, toilets etc. Effluent will be discharged to Meandu Creek.

The standard of effluent released directly into, or migrating into the local creeks should be at most 20 mg/ℓ BOD and 30 mg/ℓ Suspended Solids. In any case contact should be made with the Water Quality Control Council for recommendation of effluent standards to be attained.

During dry periods (approximately 50% of the year) Meandu Creek will have no flow. The stream will most likely consist of a series of wet areas and isolated waterholes. During this time most of the effluent from either the package plant or the septic tanks would accumulate in the waterholes immediately downstream of the discharge point. Although treated, this effluent will be comparatively high in nutrient levels and may pose problems to downstream users. It is recommended that the effluent be disposed of by land spreading before reaching the creek system to reduce the nutrient loads. Alternatively the effluent could be dis-

charged to a shallow lagoon with sufficient freeboard to ensure that discharge occurs only in wet weather when sufficient dilution will be available in the creek.

Coarse Solids

Solid wastes from the mining operations will include reject material from the breaker station, wash plant and preparation areas. This material is to be stockpiled and subsequently disposed of as filling in worked mine pits. It is not anticipated that this would cause any serious impact, but if the reject material is left lying on the surface for any length of time before disposal, leachate and storm runoff passing through it could cause some problems. Adequate drainage should be provided around these heaps to divert surface water away from them.

Fine Solids

Tailings from the wash plant will be disposed of in the tailings dams in local depressions draining into Meandu Creek. Impoundment of the tailings in the dams will provide a significant impact on the local area. All flora and fauna habitats in these areas will be destroyed. Adequate measures should be taken to ensure that leachate from the dams does not migrate to Meandu Creek. Diversion channels will need to be constructed around the dam and a thorough maintenance programme established to ensure a successful operation of the system.

Supernatent liquid from the tailings will be returned to the wash plant thus reducing the large amounts of water required in coal preparation.

When the tailings dam is full, adequate measures must be taken to ensure that pollution of the natural water system from dam runoff is avoided. In addition access to the dam surface must be prohibited. The Queensland Mines Department has indicated that generally it prefers that the dam is not covered with overburden and soil for this purpose.

Pit Drainage

Stormwater runoff and groundwater which drains into the mine pit could be acidic. If so it should be pumped to suitably located evaporation basins. A detailed description of the recommended treatment for pit drainage is given in Sub Section 4.2.2.

Volatile Oils

As well as the solid rejects, a number of volatile oils would be periodically rejected from processes within the plant and machinery on site. These would include lubricating and hydraulic oils. While most Queensland coal mines re-use these volatiles as much as possible or dispose of them by spreading on roads, in some cases incineration is used.

Because of the proximity of the towns of Nanango and Yarraman, it is recommended that burning as a disposal method is not used unless favourable wind conditions exist. In such cases incineration must be under conditions which comply with all Clean Air Regulations.

(ii) Nanango

Based on the 1976 Census, Nanango has a population of 1111 persons. The possible impacts to the town's infrastructure facilities can be identified by reviewing the spare capacity available in these utilities.

Table 4.23 gives this spare capacity currently existing in the infrastructure of Nanango.

TABLE 4.23

INFRASTRUCTURE CAPACITY - NANANGO

Public Utility	Existing Design Population	Existing Spare Capacity
(a) Vacant Homesites		640 vacant 120 fully serviced
(b) Caravan Sites	112 with power	Additional 500 planned
(c) Water Supply	2000 ep*	800 ep
(d) Sewerage		
(a) Reticulation	3000 ep	1800 ep
(b) Treatment Works	1600 ep	400 ep
(e) Roadworks & Drainage	sealed kerb to kerb with drainage - partially complete	
(f) Telecommunications	manual	proposed for upgrading to a 600 line automatic in 1981-1982

* ep: equivalent population

Reviewing the table, it is evident that if an equivalent 400 population are located in the town, existing services will need to be extended to presently unserviced vacant homesites and augmentation will be required to the sewerage treatment works in the town. Thus it could be assumed then that the upper limit of population of the town before major upgrading of public utilities was required would be 1500.

From Table 4.14 it can be seen that the peak of the construction phase of the mining project is expected to increase Nanango's population by between 288 (Alternative 2) or 327 (Alternative 1). This is expected to create a demand for 105 caravan sites in the town in the peak construction year of 1984. This number could be accommodated on the presently existing sites but with the additional demand caused by the power station construction workforce plus other general use, a significant increase in the number of sites will be required (ref. Sub Section 4.3.3 (i)).

The additional mine construction workforce population will take up all of the spare capacity of the sewage treatment plant. However the total population influx from both mine and power station in the peak construction year of 1984 could be from 1659 (Alternative 2) to 1698 (Alternative 1) (ref. Table 4.15). This population will require significant increases in water supply and sewage treatment capacity.

From Table 4.15 it can be seen that the estimated operational population in the typical production year of 1992 could vary from 898 (Alternative 2) to 1573 (Alternative 1). Assuming all of the necessary infrastructure augmentations were carried out during the construction phase, then to accommodate the maximum operational workforce the only further infrastructure work required would be the extension of services to vacant allotments, including roadworks and drainage. Should Alternative 2 be adopted, much of the newly developed infrastructive capacity for the construction phase will not be required during the operation phase.

(iii) Kingaroy

The current population of Kingaroy is 5088 and it is expected that despite the additional travelling distance to the minesite from this town over that from Nanango, Kingaroy will attract at least part of the population generated by the project because of its high service level.

Examination ofmajor public utilities, as shown in Table 4.24, gives an indication of the ability of the town's infrastructure to cope with an influx of population.

TABLE 4.24

INFRASTRUCTURE CAPACITY - KINGAROY

Public Utility	Existing Design Population	Existing Spare Capacity
(a) Vacant Homesites		408 vacant 235 fully serviced
(b) Caravan Sites	111 (81 powered)	additional 90 planned
(c) Water Supply	10,000 ep	4900
(d) Sewerage	7,200 ep	2100
(e) Roadworks & Drainage	Most residential streets paved, kerbed & underground drainage	
(f) Telecom	automatic exchange operational	

This table indicates that the most significant impact to the town's infrastructure will occur when the available fully-serviced homesites have been occupied. There appear to be no constraints to either water treatment and supply or sewerage reticulation and treatment as there is ample spare capacity in the existing systems and each has been designed for and is capable of simple augmentation.

From Table 4.14 it can be seen that the peak of the construction phase of the mining project is expected to increase Kingaroy's population by between 194 (Alternative 1) and 224 (Alternative 2). This is expected to create a demand for approximately 75 caravan sites in the town in the peak construction year of 1984. This number could be accommodated on the presently existing sites, but with the additional demand caused by the power station construction workforce together with other general use, a significant increase in the number of sites will be required (ref. Sub Section 4.3.3 (i)). It is expected that this demand will be substantially met by a proposed new development of 90 sites.

The total project construction population from both the mine and power station could vary from 1187 (Alternative 1) to 1217 (Alternative 2) (ref. Table 4.15). Based on these figures no augmentation of existing infrastructure services will be required apart from the above-mentioned increase required in caravan sites.

From Table 4.15 it can be seen that the estimated operational population in the typical production year of 1992 could vary from 767 (Alternative 1) to 1285 (Alternative 2). With Alternative 1, no mine workforce will be accommodated in Kingaroy. With the Alternative 1 population no increase in infrastructure services will be required. With Alternative 2 the only increase required will be an extension of services to some of the currently unserviced vacant blocks. No major augmentation of utilities would be necessary.

(iv) Yarraman

Yarraman currently has a population of approximately 600 people and has been fairly stable at this level for a number of years.

The current prediction is that due to the "direct-line" proximity of Yarraman to the mine site and because of the small scale rural community atmosphere of the town, a proportion of the development's generated population will want to locate in this centre. The ability of Yarraman's infrastructure to cope with an influx of people can be estimated from Table 4.25.

TABLE 4.25

INFRASTRUCTURE CAPACITY - YARRAMAN

Public Utility	Existing Design Population	Existing Spare Capacity
(a) Vacant Homesites		85 fully serviced
(b) Caravan Sites	12 unpowered sites	
(c) Water Supply	850 ep	250 ep
(d) Sewerage	800 ep	200 ep
(e) Roadworks & Drainage	all residential streets sealed K & C approximately 80% complete	
(f) Telecom	manual system currently operating	

This table indicates that while serviced vacant homesites will caterfor an additional population in excess of 300, the spare capacity in the present sewerage system will only caterfor 200 additional persons before substantial upgrading of the treatment plant needs to be undertaken. Water supply augmentation will be required with an additional 250 persons.

For the purposes of comparison then, an upper limit of population in the town before additional works are required, could be taken as 800 people.

From Table 4.14 it can be seen that the peak of the construction phase of the mining project is expected to increase Yarraman's population by between 117 (Alternative 1) and 126 (Alternative 2). This is expected to create a demand for approximately 45 caravan sites in the town in the peak construction year of 1984. The number of available caravan sites will have to be increased significantly in order to meet this demand. A further increase will be required to meet the demand likely to be exerted by the power station construction workforce.

The total project construction population from both the mine and the power station could vary from 590 (Alternative 1) to 599 (Alternative 2) (ref. Table 4.15). Based on these figures extensive augmentation of both water supply and sewerage facilities will be required.

From Table 4.15 it can be seen that the estimated operational workforce in the typical production year of 1992 could vary from 287 (Alternative 1) to 444 (Alternative 2). With Alternative 1 no mine workforce will be accommodated in Yarraman. Assuming all of the necessary infrastructure augmentations were carried out in the construction phase, then to accommodate the Alternative 1 operational workforce no further work would be required. For the Alternative 2 population all that will be required will be the creation of some additional serviced blocks.

(v) Blackbutt

Blackbutt's population is approximately 420, and it is considered likely that a portion of the mine generated population will locate in this town because of its closer location to Brisbane compared with the other major centres discussed previously. Blackbutt is some 15 kilometres closer to Brisbane than Yarraman and is provided with a passenger bus service. This, together with the appearance and nature of the town, will make it attractive to some of the population.

The ability of the town's infrastructure to cope with the possible influx of people can be illustrated by Table 4.26.

TABLE 4.26

INFRASTRUCTURE CAPACITY - BLACKBUTT

Public Utility	Existing Design Population	Existing Spare Capacity
(a) Vacant Homesites		110 vacant
(b) Caravan Sites	12 unpowered sites	
(c) Water Supply	adequate for existing population	
(d) Sewerage	720 ep	300 ep
(e) Telecom	Manual exchange operates	

This table indicates that with the exception of the water supply, the town could adequately caterfor an additional 300 people.

The water supply for the town currently supplies potable water to both Blackbutt and Benarkin and has some spare capacity but is limited due to a lack of storage at the creek pump out. A study would be required to determine the capacity of this facility before allowing an increase in the population of the town.

It has been estimated(ref. Table 4.14) that the construction phase of the mining operation will increase the population of Blackbutt by approximately 68 people. This is expected to create a demand for 26 caravan sites in the peak construction year of 1984. The number of available caravan sites will have to increase significantly in order to meet this demand. Some additional increase may be required to meet the demand likely to be exerted by the power station construction workforce.

The total project construction population from both the mine and the power station could be of the order of 150. It is likely that given this population increase augmentation of the water supply system will be necessary.

During the operational phase it is not intended that any of the mine workforce be accommodated in Blackbutt. However a small proportion of the power station workforce may locate here. Should this occur the newly augmented water supply system would not be used to full capacity except during the brief period of the construction phase.

(vi) Other Centres

During the peak of the construction phase it is possible that a small number of mine workers may locate in other centres near the site such as Maidenwell or Cooyar. Because of the relatively small number of such people and the short period during which they would want to remain in these centres, it is unlikely that any significant upgrading of public utilities will be necessary, with the possible exception of some additional caravan sites (ref. Table 4.16). However the Advisory Committee has indicated that some of the permanent power station employees may reside in some of the surrounding centres, particularly Maidenwell. If so some permanent increase in infrastructure capacity may be necessary.

(vii) Summary

The foregoing analysis has indicated shortfalls in infrastructure capacities in some towns while other towns have ample room for expansion without requiring augmentation of public utilities. For example, should the population be distributed in accordance with the pattern given in Tables 4.14 and 4.15, then significant infrastructural augmentation will be required in Nanango and Yarraman but not in Kingaroy. Further in some cases excessive augmentation will be required for the construction phase which will not be fully utilised during the operational phase. Based on these implications it may be advisable to reappraise the population distributions so that expenditure on upgrading public utilities which will only be required during the relatively short construction period could be minimised.

4.3.12 NATIONAL ESTATE

(i) Archaeology

As discussed in Sub Section 3.3.3 an archaeological investigation of the proposed lease area has been undertaken by an archaeologist approved by the Department of Aboriginal and Island Affairs (Hill, 1979). This investigation yielded very few lithic artifacts and few indications of past Aboriginal occupation. The investigation report concluded that there appears to be no archaeological objection to mining or other engineering activities in the inspected area.

(ii) National Parks

The proposed National Park (ref. Sub Section 3.3.3) in the area south west of the site will not be directly affected to any significant extent by the proposed mining operation. Some

increase in ambient noise levels throughout the area could be expected. An increased demand for use of the area for recreation is likely to occur as a result of the significant increase in population which will occur as a result of the project.

4.3.13 AESTHETICS

The proposed mining operation will substantially alter the aesthetic character of the minesite and the surrounding area during the lifetime of the mine. This impact will arise from the temporary alteration of the existing landform, the removal of natural vegetation, the creation of overburden spoil heaps and the coal stockpile, and the construction of the preparation plant and facilities.

The initial overburden spoilpile and the coal stockpile will be highly visible due to their height, bulk, and colour which will contrast sharply with the existing landscape. The remaining overburden spoilpiles will in parts be lower than the original surface level due to the large depths of coal which will be removed. The visual deterioration of the landscape created by an open-cut mining programme is unavoidable in the short term. However, progressive rehabilitation and judicious planting of vegetative screens at points where the facility is in direct public view, could substantially lessen this impact. In the long term, once mining has ceased, the disturbed area properly rehabilitated, and all plant dismantled and removed, no significant adverse aesthetic impact should be apparent.

The importance of the visual impact of the proposed mine is directly related to the number of people likely to be affected by it. For example, where large opencuts are readily visible from a well used road or are located relatively close to urban areas, a high level of impact will most likely be perceived. Further the question of visual impact usually is highly emotive and often draws the most vehement of public protests when it is perceived as directly affecting personal lifestyles. Quite often such protests are based on a mis-conception of how mine plants, stockpiles and spoilpiles will tend to dominate the visual outlook of the area, when in fact even the largest structures and dumps rapidly come to subtend a small visual angle as the distance to the observer increases.

The major road which is closest to the minesite is the Cooyar-Nanango Road (via Maidenwell). However at its closest point the road will be over 2 km from the nearest mining area, and views of the mine from the road will be very limited due to the presence of an intervening ridge. Significant views of the minesite will be obtained from the Cooyar Range road which runs along the ridge to the east of the mining areas which forms the western boundary of State Forest 289. However little use is made of this road apart from local access and hence the significance of this visual effect is not considered as serious. No views of the mine will be obtained from either the D'Aguilar or New England Highways.

Within the preparation plant area scrap yards will need to be established for derelict and obsolete equipment. Such waste material dumps should be planned so that they are shielded from obvious vantage points by vegetation screens. In addition the height of stockpiles and overburden heaps should be kept to a minimum to aid in reducing visual impact. Cladding materials used in the plant construction should be selected so as to blend in with the surrounding environment as much as is possible.

SECTION 5

Summary of Environmental Consequences

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5.0 SUMMARY OF ENVIRONMENTAL CONSEQUENCES

5.1 GENERAL

This section of the report summarises the significant environmental consequences that are anticipated as a result of the implementation of the proposed project. Essentially the salient aspects of the previous section have been considered and divided into beneficial and detrimental impacts. Following this is a summary of construction and operating procedures aimed at minimising environmental effects, and then a comment, in general terms, on the requirements of the relevant Government and Semi-Government Authorities.

5.2 MAIN BENEFICIAL IMPACTS

At the State level significant impacts will accrue to the Q.E.G.B. in having a reliable, close-by and thus cheap supply of coal being developed specifically for their power station operation. Costs and delays in long distance coal transportation will consequently be eliminated. In addition the project will serve to reinforce the State's policy of decentralisation of industry and population through the building up of existing "natural" centres rather than through the creation of "artificial" ones.

Significant fiscal contributions will accrue to all levels of Government. The Australian Government will receive additional company tax and personal income tax payments. The Queensland Government will receive royalties, lease rental and infrastructure costs, and the relevant Local Authorities will receive increased rates as well as Company contributions to housing and community facilities.

The proposed project will broaden the economic base of the region by significantly diversifying from the rural sector to the mining and industrial sector. This will lead to more economic stability in the region and a significant increase in the demand for existing and new business.

In terms of employment and production, the proposed project will generate additional direct demands for labour and many indirect demands for goods and services at the local, regional and State levels. These demands for goods and services will be most strongly felt in Kingaroy, Nanango and Yarraman, and to a lesser extent in Brisbane and Toowoomba. Significant beneficial impacts in the reduction of unemployment levels, the greater diversification of local job opportunities, the increase in business demand, and the widening of the regional economic base, will all be realised.

5.3 MAIN DETRIMENTAL IMPACTS

A number of what can be seen as detrimental impacts can be associated with the project at the local level. Generally, these potential impacts are of a relatively short term nature and many can be mitigated through the implementation of the recommended environmental safeguards (ref. Sub Section 5.4). In many instances these anticipated impacts will be unavoidable, should the project proceed.

Terrain

The proposed open cut mining operation will result in significant and unavoidable topographic changes in the short term, with subsequent "flow on" effects to the existing biology and aesthetics of the area. Such changes will however be localised to the actual mining areas and will be mitigated over time by the proposed rehabilitation programme. The potential exists for soil erosion to occur over the disturbed areas but the likely harmful effects can be significantly reduced by implementing the recommended safeguards.

Water Quality

During the construction phase increased sediment loads will be discharged to Meandu Creek from cleared land. In addition the potential exists for the discharge of acidic or nutrient laden effluents and runoff containing a high percentage of suspended coal particles. However the recommended operating procedures have been derived to reduce all potentially detrimental pollutants before they are discharged to the natural creeks. No long term detrimental impacts are likely.

Biology

The clearing of mined areas will cause the destruction of all flora and fauna habitats in the area. However no individual species can be considered threatened due to the widespread distribution of the species outside the area. Initially there will be a significant decrease in populations of non-specific habitat species within the general development area. However a build up in the population of exotic species will occur in disturbed areas as rehabilitation proceeds. Eventually it is likely that most pre-development species will become re-established.

Noise

Noise from the mining operation will be significant within the immediate location of the mine area. In particularly noisy areas, plant operators may be exposed to excessive levels and some form of protection may be required.

Rural residences within 4 km of the mine may be annoyed by mining noise if downwind of the source, particularly at night time. Blasting noise will be audible over a larger area but will occur, on average, only once per daylight shift.

Air Quality

Within the immediate mining area significant rates of dust fallout will be experienced from earthmoving and mining operations. No significant effects are likely beyond the proposed lease area. Dust coating of vegetation is not considered harmful. No significant long term effects are likely from smoke or gaseous emissions.

Housing

Potentially detrimental impacts could arise if sufficient worker accommodation is not available at the time it is required. Should insuffucient housing be available, sub standard housing conditions could occur leading to public health, social, and industrial relations problems. However, provided sufficient time is made available to enable all necessary infrastructural augmentation to be undertaken, and all of the Company built housing is constructed before the workers arrive on site, no significantly detrimental housing impacts should arise.

5.4 RECOMMENDED SAFEGUARDS

The following lists the most significant safeguards and construction and operating procedures which should be implemented in order to provide maximum protection to the environment. Whilst the Company has indicated that most of these procedures would be adopted (ref. Section 3), they have been presented here as a checklist.

(i) Clearing/Earthworks

- Clearing of each pit area to be carried out progressively in advance of each particular mining phase.
- Careful compaction control and surface stabilisation to be used for embankment surfaces.
- Silt traps to be constructed at the base of spoil piles.

(ii)Surface Water

- All plant area runoff to be diverted to a system of detention basins.
- Pit drainage to be disposed of in adequately designed evaporation basins if necessary.
- Regular maintenance of stormwater retention basins and diversion channels.
- Maintaining a freshwater monitoring programme for the creek system within and adjacent to the mining area.
- Construction of diversion channels around all open pit areas and the tailings dam.
- Diversion of haul road drainage to suitable areas to allow the settling out of coal particles.
- Lagooning or land spreading of sewage effluent before discharging to Meandu Creek.

(iii) Reject Material

- Fine reject material should be buried within the spoil heaps to prevent leachate from entering the freshwater system.

(iv) Overburden Rehabilitation

- Overburden to be recontoured to produce undulating terrain with stable slopes.
- Overburden sampling and analysis be undertaken to identify properties likely to limit vegetation growth.
- Test plots to be established to determine the correct fertilizer/plant species mix and the optimum preparation and management procedure.
- Overburden recontouring and rehabilitation to proceed progressively following mining operations.
- Records (and photographs) be kept of the progress of the rehabilitation programme.

(v) Air Quality

- Haul roads to be surfaced and watered regularly.
- Conveyors to be fitted with spray systems at transfer points and other dust generation points.
- The administration and mine buildings area should not be located downwind of the plant and raw coal stockpile area.
- Careful phasing of the clearing operations so that large areas of exposed ground are not left standing for long periods.
- Burning of cleared vegetation should be carried out only when the wind is blowing away from inhabited areas.

(vi) Noise

- Provision of ear protectors and/or sound proof cabins to be made for workers in noisy areas.
- Permit blasting only during daylight shifts.

(vii) Infrastructure

- Effluent from package sewage treatment plant to be lagooned or land spread before discharge to Meandu Creek.
- Negotiation with the Nanango, Kingaroy and Rosalie Shire Councils to ensure that all relevant public

utilities are upgraded where necessary to provide sufficient capacity for the incoming workforce.

- Ensure that all Company built houses are constructed well in advance of the time that they will be required.

- The Company negotiates with the relevant Local Authorities to establish the nature of its contributions towards the social and community facilities of those towns in which its workforce is located.

(viii) Aesthetics

- Ensure maximum possible retention of existing vegetation.

- Introduce vegetation screens as early as possible.

- Establish plant nursery at minesite to provide seedlings for use in the landscaping and rehabilitation programme.

5.5 GOVERNMENTAL REQUIREMENTS

In the planning and execution of the mining programme, it will be necessary for the Company to comply with the regulations and controls which have been established by various regulatory authorities and government departments. These requirements, as far as they effect environmental matters, have been summarised below.

(i) Queensland Electricity Generating Board

- Consultation with Q.E.G.B. on housing policies, contributions to any necessary upgrading of recreational or community facilities, and road improvements.

- Negotiations with Q.E.G.B. on the provision of water and power for the proposed mine together with all common engineering factors at the mine/power station interface.

(ii) Local Authorities

- Liaison with the relevant Local Authorities to ensure that all necessary upgrading of public utilities is undertaken before the workforce settles in the area.

- Negotiation with the Local Authorities as to the level of contributions to be made to the recreational and community facilities in the relevant towns.

(iii) Main Roads Department

- Negotiation with the Main Roads Department as to the likely traffic volumes which the mine workforce will generate and the

requirements for the upgrading of some of the regional roads.

(iv) Water Resources Commission

- Compliance with W.R.C. and D.P.I. requirements regarding any necessary drainage diversions at the mine site.
- Compliance with W.R.C. requirements regarding the use of underground water as a source of construction water supply.
- Compliance with W.R.C. requirements regarding the design and construction of water retaining structures.

(v) Water Quality Council

- Compliance with W.Q.C. regulations regarding the standard of effluent permitted to be discharged to any natural waterway.

(vi) Air Pollution Control

- Compliance with Council requirements regarding the burn-off of cleared vegetation. Written notification should be given to the Council advising them of details of the proposed burning.

(vii) Department of Primary Industries

- Erosion control measures should be implemented in accordance with any requirements established by the Soil Conservation Branch, D.P.I.

(viii) Queensland Housing Commission

- Negotiation with Q.H.C. regarding the provision of houses for mine employees.

(ix) Education and Health Departments

- Early notification to the Education and Health Departments of the proposed housing and development programme so that sufficient time is available for all necessary improvements to existing facilities.

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APPENDICES

Appendix A

SPECIES LIST

FAUNA LIST

This fauna list has been compiled from a number of sources. The list of freshwater organisms is from Coffey & Hollingsworth and Environment Sciences & Services (1973) - the list of fishes should be regarded as indicative only. The lists of amphibians, and part of the bird and mammal lists have been compiled from work by the Wildlife Research Group in the north western portion of S.F. 289 during October, 1976. Bill Fisher and John Kehl of the Department of Forestry were contacted with regard to birds and mammals respectively. Field work in May, 1979 verified some bird and mammal sightings. The list of bats is from Kirkpatrick (1966) and as it is for the Warwick district should be regarded as indicative only. The list of reptiles was provided by staff of the Queensland Museum, who also checked and added to the other species lists.

The status of macropods in Queensland is from Burbidge (1977) (denoted ++). The code is:-

1. Common: range either little changed or increased since European settlement.
2. Range reduced but plentiful in remaining habitat which is fairly extensive.
3. Range and numbers greatly reduced, remaining only in a few isolated places.
4. Very rare or extinct.

A. Occurs in good numbers outside reserves.

B. Adequately provided for in reserves.

C. Occurs on a very few reserves only. In need of further reservation and/or intensive management of existing reserves.

D. Does not occur on reserves. In need of survey, reserve acquisition and intensive management.

The status of the rodents in Queensland is from Watts (1979) whilst the status given for other mammals follows this source. This code is denoted ** and is as follows:-

Status Code
- A Abundant in suitable habitat which is also abundant.
- C Common in suitable habitat which is also common,
- CL Common in suitable habitat which is of limited extent.
- S Sparsely scattered in habitat which is abundant.
- R Rare: either seldom collected or known only from small areas within suitable habitat which is common or abundant.
- RL Rare: in habitat of limited extent.

Abbreviations used in describing habitats are vf - vine forest, gr - grassland, of - open forest, lof - layered open forest, grof - grassy open forest, and cult.- cultivation.

Introduced Species are denoted by '-' before the scientific name.

The following organisms were collected from Meandu Creek during March, 1973. (Coffey & Hollingsworth Pty. Ltd. and Environment Sciences & Services (QLD) Pty Ltd, 1973)

	Group	Family	Genus, Species	Common Name
1.	Mollusca	Sphaeriidae	*Sphaerium* sp.	cockle
		Planorbidae	*Gyraulus* sp.	snail
			Physastra sp.	snail
			Bulinus sp.	snail
		Lymnaeidae	*Lymnaea* sp.	snail
2.	Crustacea	Palaemonidae	-	prawn
3.	Oligochaeta	-	-	worm
4.	Insects			
	Odonata	Gomphidae	-	dragonfly
		Libellulidea	-	dragonfly
		Corduliidae	-	dragonfly
		Coenagrionidae	*Austroagrion cyane*	damselfly
	Lepidoptera	Pyralidae	-	caterpillar
	Ephemeroptera	Caenidae	*Tasmanocoenis* sp.	mayfly
		Baetidae	*Baetis* sp.	mayfly
	Tricoptera	Hydropsychidae	-	caddisfly
	Coleoptera	Hygrobiidae	*Hygrobia* sp.	beetle
	Diptera	Psychodidae	-	(larvae) fly
	Hemiptera	Corixidae	-	water boatman

The following fish species are considered to be present in the headwaters of the Burnett River system, Meandu and Barker Creeks.

	Scientific Name	Common Name
CLASS:	OSTEICHTHYES	fish
	Neoceratodus forsteri	lungfish
	Anguilla reinhardti	long finned eel
	Fluvialosa elongata	Qld. bony bream
	Retropinna semoni	Aust. smelt
	Tandanus tandanus	freshwater catfish
	Gambusia affinis	mosquito fish
	-	rainbow fishes
	Craterocephalus marjoriae	Marjorie's hardyhead

	Scientific Name	Common Name
CLASS:	OSTEICHTHYES (CONTD.)	Fish
	Pseudomugil sp.	blue eyes
	Notesthes robusta	bullrout
	Ambassis nigripinnis	dive perchlet
	Madigania unicolor	spangled perch
	Amniataka percoides	black-striped grunter
	Mugil cephalus	bully mullet
	Hypseleotris compressus	carp-gudgeon
	H. galii	firetail gudgeon
	H. klunzingeri	western carp-gudgeon

	Scientific Name	Common Name	Habitat
CLASS:	AMPHIBIA	Amphibians	
	Adelotus brevis	Tusked frog	vf, lof, gr (logs, cavities near water)
	Ranidella signifera	Common eastern froglet	most
	R. parinsignifera		grass near temporary inundated areas
	Limnodynastes terr-aereginae	Northern banjo frog	near permanent water
	Limnodynastes ornatus	Ornate Burrowing frog	of, vf
	Mixophyes fasciolatus	Great barred frog	terrestrial vf, lof
	M. iteratus	Giant barred frog	terrestrial vf, lof
	Pseudophyrne bibronii	Brown toadlet	under rocks, logs etc. in of
	P. coriacea	Red-backed toadlet	under logs, deep grass near creeks, swamps
	Uperoleia rugosa	Red-groined toadlet	logs, crevices, lof, of near water
	U. marmorata	Yellow-spotted toadlet	" " " "
	U. laevigata		
	Litoria fallax	Eastern dwarf treefrog	reeds, floating plants near and in water
	L. latopalmata		terrestrial, nocturnal
	L. lesueurii	Lesueur's frog	terrestrial, nocturnal, vf, of

	Scientific Name	Common Name	Habitat
CLASS:	AMPHIBIA (CONTD.)	Amphibians	
	L. peronii	Peron's tree frog	all, semi arboreal
	L. rubella	Desert tree frog	arboreal, all near water
	L. verreauxii		of, gr, water
CLASS:	REPTILIA	Reptiles	
	Chelodina longicollis	Longnecked tortoise	creeks
	Diplodactylus vittatus	Wood gecko	of, lof
	Gehyra australis	Northern Dtella	of
	Oedura robusta	Robust velvet gecko	of (arboral)
	Oedura tyroni	Southern spotted velvet gecko	of
	Underwoodisaurus milii	Thick-tailed gecko	lof, of
	Lialis burtonis	Burtons snake lizard	lof, vf
	Amphibolurus barbatus	Bearded dragon	of, lof, gr
	Amphibolurus nobbi	Nobbi	of
	Diporiphora australis		of
	Physignathus lesueurii	Eastern water dragon	semi aquatic, arboreal
	Varanus tristis		arboreal
	Varanus varius	Lace monitor	arboreal
	Anomalopus verreauxii		of (burrowing)
	Carlia burnettii		
	Carlia pectoralis		
	Carlia schmeltzii		
	Carlia vivax		
	Cryptoblepharus virgatus		
	Ctenotus robustus		of, lof
	Ctenotus taeniolutus	Copper-tailed skink	of
	Egernia frerei	Major skink	of, vf
	Egernia striolata	Tree skink	of, vf arboreal
	Lampropholis delicata		
	Morethia boulengeri		of
	Morethia taeniopleura	Fire-tailed skink	of, vf
	Sphenomorphus quoyii	Eastern-water skink	near creeks
	Sphenomorphus scietirostrum		of, vf
	Sphenomorphus tenuis		arboreal
	Tiliqua scincoides	Eastern blue-tongue lizard	of

	Scientific Name	Common Name	Habitat
CLASS:	REPTILIA (CONTD.)		
	Python spilotes	Carpet python	of, vf
	Amphiesma mairii	Freshwater snake	near & in water
	Boiga irregularis	Brown-tree snake	of arboreal
	Dendrelaphis punctulatus	Common-tree snake	arboreal
	Cacophis squamulosus	Golden-crowned snake	of, vf
	Cryptophis nigrescens	Eastern small-eyed snake	of, vf
	Demansia psammophis	Yellow-faced whip snake	of
	Furina diadema	Red-naped snake	of
	Pseudechis porphyriacus	Red-bellied black snake	of near water
	Pseudonaja textilis	Eastern brown snake	of, lof
	Vermicella annulata	Bandy-bandy	of, lof
CLASS:	AVES	Birds	
	Podiceps novaehollandiae	Little grebe	creeks and dams
	Phalacrocorax melanoleucos	Little pied cormorant	creeks and dams
	P. sulcirostris	Little black cormorant	creeks and dams
	Anhinga rufa	Darter	creeks and dams
	Ardea pacifica	White-necked heron	creeks and dams
	A. novaehollandiae	white-faced heron	creeks and dams
	Egretta alba	White egret	swampy areas
	E. intermedia	Plumed egret	swampy areas
	Threskiornis molucca	Straw-necked Ibis	swampy areas
	Anas superciliosa	Black duck	creeks and dams
	Anas gibberifrons	Grey teal	creeks and dams
	Aythya australis	White-eyed duck	creeks and dams
	Chenonetta jubata	Wood duck	creeks and dams
	Elanus notatus	Black-shouldered kite	of, cult.
	Aviceda subcristata	Crested hawk	vf
	Accipiter cirrocephalus	Collared sparrow hawk	of, gr
	Accipiter novaehollandie	Grey goshawk	vf
	A. fasciatus	Brown goshawk	occ. vf and along creeks
	Aquila audax	Wedge-tailed eagle	all
	Hieraaetus morphnoides	Little eagle	of
	Falco cenchroides	Nankeen kestrel	gr. cult.
	Falco berigora	Brown falcon	gr. of

	Scientific Name	Common Name	Habitat
CLASS:	AVES (CONTD.)		
	Alectura lathani	Brush Turkey	vf. lof
	Coturnix pectoralis	Stubble quail	cult.
	Turnix melanogaster	Black-breasted button quail	vf (drier)
	Burhinus magnirostris	Bush stone curlew	gr & of
	Vanellus miles	Spur-winged plover	gr, cult.
	Ptilinopus regina	Red-crowned pigeon	vf
	Lopholaimus antarcticus	Topknot pigeon	of (summer)
	Macropygia amboinensis	Brown pigeon	vf
	Geopelia striata	Peaceful dove	gr, of, gr
	Geopelia humeralis	Bar-shouldered dove	of, uf/gr, vf/of
	Chalcophaps indica	Green-winged pigeon	vf (drier)
	Ocyphaps lophotes	Crested pigeon	gr, cult.
	Leucosarcia melanoleuca	Wonga pigeon	vf
	Calyptorhynchus funereus	Yellow-tailed black cockatoo	vf, of
	Cacatua roseicapilla	Galah	Gr. cult. of
	C. galerita	Sulphur-crested cockatoo	Gr. cult, of
	Trichoglossus haematodus	Rainbow lorikeet	of
	T. chlorolepidotus	Scaly-breasted lorikeet	of
	Glossopsitta pusilla	Little Lorikeet	of
	Alisterus scapularis	King parrot	all
	Nymphicus hollandicus	Cockatiel	gr of
	Platycercus adscitus	Pale-headed rosella	of, cult
	Platycercus elegans	Crimson rosella	vf, of
	Culculus pyrrhophanus	Fan-tailed cuckoo	all
	Chrysococcyx lucidus plagosus	Golden bronze cuckoo	vf
	Fadynamys scolopea	Indian koel	vf, of
	Scythrops novaehollandiae	Channel-billed cuckoo	vf
	Centropus phasianinus	Pheasant coucal	vf
	Ninox strenua	Powerful owl	vf
	N. novaeseelandiae	Boobook owl	of
	N. connivens	Barking owl	all
	Tyto alba	Barn owl	all
	Podargus strigoides	Tawny frogmouth	all

	Scientific Name	Common Name	Habitat
CLASS:	AVES (CONTD.)		
	Aegotheles cristatus	Owlet night jar	gr of
	Eurostopodus mystacalis	White-throated night jar	of
	Dacelo gigas	Kookaburra	of, gr
	Halcyon macleayi	Forest kingfisher	of
	Halcyon sancta	Sacred kingfisher	of
	Merops ornatus	Rainbow bird	of
	Eurystomus orientalis	Dollar Bird	of
	Pitta versicolor	Noisy pitta	vf
	Cheramoeca leucosternum	White-backed swallow	cult, gr of
	Hirundo neoxena	Welcome swallow	cult, gr
	Cecropis ariel	Fairy martin	of near water
	Pteropodocys maxima	Ground cuckoo-shrike	of
	Coracina novaehollandiae	Blackfaced cuckoo shrike	of, woodland
	C. tenuirostris	Cicada bird	vf, of
	Microeca leucophaea	Jacky winter	
	Eopsaltria australis	Yellow robin	
	Pachycephala rufiventris	Rufous whistler	of
	P. pectoralis	Golden whistler	vf
	Colluricincla harmonica	Grey shrike thrush	vf
	Monarcha melanopsis	Black-faced monarch	vf
	Monarcha trivirgata	Spectacled monarch	vf
	Myiagra inquieta	Restless flycatcher	of
	M. rubecula	Leaden flycatcher	of
	Rhipidura rufifrons	Rufous fantail	of, vf (summer)
	R. fuliginosa	Grey fantail	of
	R. leucophrys	Willie wagtail	of
	Psophodes olivaceus	Eastern whipbird	vf
	Pomatostomus temporalis	Grey-crowned babbler	open woodland
	Acrocephalus stentoreus	Reed warbler	gr/water
	Megalurus timoriensis	Tawny grassbird	gr/water
	Cisticola exilis	Golden-headed cisticola	lof
	Malurus cyaneus	Superb blue wren	of, vf margins
	Malurus lamberti	Variegated wren	vf margins
	M. melanocephalus	Red-backed wren	of. gr.
	Sericornis magnirostris	Large-billed scrub wren	vf
	S. citreogularis	yellow-throated scrub wren	vf
	S. frontalis	Buff-breasted scrub wren	vf

Scientific Name	Common Name	Habitat
CLASS: AVES (CONTD.)		
S.saggittatus	Speckled warbler	woodlands
Acanthiza pusilla	Brown thornbill	vf, lof
A. lineata	Striated thornbill	vf margins
A. chrysorrhoa	Yellow-tailed thornbill	gr
A. nana	Yellow thornbill	lof
A. reguloides	Buff-tailed thornbill	vf of margins
Gerygone mouki	Brown warbler	vf
G. olivacea	White-throated warbler	vf margins, vf
Smicrornis brevirostris	Weebill	of
Daphoenositta chrysoptera	Varied sittella (white-headed)	woodland
Climacteris leucophaea	White-throated treecreeper	vf, of
Philemon corniculatus	Noisy friar bird	of
P. citreogularis	Little friar bird	of
Manorina melanocephala	Noisy minor	of
Meliphaga lewinii	Lewin's honeyeater	vf
Lichenostomus chrysops	Yellow-faced honeyeater	lof
Lichenostomus leucotis	White-eared honeyeater	vf (rare: edge of range)
Melithreptus brevirostris	Brown-headed honeyeater	of
Melithreptus albogularis	White throated honeyeater	vf
Lichmera indistincta	Brown honeyeater	vf/of, of
Entomyzon cyanotis	Blue-faced honeyeater	of
Acanthorhynchus tenuirostris	Eastern Spinebill	vf
Myzomela sanguinolenta	Scarlet honeyeater	of
Dicaeum hirundinaceum	Mistletoe bird	of
Pardalotus punctatus	Spotted pardalote	of
P. striatus	Black-headed pardolote	of
Zosterops lateralis	Grey-breasted silvereye	vf/gr, vf/of, of
Passer domesticus	House sparrow	cult. houses
Emblema temporalis	Red-browed finch	vf margins, of
Poephila bichenovii	Double-barred finch	of, vf margins
Sturnus vulgaris	Common starling	gr, cult.
Sphecotheres viridis	Figbird	vf
Oriolus sagittatus	Olive-backed oriole	vf, of
Ptilonorhynchus violaceus	Satinbower bird	vf
Sericulus chrysocephalus	Regent bower bird	vf
Ptiloris paradiseus	Paradise rifle bird	vf

	Scientific Name	Common Name	Habitat
CLASS:	AVES (CONTD.)		
	Ailuroedus crassirostris	Green catbird	vf
	Struthidea cinerea	Apostle bird	of
	Grallina cyanoleuca	Magpie lark	of, cult, gr
	Artamus cyanopterus	Dusky wood swallow	above of, of margins
	Cracticus nigrogularis	Pied butcherbird	of
	C. torquatus	Grey butcherbird	of
	Gymnorhina tibicen	Black-backed magpie	of, cult, gr
	Strepera graculina	Pied currawong	over vf
	Corvus coronoides	Australian raven	of, gr, vf margins
	Corvus orru	Australian crow	of, gr, vf margins

	Scientific Name	Common Name	Habitat	Consvn. Status
CLASS:	MAMMALIA	Mammals		
	Tachyglossus aculeatus	Echidna	of, gr	C**
	Antechinus sp.		vf	
	Phascogale tapoatafa	Brush-tailed Phascogale	of, vf	S**
	Sminthopsis murina		of	
	Dasyurus maculatus	Tiger Cat	of, vf	S**
	Isoodoon obesulus	Short nosed bandicoot	of, vf	CL**
	Petaurus breviceps	Sugar glider	of (blue gum flats)	C**
	Pseudocheirus peregrinus	Common ring-tail	vf, lof	C**
	Schoinobates volans	Greater glider	of (blue gum flats)	C**
	Trichosurus vulpecula	Brush-tailed possum	of	A**
	Trichosurus caninus	Mountain possum	vf	C**
	Phascolarctos cinereus	Koala	of	S**
	Aepyprymnus rufescens	Rufous rat-kangaroo	vf, of	2AC++
	Thylogale stigmatica	Red-legged pademelon	vf	2AB++
	Thlogale thetis	Red-necked pademelon	vf	2AB++
	Wallabia bicolor	Swamp wallaby	vf, lof	1AB++
	Macropus rufogriseus	Red-necked wallaby	lof, of	1AB++
	Macropus dorsalis	Black-striped wallaby	vf	2A++

	Scientific Name	Common Name	Habitat	Consvn. Status
CLASS:	MAMMALIA (CONTD.)			
	Macropus parryi	Whiptail wallaby	of, gr	2A++
	Macropus giganteus	Grey kangaroo	of, gr	1AB++
	Hydromys chrysogaster	Water rat	riverine	A**
	Rattus culmorum (= tunneyi)		plantation, creeks in vf	S**
	Rattus fuscipes		vf	A**
	Rattus rattus	Ship rat	of, gr, vf margins	A**
	Mus musculus	House mouse	cult, gr	A**
	Melomys cervinipies	Scale-tailed rat	vf	A**
	Lepus europaeus	Hare	of, cult.	C**
	Canis familiaris dingo	Dingo	of, vf margins	S**
	Vulpes vulpes	Fox	cult, of	A**
	Felix catus	Cat	cult, of, gr	C**
	Bos taurus	Cattle	of, gr	A**
	Pteropus poliocephalus	Grey headed flying fox	all	
	Pteropus scapulatus	Collared flying-fox	all	
	Nyctophilus timoriensis	Large long-eared bat	of	
	Nyctophilus geoffroyi	Geoffroy's long-eared bat	of	
	Eptesicus pumilis	Little bat	all	
	Pipistrellus tasmaniensis	Pipistrel	adjacent vf	
	Chalinolobus gouldii	Gould's lobe-tipped bat	vf, of	
	Nycticeius orion	Eastern broad-nosed bat	of	
	Nycticeius rupellii	Greater broad-nosed bat	of	
	Miniopterus schreibersii blepotis	Bent-winged bat		
	Taphozous flaviventris	Yellow-bellied free-tailed bat	of	
	Tadarida norfolkensis	Mastiffbat	of	
	Rhinolophus megaphyllus	Horseshoe bat		

FLORA LIST

This flora list has been compiled from that in Coffey and Hollingsworth and Environment, Sciences and Services (1973), from limited field work and specimens identified during May, 1979, and checked by W.J.F. McDonald, Botany Branch, D.P.I. A list of species recorded and/or collected during April, 1978 in vine forest in State Forest 289 to the west of the lease area by officers of the Botany Branch, D.P.I., has also been incorporated.

Scientific Name	Common Name	Vegetation Type
APOCYNACEAE		
Alstonia constricta	bitter bark	vf
Alyxia ruscifolia		vf
Carissa ovata	carissia	vf
Parsonia straminea		vf
ARAUCARIACEAE		
Araucaria bidwillii	bunya pine	vf
A. cunninghamii	hoop pine	vf
ASCLEPIADACEAE		
Asclepias physocarpa	cotton bush	of,gr
Marsdenia suberosa		vf
Secamone elliptica		vf
BIGNONIACEAE		
Pandorea pandorana	wonga wonga vine	vf,lof
CAPPARIDACEAE		
Capparis arborea		vf
C. sarmentosa		lof,vf
CELASTRACEAE		
Celastrus subspicatus		vf
Denhamia pittosporoides	denhamia	vf
Maytenus bilocularis		vf
COMPOSITAE (ASTERACEAE)		
Bidens pilosa	cobbler's pegs	cult, road sides
Tagetes minuta	stinking roger	cult, road sides
CYPERACEAE		
Cyperus halpan		creek banks
Gahnia aspera		of

Scientific Name	Common Name	Vegetation Type
DICRASTYLIDACEAE		
Spartothamnella juncea		vf
DILLENIACEAE		
Hibbertia sp.		of
EPACRIDACEAE		
Leucopogon sp.		of
ERYTHROXYLACEAE		
Erythroxylum australe		vf
EUPHORBIACEAE		
Acalypha capillipes		vf
Breynia oblongifolia		vf
Coelebogyne ilicifolia		vf
Croton insularis	Queensland Cascarilla	vf
Drypetes australasica	yellow tulip wood	vf
Excoecaria dallachyana		vf
Petalostigma pubescens		of
FLACOURTIACEAE		
Casearia multinervosa		vf
FLINDERSIACEAE		
Flindersia australis	crows ash, teak	vf
F. collina	leopards ash	vf
GOODENIACEAE		
Goodenia sp.		of
GRAMINEAE (POACEAE)		
Sporobolus sp.	rat's tail grass	of, gr
Chloris gayana	rhodes grass	of, gr
Stipa ventricillata	bamboo grass	of, gr
Aristida spp		of, gr
Ancistrachne ancinuata		vf
Rhynchelytrum repens	red natal grass	of, gr
Imperata cylindrica	blady grass	of, gr
Cymbopogon refractus	barbwire grass	of, gr
Themeda australis	kangaroo grass	of, gr
HYDROCHARITACEAE		
Ottelia ovalifolia	swamp lily	fw ponds

Scientific Name	Common Name	Vegetation Type
LABIATAE		
Stachys arvensis	stagger weed	cult, road sides
LILIACEAE		
Dianella sp.		of
MELIACEAE		
Owenia venosa		vf
Turraea brownii		vf
MIMOSACEAE		
Acacia aulococarpa	brush iron-bark wattle	vf, lof
A. cunninghamii	Curracabah	of
A. glaucocarpa		
A. implexa	Hickory	of
A. maidenii	Maidens wattle	vf
MORACEAE		
Malaisia scandens	crow ash	vf
MYRTACEAE		
Angophora costata	sugar gum	of
A. subvelutina	broad-leaved apple	of
Austromyrtus acmenoides		vf
Eucalyptus crebra	narrow-leaved ironbark	of
E. drepanophylla	grey ironbark	of
E. intermedia	pink bloodwood	of
E. maculata	spotted gum	of
E. moluccana	gum-topped box	of
E. populnea	poplar box	of
E. robusta	swamp mahogany	of
E. tereticornis	forest red gum, blue gum	of
E. siderophloia	broad-leaved ironbark	of
Melaleuca quinquenervia	paperbark	
Rhodamnia sp. aff. *R.argentea*	malletwood	vf
NAJADACEAE		
Najas graminea		fw ponds
OXALIDACEAE		
Oxalis sp.		of

Scientific Name	Common Name	Vegetation Type
PAPILIONACEAE (FABACEAE)		
Glycine sp.		of
Hardenbergia violaceae		of
Jacksonia scorparia	dog-wood	of
Kunstleria blackii		vf
Medicago sp.		of
Melilotus indica	hexam scent	of, cult.
PHILESIACEAE		
Eustrephus latifolius		vf
PITTOSPORACEAE		
Bursaria incana		of
Citriobatus linearis		of
C. pauciflorus	orange thorn	of
POTAMOGETONACEAE		
Potamogeton tricarinaties	a floating pond weed	fw ponds
PROTECEAE		
Banksia integrifolia		of
Grevillea robusta	silky oak	vf
Persoonia sp.	geebung	of
RHAMNACEAE		
Alphitonia excelsa	red ash	vf, vf edges
RUBIACEAE		
Pomax umbellata		vf
Canthium buxitolium		vf
C. vacciniifolium		vf
RUTACEAE		
Acronychia laevis		vf
Euodia micrococca		vf
Geijera salicifolia var. *latigolia*	brush wilga	vf
Zanthoxylum brachyacanthum	thorny yellow-wood	vf
SANTALACEAE		
Exocarpos cupressiformis	native cherry	of
E. latifolius	scrub cherry	vf
SAPINDACEAE		
Atalaya virens		vf
Cupaniopsis parvifolia		vf
Ellattostachys xylocarpa		vf

Scientific Name	Common Name	Vegetation Type
SOLANACEAE		
Solanum mauritianum	wild tobacco	road sides in vf
S. nigram	black nightshade	road sides
Dubosia sp.		
STERCULIACEAE		
Brachychiton discolor	Flame tree	vf
B. populneum	Kurrajong	vf
B. ruprestris	Queensland bottletree	of
STRYCHNACEAE		
Strychnos axillaris		vf
THYMELAEACEAE		
Pimelea latifolia ssp. *altior*		vf
VERBENACEAE		
Lantana camara	lantana	of,gr
Premna lignum-vitae		vf
XANTHORRHOEACEAE		
Lomandra sp.		of

Appendix B

ARCHAEOLOGICAL REPORT

Office of the
Minister for Aboriginal and Island Affairs

Telephone:
229 5426

FIRST FLOOR • LAND ADMINISTRATION BUILDING • GEORGE STREET BRISBANE
P.O. BOX 181, BRISBANE NORTH QUAY, 4000, QLD

23rd February, 1979.

Major I.W. Hill,
43 Highland Terrace,
ST. LUCIA. 4067

Dear Major Hill,

Your application to undertake an archaeological examination of the C.R.A. Explorations Lease south of Tarong has been considered and it is advised that approval is granted for you to undertake the examination of this area.

As with previous permits granted to you any artefacts collected must be provided to the Archaeology Branch of my Department along with a detailed report of your undertaking.

I look forward to receiving your reports and wish you well in your work.

Yours sincerely,

(Charles Porter)
Minister for Aboriginal
and Island Affairs and
Member for Toowong.

INSPECTION SCHEDULE

DATE	TIMINGS START	TIMINGS FINISH	HRS	METEOROLOGY	AREA INSPECTED	REMARKS
26 FEB 79	0930	1730	3.0	AM: 4/10 low cumulus; hot, humid. PM 10/10 o'cast; hot, humid.	Recce whole site; courtesy calls; schedule preparation; Pors 113,114,161	
27 FEB 79	0700	1800	11.0	AM: 2/10 scat cumulus; light wind;warm PM: 2/10 scat cumulus; light wind;warm	Pors 132,133,134,135,136,137.	
28 FEB 79	0700	1805	11.0	AM: 7/10 low cumulus; early AM fog;wind PM: 3/10 scat cumulus; windy; cool	Pors 106, 107, 108, 109.	
01 MAR 79	0700	1802	11.0	AM: 2/10 scat cumulus; strong wind,cool PM: 7/10 low cumulus;strong wind; cool	Pors 62, 63, 64, 65, 66, 67, 68, 69 and 70.	Fringe effects of Cyclone 'Kerry'.
02 MAR 79	0700	1838	11.5	AM: 9/10 low cumulus; cool PM: 2/10 scat cumulus; warm	Pors 110, 111, 112 and port Por 3	
03 MAR 79	0700	1831	11.5	AM: 2/10 cirrostratus; hot. PM: 3/10 scat cumulus; hot.	Part Por 3, Pors 10, 57, part Por 71, Pors 104 and 105.	
TOTAL:			64.0 hrs			

ARCHAEOLOGICAL REPORT

1. General

a. In accordance with the request made by Investogator Coal Exploration Pty Ltd (letter d/20 February 1979) and under the authority of the Minister for Aboriginal and Islanders' Affairs d/23 February 1979 (p. 1 herein) an Archaeological Inspection of the proposed Coal Mining Site at TARONG, Queensland, was conducted.

b. The Inspection commenced on the morning of 26 February and was concluded in the evening of 03 March 1979.

c. No historical background has been included in this Report as it is considered that this aspect lies outside the terms of reference for this Inspection.

2. AIM

a. The aim of this Inspection was to carry out a close investigation of the area noted in Para 1.a. above with a view to identifying locations where Aboriginal relics and/or sites might exist and to advise procedures for the identification and protection of such sites or relics discovered during any future operations in the area.

b. Particular attention was to be paid to:-

(1) Camp sites and/or middens
(2) Stone arrangements
(3) Incised trees, including:-
  (a) Canoe trees
  (b) Shield trees
  (c) Container trees
  (d) Shelter trees
  (e) Possum and/or Honey trees
  (f) Dendroglyphs
(4) Rock shelters and/or overhangs and any attendant rock paintings or engravings
(5) Quarries
(6) Axe grooves
(7) Petroglyphs
(8) Lithic artifacts:-
  (a) In association with any of the above
  (b) Isolated finds
(9) Any other indications of past Aboriginal occupation or activity.

3. TOPOGRAPHY

a. The area of the proposed mine site consists of steeply folded country enclosing narrow, fertile valleys.

b. The topsoil varies from a sandy loam in the valleys to red soil on the tops of ridges, particularly that forming the eastern boundary.

c. Sandstone outcrops occur plentifully. These mainly consist of

3. c. continued

a bed of sandstone 30.0 - 50.0 cm in depth overlying a stratum of heavy conglomerate, the latter including a high percentage of quartz pebbles. In many areas the sandstone is vesicular. In general, the exposed surface of the sandstone outcrops is well-weathered and friable.

d. On the tops of many of the numerous ridges gravel outcropping occurs. This consists of a high percentage of quartz pebbles together with other rocks and minerals. Loose gravel is also found on the wooded slopes where rain erosion and surface runoff has exposed the underlying stratum below the topsoil as the latter is washed into the valleys below.

e. The main waterway is MEANDU CREEK which roughly parallels the western boundary of the site. At the present time this Creek is flowing in several places. Where it is apparently dry a shallow excavation reveals water a little way below the surface. Apart from this main waterway the area contains a number of dams and most properties possess at least one windmill bore.

4. FLORA

a. The slopes of all the many ridges, where they have not been cleared and prepared for pastureland, are heavily timbered with dry sclerophyll forest and a uniformally heavy undergrowth of lantana (Lantana camara) and other low-growing vegetation and secondary growth.

b. On the crests of the ridges, where the canopy is less dense, the grass cover is heavy, reaching a height of >1.0 m. On the slopes, where these have been cleared for pasture the grass cover is very thick and lush even following signs of recent grazing.

c. In no areas is the forest canopy sufficiently dense as to inhibit grass growth entirely other than on patches of gravel outcropping noted above (para 3.d.).

d. The areas of the site given over to cultivation appear to be solely sorghum (Andropogon spp.) or, as is the case in many instances, are lying fallow.

5. FAUNA

a. The area is primarily noteworthy for its obvious lack of the larger Macropodia spp. No kangaroos were sighted although a number of Swamp Wallabies (Wallabia bicolor) were seen about the steep slopes of the ridges, particularly amongst the denser undergrowth.

b. A total of seven Dingoes (Canis familiaris) were seen including one which had been killed by a vehicle.

c. A single Fox (Vulpes vulpes) was also sighted in Portion 113.

d. The Reptilia family is well represented, many goannas, frill-necked lizards, Bluetongues (Tiliqua scincoides) and Geckos (Gehydra variegata) being noted. A single example of Black Snake (Pseudechis porphyriacus) was found dead at the side of the road, probably run over by a vehicle.

e. Avian faunae are well represented also, the more common sightings including:-

5. e. continued

Wonga pigeon (Leucosarcia melanoleuca)*
Crested pigeon (Ocyphaps lophotes)
Laughing Kookaburra (Dacelo gigas) - no D. leachii observed.
Plains turkey (Australian Bustard - Ardeotis australis)
Scrub turkey (Alectura lathami)
Galah (Cacatua roseicapilla)*
Black duck (Anas superciliosa) } Both seen only on dams
Dusky moorhen (Gallinula tenebrosa) }
Whipbird (Psophodes olivaceus)
Wedgetailed eagle (Aquila audax)
Magpie (Gymnorhina tibicen)
Willie wagtail (Rhipidura leucophrys)

*A local informant states that these two spp. have recently returned to the area after a prolonged absence.

6. ETHNOGRAPHY

In accordance with N.B. Tindale's Tribal Boundaries in Aboriginal Australia (1974) -(see Map 'A' herein), the inspected area lies adjacent to the boundary separating the KAIABARA tribe and the GARUMGA - one of the DALLA small tribes.

7. METHODOLOGY

a. A 4-wheel drive, Diesel vehicle was provided by the Company. This proved to be an ideal vehicle for the purpose since some of the log-snigging trails were badly scoured. The number of roads intersecting the site and the tracks made by drilling teams made approach to the more difficult areas a good deal easier.

b. The entire inspection was carried out on foot, a total distance of 158.3 km being covered in this manner (average 26.4 km per day).

c. A number of exploratory drill-holes were encountered but since these were unnumbered they were of little value in determining precise locations. However the folded nature of the ground and the Council roads were adequate for this purpose when related to the 1:100,000 map.

d. On arrival at the Site, having driven the vehicle from Brisbane early on 26 March a careful ground reconnaissance was made by vehicle to determine the inspection schedule. This was based upon property boundaries and is illustrated on Map 'B' herein.

e. Courtesy calls were paid to all homesteads on the properties involved with the following results:-

(1) Contacted:

Mr & Mrs A.C. Bain	- Pors:	Part 3.
Mr. R.J. Richardson	-	112, 132.
Mr. W.A. Richardson	-	10,57,104,110,111.
Mr. J.H. Lewis	-	116.
Mr. S.N. Lewis	-	114.
Mr. L.V. Sanders	-	133,136,137.
Mr. M.W. Hood	-	Part 71,72.

7. e. continued

(2) The following property owners were not contacted. Calls were made at the various homesteads but these were unoccupied at the time. Where mail-boxes existed a business card was left in lieu:-

Mr. O.J. Richardson	-	Por 105,108.
Mr. R.B. Pointon	-	107,109.
Messrs J.L. & J.A. Postle		134,135.
Mrs. A. Smith	-	106
Mr & Mrs K.G. Schloss	-	63,64,65,66,74,75.
Mr. J.N. Hood	-	67,68.
Messrs Quail & Olive	-	62,69,70.

f. All property owners were most courteous and helpful.

g. The proposed mine site was inspected in accordance with the Schedule set out at page 2 herein.

8. ARCHAEOLOGICAL FINDINGS

a. As a broad statement it may be observed that the inspected area yielded very few lithic artifacts and, indeed, few other indications of past Aboriginal occupation. There are, perhaps, a number of reasons for this paucity of occupational traces:-

(1) The intensive cultivation/clearing of the valleys. Coupled with a considerable amount of timber-cutting the signs of which are evident everywhere in the more heavily forested areas which include the very recent (with logs still waiting to be snigged out) to stumps of great age. The resultant change in the ecology has caused surface runoff which in turn has carried topsoil into the valleys, adding to their fertility.

(2) The nature of the rock formation - largely vesicular or conglomerate, neither of which forms were favoured by the Aborigines for stone-tool making. The exception to this statement being the numerous quartz pebbles found in the coarse conglomerate - these were frequently used for hammerstones, scrapers, etc.

(3) The BUNYA MOUNTAINS, a recorded favoured site for the Aborigines, lie some 30.0 km to the west of the site. It is suggested that tribal groups travelling to the mountains may well have used the inspected area as a corridor through which to mass en route.

b. That the Aborigines were in the area is unquestioned and the proof is readily to hand:-

(1) A local informant showed the writer a number of well made edge-ground and flaked-edge axes which he has brought to light over the years during cultivation. The majority of these have been exposed at a depth of >30.0 cm below the surface. Moreover, all are formed on rock or mineral which is not found in the immediate local vicinity. This indicates that they were carried in. (See Photo section).

8. b. continued

(2) The same informant states that, as a boy, he was shown a number of incised trees in the area (from his description these were container trees); all, he says, are now gone either from age, bush-fires or clearing operations. He also relates that the Bunya pine (Araucaria bidwilli)was plentiful in the area but these, too, have now all disappeared.

(3) No examples of incised trees were located despite diligent searching in the light of the foregoing information.

(4) One example of axe-grooving was located on the bed of MEANDU CREEK at GR 830335 (see Photo section). 30.0 m. south of these a concrete bar has been built across the creek. The same informant relates that this work was carried out in the late 1930s with the object of raising the level of what was then a popular swimming-hole which had silted up. It is now a shadow of what must have been its former dimensions; has again silted up and is fringed with reeds, bull-rushes, etc. Regrettably, the building of the concrete bar unwittingly covered over another and apparently more extensive set of axe-grooves.

(5) 1.5 km north of this area lies a badly eroded piece of high ground above a crossing over MEANDU CREEK at GR 834359. Despite heavy scouring this shows the remains of a flaking floor. Five artifacts were recovered and a number of waste flakes noted.

(6) At GR 918345, in a heavily-wooded slope below Por. 39 (the property of Mrs. A. Smith) a very light scatter of artifacts was located over an area of some 500.0^2. They included a good example of Horsehoof core, well retouched. Other random recoveries are listed below.

c. Recovered lithic artifacts

(1) BAG 1 - GR 834389 - Flaking floor

1. Convex-end scraper
2. Knife flake
3. Convex-end scraper/adze flake (quartz)
4. Side scraper
5. Waste flake with pronounced percussion bulb.

(2) BAG 2 - GR 918345 - light scatter

1. Horsehoof core
2. Convex-end scraper
3. 2-side/end scraper
4. Side scraper
5. Knife blade
6. Knife blade (pebble tool)
7. Convex-end scraper
8. Heavy knife flake; left distal margin pointed
9. End scraper
10. Pebble scraper (quartz).

8. c. continued

(3) BAG 3 - Random recoveries

RR1 - Core scraper)
RR2 - End scraper (quartz)) GR 903321

RR3 - Trigonal scraper (quartz))
RR4 - Hammerstone (quartz pebble impact-scarred) GR 988336
at distal end.)

9. CONCLUSIONS

a. The very heavy grass cover both in the cleared pasturelands and on the ridges of the intervening hills made inspection difficult. Negotiating the very steep slopes was laborious and time-consuming. Cultivation, having disturbed the surface of the ground, did not help recovery of lithic artifacts - in fact, none were found on this type of ground.

b. No camp-sites were located despite reports of previous presence of Aborigines (as noted above) and no incised trees were encountered.

c. Axe-grooving was limited to the single example detailed above (para 8. b. (4) above). The surface of the sandstone boulder on which these occur is friable and the grooves are barely visible. MEANDU CREEK is flowing at this point and is thus adding to the steady erosion of the rock surface. The poor state of the grooving at this site does not appear to warrant any attempt at salvage; and those grooves now covered by the concrete bar would defy any attempt to remove the cement without irrepairable damage to the grooving.

d. The drain, chipped into the rock surface (see Photo section) appears to be the work of Europeans and to have been made with a crow-bar. The purpose is uncertain since the flow of water (possibly due to land tilt) no longer feeds this drain.

e. The comparatively few lithic artifacts recovered do not indicate any prolonged occupation of the area by Aborigines and this view is supported by the lack of evidence for camp-sites.

f. In the light of the foregoing and to the best of the writer's knowledge and experience, there appears to be no archaeological objection to mining or other engineering activities in the inspected area.

10. RECOMMENDATIONS

a. In view of the number of good examples of edge-ground and flaked-edge axes recovered by the informant (para 8. b. (1) above) it is recommended that persons in charge of removing the upper 1.0 m of overburden during open-cut operations be requested to watch for any lithic artifacts of this nature and to notify the Department of Aboriginal & Islanders' Advancement Archaeology Branch of any recoveries.

b. Company employees should be reminded of the provisions of the Act - viz. that all Aboriginal cultural material and/or sites (including lithic artifacts) are the property of the Crown and findings should be reported as soon as possible.

11. ACKNOWLEDGEMENTS

The writer would like to express his gratitude to Mr. S.N. Lewis for the invaluable information he was able to impart and for the courtesy of permitting him to photograph a number of lithic artifacts in his possession.

Appendix C

POPULATION AND WORKFORCE CHARACTERISTICS

TABLE C.1

HOUSING, 1976

LOCALITY	TOTAL DWGS	OCCUPIED PVTE DWGS	UNOCCUPIED PVTE DWGS	NON-PVTE DWGS	PERSONS/ OCC. PVTE DWGS	% OCCUPIED PVTE DWGS	PVTE DWGS BLT AFTER 6/71	DWGS ON RURAL HOLDINGS	MOBILE	MULTI-UNIT PVTE DWGS
NANANGO SHIRE	1001	886	106	9	3.26	88.5	56	356	4	54
NANANGO URBAN AREA	400	350	46	4	3.13	87.5	20	10	0	32
NEUMGNA LOCALITY	62	56	4	2	3.48	90.3	2	48	0	0
YARRAMAN URBAN AREA	212	184	24	4	3.11	86.8	4	0	0	16
KINGAROY URBAN AREA	1703	1544	142	17	3.07	90.7	118	18	2	202
COOYAR LOCALITY	79	60	18	1	3.75	75.9	2	34	2	4
BLACKBUTT URBAN AREA	138	128	8	2	3.19	92.8	16	0	0	2

SOURCE: ABS

TABLE C.2

POPULATION AGE STRUCTURE, 1976

(PERCENT)

AGE GROUP (YEARS)	NANANGO SHIRE	NANANGO URBAN AREA	NEUMGNA LOCALITY	YARRAMAN URBAN AREA	KINGAROY URBAN AREA	COOYAR LOCALITY	BLACKBUTT URBAN AREA	QUEENSLAND
0-4	9.0	8.1	13.9	7.4	8.5	6.1	7.1	9.1
5-9	13.3	13.4	11.2	10.0	8.5	9.1	12.4	9.5
10-14	10.2	9.6	10.2	14.7	9.4	18.4	11.4	9.4
15-19	7.4	8.6	6.0	6.4	9.7	8.3	2.8	9.1
20-24	6.0	6.4	4.7	8.0	8.5	4.6	6.0	8.1
25-29	6.6	5.7	10.8	5.0	6.0	4.5	7.6	8.0
30-34	5.8	5.8	7.5	4.3	6.4	1.0	5.5	6.7
35-39	5.6	4.0	2.8	5.3	4.8	1.9	7.6	5.7
40-44	5.6	4.9	5.2	7.6	5.1	4.7	6.3	5.0
45-49	5.5	6.1	6.5	6.6	5.9	12.0	4.4	5.3
50-54	5.1	4.9	2.8	3.7	6.1	5.5	5.6	5.2
55-59	5.0	5.1	6.2	4.5	4.5	5.5	3.5	4.6
60-64	4.4	4.4	2.3	5.3	4.7	3.6	4.4	4.3
65+	10.5	12.8	10.3	11.7	12.0	14.0	15.5	9.4
NS								0.3
TOTAL	100	100	100	100	100	100	100	100

Source: ABS

TABLE C.3

WORKFORCE (1976)

	Males		Females		Total	% Population in workforce
	No	%	No	%		
Nanango Shire	811	64.3	450	35.7	1262	42.6
Nanango Urban Area	242	64.2	135	35.8	377	33.9
Neumgna Locality	57	59.4	40	41.6	96	47.8
Yarraman Urban Area	156	68.7	70	30.8	227	38.0
Kingaroy Urban Area	1359	61.9	839	38.1	2197	43.2
Cooyar Locality	61	56.0	47	43.1	109	47.8
Blackbutt Urban Area	112	70.9	46	29.1	158	37.4

Source: ABS

TABLE C.4

INDUSTRY OF EMPLOYED PERSONS, 1976

	Nanango Shire				Nanango Urban Area				Neumgna Locality				Yarraman Urban Area				Kingaroy Urban Area				Cooyar Locality				Blackbutt Urban Area			
	Male	Female	Persons	%	Male	Female	Persons	%	Male	Female	Persons	%	Male	Female	Persons	%	Male	Female	Persons	%	Male	Female	Persons	%	Male	Female	Persons	%
AGRICULTURE, FORESTRY, HUNTING	364	162	526	43.0	8	2	10	2.7	41	23	64	67.6	47	3	50	22.2	90	44	134	6.3	42	24	67	62.4	41	4	46	29.6
MINING	4	0	4	0.3	2	0	2	0.5	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	2	2	4	4.0	0	0	0	0.0
MANUFACTURING	70	17	87	7.1	22	4	26	7.2	0	0	0	0.0	16	0	16	7.1	144	26	170	8.0	0	0	0	0.0	22	9	31	20.0
ELECTRICITY, GAS, WATER	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	6	0	6	2.7	38	3	41	1.9	0	0	0	0.0	0	0	0	0.0
CONSTRUCTION	59	2	61	5.0	32	0	32	8.8	4	0	4	3.9	6	0	6	2.7	154	19	173	8.1	6	0	6	5.7	12	0	12	7.5
WHOLESALE, RETAIL	84	63	148	12.1	64	30	95	26.1	2	2	4	4.0	18	18	36	15.9	489	233	722	33.9	0	2	2	2.1	2	11	13	8.3
TRANSPORT AND STORAGE	32	8	40	3.3	18	6	24	6.6	2	0	2	2.0	16	2	18	8.0	31	6	38	1.8	2	2	4	4.0	8	2	10	6.4
COMMUNICATIONS	9	9	18	1.5	6	5	11	3.0	0	0	0	0.0	2	10	12	5.3	31	10	41	1.9	0	2	2	2.1	2	4	6	4.1
FINANCE, BUSINESS SERVICES	13	12	25	2.0	11	10	21	5.8	0	0	0	0.0	4	3	7	3.1	76	63	139	6.5	0	0	0	0.0	2	0	2	1.3
PUBLIC ADMINISTRATION, DEFENCE, ETC.	63	6	69	5.7	20	0	20	5.6	5	0	5	6.1	22	2	24	10.6	58	24	82	3.9	0	0	0	0.0	6	2	8	5.1
COMMUNITY SERVICES	38	88	126	10.3	20	34	54	14.9	2	10	12	12.8	12	12	24	10.6	103	241	343	16.1	0		4	4.0	8	4	12	7.5
ENTERTAINMENT, RECREATION, ETC.	22	25	47	3.8	14	14	28	7.8	1	1	2	2.1	2	7	9	4.0	53	66	119	5.6	1	1	2	1.9	2	6	8	5.4
OTHER, N.S., N.E.I.	25	49	73	6.0	14	25	39	10.8	1	2	3	3.1	6	12	18	7.9	64	64	127	6.0	6	9	15	13.9	4	3	7	4.6
TOTAL EMPLOYED	783	440	1224	100	232	131	363	100	57	38	94	100	156	68	225	100	1332	799	2131	100	59	47	107	100	108	46	154	100

Source: ABS

TABLE C.5

OCCUPATION OF EMPLOYED PERSONS, 1976

OCCUPATIONAL CLASSES	NANANGO SHIRE*				NANANGO URBAN AREA				NEUMGNA LOCALITY				YARRAMAN URBAN AREA				KINGAROY URBAN AREA				COOYAR LOCALITY				BLACKBUTT URBAN AREA			
	MALE	FEMALE	PERSONS	%	MALE	FEMALE	PERSONS	%	MALE	FEMALE	PERSONS	%	MALE	FEMALE	PERSONS	%	MALE	FEMALE	PERSONS	%	MALE	FEMALE	PERSONS	%	MALE	FEMALE	PERSONS	%
TEACHERS	14	36	50	4.1	4	15	19	5.3	2	6	8	8.1	8	6	14	6.2	32	68	100	4.7	0	0	0	0.0	4	4	8	5.3
MEDICAL/DENTAL, NURSES ETC.	2	18	20	1.6	2	4	6	1.7	0	2	2	2.0	0	0	0	0.0	13	45	58	2.7	0	0	0	0.0	0	0	0	0.0
OTHER PROFESSIONAL TECHNICAL	8	0	8	0.6	6	0	6	1.7	0	0	0	0.0	6	0	6	2.7	58	19	77	3.6	0	0	0	0.0	0	0	0	0.0
ADMIN., EXEC., ETC.	31	6	37	3.0	17	6	23	6.4	0	0	0	0.0	10	1	11	4.9	164	16	180	8.5	0	0	0	0.0	6	0	6	3.8
CLERICAL WORKERS	22	61	83	6.8	19	30	50	13.6	0	1	1	1.1	6	9	15	6.6	73	247	320	15.0	0	5	5	5.1	1	12	13	8.3
SALES WORKERS	26	42	68	5.6	24	18	42	11.7	2	2	4	4.0	6	14	20	8.8	144	107	251	11.8	3	2	5	4.9	0	11	11	7.0
FARMERS, FARM WORKERS ETC.	319	160	479	39.2	2	0	2	0.6	39	23	62	65.6	8	5	13	5.8	86	40	126	5.9	42	27	69	64.4	6	4	10	6.5
HUNTERS, TIMBER WORKERS, ETC.	89	0	89	7.3	14	0	14	3.9	5	0	5	5.1	45	0	45	19.9	14	0	14	0.6	2	0	2	1.9	45	0	45	29.3
MINERS, QUARRYMEN	4	0	4	0.3	2	0	2	0.5	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
TRANSPORT COMMUNIC.	40	10	50	4.1	26	6	32	8.8	0	0	0	0.0	22	12	34	15.0	71	10	81	3.8	2	2	4	4.0	4	4	8	5.3
METAL, ELECTRICAL TRADESMEN	31	0	31	2.6	24	0	24	6.6	0	0	0	0.0	14	0	14	6.2	229	2	231	10.8	0	0	0	0.0	4	0	4	2.5
WOOD TECH, BUILDING TRADESMEN	50	6	56	4.6	10	0	10	2.7	0	0	0	0.0	8	0	8	3.5	100	0	100	4.7	0	0	0	0.0	19	2	21	13.9
OTHER TRADESMEN, PROD. PROC. WKRS.	42	6	48	3.9	28	4	32	8.8	2	0	2	2.0	10	0	10	3.9	125	57	183	8.6	6	0	6	5.7	2	0	2	1.2
LABOURERS	49	2	51	4.2	20	0	20	5.5	6	0	6	5.9	6	0	6	2.7	111	6	117	5.5	0	0	0	0.0	13	0	13	8.1
SERVICE, SPORT, RECREATION	28	51	79	6.4	18	24	42	11.7	1	2	3	3.1	4	12	16	7.1	66	133	198	9.3	0	2	2	2.1	3	6	9	6.0
ARMED FORCES	4	0	4	0.3	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0
OTHER, NEI, N/S	25	42	67	5.4	15	23	38	10.5	1	2	3	3.1	4	10	14	6.2	47	49	96	4.5	4	9	13	12.0	2	2	4	2.7
TOTAL EMPLOYED	783	440	1224	100	232	131	363	100	57	38	94	100	156	68	255	100	1332	799	2131	100	59	47	107	100	108	46	154	100

* Note: Nanango Shire includes Nanango Urban Area, Neumgna Locality and Blackbutt Urban Area

Source: ABS

TABLE C.6

REGISTERED UNEMPLOYED PERSONS

Month	Rosalie Shire*			Nanango Shire*			Kingaroy Shire		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
April, 1978	29	15	44	91	23	114	122	53	175
July, 1978	32	6	38	56	14	70	87	30	117
October, 1978	25	11	36	73	20	93	82	39	121
April, 1979	32	22	54	63	35	98	60	71	131

Source: Dept. of Employment and Youth Affairs, Manpower Research and Information Branch

*Some persons from these shires may be registered outside the Gympie Employment Region

TABLE C.7

UNEMPLOYMENT STATISTICS, 1978-1979

OCCUPATIONAL GROUP	Toowoomba Employment Region[1]								Gympie Employment Region[2]									
	July, 1978*		October, 1978		February, 1979		May, 1979		July, 1978		October, 1978		February, 1979		May, 1979			
	Persons	%	Persons	%	Persons	%	Persons	%	Persons	%	Persons	%	Persons	%	Persons	%		
RURAL	240	7.43	93	4.36	122	4.39	102	4.12	70	9.31	77	10.25	80	7.67	66	8.80		
PROFESSIONAL AND SEMI-PROFESSIONAL	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00		
CLERICAL AND ADMINISTRATIVE	892	27.63	614	28.77	974	35.07	878	35.46	196	26.06	163	21.70	391	37.50	287	38.27		
SKILLED MINING	1	0.03	0	0.00	0	0.00	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00		
SKILLED BUILDING AND CONSTRUCTION	150	4.65	90	4.22	85	3.06	52	2.10	39	5.19	29	3.86	35	3.36	12	1.60		
SKILLED METAL TRADES	87	2.70	52	2.44	100	3.60	61	2.46	30	4.00	35	4.66	43	4.12	23	3.07		
OTHER SKILLED	29	0.90	20	0.94	42	1.51	45	1.82	9	1.20	10	1.33	10	0.96	2	0.27		
SEMI-SKILLED	593	18.37	434	20.34	498	17.93	459	18.54	92	12.23	79	10.52	103	9.88	75	10.00		
UNSKILLED	848	26.27	548	25.68	597	21.50	546	22.05	254	33.78	287	38.22	286	27.42	205	27.33		
SERVICE OCCUPATIONS	388	12.02	283	13.26	359	12.93	330	13.33	62	8.24	71	9.45	95	9.11	80	10.67		
TOTAL	3228	100.0	2134	100.0	2777	100.0	2476	100.0	752	100.0	751	100.0	1043	100.0	750	100.0		

[1] Toowoomba Employment Region includes Toowoomba City and the Shires of Cambooya, Clifton, Crows Nest, Jondaryan, Millmerran, Pittsworth and Rosalie. Before August, 1978, the Dalby Employment Region was included in Toowoomba Employment Region

[2] Gympie Employment Region includes Gympie City and the Shires of Kilkivan, Kingaroy, Murgon, Nanango, Widgee and Wondai

* Note: These figures include the Dalby Employment Region

Source: Dept. of Employment and Youth Affairs, Manpower Research and Information Branch

TABLE C.8

RELATIVE IMPORTANCE OF INDUSTRIES IN

NANANGO PLUS KINGAROY, WIDE BAY-BURNETT,

QUEENSLAND AND AUSTRALIA

Industry	Nanango and Kingaroy 1971		Wide Bay-Burnett 1973-74		Queensland 1973-74		Australia 1968-69	
	Employment (persons)	Percent	Output ($,000)	Percent	Output ($,000)	Percent	Output ($,000)	Percent
Agriculture	1,601	36	148,459	26	1,163,045	12	3,735,795	7
Mining	21	0.5	7,315	1	656,873	7	1,000,621	2
Manufacturing	396	9	166,611	29	2,948,028	30	16,525,741	33
Electricity, gas & water	10	0.2	16,389	3	296,986	3	1,157,247	2
Building & construction	252	6	65,597	11	1,091,823	11	4,845,692	10
Wholesale & retail trade	1,027	23	52,474	9	1,116,416	11	6,056,729	12
Transport & communication	205	4	33,681	6	722,057	7	3,384,996	7
Finance, insurance & business services	172	4	34,167	6	854,301	9	4;990,694	10
Public administration & defence	182	4	16,175	3	419,045	4	2,050,210	4
Community services & entertainment, recreation & personal services	577	13	31,969	6	614,912	6	6,610,854	13
TOTAL	4,443	100	572,837	100	9,883,486	100	50,358,579	100

Source: Nanango and Kingaroy - calculated from Australian Bureau of Statistics, Population Census, 1971
Wide Bay-Burnett and Queensland - calculated from GRIT table for 1973-74
Australia - calculated from the 1968-69 Australian input-output table adjusted to the GRIT format

Appendix D

COMMERCIAL AND INDUSTRIAL FACILITIES

NANANGO TOWNSHIP

(i) Commercial and Industrial Establishments

Supermarket
Milk Bar/Cafe (3)
Electrical Goods (2)
Footwear/Sporting Goods
Banks (3)
Butcher (2)
Drapery (2)
Pharmacy (2)
General Store/Merchant (2)
Solicitor
Dress Shop (3)
Ladies Hairdresser
Newsagent
TAB
Tax Agency (2)
Real Estate Agency (2)
Bakery
Menswear
Hotel (3)
Accountant (2)
Insurance Agency
Stock and Station Agency
Opportunity Shop
Furniture
Motel (1 + 1 u/c)
Caravan Park (3)
Dentist
Hardwear
Footwear
Gift Shop
Veterinary Surgeon
Farm Produce Merchant
Machinery Hire Service
Bank Agency (3)
Engineering Works
Garage (5)
Panel Beater
General Carrier (5)
Plumber
Tyre Service (2)
Refrigeration Service
Milk Collection Depot
Soft Drink Depot
Sand and Gravel Contractor
Fuel Depot
Timber Mill
Stock Saleyards
Dairy Factory
Nanango Shire Council Works Depot

(ii) Institutional Facilities

Post Office
Q.A.T.B. Centre
Police Station

Courthouse
Shire Council Offices & Civic Centre
Department of Primary Industries
Kindergarten
Catholic School
State Pre-school Centre
Nanango State School (with Secondary Dept.)
Cemetery
Fire Brigade
Telecom Depot
Public Library
Hospital
Maternal and Child Welfare Centre
Light Aircraft Landing Strip
Red Cross
Aged Peoples Units (2)

(iii) Recreational and Community Facilities

Show Grounds
Racecourse
Municipal Swimming Pool
Bowling Green (2)
Sports Oval
Tennis Courts (3 used, 2 unused, 2 at State school, 1 at Catholic school)
Cricket Oval
Stables
Basket Ball Courts (2)
Squash Court
Football Ovals with night lights (2)
Golf Course
Scout Den
Baptist Church
Salvation Army Hall
Uniting Church (2)
S.E.S.
Anglican Church
Catholic Church
Lutheran Church
Masonic Lodge Hall
Tara's Hall

Associated with the above facilities are many sporting, social and service clubs. The sporting clubs are relatively strong within the community, and include such clubs as golf, bowls, league, cricket and swimming. Service clubs include such groups as Lions, C.W.A., Jaycees, Rural Youth, Show Society, Parents & Citizens Assn. and so on. In all, Nanango is reasonably well served by social facilities and organisations considering the population base within the district.

YARRAMAN TOWNSHIP

(i) Commercial and Industrial Establishments

Butcher (2)
Hotel (3)
Stock and Station Agent (2)
Bank
Newsagent (2)
Electrical Goods
Supermarket (2)
Cafe
Visiting Tax Agent
Hardware
Drapery
Real Estate
Milk Bar/Cafe
Visiting Solicitor
Pharmacy
Ladies and Menswear
Motel
Dry Cleaning Agent
R.A.C.Q. Agent
Farm Produce Merchant
Bacon Factory
Bus Depot
Saw mill (3)
Carrier (4)
Fuel Depot (2)
Equipment Hire/Contractor
Trucks and Farm Machinery
Garage (4)
Engineering Works

(ii) Institutional Facilities

Police Station
Department of Forestry - District Headquarters & Nursery
Railway Terminal
Department of Primary Industries - Inspector
Q.A.T.B. Centre
Rosalie Shire Council Works Depot
Post Office
Fire Brigade
Maternal and Child Welfare Centre
State School - Pre-school, Primary and Secondary

(iii) Recreational and Community Facilities

Showgrounds
Memorial Hall
C.W.A. Hall
Sports Oval and Football Field

Tennis Courts (3)
Bowling Green
Billiard Saloon
Anglican Church
Catholic Church
Jehovah's Witnesses
Lutheran Church and Hall
Synagogue and Hall
Public Toilets

Associated with the above facilities are several sporting, social and service clubs. The size of the Yarraman community has tended in the past to preclude the development of a wide range of social clubs and activities.

Appendix E

SURFACE WIND ANALYSIS - KINGAROY

BUREAU OF METEOROLOGY - SURFACE WIND ANALYSIS

PERCENTAGE OCCURRENCE OF SPEED VERSUS DIRECTION
BASED ON 8 YEARS OF RECORDS

KINGAROY

JANUARY 0900 HOURS LST

SPEED (KM/HR)

DIRN	CALM	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N	19		2	4	*				6
NE		1	6	9	1				17
E		1	5	6	3	*			14
SE		1	4	19	5				28
S							*		*
SW			1	1	1				3
W			1	*					1
NW		*	3	5	1				10
ALL		4	22	43	11	*	*		

NO. OF OBS. 216

JANUARY 1500 HOURS LST

SPEED (KM/HR)

DIRN	CALM	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N	19	*	1	1	*		*		4
NE		1	4	9	3				17
E		*	6	7	4				18
SE			2	20	2	1			26
S				1					1
SW			2	2	*				5
W		*	1	3					5
NW		*	1	2					4
ALL		3	19	47	10	1	*		

NO. OF OBS. 206

FEBRUARY 0900 HOURS LST

SPEED (KM/HR)

DIRN	CALM	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N	11		1	2					3
NE			3	5	2				9
E		1	6	11	5				22
SE			9	22	7	4	1		42
S									
SW			1	1					1
W			2	1					2
NW			2	8	1				11
ALL		1	22	49	14	4	1		

NO. OF OBS.196

FEBRUARY 1500 HOURS LST

SPEED (KM/HR)

DIRN	CALM	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N	17	1	1	1	1				2
NE			3	8	2				13
E			6	8	2	1			16
SE			5	23	11	2	1		41
S				2					2
SW			1						1
W			1	1					2
NW			2	4	1				6
ALL		1	17	47	16	2	1		

NO. OF OBS.189

MARCH 0900 HOURS LST

SPEED (KM/HR)

DIRN	CALM	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N	14		*	1	*				2
NE			1	2	1				4
E			4	11	6				22
SE			6	25	8	1			40
S				1					1
SW			1	2		*			4
W			2	3					5
NW			2	6	1				8
ALL			17	50	17	2			

NO. OF OBS.217

MARCH 1500 HOURS LST

SPEED (KM/HR)

DIRN	CALM	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N	13		1	1					2
NE			3	3	2				8
E		*	7	5	5	*	8		20
SE			15	21	4	1			41
S				1					1
SW			*	4	1	*			7
W				1					1
NW			1	5					6
ALL		*	28	43	13	2	*		

NO. OF OBS. 205

BUREAU OF METEOROLOGY - SURFACE WIND ANALYSIS

PERCENTAGE OCCURRENCE OF SPEED VERSUS DIRECTION
BASED ON 8 YEARS OF RECORDS

KINGAROY

APRIL 0900 HOURS LST

SPEED (KM/HR)

DIRN	CALM 31	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N			*		*	1			2
NE		1	1	1					3
E		*	5	4	2			*	12
SE		1	7	22	3	2	*		36
S			*	1		*			2
SW			2	2	*				5
W				1					1
NW		1	2	5	1				9
ALL		4	17	36	8	3	*	*	

NO. OF OBS. 208

APRIL 1500 HOURS LST

SPEED (KM/HR)

DIRN	CALM 21	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N			1	1	1				2
NE			4	2		1			6
E		1	4	7	3	1			16
SE		*	7	24	2	2			34
S			1	1	1				2
SW			2	7	2	1			12
W				1	1				1
NW			3	3	1		1		7
ALL		1	21	45	8	4	1		

NO. OF OBS. 190

MAY 0900 HOURS LST

SPEED (KM/HR)

DIRN	CALM 33	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N		*							*
NE			1	*					2
E		1	3	1	1				6
SE		2	8	19	3	1	*		33
S			2	1					3
SW		1	5	5	2	*	1		14
W			1	2	*		1		5
NW		1	2	*					4
ALL		5	22	29	7	2	2		

NO. OF OBS. 211

MAY 1500 HOURS LST

SPEED (KM/HR)

DIRN	CALM 19	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N				*					*
NE		1	1	2					5
E		1	5	3		*			10
SE		1	8	13	2	1			25
S			1	2	*				3
SW		*	4	10	4	3	*		23
W			2	2	1	*	*		7
NW		*	2	3		1			7
ALL		4	24	37	8	6	1		

NO. OF OBS. 201

JUNE 0900 HOURS LST

SPEED (KM/HR)

DIRN	CALM 46	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N									
NE									
E			2	2	*				4
SE			8	14	3	*			26
S			1	*	*				2
SW		1	5	6	2	1			16
W		*	1	1	*				4
NW		*	*	*					1
ALL		2	18	25	7	1			

NO. OF OBS. 203

JUNE 1500 HOURS LST

SPEED (KM/HR)

DIRN	CALM 26	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N				1					1
NE			3						3
E			3	2					5
SE		1	9	16	4				30
S			1	1	1				2
SW		1	5	11	5	2	1		25
W		2	2	3	1	1			8
NW			1	1	1				2
ALL		4	23	34	10	2	1		

NO. OF OBS. 194

BUREAU OF METEOROLOGY - SURFACE WIND ANALYSIS

PERCENTAGE OCCURRENCE OF SPEED VERSUS DIRECTION
BASED ON 8 YEARS OF RECORDS

KINGAROY

JULY 0900 HOURS LST

SPEED (KM/HR)

DIRN	CALM 46	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N			*	*	*				1
NE			1	1					2
E		2	1	1	2				6
SE		1	8	8	1	2	*		22
S		*	1	1	*	*			3
SW			4	5	2	1			12
W			1	2	*	*			4
NW			2	*	*				3
ALL		4	19	19	7	4	*		

NO. OF OBS. 216

JULY 1500 HOURS LST

SPEED (KM/HR)

DIRN	CALM 25	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N		*	*	*					1
NE			2	1					3
E		1	3	3	1				8
SE		*	6	10	2				18
S		*		3	*				4
SW			6	13	5	1	*		26
W			1	4	1	*			7
NW		*	3	3	1				7
ALL		3	22	37	11	2	*		

NO. OF OBS. 208

AUGUST 0900 HOURS LST

SPEED (KM/HR)

DIRN	CALM 41	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N			*	1					1
NE			2	1	*				3
E			3	2	*	*	*		6
SE		1	4	9	4	1	*		19
S			2	1	*				3
SW		1	5	4	3	1	*	*	15
W		*	1	1	*		*		3
NW		1	3	4	1				8
ALL		3	19	23	10	2	1	*	

NO. OF OBS. 245

AUGUST 1500 HOURS LST

SPEED (KM/HR)

DIRN	CALM 17	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N			2	2	*	*			5
NE			6	2					8
E		*	2	3	1				7
SE		*	6	8	1				16
S			*	2		*			3
SW			6	9	7	1	*		23
W			3	4	3	1			11
NW		*	4	5	1				10
ALL		1	30	34	14	3	*		

NO. OF OBS 218

SEPTEMBER 0900 HOURS LST

SPEED (KM/HR)

DIRN	CALM 18	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N			1	2	1				3
NE			2	5	1				9
E			3	2	1				5
SE			6	9	1	2			17
S			*	3	*	*			4
SW		*	5	8	3	1			18
W			2	3	*		*		6
NW		*	6	10	2	*	*		20
ALL		1	24	42	10	4	1		

NO. OF OBS. 238

SEPTEMBER 1500 HOURS LST

SPEED (KM/HR)

DIRN	CALM 14	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N			*	1					2
NE			5	3	*				8
E			3	4	*				7
SE		*	2	7		*			10
S			1	1	1		*		3
SW			5	12	5	2		*	24
W		*	3	6	2	1	*		12
NW			4	12	3	1			20
ALL		1	23	46	11	4	1	*	

NO. OF OBS. 230

BUREAU OF METEOROLOGY - SURFACE WIND ANALYSIS

PERCENTAGE OCCURRENCE OF SPEED VERSUS DIRECTION
BASED ON 8 YEARS OF RECORDS

KINGAROY

OCTOBER 0900 HOURS LST

SPEED (KM/HR)

DIRN	CALM 14	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N			5	2	*				7
NE			5	7	*				12
E		*	8	7	1	*			17
SE		*	4	5	4	*			14
S			*	*					1
SW			3	4	2	*			9
W		*	2	2					4
NW			8	11	3	*			22
ALL		1	34	39	11	2			

NO. OF OBS.244

OCTOBER 1500 HOURS LST

SPEED (KM/HR)

DIRN	CALM 15	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N			4	4					8
NE		1	6	11	2				19
E		1	4	5	1	*			11
SE		*	3	6	2				12
S			1	1					2
SW			4	6	3	1			13
W		*	2	2	1				5
NW			6	7	1	*			14
ALL		3	29	42	10	2			

NO. OF OBS.236

NOVEMBER 0900 HOURS LST

SPEED (KM/HR)

DIRN	CALM 14	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N		*	3	2					5
NE		*	3	8					12
E		1	5	7	3	*			17
SE		*	6	6	2	*			15
S		*	1	*	*				2
SW			1	4	1	*			7
W			1	3	1				6
NW		1	8	11	2				22
ALL		5	27	42	11	1			

NO. OF OBS.205

NOVEMBER 1500 HOURS LST

SPEED (KM/HR)

DIRN	CALM 10	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N			4	2	1				6
NE		1	4	10	1				15
E		2	8	3	1	1			13
SE		1		7	1				8
S									
SW		2	5	9	5	1			21
W		1	2	4	2		1		9
NW		1	5	11					17
ALL		6	27	45	9	2	1		

NO. OF OBS.194

DECEMBER 0900 HOURS LST

SPEED (KM/HR)

DIRN	CALM 18	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N		*	1	5	*	*			8
NE			7	7	1				15
E		1	3	7	5	1			17
SE		*	2	11	1	*			16
S						*			*
SW			1	1					2
W		*	2	2	1				6
NW		3	4	8	2				17
ALL		6	21	42	11	2			

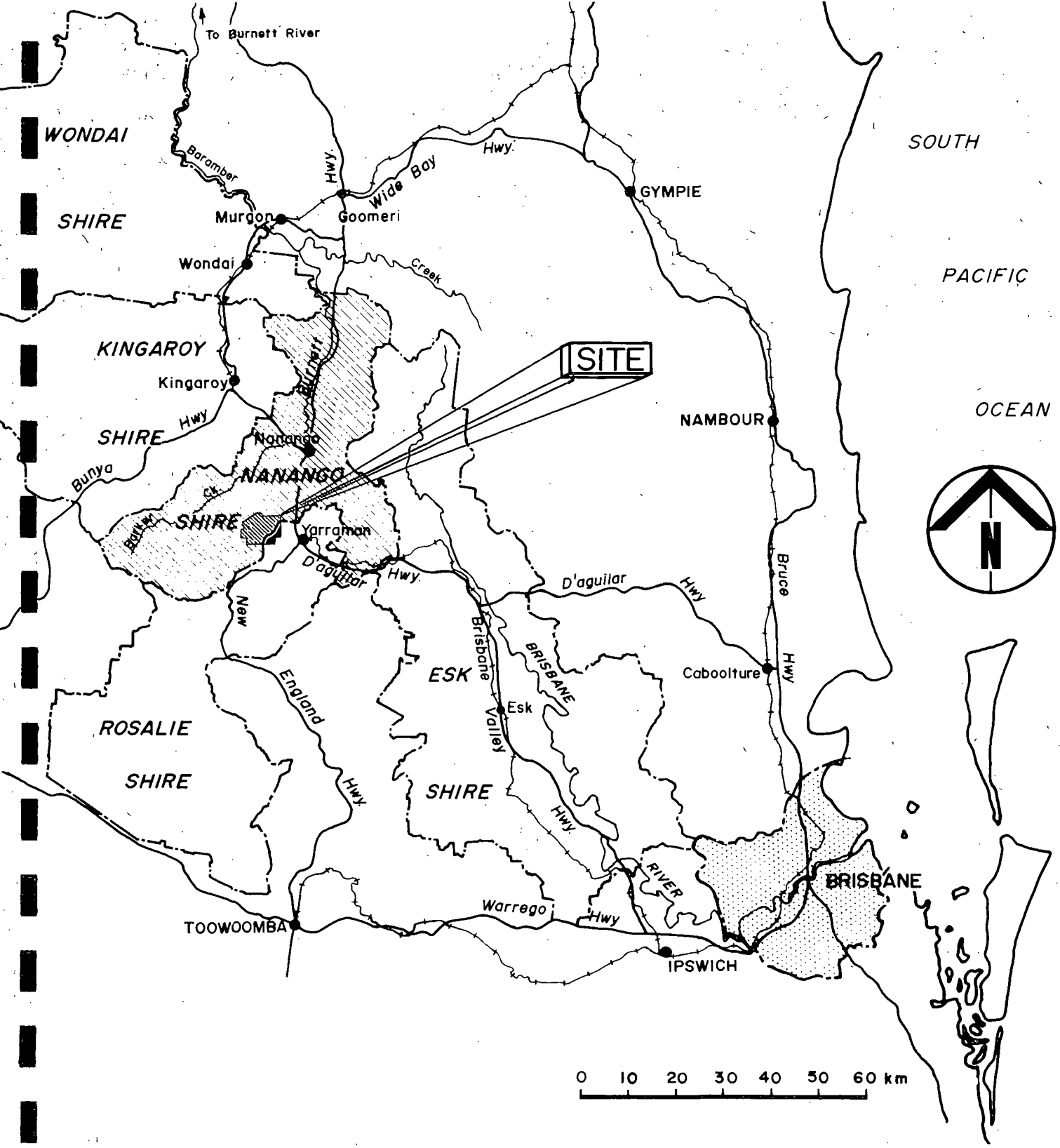
NO. OF OBS.213

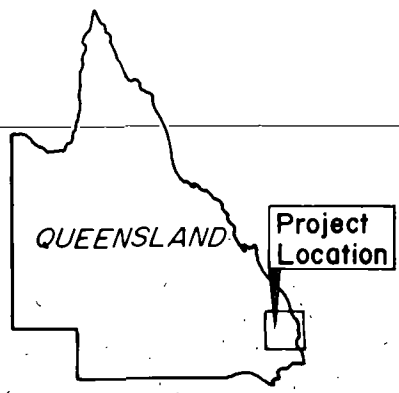
DECEMBER. 1500 HOURS LST

SPEED (KM/HR)

DIRN	CALM 16	1 TO 5	6 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 & UP	ALL
N		*	1	3	1	*			7
NE		1	3	9	1				16
E		*	4	9	*				15
SE		*	3	12	3	*			19
S				*					*
SW		*	1	3	*	*			6
W		*	1	3	1				5
NW		1	1	9	3	1			16
ALL		5	17	49	11	2			

NO. OF OBS. 203





Peter Hollingsworth
and associated consultants

INVESTIGATOR COAL EXPLORATION PTY. LIMITED

TARONG COAL PROJECT

REGIONAL LOCATION

DATE	DRAWN by	SCALE	DRG No
JUNE 1979	A.B.	as shown	E 0351/1

KINGAROY
Kingaroy
KINGAROY
Goomeri
Hwy
Creek
Taabinga
Coolabunia
Glan Devon
Hwy
NANANGO
To Dalby
Bunya
SHIRE
MRD 419
Creek
Burnett
Range
Barker
Brisbane
Goodger
NANANGO
MRD 419
Sandy Ck.
MRD 429
MRD 40C
Creek
SHIRE
Brooklands
Meandu Creek
South Nanango
Creek
Cooyar
Tarong
Tanduringie Swamp
Meandu
Taromeo Ck.
Creek
Neumgna
ROSALIE
YARRAMAN
Maidenwell
Hwy
D'aguilar
To Brisban
Yarraman
MRD 22A
Hwy
Blackbutt
Range
New England
SHIRE
Cooyar
Creek
Cooyar
N
COOYAR
To Toowoomba

SCALE 1:150000

0 1 2 3 4 5 6 7 8 9 10km

LEGEND

- Roads
- Shire Boundaries
- Proposed Mining Lease Area

Peter Hollingsworth
and associated consultants

INVESTIGATOR COAL EXPLORATION PTY. LIMITED

TARONG COAL PROJECT

REGION OF INFLUENCE

DATE	DRAWN by	SCALE	DRG No
JUNE 1979	A.B.	1 : 150000	E 0351/2

KINGAROY

KINGAROY

Taabinga

Hwy

Coolabunia

Hwy

Bunya

SHIRE

Goodger

Barker

Creek

Burnett

NANANGO

Range

Brisbane

NANANGO

Brooklands

Meandu Creek

SHIRE

South Nanango

S.F 118

Tarong

Meandu

Creek

Cooyar

Creek

Creek

S F 289

YARRAMAN

R.163

Maidenwell

Hwy

Yarraman

D'aguilar

ROSALIE

Hwy

Blackbutt

Range

New England

SHIRE

The Palms National Park

Cooyar

Creek

Cooya

COOYAR

N

SCALE 1:150000

0 1 2 3 4 5 6 7 8 9 10km

LEGEND

- Roads
- Shire Boundaries
- Proposed Mining Lease Area
- State Forest
- Proposed National Park
- AtoP 235C

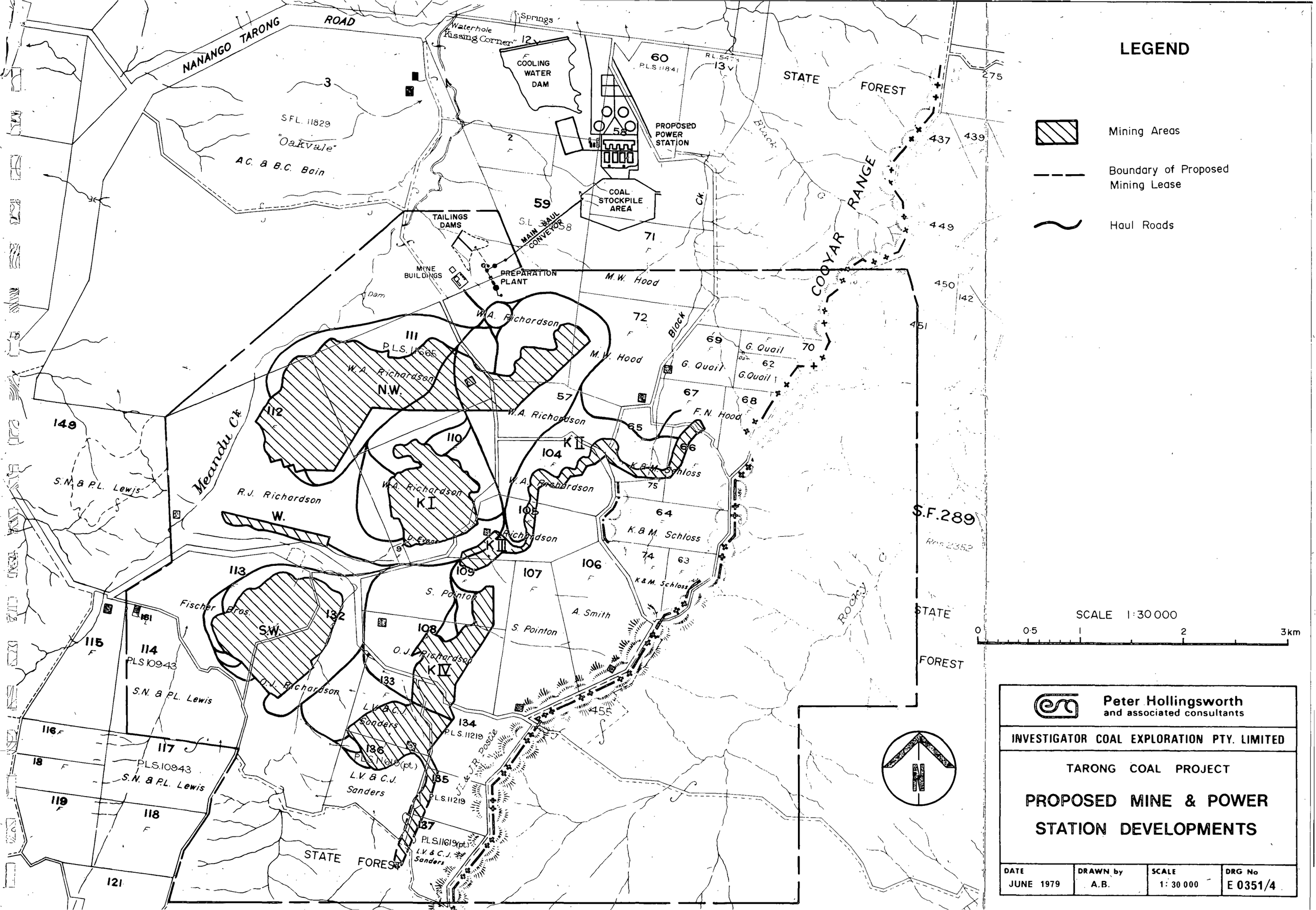
Peter Hollingsworth
and associated consultants

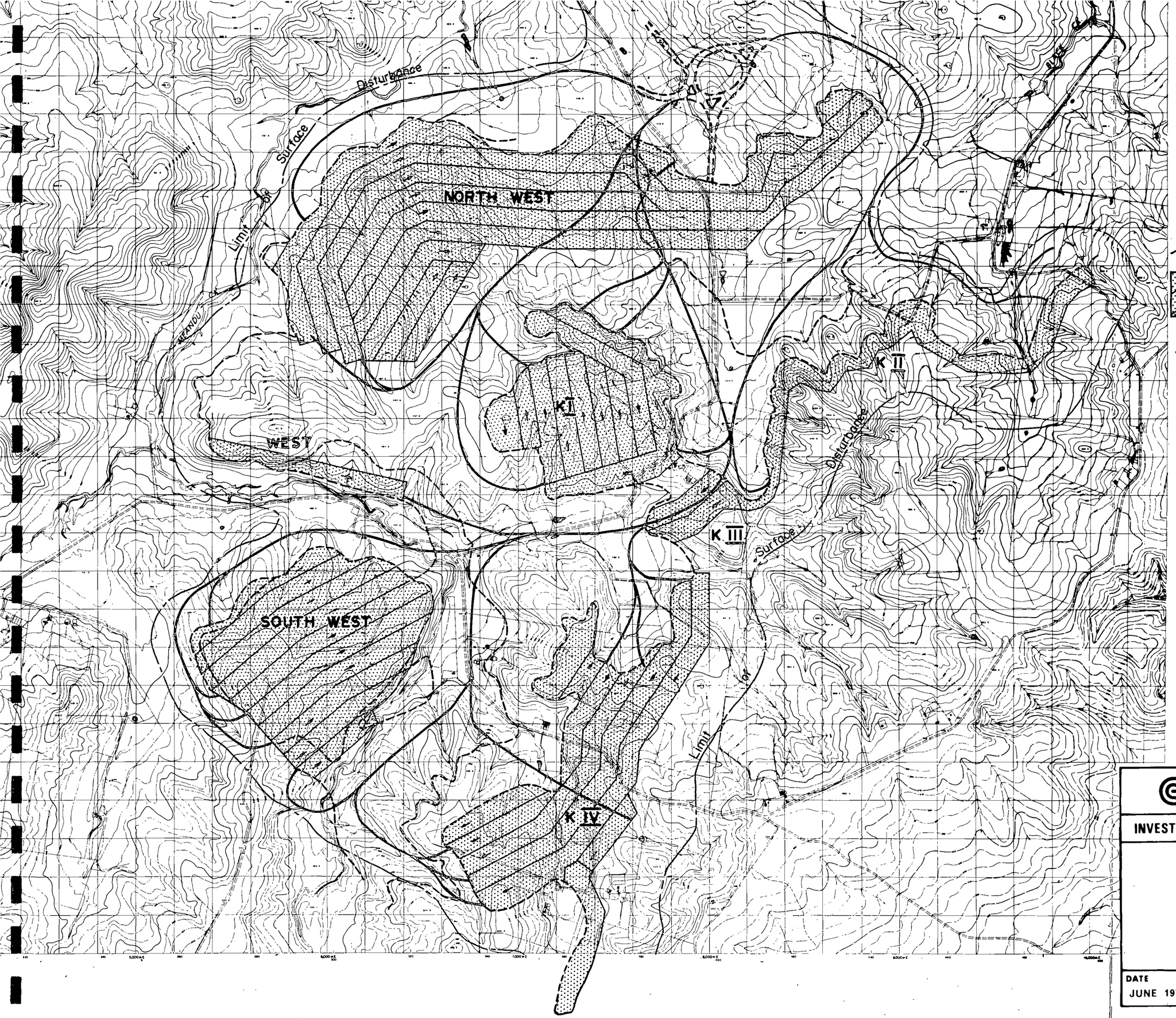
INVESTIGATOR COAL EXPLORATION PTY. LIMITED

TARONG COAL PROJECT

SIGNIFICANT STATUTORY AREAS

DATE	DRAWN by	SCALE	DRG No
JUNE 1979	A.B.	1 : 150 000	E 0351/3


LEGEND
Mining Areas
Boundary of Proposed Mining Lease
Haul Roads
SCALE 1:30 000
0 0.5 1 2 3km
NANANGO TARONG ROAD
Waterhole "Kissing Corner"
Springs
COOLING WATER DAM
PROPOSED POWER STATION
COAL STOCKPILE AREA
TAILINGS DAMS
MAIN HAUL CONVEYOR
MINE BUILDINGS
PREPARATION PLANT
STATE FOREST
COOYAR RANGE
S.F.289
Meandu Ck
Black Ck
Rocky C
S.F.L. 11829
"Oakvale"
A.C. & B.C. Bain
M.W. Hood
W.A. Richardson
N.W.
W.
S.W.
K I
K II
K III
K IV
R.J. Richardson
S.N. & P.L. Lewis
Fischer Bros.
O.J. Richardson
S. Pointon
A. Smith
K.& M. Schloss
G. Quail
F.N. Hood
L.V. & C.J. Sanders
J.L. & J.R. Postle
P.L.S. 11665
P.L.S. 10943
P.L.S. 11219
P.L.S. 11619(pt)
Peter Hollingsworth and associated consultants
INVESTIGATOR COAL EXPLORATION PTY. LIMITED
TARONG COAL PROJECT
PROPOSED MINE & POWER STATION DEVELOPMENTS
DATE JUNE 1979
DRAWN by A.B.
SCALE 1: 30 000
DRG No E 0351/4



LEGEND

- Direction of Workings
- Limit of 3metre Unoxidized Coal
- Mining Strip Areas
- Haul Roads

N

0 0·2 0·4 0·6 0·8 1 km

Contour Interval 5m.

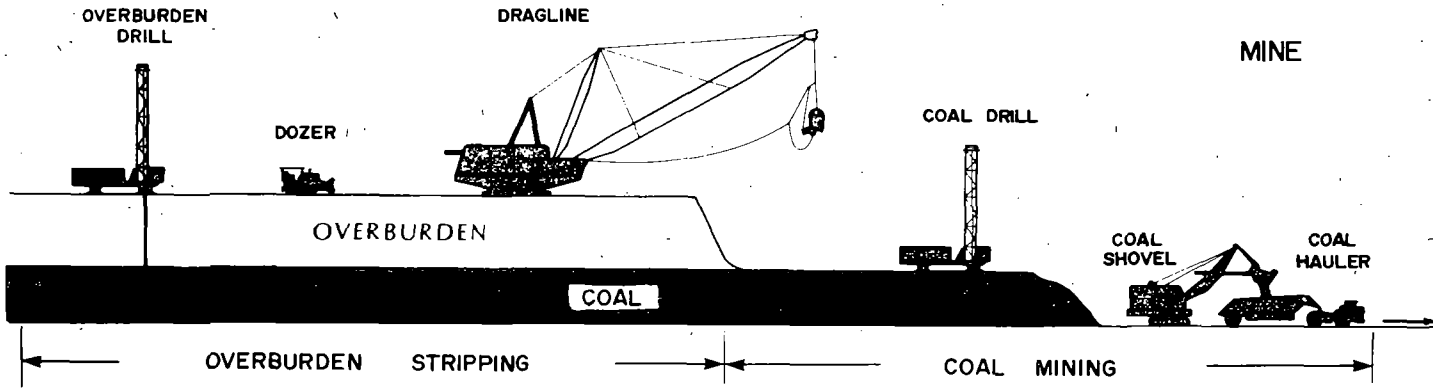
Peter Hollingsworth
and associated consultants

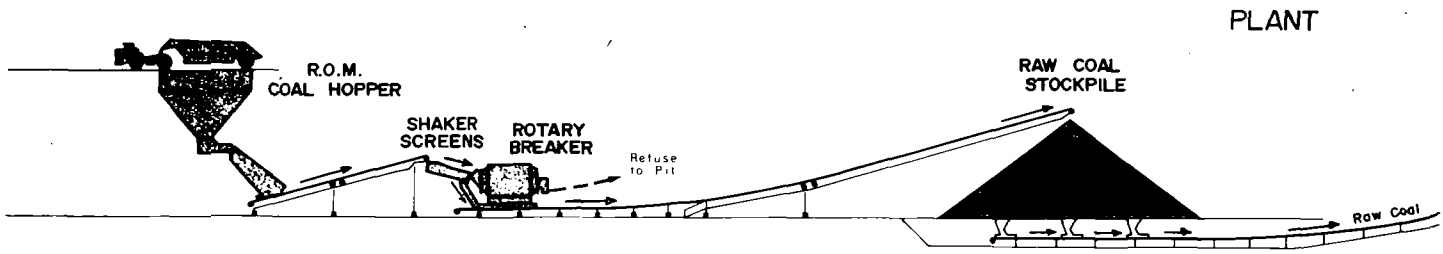
INVESTIGATOR COAL EXPLORATION PTY. LIMITED

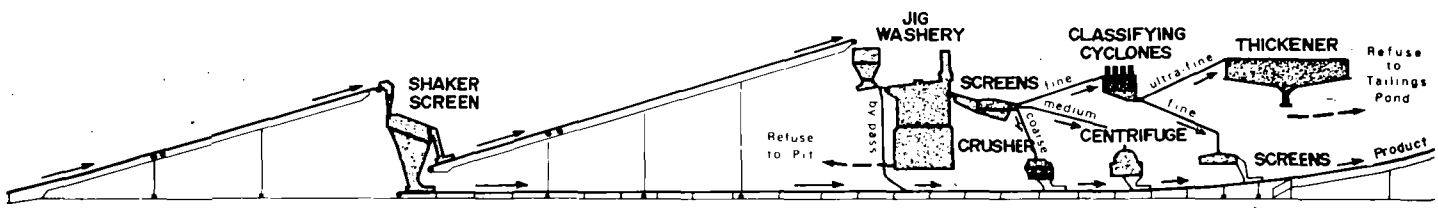
TARONG COAL PROJECT

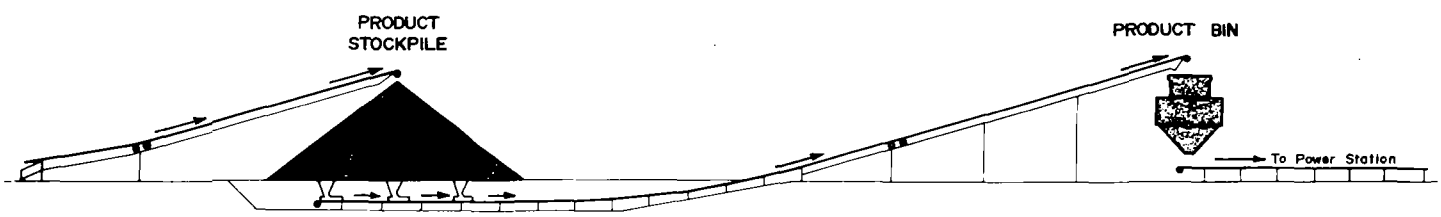
MINING PLAN

DATE	DRAWN by	SCALE	DRG No
JUNE 1979	A.B.	as shown	E 0351/5









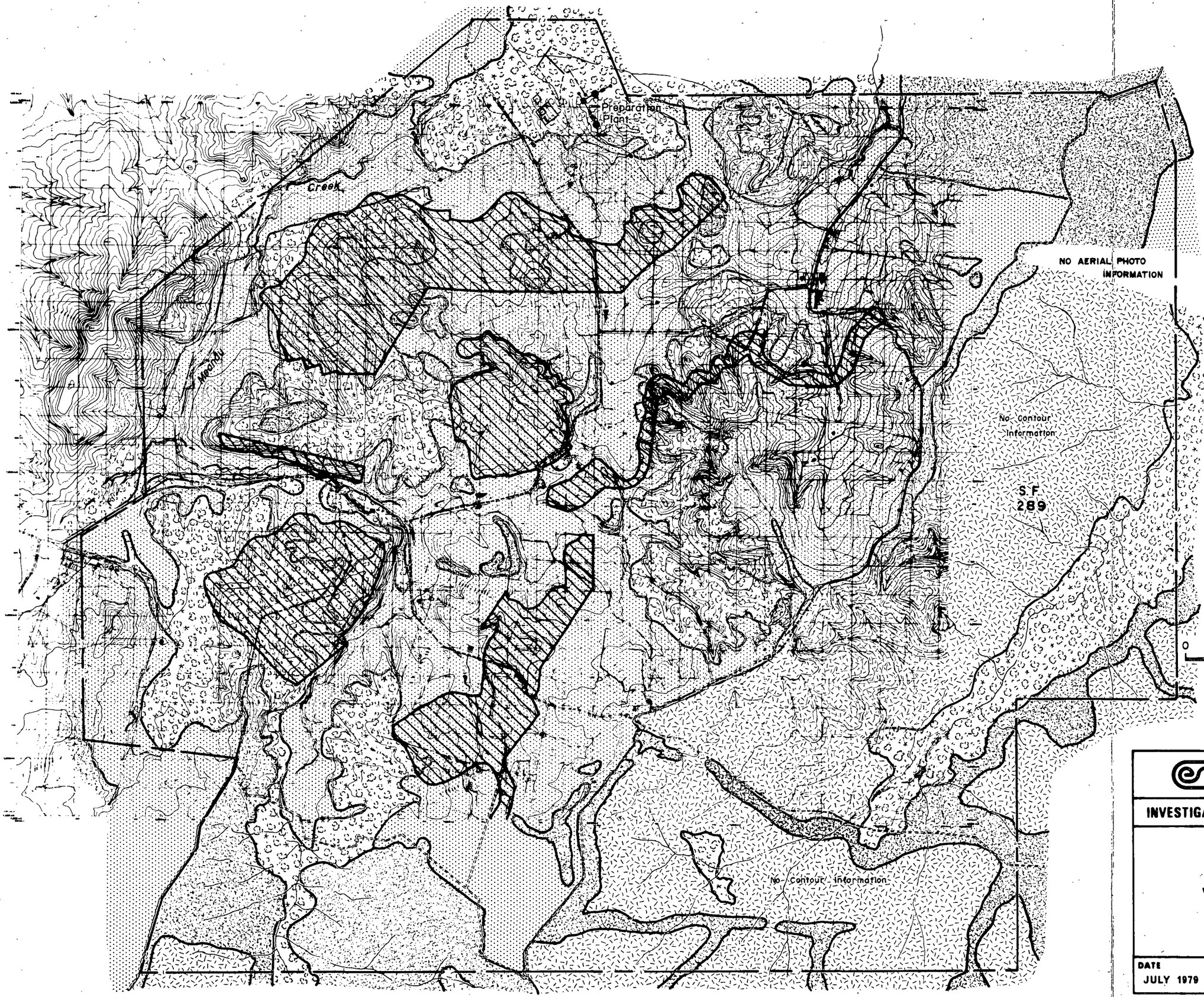
Peter Hollingsworth
and associated consultants

INVESTIGATOR COAL EXPLORATION PTY. LIMITED

TARONG COAL PROJECT

MINING & PREPARATION PROCESS

DATE	AFTER	SCALE	DRG No
SEPT 1979	C.R.A. Ltd.		E 0351/6



LEGEND

- Eucalyptus Open Forest
- Closed Vine Forest
- Plantation
- Grassland

N

SCALE 1:25000

0 0·5 1·0 1·5 2·0km

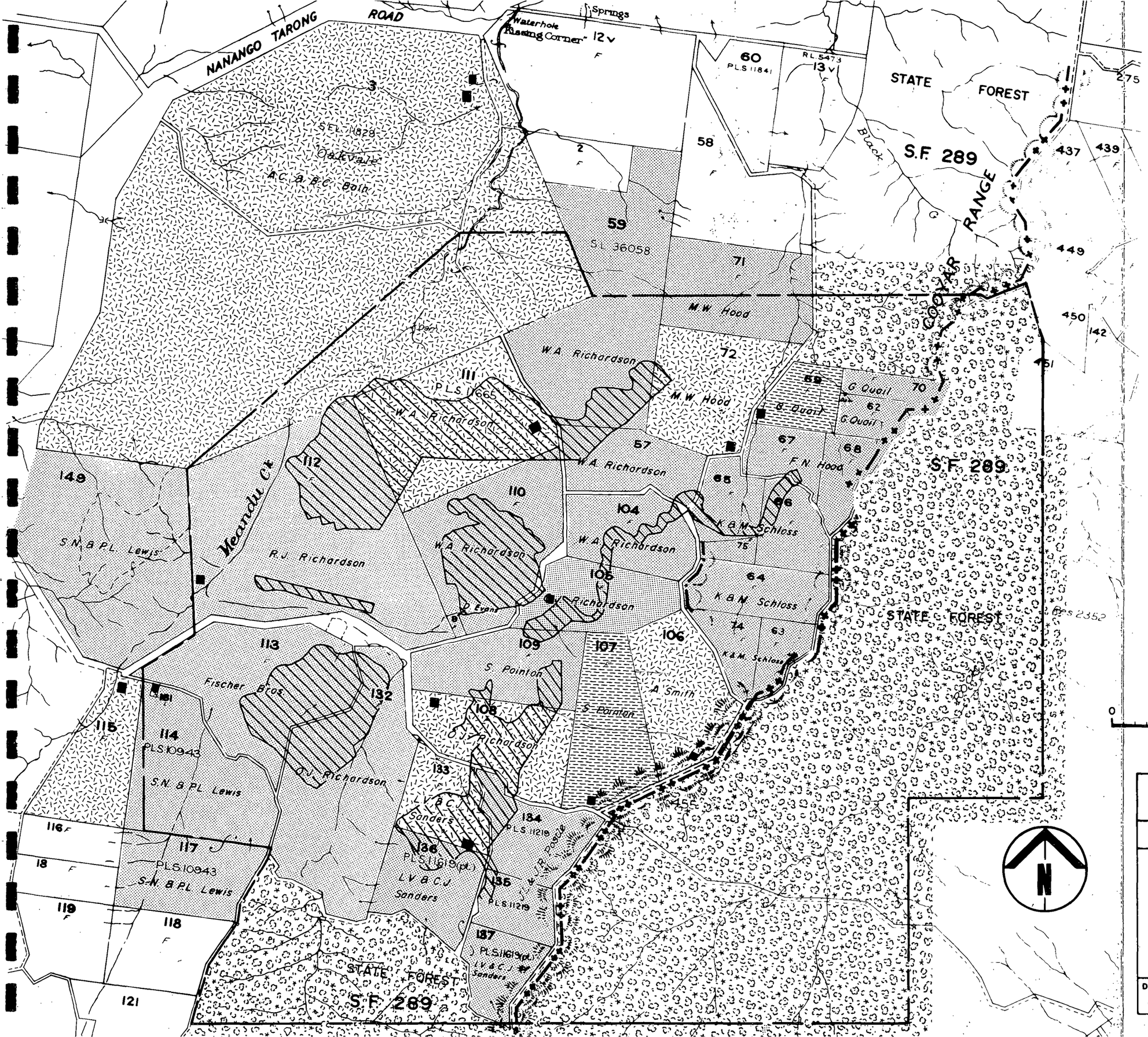
Peter Hollingsworth and associated consultants

INVESTIGATOR COAL EXPLORATION PTY. LIMITED

TARONG COAL PROJECT

VEGETATION TYPES

DATE	DRAWN by	SCALE	DRG No
JULY 1979	A.B.	1 : 25 000	E 0351/7



LEGEND

- Occupied Permanently
- Occupied Occasionally
- Unoccupied
- State Forest
- Rural Residence
- Boundary of Proposed Mining Lease
- Mining Areas

Peter Hollingsworth
and associated consultants

INVESTIGATOR COAL EXPLORATION PTY. LIMITED

TARONG COAL PROJECT

LAND TENURE

DATE	DRAWN by	SCALE	DRG No
JUNE 1979	A.B.	1: 30 000	E 0351/ 8

Appendix G

Community Consultation Plan



COMMUNITY CONSULTATION PLAN

Version 1.0

26 May 2022

MEANDU MINE

TRANSITIONAL PROGRESSIVE REHABILITATION AND CLOSURE PLAN

Submission : 30 May 2022

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Background

This plan outlines the community consultation, communication objectives and associated actions Stanwell has and will undertake with identified community members to inform them regarding the Progressive Rehabilitation and Closure Plan (PRC Plan) and to understand their needs, inputs and objectives so as to better inform the PRCP and its future development.

In addition to the community consultation and inputs conducted to develop the Transitional PRC Plan, this plan includes description of the additional activities Stanwell will undertake throughout the life of the PRC Plan to keep community members informed and updated in regard to;

- ongoing rehabilitation progress and general conformance to the PRC Plan;
- discussion of issues raised by the community and how they are being considered and included (or not included) in future consideration of the PRC Plan development; and
- Meandu Mine's PRC Plan development and any future proposed amendment.

This document forms part of the information requirements to support a properly made application to the Department of Environment and Science (DES) for Meandu Mine's Transitional PRC Plan and associated Schedule.

Project Proponent: TEC Coal

TEC Coal Pty Ltd (TEC Coal) owns the Meandu Mine and is the holder of ML6674 and EA EPML00709113. TEC Coal is a wholly owned subsidiary of Stanwell Corporation Limited (Stanwell). Stanwell is a Queensland Government Owned Corporation under the Government Owned Corporations Act 1993 and registered under the *Corporations Act 2001.*

The term Stanwell is used in this document to represent the actions and commitments that will be made by the organisation, inclusive of TEC Coal.

Legislative Requirements

A PRC Plan is a critical element of the Queensland Government's Mined Land Rehabilitation Policy.

Organisations carrying out mining activities in Queensland are legally obligated to rehabilitate the land. The Queensland Government has improved rehabilitation and financial assurance outcomes in the resources sector by delivering a broad package of reforms.

A key element of this reform package is the *Mineral and Energy Resources (Financial Provisioning) Act 2018* (MERFP Act) that forms a part of the government's response to issues raised in the Review of Queensland's Financial Assurance Framework (Queensland Treasury Corporation, 2017) and the Better Mine Rehabilitation for Queensland (State of Queensland, 2017) discussion paper.

Passed by Parliament on 30 November 2018, the MERFP Act:

1. replaces the financial assurance arrangements for resource activities under the *Environmental Protection Act 1994* (EP Act) with a new financial provisioning scheme;

2. changes how the estimated rehabilitation cost for an environmental authority (EA) is calculated; and

3. amends the EP Act to introduce new requirements for the **progressive rehabilitation and closure** of mined land.

Purpose of a PRCP

The purpose of the PRC Plan is to:

- require the holder of an EA to plan for how and where activities will be carried out on land in a way that maximises the progressive rehabilitation of the land to a stable condition; and
- provide for the condition to which the holder must rehabilitate the land before the EA may be surrendered.

A PRC Plan is an extensive submission and includes Life-of-Asset planning for mining sequences, rehabilitation sequences and mine closure.

Meandu Mine (ML6674) Transitional PRC Plan

The *MERFP Act* includes transitional provisions for the application of the PRC Plan requirement concerning existing mines. All existing mine sites in Queensland will be transitioned to a PRC Plan by November 2022, and at any time within three years of the amended legislation, will be issued a formal transition notice by the administering authority, DES to submit their PRC plans for approval.

Meandu Mine is the holder of an existing EA for mining activity relating to a mining lease approved through a site-specific application and voluntarily chose to progress this requirement ahead of being issued a formal notice by DES. Following commencement of this process, TEC Coal was issued with a transition notice on 11 September 2020.

Meandu Mine's PRC Plan consists of a rehabilitation planning section, and a PRC Plan schedule, which will be submitted for approval by the administering authority (Department of Environment and Science).

Therefore, Stanwell is preparing the Meandu Mine PRC Plan to:

- meet a legislated requirement under the Queensland *Environmental Protection (EP) Act 1994*; and
- replace the current 'Plan of Operations' documentation.

During preparations for the PRC Plan lodgement, Stanwell undertook the necessary works and EA amendment application to increase the number of approved post mining land uses. This EA amendment was approved in February 2021 and increased the number of approved land outcomes in the current EA to seven, being; native vegetation, water storage, retained infrastructure, beef cattle grazing, plantation timber and creek diversion.

In parallel, Stanwell developed and will lodge in May 2022 a PRC Plan and schedule that achieves the four goals for rehabilitation set out by the Queensland Government. These are:

- safe to humans and wildlife;
- non-polluting;
- stable; and
- able to sustain an agreed post mining use.

Surface rights area and proposed landform results

The current surface rights area of Meandu Mine is approximately 2,640 ha within ML6674. The remaining land outside of the surface rights area is predominantly State Forrest (Yarraman State Forest) and is held under license for the production of planation timber. At the time of compilation of this PRC Plan in May 2022, TEC Coal has received State Government Approval and is finalising Commonwealth Approval to increase the approved surface rights area at the Meandu Mine.

The King 2 East (K2E) Project involves increasing the approved surface rights area within ML6647 by an additional 186 ha which will allow progression of the existing K2E pit to the east. State approval for the K2E Project was sought via an EA amendment application for EPML00709113 under the EP Act which was approved by DES on 23 November 2021 and incorporated in the current EA (12 January 2022). The Regional Interests Development Approval (RIDA) was granted on 10 May 2022. Commonwealth approval for the K2E Project under the Environment Protection and Biodiversity Act 1999 (EPBC Act) is currently being assessed with further information provided via the Preliminary Documentation Assessment Report which was submitted to the Department of Agriculture, Water and the Environment on 17 May 2022.

The planned landform shapes and rehabilitation will provide a natural appearance and offer a variety of different slopes and orientations suited to a range of post mining land uses.

Development of the Community Consultation Plan

The legislation requires both records of evidence-based community consultation to accompany the submission of a PRC Plan and schedule, and a plan for how Stanwell will continue to keep identified community members informed about the progress of the rehabilitation throughout the life of the PRC Plan.

Development of the PRCP for Meandu has adopted a mix of post mining land uses that considers and reflects the inputs received from community consultation regarding how members would like to see the land used into the future. The most significant change from prior proposed rehabilitation is the incorporation of a significant allocation of beef cattle grazing post-mining land use, including complementary water storage. The allocation of plantation forestry post-mining land use has also been limited to existing mature plantings undisturbed by mining. Ongoing consultation with community members will inform and support any future development of the PRC Plan and post mining land use allocation intended to generate a high level of community acceptance of the final landform and land uses post-closure of Meandu Mine.

DES has outlined the types of community members who may have a *[1]specified interest in post mining land uses.

The development phase of a PRC Plan offers the community an opportunity to influence the rehabilitation and land outcomes. This plan will include those community members who Stanwell assesses as falling under one of the following interest categories:

- Direct impact – underlying and adjacent land holders
- Cultural interest – e.g. indigenous communities, Traditional Owners including Native Title holders
- Heritage interest – state or local government or relevant community groups where heritage value is identified on the land the activity is to occur
- Recreational interest – relevant community groups who use the immediate, adjacent, upstream or downstream land for recreational purposes
- Land use interest – e.g. overlapping tenure holders, agricultural entities or local government where a planning scheme is in place
- Health interest – e.g. state or local government or relevant community groups who have health concerns relation to the rehabilitation processes and final land outcomes for the project.

[1] Information sheet - EPA 1994 Community consultation for Progressive Rehabilitation and Closure Plan EXR/2019/5101 – Version 1.00 Effective 1November 2019

In additional to the legislative requirements, the design of the PRC Plan Community Consultation Plan will enable Stanwell to understand the potential environmental, economic and social risks associated with mine closure. The community consultation process provides Stanwell an early engagement opportunity to build long-term relationships, manage expectations and build awareness and understanding of the communities needs and objectives.

Stanwell will record:

- details of the consultation undertaken by the applicant in developing the proposed PRC
- details of how the applicant will undertake ongoing consultation in relation to the rehabilitation to be carried out under the plan
- consultation date(s)
- identification of each community member
- description of consultation type (workshop, quarterly meetings, etc.)
- information provided to the community
- issues raised/discussed by the community
- how issues have been considered
- decisions/outcomes of engagement
- commitments made by the applicant.

Project timelines

Timeframe	Key deliverables	Responsible
30 April 2020 to 15 May 2020	• Finalise PRC Plan Community Consultation Plan • Develop Community Consultation Packs to include individual and group face to face or digital engagement/consultation and presentations • Arrange appropriate COVID-19 compliant appointments for identified external community members	Community Relations Manager and Senior Marketing and Communication Advisor Technical Resources Manager, Senior Mining Engineer Long Term Planning Community Relations Manager and Marketing Communication Coordinator
30 April 2020 to 31 December 2020	• Internal consultation to occur simultaneously to ensure feedback provided does not conflict with external consultation	Community Relations Manager, Technical Resources Manager, Senior Mining Engineer Long Term Planning

Timeframe	Key deliverables	Responsible
18 May 2020 to 31 December 2020	• Lead and complete consultation with identified community members in an order that supports the EA amendment lodgement and PRC Plan • Record consultation, feedback etc. in Community Consultation Register • Summarise feedback for Project Team review and utilisation in EA application	Community Relations Manager, Technical Resources Manager, Senior Mining Engineer Long Term Planning
January 2021 to May 2022	• Ongoing consultation with the community members as development of the PRC Plan and schedule are finalised	Strategy and Engagement team
February 2022	• Letter to consultation participants to provide an update of the progression of the PRC Plan and updated PMLUs • PRC Plan update in Community newsletter (1200 residences) to provide those residents in the areas directly surrounding the mine an update on the progression of the PRC Plan.	Strategy and Engagement team
May 2022 – ongoing	• Inform relevant community members about the progress of rehabilitation to ensure Stanwell complies with PRC Plan approvals and meets community consultation requirements in an ongoing way	Strategy and Engagement team

Purpose and scope of this plan

The purpose of this community consultation plan is to ensure clear, consistent and timely communication about the PRC Plan in a proactive and systematic way. A strategic approach to engaging internal and external community members and identifying other potential community members is required to achieve project outcomes.

Successful engagement and consultation with community members supports the project's risk management process, specifically the early identification and avoidance/management of potential impacts (negative and positive). It also supports Stanwell's social licence to operate, manages community member expectations, enhances reputation, and improves our decision-making and performance.

This plan articulates Stanwell's approach to communication and engagement about our PRC Plan in a way that builds and maintains trust, addresses local issues or concerns, manages reputational risks, and enables the site to the maintain the communities continued support of the Tarong power stations' and Meandu Mine's operations.

Engagement objectives

Stanwell will lead the engagement with identified community members in ways that:

- Use clear, accurate and timely communication and in summarised forms that they understand to facilitate clear understanding and support them in making informed responses. Further information and detail may be provided in response to specific questions and supporting discussions.
- Actively seeks out community members who have a direct interest in the mine plan, its extent and ongoing rehabilitation methods, staging and outcomes and establishes accessible and inclusive ways for them to participate in the development of the mine and PRC plans and receive progress reports during the life of the mine.
- Identifies and explains the engagement process, the role of community members in the engagement process, and communicates how their input will be considered and inform the development and revision of the mine and PRC plans.
- Measures Stanwell's engagement activities to assist in understanding the effectiveness and opportunities to improve the quality (e.g. content, clarity etc.) of future engagement.

Communication and engagement objectives

Our engagement objective is to ensure identified community members (representing the broader community) feel they have ownership of the agreed post mining land uses and are supportive that the end result will be a positive legacy for future generations.

Overarching objectives of this plan are to:

- Ensure consultation meets the legislative requirements for community consultation ahead of the lodgement of the PRC Plan and ongoing throughout the life of the mine.
- Take a strategically considered approach to identifying those community members that have a direct interest in the mine plan, its extent and ongoing rehabilitation methods, staging and outcomes, and identifies and includes any new or additional community members that may be identified in the future.
- Ensure that personnel developing, managing and administering Stanwell's mine and PRC plans understand the social, environmental and economic needs and expectations of identified community members and can articulate how their needs and expectations have been considered.
- Contribute to the value of the approved post mining land uses.
- Identify and monitor potential reputational risks that have the potential to create future issues that may impact upon the mine and PRC plans, rehabilitation methods and staging and scheduled implementation.

Community member analysis

The following analysis details those community member groups Stanwell has identified as having an interest in the project and those who will be engaged throughout the development and life of the PRC Plan. A separate register will record individual contributions from community members and will function as a tracking tool to ensure Stanwell complies with the final approval.

It is acknowledged that the existing Meandu Mine Environmental Authority (EA) approved post mining land uses will set the scene for engagement. Over 600 hectares of the mine is rehabilitated to native vegetation and Stanwell is planning to submit a rehabilitation certification application for a portion of this land prior to the final submission of the PRC Plan. Community consultation undertaken will support the lodgement and approval for EA amendments, the PRC Plan for King 2 East and the existing mined areas within ML6674. Further detail on the form of engagement / consultation type is provided in the following section.

Note – COVID-19 impacts: Where proposed engagement tactics include face-to-face activities (throughout 2020, 2021, 2022), they have been modified in line with current COVID-19 advice and restrictions at the time.

Community member type	Nature of interest in the PMLU of Meandu Mine	Type of interest	Engagement resources	Consultation Group	Measure of engagement success
Make Good Agreement landholders	• Stanwell has current make good agreements (MGA) in place • Concerns about potential for their groundwater to be impacted by future mining operations	• Direct • Land use • Environmental	• Feedback forms • Maps • Online	• MGA holders	Continue the good relationship with MGA holders Any concerns or issues addressed to their satisfaction and support offered for final PRCP.
Adjacent / underlying landowners	• The final land form and uses do not conflict with or interfere with their current or future plans • Are there new opportunities or risks created by the PMLU and NUMA that benefit them now, or in the future, e.g. fire or other risks? • When will they know if grazing land becomes available? • Will PMLU for Plantation Timber be offered to HQ Plantations or tendered?	• Direct • Land use • Environmental • Heritage	• Feedback forms • Maps • Online	• Underlying and surrounding / adjacent landholders • Department of Resources • Department of Environment and Science • Near Neighbour Consultative Committee • HQPlantations	NNCC and adjacent landowners participated in consultation Concerns or issues addressed to their satisfaction and support offered for final PMLU
Downstream	• The continuity, quality and reliability of water discharged from water storage for irrigation, stock and recreational use • PRC Plan/planning does not conflict with end of life rehabilitation for TPS	• Direct • Land use • Environmental • Recreational • Heritage	• Feedback forms • Maps • Online	• The Meandu Barker Creek Water Advisory Committee (MBCWAC) • The Department of Regional Development, Manufacturing and Water (DRDMW) • Tarong power stations • Recreational Fishing members - Kingaroy Sport Fishing Club	MBWAC and recreational use groups participated in consultation Concerns or issues addressed to their satisfaction and support offered for final PMLU

Community member type	Nature of interest in the PMLU of Meandu Mine	Type of interest	Engagement resources	Consultation Group	Measure of engagement success
Traditional Owners	• What will happen to the cultural heritage material that has been uplifted and kept in The Keeping Place? • How will the PMLU reflect cultural heritage values and will they conflict with other PMLU tenure holders rights/preferences? • How will native title areas be reinstated safely (culturally etc.), and will there be areas that Wakka Wakka members can access when native title is determined? • How will Stanwell engage Traditional Owners throughout the PRCP for advice and involvement? • Will PMLU include employment opportunities of WW people?	• Direct • Land use • Cultural • Recreational	• Feedback forms • Maps • Online	• Queensland South Native Title Service • Wakka Wakka People represented by the Wakka Wakka #3 People Native Title Applicant Group	TO's participated in consultation Concerns or issues addressed to their satisfaction and support offered for final PMLU
Local / State Government	• Will PMLUs have ongoing costs for ratepayers? • Are PMLU consistent with current and future Planning legislation and policies? • What broader community benefits will the PMLU contribute to new economic benefits and offer the social fabric of the region? • Concern for future water storage options, will that include broader community benefits aligned with Council's water security and economic development plans • Will there be residual environmental health risks or other impacts that will require ongoing management by Council (downstream/upstream)? • Will environmental values that existed prior to mining be re-established in PMLU e.g. vine thicket, BBB Quail? • Is the design of the road network consistent with Council policies and planning?	• Direct • Land use • Environmental • Heritage	• Feedback forms • Maps • Online	• South Burnett Regional Council • Toowoomba Regional Council local government areas • Department of Environment and Science	Elected and professional staff participated in consultation Concerns or issues addressed to their satisfaction and support offered for final PMLU

Community member type	Nature of interest in the PMLU of Meandu Mine	Type of interest	Engagement resources	Consultation Group	Measure of engagement success
Historical societies and local historians	• Will PMLU and NUMA be consistent with historical heritage values? • How will the PMLU recognise the aboriginal cultural heritage values, i.e. route to Bunya Mountains and historical values of dairying and timber?	• Land use • Environmental • Heritage • Cultural	• Feedback forms • Maps • Online	• Yarraman & District Historical Society	Historians and groups participated in consultation Concerns or issues addressed to their satisfaction and support offered for final PMLU
Underlying/adjacent owners, that are part of the Qld Gov't or for HQPlantations who manage adjoining State Land	• Owners of adjacent land and as regulators (DES) • Are PMLU consistent with national climate change and other policies? • What role will DAF have in overseeing the plantation licence HQPlantations have under the Forestry Act, and what role will DES (Parks division) play in the future with proposed plantation timber PMLU. • Who owns the land underneath of the various parts of the mine and does it encumber the State to any future, known or unknown obligations? • Will PMLUs create a positive legacy for Qld Gov't including economic, environmental and social benefits for future generations • How do PMLU align with State Planning policies and legislations, now and in the future	• Direct • Land use • Environmental • Health	• Feedback forms • Maps	• Department of Environment and Science (DES) • The Department of Regional Development, Manufacturing and Water (DRDMW) • Department of Resources (DoR) • HQPlantations Limited.	Relevant responsible staff participated in consultation Concerns or issues addressed to their satisfaction.
Local community and environmental groups	• Economic development and investment in the region. • Any known or expected change in environmental impacts. • Adequate access to Yarraman Forestry for HQ Plantations • Long-term plans and the proposed end of life for the Tarong power stations • Will PMLU's change community safety i.e. increased fire risk	• Direct • Land use • Environmental • Heritage • Recreational • Health	• Feedback forms • Maps Online	• Burnett Mary Group – Burnett Catchment Care Association • QFES • South Burnett Grazing Network • Bunya Valley Landcare	Community Groups participated in consultation Concerns or issues addressed to their satisfaction and support offered for final PMLU

Consultation tools and methods of engagement

The following summary displays the range of different consultation methods that will be utilised to engage with the community both during the PRC Plan development and following the lodgement and approval of the PRC Plan. The table is organised by the various community and stakeholder groups that Stanwell will consult with on the PRC Plan.

Note – COVID-19 impacts: Where proposed engagement tactics include face-to-face activities (throughout 2020, 2021, 2022), they have been modified in line with current COVID-19 advice and restrictions at the time.

Consultation technique	Make Good Agreement landowners	Adjacent landowners	Downstream	Traditional Owners	Local Government	Historical societies and local historians	Underlying/adjacent owners, that are part of the Queensland Government or for HQPlantations who manage adjoining State land	Local community and environmental groups
Direct community member contact	✓	✓	✓	✓	✓	✓	✓	✓
Online surveys	✓	✓	✓	✓	✓	✓	✓	✓
Information packs	✓	✓	✓	✓	✓	✓	✓	✓
Community information sessions	✓	✓	✓	✓	✓	✓		✓
Local community events	✓	✓	✓		✓		✓	
Community newsletters	✓	✓		✓		✓		
Website/Phone/ Email	✓	✓	✓	✓	✓	✓	✓	✓

Community Consultation Plan

PRC Plan Development period May 2020 – May 2022

The following action plan outlines key engagement and communication activities to be undertaken during each stage of the project during development and lodgement of the PRC Plan.

Timing	Activity	Objective	Community member(s)	Channel / tools	Responsibility	Outcome
Stage one - (May – December 2020)						
May – July (initial) August – December (ongoing)	Arrange COVID-19 compliant appointments with community members in order to gain EA amendment feedback, followed by overall consultation	Gain understanding of support for amended PMLU in current EA. Undertake sufficient community consultation to develop the PRC Plan and secure approval	Adjacent/upstream neighbours Internal stakeholders Downstream landowners Traditional Owners History associations/Historians Local Councils Community groups – e.g. Police, Botanical groups State of Qld – Depts - DRNME Shareholding Ministers	Information packs including hardcopy feedback forms and maps Digital tools – online meetings and options for survey/feedback Site visits (if required for TOs) Briefing notes	Strategy and Engagement team	Complete
In-line with PRC plan development	Government briefings	Gain early understanding of their views on the PMLU Provide Government with up-to-date information as required, supporting the approval pathway.	DNRME Department of Resources Department of Environment and Science	Briefing Note	Strategy and Engagement team	Complete
Monthly	PRCP Steering Committee meetings held monthly	To provide strategic advice and direction as required	Stanwell Steering Committee	Steering meetings	Community Relations Manager, Technical Resources Manager, Senior Mining Engineer Long Term Planning, and General Manager Mining	Complete
In-line with key project milestones/ongoing	Community meetings (events, meetings, information sessions)	To provide key opinion leaders and community members with current information about the progress of PRC Plan, and maintain their ongoing support for Stanwell's operations in the South Burnett	Key opinion leaders Near neighbours Other relevant community members	Information sessions NNCC briefings Phone Calls Emails	Strategy and Engagement team	Complete

Timing	Activity	Objective	Community member(s)	Channel / tools	Responsibility	Outcome
Stage two – (January 2021 – May 2022)						
Ongoing	Arrange COVID-19 compliant appointments as needed with community members in order to continue with consultation.	Undertake sufficient community consultation to develop the PRC Plan and secure approval	Adjacent/upstream neighbours Internal stakeholders Downstream landowners Traditional Owners History associations/Historians Local Councils Community groups State of Qld	Information packs including hardcopy feedback forms and maps Digital tools – online meetings and options for survey/feedback Site visits for TOs Briefing notes	Strategy and Engagement team	Complete
In-line with PRC plan development	Government briefings	Provide Government with up-to-date information as required, supporting the approval pathway. Engage with relevant department to understand input required / sought and provide any necessary feedback as the plan progresses.	DNRME Department of Resources Department of Environment and Science Department of Regional Development, Manufacturing and Water	Briefing Notes Information packs including meeting agendas and packs Site visits as needed Online meetings and feedback forms.	Strategy and Engagement team, Community Relations Manager, Technical Resources Manager, Senior Mining Engineer Long Term Planning, and General Manager Mining	Complete
Monthly	PRCP Steering Committee meetings held monthly	To provide strategic advice and direction as required	Stanwell Steering Committee	Steering meetings	Community Relations Manager, Technical Resources Manager, Senior Mining Engineer Long Term Planning, and General Manager Mining	Complete
In-line with key project milestones/ongoing	Community meetings (events, meetings, information sessions)	To provide key opinion leaders and community members with current information about the progress of PRC Plan, and maintain their ongoing support for Stanwell's operations in the South Burnett	Key opinion leaders Near neighbours Other relevant community members	Information sessions NNCC briefings Phone Calls Emails	Strategy and Engagement team	Complete

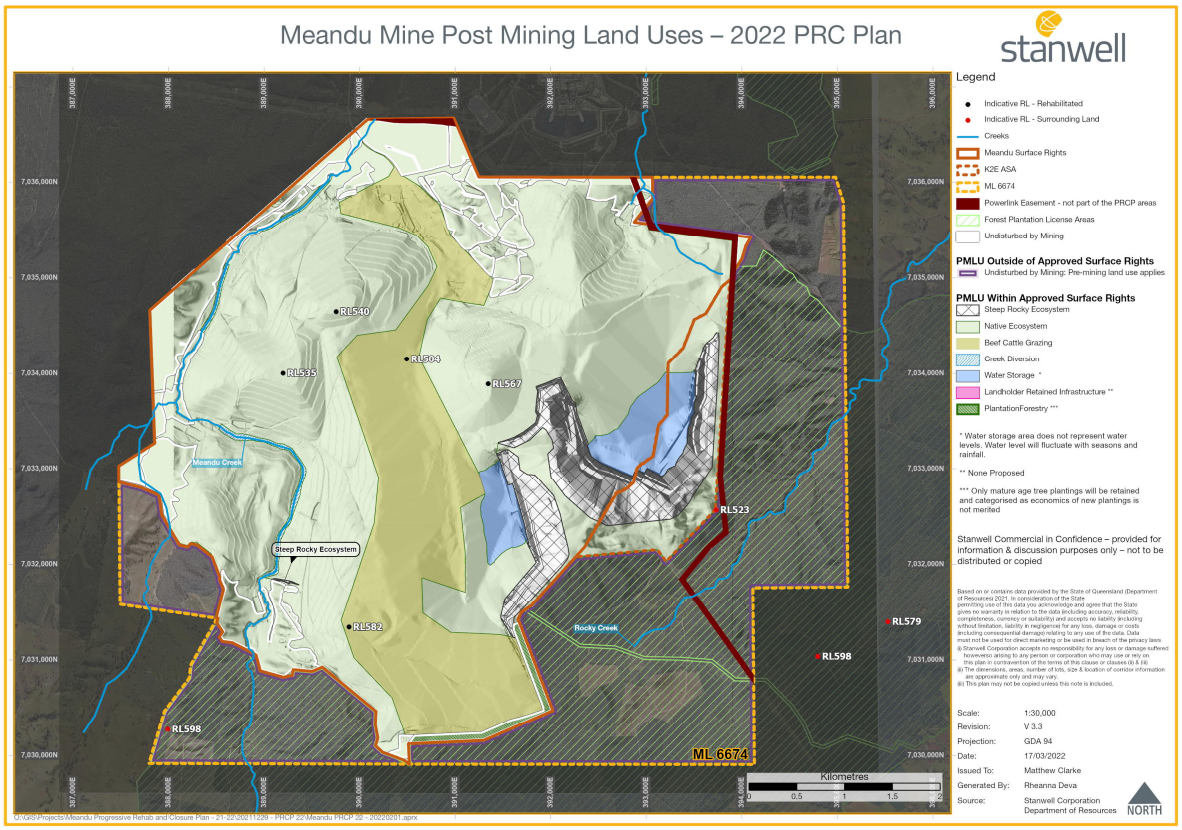
Ongoing consultation for the Meandu PRC Plan after lodgement

The following action plan outlines the plan for how the ongoing consultation for the Meandu PRC Plan will take place following lodgement and approval. The community consultation register will continue to maintained and regularly updated with all relevant consultation activities, with the matters raised and resulting outcomes recorded in the template format required by the PRCP Guideline.

Community Consultation Plan					
Objective	**Relevant community members**	**Engagement type**	**Proposed consultation frequency**	**Released information**	**How feedback/comments are considered**
To ensure identified community members maintain their support, have a current understanding and know how they can provide ongoing feedback and receive more information about Meandu Mine's LOM Plan, approved PRC Plan, rehabilitation methods and staging and the progress of rehabilitation.	Internal community members Make Good Agreement Landowners Adjacent Landowners Downstream Traditional Owners Local Government Historical societies and local historians Underlying/adjacent owners, that are part of the Queensland Government or for HQPlantations which manages adjoining State Land Local Community & Environmental Groups	Face to face information and consultation sessions where consulted stakeholder group representatives are present (hosted by Stanwell)	Annually (min) and as scheduled (usually 6 months)	Rehabilitation progress/timelines updates; feedback and consultation on progress and opportunity to gain new information for consideration and/or feedback	Feedback recorded in PRC Plan project portal within Consultation Manager register. Community Relations team and mining teams consider, identify any actions and respond to community members. All feedback to be collated and reviewed minimum annually by Stanwell relevant teams. Community members advised and an agreed response/plan documented and implemented in Consultation Manager.
		Relevant PRC Plan updates included in speech notes where Stanwell is represented at community engagement events (hosted by others)	Ongoing and where invited by others to provide a speech or presentation on current activities	Rehabilitation updates, invitation to identify new information or feedback	
		PRC Plan update and content included in community and near neighbour newsletters, print and social media	Annually (min); Newsletters (6 monthly) Social Media/print (annually)	Rehabilitation updates, feature stories, education & awareness pieces and feedback options about PRC Plan's progress	
		Stanwell's website	Ongoing	Feature stories, education and awareness pieces and how feedback can be provided	
		Stanwell website – online feedback forms	Ongoing	Where more information can be obtained and feedback provided for Stanwell's consideration	
To facilitate opportunities where existing and/or new stakeholders who have an identified interest in the PRC Plan and PMLU's can provide ongoing feedback for Stanwell's consideration	Internal community members Make Good Agreement Landowners Adjacent Landowners Downstream Traditional Owners Local Government Historical societies and local historians Underlying/adjacent owners, that are part of the Queensland Government or for HQPlantations which manages adjoining State Land Local Community and Environment groups	Face to Face information and consultation sessions where consulted stakeholder group representatives are present (hosted by Stanwell)	Annually (min) and as scheduled (usually 6 months)	Rehabilitation progress/timelines updates; feedback and consultation on progress and opportunity to gain new information for consideration and/or feedback	Feedback recorded in PRC Plan project portal within Consultation Manager register. Community Relations team and mining teams consider, identify any actions and respond to community members. All feedback to be collated and reviewed minimum annually by Stanwell relevant teams. Community members advised and agreed response/plan documented and implemented in Consultation Manager.
		Relevant PRC Plan updates included in speech notes where Stanwell is represented at community engagement events (hosted by others)	Ongoing and where invited by others to provide a speech or presentation on current activities	Rehabilitation updates, invitation to identify new information or feedback	
		PRC Plan update and content included in community and near neighbour newsletters, print and social media	Annually (min); Newsletters (six monthly) Social Media/print (annually)	Rehabilitation updates, feature stories, education and awareness pieces and feedback options about PRC Plan's progress included	

Community Consultation Plan					
Objective	**Relevant community members**	**Engagement type**	**Proposed consultation frequency**	**Released information**	**How feedback/comments are considered**
		Stanwell's website	Ongoing	Feature stories, education and awareness pieces and how feedback can be provided	
		Stanwell website – online feedback forms	Ongoing	Where more information can be obtained, and feedback provided for Stanwell's consideration	

Figure 1 – Proposed Post Mining Land Use Maps – Meandu Mine



Attachment A: Community Consultation Register – current at time of lodgement May 2022

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
21 November 2019	Near neighbours of Meandu mine and Tarong power stations: [names redacted] Local government: South Burnett Regional Council	Meeting/Briefing	Introduction to PRCP Mine planning King 2 East project update Tarong power stations update. Meandu Mine air quality monitoring, dust management practices and technical studies underway.	The following themes have been summarised from the meeting: **Grazing** – allocation of some areas for grazing will be welcomed by the community **Water storage** – Water security will be paramount going forward and provision of water storages will be important, with commercial options (due to other infrastructure across the TPS/MM footprint) available to the South Burnett and Toowoomba regions. **Wildlife corridors:** however with consideration that the vegetation doesn't harbour pest animals. Native vegetation had historically been left on the less productive land that also provided wildlife corridors and linkages; this is an important consideration when allocating the final land uses **Commercial timber plantations** **Value add options** – trees etc suitable for apiarists **Landform** – spoil dumps to be lower/similar to original landforms when finished. There are some quite high dumps that can be seen from neighbouring properties; there is interest in seeing these returned as similar as possible to what was here before	Stanwell consulted widely with the community prior to commencing detailed work on the PRCP and the assessment of landform and PMLUs appropriate. This commitment to early and detailed consultation allowed Stanwell to allocate PMLUs in strong alignment with community expectations. With this feedback, Stanwell chose to proceed with an application to amend the existing EA EPML00709113 to include an additional two (2) PMLUs: Beef Cattle Grazing and Plantation Forestry. This process entailed further engagement and feedback from DES, which resulted in the creation and approval of two (2) further PMLUs: Creek Diversion and Steep Rocky Ecosystem. The amended EA was approved and issued in February 2021. With respect to the feedback received: • The community is strongly in favour of PMLUs with an economic return and particularly in favour of cattle grazing. As a result of this feedback, following financial assessment and investigation on appropriate top and sub-soil requirements, Stanwell has now included approximately 550Ha of Beef Cattle Grazing in the PMLU allocation for the PRCP. • Plantation Forestry has been restricted to only existing mature trees, with no additional plantings considered in the PRCP. This is consistent with the majority of the community and near neighbours consulted (inclusive of the neighbouring plantation license holder) in that additional Plantation areas are not valued by the community.	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Further stakeholder consultation will be planned via the Community Relations Manager with the rehabilitation landforms and land uses shown on maps and other visualisations.

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					• The community feedback highlighted the importance of not creating any additional demand for local water resources, and increasing water storage if possible. Consequently, the PRCP preparations included assessment of the water storage volumes with scenarios for maximum and minimum use to support the associated PMLUs. • Many parts of the community expressed a desire for native vegetation to continue to play a major part in the post-closure use of the mine footprint, and this was an important consideration in the decision to continue allocating parts of the future rehabilitation areas to this PMLU.		
14 April 2020	Department of Environment and Science, Environmental Services and Regulation	Meeting/Briefing	Presentation on K2E Project providing an overview of the K2E ASA, approval requirements and project timeframes. Summary of upcoming applications provided for: A. Groundwater/Surface Water (EA amendment Application) B. Rehabilitation Success Criteria (EA Amendment Application) C. K2E (EA Amendment Application) D. Progressive Rehabilitation and Closure Plan (PRCP)	DES will provide feedback to Stanwell as part of pre-lodgement discussions and meetings. Business Centre Coal (BCC) will work closely with the PRCP Team. Where required, BCC will provide the rehabilitation success criteria and K2E information to the PRCP Team to assist inform the PRCP application. PRCP Team will make a decision on the call in date for Stanwell for PRCP, and will continue consultations with Stanwell and BCC to help inform this date.			

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19 May 2020	Local Community	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: Background Information - Proposed post mining land uses. - Indicative maps - Frequently asked questions - Options to provide feedback. - Feedback questionnaire.	**Post mining:** Land ownership and management (e.g. pests & fire hazards). Return land to safe, stable, non-polluting landforms with economically productive land uses. **Water Storage**: Will the storage areas be filled with water? Will existing bores stay? **Future road reserve:** Underutilised compared to other roads in the area, accuracy of map location and description. **Forestry:** Why was a forestry put in the PRC Plan, are timber industries economically sustainable? logging trucks destroy roads in the local area. **Grazing:** The definition of beef cattle grazing vs grazing; grazing preferred; what was the selection criteria for grazing; all country <15% gradient should be considered for grazing; 15% gradient was too steep - 8 or 10 would be enough; no water facilities in proposed plan. **Historical connection to the land;** option to purchase land back. **Tourism:** Fond childhood memories of playing at Tarong Beach.	Refer to cell F3	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Community member to complete feedback from. Feedback form to be collected by the community relations team mid-June 2020. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP.
19 May 2020	Direct land use Environmental	Phone Call (Out)	Discussed PRCP information pack with the stakeholder(s). The stakeholders advised during conversations he had purchased an adjoining block on Rocky Creek.	Water reliability - underground and surface water into rocky creek.	Existing agreement.	Dealt with under existing arrangements	To discuss further with PM and come back to Landowner
19 May 2020	Make good agreement landowners	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses - Indicative Maps - Frequently asked questions - Options to provide feedback - Feedback questionnaire	**Pre-Mining:** Tarong Power Station & Meandu Mins was one of the best things that happened to the local area; proposed post mine land uses would be an improvement on pre-mining land uses. **Waterways:** Flow the water back into Rocky creek? Local council consultation **Forestry:** Privatisation of the plantations lead to poor management of the local forestry's; do not support gum trees. Return land to safe, stable, non-polluting landforms with economically productive land uses. **Tourism:** Tarong beach was a great location for the local community. **Future of TPS:** Once the coal resources have been utilised can the power station be fuelled by gas?	Refer to cell F3	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Community members to complete feedback form. Form to be collected by the Community Relations team mid-June 2020. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP.

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
20 May 2020	Adjacent landowners	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses. - Indicative maps - Frequently asked questions - Options to provide feedback. - Feedback questionnaire.	**Post Mining:** Return land to safe, stable, non-polluting landforms with economically productive land uses; freehold or leased? Could it be leased for grazing? **Grazing:** What was the selection criteria for grazing; preferred choice from many residences in adjacent area; capacity to purchase grazing land; no erosion problems; 200mm of topsoil is not very deep. **Water storage:** Totally capacity? Stocked with fish? **Forestry:** Ownership and management (pests & fire hazards) **Tourism:** Beneficial for the whole community; accommodation, water sports, sport stadium. Tarong beach was a great local attraction. **Native Vegetation:** Habitat for wildlife, what species of trees and grasses will be in the native vegetation? Will there be trees or koalas; the rehabilitation undertaken at Meandu, to date, is quite impressive. **Would a change of government influence changes to the plan?**	Refer to cell F3	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Community members to complete feedback form. Form to be collected by the Community Relations team mid-June 2020. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP.
22 May 2020	Adjacent landowners	Phone call / Email	The Stakeholder requested the PRCP information to be emailed to their email address. Invitation to provide feedback and input on the Meandu Mine Progressive Rehabilitation & Closure Plan. Stanwell is voluntarily preparing its PRC plan ahead of being directed to by DES, and to do so, we must present the current and proposed post mining land uses to members of the community for their feedback and input. As a near neighbour to Meandu we would appreciate any time that you have available to discuss this. Due to the COVID impacts currently imposed on large group gatherings, and the physical distancing requirements, we are mindful that some community members may not want to participate in person. We have prepared a comprehensive Community Information pack that creates several options for people to provide their input.	No feedback received to date.	NA		Continue to keep the stakeholders updated via communication channels such as consultation meetings & newsletters.

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22 May 2020	Adjacent landowners	Phone call / Email	The stakeholder requested the PRCP information to be emailed to their email address. Invitation to provide feedback and input on the Meandu Mine Progressive Rehabilitation & Closure Plan. Stanwell is voluntarily preparing its PRC plan ahead of being directed to by DES, and to do so, we must present the current and proposed post mining land uses to members of the community for their feedback and input. As a near neighbour to Meandu we would appreciate any time that you have available to discuss this. Due to the COVID impacts currently imposed on large group gatherings, and the physical distancing requirements, we are mindful that some community members may not want to participate in person. We have prepared a comprehensive Community Information pack that creates several options for people to provide their input.	No feedback received to date.	NA		Continue to keep the stakeholders updated via communication channels such as consultation meetings & newsletters.
22 May 2020	Adjacent landowners	Phone Call	Invitation to provide feedback and input on the Meandu Mine Progressive Rehabilitation & Closure Plan. Stanwell is voluntarily preparing its PRC plan ahead of being directed to by DES, and to do so, we must present the current and proposed post mining land uses to members of the community for their feedback and input. As a near neighbour to Meandu we would appreciate any time that you have available to discuss this. Due to the COVID impacts currently imposed on large group gatherings, and the physical distancing requirements, we are mindful that some community members may not want to participate in person. We have prepared a comprehensive Community Information pack	Declined the invitation to participate in the PRCP community consultation feedback and input.	NA		Continue to keep the stakeholders updated via communication channels such as consultation meetings & newsletters.

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			that creates several options for people to provide their input.				
22 May 2020	Adjacent landowners	Phone Call (Out)	An invitation to provide feedback and input on the Meandu Mine Progressive Rehabilitation & Closure Plan. Stanwell is voluntarily preparing its PRC plan ahead of being directed to by DES, and to do so, we must present the current and proposed post mining land uses to members of the community for their feedback and input. As a near neighbour to Meandu we would appreciate any time that you have available to discuss this. Due to the COVID impacts currently imposed on large group gatherings, and the physical distancing requirements, we are mindful that some community members may not want to participate in person. We have prepared a comprehensive community information pack that creates several options for people to provide their input.		NA	The stakeholder declined the invitation and advised to consult their husband and son. The son then offered to discuss the PRCP community consultation request with them and if applicable will communicate feedback to the community relations team. A meeting was scheduled for the son to present the PRCP community consultation information pack on 29 May 2020.	Continue to keep stakeholder updated via communication channels such as community consultation meetings and newsletters.

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
25 May 2020	Near Neighbours	Phone Call (Out)	Invitation to provide feedback and input on the Meandu Mine Progressive Rehabilitation & Closure Plan. Stanwell is voluntarily preparing its PRC plan ahead of being directed to by DES, and to do so, we must present the current and proposed post mining land uses to members of the community for their feedback and input. As a near neighbour to Meandu we would appreciate any time that you have available to discuss this. Due to the COVID impacts currently imposed on large group gatherings, and the physical distancing requirements, we are mindful that some community members may not want to participate in person. We have prepared a comprehensive Community Information pack that creates several options for people to provide their input		NA	22/05/2020 - Meeting scheduled at stakeholders house 25/05/2020 - advised stakeholders will not be proceeding with the scheduled PRCP community consultation meeting as they had changed their minds and decide they did not want to participate in the PRCP community feedback and input	Continue to keep the stakeholders updated via communication channels such as Community Consultation meetings & newsletters.
25 May 2020	Near Neighbours	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack:		Refer to cell F3	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Community member to complete feedback form. Feedback form to be collected by the community relations team mid-June 2020. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP.

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26 May 2020	Adjacent Landowners	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses. - Indicative maps - Frequently asked questions - Options to provide feedback. - Feedback questionnaire.	**Post Mining:** land ownership and management (e.g. pests & fire hazards). Return to land to safe, stable, non-polluting landforms with economically productive land uses. - Water storage: will the storage areas be filled with water? will existing bores stay? **Future road reserve:** underutilised compared to other roads in the area, accuracy of map location and description. **Forestry:** why was a forestry put in the PRCP Plan, are timber industries economically sustainable, logging trucks destroy roads in the local area. **Grazing:** The definition of beef cattle grazing vs grazing; grazing preferred; what was the selection criteria for grazing; all country <15% gradient should be considered for grazing: 15% gradient was too steep - 8 or 10 would be enough; no water facilities in proposed plan. **Historical connection to the land:** option to purchase land back. **Tourism:** fond childhood memories of playing at Tarong Beach.	Refer to cell F3	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Community member to complete feedback from. Feedback form to be collected by the community relations team mid-June 2020.
27 May 2020	Adjacent landowners	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan consultation Pack: - Background Information - Proposed post mining land uses. - Indicative maps - Frequently asked questions - Options to provide feedback. - Feedback questionnaire.	**Post Mining:** Return land to safe, stable, non-polluting landforms with economically productive land uses; land ownership and management? **Water Storage:** Supportive of water storage areas. **Pre-Mining:** Grazing land; ironbark and pine forestry's, which grew well in the local area. **Grazing & Forestry:** Pictured larger areas of grazing and forestry in the PRC Plan. **Tourism:** Good memories of Tarong beach but didn't like the vandalism that was done to it; wouldn't like commercial attractions there.	Refer to cell F3	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Community members to completed feedback form. Form to be collected by the community relations team mid-June 2020. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP.

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27 May 2020	Near Neighbours	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background information - Proposed post mining land uses - Indicative maps - Frequently asked questions -Options to provided feedback - Feedback questionnaire	**Post mining:** Return land to safe, stable, non-polluting landforms with economically productive land uses (Suitable grasses, iron bark preferred, wattle is a pest); land ownership and management (e.g. **control Giant Rats Tail (GRT)** **- Grazing:** Supports grazing; don't fill the land with wattle - grass won't grow where wattle trees are, option to lease grazing land: gradient of land not a concern. Water Ways: Restore water to Baines Creek and gullies; water disappeared when bores were introduced. **Pre-mining:** Grazing land, dairy farms, water in creeks. **Forestry:** Supportive if managed correctly and suitable timbers are grown. **Tourism:** Good memories of Tarong Beach. Historical connection to land. **Unpleasant recalls:** Installation of powerlines and interconnector on their property; exploration appeal from Bowen energy in 2011; calving rate decline when the powerlines/interconnector were installed, proposed train line.	Refer to cell F3	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Community members to complete feedback form. Form to be collected by the Community Relations team mid-June 2020. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP.
28 May 2020	Near Neighbours	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses - Indicative maps - Frequently asked questions - Options to provide feedback - Feedback questionnaire	**Pre Mining:** Capacity to drive along Ridge Rd. Have they started moving the power lines yet? **Post Mining:** Is this plan based on the projections for life mine or power station? Will the land be sold off privately? Where does this fit in the Kunioon plan? Is Kunioon a cheaper option? Are they basing this plan on other mines or is it unchartered territory? **Water Ways:** Would the water quality be suitable for stock feed? **Water Storage:** Would the water quality be suitable for stock feed? Keep the water clear and fit to human consumption. This would probably only affect a handful of people. **Forestry:** Agrees with the concept. It doesn't look like it would affect anyone who lives besides the forest. **Tourism:** Like to see an area open to the public, with multiple uses such as camp sites, even a small fee required to keep it running. Would also like to see a train line put back in for the community. Often receives comments from the community about reopening Tarong Beach. **Future of TPS:** Like to see Tarong Power Station stay open for as long as possible; can predict the flow on effects from the closure of the mine and power stations,	Refer to cell F3	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Community members to complete feedback form. Form to be collected by the Community Relations team mid-June 2020. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP.

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28 May 2020	Near Neighbours	Phone call & email	As requested by the stakeholder, the below information was emailed on the 28/5/2021. Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses - Indicative maps - Frequently asked questions - Options to provide feedback - Feedback questionnaire	On 28/05/2020 6:02pm sent a text message advising "We are unable to participate. A lot happening with us atm"	NA	Landowners not participating in the 'feedback stage' of the PRCP community consultation process.	Continue to keep the stakeholders updated via communication channels such as Community Consultation meetings & newsletters.
29 May 2020	Near Neighbours	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses - Indicative maps - Frequently asked questions - Options to provide feedback - Feedback questionnaire	**Post Mining:** Return land to safe, stable, non-polluting landforms with economically productive land uses. Options would depend on how land is broken up and subdivided; require more details on how land would be set up to sustain grazing e.g. shade trees. Sustainable grazing as a productive land use would probably require planting other improved pastures &/or improving the top soil. Suggested that we consider multi-use, for example why not consider grazing and plantation timber? Unsure if grazing would be sustainable on its own. **Water Storage:** Consider designing access for cattle i.e. consider dropping batter angle in current design/specification for retention dams, from 3:1 to 4:1. **Grazing:** Us a preferred post mining land use but wouldn't graze cattle on the existing rehabilitation; too many wattles in the currently rehabilitation - why is it planted so thick ; would require access to water. **Native vegetation/ forestry:** native forest harbours wild dogs to move around from Yarraman state forest to Tarong State forest . Would require more open accessible areas. **Infrastructure:** What would the workshops/sheds be utilised for? Would they be auctioned off?	Refer to cell F3	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Community members to complete feedback form. Form to be collected by the Community Relations team mid-June 2020. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP.

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1 June 2020	Stanwell Property & Environmental Specialist Stanwell Portfolio Coordinator	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses - Indicative maps - Frequently asked questions - Options to provide feedback - Feedback questionnaire	Below are the key points discussed and feedback provided during the presentation of the PRCP consultation pack. · Can PMLU's be amended over time as community and shareholder's change. · Agree with proposed water and infrastructure uses – good to reuse voids and infrastructure. Suggested road access points be deployed in maps for consultation. Advised this is detail not yet available as the focus is on the category of post mining land uses. ·Trees would be bad to give away. ·Include areas of each land use allocations	Details of the consultation will be used by the PRCP Project Manager and PRCP steering committee to develop and inform the outcomes stated in the PRCP Plan.	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Feedback from PRCP consultations to be documented for the PRCP Project team. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP
2 June 2020	Local government stakeholders from the South Burnett Regional Council (SBRC)	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses - Indicative maps - Frequently asked questions - Options to provide feedback - Feedback questionnaire	Key points discussed during the presentation of the PRCP. **Wildlife:** How does the native wildlife come back? **Future Road Reserve:** Undertake consultation with Toowoomba Regional Council.	Details of the consultation will be used by the PRCP Project Manager & WSP to develop and inform the outcomes states in the PRC Plan.	The SBRC Executive Leadership Team to introduce the concept to the SBRC Councillors on 3 June 2020. SBRC to schedule a meeting with Stanwell representatives to present the SBRC feedback by the end of June	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning.
2 June 2020	Adjacent landowners	Email (In)	The stakeholder(s) provided PRCP feedback by email. Received on 3 June 2020.	Feedback included: - Turn the site into a tourist attraction, as this will benefit the whole area. - The buildings could be converted to Youth hostel type of accommodation or indoor sports pavilions. -Dams could be stocked with fish and also used for kayaking, swimming and recreational areas. -Bike trails, where suitable. - Strictly control of grazing areas so that the areas is not overstocked and weeds managed. Keep the remaining area as a nature reserve and koala habitat.	Refer to cell F3	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Stanwell to continue to inform community members about the progress of the PRCP.

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3 June 2020	Stanwell Tarong Power Stations Site Manager	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses - Indicative maps - Frequently asked questions - Options to provide feedback - Feedback questionnaire	Below are the key discussion points and feedback received during the presentation of the PRCP community consultation information pack: - Be clear on timeframes when doing consultations - (advised this is verbally indicated at beginning) - Consider 2024 timeline to resolve biofuels strategy when looking at post mining land use? Talk the project manager for the biofuels strategy. - Look for uses that give an economic return. That will help the local region post closure of the power station and mine. - Consider possibility of accessing coal combustions products (CCPs) after closure to have an industry. - Consider the water options available through dams at TPS & MM and the economic benefits downstream. - Tarong Power Station internal consultation stakeholders identified.	Refer to cell F3	The PRCP Project team will consider the feedback received from the internal stakeholders and will initially work with the PRCP steering committee and the K2E Project steering committee to agreed if there are any actions for the PRCP or for functionally/ business plans that arise out of the internal engagement.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Feedback from PRCP consultations to be documented for the PRCP Project team. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP. Follow up meeting with Project Manager.
4 June 2020	Adjacent landowners	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses - Indicative maps - Frequently asked questions - Options to provide feedback - Feedback questionnaire	Below are the key points discussed and feedback received during the presentation of the PRCP consultation pack: - Agrees with the addition of PMLU of beef grazing & plantation forestry. - Would like to see something similar to Tarong Beach; an area which can be utilised by the whole community. - The Tarong complex is viewed as a part of the community and they would like to see it remain in the area for as long as possible; helps with jobs in the local area.	Refer to cell F3	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Feedback from the PRCP consultations to be documented for the PRCP project team. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP.

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
8 June 2020	Representatives from the Stanwell Tarong Power Station site leadership team Asset and Engineering Manager	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan consultation Pack: - Background Information - Proposed post mining land uses. - Indicative maps - Frequently asked questions - Options to provide feedback. - Feedback questionnaire.	Below are the key points discussed and feedback provided during the presentation of the PRCP consultation pack. **Beef cattle grazing** - can this description be modified to grazing only? **Plantation forestry** - does this include biofuels? - Does the ownership of the land change at the end of the life of the mine? Consider in developing PMLU's how they can be optimised for the broader Tarong complex such as biofuel hydro, wind & Solar. Can northern facing slopes be used or maximised for solar generation. - Can hills be shaped to optimise for possible wind generation? - What is the plans for the ash storage when the mine closes?	Refer to cell F3	The PRCP project team will consider the feedback received from the internal stakeholders and will initially work with the PRCP steering committee and the K2E project steering committee to agree if there are any actions for the PRCP or for functional/ business plans that arise out of the internal engagement.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Feedback from PRCP consultations to be documented for the PRCP Project team. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP.
9 June 2020	Water Advisory Committee	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses - Indicative maps - Frequently asked questions - Options to provide feedback - Feedback questionnaire	**Post Mining:** Don't create a haven for vermin - current perception is that the Kunioon is a harbour for pigs. Have an ongoing human presence. - Who will own the land post mining? **Grazing:** Have as much grazing land as possible; the cattle will keep the young wattle down. A higher gradient such as 17% would be fine, 25% would be too high and cause erosion. Ensure the final ripping doesn't leave large gouges and rough land, that make it unsafe for cattle to graze on. **Water Storage:** Will the PRCP be good for Rocky Creek? **- Future of TPS:** Could the power station be fuelled by gas? **- Other:** Will the PRCP flow over to the Kunioon test pit? The mine is in a good position for intensive farming (e.g. feedlots, piggeries, chicken farms), as it has good qualities such as water security and isolated valley. Would it be possible to create a 3D simulation map? Consider joining the water market.	Details of the consultation will be used by the PRCP Project Manager & WSP to develop and inform the outcomes states in the PRC Plan.	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Community member to complete feedback form. Feedback form to be collected by the community relations team mid-June 2020. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP.

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
23 June 2020	Local Community	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses - Indicative maps - Frequently asked questions - Options to provide feedback - Feedback questionnaire	The following was asked /discussed: -Asked what the two new proposed range of land uses are. - Questioned why the area shown on the map on page 12 was so large for infrastructure. - Commented on the large water storage area. - Questioned where Meandu Creek was situated in relation to the map on page 12. Feedback received 3/9/2021 - As part of an overall land use plan there is an opportunity to develop a fishing and recreation facility that will benefit the community in many ways. Fishing is well placed to provide community and commercial benefits that are able to be enjoyed by all. Some water storages are already in the plan and I would like to suggest that these storages be considered as part of a wider fishing and recreation strategy by increasing the available storage area, deepening the storage depth and provision of a diverse range of marine environments. Fishing is a major driver in outdoor recreation in the South Burnett region however the southern part of our region is less well serviced and requires people to drive some distances to access suitable waters. Facilities that would enhance and increase the usage of any water storages may be able to utilised from existing buildings e.g. day use areas, toilet and wash facilities.	Details of the consultation will be used by the PRCP Project Manager and PRCP steering committee to develop and inform the outcomes stated in the PRCP Plan.	The PRCP project team will consider the feedback received from the internal stakeholders and will initially work with the PRCP steering committee and the K2E Project steering committee to agree if there are any actions for the PRCP or for functionality / business plans that arise out of the internal engagement.	Feedback from the PRCP consultations to be documented for the PRCP project team. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP. Follow up email sent with survey/feedback request.
23 June 2020	Adjacent landowners	Email (In)	The stakeholder(s) completed PRCP feedback form. Received 23 June 2020	Feedback included: Workable land / Good shade trees. Make parks and trial tracks for the community. Plant improved pastures suitable for grazing cattle.	Refer to cell F3	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Stanwell to continue to inform community members about the progress of the PRCP.

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
23 June 2020	Adjacent landowners	Email (In)	The stakeholder(s) completed PRCP feedback form.	Feedback included: -Grazing Country - It would be best for that. - As long as there's an area left usable to get around the land - everything filled, no holes and no mountains. - Keep informed doing a good job maybe you will give me a chance to lease some land. - Thank you for the opportunity to talk to you in this way just keep doing your good work.	Refer to cell F3	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Stanwell to continue to inform community members about the progress of the PRCP.
23 June 2020	Near Neighbours	Email (Out)	Email re: PRCP - Feedback survey link/form	No response	NA		
23 June 2020	Adjacent landowners	Email (Out)	Email re: PRCP - Feedback survey link/form	No response	NA		
23 June 2020	Water Advisory	Email (Out)	Email re: PRCP - Feedback survey link/form	No response	NA		
24 June 2020	Department of Environment and Science, Department of Agriculture and Fisheries	Video conference meeting	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses - Indicative maps - Options to provide feedback	Key points discussed during the meeting are: **Rehab timing:** discussion on the rehabilitation sequence and what the success criteria would be. Likely post mining rehabilitation time scale and the maintenance requirements. Noted that we have approx. 200ha ready for certification and that milestones and success criteria will be subject to an EA Amendment application. **Tenure**: advice received that tenure treated differently to PMLU, but needs to support the PMLU. Discussion about ownership options including freeholding in the future. Void and hardwood planting on state forest tenure is not supported. **Water Storage**: will require further discussions on this. Noted K2E is the last operational pit and the optimum place for the void and water storage areas. Discussed Rocky and Meandu Creek Catchment divide. Asked if the water quality would be safe for use or recreation. Noted that this will be the subject of water modelling specifically for the PRCP. Discussed void locations again - DES/DAF reiterating cannot be a void on state leasehold land.	The feedback has influenced the decision to progress towards the freeholding of the leasehold land prior to closure of the mine. Comments on Hardwood plantation versus softwood plantation add weight to decision not to include any further plantation areas beyond current softwood mature trees.	Stanwell proposes that no additional Plantation Forestry area will be allocated as PMLU, maintaining this PMLU only for the existing mature tree where they border the HQPlantations existing license area. Stanwell is progressing on the process towards freehold of the applicable leasehold areas.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Feedback from the PRCP consultations to be documented from the PRCP project team. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
				Forestry: Discussion on softwood vs hardwood plantations. Hardwood may not be preferred use. **Mine life**: Confirmed the link between mine life and powerstation life. Black Breasted Button Quail: We were asked if the specific area could be reinstated. Explained that this is not possible in this area given terrain at end of life, but is being managed through offsets and enhancement of other areas.			
26 June 2020	HQ Plantations	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses - Indicative maps - Frequently asked questions - Options to provide feedback - Feedback questionnaire	Below are the key points discussed during the presentation of the PRCP Consultation Pack. Further feedback to come and will be recorded separately. · Seed – will it be locally sourced seed that is used for timber plantation **Rehab –** Spotted gum likes the soil type in the area, and the topsoil depth is available. **Water storage –** pleased to see available water storage nearby due to the increased threat from fire with eucalypt next door to their plantations, and that they would also function as a fire break between the 2 areas. **Tenure – State Forest –** what happens at end of life depends on DES (Parks). DES have asked to not have a void and Stanwell could return land to native woodland. HQ have several private blocks around Burnett and not actively seeking more country at this time. They are not progressing hardwood aspects at this time, due to limited success in hardwood. Focus is on softwood. **- Area:** what size is the area being considered for plantation timber. **- Timing:** when would trial for plantation timer and water access start. - As a neighbour they have a strong interest in fire impact from eucalypt near a hoop pine. Design of dame gives comfort, and a reasonable fire break allays concerns. - Personal view – grazing is a good land use adjacent to HQ Planation with stock permits to reduce fire risks.	The feedback from HQPlantations that they are not seeking any additional plantation area in the South Burnett, and the concern with respect to bush fires and the preference for firebreaks, has directly influenced the allocation of the grazing and plantation PMLUs.	Stanwell proposes that no additional Plantation Forestry area will be allocated as PMLU, maintaining this PMLU only for the existing mature tree where they border the HQPlantations existing license area.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Feedback from the PRCP consultations to be documented from the PRCP project team. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
28 June 2020	Adjacent landowners	Email (In)	Online PRCP Survey response received from the stakeholder(s) consulted.	First preference - Plantation Forestry. Land suitable should be returned to industry previously there and reduce pest harbourage. Second preference: Water storage	Refer to cell F3	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Feedback from the PRCP consultations to be documented from the PRCP project team. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP
29 June 2020	Local Community	Email (In)	Meandu Mine Progressive Rehabilitation & Closure Plan Initial Consultation/ Discussion -Background Information -Proposed post mining land uses -Indicative maps -Frequently asked questions -Options to provide feedback - Feedback questionnaire	Below are the key points discussed during the initial discussion of the PRCP. Attendee to complete compile their feedback and that information will be recorded separately. Questions/Comments: With the return to native vegetation (if proposals for plantations and cattle aren't allowed), I've seen rehabs where they've simply sprayed black wattle seed everywhere, in a native scrub area, which created a bit of a mess as you can imagine. Is there guidelines as to what native vegetation is replanted? If there is scope for replanting native grasses as well as trees/shrubs etc this might help in meeting both the current legislation of revegetation and maintaining the viability of the land for future enterprises. There are some great environmental benefits of carbon sequestration with grasslands and regenerative grazing, so hopefully the government will be open to options.	Refer to cell F3	Email a pdf copy of the PRCP presentation. Keep in contact regarding setup of follow up consultation meeting with the South Burnett grazing network.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Community members to complete online survey feedback. Stanwell to undertake ongoing community consultation and continue to inform community members about the progress of the PRCP.

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
14 July 2020	Adjacent landowners	Email (Out)	conversation with the stakeholder Re: PRCP followed up with an email request for feedback/ survey and included map.	No response	NA		
21 July 2020	Bunya Valley Landcare Group:	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses - Indicative maps - Frequently asked questions - Options to provide feedback - Feedback questionnaire	Below are the key points discussed during the presentation of the PRCP consultation pack. Further feedback to come and will be recorded separately. • Tenure: What would the post mining tenures be like? Will the soil quality dictate the tenures and PMLU? • Water: Suitability of water (in final voids) post mining? How much coal will remain post mining and will it affect the water quality? What is the capacity of the water reserves and will they retain water? Does the water level fluctuate and if so, is the revegetation designed for periodic inundation? If the water levels are low would the area look like a scar on the land? Could a weir be designed (to maintain a constant water level in the voids)? • Infrastructure: Convert existing buildings into apartments/units for people to live in or set up an industry hub. What is the current internet connectivity like at the mine? • Vegetation: A large interest was shown in the current native vegetation rehabilitation at Meandu (e.g. species of native, current quality, growth, design, weeds, strike rate, cost, source of seeds). What percentage of the land was native vegetation pre mining? A strong support to get back to nature and return the PMLU to native vegetation. Consider species that grow in wet and dry soil. From photos in the PRCP presentation and discussions positive feedback was received about Meandu existing rehabilitation and it was suggested to continue with the native vegetation rehabilitation work being undertaken at Meandu • Plantation Forestry: Suggestion to grow hemp • Grazing: Largely not supportive of grazing; compacts the soil and consumes native vegetation • Other: PMLU - natural parks surrounding	Refer to cell F3	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Discussion around the possibility of a small plot being made available to the Bunya Valley Landcare group for trialling natural ecosystem restoration (wholistic approach using bio-dynamic farming concepts) i.e. alternative to conventional mine rehabilitation methods.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Feedback from PRCP consultations to be documented for the PRCP Project team. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP. Due to the large interest in the rehabilitation at Meandu and the importance of relationships with the local land care groups, a site tour for Bunya Valley Landcare Group was recommended.

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
				recreational swimming holes. Is the vegetation cleared for mining mulched with a suggested use of native windrows spread over offset or incorporation of mulch into the topsoil prior to spreading?			
July 2020	Toowoomba Regional Council representatives	Meeting	Stanwell seeks input from Toowoomba Regional Council into the proposed post-mining land uses described in the attached information pack. Meandu Mine, like all operating mines in Qld is undertaking the preparation of a Progressive Rehabilitation and Closure Plan for formal submission to the Department of Environment & Science. Stanwell welcomes your feedback on what post mining land use would be of most value to the Toowoomba Regional Council and the surrounding community. Your comments and suggestions will inform our submissions and the approval outcomes. To provide your feedback you can either: • Arrange a face to face consultation with Stanwell staff (contact details below). We are happy to travel to Toowoomba to meet with respective staff and/or councillors • Complete a short online survey. To access the survey click https://www.surveymonkey.com/r/K7LRHVY , or • Complete in hard copy the survey questions included in the attached and email				Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Feedback from PRCP consultations to be documented for the PRCP Project team.

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
17 August 2020	DNRME (now DoR)	Meeting/Briefing	Meandu Mine Progressive Rehabilitation & Closure Plan Consultation Pack: - Background Information - Proposed post mining land uses - Indicative Maps - Frequently asked questions - Options to provide feedback	Below are the key points discussed during the presentation of the PRCP consultation pack. Further feedback to come and will be recorded separately. Tenure: − Provide clarity of the tenures on a map. − Aware there are a couple of leases – freeholding – look into the conditions of the lease – conversion - whole of the lot− Option to surrender, lease, or freehold and manage the remediation. It would seem inappropriate to transfer as can only be transferred for a like purpose. Is there a mining lease in that area? − A part of the road to the north has a permit to occupy − Application must be in TEC Coal.	Details of the consultation will be used by the PRCP Project Manager & WSP to develop and inform the outcomes stated in the PRC Plan.	Feedback to be provided for inclusion in the PRCP planning. EA amendment approved and 2 additional PMLU's included. PMLU distribution and layout in the final plans undertaken to align with the key themes of the community consultation feedback per column F.	Stanwell will propose outcomes that consider the feedback received from the community together with other relevant aspects of past rehabilitation and future rehabilitation planning. Feedback from the PRCP consultations to be documented from the PRCP project team. Undertake ongoing community consultation and continue to inform community members about the progress of the PRCP
17 September 2020	Local Community	Email (Out)	emailed Queensland Fire and Emergency Services (QFES) requesting PRCP feedback.	No feedback received	NA		
18 September 2020	Toowoomba Regional Council (TRC)	Email (Out)	emailed TRC to follow up on the July meeting and request feedback. PRCP pdf pack provided in email - Background Information - Proposed post mining land uses - Indicative maps - Frequently asked questions - Options to provide feedback - Feedback questionnaire	No feedback received	NA		
2 October 2020	Local Community	Email (Out)	emailed Fire Emergency Services requesting PRCP feedback.	No feedback received	NA		
24 March 2021	Near neighbours and 1200 stakeholders living in surrounding areas of Meandu mine.	Newsletter (posted)	A mine rehabilitation/our progressive rehabilitation and closure plan article was featured in the March 2021 Tarong power station and Meandu mine community newsletter.	No feedback received.	NA		
30 March 2021	Tarong power station and Meandu mine key opinion and business leaders, traditional owners, historians, Meandu	Newsletter (emailed)	A mine rehabilitation/our progressive rehabilitation and closure plan article was featured in the March 2021 Tarong power station and Meandu mine community	No feedback received.	NA		

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
	Barkers Creek consultation committee, South Burnett and Toowoomba regional councils		newsletter. https://www.stanwell.com/wp-content/uploads/TPS-newsletter-A4.pdf				
22 April 2021	Make good agreement landowners	Face to Face	Meandu Mine Progressive Rehabilitation & Closure Plan discussed during site visit to Meandu Mine: -Background Information - Proposed post mining land uses - Indicative Maps - Frequently asked questions - Options to provide feedback	No further feedback	NA		
9 July 2021	Make good agreement landowners	Face to Face	Meandu Mine Progressive Rehabilitation & Closure Plan discussed during a make good agreement visit to the landowners: -Background Information - Proposed post mining land uses - Indicative Maps - Frequently asked questions - Options to provide feedback	No further feedback	NA		
9 July 2021	Make good agreement landowners	Face to Face	Meandu Mine Progressive Rehabilitation & Closure Plan discussed during a make good agreement visit to the landowners: -Background Information - Proposed post mining land uses - Indicative Maps - Frequently asked questions - Options to provide feedback		NA		

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
27 July 2021	DNRME (now DoR)	Face to Face	PRCP Consultation Feedback from Department of Resources, Land Services	Further to the meeting on Monday, 17 August 2020 please note advice provided by XX below:- * Contamination : a conceptual site model should be prepared for all disturbed areas representing a 'source - pathway - receptor' model with breakages in the links confirmed. This would be supplemented with a Contaminated Land Investigation Document (CLID) stating the land is suitable for the preferred land-use. * Contamination: acid mine drainage must be remediated and prevented. * Landform stability: erosion modelling would be beneficial to justify a self-sustaining landform. Excessive rates of erosion (compared to baseline, natural) would not be acceptable. * Infrastructure: who will own and maintain residual infrastructure and what condition must it be in at closure. For example, if Stanwell currently own the high voltage electrical network, will it need to be transferred to another power entity and what costs will be incurred to ensure it meets their specification in order to take over ownership. The landowner will not want ongoing maintenance liability. This applies to all infrastructure that poses a safety risk. * Water storages, sedimentation dams and stream diversions (if any) : who will manage and maintain water containing structures (i.e. dam walls and spillways) or diverted waterways. * Voids : water balances required to justify water containment and/or groundwater impacts. * Voids : consider water chemistry in the water balance - will anoxic conditions affect chemistry. * Suitable material : map your closure land uses according to material types and current location. Or, during mining operations consider placing material types in locations that match the proposed future closure land use. If you wish to discuss or clarify any of the above points please contact directly. In relation to State Land Asset Management tenures, I have attached a schedule of existing tenures and comments.	Refer to cell F3	Future Land tenure options to be followed up with DoR Land services	

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
26 August 2021	Traditional Owners	Email	PRC Plan information pack We have mentioned previously that Stanwell is undertaking the process of transitioning to a Project Closure and Rehabilitation Plan (PRC Plan) and that we have been seeking community feedback in relation to the options being considered for that PRC Plan. The PRC Plan defines the post mining land use, landform design and rehabilitation goals, and the annual incremental commitments in progressing to this outcome. The proposed agenda for the site visit includes viewing rehabilitation areas and other aspects of the current site which may provide useful context for feedback in relation to the PRC Plan. Attached to this email is an information pack about the PRC Plan and the feedback options – would you please distribute this information pack to the Wakka Wakka #5 Applicant (who should feel free to distribute to their family members as previously noted). While Stanwell personnel attending the site visit will review this information with the ICC Members, the ICC Members in particular may also like to read the information in advance of the site visit. The information pack identifies multiple options by which feedback can be provided, which in this case also includes an opportunity to ask questions and provide feedback during the site visit.	The ICC Members to be further briefed about and to see other parts of the Meandu site that are relevant to the future activities we have previously mentioned. In particular, this includes the K2E Project (Stanwell's current project which will enable the extension of the existing King 2 East mine pit) and Stanwell's Project Closure and Rehabilitation Plan at the meeting being held at Meandu Mine on the 1 September 2021.	NA		

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
26 August 2021	Traditional Owners	Email sent by Clayton Utz	Referenced the email sent to Archeo in relation to the proposed site visit on 1 September 2021 and the PRC Plan information pack. We have mentioned previously that Stanwell is undertaking the process of transitioning to a Project Closure and Rehabilitation Plan (PRC Plan) and that we have been seeking community feedback in relation to the options being considered for that PRC Plan. The PRC Plan defines the post mining land use, landform design and rehabilitation goals, and the annual incremental commitments in progressing to this outcome. The proposed agenda for the site visit includes viewing rehabilitation areas and other aspects of the current site which may provide useful context for feedback in relation to the PRC Plan. Attached to this email is an information pack about the PRC Plan and the feedback options – would you please distribute this information pack to the Wakka Wakka #5 Applicant (who should feel free to distribute to their family members as previously noted). While Stanwell personnel attending the site visit will review this information with the Interim Consultation Committee (ICC) Members, the ICC Members in particular may also like to read the information in advance of the site visit. The information pack identifies multiple options by which feedback can be provided, which in this case also includes an opportunity to ask questions and provide feedback during the site visit.	The ICC Members to be further briefed about and to see other parts of the Meandu site that are relevant to the future activities we have previously mentioned. In particular, this includes the K2E Project (Stanwell's current project which will enable the extension of the existing King 2 East mine pit) and Stanwell's Project Closure and Rehabilitation Plan at the meeting being held at Meandu Mine on the 1 September 2021.	NA		

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
1 September 2021	Traditional Owners	Face to Face	Tech Resources Mgr. provided an overview of the Meandu Mine Progressive Rehabilitation and Closure Plan (PRCP), and detailed the following: • Reference was made to initial contact regarding this subject and the PRCP presentation package as provided prior to the site visit via QSNTS; • The rehabilitation work at Meandu Mine essentially progresses from west to east; • Two options are being considered for post mining land use: • majority of site as native vegetation with two final void water storage areas; and • grazing on lower sloping land in the central rehabilitated area in conjunction with native vegetation of the remainder, excepting two final void water storage areas; • All infrastructure is currently planned to be demolished and removed; • A number of dams and drains may remain in place with some associated pumping infrastructure (subject to requirements of the selected post mining land use); • Stanwell requests any input / feedback on the proposed final land use/s and on any other aspect of the PRCP - whether by phone, email or completion of the hardcopy form provided (this is also available online).	Stakeholder requested that some time be allowed for discussion within the Wakka Wakka People #3 Applicant group to assemble thoughts / feedback on the PRCP. Additional print copies were provided by Stanwell to facilitate this. 10/12/2021 - Stanwell legal representatives issued follow up email to Clayton Utz to ask QSNTS about the details of distribution of the PRCP pack.	NA		
19 October 2021	Local Community	Face to Face	The Stanwell General Manager Mining provided an update on: • Mining to support increased generation requirements • MSA • King 2 East • PRCP - project status, including updated PMLU based on consultation and preparing for submission in May 2022	No issues raised	NA		

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
27 October 2021	Department of Environment and Science, Environmental Services and Regulation	Video conference meeting	Formal agenda Verbal discussion	Importance of submission date and unable to be extended reiterated by DES. Review by DES will be piecemeal e.g. undertaken by different people Schedule milestones must be S.M.A.R.T. Include as much as possible in a pre-lodgement. Justify any section of Guidelines that is not applicable / not included. Approach to transitional site will be pragmatic. PMLUs must be substantially similar to pre-approved LOD's. e.g. grazing with native ecosystem on higher slopes. Creek diversion should be consistent with previous EMOS docs. Any rehab criteria in the EA must be in the PRC Schedule. Risk Assessment - must allow for and include sufficient time contingency for achieving the schedule e.g. weather or labour availability, climate change impacts. Offsets for K2E project requested to be in the Land Mgmt. Plan.	Review of milestone criteria for PRC Schedule. Readjustment of project timeline to achieve pre-lodgement.	Environmental Management Overview Strategy (EMOS) inputs for Creek Diversion will be included. Review of milestones against Specific Measurable Appropriate Relevant Timing (SMART criteria). Risk Assessment to include weather and labour risk delays. Aim for pre-lodgement end of Feb/start of Mar 2022.	Ongoing 6 weekly meeting.
23 November 2021	Local Community and Traditional Owners	Face to Face	The Stanwell General Manager Mining provided an update on: • Mining to support increased generation requirements • MSA • King 2 East • PRCP - project status, including updated PMLU based on consultation and preparing for submission in May 2022	No issues raised	NA		
1 December 2021	Underlying/adjacent owners, that are part of the QLD government or of HQ plantations who manage adjoining state land	Video conference meeting	Formal agenda Verbal discussion Update on Water Modelling progress for the PRCP	PRCP doc to include as much as possible for rehab and reveg - intended by DES to be a single point of truth Conditions will be moved from EA to PRCP w.r.t. rehab. Stanwell noted creek diversion meeting with DRDMW (department of regional development, manufacturing and water) following week. Water model discussed - advised that the PRCP must demonstrate appropriate mgmt. and monitoring, needs to show the water quality in the long term. Stanwell noted intention not to retain any infrastructure. JM advised that if the risk assessment outcomes showed any infrastructure is required then this must be included in the PRCP.	Stanwell review of reporting process and adjustment. Stanwell review process of infrastructure and workshop to identify any need to retain infrastructure.	Adjusted the planned risk assessment process for the PRCP to include DES advice to explicitly consider the technical report actions.	Ongoing 6 weekly meeting.

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
				Any technical work underpinning the PRCP is requested to be summarised incl. any assumptions and calibration.			
7 December 2021	Near neighbours	Face to Face	Meandu Mine update: PRCP - project status (PMLU update) and preparing for submission in May 2022. • Site impacts and challenges of COVID – i.e. temperature checking, maximum number of people in rooms, no large gatherings • Operations update: Mining to support increased generation requirements • MSA • King 2 East • Downer sale update • Introduction to new Contractor Meandu Project Manager/Site Senior Executive (SSE)	No feedback or issued raised	NA		
9 December 2021	Department of Regional Development, Manufacturing and Water (DRDMW)	Face to Face	Formal Agenda Verbal Discussion Site inspection - Meandu Mine LOMP and final landform features - dams remaining as part of natural landform profile - EA success criteria for PMLUs - PRCP and associated assessments particularly with regards to the Creek Diversions - 3 x Diversions discussed including their design, current status, intent to retain post closure - Final voids as water storage PMLU - Discussion on Meandu Creek Dam intent to reatain post-closure	No expected issues from DNRME or objections for Creek Diversions and associated in stream retention dams to remain as PMLU / part of landform post closure as long as they are stable and operating as intended. Can leave as-is including drop structures. Accepting / certifying would include relinquishing the water licence in addition to any other rehabilitation certification required under the current EA conditions transferred to the PRC Plan. No objections to Meandu Creek Dam being retained post-closure (not part of the PRC Plan but needs to be considered for the water modelling). Future ownership and responsibilities requires further consideration by DRDMW.	Stanwell considered both this advice and the previous conversations with representatives of DRDMW and DoR in considering the rehabilitation milestone criteria for the Creek Diversions, the footprint of the applicable PMLUs and the timing of the PRC Schedule.	Following further assessment of the rehabilitation strategies, adjusted as needed the revegetation plan and the PRC Schedule timing to ensure appropriate allowance for achievement of the applicable Rehabilitation Milestones.	Continue regular discussions and engagement with DRDMW centred on regular license renewal discussions.

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
12 January 2022	Department of Environment and Sciences, Environmental Services and Regulation	Video conference meeting	Formal agenda Verbal discussion	Discussion on how to treat PMLU for areas not within ML surface rights. Advised by DES to mark as one PMLU and assign this as the 'pre-mining' land use, as the land has not been used for mining. Stanwell noted intent to provide the Rehab Areas map at the next meeting. Stanwell discussed intent with trials - 2 off: Beef Cattle Grazing specific to demonstrating soil can support the required pasture and Steep Rocky Ecosystem via a monitoring program. DES advised this is a good approach, and the only need for a trial was if something new was happening without good experience. Make sure the area for the trial is clear in the PRCP submission with a polygon included. Distinguish whether it is an actual prescribed trial or a data collection/monitoring trial on the actual landform outcome (e.g. the Steep Rocky Ecosystem is just a data collection). DES reiterated that timing in the rehab sequence must include contingency for any items identified in the risk assessment process e.g. weather events, climate change, labour or machinery issues. DES is compiling a list of example milestones and criteria, this will be provided to Stanwell.	Review and discussion of PMLU map. Development of trial metrics for the two noted trials (Steep Rocky Ecosystem and Beef Cattle Grazing soil/subsoil alternatives). Input to Risk Assessment workshop for timing of rehab.	PMLU map and polygons adjusted inline with DES feedback. Development of language in the description of PMLU trials consistent with DES advice.	Pre-lodgement target 14th March 2022 unless agreed otherwise with DES.
Feb 2022 Letter 4 Mar 2022 Meeting	State Government : Department of Resources (DoR) - Land	Written letter and follow up meeting	Meandu confirmation of intent to freehold lands within Mining Lease currently as leasehold	DoR is supportive of TEC Coal making an application to freehold the land. • Lots 1_SP181280 and 111_FY817 will need to be amalgamated as 111 has no legal point of access • DoR noted that TEC Coal may wish to seek their own legal advice. • TEC Coal can kick off the freehold application process as soon as they are ready. • DoR noted that due to a State-wide prioritisation process it may take an extended period to process the application (could be two years) • DoR agree there is no need to address the Permit to occupy in this process. It can be handed back at TEC Coal's election	Meandu consideration as part of PRCP process.	Subject to consultation with DoR	Meandu capital budget and timing provision to support freeholding.

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
28 February 2022	Community Consultation Stakeholders	Letter	PRCP Update: -The plan will be submitted in May 2022 and approved by the Department of Environment and Science (DES). - Stanwell will be legally obligated to progressively rehabilitate the land in accordance with the progress plans, schedule and standards of its approved PRC Plan. While coal production at Meandu Mine is not expected to conclude until 2037, it is important that Stanwell takes progressive steps to rehabilitate and makes early plans to set out what the site's final landform and land use will look like after mining ceases. - During the development phase of Stanwell's proposed PRC Plan, we engaged with you, and various community and stakeholder groups to get your feedback and input on the progressive rehabilitation plan and post mining land uses (PMLUs) for the Meandu Mine site. - The feedback was taken on board and Stanwell's Environmental Authority for Meandu Mine was amended in February 2021 to include a total of seven approved PMLU types. This has resulted in four additional PMLUs being added into Stanwell's PRC Plan submission. Approved PMLUs (under Stanwell's Environmental Authority) now include: · Native ecosystem: The main PMLU by area proposed is native ecosystem; · Creek diversion: Addressing the remediation and restoration of historical Meandu Creek diversions; · Beef cattle grazing: Approximately 500 to 600 Ha of low slope areas of rehabilitation with access to	No feedback or issued raised	N/A	N/A	N/A

Consultation Date	Community Member	Consultation Type	Information Provided	Issues raised by community	How issues were considered	Decisions/ Outcomes	Commitments
			water which will be suitable for grazing; · Plantation forestry: A small belt of mature hoop pine plantation is reserved adjoining the Yarraman State Forest; · Water storage: Proposed in the two final mine voids, to support and complement Native Ecosystem, Steep Rocky Ecosystem and Beef Cattle Grazing PMLUs; · Landholder retained infrastructure: Prior rehabilitation plans considered retention of some mine infrastructure. On review, it is confirmed that no landholder retained infrastructure is required nor proposed within the Mining Lease; and · Steep rocky ecosystem: Final highwalls in residual voids will be rehabilitated to form a steep rocky ecosystem, providing native fauna and flora habitat with a diversity of slopes. The allocation of the PMLUs across the disturbance area of the mine is in final draft (meaning it may undergo some change prior to submission)				

END OF DOCUMENT

Appendix H

Meandu Mine Landform Design Report



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Landform Design Report

Meandu Mine



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Document control

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Revision History

Version	Date	Details of Revision
1.0	24/05/22	Document created to support the Meandu 2022 PRC Plan

1. Introduction

1.1. Purpose

The purpose of this report is to meet the requirement for the Landform Design Report as described in the Progressive Rehabilitation and Closure Plan (PRCP) Guideline (ESR/2019/4964, V2.00, Effective 17th March 2021) in regard to Environmental Authority (EA) EPML00709113 associated with Mining Lease (ML) 6674. This report is intended to be provided as a supporting document to the PRCP for the Meandu Mine ('the PRCP') and outlines the information used to develop and inform the proposed post-mining final landform so as to be safe and long-term structurally stable. Moving forward, this document will function as the guidance document for any updates or improvements that are undertaken to the final landform design.

The objectives of the proposed final landform include:

- Creating a safe final landform for humans, livestock and native fauna;
- Achieving long-term geotechnical stability;
- Constructing a final landform that does not cause environmental harm to the surrounding environment (non-polluting);
- Minimising as far as is practicable (given the geometry and water storage constraints) the final void footprint; and
- Supporting the post-mining land uses (PMLUs) proposed in the PRCP.

1.2. Relevant Legislation and Policies

Environmental Protection Act 1994

The amendments to the *Environmental Protection Act 1994* (EP Act) requiring mines with site-specific Environmental Authorities to have a PRC Plan, came into effect on 1 November 2019. The EP Act states the legislative information requirements for the rehabilitation planning part (section 126C) and PRCP schedule (section 126D). The EP Act also details the assessment process for the approval of a proposed PRCP.

The EP Act contains transitional provisions relating to existing site-specific mines. During the three-year transition period, DES issued notices to existing mines requiring them to develop and submit a proposed PRCP by a specific date. TEC Coal Pty Ltd received a transition notice for the Meandu Mine dated 31 August 2020 stating that the PRCP must be submitted by 31 May 2022.

PRCP Guideline

The PRCP Guideline is a statutory guideline made under section 550 of the EP Act and includes additional information requirements the administering authority deems necessary or desirable within a PRC Plan.

The PRCP Guideline provides information about the assessment process for a PRCP, information requirements for the PRCP, relevant post-approval processes and transitional provisions. The PRCP Guideline stipulates the detailed technical information that is expected to be included in a proposed PRCP.

Final Landform Design Requirements

The requirements of the final landform design, as described in the PRCP Guideline, have been summarised below along with the relevant section of this report addressing each requirement (**Table 1**).

Table 1. Final Landform Design Requirements

PRCP Guideline Requirement	Relevant Section of Final Landform Report
3D design plans of the final landform	Section 3
Method of determining final landform	Section 4
Modelling predicting the long-term stability of the final landform design	Section 5
Method of Construction	Section 6
Quality Assurance / Quality Control requirements	Section 7
Trial methodology to verify the predicted success of the final landform design	Section 8
Limitations and assumptions of the final landform design	Section 9

1.3. PMLU Goals

The PMLU goals for Meandu Mine include meeting the legislative requirements and achieving the relevant PMLUs currently identified in the EA. The PRCP framework requires all land with a PMLU to be rehabilitated to achieve *stable condition*. Section 111A of the EP Act states "Land is in a stable condition if-

a) the land is safe and structurally stable; and

b) there is no environmental harm being caused by anything on or in the land; and

c) the land can sustain a post-mining land use."

The current Meandu Mine EA (dated 12 January 2022) is a Land Outcome Document for the purposes of the PRC Plan and specifies that the site is to be rehabilitated in accordance with the criteria shown in **Appendix A** of this document, which includes final land uses and rehabilitation success criteria for landforms.

There are seven approved PMLUs for Meandu mine, including:

- Native Ecosystem;
- Creek Diversion;
- Beef Cattle Grazing;
- Plantation Forestry;
- Water Storage;
- Landholder Retained Infrastructure; and
- Steep Rocky Ecosystem.

Since the issue of Meandu Mine's amended EA (2 February 2021) which included these seven PMLUs, substantial work has since been conducted in preparing for submission of the Transitional PRCP. While seven PMLUs were approved in the EA, six PMLUs have been incorporated into the Transitional PRCP planning.

- The PMLU of Landholder Retained Infrastructure is not allocated in the final PRCP. A justifiable and appropriate beneficial use has not been able to be identified for mining infrastructure, and as a result all built infrastructure associated with mining is to be demolished and rehabilitated.
- Limited use is made of Plantation Forestry, restricted to an area undisturbed by mining that was planted to forestry adjoining the southern boundary of the surface rights area of Mining Lease 6674.

The revised final PMLUs and locations determined for this PRCP submission are shown in **Figure 1**.

1.4. Site Description

TEC Coal Pty Ltd (TEC Coal) owns the Meandu Mine which is approved under ML 6674 and EA EPML00709113. TEC Coal is a wholly owned subsidiary of Stanwell Corporation Limited (Stanwell). Stanwell is a Queensland Government Owned Corporation under the *Government Owned Corporations Act 1993* and registered under the *Corporations Act 2001*. Stanwell is one of Queensland's largest electricity generators and owns the Meandu Mine and Tarong and Tarong North power stations (Tarong power stations).

Mine disturbance and infrastructure at the site includes:

- Clearing and topsoil stripping ahead of active mining pits;
- Mine pits (Central Pit, Ramp 5 Pit, K4E Pit, K4S Pit and K2E Pit);
- Mine access ramps;
- Haul roads and access tracks;

- Magazine / storage compounds;
- Water management infrastructure;
- In-pit and out-of-pit spoil dumps incorporating rejects cells;
- Coal Preparation Plant, stockpiles and conveyor to Tarong power stations;
- Mine infrastructure area (including administration, warehouse, workshops, shutdown areas etc);
- Associated infrastructure and services; and
- Tailings and coal combustion by-product (ash) storage facilities.

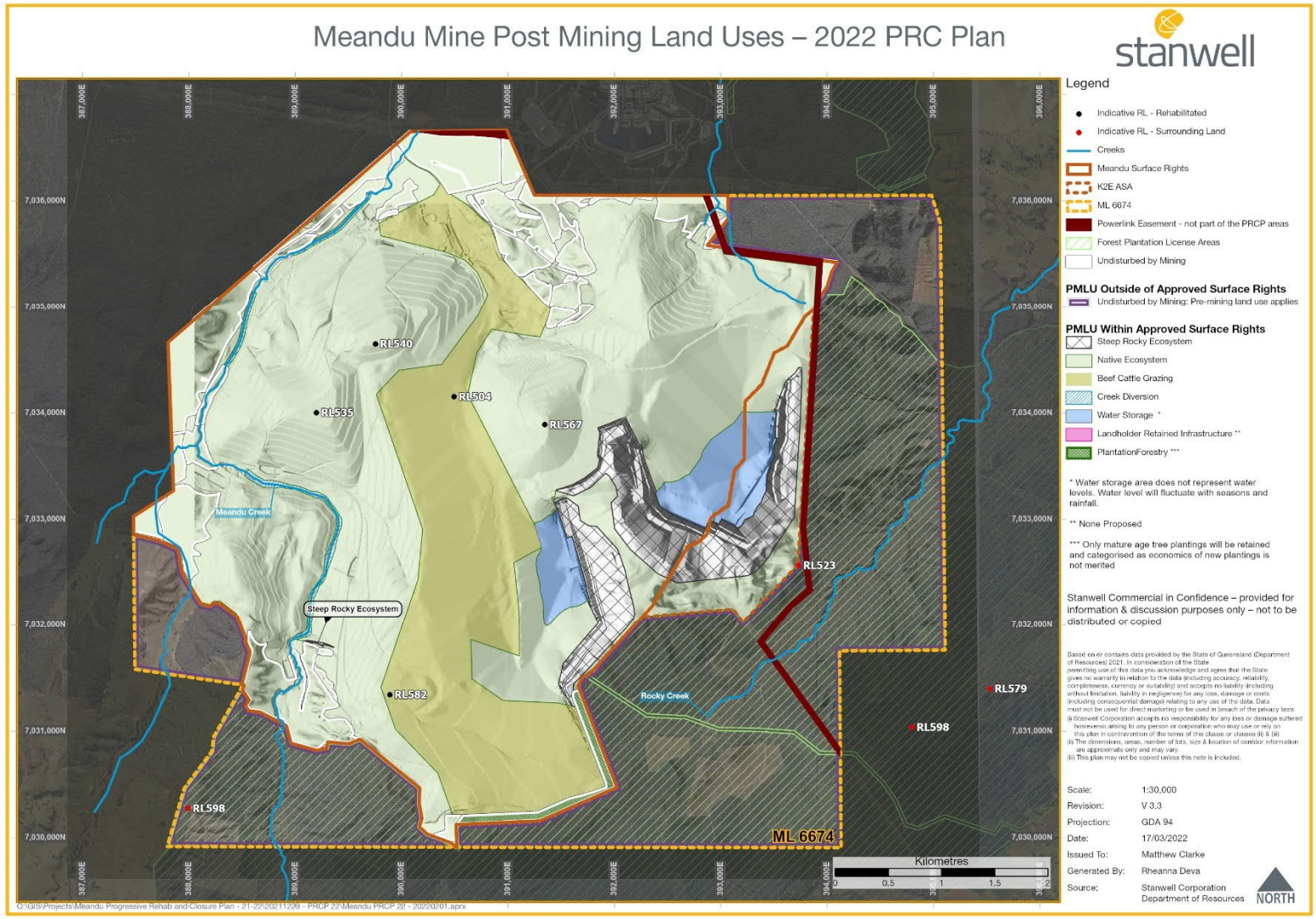

Figure 1: Final Land Uses and Locations for Meandu Mine Transitional PRC Plan Submission

1.5. Landform commitments

Table 2 summarises the commitments Stanwell have made relating to landform design.

Table 2. Landform Commitments

Source	Commitment
Landform Design Parameters	• Steep Rocky Ecosystem, Water Storage, Plantation Forestry, Beef Cattle Grazing and Native Ecosystem PMLUs to achieve a Geotechnical Factor of Safety >1.5 for stability, with Steep Rocky Ecosystems being assessed at the projected stable crest. • Native Ecosystem PMLU to have majority of slopes ≤ 17% with minor areas up to a maximum of 25% to achieve tie-in with surrounding areas. • Beef Cattle Grazing PMLU to have 80% of slopes ≤ 15% with minor areas up to a maximum of 25% to achieve tie-in with surrounding areas. • The landform for the Steep Rocky Ecosystem PMLU to provide a diversity of slopes, including a mix of predominantly flat benches and batters up to 80 degrees. • The landform needs to reflect the Creek Diversion PMLU which includes the three historic diversions that have been constructed according to approved, certified design plans
Waste Placement Parameters	• Rejects (including tailings) to be covered by a minimum 6 m NAF material below the final landform. • Coal combustion products (Ash) to be covered by a minimum 2 m NAF material below the final landform.

2. Final landform design criteria

The following items are the key design criteria for the Meandu Mine final landform. They have guided the evolution of the current landform and remain the principles on which any future amendment or improvement the landform is undertaken.

Table 3. Landform Design Criteria

Aspect	Design Criteria
Final Voids	• Maintain or optimise the location and geometry of the two final voids • Where possible, minimise size, depth and volume of final voids • Ensure drainage into the final voids is in alignment with the water storage requirements • Assess against the final highwall setback criteria, to avoid key assets/ infrastructure between the FOS 1.5 setback line and pit crest and provide adequate standoff from the site boundary.
Material Placement	• Integrate selective waste placement in accordance with design guidelines for material characterisation and to meet sub and topsoil requirements for each PMLU. • Achieve minimum PAF (6 m) and ash (2 m) capping waste placement requirements as indicated in Table 2. • Achieve Life of Mine (LOM) power station ash storage, with a contingency tailings storage portion, within a pit void facility. • Achieve progressive LOM placement of Mixed Plant Rejects (MPR) within pit void catchments excluding the planned K2E ASA.
Integrated Landform Design	• Maintain a general alignment to the existing constructed landforms. • Enable the grazing PMLU footprint identified and included in the consultation and latest LOM. Target similar size footprint and target an average gradient of equal or less than 15%. • Assign a maximum overall grade of 7.5 degrees for LOM conceptual design (8 degrees for in-pit low-wall), noting detailed design will result in localised steepening in individual areas. • Final landform slopes to be generally designed <17% (preferably <15%), with minor areas up to a maximum of 25% to achieve tie-in with surrounding areas. • Achieve and optimise offsite drainage objectives for catchment return to Rocky Creek from the rehabilitated landform.

3. Design plans of the final landform

3.1. Results

The final 3D landform from the 2021 LOM plan underpinning the 2022 PRCP submission achieves the objectives outlined in Section 1 and design criteria in Section 2.

The two final voids are in similar locations to the previous landform, in the K2E and K4E pits, and have been optimised to reduce their size and extent. A smoother and gentler slope has been achieved in Central, Ramp 5 and the upper slopes of K4E than the prior 2019 LOM plan. Overall grades have been kept below 7.5 degrees for spoil dump areas (8 degrees for lowwall areas in final voids) that have been reshaped as part of the 2021 LOM final landform. **Figure 2** shows the 2021 LOM plan final landform conceptual design. Minor subsequent amendments have been made to the landform to tailor specifically to mine progress, and to ensure achievement of appropriate cover and drainage objectives.

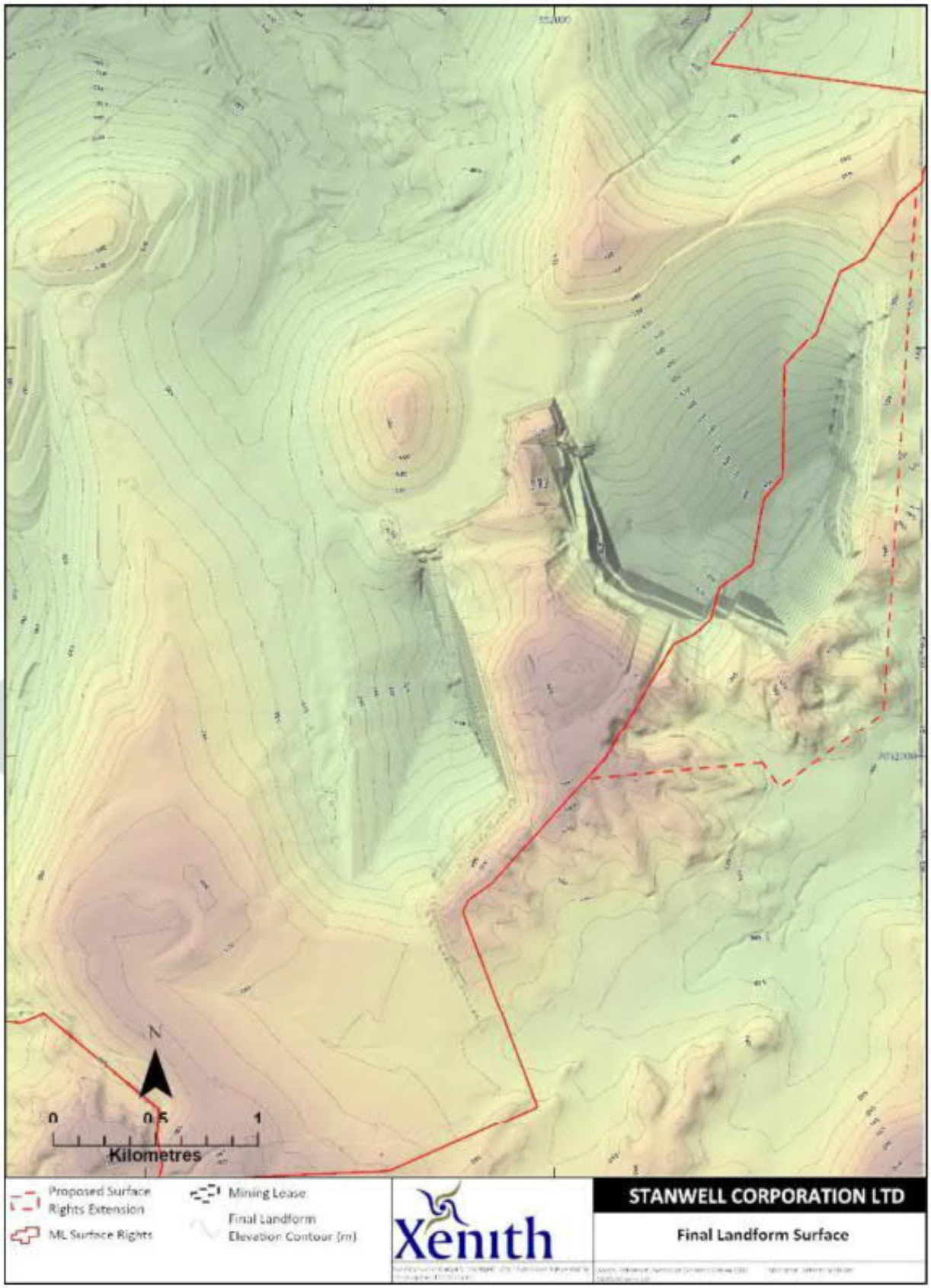

Figure 2: Final landform design

The Beef Cattle Grazing PMLU has been nominated for areas in the Western pit areas with overall grade generally < 10% (5.67 degrees) with some slopes in specific areas up to 15%. **Figure 3** is a grade plot of the final landform with the grazing PMLU defined by the red dashed polygon. The conceptual final landform as illustrated in Figure 2 and Figure 3 has been used as the basis for the detailed rehabilitation design for execution. This includes the design of any required waterways and is the landform from which the selective placement of material will be scheduled in the short term and annual mining plans.

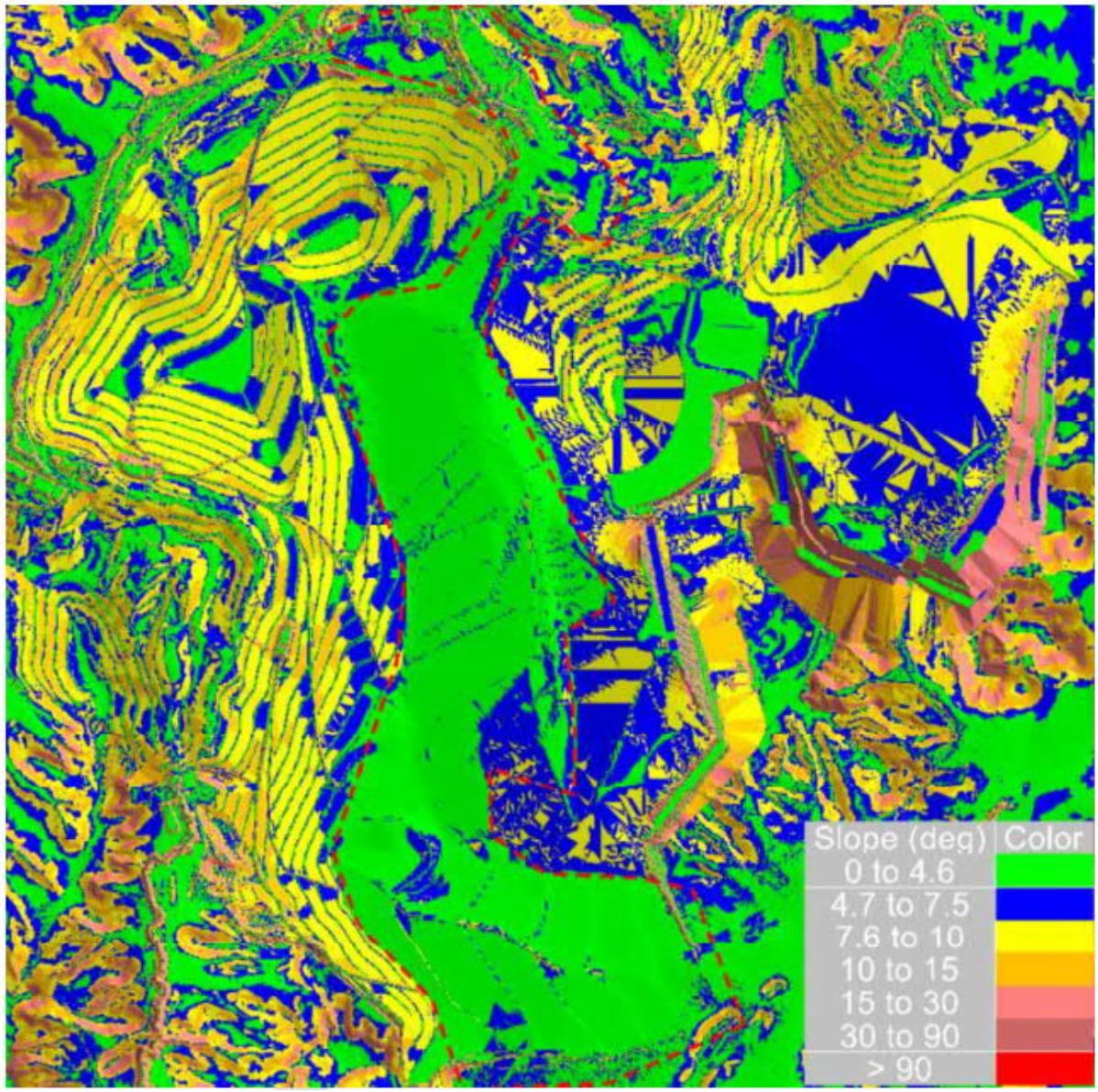

Figure 3: Final landform grade (degrees)

3.2. Comparison to previous landform designs

Considerable work has been undertaken to optimise the design and smooth the slopes in the 2021 LOM final landform, with the following key differences over the previous 2019 LOM plan:

- The landform now provides an extended gentle slope in the western pit areas for the Beef Cattle Grazing PMLU zone;
- There is an increased area returned to the Rocky Creek catchment in the north of K2E;
- The final voids surface area and catchment area have been reduced;
- There is a slight reduction to the overall grade in the K2E low wall area;
- Stockpiles of NAF material have been provided above the final landform profile in the western pit areas. These are rehandled later in the LOM plan to backfill K4E and K4S pits. This is due to shortage of dump room at times during the schedule and influences the timing of rehabilitation in these areas.

3.3. Dump locations

There are ten dumps within the final landform as shown in **Figure 4**.

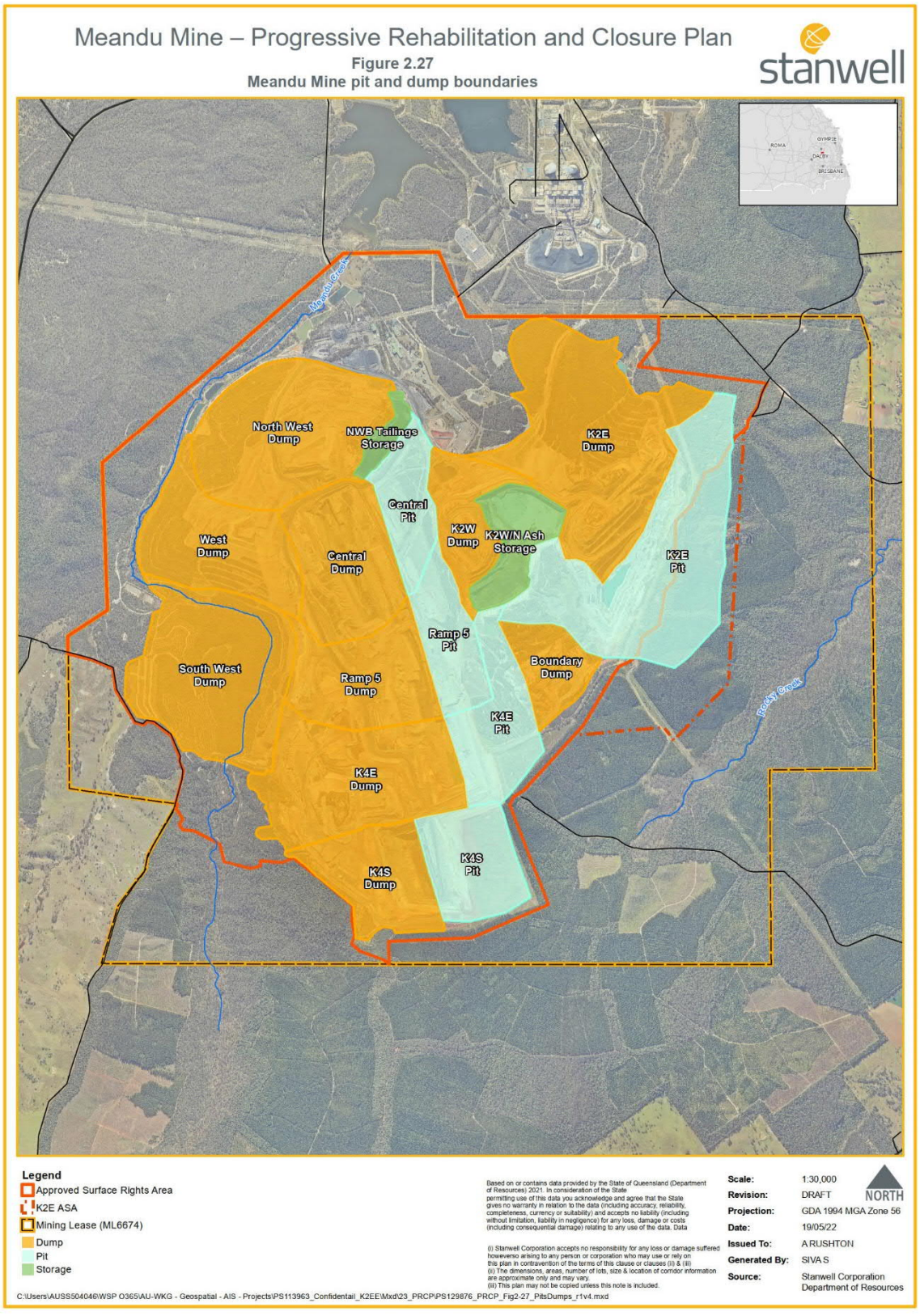

Figure 4. Meandu Mine Dump Areas

3.4. Creek diversions

Diversions of Meandu Creek are included in the PMLU allocation, with the PMLU of Creek Diversion. Three sections of creek diversion have historically been constructed within the Meandu Mine surface rights area since mining commenced, including:

- Downstream diversion, 1986, approximately 970 m in length;
- Middle diversion, 1992, approximately 780 m in length; and
- Upstream diversion, 2005, approximately 2,300 m in length.

The older (Downstream and Middle) creek diversions were approved in accordance with the requirements of the time, being the Mining Lease and the attendant creek diversion designs, with construction undertaken in accordance with design. The more recent Upstream diversion work was conducted under Water Licence 102005 and according to approved design plans (URS 2010). Construction and rehabilitation have been undertaken in accordance with the specific approved designs and works have been inspected as certified as in compliance with design.

3.5. Watershed / Catchments

In development of the final landform the two key watershed drainage objectives were;

- To reduce where possible the catchment area for the final voids; and
- To return as much area as was reasonable of the K4S rehabilitated area to the Rocky Creek catchment without causing downstream stream erosion issues

The application of these objectives to the 2021 LOM has resulted in an improved balance of catchment returns to Meandu Creek and Rocky Creek relative to the previous 2019 LOM plan. The current mine plan provides the opportunity to return catchment from some of the northern K2E mining area to Rocky Creek. Waterways have been designed into the landform adjacent to the K2E and K4E final voids, to reduce the respective catchments reporting to these voids.

Much of the K4S landform has been engineered to return the area to the Rocky Creek catchment. The remainder of the western areas of the mine footprint drain north into Meandu Creek. In K2E a portion of the landform area drains into the Rocky Creek catchment while the rest drains north into the Black Gully catchment and ultimately Meandu Creek (via Black Creek Dam).

The proportion of the catchment that reports to each of the main waterways is shown in **Table 4**.

Table 4. Proportion of catchment area into main waterways as a percentage of total Surface Rights Area.

Catchment	Percentage of footprint
Meandu Creek	64
K2E Void	12
Rocky Creek	11
K4E Void	7
Black Gully	6
Total	100

Flood modelling on the final landform from the 2021 LOM has been undertaken by SLR (2021). The modelled Meandu Creek catchment covers a total area of approximately 75 km^2, 55 km^2 of which drains to Meandu Creek Dam, with the remainder draining to the final voids and Black Creek Dam associated with the Tarong Power Stations. The modelled Rocky Creek catchment covers an area of approximately 35 km^2. Sub-catchments were delineated using the post-mining model landform as illustrated in **Figure 5**.

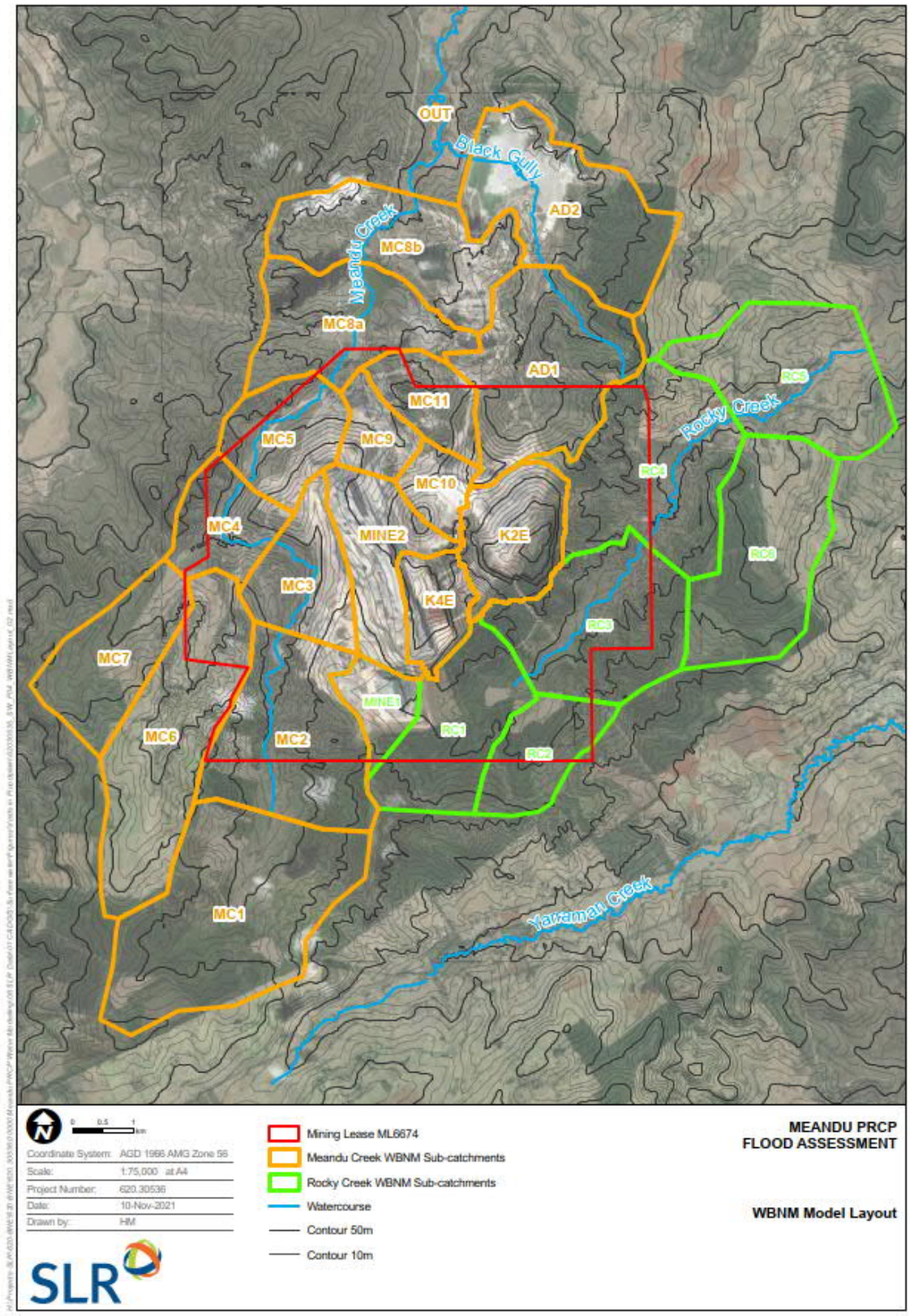

Figure 5: Sub-catchment Areas (SLR, 2021)

The potential downstream impacts were assessed by SLR with regard to the following considerations:

- The catchment area and land use coverage of Rocky Creek will be effectively unchanged following rehabilitation in comparison to pre-mining conditions.
- The catchment area of Meandu Creek will be reduced by approximately 0.05 km^2 (less than 8% of the overall catchment area) i.e. the local catchment area associated with the final voids.
- Meandu Creek drains to the existing Meandu Creek Dam immediately downstream of the project extent.

Therefore, it can be reasonably expected that the hydrologic regimes downstream of the project extent will not be significantly impacted due to the proposed post-mining conditions in both Meandu Creek and Rocky Creek. This is a result of little change to the overall catchment area (<8% catchment reduction) due to the containment, and effective minimisation through the LOM planning process, of the catchments immediately surrounding the voids. Furthermore, changes to the flow regime are interrupted and attenuated by the Meandu Creek Dam. The proposed final voids are located outside of the flood inundation footprint of both Meandu Creek and Rocky Creek for the modelled flood events up to and including the Probable Maximum Flood (PMF) (SLR, 2021).

3.6. Checklist – methods of design

The table below summarises the design requirements for the final landform.

Table 5. Design method requirements

Aspect	Landform Requirements
Post-mining land use	Slopes and material suitable for the proposed PMLU for the area.
Landform stability	>1.5 Factor of Safety achieved for Geotechnical Stability. Appropriate setback allocated for final highwalls assessed at projected pit crest, with no key infrastructure or assets located between highwall crest and setback line.
Material characterisation and placement	Material placement to comply with the Material Design Parameters.
Material balance	Sufficient material availability to comply with the Material Design Parameters.
Sensitive receptors and visual amenity	Final landform aims to blend into the surrounding land uses and shaped as to minimise as much as is practicable negative visual amenity at sensitive receptors.
Final voids	Final void extents minimised as much as is practicable given the geometry and water storage constraints.
Creek diversions	Certified design plans under pre-existing approvals
Water balance	Water retained within the final voids to at a minimum meet the requirements for the water storage PMLU.

4. Method of determining Final Landform design

4.1. Overview of the design process

Developing a final landform is a reiterative process as new information and considerations are incorporated. **Figure 6** shows the general process.

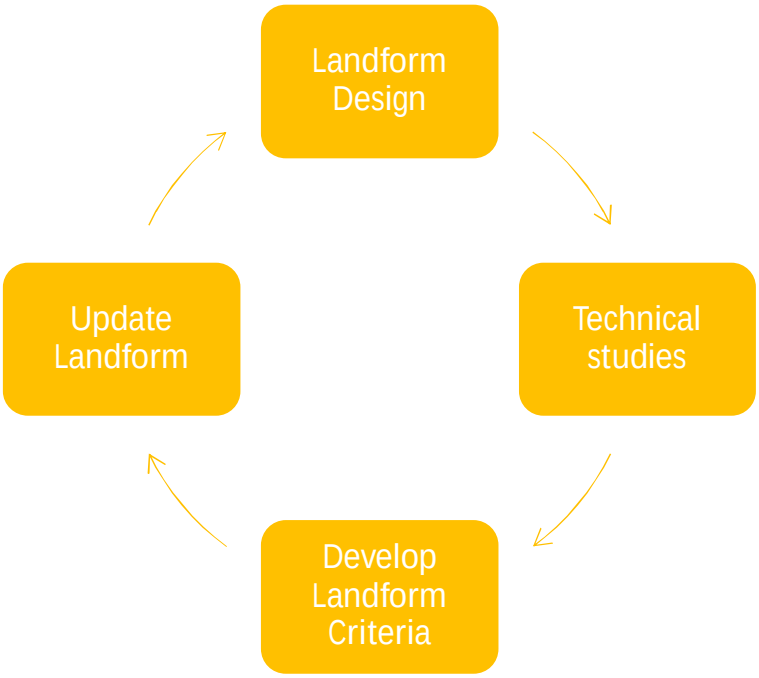

Figure 6. Landform Design Process

The process starts with a preliminary landform design which allows the parameters used in the design to be tested. Technical studies that are typically undertaken to support the landform design include erosion modelling, waste characterisation, flood modelling and mine planning. The inputs from these studies are used to create landform design criteria to suit the proposed post-mining land use, that are then used to update the final landform. The design criteria are reviewed, and landform updated accordingly as more technical information becomes available.

Using the 2019 LOM final landform design as a preliminary design, the design criteria in Section 2 have been developed based on technical studies as outlined in Section 4. The 2021 LOM Plan incorporates strip and pit design improvements including:

- Incorporating results from the 2020 Geotechnical Stability of Final Highwalls assessment into final highwall designs;
- Redefining K2E pit limits by reducing box cut movements, improving in-pit dumping and realigning strips; and
- Reserving of staged pits in K2E to improve access and haulage efficiencies.

The final landform has been developed using the process outlined below, to meet the key objectives outlined in Section 1.1 of this report:

- Utilise the 2019 LOM final landform as a starting point, which was based on an optimisation study addressing mine planning and coal supply over the life of the Tarong Power Stations;
- Reserve the major material types and develop an initial dumping schedule that considers selective placement of material types within the landform;
- Design the final landform based on the as-dumped landform of the initial dumping schedule;
- Update the dumping schedule to achieve the designed final landform, where possible reducing the bulk earthwork volume required at closure;
- Develop a bulk earthworks schedule to achieve the final landform post mining;
- Refine drainage requirements including localised regrading to optimise landform stability;
- Determine progressive disturbance and rehabilitation areas from mining and dumping stage plans; and
- Generate final landform for the 2022 PRCP submission.

The Deswik Landform Engineering tool and 3d Dig were used in conjunction to undertake the design work. Multiple iterations of the final landform were performed and reviewed before arriving at the final landform design for closure.

4.2. PMLU requirements

The landform requirements that are incorporated into the Rehabilitation Milestones for the four main PMLUs have been summarised in **Table 6**. For the complete details of these criteria refer to the rehabilitation milestones associated with the PRC Schedule.

Table 6. PMLU Landform Requirements

Post-mining land uses	Slopes	Factor of Safety
Native Ecosystem	N/A	>1.5
Beef Cattle Grazing	80% of slopes ≤ 15 % Minor areas up to a maximum of 25%	>1.5
Plantation Forestry	N/A	>1.5
Steep Rocky Ecosystem	Diversity of slopes including mix of predominantly flat benches and batters up to 80 degrees	>1.5 assessed at the projected stable crest
Creek Diversion	As per certified design plans	N/A for landform design process

4.3. Landform stability

The geotechnical criteria used in the landform design is based on the site Geotechnical Reference Report (Sherwood Geotechnical and Research Services, 2020), which is regularly updated to represent a compilation of information that is current to the issue date of the report. It includes a guide to geological and geotechnical conditions and recommended parameters for stability and groundwater pressure analysis purposes. Geotechnical recommendations for excavated slopes are based on a combination of back analyses of prior instabilities, design analyses based on adopted strength parameters, and observations of slope profiles that have demonstrated acceptably stable performance

Operational highwall angles of 70 degrees are generally used in competent material at Meandu Mine; this applies to the majority of the dragline passes except in K2E, Central and the northern Ramp 5 dragline passes where highwall angles are 45 degrees. Ramping systems have been included in each strip design where applicable.

Final landform stability has been assessed by Henderson Geotech (2019, 2020, 2021) and results have been incorporated into the landform design process.

4.3.1. Final Highwall Stability

Final highwall design parameters have also been based on results from the Assessment of Geotechnical Stability of Final Highwalls (Henderson Geotech, 2020). An assessment of the geotechnical stability for the proposed final highwalls at Meandu Mine was undertaken by Henderson Geotech Pty Ltd (2020) using limit equilibrium slope stability analyses. Overburden properties and geometric profiles were based on the information in the Geotechnical Reference Report, as summarised above. The geological model and long-term mine plan were interrogated for six locations around the planned two final voids to define the range of overburden conditions, with the following results:

- Residual soil (Miocene deposits) – up to 90 m thick;
- Weathered coal measure rocks – 10 m to 120 m thick; and
- Overall pit depth – 160 m to 300 m.

Stability analyses were carried out using *Slide v6.0* software for various combinations within those ranges, and in each case the distance behind the wall beyond which the Factor of Safety was ≥1.5 for all potential slip surfaces was determined. Statistical regressions were performed on the results and the output equations were adjusted to provide slightly conservative predictions for set-back, as shown in **Figure 7**.

Minimum set-back from wall toe: **S = maximum of (S3, S2 + Wf *and* S1 + Wf + Ww)**

Where:

S3 = 2.7*Tm + 2.2*Tw + 1.5*Tf – 70

S2 = 4*Tm + 2.3*Tw + 9.8*Tm/Tw – 32

S1 = 5.1*Tm – 59

Tm = *thickness of Miocene sediments (residual soil and completely weathered rock)*

Tw = *thickness of highly and moderately weathered coal measure rocks*

Tf = *thickness of slightly weathered and fresh coal measure rocks within the wall profile*

Wf = *horizontal distance from the wall toe to the top of slightly weathered and fresh coal measure rocks on the wall face.*

Ww = *horizontal distance from the base to the top of highly and moderately weathered coal measure rocks on the wall face*

Figure 7. Final highwall minimum set-back calculations

These variables are illustrated on **Figure 8**.

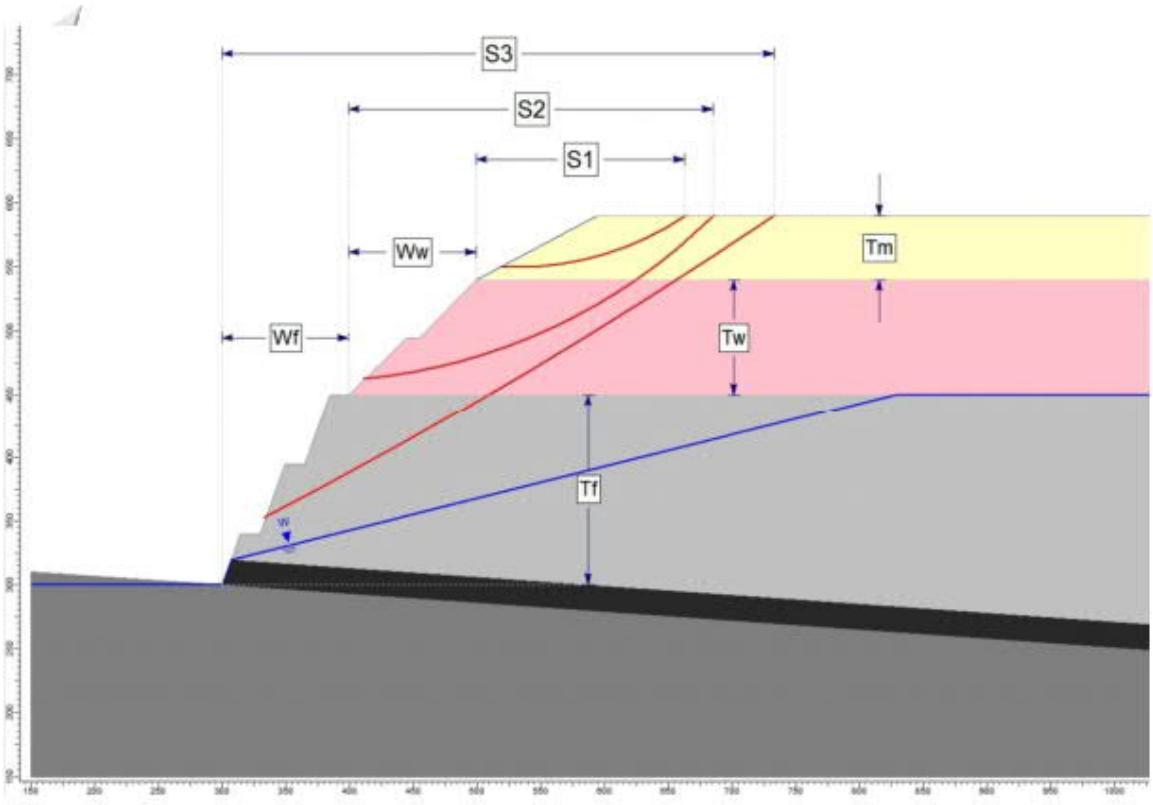

Figure 8. Definition of Parameters (Henderson Geotech, 2020)

Several final highwall locations were analysed as part of the 2021 LOM Plan to identify the setbacks required to achieve a FOS >1.5, that would be used to define the stable projected pit crest and determine an appropriate standoff from the surface rights boundary and key infrastructure. The boundary of the Steep Rocky Ecosystem PMLU footprint is assigned at the setback distance from the physical crest and a nominal 50 m buffer was applied between the Steep Rocky Ecosystem PMLU and surface rights area boundary.

4.3.2. Rehabilitated Spoil Landforms

Henderson Geotech (2021) assessed the geotechnical stability of in-pit and out-of-pit rehabilitated spoil landforms, using limit equilibrium slope stability analyses with strength properties selected from Meandu Mine Geotechnical Reference Report (Sherwood Geotechnical and Research Services, 2019). In all likely scenarios analysed, the FOS against geotechnical instability was greater than 1.5 given the following key geometries:

- Out-of-pit dump height – up to 130 m;
- In-pit (low wall) dump height – up to 300 m above spoil toe at highwall (and 370 m above the mined pit floor); and
- Spoil slopes – up to 25 %.

For out-of-pit spoil landforms the assumed worst-case rehabilitated landform was initially assessed with *Galena* slope stability software using the Spencer-Wright circular failure surface method, assuming 100 m dump height, 25% slope, 50 m depth of residual clay beneath the dump and saturated mixed spoil. The minimum FOS for this scenario was greater than 1.5 (1.72) as shown in **Figure 9,** demonstrating adequate geotechnical stability for the proposed landform. The slope, height, spoil type and depth of residual clay were varied in further analyses that confirmed that the selected case did have the lowest factor of safety and that all likely configurations had factors of safety greater than 1.5.

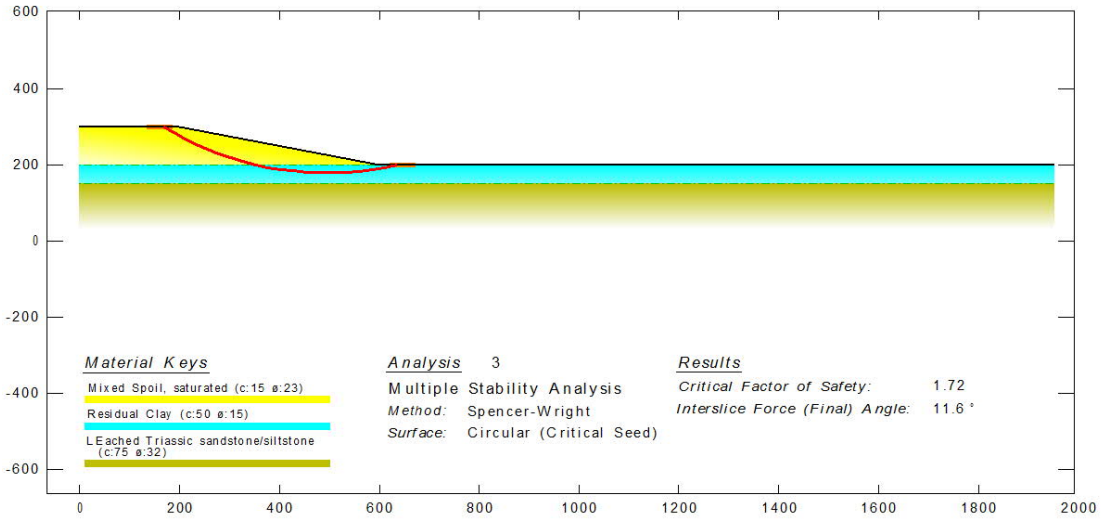

Figure 9. Analysis of out-of-pit spoil - worst case geometry and materials

Subsequent sensitivity analysis were run using Slope2 slope stability software, for out-of-pit dumps up to 130m high with slopes that were over backfilled pit to varying degrees, using

other worst-case parameters previously selected. The minimum FOS was 1.64 for the case that was entirely out-of-pit, as shown in Figure 15.

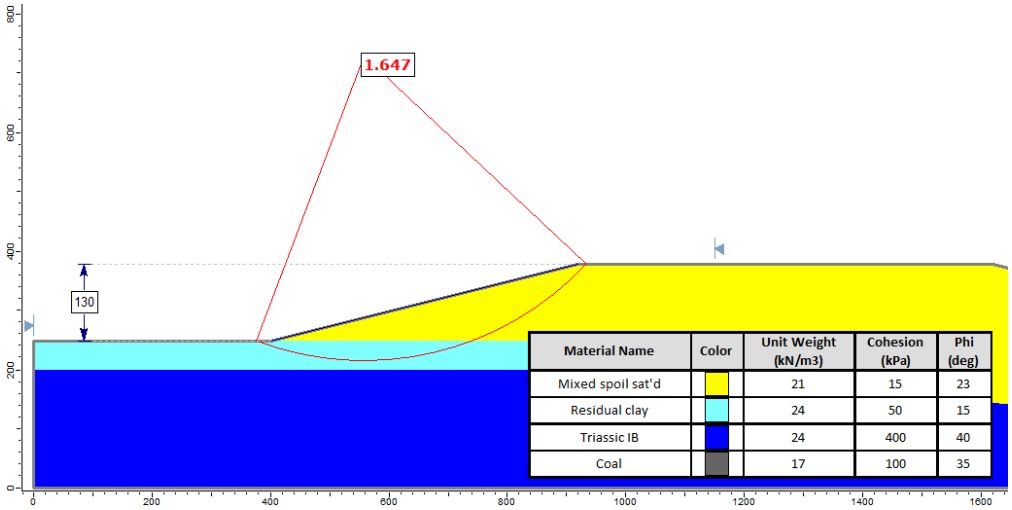

Figure 10. Batter stability of out-of-pit landforms

Spoil in the final strip's low wall is located and benched in a way such that when it is pushed to final grade it keys against the highwall. Parameters affecting geotechnical stability of in-pit spoil slopes rehabilitated to the described geometry include landform height, slope, spoil type (strength properties), pit floor dip and water table in the void.

Stability of in-pit rehabilitated spoil dumps was analysed using Slide slope stability software, determining the worst-case combination of dump height and water level, then varying floor dip and slope separately. **Figure 11** shows an example of the models used for these analyses.

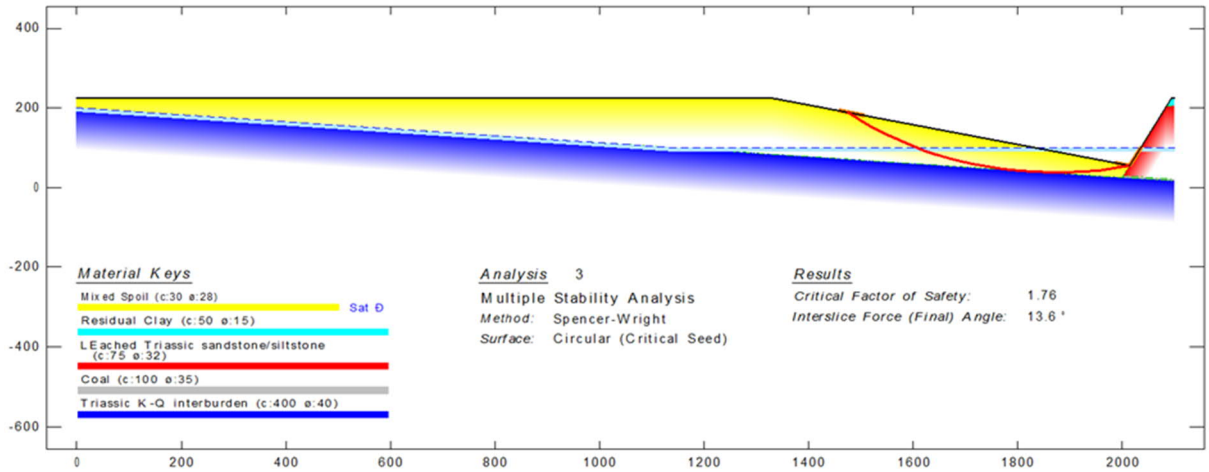

Figure 11. Model for in-pit spoil - base case geometry and materials

Results from the initial assessment are shown in **Figure 12** and **Figure 13**. The most adverse water table level was 100 m above mined floor. Dump height had an effect only at lower heights (increasing the height above 125 m had negligible effect) and floor dip also had minimal effect. The parameter with most influence on geotechnical stability was batter slope.

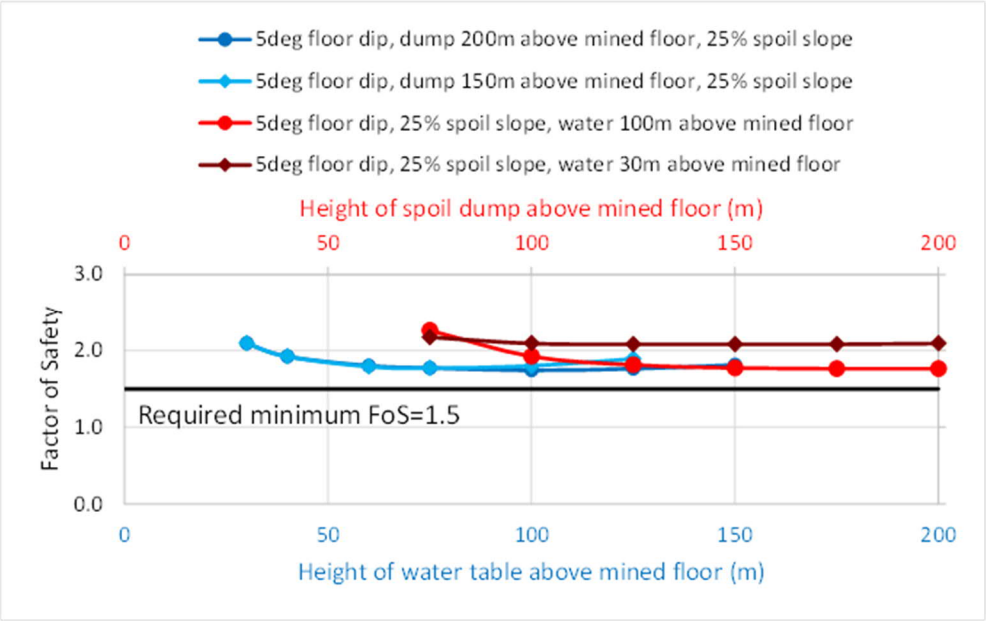

Figure 12. Effects of water table and dump height on in-pit spoil stability

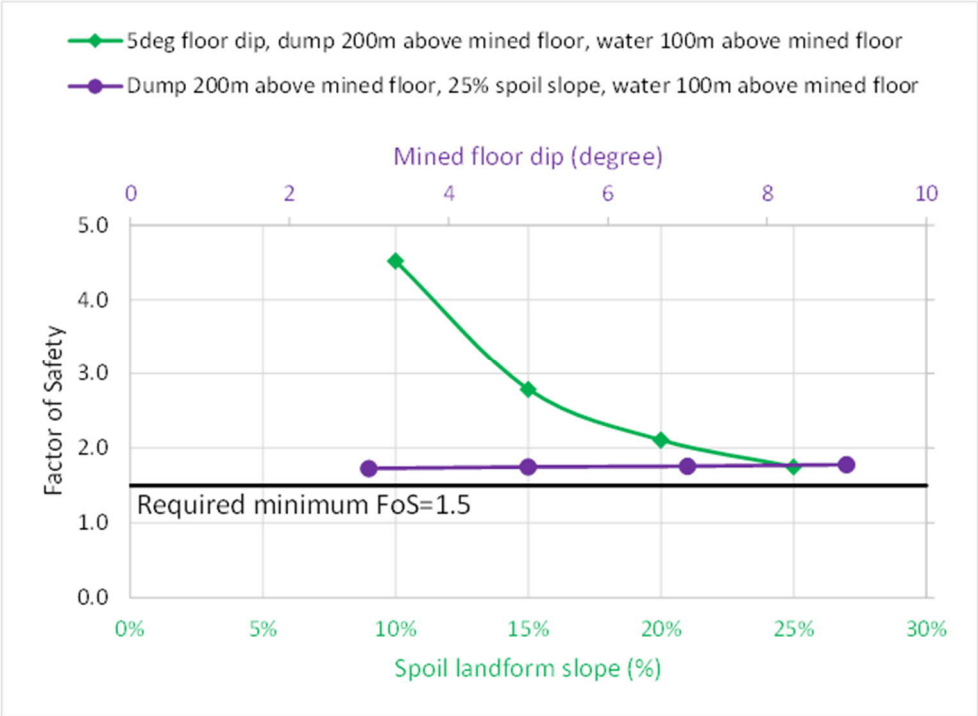

Figure 13. Effects of floor dip and slope angle on in-pit spoil stability

Additional geometries were assessed in conjunction with development of the 2021 LOM plan, including increasing the backfill against highwalls up to 70 m thick and the height of regraded low wall up to 300 m above the intersection with the highwall. These two parameters were treated as variables, along with water table height.

The results presented in **Figure 14**, show that depth of backfill had minimal impact on stability, and that changing water height also had minor impact except at low height. All foreseeable configurations assessed had a minimum factor of safety greater than 1.5.

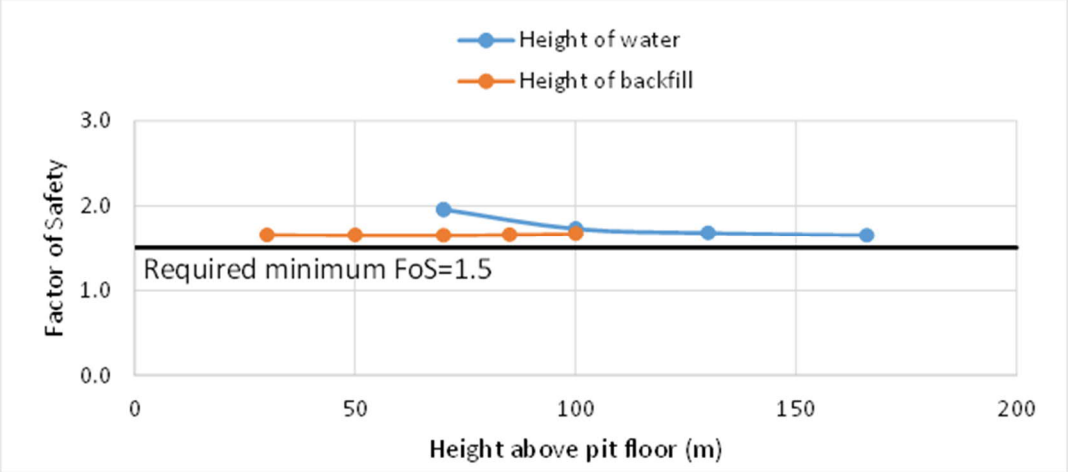

Figure 14. Effects of water table and pit backfill on stability of 300 m slope

4.4. Material requirements

4.4.1. Summary

Selective placement of different waste units to different zones within the final landform was incorporated into the LOM Plan to adhere to the Meandu Waste Management Plan and the geostatistical assessment by SRK Consulting (2021).

Four different zones were cut into the 2021 LOM Plan dump reserve set. These zones allow for definition of the following layers:

- 0 to 2 m below final landform;
- 2 to 6 m below final landform;
- Greater than 6 m below final landform; and
- Above final landform.

Dumping constraints were then used to adhere to the material placement criteria (**Table 7**).

4.4.2. Selective placement

Studies undertaken relating to mine waste material characterisation are summarised in the document Meandu Mine: Progressive Rehabilitation and Closure Plan – Waste Characterisation Report (WSP, 2021). Information from that document that relates to selective material placement is summarised in **Table 7** and forms the design parameters to be used for construction of final landforms at Meandu Mine.

Table 7. Material Design Parameters

MATERIAL	NAF	PAF[1]	Suitable for Dump Cover	Depth Below Final Landform	Notes
Topsoil	■		■	-	Average stripping depth 0.2 m
Weathered Basalt[2]	■		■	-	BA1 lithology and red clay unit. Suitable for use as grazing subsoil
Fresh Basalt	■		■	-	BA3, BA5 lithologies. Suitable for rock lining and riprap
Other Tertiary Rock Types[2]	■		■	-	Includes TE lithologies (tertiary sediments) and BA2, BA4 lithologies (partially weathered basalt). Excludes LG (lignite) which is PAF
Weathered Triassic Sandstone[3]	■			2m	Includes UT and CG(1/2) which are potentially dispersive, erodible and exhibit low PAWC
Weathered Triassic Coaly Mudstone		■		6m	CM unit, consisting carbonaceous and inferior coal units. Currently limited to K4E between CG(1) and CG(2)
Fresh Triassic Non-Coal Rock	■		■	-	SH and TI units, consisting of non-organic and carbonaceous non-coal lithologies
Fresh/Weathered Triassic Coal[4]		■		6m	Major modelled coal seams (CO) and transitional/ inferior coal units (CU, CN, CW, CY lithologies)
Spoil (NAF)	■		■	-	Material quality in historical dumps and rehabilitation areas is variable and assessed as required
Spoil (PAF)		■		6m	
Rejects		■		6m	Not to be dumped on pit floors. Includes Mixed Plant Rejects and rehandled coarse rejects
Tailings		■		6m	Stored in designated facilities (currently within the ash storage facility)
Power Station Ash	■			2m	Stored in specific voids as per EA conditions

[1] Where possible PAF material should be dumped within pit void catchments

[2] Weathered basalt preferred for use as subsoil in grazing rehab areas (minimum 1.5m loosely placed depth). Laterite not to be placed within dump cover where possible except in minor quantities (≤20%). TE may be suitable as grazing subsoil if required, pending assessment

MATERIAL	NAF	PAF[1]	Suitable for Dump Cover	Depth Below Final Landform	Notes
[3] May be used as dump cover in native vegetation rehab if other controls are in place, i.e., shallower slopes, blending with other material and/or amelioration. Blocky conglomerate in lower portion of CG unit is more erosion resistant **and may be suitable as dump cover pending assessment**					
[4] Transitional coal bands are concentrated adjacent to the major coal seams (within 2m of roof and floor of the modelled coal seams). Coal units can be mixed at a rate of 15% with NAF units to produce an overall NAF blend, that is to be kept at least 6m below final landform					

The conceptual final landform developed for the 2021 LOM plan has in general assigned maximum overall slopes of 7.5° (13%) for the Native Ecosystem PMLU areas and 5.6 degrees (10 %) for the Beef Cattle Grazing PMLU areas, with limited areas up to 8.5 degrees (15%). Detailed design will see localised steepening in some areas to accommodate waterways and improve constructability.

The domains underlying the PMLUs include spoil dumps (with and without mixed plant rejects), tailings storage, mixed ash and tailings storage, pit highwalls and infrastructure areas. The depth of cover over ash and tailings material will comply with the minimum cover depths for these materials; though most ash and tailings storages will be dumped over with a substantial additional depth of material after the initial cover placement. A gentle slope has been created from approximately the centre of K2WN Ash storage facility extending to the northern, southern and eastern adjacent rehabilitation areas, to provide adequate surface drainage.

At times during the LOM schedule there was insufficient dump room available within the target final landform surface. When this occurred material was stockpiled above the final landform surface for future rehandle to final position.

Material Characterisation – subsoil requirements of PMLUs

Landloch (2021a) have assessed the suitability of different materials for the post mining land uses of Native Ecosystem, Plantation Forestry and Beef Cattle Grazing and a summary of the results is shown in **Table 8**. This summary represents the preferred material allocation. Different blends or varying depths of certain materials will achieve the soil requirements for the Beef Cattle Grazing PMLU and will be implemented in some areas.

While there are currently no areas scheduled to be rehabilitated for Plantation Forestry, the inclusion of success criteria for this PMLU will allow its consideration in subsequent LOM plans should it be deemed viable in the future.

Table 8. Material suitability for post-mining land uses

Description	Native Ecosystem	Plantation Forestry	Beef Cattle Grazing
Tertiary Sediments	Marginally suitable for dump cover to 10 % or blend with other material. May require gypsum/ lime if dispersive	Marginally suitable for dump cover or subsoil. May require gypsum/ lime if assessed as dispersive	Marginally suitable for dump cover or subsoil. May require gypsum/ lime if assessed as dispersive
Weathered basalt	Suitable for dump cover to 17 % but not highest value use. Save for grazing PMLU where possible. Red clay material to be blended	Suitable for dump cover but not highest value use. Save for grazing PMLU where possible. Red clay material to be blended	Suitable and preferred for use in grazing PMLU where $EC_{1.5}$<0.5 dS/m and Chloride levels are marginal or satisfactory. 0.8 m depth of dump cover plus 200 mm topsoil. Clay material to be blended. Laterite unsuitable except in small quantities (<20%)
Partially weathered basalt	Place >2 m below surface or blend with other material. May be suitable as neutralising layer above PAF cells	Clay suitable for dump cover where <30 % rock otherwise place >1 m below surface	Clays placed >1 m below surface
Fresh Basalt (unweathered)	Basalt rock can be used for rock armouring steep gradients (18-33 %) in native vegetation or steep terraced landforms. Otherwise place >2 m below surface or blend with other material	Place >2 m below surface	Place >2 m below surface
Upper Triassic	May be suitable for dump cover to 15 % gradient. May require gypsum/ lime if dispersive	May be suitable for dump cover to 15 % gradient. May require gypsum/ lime if dispersive	Unsuitable within 2 m of surface due to potential dispersion, erodibility, and low PAWC
Conglomerate Sandstone	May be suitable for dump cover to 15 % gradient. May require gypsum/ lime if dispersive	May be suitable for dump cover to 15 % gradient. May require gypsum/ lime if dispersive	Unsuitable within 2 m of surface due to potential dispersion, erodibility and low PAWC
Shale	Suitable for dump cover to 20 % gradient if NAF	Suitable for dump cover to 20 % gradient if NAF	Suitable for dump cover below 0.8 m if NAF
Triassic Interburden non-coal	Suitable for dump cover to 17 % gradient if NAF	Suitable for dump cover to 17 % gradient if NAF	Suitable dump cover below 0.8 m if NAF
Spoil – mixed origin	Suitability to be assessed for each dedicated program	Suitability to be assessed for each dedicated program	Suitability to be assessed for each dedicated program. Generally unsuitable for dump cover

NAF = Non-acid producing

PAWC = Plant available water capacity

4.4.3. Erosivity of materials

Landloch (2021b) has undertaken a material erodibility and landform design options analysis to inform the final landform design. There are two main topsoil types available at the site:

1. Loams derived from sedimentary geologies, and
2. Red clay loams to light clays derived from deeply weathered basalts.

This report assesses the landform suitability of the two types of topsoil material with a focus on grazing as the post-mining land use with the strictest requirements for topsoil performance. Samples of each topsoil type were analysed by NATA accredited laboratory. The key points to note in the laboratory data are:

- Slightly Acidic pH;
- Low salinity;
- Low dispersion;
- High organic carbon; and
- Adequate levels of nutrient to sustain pasture growth. ,

The laboratory results are presented in **Table 9**:

Table 9. Results of chemical testing of the topsoil materials show no indications of instability

Test	Grey loam	Red clay
pH (1:5 in H_20)	4.78	5.84
Electrical conductivity (dS/m) (1:5 in H_20)	0.42	0.09
Chloride (mg/kg)	430	42.3
Effective Cation Exchange Capacity (cmol/kg)	6.37	12.4
Exchangeable sodium percentage	11.3	2.24
Emerson Aggregate Test	7 (non-dispersive)	3b (minor dispersion on remoulding)
Organic carbon (%)	3.56	4.26
Total Nitrogen (mg/kg)	1766	2911
Phosphorus (Colwell) (mg/kg)	34.3	34.0
Potassium (Available) (mg/kg)	259	301
Gravel % (>2mm)	16.4	8.5
Coarse sand % (0.2-2mm)	31.1	16.6
Fine sand % (0.02-0.2mm)	24.8	22.5
Silt % (0.002-0.02mm)	8.0	12.9
Clay % (<0.002mm) hydrometer	19.7	39.5

4.5. Mass balance of waste material generated

Figure 15, **Figure 16, Figure 17** and **Table 10** summarise the NAF and PAF waste movement during the LOM schedule. The quantity balance shows that there is sufficient NAF material at all points in the 2021 LOM schedule to satisfy the 6m cover thickness constraint. NAF material is planned to be stockpiled during operation to cover the coal combustion product and PAF material that remains exposed in the final year of operation, and to partially backfill the K4E final void.

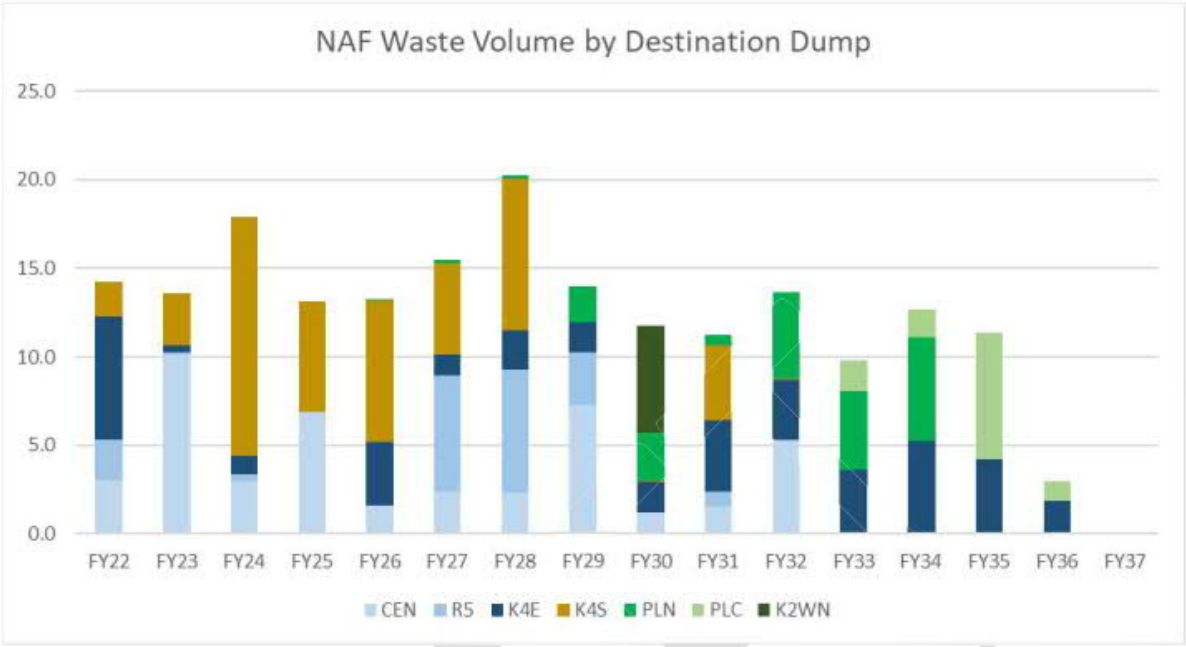

Figure 15. NAF Waste Volume by Destination

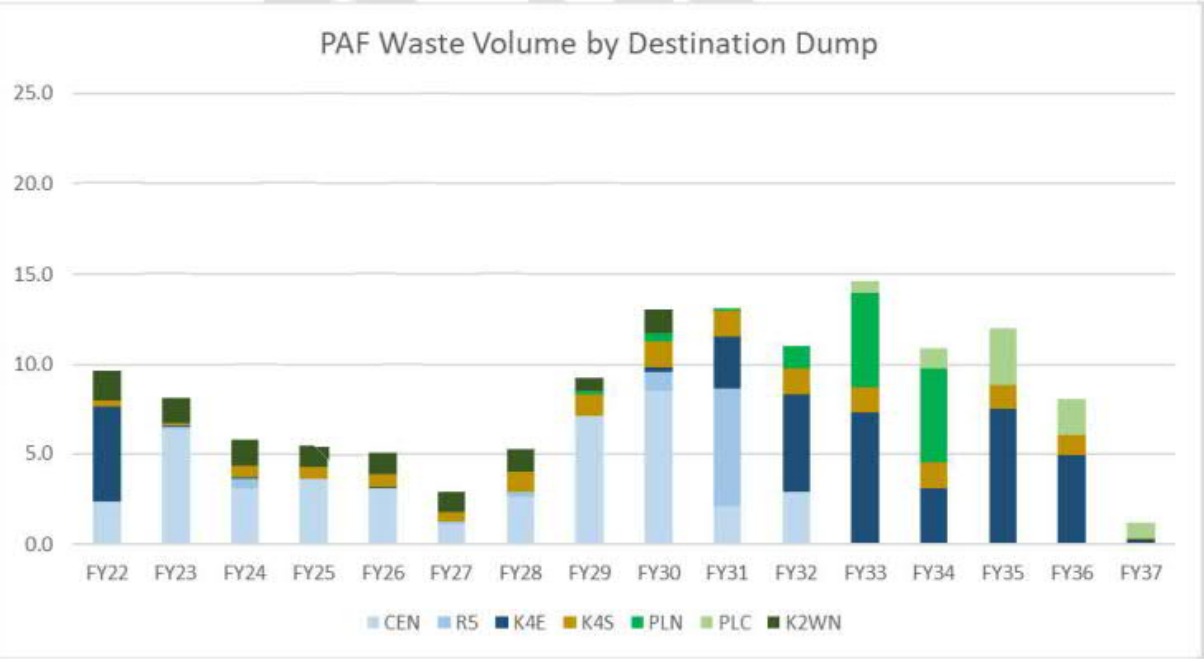

Figure 16. PAF Waste Volume by Destination

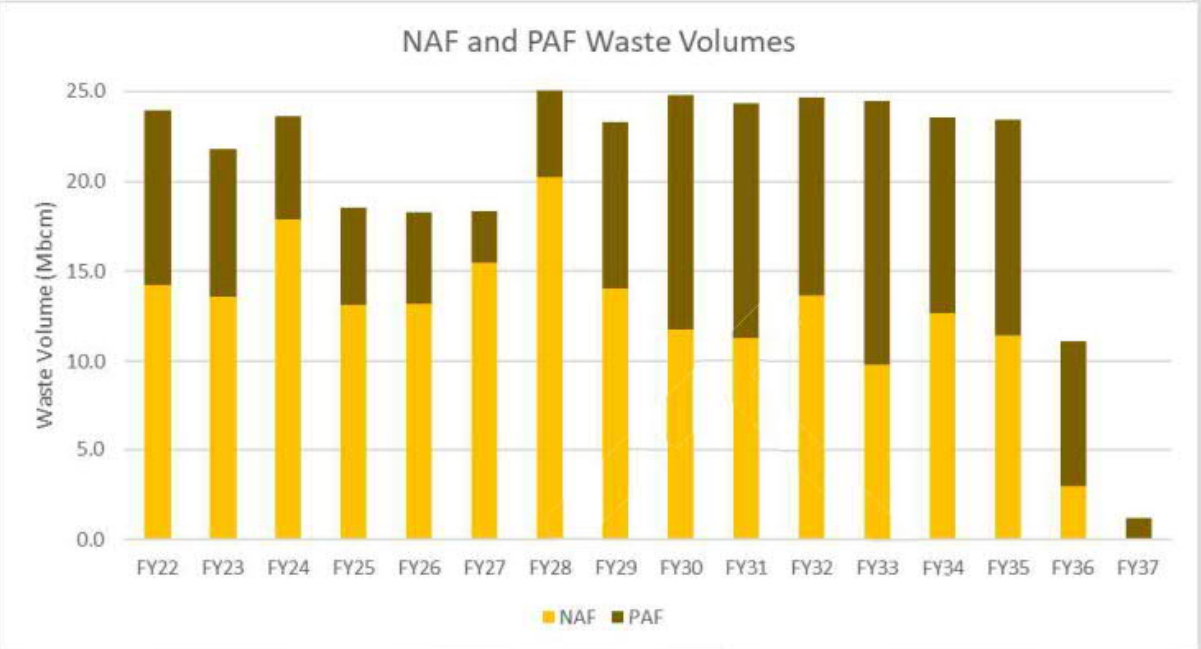

Figure 17. NAF and PAF Waste Volumes

Table 10. NAF and PAF Waste Volumes

Dump	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35	FY36	FY37	Total
NAF	14.3	13.6	17.9	13.1	13.2	15.5	20.2	14.0	11.8	11.2	13.7	9.8	12.6	11.4	3.0	0.0	**195.3**
PAF	9.7	8.2	5.7	5.4	5.1	2.9	5.2	9.3	13.0	13.1	11.0	14.6	10.9	12.0	8.1	1.2	**135.5**
Total	**23.9**	**21.8**	**23.6**	**18.6**	**18.3**	**18.4**	**25.4**	**23.3**	**24.8**	**24.3**	**24.7**	**24.5**	**23.5**	**23.4**	**11.1**	**1.2**	**330.8**

Table 11 summarises the volume of material required for selective placement compared to the volume of material available and demonstrates there is sufficient volume of source material available for the selective placement requirements.

Table 11. Selective waste placement required vs available

PMLU	WASTE COVERED	COVER SPECIFICATIONS	VOLUME REQUIRED (m^3)	POTENTIAL SOURCE	VOLUME OF SOURCE MATERIAL AVAILABLE (m^3)
Native Ecosystem	NAF Spoil*	0.2m Grey Topsoil	2,101,971	Current topsoil stockpiles, stripped topsoil from K2E	3,220,200
	PAF MP Rejects	5.8m NAF Spoil	60,957,151	Mined overburden/interburden from all pits	225,250,000
	Tailings	5.8m NAF Spoil	760,167	Mined overburden/interburden from K2E	113,170,000
	Coal Combustion Products	1.8m NAF Spoil	975,854	Mined overburden/interburden from K2E	113,170,000

PMLU	WASTE COVERED	COVER SPECIFICATIONS	VOLUME REQUIRED (m^3)	POTENTIAL SOURCE	VOLUME OF SOURCE MATERIAL AVAILABLE (m^3)
Beef Cattle Grazing	NAF Spoil*	0.2 m Red Topsoil or 0.2 m of Grey Topsoil where testing verifies suitable properties (subject to outcomes of trial).	1,098,435	K4E, K4S and K2E ASA stripped topsoil, current topsoil stockpiles (ferrosols)	1,117,100
		0.8 m Red Subsoil (RED & WB) or 0.8 m subsoil material where testing verifies suitable properties (subject to outcome of trail)	4,393,741	K4E, K4S and K2E ASA red clay from RED and WB Horizons	29,504,000
	PAF MP Rejects and Coal Combustion Products	5m NAF Spoil	23,950,732	Mined overburden/interburden from all pits	225,250,000

* Includes NAF Spoil used to cover PAF MP Rejects, Tailings and Coal Combustion Products.

4.6. Sensitive receptors and visual amenity

There are multiple sensitive receptors within a 10 km radius of the Meandu Mine, many of which are private residencies (**Figure 18**). The proposed PMLUs have been nominated to fit into the surrounding land uses. The landform has been designed to be consistent with the surrounding topography in both extent and form.

The site is predominantly a mosaic of predominantly grazing and native ecosystem with minor areas of forestry, water storage and creek diversion, consistent with the surrounding area. The surrounding land has naturally undulated hills and therefore the proposed landform will fit with the natural surroundings.

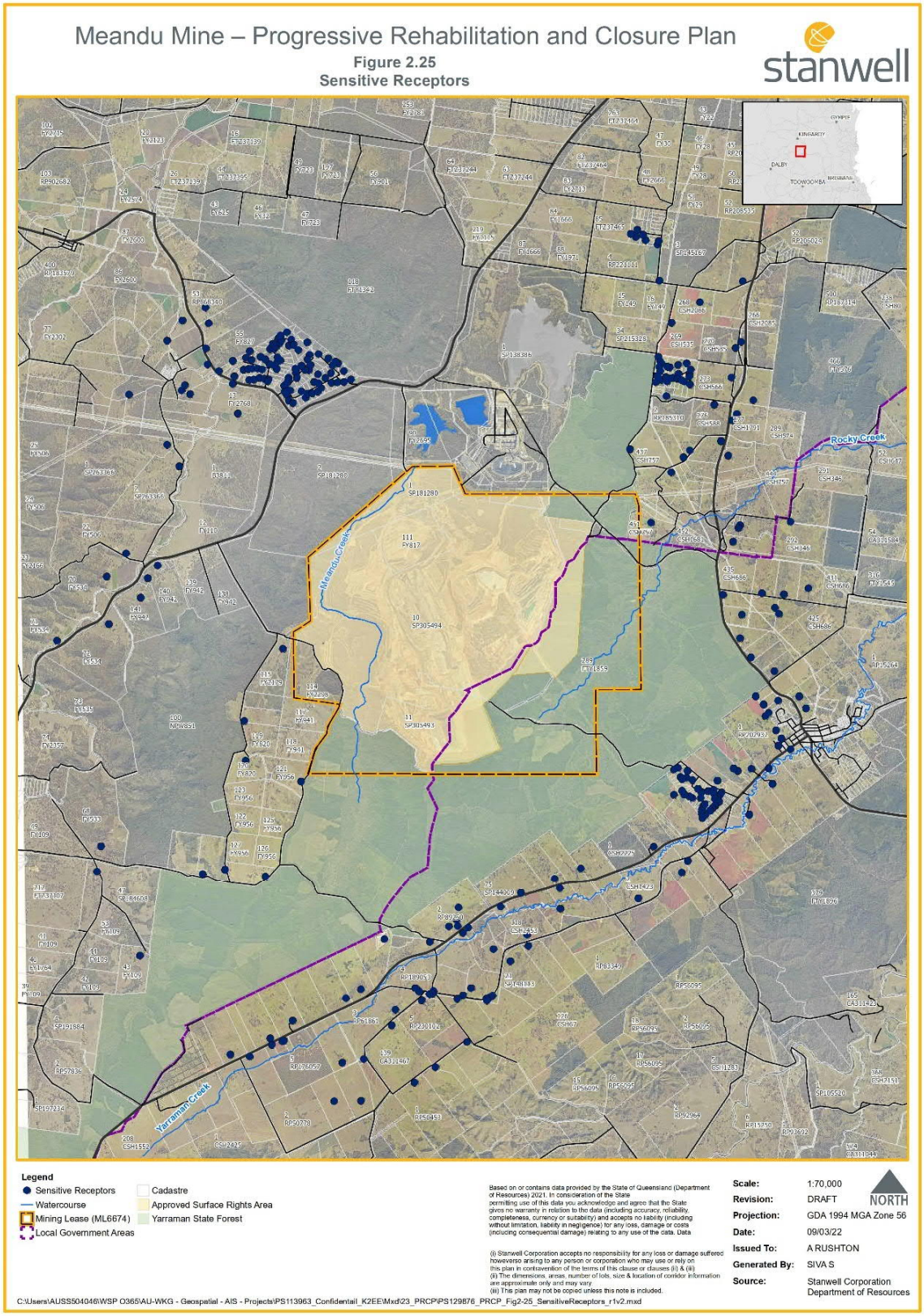

Figure 18. Sensitive Receptors

4.7. Optimisation of final voids

The pit limits utilised for the LOM Plan have been derived from the pit optimiser outputs. The optimiser provides core guidance to establishing the optimal mining pit limits and indicative pit development sequence.

The optimiser pit shells were developed by Xenith using the optimiser module within the software DeswikCAD (optimiser).

The Deswik optimiser is based on the Lerchs-Grossmann technique that is commonly used to define economic pit limits for mines. The Optimiser approach is generally as follows:

- Input the geological model into the software;
- Establish the physical pit design parameters (e.g. slope angles);
- Establish representative relationships between unit costs and product revenue parameters; and
- Apply these inputs together to generate a graphical illustration of optimised mining progression, and related tabulation of quantities and costs.

The optimiser indicates the maximum size pit that can be mined with the final walls representing marginal or breakeven limits at an applied product cost/revenue relationship.

Block quantities created within Deswik were processed through the SPRY scheduling model data flows to generate the Run of Mine (ROM) and product quantities for each block. These ROM and Product quantities have then been imported back into Deswik and referenced as inputs to the optimiser.

The Optimiser was constrained to the existing surface rights and surface rights extension boundaries. The basal seams are limited based on quality and geological confidence. The LOM plan schedule provides a minimum quantity of coal allowing for potential future production increases; this has defined the minimum pit shell requirements and consequently the pit limits.

Allowing for operational constraints, the target coal production will be accommodated by all optimiser pit shells from FF72% onwards. The FF72% pit shell (refer **Figure 19)** is generally consistent with results from previous LOM plans and has been used as one of the constraints in the design of the final highwall locations in the 2021 LOM.

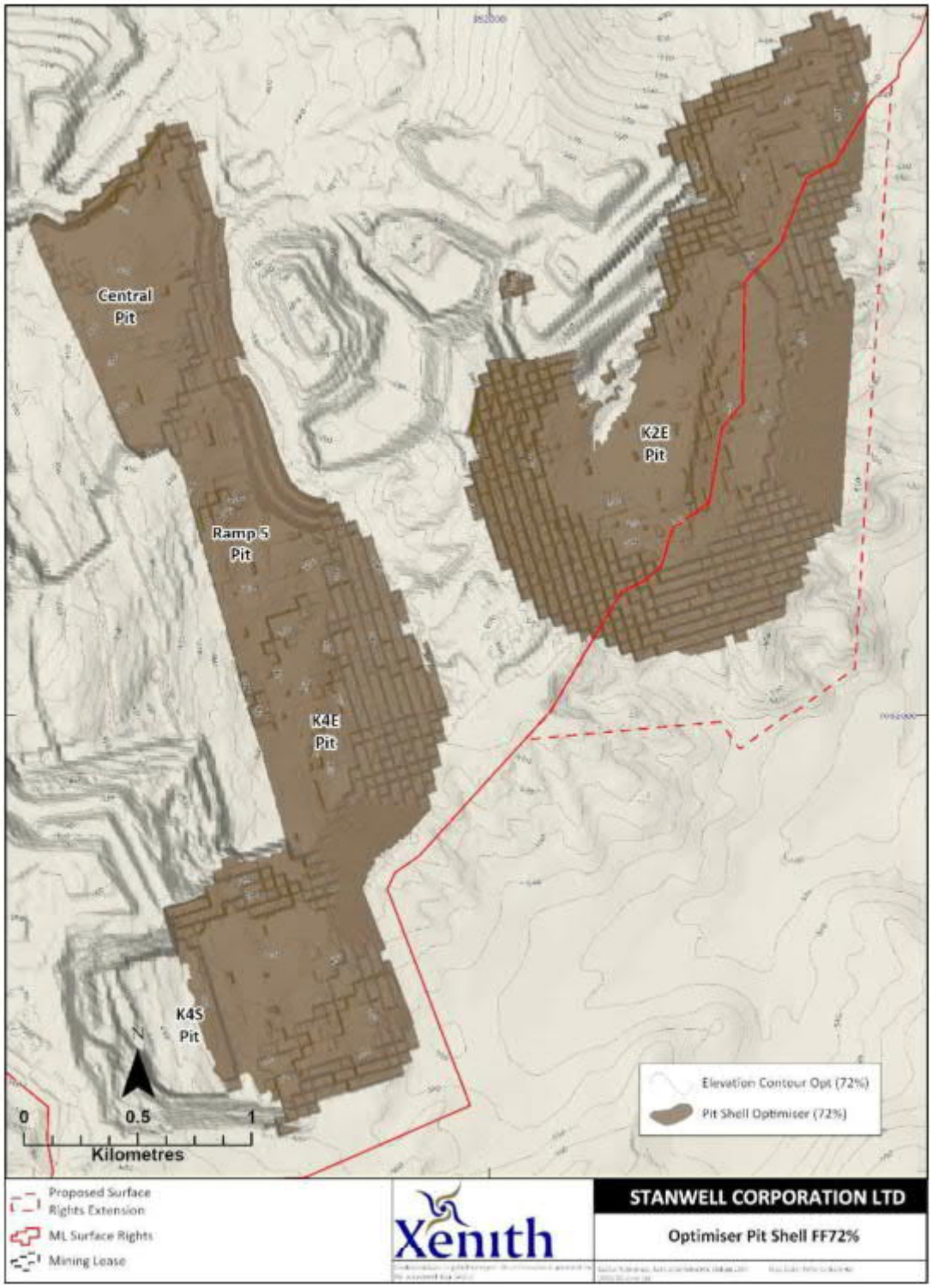

Figure 19. FF72% Optimiser pit shell

4.8. Water balance

One of the objectives of the final landform is to retain water in the final voids so:

1. water does not overtop that may cause environmental harm to the surrounding environment; and

2. To supply water to support the other PMLUs (principally Beef Cattle Grazing).

Therefore, the catchments of the K4E and K2E have been designed to be water retaining.

SLR (2021b) has developed a water balance model (WBM) for the site post closure using the GoldSim modelling package. **Figure 20** shows the direct catchment area reporting to the voids which is based on a 3D topographic model representing the final landform.

Five scenarios were assessed using the WBM, including:

- Base Case Scenario – nil extraction case.

- Water Extraction Scenario 1 – limited stock water extraction from both voids: 4.16 ML/y of stock water is extracted from K2E and K4E final voids. 2.08 ML/y is extracted from each void.

- Water Extraction Scenario 2 – maximum feasible water extraction from K2E void only. No extraction from K4E: 1 ML/d of water is extracted from K2E final void. Water is only extracted once the depth of stored water is at least 7 m and doesn't allow water depth to reduce to less than 5 m.

- Climate Change Scenario 1 – model sensitivity to increase in rainfall depths: A sensitivity analysis to climate change was also assessed. This is based on scenario 1 with a 20 % increase in rainfall.

- Climate Change Scenario 2 – model sensitivity to decrease in rainfall depths: A sensitivity analysis to climate change was also assessed. This is based on scenario 1 with a 20 % decrease in rainfall.

The results of the GoldSim model show that the water level does not exceed the overflow level in any of the above scenarios. Therefore, the final landform achieves the objective of retaining water within the voids. The model also shows that the water supply scenarios are achievable in the long-term, achieving the objective of supporting the other PMLUs.

The remaining catchments have been developed as a water shedding landform, with flows reporting to Meandu Creek (via Meandu Creek Dam or Black Creek Dam) or Rocky Creek as described in Sections 3.4 and 5.6.1.

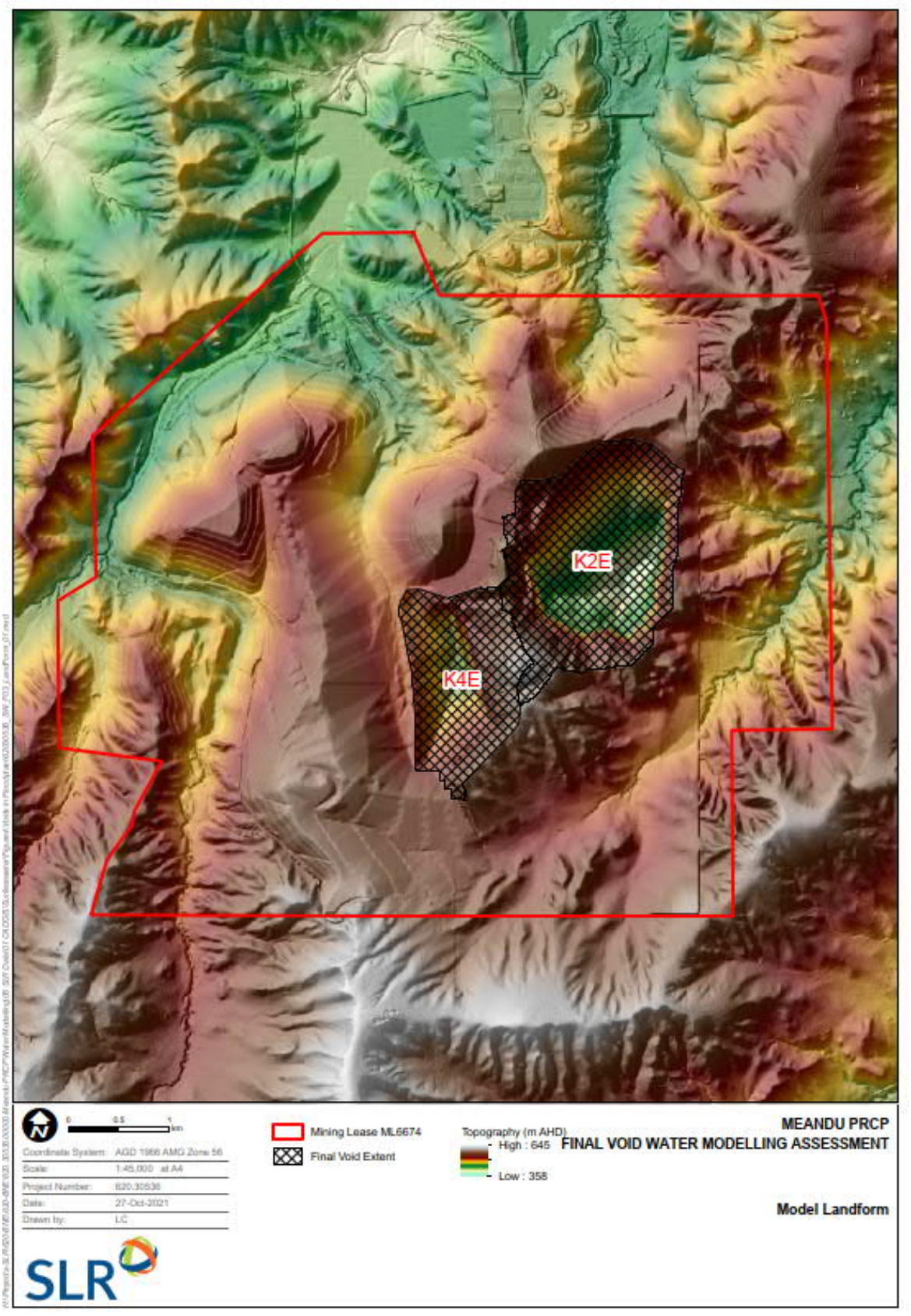

Figure 20. Final void catchments

5. Long term stability of the final landform design

5.1. WEPP Modelling

Landloch (2021b, 2022) used simulated rain and overland flows to enable the calculation of erodibility parameters for the development of a Water Erosion Prediction Project (WEPP) runoff/erosion model and SIBERIA landform evolution model.

The low erosion rates used to guide landform design are intentionally conservative, to help prevent deposition in waterways over time and rill development on the slopes, in areas that may be difficult to monitor. Surface cover strongly controls erosion rates and surface cover will therefore be used as a surrogate criterion for achievement of tolerable erosion rates.

Suggested slope length parameters derived from WEPP modelling are shown in **Table 12** and have been used to inform detailed landform design, using the LOM plan final landform as a basis. Surface covers of 70% are considered representative of established rehabilitation areas at Meandu mine. Waterways and undulations within the landform are used to limit the slope lengths as required.

Table 12. Cover levels to maintain stability in grazed areas constructed from red clay (Landloch, 2021b)

Minimum Surface Cover (%)	Gradient (%)	Slope length limit (plan view) (m)
50	5	400
50	10	90
70	10	250
50	15	30
70	15	120
50	20	20
70	20	60

5.2. Landform evolution modelling

Landloch (2022) assessed the erosional stability of the resulting landform using 3D modelling software SIBERIA, with inputs from the topsoil analysis undertaken for the preceding WEPP model. Grazing areas were assigned properties consistent with soils of basaltic origin, while native vegetation areas assigned sedimentary loam soils.

Resulting erosion and deposition was shown to be minimal and manageable. Only minor deposition was identified within designed waterways and the average annual erosion for each discrete area was modelled at approximately 5 t/ha/yr at 100 years then steadily reduces to <2 t/ha/yr over the 500 year modelling period.

5.3. Highwall stability

Quality assurance checks were conducted on the 2021 LOM pit shell by cutting cross-sections at various locations along the final walls and undertaking manual calculation verification to address the final highwall geotechnical criteria described in Section 4.3.1 (refer **Figure 21** for cross-section locations and **Figure 22** that shows an example cross-section). All locations comply or are within acceptable tolerance (within 3m of S value) of design criteria for the purposes of PRCP planning and will be reviewed in detail at the time of development of each final highwall. This indicates that geotechnical stability will be achieved at the nominated projected crestline and adequate standoffs to key assets have been considered.

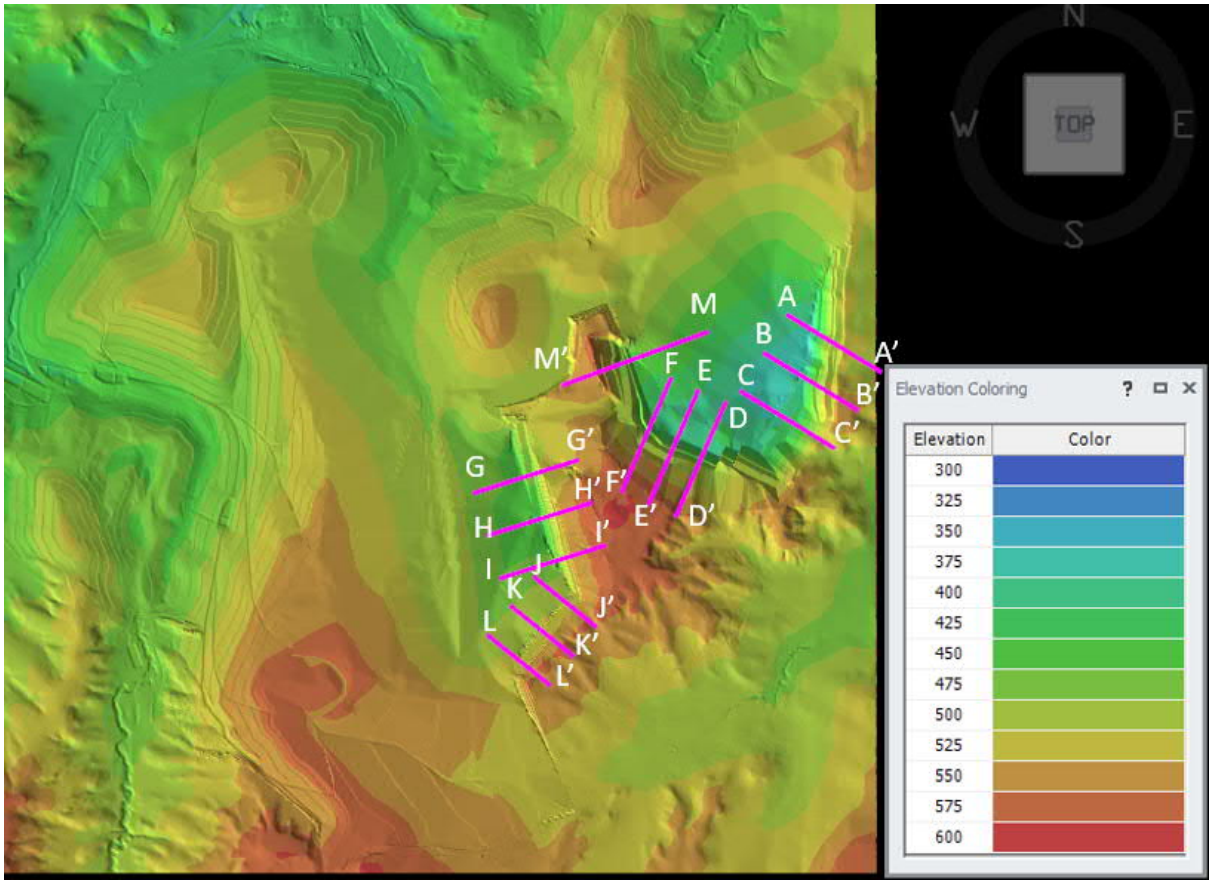

Figure 21. Final highwall stability analysis locations

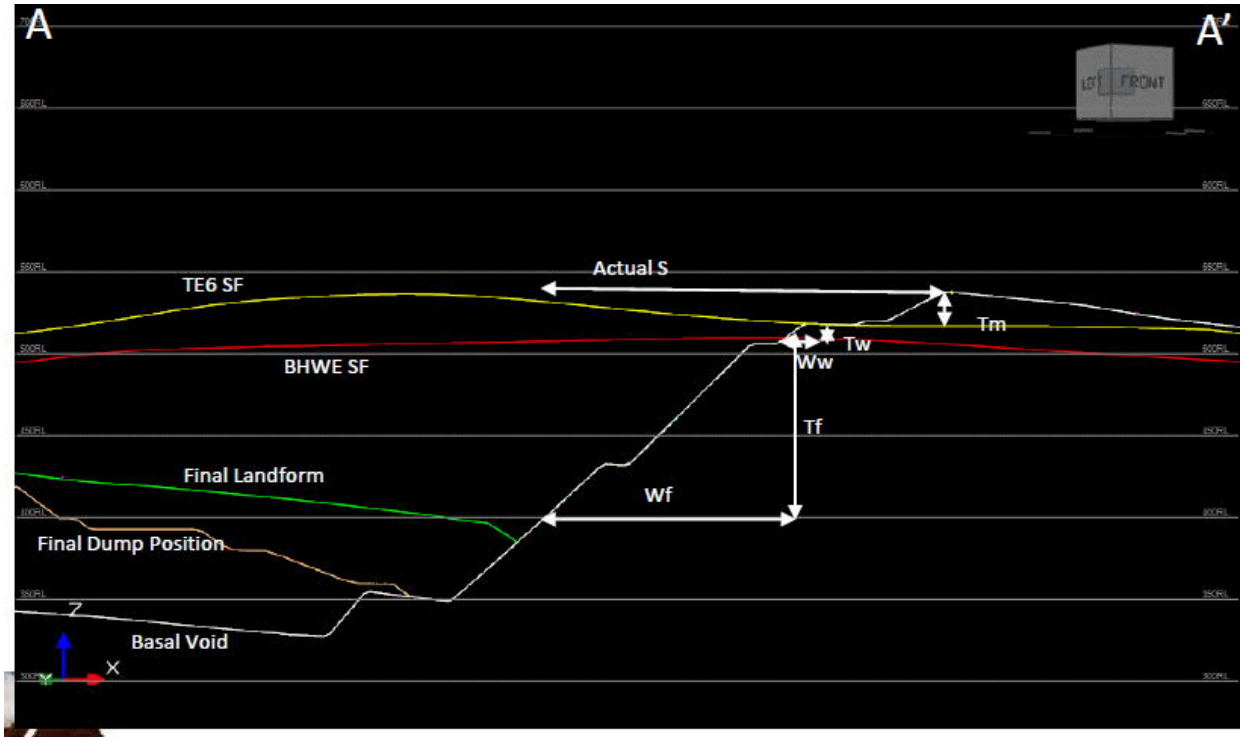

Figure 22. Example Of Cross-Section Check For Line A-A'

The ACARP Project C26019 used SIBERIA modelling to assess long-term erosional stability of as-mined highwalls that had not been disturbed for a number of years, including highwall sections at Meandu mine. Project results suggest that the steeper excavated batters will generally reduce to a shallower wall angle over the long term and that there will be some crest lowering as this occurs and the wall angles average out closer to angle of repose. The highwall crest could be expected to retreat by approximately 10 m in the weathered Triassic material and 30 m in the more erodible Tertiary material over 200 years, with some localised additional retreat associated with topographical or geological features. The evaluated crest retreat has been more generally accommodated within the projected stable pit crest setback that achieve a FOS of 1.5 for final pit highwalls.

5.4. Long term settlement

During mining operations, material will bulk up to a loose density and once placed within spoil dumps will undergo a process of self-weight, collapse and degradation-induced settlement over time (Williams and Kho 2013). Material placement associated with landform construction accounts for the majority of self-weight settlement; at Meandu this process involves paddock dump and short lift tip-heads (10-20m) by circa 400-500t trucks, with track dozing by 110t class dozers and regular watering. Collapse settlement occurs in association with water infiltration, and wetting-up of the material and degradation-induced settlement results from degradation of the material upon exposure to weather cycles.

Progressive survey monitoring and reconciliation has determined bulking factors (swell factors) for use in short- and long-term planning and these are regularly reviewed over time. The assumed swell factor that has been used in the 2021 LOM plan is 1.12 (i.e. 12% increase in volume compared with in-situ). Survey monitoring of the profiled landform is undertaken to identify areas of settlement that may require additional material and/or re-profiling. Due to the staged dump formation and shallow tip-heads associated with progressive MPR placement, this is generally minor in general spoil dump areas. Longer term monitoring is undertaken for tailings and ash storage areas before final profiling, topsoil placement and seeding is performed, to allow the underlying material to consolidate and settle and remediation to be undertaken if necessary.

5.5. Hydrological and Hydrogeological assessment

5.5.1. Hydrology

Meandu Mine is located within the headwaters of the regional catchments of Meandu Creek and Rocky Creek. Black Creek was degazetted as a watercourse under the *Water Act 2000* as part of the Tarong Ash dam life extension project in the early 2000's and in 2015 was diverted around the Tarong Ash dam to join Meandu Creek downstream of the Meandu Creek dam. **Figure 23** shows the location of the mine in relation to these catchments.

Meandu Creek flows to the north along the western boundary of the Mining Lease (and has been diverted three times for mining operations) before entering the Meandu Creek Dam. Black Creek flows to the Black Creek Dam, with flows from extreme events capable of reporting to either Meandu Creek via the diversion, or the Tarong ash dam. Meandu Creek is a tributary of Barker Creek which flows into Lake Barambah approximately 100 km downstream of Meandu Creek dam. Meandu Creek and Barker Creek are both part of the Burnett River Basin. Rocky Creek is located east of the Mine. Rocky Creek flows into Yarraman Creek which is located in the Brisbane River Basin. The topography of the mine area generally slopes towards Meandu Creek. The majority of the water discharged from mining operations is directed into Meandu Creek dam with some into Black Creek dam.

5.5.2. Geology

The Meandu Mine is located within the coal measures of the Late-Triassic Tarong Basin (**Figure 24**). The Tarong Basin is a small North-South trending basin interpreted to have formed by dextral strike slip and extensional tectonics. Basin sediments unconformably overlie basement rocks comprising the Devonian-Carboniferous Maronghi Creek Beds to the east and the Late Permian-Triassic Boondooma Igneous Complex to the west. Within the basin are the Tarong Beds coal measure sequence comprising thick coal seams interlayered with fine grained clay-, quartz-, or iron-rich stone bands of variable thickness within a sedimentary package of conglomerates, sandstones, siltstones, and mudstones. A conceptual geological profile of the site is provided in **Figure 25**.

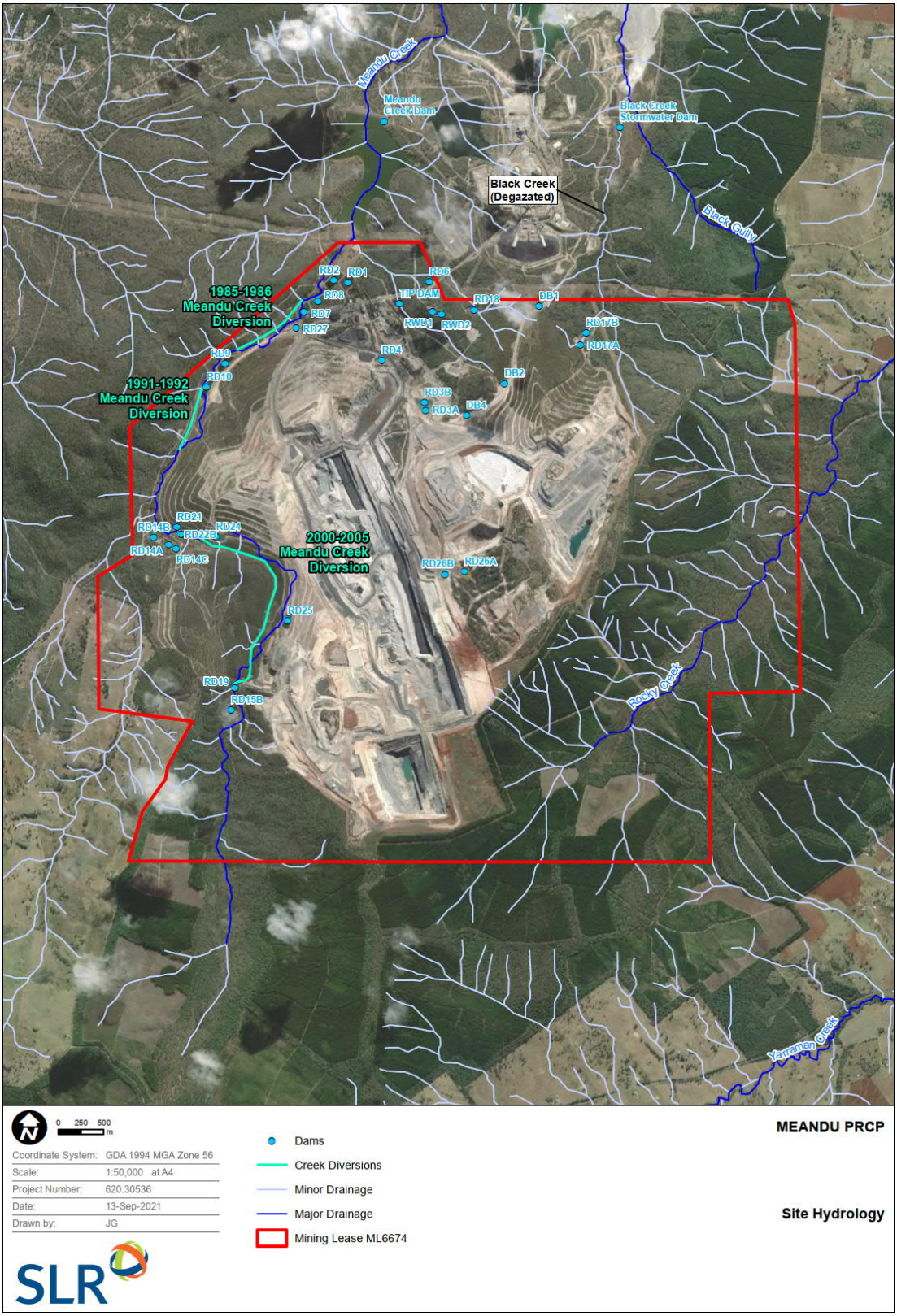

Figure 23. Site Hydrology

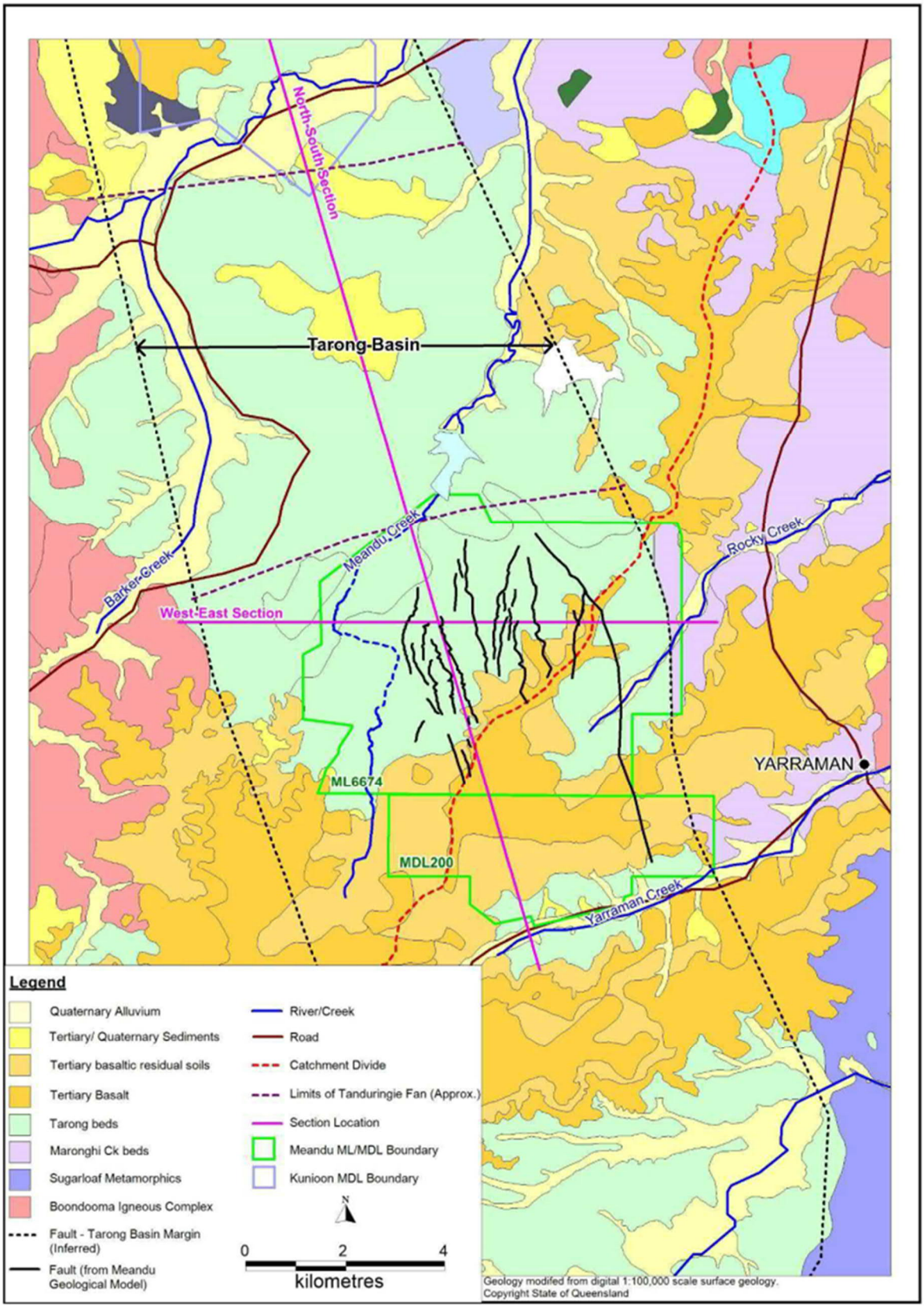

Figure 24. Surface and Structural Geology (JBT, 2021)

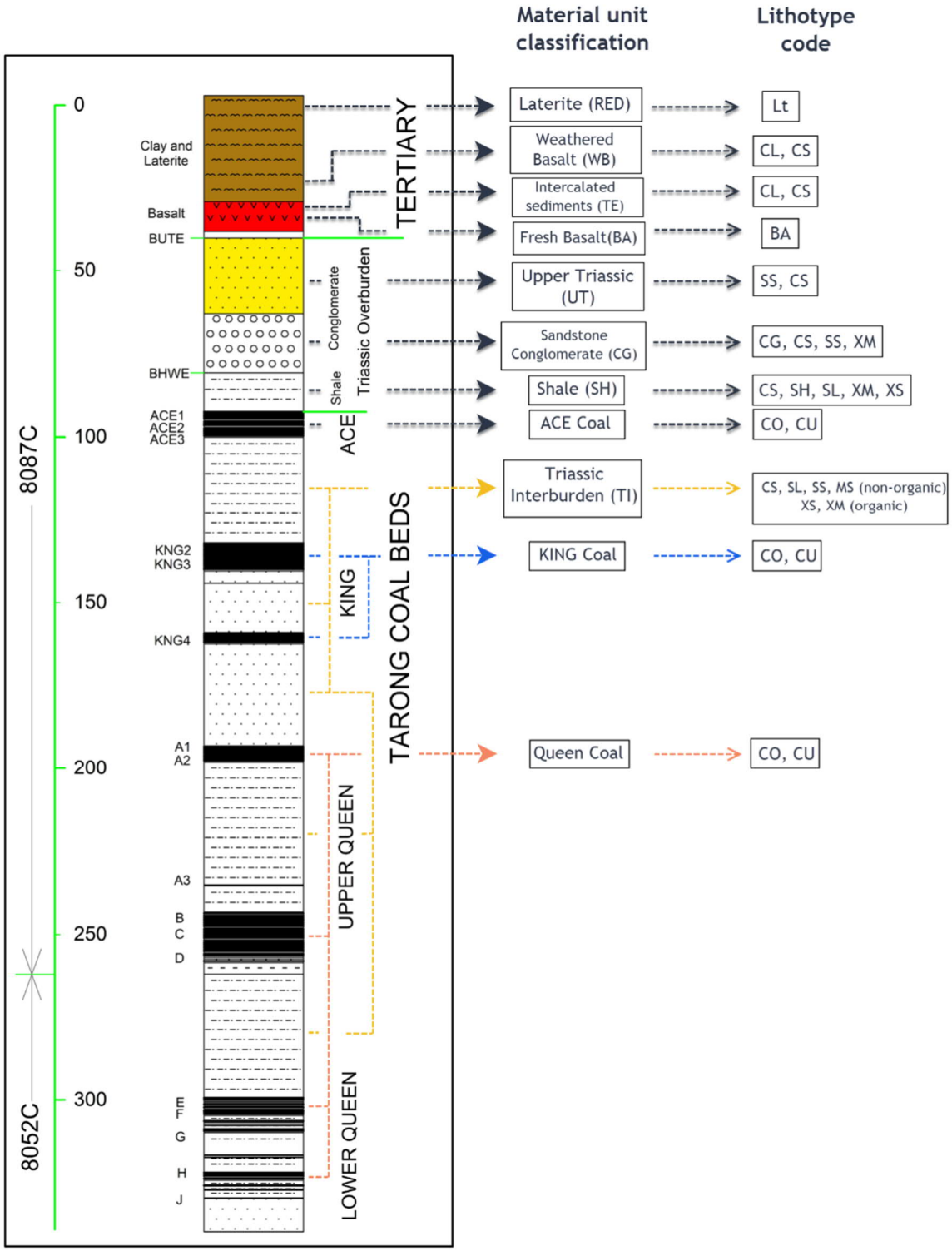

Figure 25. Conceptual geological profile at Meandu Mine (Simmons et al., 2021)

5.5.3. Hydrogeology

Groundwater at the mine is expected to be encountered in the Quaternary alluvium and Spoil, the Tertiary basalt (in discontinued fractures), the Tertiary Regolith, and the coal measures of the Triassic Tarong bed. As shown on Figure 24Figure 25, the mine groundwater system is bound by the Permo-Triassic Boondooma Igneous Complex to the west and the Carboniferous Maronghi Creek beds to the east. To the north, the mine groundwater system is bounded by the Tanduringie Fan which has been assessed to be hydraulically isolated from the mine (JBT, 2021). To the south, the basin approaches its margin, with the coal seams sub-cropping outside of the Mining Lease area within MDL200 and is thought to constitute the main conduit/s for groundwater recharge. The Queen A and B ply modelled subcrop limits underlie Yarraman Creek.

The hydrogeological stratigraphy of the mine is summarised in Table 13.

Table 13. Hydrogeological Units (SLR, 2020)

Geological Period	Geologic Unit		Aquifer/Aquitard
-	Spoil		Aquifer
Quaternary	Alluvium		Aquifer (in coarser grained areas)
Tertiary	Basalt		Aquifer (fractured rock). Unconfined in upper units and semi-confined to confined in lower units where the interbedded sediments are confined by basalt flows (JBT, 2021b).
Tertiary	Regolith		Aquifer (variable saturation)
Triassic	Tarong Beds	Coal Measures	Aquifer (coal seams)
		Interburden	Aquitard
Permian-Triassic	Boondooma Igneous Complex		Aquitard (groundwater isolated to hydraulically disconnected fractures)
Devonian-Carboniferous	Maronghi Creek Beds		Aquifer (where fractured, hydraulically isolated)

5.6. Slope design

The Meandu Mine Rehabilitation Management and Monitoring Plan (RMMP) (2022) contains rehabilitation design guidelines which have been collated by appropriately qualified persons with extensive site experience. These guidelines provide further considerations for the landform design.

6. Method of construction

6.1. Bulk Earthworks

The landform design has been developed assuming the current mining fleet (or similar) at Meandu will be utilised across the 2021 LOM plan, that currently includes a Bucyrus 1370 dragline, and various hydraulic excavator units loading rear-dump truck fleets. Bulk earthworks of material to achieve the final landform was scheduled in SPRY including dig, destination and haulage and this has enabled development of a schedule of quantities and accurate calculation of equipment hours.

The 2021 LOM plan schedule has assumed that the bulk rehabilitation earthworks commences toward the end of mining in each of the final pit areas. Key tasks associated with the bulk earthworks schedule include backfilling and shaping the K2E and K4E final voids and capping and backfilling the K4S void. The LOM schedule utilised dozer push or truck and excavator for bulk movement of materials, based on distance to be moved.

6.2. Rehabilitation Construction Methodology

Spoil and subsoil material is selectively handled and placed during excavation to produce the profile required for the relevant PMLU, after which reshaping is performed by dozers and scrapers to achieve the final landform. Preparation includes profiling the slope to achieve specifications outlined in the EA, contouring and establishing drainage systems. The dump locations for waste material are classed as either in-pit or out-of-pit. In-pit dumps are located within the footprint of previously mined out areas, with all other dumps considered to be out-of-pit. Most of the waste material at Meandu is placed into in-pit dumps.

Draglines dump in-pit, generally dumping within the immediately previous strip void, whereas trucks can accommodate more flexibility in their dumping locations and dump both in-pit or out-of-pit. This flexibility allows selective handling to occur and sufficient material to be dumped in areas to achieve the final landform as per the PRCP and current LOM plan. Through strategic planning of the mining sequence and the associated dump progression, a final undulating profile has been designed that achieves the visual amenity criteria and ties into the existing landscape and features.

Material classification is considered when determining the mining and dumping sequences. PAF material has strict dump locations and is placed at least 6 m from the surface of the final landform. Material that is more erodible or less likely to support vegetation growth is placed to avoid surface exposure or outside the upper root zone. If this material cannot be dumped at a deeper level, remediation and controls can be implemented including addition of ameliorants, lowering the design slope for the area or blending of the materials. Material classifications and cover requirements are reviewed as additional information becomes available from the forward mining areas, to provide a rehabilitated area that is safe, non-polluting, stable, and able to sustain post mining land use.

The LOM schedule allows sufficient stable and PMLU-suitable NAF material to be mined and dumped into the required zones of the final dump profile at each stage of the mine. The LOM plan is broken into a more exhaustive short-term plan before transition to a detailed execution plan.

The key activities undertaken to achieve the final landform are shown in **Table 14**.

Table 14. Rehabilitation (earthworks) steps for final landform construction

REHABILITATION STEP	ACTIVITY	INDICATIVE TIMEFRAME
Required volume of excavated material (spoil) is deposited in the area to be rehabilitated	Some overburden is moved by a walking dragline and dumped directly into the adjacent mined out strip. Excavators are used to mine the upper layers of overburden. The excavated overburden is placed into rear tip trucks and carted to in-pit and out-of-pit spoil dumps and dumped to nominated levels to ensure there is sufficient spoil volume to form the final landforms detailed in the LOM plan.	Ongoing each year. All material is classified for suitability and classed as near surface (non-acid forming or NAF) or deeper (potentially acid forming or PAF).
Dozer profiling of bulk landform	Dozers profile the dumped spoil to the final profile and establish contours and drainage systems.	12-month period after an area is no longer active and is not required for the remaining mine life (e.g. final bulk dump profile is achieved).
Drain establishment	Where required by site specific design – basalt rock placement and detailed shaping takes place.	2 months (this occurs within the 12-month period of the dozer profiling step above).
Topsoil placement	Topsoil is recovered from stockpiles or from areas in advance of mining. Topsoil spreading is undertaken with scrapers and small dozers to a design thickness of 200 mm.	Two months following completion of the dozer profile. Each year this is organised to occur prior to the wet season.
Ripping, seeding and soil enrichment	The topsoiled surface is contour ripped to a depth of 0.3-0.5 m with small dozers to aid in erosion control, root penetration and moisture infiltration. Seed and fertiliser are applied in a single pass in conjunction with contour ripping.	One month.
Rehabilitation monitoring and maintenance	Monitoring (based on bio-condition assessments) is undertaken by external consultants. Inspections of established rehabilitation is undertaken by site personnel. Where maintenance is required, this is undertaken as part of the annual rehabilitation program under the supervision of the site environment team.	Ongoing on an annual basis.

The required volume of material is generally placed within the bulk profile by dumping in 10 to 20 m high lifts or paddock dumping with the rear-dump truck fleet. Following this, track dozers are used to profile the dumps to the detailed final landform profile including any necessary features such as waterways. The dumping out into 10-20 m high lifts with the rear-dump truck fleet, followed by repeated cut-fill profiling work with 110 tonne class mine-site dozers, provide suitable levels of compaction in the outer dump layers to achieve the requirements of the overall infiltration criteria for the final landform. Landforms above coal combustion products and/or tailings storage facilities will incorporate a minimum 2 m compacted layer to achieve the design objectives for these areas. Regular survey scans of the reshaping occur to verify that it is on design and within tolerance.

Waterways are incorporated into the design stage of the final landform to provide sufficient drainage to manage the design rainfall events, with freeboard allowance to accommodate settling and deposition. Rock drains are incorporated where required to slow water velocity through the drain, that involves placement of suitably sized basalt rocks in the drain, usually completed by a 70t excavator.

Topsoil is allocated based on the PMLU-specific requirements and is spread over the area once the dump has been successfully reshaped. Scrapers are used to collect the topsoil from either recently cleared areas in advance of mining or a nearby stockpile, transport it to the area and spread it to the required depth on the rehabilitated profile (generally 200 mm thickness). Graders and water carts are utilised to maintain correct grades, assist in adhering to the design and provide dust suppression.

After the topsoil has settled, further preparatory works for the establishment of the final PMLU are undertaken. Depending on the PMLU, this can include ripping and seeding of the topsoiled surface. If deep ripping is required, a dozer rips the topsoiled surface to a nominal depth of 300-500 mm (potentially up to 900 mm) and spreads seeds and fertiliser concurrently. This ripping assists in erosion control, moisture infiltration and root penetration. During the rehabilitation establishment process, the area is monitored to the requirements of the RMMP to confirm that the rehabilitation remains on trend to achieve a successful PMLU outcome, with any necessary remediation action undertaken as outlined in the RMMP.

7. Quality Assurance / Control

7.1. Mine planning

The LOM plan is typically reviewed every two-to-three years as part of the business planning cycle. The actual rehabilitation and pit progress is provided as an input to the LOM Plan revision. Each revision will include consideration of the same information and input processes detailed in this report, for example material placement, highwall stability and erosional stability.

Drilling is undertaken periodically (generally an annual drilling program) to further define the resource, geological structures and material properties. Characterisation and mapping of material to be mined from the pit is undertaken to identify problematic source material. This information is used to update the geological model and material characterisation register, that informs progressive mine planning.

7.2. Landform design

Meandu Mine has a design / plan review and signoff process to verify that the final landform constructed meets the design criteria and objectives. Relevant checks and consent are obtained prior to commencing construction and/or progressing specific rehabilitation items, including signoff by the responsible operations and planning personnel.

The LOM Plan (including overall landform design and material placement components) is reviewed and approved by relevant parties prior to release. Detailed rehabilitation design is undertaken based on the LOM plan final landform for areas becoming available for rehabilitation in the short and mid-term mine planning timeframes. These designs are reviewed and approved for use with each annual mine plan submission under the Mining Services Agreement.

Prior to works being undertaken a dump plan is developed which considers the final landform design, approved dump shell and selective material placement. A Safe Truck/Shovel Design Checklist is used which refers to the Meandu Mine Geotechnical Reference Report for details on schematics. Weekly planning meetings are conducted to that track landform construction progress and status.

7.3. Material placement

Meandu Mine has a number of planning, inspection and monitoring requirements in place to provide ongoing material characterisation and placement in accordance with the final landform design.

Planning and design involves developing a pre-strip design based on the knowledge and understanding of how much and which parts of the overburden profile can be used in the rehabilitation process. A dig plan is developed identifying the relevant material types and dump plans match the material type with a suitable dump location. The dumps are constructed with consideration to the parameters outlined in the Material Movement Design Parameters (summarised in **Table 7**).

The Mining Engineer responsible for the dump and destination design will communicate directly with the Geologist regarding the weekly excavation plan and updates to the geological model. All dig and dump plans are discussed at planning meetings and the key points are communicated to the truck and shovel supervisors and crew for execution.

Records of PAF material placement will be maintained according to site procedures, that may refer to weekly meeting minutes, Wenco tracking data, location screenshots and summary polygons. An annual summary of all PAF and NAF dump locations will be collated.

Tailings and ash deposition will be tracked monthly, including pumped quantities and stored volumes calculated from survey data. An annual reconciliation of material volumes and locations will be undertaken.

7.4. Final landform shaping

Material placement is undertaken using GPS-equipped equipment to guide dump construction according to design. Material type is recorded for each load and allows tracking of material from source to destination. Field verification is undertaken by regular inspections by supervisors, the geologist and Open Cut Examiner (OCE). Compliance to dump design is verified by regular survey.

High precision GPS is installed on dozers and graders involved in final landform reshaping. Design plans are uploaded to equipment that guide earthworks activities with alerts that flag cut-fill requirements for each area. Compliance to design is verified via regular surveys. Topsoil placement does not occur until the reshaped landform has been assessed and approved by a representative from the site Environmental team.

7.5. Subsoil and topsoil selection and placement

Soil requirements (including source locations) are nominated in the rehabilitation program for each year with consideration of the suitability of the soil to meet PMLU requirements. Soil analysis is undertaken to determine amelioration requirements. If soil is used from (or added to) a stockpile, survey reconciliation is undertaken to calculate the volume used and the stockpile volume updated in the topsoil register.

7.6. Rehabilitation Monitoring

Meandu Mine has a Rehabilitation Monitoring Programme which outlines the monitoring approach and methodologies. The monitoring schedule approach is based on the age of the rehabilitation with intensive monitoring at the commencement and early years of rehabilitation establishment and less frequent monitoring as the rehabilitation progressively ages.

The Rehabilitation Monitoring Field Sheet is used to record data consist with the rehabilitation methodology. Meandu Mine uses a Land Rehabilitation Assessment Inspection checklist which identifies inspection criteria for each stage of rehabilitation. The form identifies hold points so that each rehabilitation stage/milestone can receive signoff from the Environmental Advisor to confirm rehabilitation is satisfactory before moving on to the next stage/milestone.

8. Trials to verify predicted success

8.1. Existing landform and rehabilitation success

In 2021, Stanwell received progressive rehabilitation certification of approximately 153 ha of rehabilitation at Meandu Mine from the Queensland Department of Environment and Science. A Progressive Rehabilitation Report was developed by Highlands Environmental (2020) to support the application. All rehabilitated areas included in this application have a PMLU of native ecosystem.

The completed rehabilitation was assessed against the completion criteria for native ecosystem as shown in Appendix A. A risk assessment was used to assess the rehabilitated area against criteria for “safe to humans and wildlife”. The hazards identified in rehabilitation were found not to be significantly different to surrounding unmined landscapes subject to the same land use.

Geotechnical stability was assessed using the same methodology described in section 4.2 based on Henderson Geotech (2019) and found that the design FOS of the landforms always exceeded the 1.5 threshold. Progressive rehabilitation monitoring had determined that groundcover, comprised of living plants, litter and rocks, exceeded the benchmark of 50% that was used as a surrogate for erosional stability.

The rehabilitation area drains to Meandu Creek and into Meandu Dam via a series of retention dams on the mine site. These dams are monitored frequently and several are considered to provide a conservative representation of the quality of runoff from rehabilitation. The median pH and electrical conductivity within these retention dams meets the completion criteria for pH (5.5-9) and EC (<2,037 µS/cm).

8.2. Planned rehabilitation trials

Two rehabilitation monitoring trials are planned to verify PMLU success. These are defined in more detail in the PRCP and summarised below:

1. Beef Cattle Grazing – Soil Performance Trial

   No prior rehabilitation has been undertaken for this PMLU at Meandu Mine. The trial will compare different subsoil combinations utilising available site materials to confirm and expand the combinations that will support vegetation establishment and the target livestock carrying density.

2. Steep Rocky Ecosystem – Monitoring Trial

   This will involve monitoring a number of exposed final benched pit walls that will form part of the final PMLU area as part of a longitudinal study to assess elements of native species ecosystem development (soil development, vegetation establishment and fauna development). The results of this trial will be utilised to create an expected trend for the rehabilitation timeline and success assessment for the final mined highwalls at the end of the LOM.

9. Limitations and Assumptions

The 2021 LOM final landform design has been developed on the following assumptions and limitations:

- The starting point of the final landform design used was the 2019 LOM Plan final landform;
- The 2021 LOM plan is based on a fuel supply scenario meeting the requirements of Tarong Power for a particular energy market case. Production rate may need to be varied from year to year due to changes in requirements to meet power station demand, and this will impact on the timing of coal and waste mining, and the progress of rehabilitation. The general sequence of mining under these circumstances is expected to follow that indicated in the LOM plan;
- The landform design was constrained by the existing surface rights and proposed K2E ASA boundaries. Existing rehabilitation is not re-disturbed other than a small section adjacent to the northern end of the K2E pit necessary to facilitate the planned coal production in that area. The landform otherwise integrates with the existing rehabilitation;
- Geotechnical criteria and operation guidelines for interim pit progression walls have been based on advice provided in the Geotechnical Reference Report (Sherwood Geotechnical and Research Services, 2020);
- Operational highwall angles of 70 degrees are used for competent material, with the exception of dragline pass highwall angles in the K2E, Central and northern Ramp 5 pits which are 45 degrees;
- Final highwall design parameters are based on calculations in the Assessment of Geotechnical Stability of Final Highwalls (Henderson Geotech, 2020). The projected stable pit crest derived using this criteria has defined the final void boundaries in the 2021 LOM Plan and the actual final pit crest will be positioned between the as-mined design and project setback line, depending on localised conditions and corresponding highwall treatment;
- Meandu Mine will continue to be the storage location for the by-product ash generated from Tarong Power Station operations to the end of its forecast life; and
- Scheduling has assumed achievement of all minimum PAF (6 m) and ash (2 m) (including K2WN and K4S ash storages) capping requirements in accordance with cover design requirements.

10. Conclusions

The conceptual final landform has been developed by Xenith (2021) as part of the 2021 LOM Plan. It is a refinement of the 2019 LOM plan incorporating a number of improvements and optimisations, specifically addressing elements of the supporting information required for preparation of Meandu Mine's PRCP.

The 2021 LOM final landform design has been developed with the following considerations which are detailed in this report:

- Intended PMLUs and their specific requirements;
- Site hydrology, geology and hydrogeology;
- Mine waste characterisation and placement;
- Soil types and rehabilitation suitability;
- Geotechnical assessments and recommendations; and
- Performance of existing rehabilitation areas.

The 2021 LOM Plan has retained the two final voids in K2E and K4E. It has reduced the area and catchment of the final voids and marginally reduced their volume, resulting in an optimised outcome for both production cost and rehabilitation risk. The final landform has been designed to minimise risk of contamination to land and water by designing final void catchments that are water retaining. Water balance modelling has shown that the water contained within the final voids will not overtop and spill into the receiving environment.

Final slopes have been designed in accordance with geotechnical recommendations to provide long term geotechnical and erosional stability. Henderson Geotech (2020, 2021) used limit equilibrium slope stability analyses to assess the FOS of rehabilitated spoil landforms at Meandu mine and found that all feasible scenarios had a FOS >1.5. The minimum set-back from the highwall toe corresponding with a FOS of 1.5 (i.e. the projected stable pit crest) was calculated for each final highwall using formulae derived from statistical regressions. Highwall cross sections from the final landform were checked against the setback equation to inform the final highwall design and provide adequate standoffs from key infrastructure. The results from the slope stability analysis and setback equation demonstrate that the final landform is considered geotechnically stable and safe in the long-term.

Drainage of the landform has been specifically designed and returns catchments to Meandu and Rocky Creeks close to the pre-mining landform proportions, with flood extent largely limited to the Creek channels and minimal impact on other PMLUs.

Design of slopes, grading and waterways considers material suitability and provide for a long-term stable landform. Erosion modelling undertaken by Landloch (2021b, 2022) demonstrates that the landform is believed to achieve long-term stability.

The selection and inclusion of PMLU allocations has considered community consultation feedback, practical mine planning and dumping to achieve the required production outcomes and specific requirements associated with the waste streams. The PMLUs have been used to inform waste placement and cover in the LOM plan.

Selective waste placement is aligned to a combination of;

- material characterisation recommendations (design matched to requirements for Native Ecosystem and Beef Cattle Grazing in particular),
- cover and capping assessment for ash / tailings storages and waste dumps, and
- stability / erodibility assessment of soil and landform slopes.

Landloch (2021a) identified the materials that were appropriate for different land uses – native ecosystem, plantation forestry and beef cattle grazing. The material suitability for these different land uses has been incorporated into the final landform design and scheduling to support the proposed PMLU.

The landform design has considered placement of PAF material at least 6 m below the surface with appropriate material acting as a cover design. This mitigates the production of AMD by limiting oxygen and water exposure.

Through the above measures, the proposed final landform meets the set objectives of:

- Creating a safe final landform for humans, livestock and native fauna;
- Achieving long-term geotechnical and chemical stability;
- Constructing a final landform that does not cause environmental harm to the surrounding environment;
- Minimising the final void footprint; and
- Supporting the proposed post-mining land uses (PMLUs) proposed in the PRCP.

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FINAL LAND USE	GOAL	OBJECTIVE	INDICATOR	CRITERIA
Native Ecosystem[1]	Safe to humans and wildlife	Safety hazards in rehabilitation are analogous to local regional ecosystems in surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the native ecosystem must have no significant difference to hazards in local regional ecosystems in surrounding unmined landscape.
	Stable	Rehabilitation is geotechnically stable in the long term.	Factor of safety	≥1.5
		Rehabilitation ensures soil surface condition is erosionally stable.	Groundcover to be established and persistent.	>50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 20%. >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes greater than 20%.
	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5-9.0 (median) EC: <2037 µS/cm (median)

FINAL LAND USE	GOAL	OBJECTIVE	INDICATOR	CRITERIA
	Able to sustain an agreed final land use	Vegetation to comprise a mixture of plant species like local regional ecosystems based on benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7[2]	Establishment of native ecosystem to resemble a mixture of benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7[2]	A. Native plant species richness: – Trees ≥4 count – Shrubs ≥6 count – Grass ≥4 count B. Cover: – Tree canopy cover is at least 20%
Creek diversion	Safe to humans and wildlife	The diversion has been constructed and is operating safely	Designed and certified, with monitoring of operation by appropriately qualified and experienced person.	Records retained of as-built drawings and certification that creek diversions are operating in accordance with approved design and associated criteria.
		Safety hazards in rehabilitation are analogous to creeks in surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the creek diversions have no significant difference to hazards in creeks in surrounding unmined landscape
	Stable	Creek diversions are both geotechnically and erosionally stable.	Stability assessed by an appropriately qualified and experienced person.	The assessment shows that the creek diversion is functioning as designed and the integrity of the watercourse diversion and/or adjoining watercourses is not threatened.

FINAL LAND USE	GOAL	OBJECTIVE	INDICATOR	CRITERIA
	Non-polluting	Diversions do not impact the environmental values of the receiving environment.	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5-9.0 (median) EC: <2037 µS/cm (median)
	Able to sustain an agreed final land use	Creek diversions are functioning as intended.	Assessment by an appropriately qualified and experienced person.	The assessment shows that the creek diversion is functioning as designed and the performance of the watercourse diversion and/or adjoining watercourses is not threatened.

FINAL LAND USE	GOAL	OBJECTIVE	INDICATOR	CRITERIA
Beef Cattle Grazing	Safe to humans and wildlife	Safety hazards in rehabilitation are analogous to grazing land in surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the grazing land to have no significant difference to hazards in grazing land in the surrounding unmined landscape.
	Stable	Rehabilitation is geotechnically stable in the long term.	Factor of safety	≥1.5
			Minimal slope greater than 15%	80% of Slopes ≤15%. Minor areas up to a maximum of 25% to achieve tie-in with surrounding areas.
		Rehabilitation ensures soil surface condition is erosionally stable.	Groundcover to be established and persistent.	>50% established and persistent groundcover for all slopes less than or equal to 18%. >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes greater than 18%.
	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5-9.0 (median) EC: <2037 µS/cm (median)

FINAL LAND USE	GOAL	OBJECTIVE	INDICATOR	CRITERIA
	Able to sustain an agreed final land use	Rehabilitation is suitable for sustainable beef cattle grazing.	Land suitability assessment by appropriates qualified and experienced person using 'Regional Land Suitability Frameworks for Queensland' (DNRM & DSITIA 2013)[3]	Grazing land to meet Class 1, 2 or 3 land suitability for grazing.
Plantation Forestry	Safe to humans and wildlife	Safety hazards in rehabilitation are analogous to grazing land in surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the plantations to have no significant difference to hazards in plantations in the surrounding unmined landscape.
	Stable	Rehabilitation is geotechnically stable in the long term.	Factor of safety	≥1.5
		Rehabilitation ensures soil surface condition is erosionally stable.	Groundcover to be established and persistent.	>50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 20%. >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes greater than 20%.

FINAL LAND USE	GOAL	OBJECTIVE	INDICATOR	CRITERIA
	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5-9.0 (median) EC: <2037 µS/cm (median)
	Able to sustain an agreed final land use	Rehabilitation is suitable for sustainable plantation forestry.	Land suitability assessment by appropriates qualified and experienced person using 'Regional Land Suitability Frameworks for Queensland' (DNRM & DSITIA 2013)[3]	Plantation land to meet Class 1, 2 or 3 land suitability for plantations. For Hoop Pine Plantations greater than or equal to 150 trees per hectare. For Hardwood Plantation greater than or equal to 100 trees per hectare.

FINAL LAND USE	GOAL	OBJECTIVE	INDICATOR	CRITERIA
Water Storage	Safe to humans and wildlife	Safety hazards are managed for humans, stock and wildlife.	Hazard assessment by an appropriately qualified and experienced person.	Design requirements are determined to ensure water storage is safe for humans, stock and wildlife
	Stable	Rehabilitation is geotechnically stable in the long term.	Factor of safety	≥1.5

FINAL LAND USE	GOAL	OBJECTIVE	INDICATOR	CRITERIA
	Able to sustain an agreed final land use	Able to sustain an agreed final land use.	Water storages contain water of a suitable quality for native wildlife and/or livestock ingestion, measured using the indicators of TDS, Calcium, Magnesium, Nitrate, Nitrite, Sulfate, Cobalt, Nickel, Zinc, Arsenic, Boron, Selenium, Molybdenum and Fluoride.	Total Dissolved Solids: <5,000 mg/L Calcium: ≤1,000 mg/L Magnesium: ≤2,000 mg/L Nitrate: ≤400 mg/L Nitrite: ≤30 mg/L Sulfate: ≤1,000 mg/L Cobalt: ≤1 mg/L Nickel: ≤1 mg/L Zinc: ≤20 mg/L Arsenic: ≤0.5 mg/L Boron: ≤5 mg/L Selenium: ≤0.02 mg/L Molybdenum: ≤0.15 mg/L Fluoride: ≤2 mg/L

FINAL LAND USE	GOAL	OBJECTIVE	INDICATOR	CRITERIA
Landholder Retained Infrastructure	Safe to humans and wildlife	Safety hazards accepted by landholder.	Legally binding agreement	Agreement executed by both parties.
		Safety hazards in rehabilitation are analogous to grazing land in surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the landholder retained infrastructure to have no significant difference to hazards in plantations in the same infrastructure in surrounding unmined landscape.
	Stable	Landholder accepts condition of infrastructure, including its structural integrity.	Legally binding agreement	Agreement executed by both parties.
	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5-9.0 (median) EC: <2037 µS/cm (median)
	Able to sustain an agreed final land use	Landholder formally accepts infrastructure for his/her ongoing benefit.	Legally binding agreement	Agreement executed by both parties.

FINAL LAND USE	GOAL	OBJECTIVE	INDICATOR	CRITERIA
Steep Rocky Ecosystem	Safe to humans and wildlife	Safety hazards are managed for humans and wildlife now and in the future.	Hazard assessment by an appropriately qualified and experienced person.	Acceptable residual hazard ranking achieved,
	Stable	The landforms are geotechnically and erosionally stable.	Factor o safety	>1.5 assessed at the projected stable crest.
	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5-9.0 (median) EC: <2037 µS/cm (median)
	Able to sustain an agreed final land use	Landform that creates native fauna and flora habitat, while still being stable and safe	Creation of a safe, stable and non-polluting landform that supports flora and fauna habitat.	The landform provides a diversity of slopes including mix of predominately flat benches and batters up to 80 degrees that create a varied environment for the future establishment of niche habitats.
		Vegetation on benches to provide an appropriate environmental outcome and be based on a species composition that ensures geotechnical stability of the benches is not compromised.	A species composition that ensures geotechnical stability of the benches is nor compromised.	Native plant species richness per appropriate ecosystem outcome, adjusted to meet geotechnical stability requirements.

Appendix I

Meandu Mine PRC Plan Groundwater Technical Report



MEANDU PRCP

Groundwater Technical Report

Prepared for:

Stanwell Corporation Limited
180 Ann Street
Brisbane 4000



SLR Ref: 620.30792-R01
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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Stanwell Corporation Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

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620.30792-R01-v2.0	25 February 2022	Kelly-Jane Wallis	Brian Rask	Brian Rask
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APPENDICES

Appendix A Summary Statistic of Bore Groundwater Quality
Appendix B Summary Statistic of Hydrogeological Unit Groundwater Quality
Appendix C Groundwater Quality Time Series
Appendix D Contaminants of Concern - Post Closure Concentrations
Appendix E IWBM Predicted Water Quality

1 Introduction

1.1 Purpose and Scope of Report

SLR was contracted by Stanwell Corporation Limited (SCL) to support the preparation of the Meandu Mine (Mine) Progressive Rehabilitation and Closure Plan (PRCP). The scope of work includes various sub-sections of Section 3 of the PRCP guideline and are primarily focused on water modelling and assessment of post mining conditions. The PRCP guideline requirements addressed in this report are detailed in **Table 1**.

Table 1 Scope of Work for the Meandu PRCP Water Modelling Project and Relevant PRCP Guideline Section

PRCP Guideline Sections	Where Requirement is Addressed
Section 3.1. Project Planning 'Project Description'	Section 1.2
Section 3.1. Project Planning 'Baseline'	Section 3
Section 3.6.1 General rehabilitation practices 'Hydrogeology'	Section 4
Section 3.6.1 General rehabilitation practices 'Water management'	Section 5
Section 3.6.3 Voids	Section 6

The scope of work provided herein is limited to that provided in **Table 1** and does not consider the following related items:

- Environmental Values that are discussed in the Meandu Mine Progressive Rehabilitation and Closure Plan, Part A: Rehabilitation planning,
- Mitigation Measures are provided in the Meandu Mine Progressive Rehabilitation and Closure Plan, Part A: Rehabilitation planning, and
- Voids in a Floodplain provided in SLR (2021).

1.2 Project Description

Meandu Mine is a thermal coal mine owned by TEC Coal Pty Ltd (TEC Coal), a wholly owned subsidiary of SCL. Meandu Mine is located in Tarong, Queensland; approximately 150km north-west of Brisbane. The Mine was commissioned in 1983 and is the sole provider of thermal coal for power production at the Tarong Power Station and Tarong North Power Station. The Mine holds approval to mine up to eleven million tonnes of Run-Of-Mine coal a year.

The Mine is located on Mining Lease ML6674, which is held by TEC Coal, ML6674 was granted on 19 February 1981 and covers an area of approximately 42.7km^2. The Mine operations are regulated through the Environmental Approval (EA) EPML00709113 and are limited to the surface rights area. TEC Coal also holds the Mining Development Lease (MDL) 200, adjoining to the south of ML6674 (**Figure 1**).

Mining operations at Meandu is by dragline in conjunction with excavator and truck fleets. The waste rock is hauled to in-pit or ex-pit overburden dumps, appropriate to the mine plan and mining location. The current Life of Mine (LOM) coal production extends to 2038. This includes the King 2 East (K2E) extension project[1] which is a brownfield development that would extend the surface rights area to the southeast of the current K2E Pit limits (**Figure 2**). Future mining to end of mine life will rely on existing Meandu Mine infrastructure using similar equipment and mining methods as currently used for the existing operations.

Following closure of the Mine, two final voids are expected to remain at K2E and King 4 East (K4E) that are located outside of the floodplain (SLR, 2021). Power station ash placement to King 4 South (K4S) void and rehabilitation (bulk waste placement, profiling and revegetation activities) continue following coal production cessation until the power stations retirement and satisfactory filling, cover installation and rehabilitation are achieved.

[1] K2E Project approved by State of Queensland. Decision note dated 23/11/21 to approve the application to amend environmental authority EPML00709113 under 172(2)(a) of the *Environmental Protection Act 1994*.

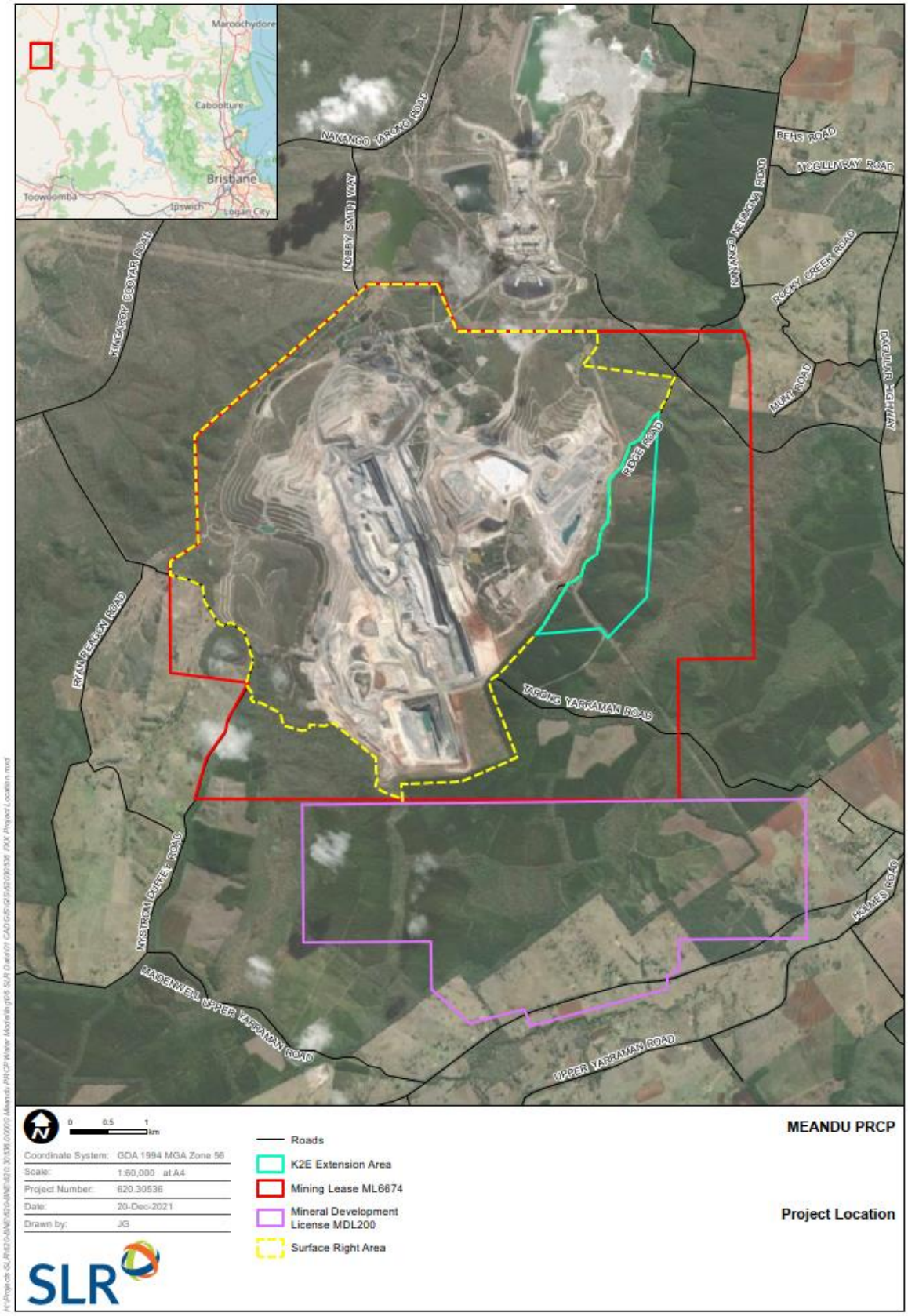

Figure 1 Project Location

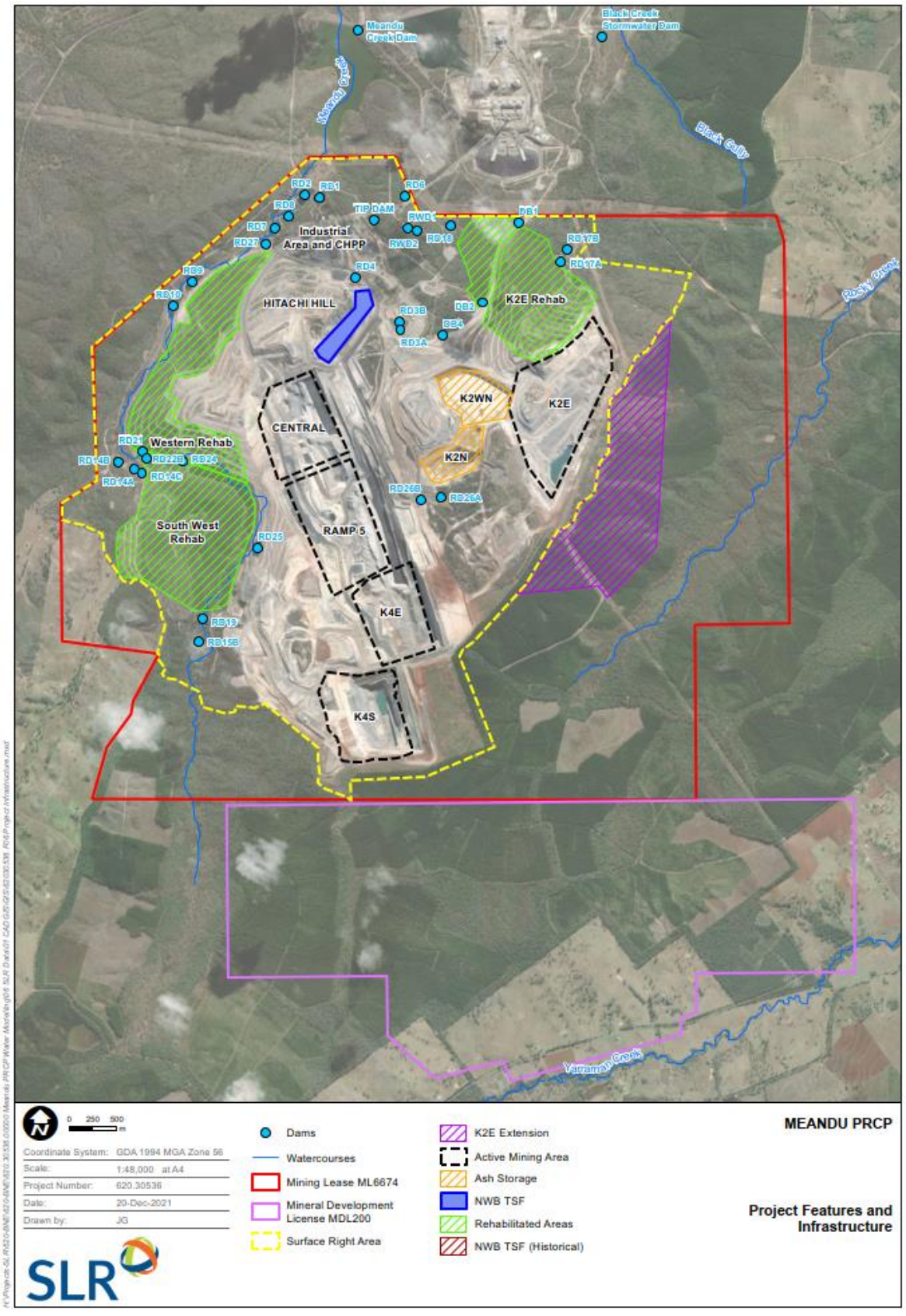

Figure 2 Project Features and Infrastructure

2 Historical Groundwater Work

2.1 Hydrogeologic Investigations

A strong history of detailed work has been undertaken on the hydrogeological environment at the Mine which has informed the PRCP assessment. These previous investigations have been considered as adequate and accurate for use in the PRCP, and their application to the PRCP is detailed in Table 2.

Table 2 Previous Hydrogeological Investigations at Meandu and Relevance to the Meandu PRCP

Hydrogeological Investigation	Scope of Investigation	Information used in the PRCP
Environmental Investigation Report – Meandu Mine (WSP, 2018) herein referred to as the Environmental Evaluation (EE) Appendix F Contaminant Hydrological Assessment (Groundwater Data Review and Conceptual Groundwater Model, JBT Consulting, 2018)	A conceptual groundwater model was developed based on groundwater quality and level data, the Meandu Mine geological model, 1:100,000 Qld geology map series and geophysics data. The hydro-geological cross sections showed groundwater units, recharge zones and flow direction.	Characterisation of: • Local aquifers • The saline plumes at Black Creek catchment and QWBV • AMD impacted seepage expresses at the surface Hydrogeological cross sections
Meandu Creek Saline Plume Investigation (SLR Consulting, 2020)	Review of water level data, water quality data and available permeability testing data to assess plume mitigation options. Indicative designs for controls to contain the plume and additional monitoring locations were recommended to further understand potential saline groundwater movement in the area.	Characterisation of QWBV salinity plume
K2E Project Appendix D – Groundwater Model (JBT Consulting, 2021a)	Compilation and review available data for the area of the groundwater model. Development of a conceptual groundwater model. Construction and calibration of a numerical groundwater model to predict the potential drawdown extent from the K2E Project.	• Groundwater model • Hydraulic conductivity estimates and aquifer storage properties • QWBV saline plume characterisation • K2E/RD17 saline plume characterisation • NWBV seepage – AMD characterisation • Metalliferous drainage characterisation • Groundwater users

Hydrogeological Investigation	Scope of Investigation	Information used in the PRCP
Annual Groundwater Data Review 2020 Calendar Year (JBT Consulting, 2021b)	Review of water level data, water quality data	Characterisation of local aquifers

2.2 Existing Numerical Model

A numerical flow model was developed by JBT (2021a) for the King 2 East (K2E) project (herein called "K2E Model") and has been used and updated for the purpose of this report. The K2E Model was developed to assess the impact of the proposed K2E project. As such, the model calibration primarily focused on the area in the vicinity of the K2E project, including the K2E Additional Surface Area (ASA) and the Boulevard Fault (substantiated in Section **4.7.1.2.9**).

The K2E Model was peer reviewed by Dr Noel Merrick in 2021 and was deemed fit for the purpose of assessing incremental impacts on Environmental Values (EVs) from the K2E project. A review of the K2E Model developed by JBT (2021a) found that the model adequately represented the complexity of the Mine hydrogeological environment at a regional scale and therefore applied to the PRCP assessment requirements.

2.3 Surface Water Investigations

Previous studies focusing on surface water investigations have been undertaken at Meandu Mine upon which the Meandu PRCP was reliant in some measure. Previous investigations were reviewed and considered as adequate for the purpose of PRCP assessment requirements. These previous investigations and the information used in the PRCP are detailed in **Table 3**.

Table 3 Previous Surface Water Investigations at Meandu and Relevance to the Meandu PRCP

Hydrogeological Investigation	Scope of Investigation	Information used in the PRCP
Environmental Investigation Report – Meandu Mine (WSP, 2018) Appendix H Integrated Water Model (Golder, 2018)	Development of an Integrated Water Model (Operational IWBM) for the purposes of simulating surface water, groundwater and geochemical components of Meandu Mine in order to estimate Acid Mine Drainage (AMD) potential. The model was developed in GoldSim (version 12.0) and was based on the 2017 Life of Mine (LOM) Plan which depicts mining operations and development from 2016 to nominal closure date of 2037.	The water quality parametrisation from this model was adopted as the basis of this assessment and updated in the PRCP IWBM to reflect conditions at closure

Hydrogeological Investigation	Scope of Investigation	Information used in the PRCP
King 2 East Project Water and Salt Balance Model - Report and WBM (WSP, 2021)	Assessment of the impact of K2E Project on quantity and quality (EC only) of water discharges at key site compliance (or release) points through a water balance/salt mass balance approach (using GoldSim)	AWBM model parameters that were calibrated in WSP (2021) were adopted for the final void WBM and the IWBM

3 Baseline Information

3.1 Climate

The climate of the Meandu Mine area is subtropical with the highest rainfall and evaporation occurring during the summer months (Bureau of Meteorology - BoM, 2021).

3.1.1 Historical Data

Historical climate data was obtained for the period January 1900 to June 2021 from the Scientific Information for Land Owners (SILO) database (Queensland Government, 2021a) for the location of the Mine (latitude -26.80, longitude 151.90). **Table 4** outlines the total average monthly rainfall and evaporation. The data shows that the total average annual evaporation (1612mm/yr) is more than double the total annual rainfall (759mm/yr). The high annual evaporation rates are strongly related to temperature, as shown on **Figure 3**.

Table 4 Total Average Monthly Rainfall and Evaporation (January 1900 to June 2021)

Average Total Monthly	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall	106	94	79	44	43	43	39	30	36	66	74	105	759
Evaporation	193	154	150	113	82	63	71	98	134	171	184	197	1612

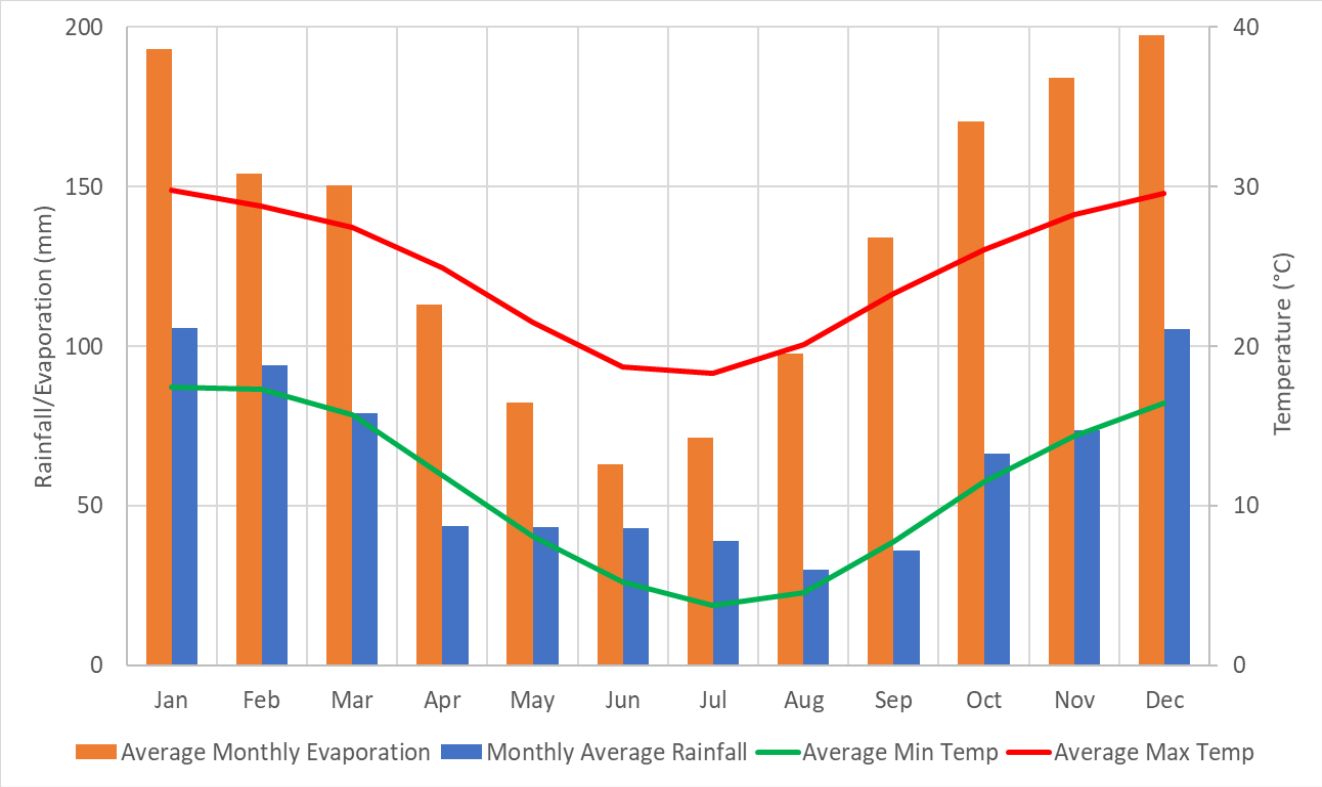

Figure 3 Average Monthly Evaporation, Rainfall and Temperature for the January 1900 to June 2021 Period

To place recent rainfall years into historical context, a cumulative rainfall departure (CRD) was calculated for the data period. This is a summation of the monthly departures of rainfall from the long-term average monthly rainfall. A rising slope in the CRD plot indicates periods of rainfall above the long-term average, as is the case for 2009 to 2013 at the Mine, whereas a falling slope indicates periods when rainfall is below the long term average (e.g. 1999 to 2007, **Figure 4**). Rainfall volumes over the more recent years of the record (2013 to 2021) have been lower than the average, as is indicated by the falling slope in the CRD.

For groundwater modelling (**Section 4.7** and **Section 6.4**), historical climate data was obtained for the period January 1900 to June 2021 from SILO for the location of the Mine (latitude -26.80, longitude 151.90). Monthly rates based on measured values were applied for the calibration period, according to the stress period set up detailed in **Section 4.7.1.3** and **Section 6.4.1.5**. The predictive (mining) simulation applied rates based on long term quarterly average (thus including seasonal variability). The predictive (recovery) simulation applied rates based on long term annual averages.

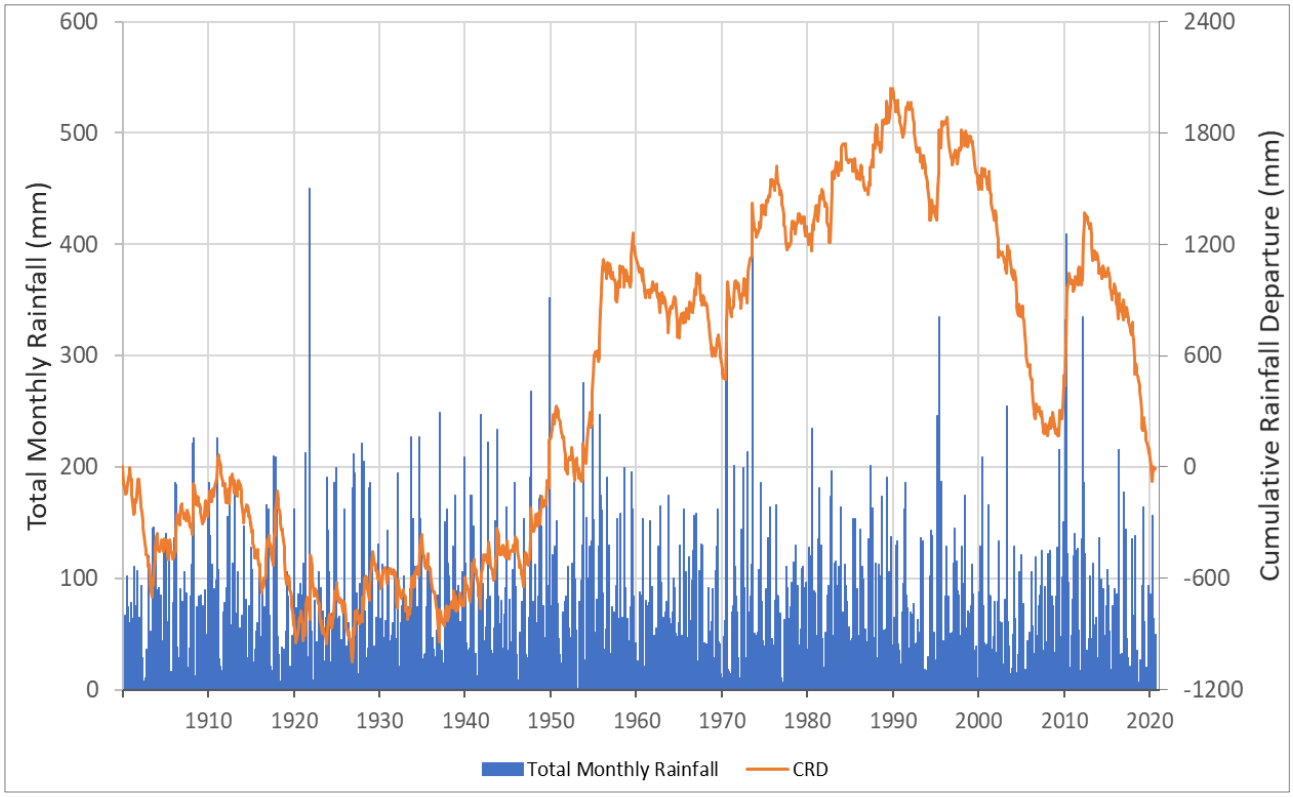

Figure 4 Cumulative Rainfall Departure and Total Monthly Rainfall

3.1.2 Climate Change

A review of the Climate Futures tool was conducted to estimate how rainfall and temperature could change in the future (CSIRO and Bureau of Meteorology, 2021).

The Climate Futures tool predicts the percentage change in rainfall and the maximum daily temperature increase for a predicted year and allows the user to explore projections in 5 year increments up until 2090. Two, time periods, were viewed - 2040 (**Table 5**), and 2090 (**Table 6**). The selected area is the "*East Coast area of Australia*". The climate projections include four Representative Concentration Pathway (RCP) scenarios, which represent different greenhouse gas concentration scenarios. The percentage value for each RCP indicates the percentage of models that had the corresponding outcome of percent rainfall or increase in temperature. For example, in 2040 for RCP 2.6, 41% (12 of 29) models predicted -5 to 5% rainfall, and 92% (24 of 26) models predicted a maximum daily temperature increase of 0.5 to 1.5°C.

Based on the predicted climate change scenarios, most scenarios showed that rainfall was likely to vary from 5% to -15% indicating little change to drier climate. Maximum daily temperature is likely to increase from 0.5 to 1.5°C by 2040 and from 1.5 to 3.0 °C by 2090, indicating a warmer to hotter climate.

Table 5 Predicted Climate Change Scenarios 2040

Scenario	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Average
Percent Annual Rainfall Comparison					
Number of Models	29	68	22	70	47
>15% (much wetter)	7%	1%	-	-	4%
5 to 15% (wetter)	7%	10%	18%	19%	14%
-5 to 5 (little change)	41%	59%	55%	39%	49%
-15 to -5 (drier)	38%	24%	27%	31%	30%
> -15% (much drier)	7%	6%	-	11%	8%
Annual Maximum Daily Temperature Increase (°C)					
Number of Models	26	66	20	67	45
>3.0 (much hotter)	-	-	-	-	-
1.5 to 3.0 (hotter)	-	12%	5%	33%	17%
0.5 to 1.5 (warmer)	92%	85%	90%	67%	84%
<0.5 (slightly warmer)	8%	3%	5%	-	5%

Table 6 Predicted Climate Change Scenarios 2090

% Annual Rainfall Comparison	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Average
Percent Annual Rainfall Comparison					
Number of models	29	68	22	70	47
>15% (much wetter)	-	-	9%	6%	8%
5 to 15% (wetter)	14%	15%	23%	13%	16%
-5 to 5 (little change)	34%	29%	27%	21%	26%
-15 to -5 (drier)	24%	40%	23%	23%	29%
> -15% (much drier)	28%	16%	18%	37%	25%
Annual Maximum Daily Temperature Increase (°C)					
Number of models	26	66	20	67	45
>3.0 (much hotter)	-	2%	15%	76%	31%
1.5 to 3.0 (hotter)	15%	77%	85%	24%	50%
0.5 to 1.5 (warmer)	77%	21%	-	-	49%
<0.5 (slightly warmer)	8%	-	-	-	8%

3.2 Site Hydrology and Fluvial Networks

Meandu Mine is located within the headwaters of the regional catchments of Meandu Creek and Rocky Creek. Black Creek was degazetted under the Water Act 2000 as a watercourse as part of the Tarong Ash dam life extension project in the early 2000's. In 2015 the Black Creek diversion channel was installed which directs high surface water flows directly to Meandu Creek. However, under normal operations surface water flows are directed towards the Black Creek dam then ultimately to the Meandu Creek. **Figure 5** shows the location of the Mine in relation to these catchments. Meandu creek flows to the north along the western boundary of the Mining Lease and has been diverted for mining operations. Meandu Creek is a tributary of Barker Creek which flows into Lake Barambah approximately 100km downstream of Meandu Creek dam. Meandu Creek and Barker Creek are both part of the Burnett River Basin. Rocky Creek is located east of the Mine. Rocky Creek flows into Yarraman Creek which is in the Brisbane River Basin. The topography of the Mine area generally slopes towards Meandu Creek. The majority of the water discharged from mining operations is directed into Meandu Creek dam and has the potential for some discharge into Black Creek dam (WSP, 2018).

3.2.1 Meandu Creek

Meandu Creek flows to the north along the western boundary of the Mine area and discharges into Meandu Creek dam. The area has been significantly modified to facilitate mining and power station operations through the diversion of the creek and creation of the Meandu Creek dam (located outside of the Mining Lease), this is further discussed below (Refer to **Section 3.2.2**). The section of creek along the length of the mine as well as Meandu Creek dam form part of the overall water management system for Meandu Mine, Tarong Power Station and Tarong North Power Station.

Meandu Creek is ephemeral and characterised by non-flowing pools of water and is classified as a stream order 2 upstream of Meandu Creek dam.

Downstream of the Meandu Creek dam (i.e., outside of the Mining Lease) where it joins with Barker Creek, the creek is perennial. This is due to releases from the Meandu Creek dam. Prior to the construction of the Mine, Power Station and Meandu Creek dam, the creek was ephemeral across this length. Barker Creek is ephemeral further upstream from the confluence with Meandu Creek.

Due to the different influences on the Meandu Creek system, the creek can be divided into the three following reaches.

- Meandu Creek upstream of the Surface Right Area (SRA) (ephemeral, upstream of mining operations);
- Meandu Creek upstream of Meandu Creek dam (direct influence by mining operations); and
- Meandu Creek downstream of Meandu Creek dam and surface right boundary (currently perennial downstream of mining operations, previously ephemeral prior to commencement of mining power station operation – see **Section 3.2.2**).

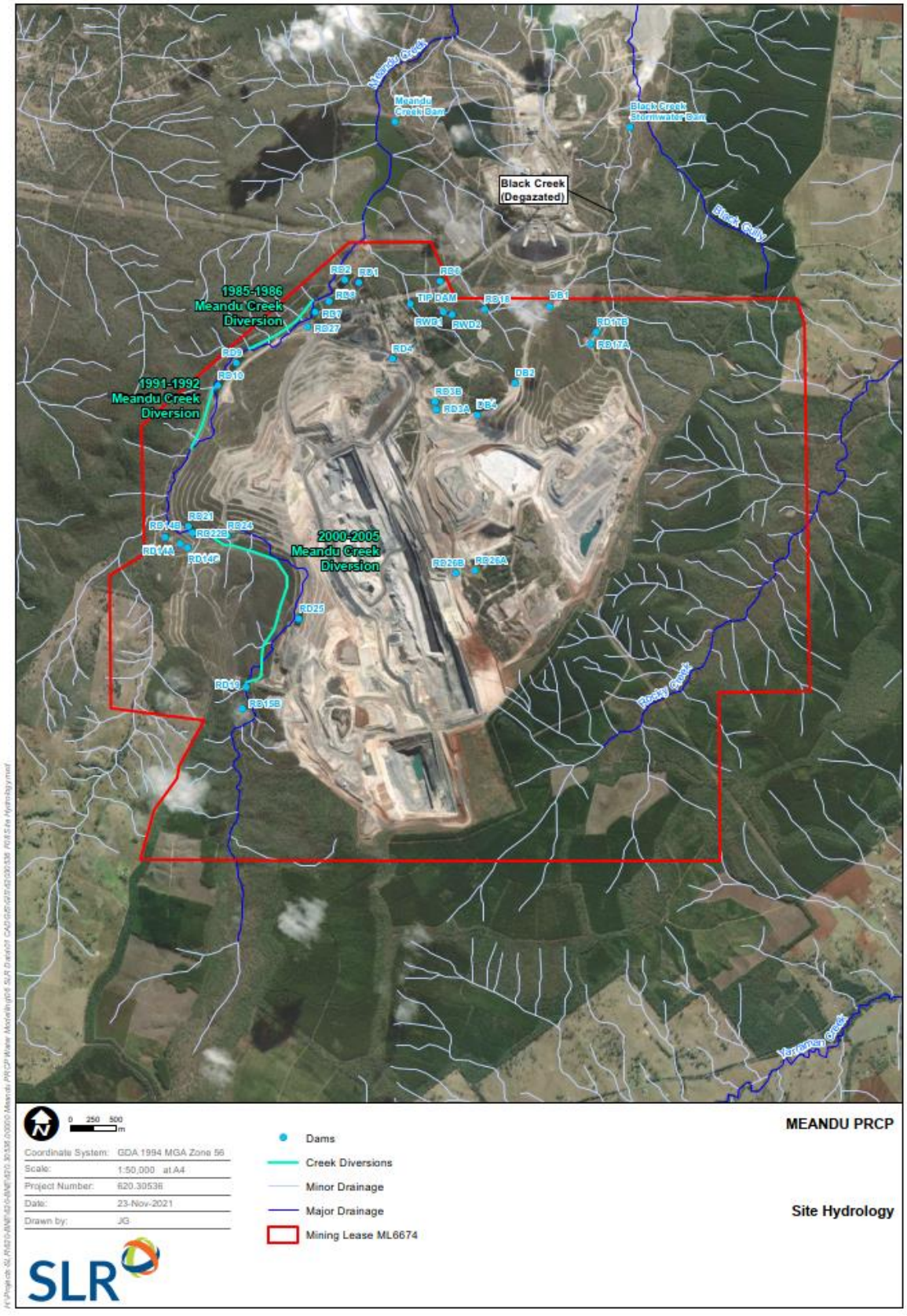

Figure 5 Site Hydrology

3.2.1.1 Meandu Creek Diversions

The area of Meandu Creek within the SRA has been significantly modified to facilitate mining operations through the diversion of the creek. Three creek diversions have been constructed within the SRA since operations commenced (**Figure 5**), these are detailed in Downer (2020) and are summarised below.

- 1985 – 1986: The creek was diverted by approximately 1km through in-situ material. RD7 was originally constructed within the original drainage channel;
- 1991 – 1992: The creek was diverted by approximately 0.8km through in-situ material. RD10 was originally constructed within the original drainage channel; and
- 2000 – 2005: The creek was diverted by approximately 2.4km through backfilled spoil to allow for mining in the Southwest as approved under water licence 102005.

The 2000-2005 creek diversion has been progressively rehabilitated in accordance with success criteria specified in the EA (Downer, 2020).

3.2.2 Meandu Creek Dam

Meandu Creek dam is located to the north of the Mine, outside of the Mining Lease. Meandu Creek dam is a water supply dam (i.e., to downstream irrigators) and licenced water discharge facility for Meandu Mine and Tarong Power Station. Meandu Creek dam is a referrable dam under the Water Supply Act, 2008.

The dam was constructed by Tarong Energy in 1982 and is currently owned and operated by SCL who own the Tarong Power Stations. The dam has a capacity of 3000 ML, a surface water area of 69 hectares (ha) and has a full supply level of 418.18mAHD (Meandu Creek dam EAP, 2020a).

The dam is a zoned earth filled dam with a central clay core and cut-off trench. The dam has a main and auxiliary spillway. The main spillway is an ogee crest weir with a concrete lined chute and dissipater blocks. The spillway has a crest length of 30m and has a capacity of 701 m^3/s. The auxiliary spillway is unlined with a fuse plug intact at RL 421.1mAHD. The crest length is 81m and it has a spillway capacity of 948 m3/s.

Currently all operational water discharged from mining operations is conveyed into the dam. The dam also receives blow-down water from the Tarong power stations, overflow from the cooling water dam and storm water runoff from Meandu Creek and Tarong Power Station.

Dam water is released into Meandu Creek from a release valve in the dam wall. Water is discharged at a relatively constant rate to Meandu Creek. Water discharged to Meandu Creek is the main source of water to Meandu Creek downstream of Meandu Creek dam. Release volumes are typically 15ML/day but depend on the water levels in the dam. Users of dam release water are those who are licenced by the Department of Resources (DOR). Water release needs, by licenced users, are determined by the Meandu and Barkers Creek Water Advisory Committee (WSP, 2018).

3.2.3 Black Creek and Black Creek Dam

Black Creek is a small tributary where surface waters flow into the Black Creek dam; then ultimately to diversion weirs to the east of the Tarong Power Station (TPS) ash dam. Only under extreme surface flow events (i.e., 1 in 100 event) will waters in the Black Creek be conveyed via the diversion channel and towards joins Meandu Creek north of the power station (downstream of Meandu Creek dam). Black Creek was degazetted as a watercourse under the Water Act 2000 by DNRME (now DOR) because it has been significantly modified from its natural state and is used for industrial purposes. Black Creek dam is located outside of the Mining Lease and upstream of the Tarong power stations and TPS ash dam. The Black Creek dam has a capacity of 500ML. The dam receives runoff from the upstream catchment and provides water to the Tarong power stations. It is used in part of the ash disposal process due to its effect on the ash dam water balance. Black Creek dam was constructed in 1987 and in 2015 a diversion channel was constructed to direct extreme surface water flows (i.e., 1 in 100 event)around the TPS ash dam and towards Meandu Creek.

3.2.4 Rocky Creek

Rocky Creek is located 5km to the east of the Mine site, partially within the Mining Lease but outside of the SRA. The creek flows east into Yarraman Creek which ultimately flows into the Brisbane River (Downer, 2020). The creek is ephemeral and flows only briefly following heavy rainfall events. This is partially due to the creek location in the upper catchment and steep stream bed. A large farm dam has been constructed across the Rocky Creek drainage line approximately 6km downstream of the Meandu Mine. The Meandu Mine water management system currently diverts all mine affected waters away from the Rocky Creek Catchment and towards the Meandu Creek and Black Creek catchments (WSP, 2018). The life of mine final landform design and rehabilitation plan intends to return catchment area to Rocky Creek from the King 4 South (K4S) and King 2 East (K2E) areas approximately equal to the mining catchment area prior to the latest two surface rights extensions.

Rocky Creek Catchment is currently outside of the SRA. The proposed (i.e., unapproved) K2E Project surface rights extension will expand the Mine into the Rocky Creek catchment. As detailed in JBT (2021a), impacts are expected to be limited to a minor reduction in stormwater runoff, primarily associated with changes to the contributing catchment area.

4 Hydrogeology

4.1 Groundwater Occurrence

Groundwater at the Mine is encountered in the Quaternary alluvium and Spoil, the Tertiary basalt (in discontinued fractures), the Tertiary Regolith, and the coal measures of the Triassic Tarong beds. As shown on **Figure 6**, the Mine groundwater system is bound by the Permo-Triassic Boondooma Igneous Complex to the West and the Carboniferous Maronghi Creek beds to the East. To the North, the Mine groundwater system is bounded by the Tanduringie Fan, which has been assessed to be hydraulically isolated from the Mine (JBT, 2021a). To the south, the basin approaches its margin, with the coal seams sub-cropping outside of the Mine Lease area within MDL200 and is thought to constitute the main conduit/s for groundwater recharge. The Queen A and B ply modelled sub-crop limits underlie Yarraman Creek.

The hydrogeological stratigraphy of the Mine is summarised in **Table 7**. Each hydrogeological unit is discussed in **Section 4.1.1.1** through **Section 4.1.1.6**.

Table 7 Hydrogeological Units (SLR, 2020)

Geological Period	Geologic Unit		Aquifer/Aquitard
-	Spoil		Aquifer
Quaternary	Alluvium		Aquifer (in coarser grained areas)
Tertiary	Basalt		Aquifer (fractured rock). Unconfined in upper units and semi-confined to confined in lower units where the interbedded sediments are confined by basalt flows (JBT, 2021b).
Tertiary	Regolith		Aquifer (variable saturation)
Triassic	Tarong Beds	Coal Measures	Aquifer (coal seams)
		Interburden	Aquitard
Permian-Triassic	Boondooma Igneous Complex		Aquitard (groundwater isolated to hydraulically disconnected fractures)
Devonian-Carboniferous	Maronghi Creek Beds		Aquifer (where fractured, hydraulically isolated)

4.1.1 Aquifers

4.1.1.1 Spoil

The spoil comprises reworked material (waste rock) from coal mining as well as mixed plant rejects and is present as piles above the deepest mined surface near the open pit. The spoil progressively replaces the voids as mining progresses. Groundwater within the unit occurs within the lower portion of the spoil pile. The aquifer is unconfined and there is no evidence of significant groundwater mounds or perched water tables (JBT, 2018a).

4.1.1.2 Alluvium

The Quaternary alluvium is primarily associated with Meandu Creek, Rocky Creek and Yarraman Creek (**Figure 6**). The Rocky Creek alluvium is relatively thin.

Black Creek is located at the top of the drainage system and does not contain significant alluvium to host groundwater (JBT, 2018a).

This unit is comprised of clay, silt, sand and gravel. The thickness and extent of the alluvium is variable, with the average observed thickness near Meandu Creek generally less than 5m, although thicknesses up to 35 metres have been observed from drilling along Barkers Creek (Pegrem, 1986). Bore logs indicate that upstream of the confluence of Barker Creek and Meandu Creek the alluvium is more extensive than shown by geological mapping. The sand and gravels are the main water bearing features of the unit and are exploited for irrigation and town water supply, particularly from the alluvial deposits at Barkers Creek and downstream of the confluence between Barkers Creek and Meandu Creek (JBT, 2021b).

4.1.1.3 Basalt

The Tertiary basalt is present as ridge-top deposits in the central-eastern area of the Meandu Mine (JBT, 2018a). The unit is comprised of olivine basalt flows and some pyroclastics, interbedded with minor siltstone, shale, sandstone and silcrete. Where present, the Tertiary basalt has a thickness between 30 and 80m, however can be up to 200m thick where paleo-valleys have been infilled with multiple flows. Basalt distribution is well mapped within the surface rights area. Site groundwater monitoring bores that are screened in the basalt are installed to depths of approximately 40 to 66mbgl. Groundwater typically occurs in fractures within the basalt and within the interbedded sediments. Due to the nature of the fractured rock aquifer, some areas are unsaturated and historically most groundwater bores located in basalt have been perpetually dry. The aquifer is unconfined in upper units and semi-confined to confined in lower units where the interbedded sediments are confined by basalt flows (JBT, 2021b).

4.1.1.4 Regolith

The Tertiary Regolith occurs across the entire Mine area and is present below the alluvium, basalt, spoil and is exposed at surface in some areas. The unit is primarily the upper 20 to 30 m of weathered Tarong beds. This unit is comprised of weathered sandstone, siltstone, shale and conglomerate. Regionally, the regolith is generally unsaturated, although may become saturated in some areas following rainfall recharge. The aquifer is unconfined to semi-confined (JBT, 2021b). Within the Mine, the regolith is mostly saturated where present below the spoil which acts as a recharge area. It is conceptualised that prior to mining the unit was primarily dry with groundwater occurring only around creek beds which were the dominant recharge mechanism (JBT, 2018a).

4.1.1.5 Tarong Beds

The Triassic Tarong beds occur across the entire Mine area, below the regolith, and are exposed near the pits. The unit dips towards the Southeast at approximately 5° and is heavily faulted by several northwest/southeast trending faults (JBT, 2018a). The unit is comprised of poorly sorted fine to very coarse grained arkosic to sub-arkosic sandstone and matrix supported conglomerate with minor shale, siltstone, mudstone and coal. The conglomerate is more dominant towards the base of the sequence and the basin margins (Pegrem, 1986).

In the area of the Mine site, the unit is host to the Ace, King and Queen coal seams that are targeted for mining. The Ace seam is the top seam that is mined, it is generally devoid of groundwater and oxidised. The King seam occurs approximately 60 m below the Ace seam and contains groundwater in most areas. The Queen seam occurs approximately 30 to 40 m below the King seam and typically contains groundwater. The coal seams are the dominant aquifers within the Tarong beds unit, with groundwater occurring primarily within fractures.

The interburden between the coal seams has low permeability and can be classified as aquitards in comparison to the coal seams (JBT, 2021b). Due to the faulting, the coal seams are cut off by the less permeable interburden and form hydraulically isolated areas from each other.

More coal seams occur below the Queen seam, but they are not economic and therefore not mined at Meandu Mine. These are more significant in the western area of the Mine where the dip of the strata brings them closer to the surface (JBT, 2018a).

4.1.1.6 Maronghi Creek Beds

The Devonian-Carboniferous Maronghi Creek Beds occur to the east of the mining area and occur at the surface due to the faulted eastern margin of the Tarong Basin (JBT, 2018a). This unit is comprised of mudstone, shale, arenite, chert, jasper and felsic to mafic metamorphosed volcanics (JBT, 2021b). Groundwater occurs in fractures that are typically discontinuous and hydraulically isolated, however some fractured areas are dry. In areas where groundwater bearing fractures are more dominant, the aquifer has the potential to provide water supplies of low yield (JBT, 2018a). There are a number of groundwater bores developed in this unit that are likely only used for stock watering (as suggested by the salinity of the unit) (JBT, 2021a).

4.1.2 Aquitards

4.1.2.1 Boondooma Igneous Complex

The Permian-Triassic Boondooma Igneous Complex is present at the surface to the west of the Mine and defines the faulted western margin of the Tarong Basin. This unit is comprised of medium-to-coarse grained pink biotite-hornblende granite with minor quartz diorite. Publicly available information on the construction of registered groundwater bores shows that there are very few screened in the unit, suggesting it is not a significant regional groundwater source (JBT, 2021b). The unit is a fractured rock aquifer with groundwater occurrence typically limited to fractures (JBT, 2018a).

4.1.3 Formation of Tarong Beds

4.1.3.1 Regional Geology

Meandu Mine is located over the Triassic aged Tarong Basin, which is characterised as a north-northwest to south-southeast trending pull-apart basin, up to 80km long and 30km wide (Pegrem 1986). The basin is described by Flood & Garces (1986) as originating from a dextral, strike-slip, pull-apart mechanism. Sedimentation within the basin formed an alluvial fan complex known as the Tanduringie Fan (Flood and Garces 1986). The Tarong Beds and associated coal deposits were formed from Peat swamp depressions to the north and the south of the Tanduringie Fan. The Tarong Beds are up to 450m thick and comprise coarse grained, clastic sediments and thick coal accumulations (Pegrem, 1986).

The extents of the Tarong Basin are presented on **Figure 6** based on the boundary between the sediments of the Tarong Beds with the Boondooma Igneous Complex (Permo-Triassic intrusives) in the west and with the Maronghi Creek beds in the east. The vertical (i.e. depth) and lateral extent (north-south) of the Tanduringie Fan is presented in **Figure 7** (refer to **Figure 6** for the location of the cross section). The Meandu Mine targets the coal deposits to the south of the Tanduringie Fan. The Kunioon deposit (not mined), lies to the north of the Tanduringie Fan. As detailed by Pegrem (1986) and shown on **Figure 7,** there are no known coal deposits within the Tanduringie Fan between Meandu Mine and the Kunioon deposit and are hydraulically isolated from one another meaning that there is no connectivity with the coal seam aquifers either side.

Regionally, the surface geology is comprised of thin Quaternary alluvial deposits associated with the ephemeral Meandu Creek and Barker Creek (Burnett River Catchment) and Rocky Creek and Yarraman Creek (Brisbane River Catchment). Deposits of Tertiary basalt (Main Range Volcanics) can be found south, south-east and north-west of the Meandu Mine (**Figure 6**).

The mapped structural geology shows the presence of lineaments, mostly trending northwest to southeast within the Tanduringie Fan area. Major faults mapped within the Meandu Mine geological model typically trend parallel to the basin axis (**Figure 6**).

4.1.3.2 Local Geology

A site geological section developed by JBT (2021a) is presented on **Figure 8.** The location of the cross section is shown on **Figure 6**.

The width of the Tarong Basin is approximately 10km in the area of the Meandu Mine. Mining operations are associated with the Late Triassic Tarong Beds which occur across the entire mine site, below the regolith and which are exposed near the pits. The unit dips towards the Southeast at approximately 5° and is heavily faulted by several northwest / southeast trending faults (**Figure 8**). The unit is comprised of poorly sorted fine to very coarse grained arkosic to sub-arkosic sandstone and matrix supported conglomerate with minor shale, siltstone, mudstone and coal (JBT, 2018a). The conglomerate is more dominant towards the base of the sequence and the basin margins (Pegrem, 1986).

In the area of the Mine site, the Ace, King and Queen coal seams are mined. These seams are comprised of a series of seams/plies separated by interburden. Additional coal seams occur below the Queen seam (e.g. Prince seam) but they are not mined at Meandu Mine (**Figure 8**).

Surface geology is characterised by Tertiary basalt deposits, which occur in the southern and central eastern areas of the Mining Lease and Quaternary alluvium deposits. As described by JBT (2018a), the basalt present in the central eastern area is a remnant ridge top deposit. Toward the south, the basalt deposit is thicker. The Quaternary alluvium deposits are associated with the ephemeral Meandu Creeks and Rocky Creek.

Major faults mapped from the Mine geological model have been reproduced on **Figure 6** and **Figure 8.** The faults generally trend parallel to the basin axis and disrupt the continuity of coal seams within the Meandu Mine area. As discussed in JBT (2021a), the Boulevard Fault is the most significant fault within the Mine area, with a recorded throw of up to 50m.

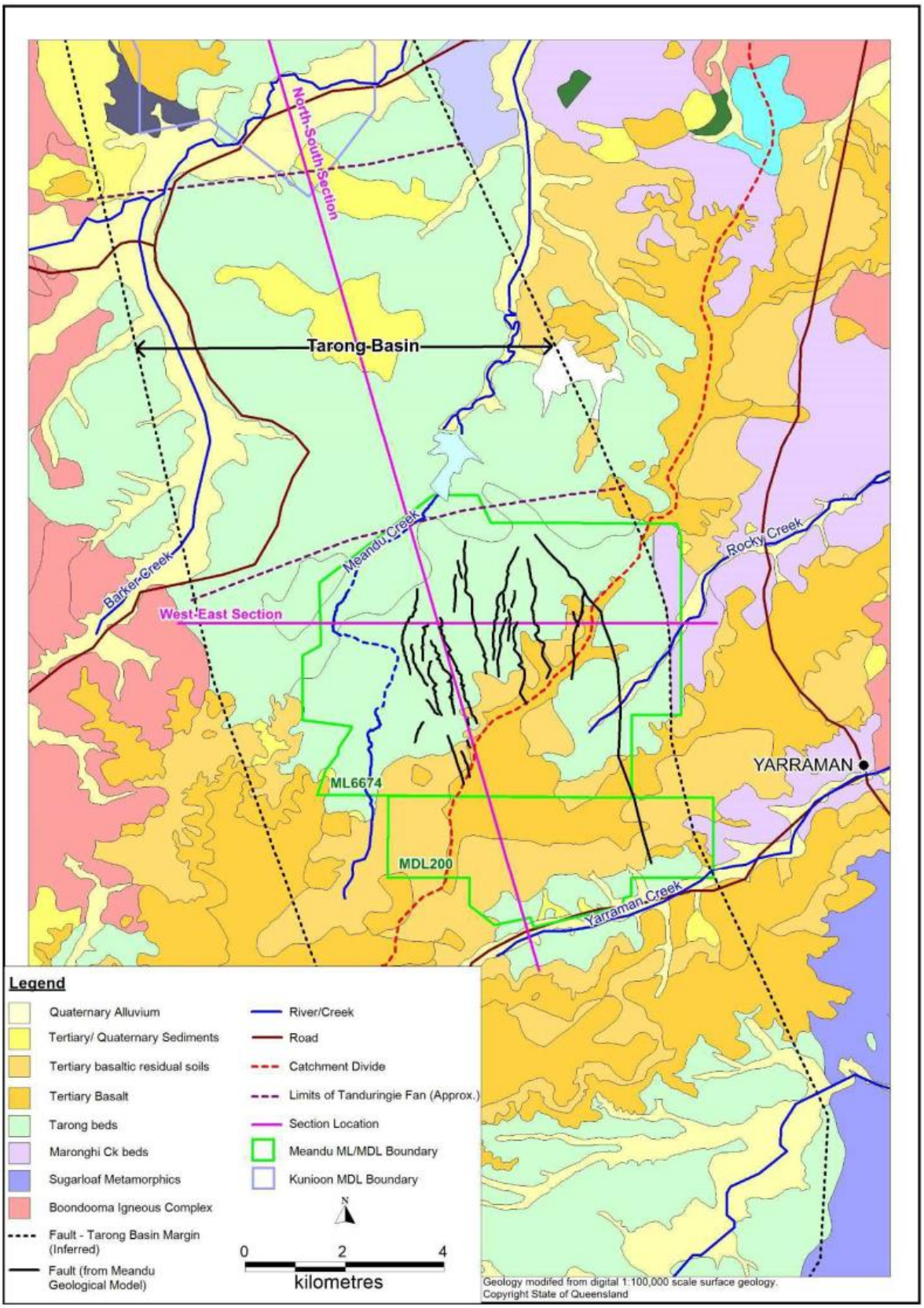

Figure 6 Surface and Structural Geology (JBT, 2021a)

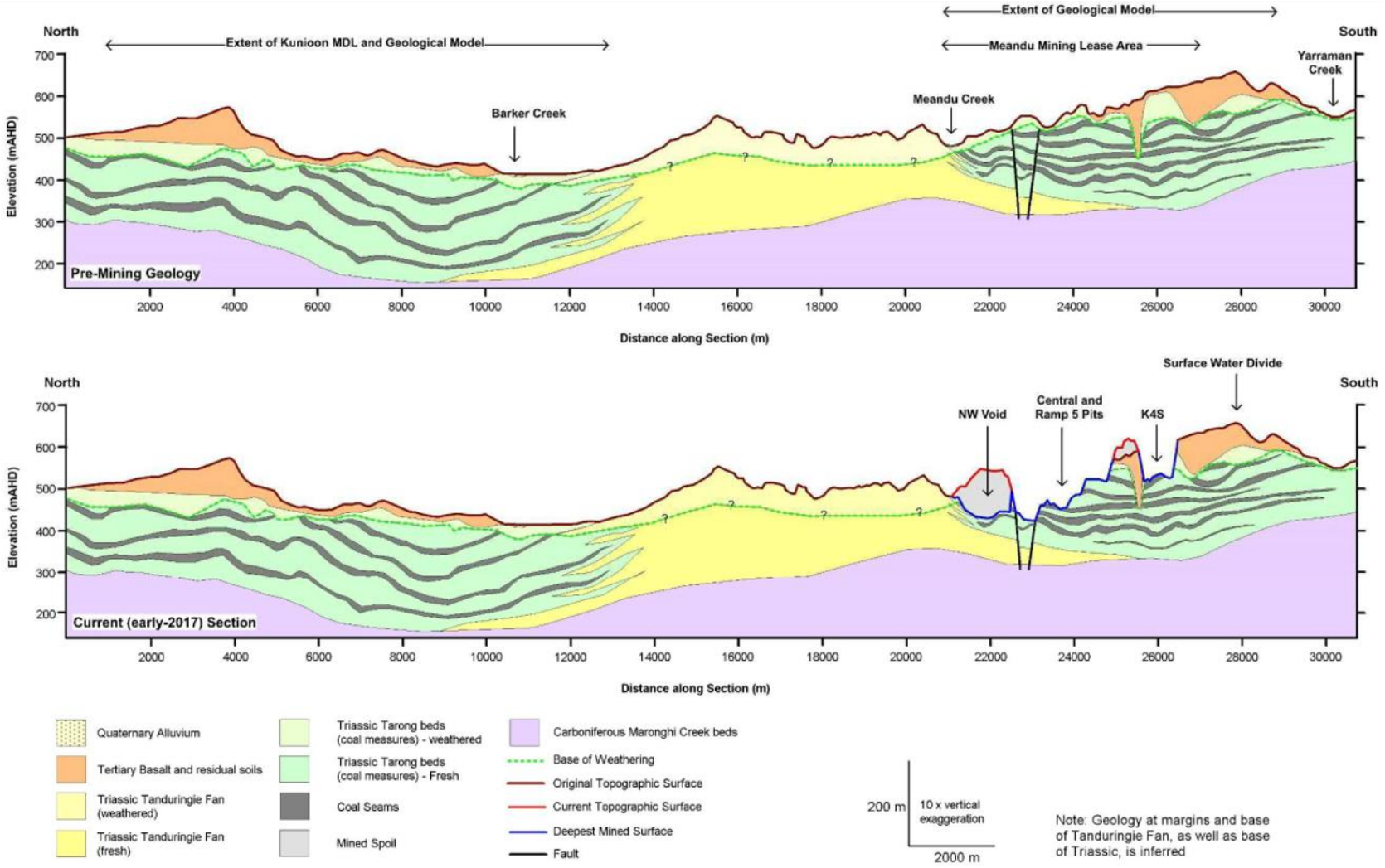

Figure 7 Regional, North-South Geological Section (JBT, 2021a)

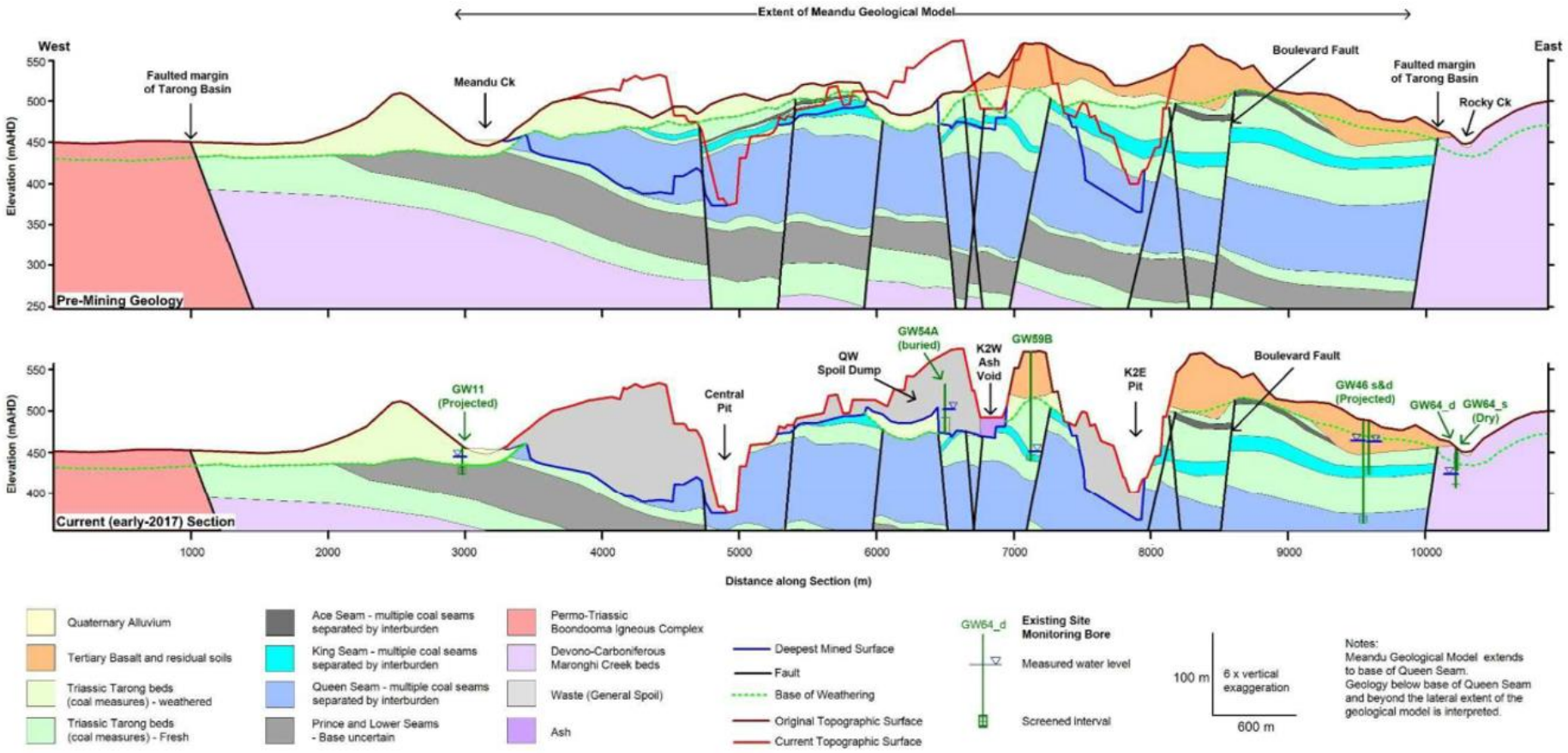

Figure 8 West-East Geological Section (Adapted from JBT, 2021a)

4.2 Groundwater Recharge and Discharge Locations

4.2.1 Regional Context

Groundwater recharge occurs via direct rainfall recharge to surface geological units (i.e., alluvium, regolith and basalt). Recharge to the basalt occurs primarily through fractured zones. The coal seams of the Tarong beds are primarily recharged through downward seepage where the coal subcrop the regolith and alluvium. The alluvium is recharged via rainfall and seepage from the regolith. Ephemeral water flow in the creeks may also contribute to alluvial recharge.

Groundwater may temporarily discharge in the form of baseflow from the alluvium (e.g., some waterholes in Rocky Creek) and via evapotranspiration, primarily along drainage channels where the water table is shallower and groundwater dependant vegetation exists. Groundwater may support some aquatic and terrestrial GDE along the main drainage channels. Groundwater is also extracted regionally from landholder bores for agricultural and domestic purposes.

4.2.2 Local Context

Local recharge to the groundwater system primarily occurs from rainfall and seepage/infiltration between groundwater units. Natural recharge pathways (i.e. pre-mining and current) are:

- Recharge to the Quaternary alluvium occurs directly from rainfall and seepage from creek beds following rainfall event (i.e. when creeks are flowing).
- Recharge to the Tertiary regolith occurs directly from rainfall. Recharge also occurs through the alluvium where present in creek beds (e.g. Meandu Creek and Black Creek drainage channel) or where the regolith is directly exposed (e.g. Rocky Creek). It is conceptualised that this was the predominant recharge mechanism before mining, with groundwater primarily occurring around the creek beds and the rest of the unit being dry.
- Recharge to the Tertiary basalt is directly via rainfall, with recharge occurring more easily through fractures. The units that underlie the basalt will receive some component of recharge via downward seepage (which could have an impact on groundwater chemistry).
- Recharge to the coal seams (water bearing units of the Triassic Tarong Beds) occurs primarily where the unit underlies the regolith and alluvium. It is conceptualised that the main area where recharge occurs to the coal seams is where the Queen A and B plies in particular subcrop beneath Yarraman Creek to the south of Meandu Mine outside of the Mining Lease within MDL200.

Anthropogenic influences have modified the natural recharge processes as follows:

- Downstream of Meandu Creek dam (i.e. outside of the Mining Lease), recharge to the Quaternary alluvium occurs as a result of dam water releases from Meandu Creek dam.
- The spoil is recharged directly from rainfall. The reworked material is permeable and porous relative to in-situ material. Modelling of deep drainage (i.e. recharge) through spoil conducted by Landloch (2021a) indicates that spoil recharge occurs primarily after heavy rainfall (only when much greater than average rainfall); with recharge rates estimated from 0.03 to 5% of rainfall depending on the level/type of vegetation and soil compaction.

- Recharge to the Tertiary regolith occurs through the spoil where present. The Tertiary regolith plays an important role in seepage transport where topography is the main driver for movement and shallow seepage is preferentially transported within the shallow regolith.
- Tailings and other less permeable mine rejects may form hydraulic barriers and reduce recharge and seepage. Areas that are capped (i.e. low permeability capping) also significantly reduce potential recharge to underlying units.

Locally, natural discharge to the groundwater system (i.e. pre-mining and current) occurs through:

- Evapotranspiration: Mostly along drainage lines where groundwater levels are shallow (i.e. <5m).
- Baseflow: Creeks may receive some baseflow from the alluvium, for example, ponded water that occurs in some of the Rocky Creek waterholes may receive some discharge from groundwater for at least some of the year.

Anthropogenic discharge comprises of:

- Groundwater extraction from landholder bores. The closest bores from the mining lease are RN 189817 and Hilltop bore (approximately 800m from the mining lease). However, these bores are upgradient from the mine groundwater flow. It is noted that no private bores downgradient of the mine have been identified within 3km from the mining lease.
- Minor rates of (combined) pit seepage that are generally less than 5L/s that are directed via surface drains to pit sumps and removed from the pits with surface water runoff and handled through the site water management system.
- Groundwater extraction via pumping in the NWBV area. Current extraction rates are approximately 8L/s for the combined bores GW48 and GW49. A third dewatering bore (i.e. GW98) was commissioned and tested in September 2021 but has been put into stand-by mode until all dewatering data can be analysed to determine if it is required. All groundwater extraction bores have a capacity to dewater at a rate of ~3 L/s (each).

4.3 Groundwater Quality

4.3.1 Aquifers

A summary statistic of baseline data for pH, electrical conductivity (EC) and major ions is presented in **Table 8.** Baseline data is defined here as, non-impacted by mining. The bores assessed as not impacted by mining (control and background bores) in WSP (2018) and Stanwell (2020b) have been selected as representative of baseline data.

Overall, the data show coal measures and alluvium to have a median pH of 6.16 with a median EC of 2,473 µS/cm waters. Sulfate concentration is below 100 mg/L in the coal measures and below 200mg/L in the alluvium. It is noted that the baseline data is based on a limited number of locations (especially for the alluvium and coal measures below Queen Seam) and cannot be interpreted as being representative of the pre-mining water quality in all water bearing zones of the same geological unit.

Table 8 Summary Statistics of Baseline Data for pH, EC and Major Ions

sites	statistic	pH Field	EC Field (µS/cm)	SO_4^{2+} (mg/L)	Cl^- (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^+ (mg/L)	K^- (mg/L)	F^- (mg/L)
Queen Seam (GW43D, GW44D, GW44S, GW45D, GW46D, GW63D)	Total Number	97	98	149	149	149	8	149	149	149
	Min	5.72	713	0.5	165	8	11	98	5	0.05
	Median	7.23	2112	69	508	62	24.5	317	16	0.05
	Max	8	13360	740	4670	785	516	1580	81	0.4
King Seam (GW45S, GW46S, GW58D)	Total Number	73	64	97	97	97	5	97	97	97
	Min	5.73	956	30	254	5	26	129	4	0.05
	Median	6.38	1712	52	421	35	32	261	18	0.1
	Max	7.01	5750	376	1950	321	153	608	56	1.6
Alluvium (GW39)	Total Number	17	17	38	38	38	2	38	38	25
	Min	5.99	2320	134	0.5	27	33	391	0.5	0.2
	Median	6.16	2473	188.5	667	32	39.5	433.5	8	0.2
	Max	7.33	2710	214	775	46	46	534	11	0.3

A statistical summary of baseline data for dissolved metals/metalloids is shown in **Table 9**. Baseline data is defined here as non-impacted by mining. The bores assessed as not impacted by mining (control and background bores) in WSP (2018) and Stanwell (2020b) have been selected as representative of baseline data.

Overall, the data show that median dissolved metal/metalloid concentration is generally below the laboratory limits of reporting (LOR) in the coal measures and alluvium. Exceptions are barium, manganese, boron and iron. It is noted that the baseline data is based on a limited number of locations (especially for the alluvium and coal measures below Queen Seam) and cannot be interpreted as representative of the pre-mining water quality in all water bearing zones of the same geological unit.

Table 9 Summary Statistics of Baseline Data for Dissolved Metals

Sites	Alluvium (GW39)		King Seam (GW45S, GW46S, GW58D)		Queen Seam (GW43D, GW44D, GW44S, GW45D, GW46D, GW63D)		Coal Measures Below Queen Seam (GW87d)	
Statistic	Median	Max	Median	Max	Median	Max	Median	Max
Al (mg/L)	<LOR	0.03	<LOR	0.04	<LOR	10	0.02	2.17
Sb (mg/L)	<LOR	0.001	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
As (mg/L)	<LOR	0.001	<LOR	0.002	<LOR	0.004	<LOR	<LOR
Be (mg/L)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Ba (mg/L)	0.063	0.2	0.137	0.673	0.1325	1.4	0.182	0.228
Cd (mg/L)	<LOR	<LOR	<LOR	0.0001	<LOR	0.0003	<LOR	0.0027
Cr (mg/L)	<LOR	<LOR	<LOR	0.005	<LOR	0.002	<LOR	0.0010
Co (mg/L)	0.002	0.003	<LOR	0.012	<LOR	0.008	<LOR	0.0450
Cu (mg/L)	<LOR	0.012	<LOR	0.003	<LOR	0.074	0.004	0.349
Pb (mg/L)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Mn (mg/L)	0.268	0.381	0.1445	0.649	0.09	1.32	0.9630	5.8500

Sites	Alluvium (GW39)		King Seam (GW45S, GW46S, GW58D)		Queen Seam (GW43D, GW44D, GW44S, GW45D, GW46D, GW63D)		Coal Measures Below Queen Seam (GW87d)	
Mo (mg/L)	<LOR	0.002	<LOR	0.006	<LOR	0.004	<LOR	<LOR
Ni (mg/L)	0.003	0.012	0.001	0.034	<LOR	0.01	0.006	0.048
Se (mg/L)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Ag (mg/L)	<LOR	<LOR	<LOR	0.001	<LOR	<LOR	<LOR	<LOR
Tl (mg/L)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
U (mg/L)	<LOR	<LOR	<LOR	<LOR	<LOR	0.002	<LOR	<LOR
V (mg/L)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Zn (mg/L)	0.045	0.128	0.0095	0.132	<LOR	0.194	0.088	0.635
B (mg/L)	0.06	0.11	0.14	0.34	0.06	0.15	0.12	0.13
Fe (mg/L)	0.22	1	6.455	33.1	0.885	6.84	26.3	30.3
Hg (mg/L)	<LOR	0.0001	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR

4.3.1.1 Alluvium

Bore GW39 (Background bore) and GW40 monitor groundwater in the alluvium along Meandu Creek, upstream of Meandu Creek dam. Groundwater monitoring results for these two bores have a median field pH of 6.0 and a median field EC of 2,614 µS/cm. There is no evident relationship between EC and/or pH and the CRD (**Figure 9** and **Figure 10**), and Na-Cl is the dominant water type (**Figure 11**). The lack of relationship between EC and/or pH and the CRD indicates that GW39 and GW40 likely monitor small aquifers with limited rainfall recharge. This is reflective of the alluvium aquifers that are described as variable in extent and often discontinuous, with limited hydraulic connectivity between water bearing zones.

Groundwater quality in the alluvium was assessed by WSP (2018) as part of the Environmental Evaluation (EE) and recently in 2021 by JBT (2021a) as part of the annual groundwater data review. Both studies concluded that there was no evidence to date of mining impacts to water quality of the Meandu Creek alluvium (based on groundwater quality measurements at GW39 and GW40).

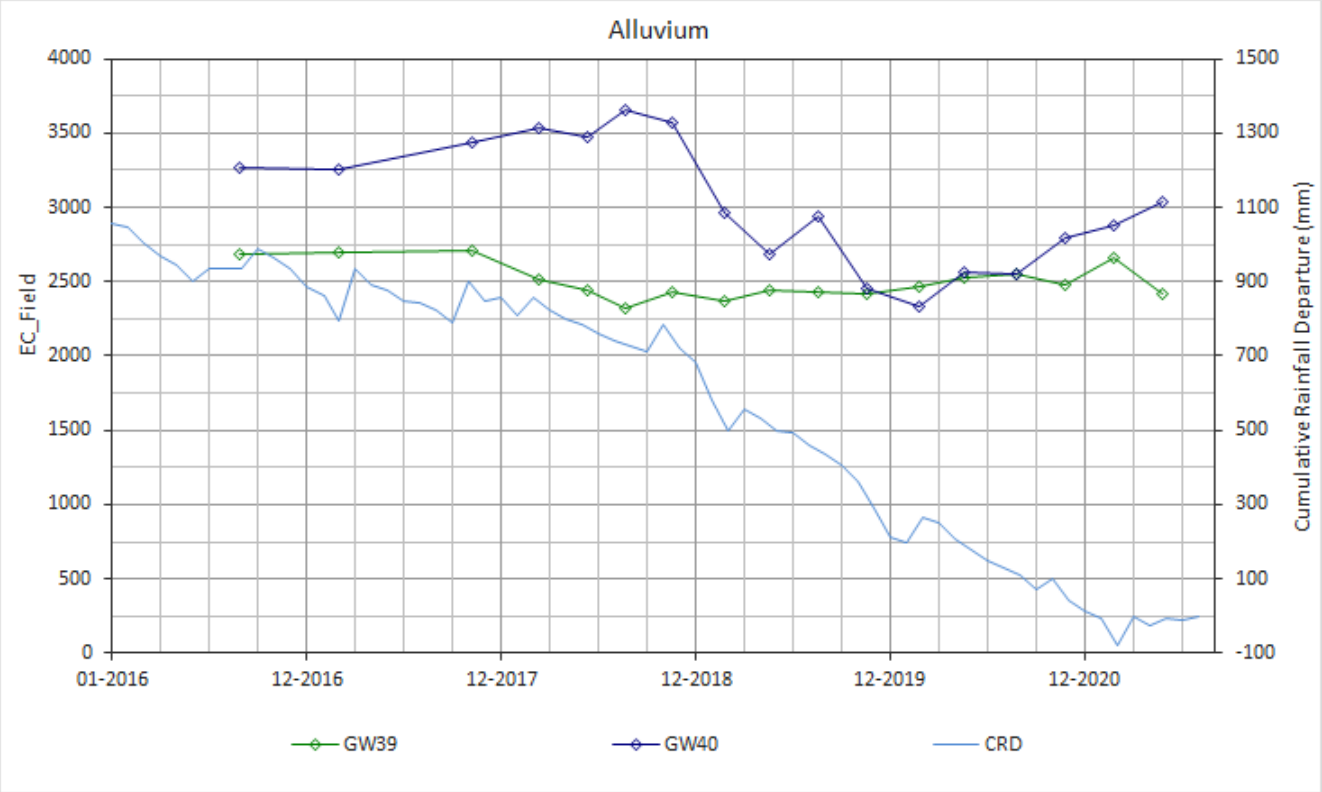

Figure 9 Field EC (µS/cm) Measured in Alluvium Bores

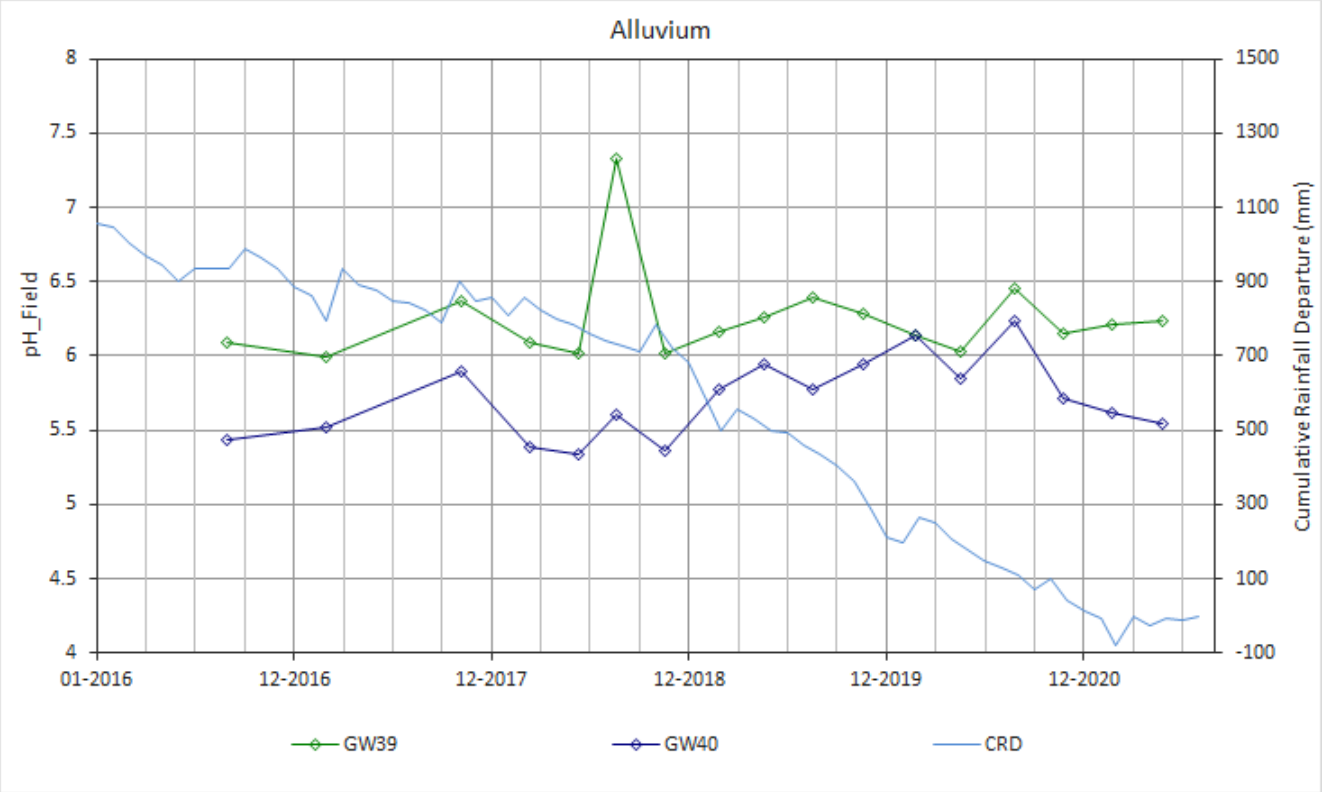

Figure 10 Field pH Measured in Alluvium Bores

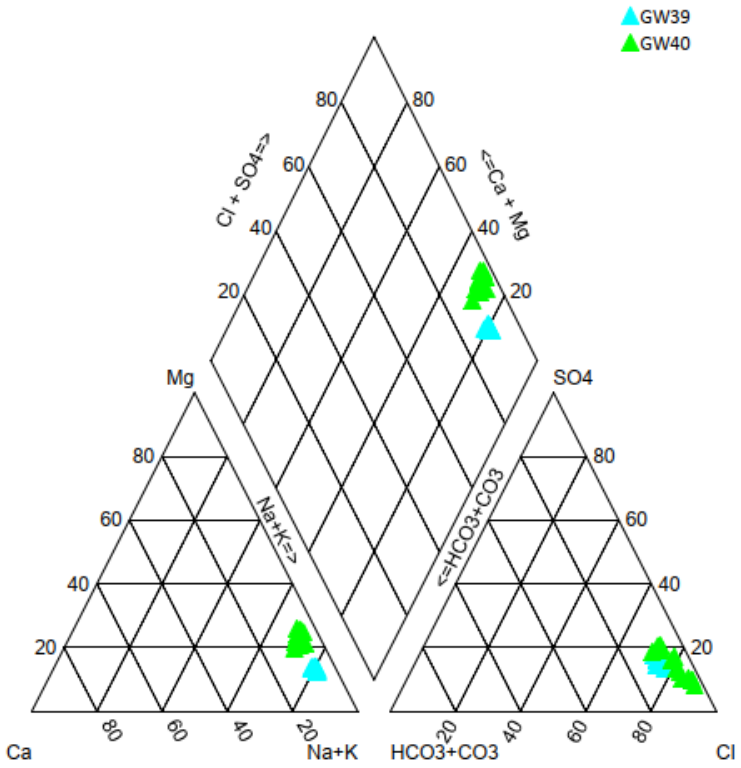

Figure 11 Piper Diagram Alluvium

4.3.1.2 Basalt

Groundwater monitoring results for the only saturated bore screened in the Tertiary basalt (i.e. GW43_s) shows a median field pH of 6.9 and a median EC of 2,270 µS/cm. No clear correlation can be made between either EC and/or pH and the CRD (**Figure 12** and **Figure 13**). The dominant water type is Mg-HCO_3), with HCO_3 type water generally reflective of younger water (**Figure 14**). No evidence of mining impact was reported for this bore by WSP (2018) and JBT (2021a).

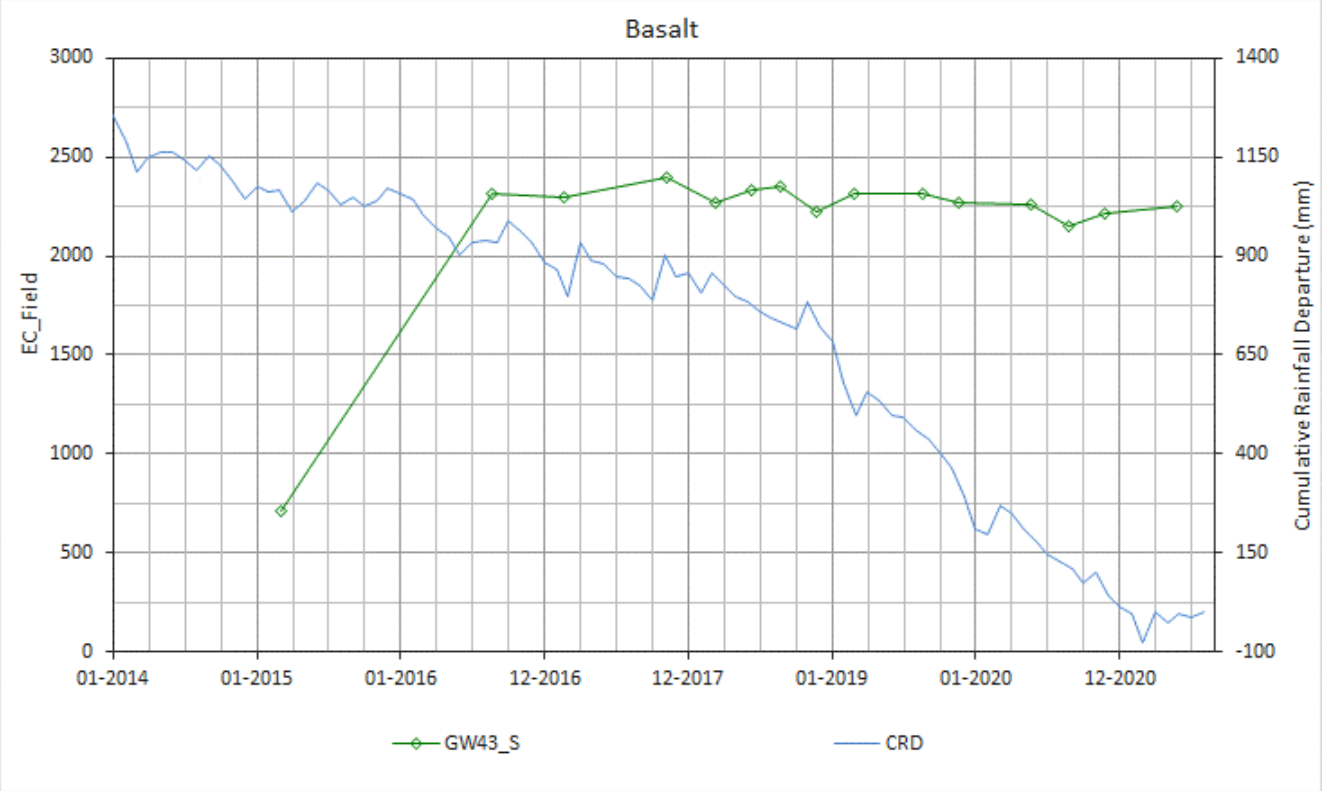

Figure 12 Field EC (µS/cm) Measured in Basalt Bore

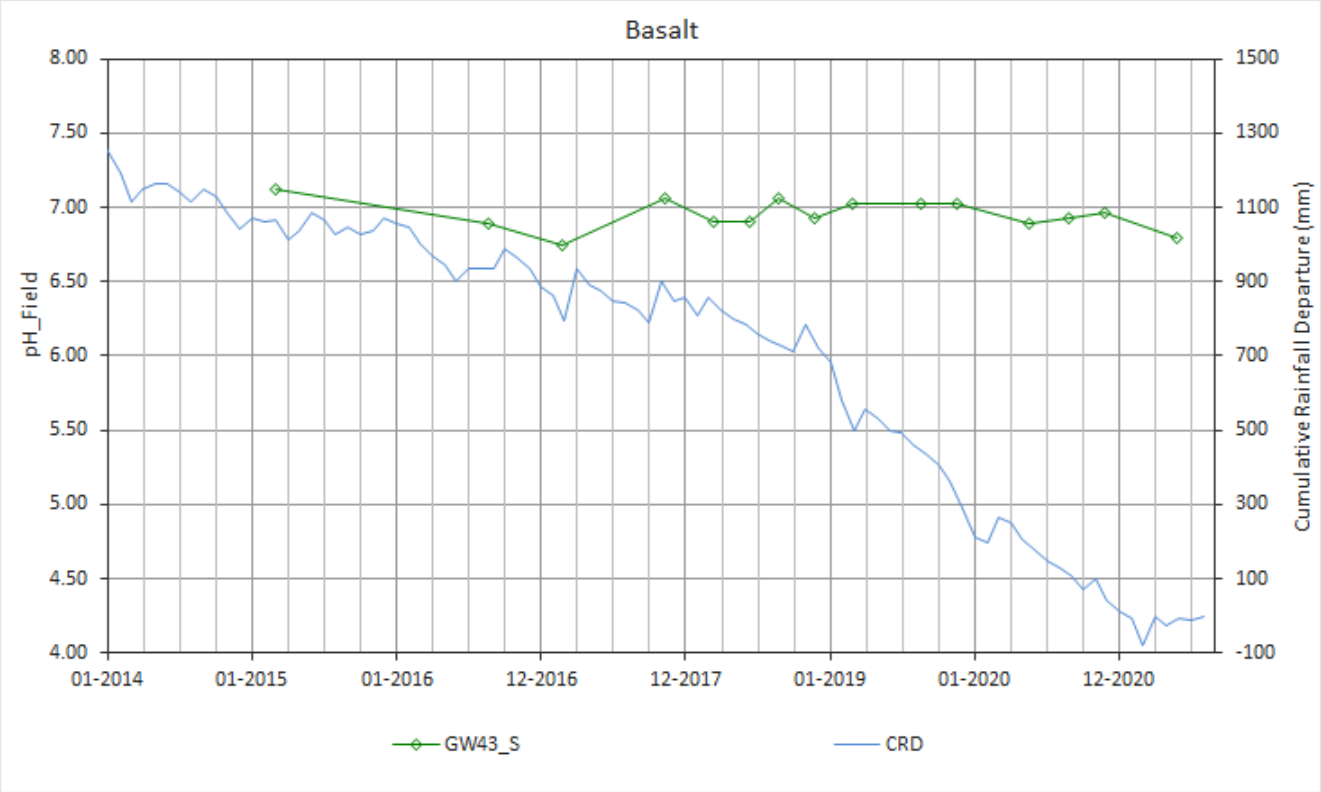

Figure 13 Field pH Measured in Basalt Bore

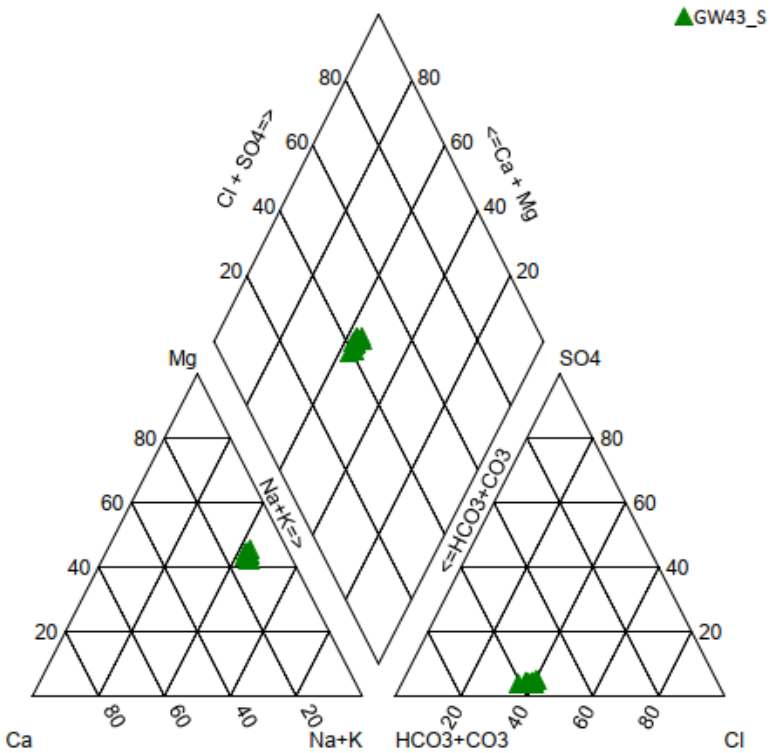

Figure 14 Piper Diagram Tertiary Basalt

4.3.1.3 Spoil

Groundwater monitoring results for the bores screened in the spoil has a median field pH of 5.9 and a median EC of 3,241µS/cm. No clear correlation can be made between either EC and/or pH and the CRD (**Figure 15** and **Figure 16**). pH results are comparable to overburden rock samples tested by Landloch (2021b) showing four samples with a pH below 6 and four with a pH above 6. However, EC results are generally greater than Landloch (2021b) (i.e. EC < 1000µS/cm), likely reflective of the water residence time in the spoil.

Bores GW41 (13m deep and monitoring the spoil / natural siltstone ground surface, located at the northeastern periphery of NWBV adjacent to the NWB tailings storage facility and GW70 (26m deep and monitors spoil interface to underlying clay, located in the K2E spoil in Black Gully area) have high EC when compared to other bores screened in spoil. Bores GW71 and GW70 (35m deep and monitors spoil interface to underlying clay, located in the K2E spoil in Black Gully area) shows a consistent upward trend in EC (**Figure 15**).

The Mann-Kendall trend analysis (**Appendix A**) detected an upward trend at bores GW71 and GW48; and a downward trend at bores GW76, GW75 and GW72.

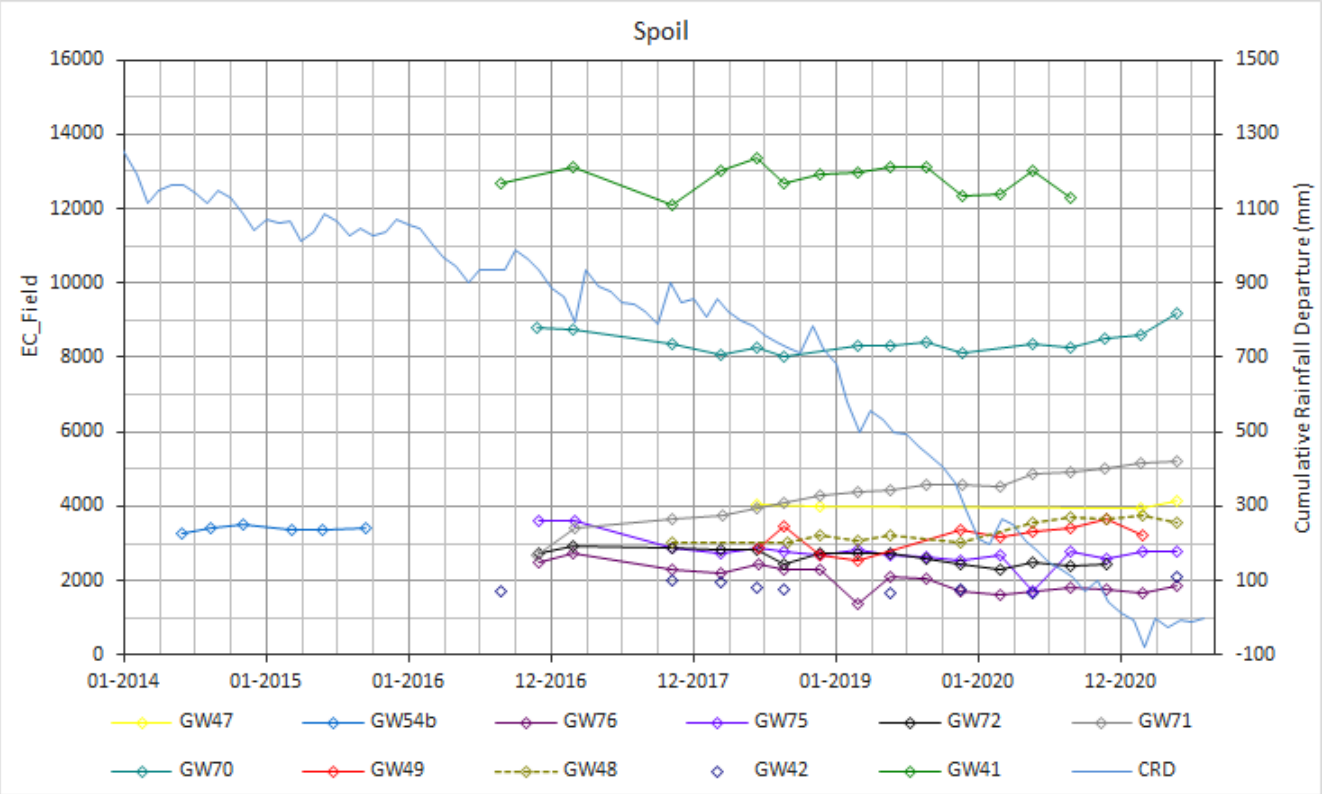

Figure 15 Field EC (µS/cm) Measured in Spoil Bores

The pH at bores GW54B (nearby QW sump) and GW71 (northern portion of K2E rehabilitation) are significantly lower than other bores screened in spoil (**Figure 16**). These bores are located within an area identified with high salinity and are further discussed in **Section 4.3.3.** The Mann-Kendal trend analysis did not detect any downward trend in pH (**Appendix A**), as shown on **Figure 16.**

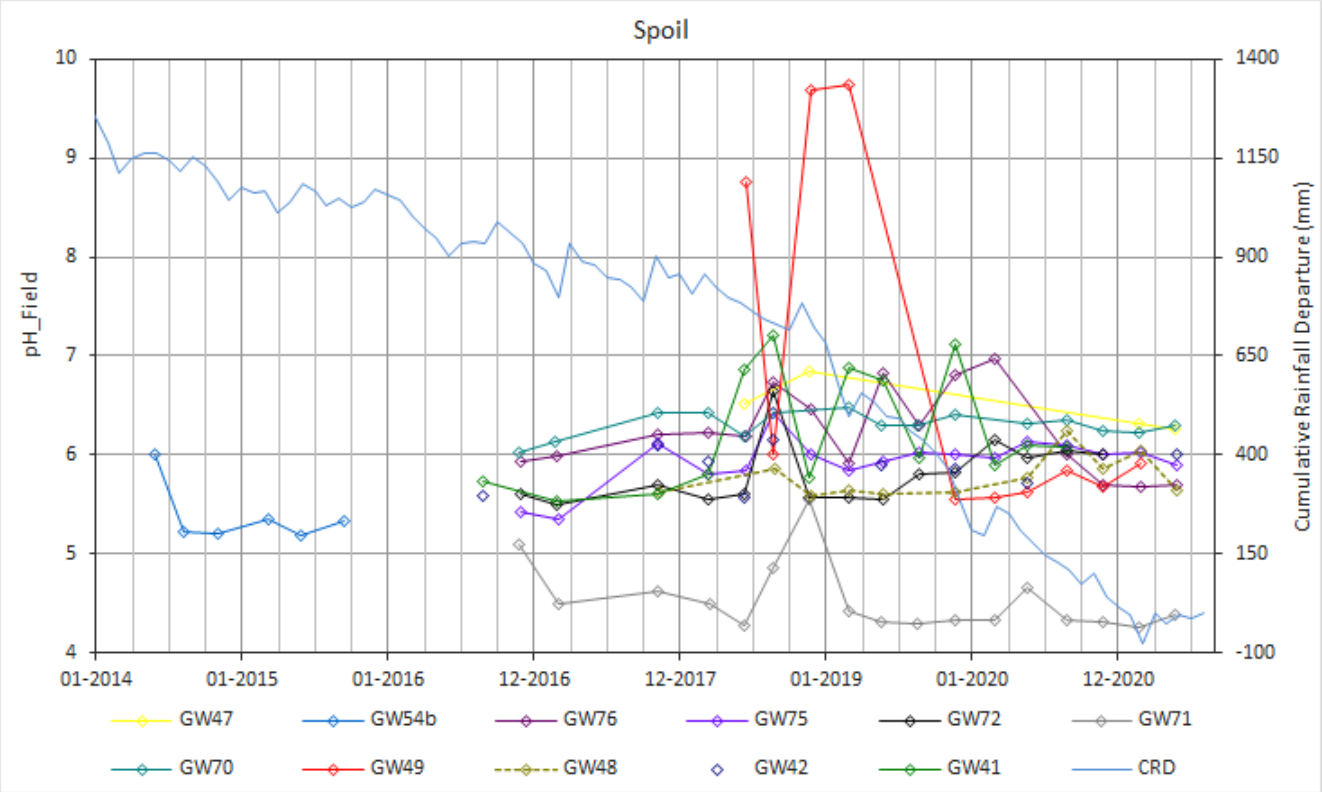

Figure 16 Field pH Measured in Spoil Bores

The dominant water type is Na-Cl, to the exception of bore GW75 (Mg-SO_4) and bores GW49 and GW72 (Mg-Na-SO_4) (**Figure 17**). Bores GW75, GW49 and GW72 are impacted by mining and further discussed in **Section 4.3.3.**

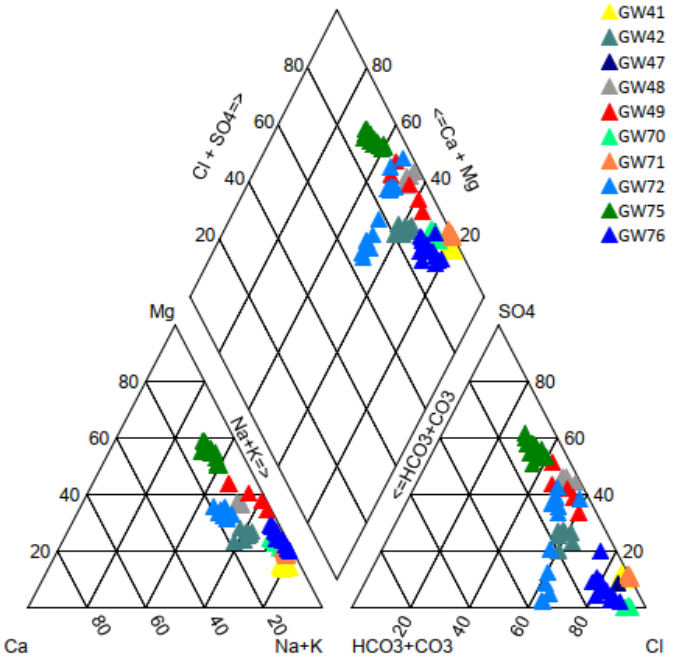

Figure 17 Piper Diagram Spoil

4.3.1.4 Regolith

Groundwater monitoring results for the Tertiary regolith have an average pH of 5.9 and an average EC of 5,152µS/cm. There is no evident relationship between the EC and the CRD (**Figure 18**).

Bore GW82 is located adjacent to RD16 tailings storage facility (capping completed April 2020), and shows significantly higher EC than other regolith bores. Historical data show that overall, EC in monitoring bores have been stable or decreasing. This is confirmed by the Mann-Kendall trend analysis that shows a decrease over the recording period at bores GW61s, GW73 (Black Gully), GW69 (adjacent to ROM stockpile) and GW80 (adjacent to RD3A and 3B); an upward trend is detected for bore GW37 (some 600m north northeast of GW69); and no trend at the remaining bores (**Appendix A**). The "dip" observed at bore GW81 in 2020 is likely an outlier.

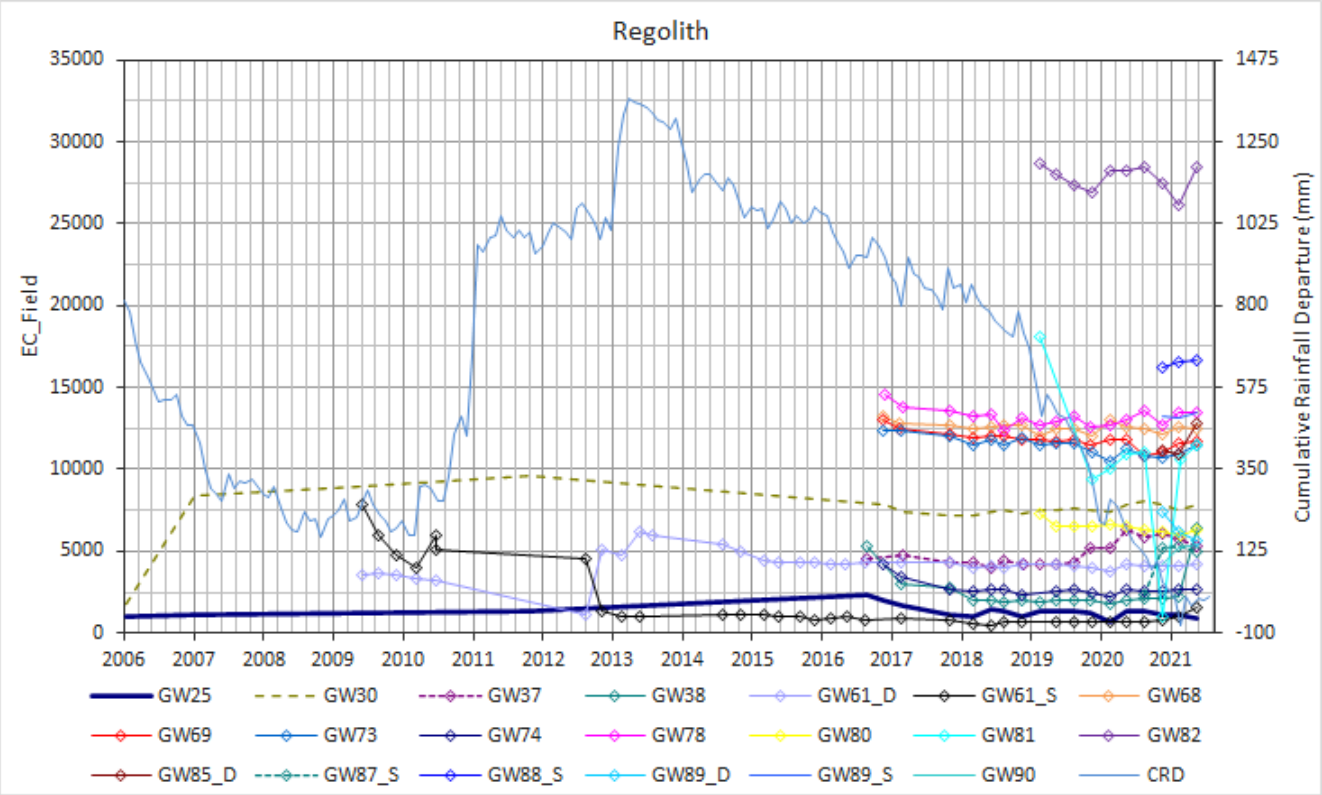

Figure 18 Field EC (µS/cm) Measured in Regolith Bores

Significant pH variations have been recorded at bores GW61s, GW61d in Black Gully, and GW25 (the dip observed in 2020 is likely to be an outlier) and GW87s. At bores GW61s, GW74 in Black Gully, GW82 adjacent to RD16 tailings storage facility (now capped) and GW87s pH values below 5.0 have been recorded (**Figure 19**). The Mann-Kendal trend analysis did not detect any downward trend in pH (**Appendix A**).

The water type is dominantly Na-Cl (**Figure 20**).

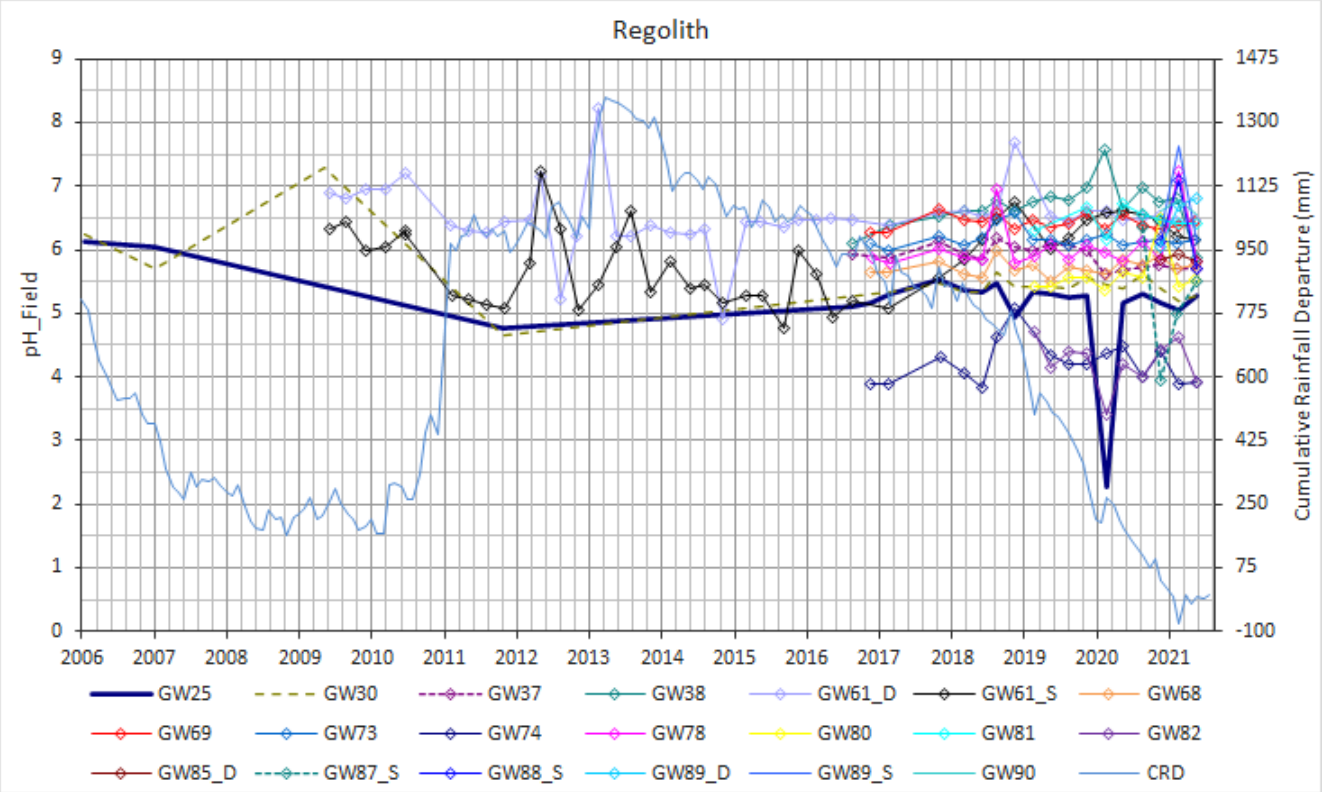

Figure 19 Field pH Measured in Regolith Bores

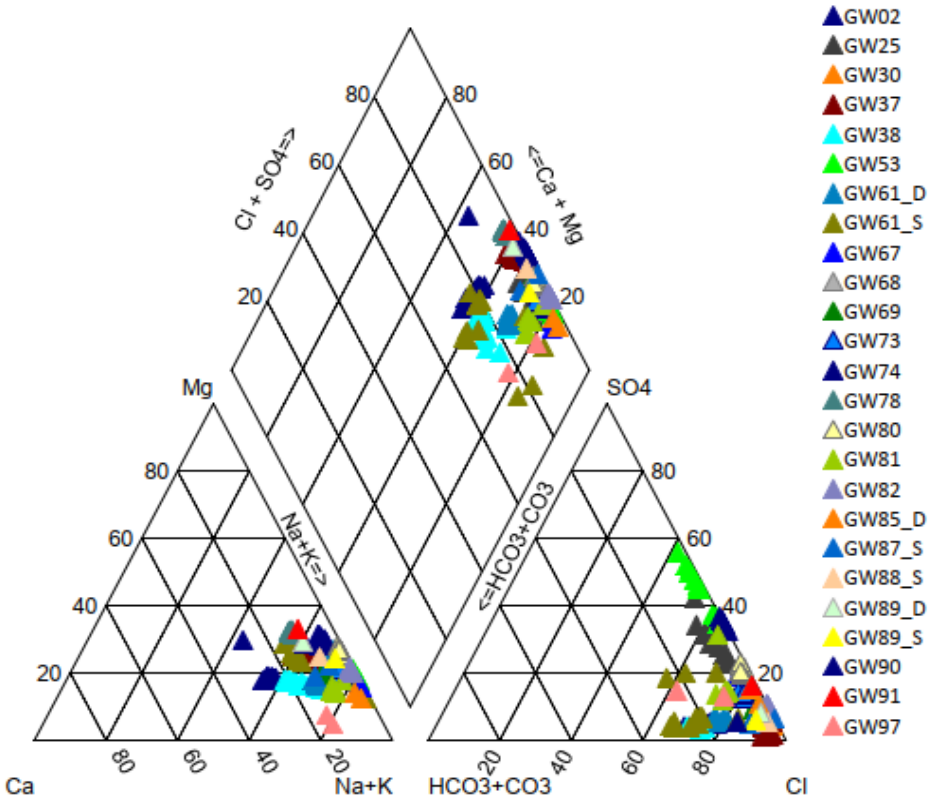

Figure 20 Piper Diagram Tertiary Regolith

4.3.1.5 Tarong Beds

4.3.1.5.1 Mined Coal Seams

Groundwater monitoring results for the bores screened within the mined coal seams indicates a high variability in EC, with observations ranging from 647 µS/cm to 13,360 µS/cm. The dip recorded for bore GW56d is inconsistent with the rest of the data and likely to be an outlier.

- Ace Seam: has a median pH of 5.9 and a median EC of 940 µS/cm.
- King Seam: has a median pH of 6.2 and a median EC of 1,862 µS/cm.
- Queen Seam: has a median pH of 6.9 and median EC of 2,190 µS/cm.

There is no evident relationship between the EC and the CRD (**Figure 21** to **Figure 26**). The water type is dominantly Na-Cl, except for GW59B (Na-Mg-SO_4), GW45_s and GW46_s (Na-Mg-Cl) (**Figure 27**).

Elevated EC (when compared with other bores in the same seam) have been recorded at GW44s, GW44d (over 2 kilometres from mining operations on the southeast Mining Lease limit) and GW55d (nearby RD26B). The Mann-Kendal analysis detected several decreasing trends at bores GW56Bd, GW45s, GW58d, GW60 which are all located greater than 500m to the southeast from mining operations, GW55d adjacent to K2N tailings storage facility and GW56d; and an upward trend at bore GW05 (**Appendix A**).

Bore GW55d adjacent to K2W tailings storage facility recorded one occurrence of pH below 5.0. A downward trend in pH was detected at bores GW56Bd, GW45s, GW05 and GW55d (**Appendix A**).

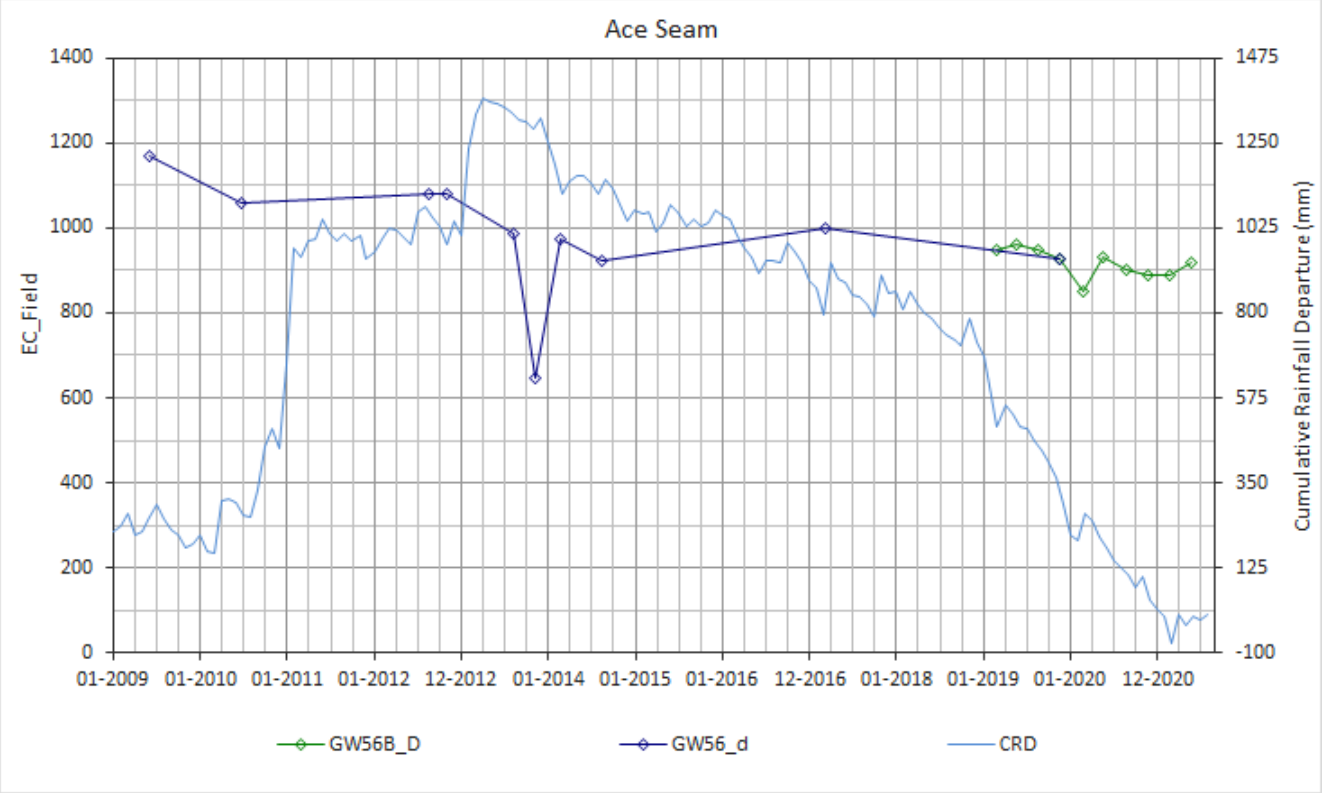

Figure 21 Field EC (µS/cm) Measured in The Ace Seam

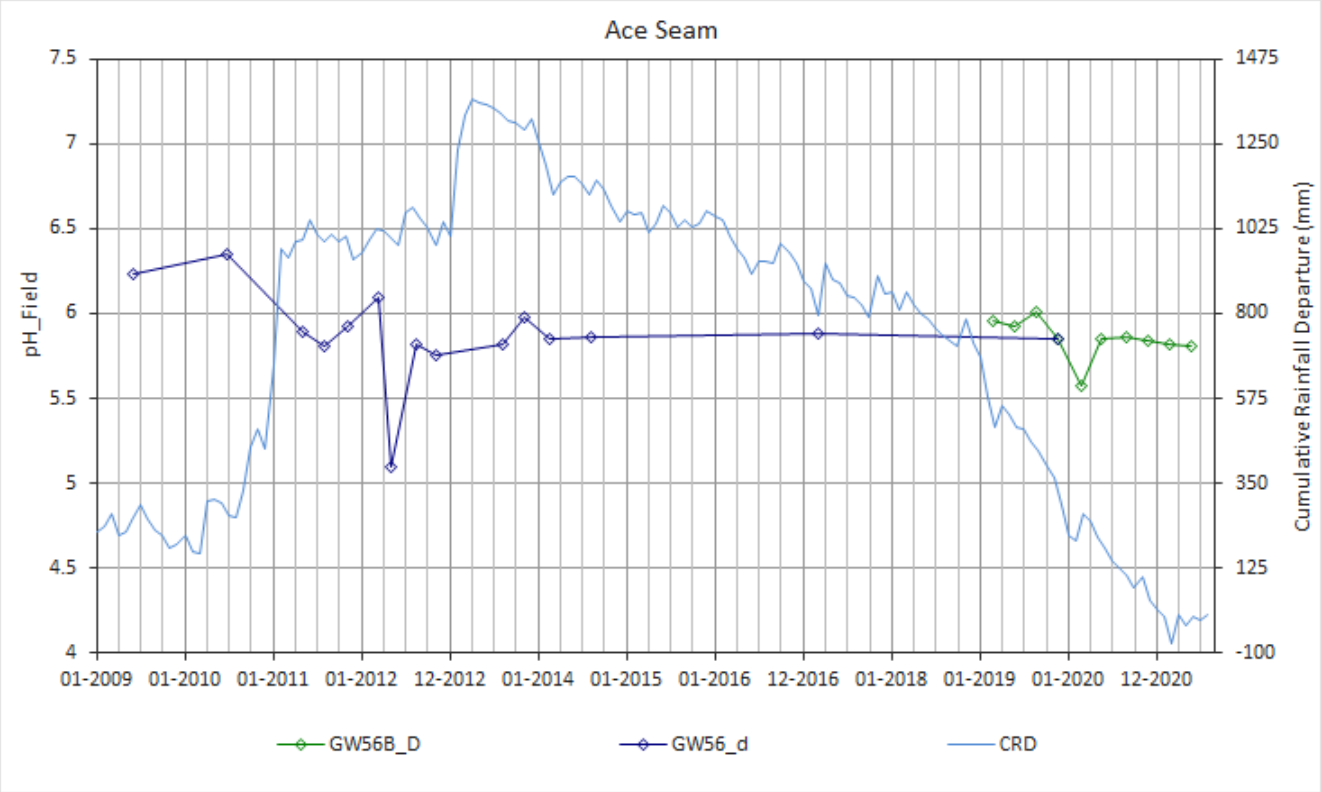

Figure 22 Field pH Measured in The Ace Seam

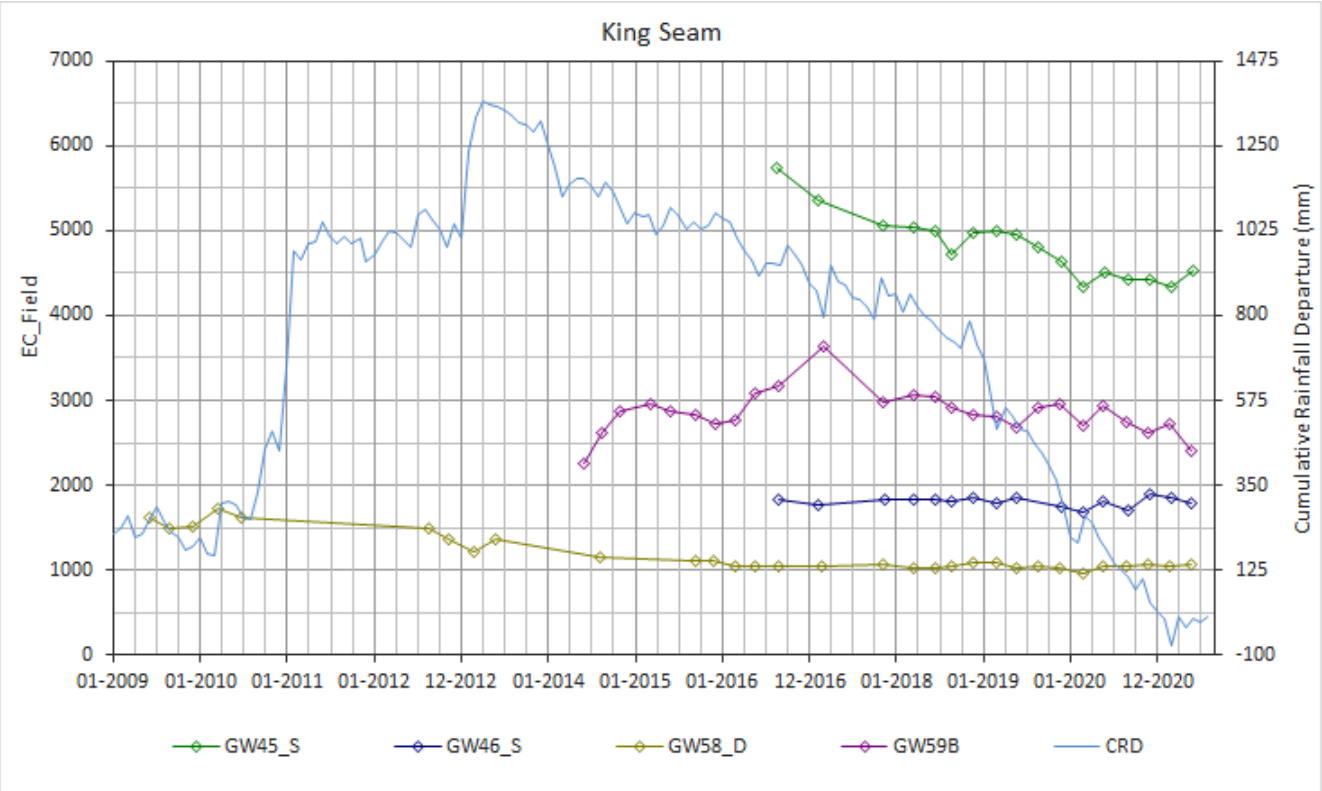

Figure 23 Field EC (µS/cm) Measured in The King Seam

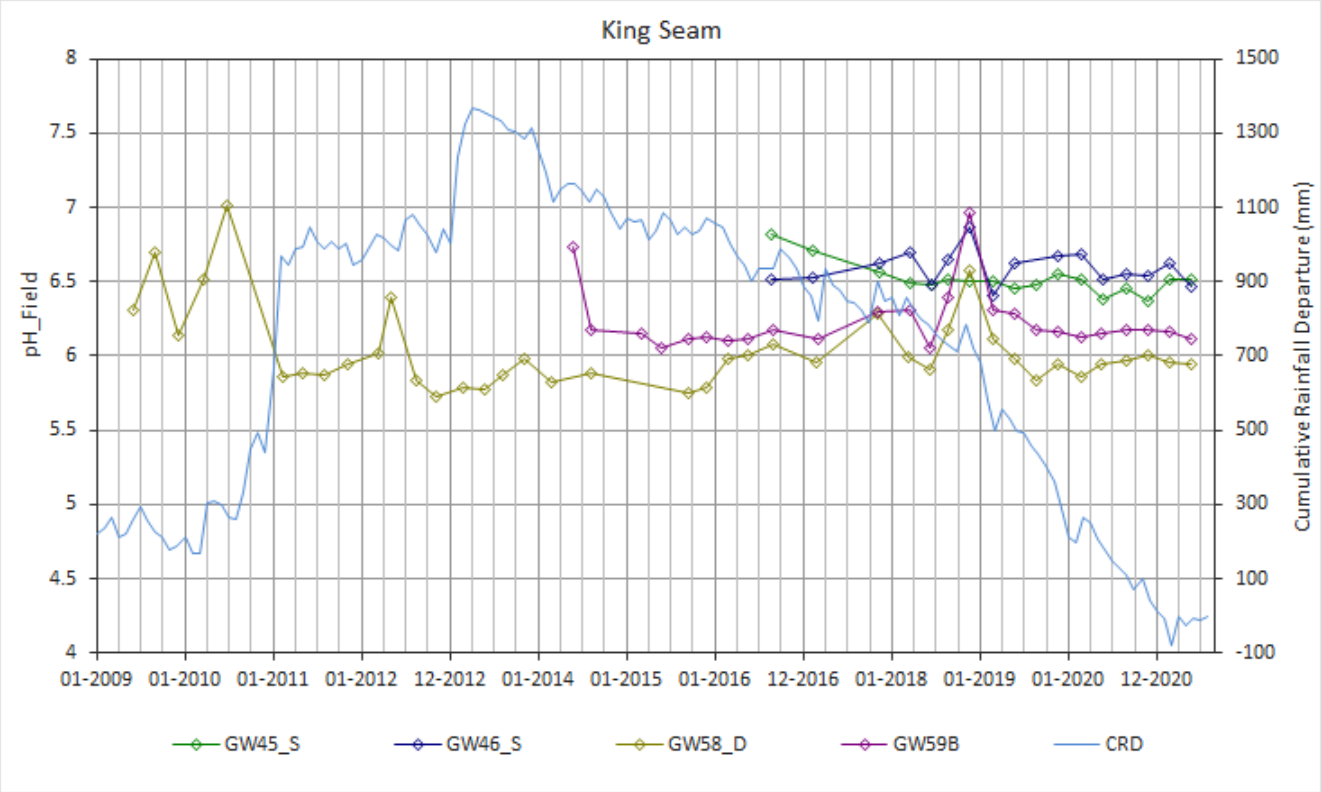

Figure 24 Field pH Measured in The King Seam

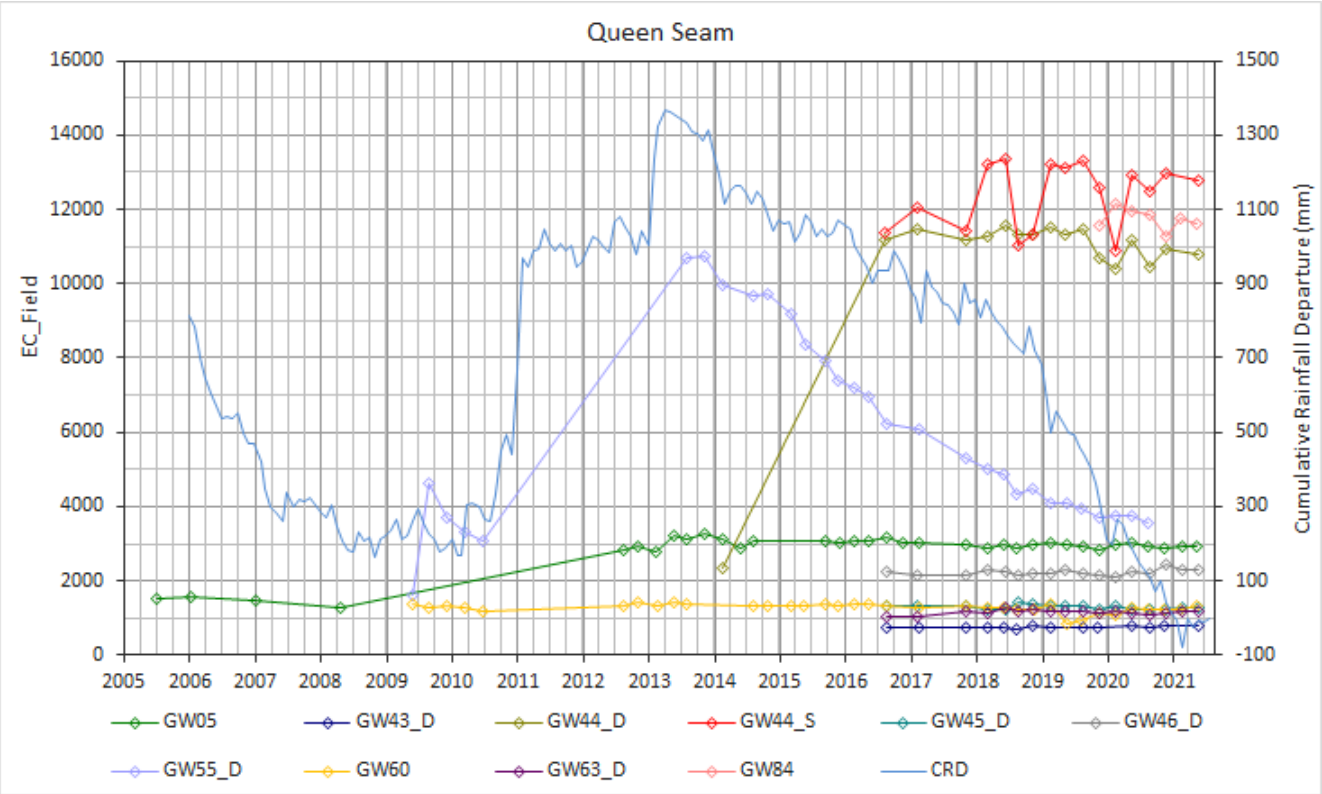

Figure 25 Field EC (µS/cm) Measured in The Queen Seam

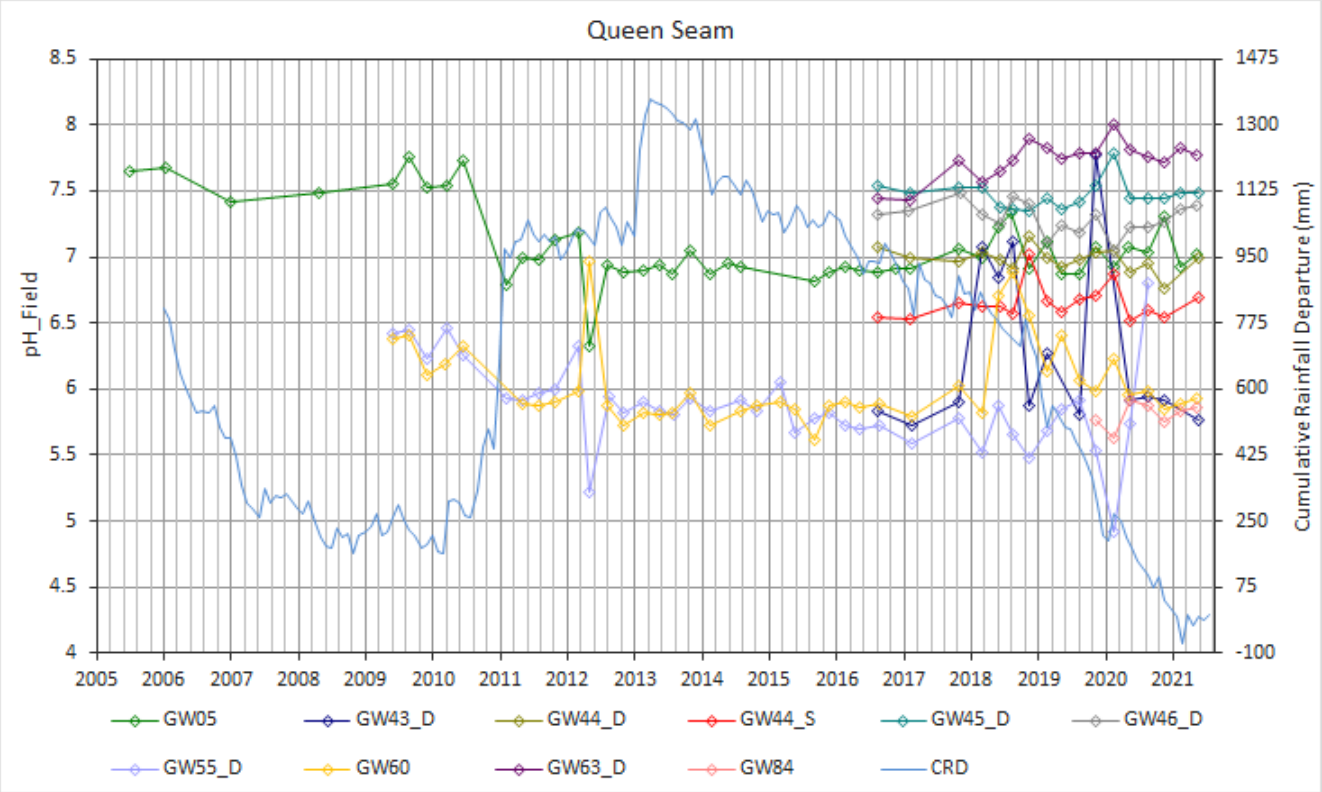

Figure 26 Field pH Measured in The Queen Seam

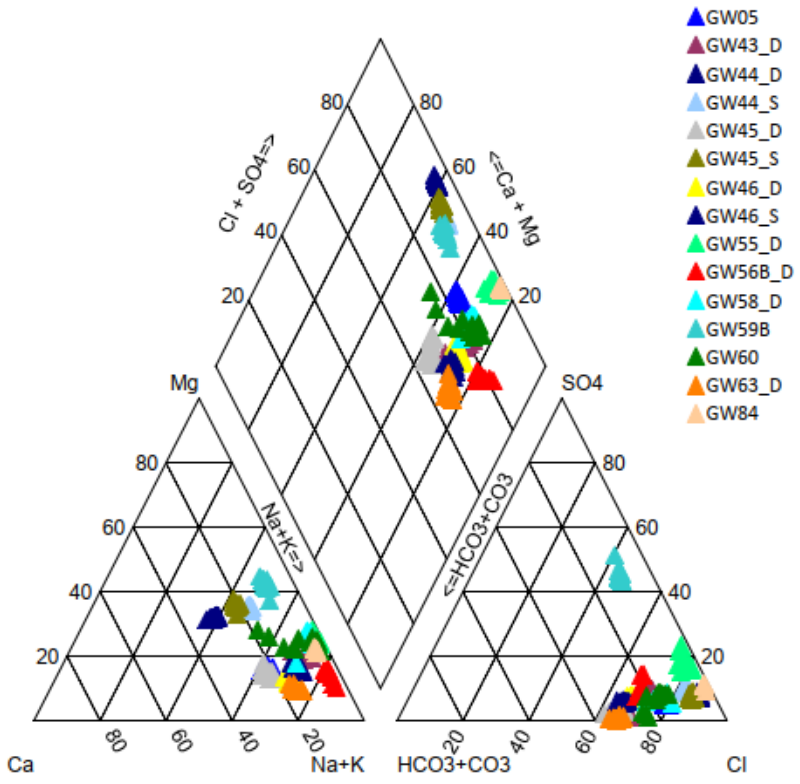

Figure 27 Piper Diagram Tarong Beds – Coal

4.3.1.5.2 Coal Measures Below Queen Seam

Groundwater monitoring results for the coal measures below the Queen seam have a median pH of 6.1 and a median EC of 2,951 µS/cm).

There is no evident relationship between the EC and the CRD (**Figure 28** and **Figure 29**). The water type is dominantly Na-Cl (**Figure 30**).

Elevated EC (when compared with other bores in the same seam) have been recorded at GW94. The Mann-Kendal analysis detected one decreasing trends at bore GW02 (adjacent to Meandu Creek and to the northwest of NWBV) and upward trends at bores GW09 and GW22 (the latter to the west of Meandu Creek and at the periphery of the surface rights area) (**Appendix A**).

Bore GW87d and GW09 both recorded one occurrence of pH below 5.0. A downward trend in pH has been detected at bore GW09 (**Appendix A**).

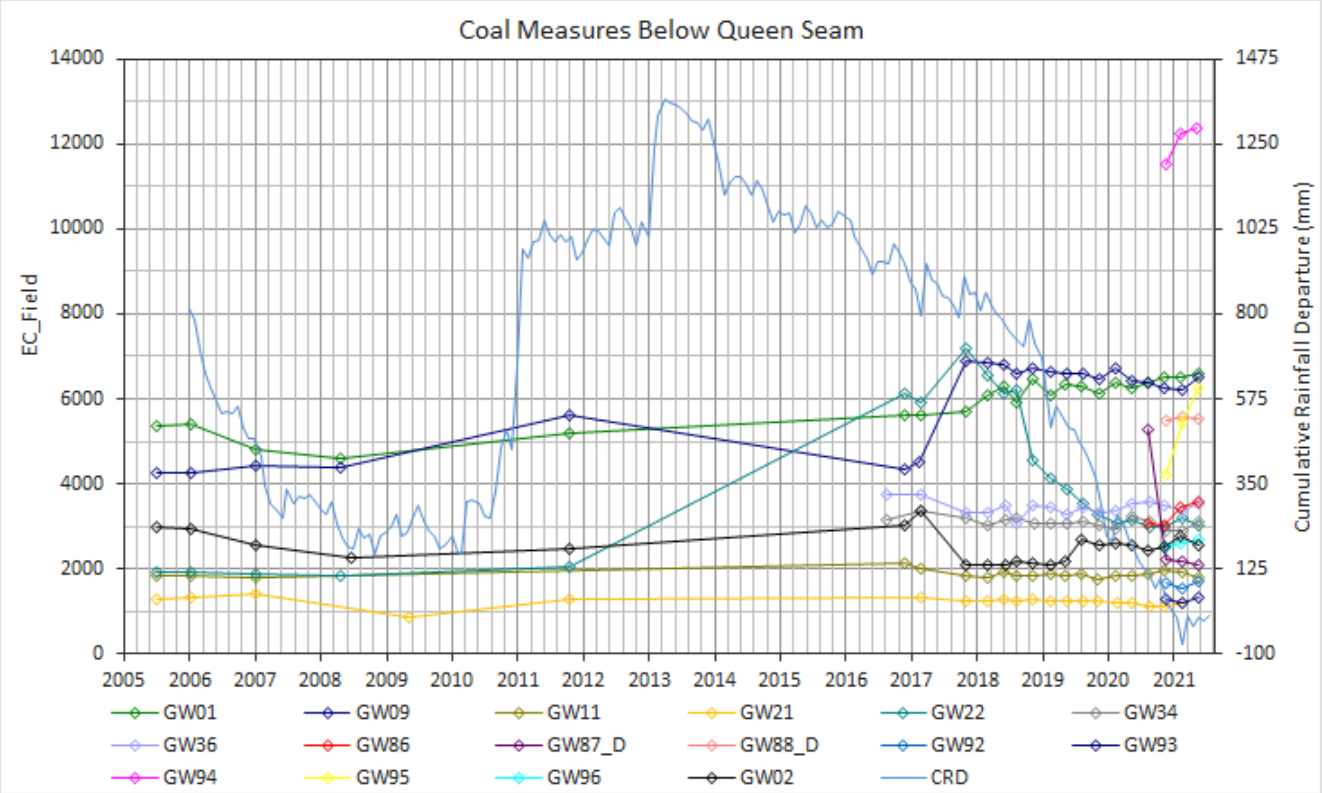

Figure 28 Field EC (µS/cm) Measured in The Coal Measures Below Queen Seam

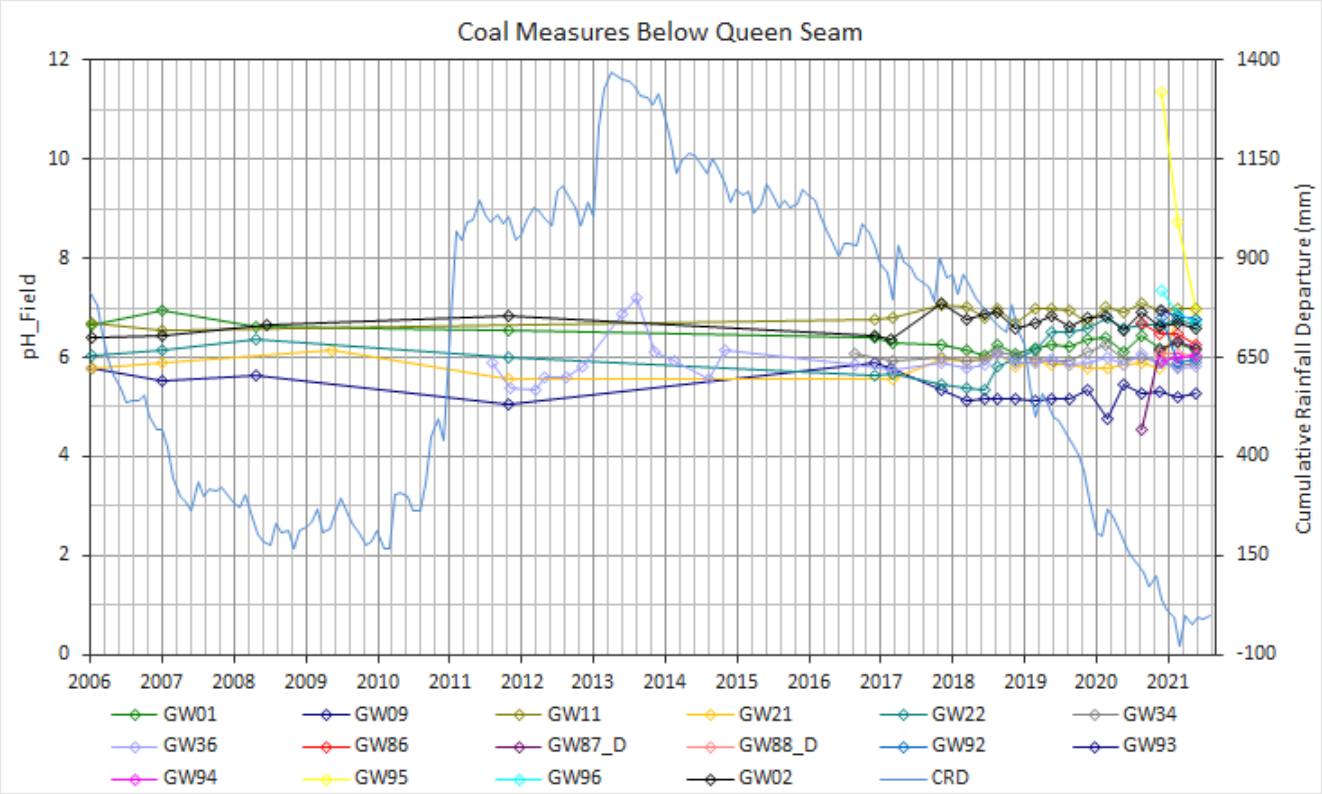

Figure 29 Field pH Measured in The Coal Measures Below Queen Seam

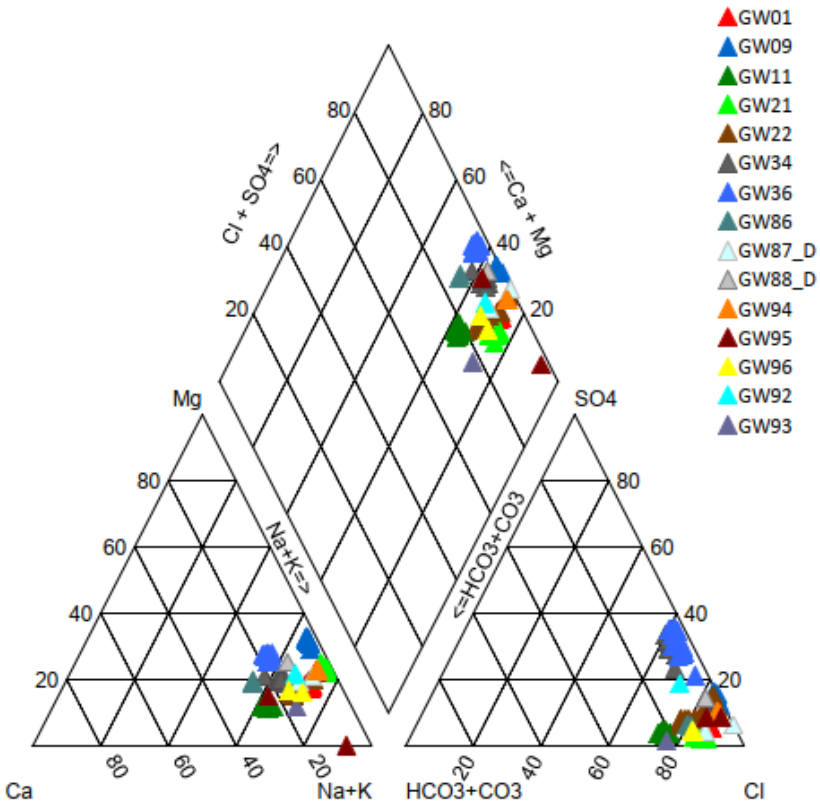

Figure 30 Piper Diagram Tarong Beds – Coal Measures Below Queen Seam

4.3.1.6 Maronghi Creek Beds

Groundwater monitoring results for the two bores screened within the Devonian-Carboniferous Maronghi Creek Beds indicate a neutral pH (median pH of 7.2) and average EC of (3,340 µS/cm) indicating groundwater quality is moderately brackish (**Figure 31** and **Figure 32**). GW65 (located some 1500m to the east of mining operations at K2E and outside of the surface rights area) may be responding to the lack of rainfall recharge as indicated by the overall EC increase correlated with the CRD decrease (**Figure 31**). The dominant water type in Na-Cl (**Figure 33**).

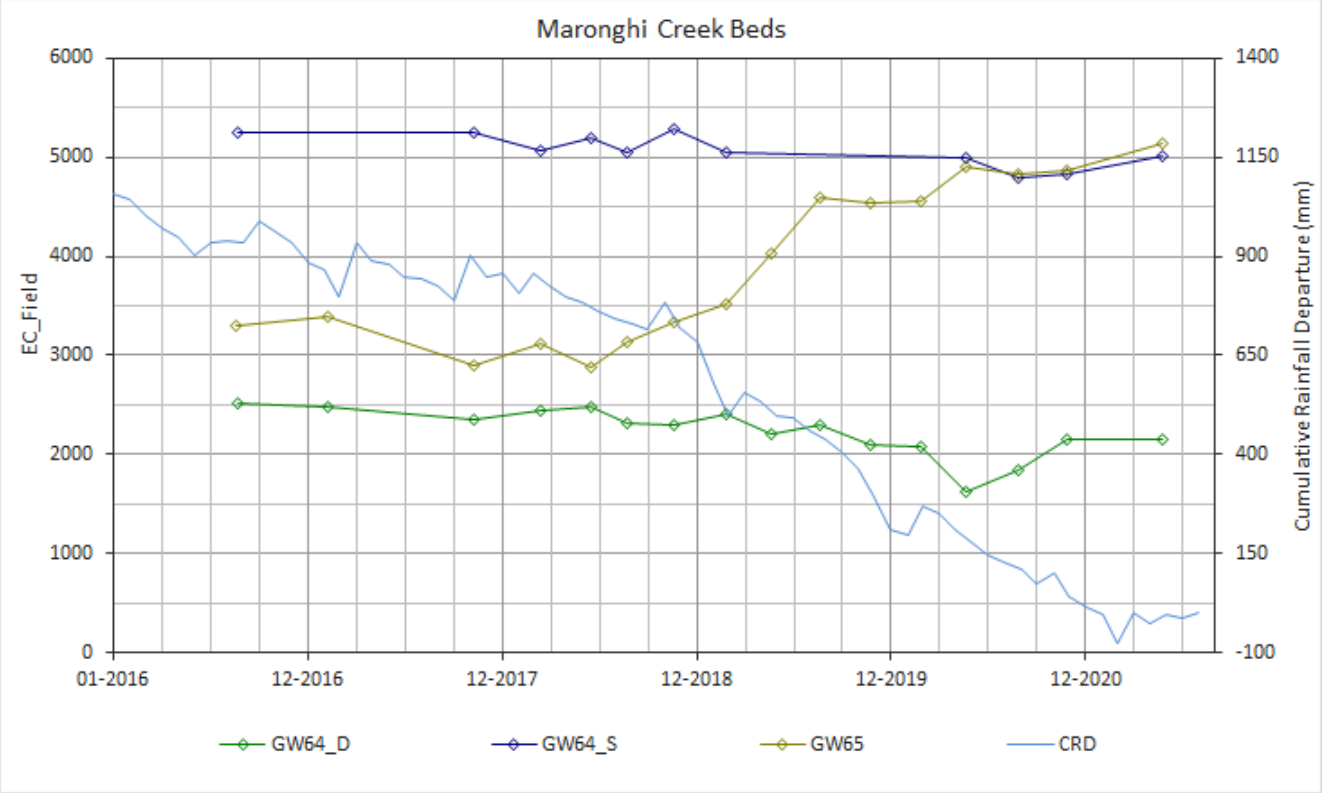

Figure 31 Field EC (µS/cm) Measured in the Maronghi Creek Bed

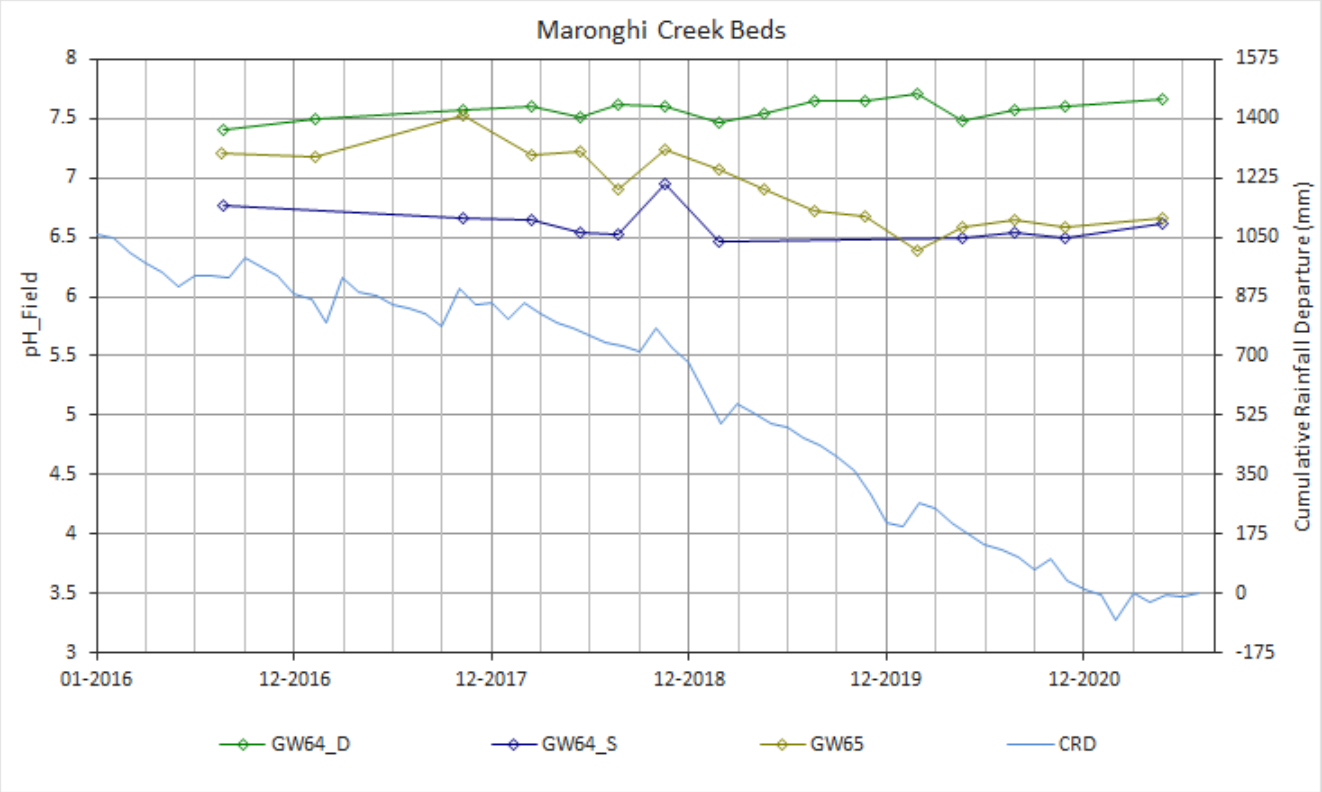

Figure 32 Field pH Measured in the Maronghi Creek Bed

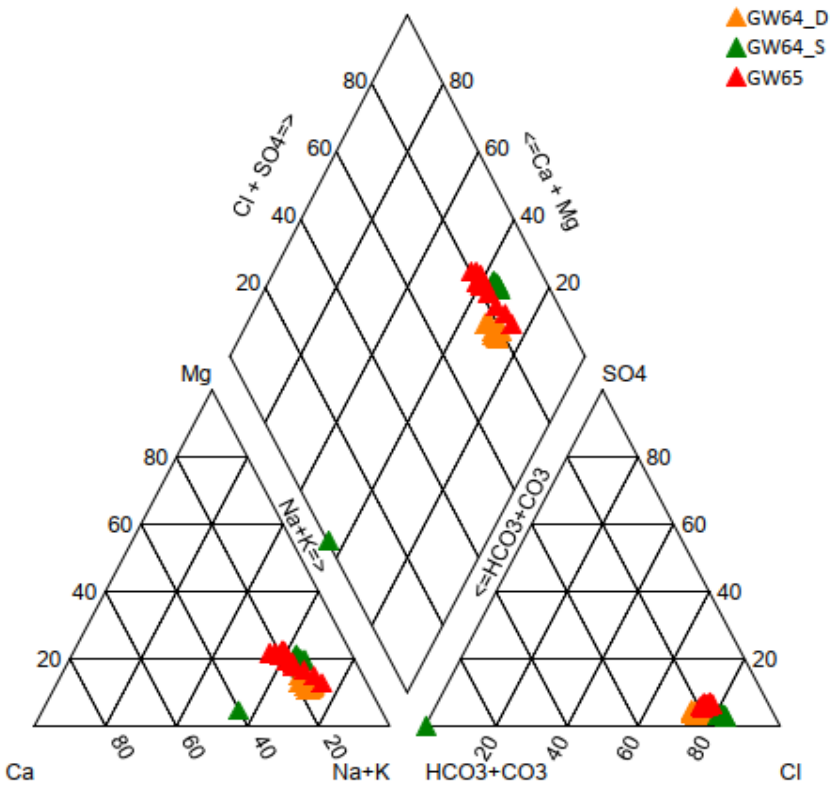

Figure 33 Piper Diagram - Maronghi Creek Beds

4.3.2 Metals & Metalloids

A statistical summary of baseline data for dissolved metals/metalloids is shown in **Table 9**. Baseline data is defined here as non-impacted by mining. The bores assessed as not impacted by mining (control and background bores) in WSP (2018) and Stanwell (2020b) have been selected as representative of baseline data.

Overall, the data show that median dissolved metal/metalloid concentration is generally below the LOR in the coal measures and alluvium. Analytes with concentrations above the LOR are barium, manganese, boron and iron, however concentrations are relatively low with median values being below health related drinking water guidelines (NHMRC, NRMMC (2011)) except for manganese in the Coal Measures Below Queen Seam. It is noted that the baseline data is based on a limited number of locations (especially for the alluvium and coal measures below Queen Seam) and cannot be interpreted as representative of the pre-mining water quality in all water bearing zones of the same geological unit.

Combined site data (i.e. for all bores) is presented as a summary statistics for each bore (**Appendix A**) and aquifer (**Appendix B**). Time series for each bore are presented in **Appendix C**.

4.3.2.1 Water quality trends

A trend analysis was conducted for all bores and analytes using the Mann-Kendal test (**Appendix A**). A summary of the upward trend in dissolved metals/metalloids is provided in **Table 10**. Metals/metalloids indicative of AMD or Ash seepage (as per WSP, 2018) are highlighted in grey and blue respectively in the **Table 10**.

Bores that have been assessed as impacted by AMD and/or Ash seepage are discussed in **Section 4.3.3**.

Table 10 Summary of Bores with Upward Trend in Dissolved metals

Dissolved Metal	Detected Upward Trend in Bore (Mann-Kendal test)
Aluminium	GW37, GW46_D, GW63_D, GW71
Antimony	GW42
Arsenic	GW21, GW42, GW49, GW70, GW71
Barium	GW22, GW38, GW48, GW56B_D, GW63_D, GW70, GW71, GW73, GW78
Beryllium	GW37
Boron	GW46_D, GW55_D
Cadmium	GW71, GW73
Chromium	GW71
Cobalt	GW36, GW37, GW48, GW56B_D, GW71, GW76
Iron	GW34, GW44_D, GW44_S, GW45_S, GW46_D, GW48, GW61_S, GW64_D, GW65, GW71, GW84
Lead	GW37, GW70, GW76, GW82
Manganese	GW05, GW21, GW34, GW43_S, GW44_D, GW44_S, GW45_D, GW45_S, GW46_D, GW46_S, GW48, GW61_S, GW65, GW71
Mercury	GW70
Molybdenum	GW60, GW64_D
Nickel	GW02, GW05, GW21, GW30, GW36, GW37, GW39, GW41, GW43_D, GW43_S, GW44_D, GW44_S, GW45_S, GW46_D, GW46_S, GW48, GW56B_D, GW58_D, GW59B, GW60, GW61_D, GW64_D, GW68, GW71, GW73, GW76, GW78
Selenium	No trend detected

Dissolved Metal	Detected Upward Trend in Bore (Mann-Kendal test)	
Vanadium	GW71	
Zinc	, GW02, GW05, GW30, GW36, GW37, GW39, GW40, GW42, GW43_D, GW43_S, GW44_D, GW44_S, GW45_S, GW46_D, GW46_S, GW48, GW61_D, GW63_D, GW71, GW73, GW74, GW78	
KEY		AMD Indicator
		Ash Seepage indicator

4.3.3 Current Mine Affected Groundwater

4.3.3.1 NWBV Seepage

An area of seepage expression downgradient of the NWBV was characterised as impacted by AMD in 2018 by WSP (2018). The NWBV is located within the Hitachi Hill dump. The Hitachi Hill dump was progressively formed over several legacy mine features including the North West Pit, which was used to store tailings (the NWA TSF) and backfilled with spoil and rejects. The NWB TSF is located up-gradient of the NWA TSF and was used for tailings deposition after the NWA TSF. The NWB TSF is currently undergoing decommissioning with an initial 2m capping layer being progressively emplaced from north to south.

A review of groundwater quality in the bores up-gradient of the surface expression area and surrounding Hitachi Hill is shown in **Table 11**. Bores inferred as being impacted by AMD are highlighted in grey. AMD impacted bores are inferred based on elevated (i.e. when compared to background) concentration of AMD indicators such as sulfate, EC, pH and metals/metalloids (shaded grey on **Table 10**) as discussed in **Table 11**.

Table 11 NWBV Seepage – AMD Characterisation

Bore	Aquifer	Location	Comments (Updated from JBT, 2021a)
GW48	Spoil	NWBV seepage	This dewatering bore was installed in 2019 to pump out seepage from the NWBV area and has the following water quality trends: _The EC has increased over time to reaching ~3,800 µS/cm in 2020. _ All metals indicative of AMD (refer to **Table 10**) display an upward trend as determined by the Mann-Kendal test. Manganese, nickel and zinc show clear lineal increasing trends (**Appendix A**).
GW49	Spoil	NWB seepage	This dewatering bore was installed in 2019 to pump out seepage from the NWBV area and has the following water quality trends: _ The EC has fluctuated though rose from <3,000 µS/cm in 2019 to ~3,800 µS/cm in in 2020. _Sulfate concentration ranges from 444 to 936 mg/L. _No upward trend in in AMD metals/metalloids.
GW75	Spoil	Western area of NWBV, within rehabilitated spoil	This site does not show increasing concentrations of dissolved metals indicative of AMD or Ash seepage. The EC at this site is relatively low (~3,500 µS/cm). However, the sulfate concentration is relatively high (>800 mg/L) as is the concentration of AMD indicator parameters including dissolved cobalt, iron, manganese, nickel and zinc.
GW76	Spoil	Western area of NWBV, within rehabilitated spoil	The EC at this site is relatively low (<2,000 µS/cm) and the sulfate concentration is also relatively low (<100mg/L). The concentration of some AMD indicator parameters is relatively high (e.g. iron and manganese). The bore is located within the zone of interpreted seepage from the NWBV and the presence of AMD is tentatively inferred at this stage, based mainly on the concentration of AMD indicator parameters such as iron and manganese.

Bore	Aquifer	Location	Comments (Updated from JBT, 2021a)
GW25	Regolith	Western side of NW spoil dump, east of Meandu Creek	This site is interpreted to be impacted by seepage from the NWBV, however several indicators of AMD impact have been reducing in concentration between 2016 and November 2020, based on the following water quality trends: _ EC rose from <1,000 µS/cm in 1999 to > 2,000 µS/cm in August 2016, though the trend since that time has been a generally decreasing EC, with 1,120 µS/cm recorded in November 2020; _ Sulfate rose from <100 mg/L in 1999 to > 450 mg/L in August 2016, but has shown a decreasing trend since that time, with a concentration of 152 mg/L recorded in May 2021; and, _ Dissolved manganese is elevated at this site relative to other bores in the area; however, the site is displaying a decreasing trend from >15 mg/L in 2016 to 1.08 mg/L in May 2021.
GW38	Regolith	Adjacent to Meandu Creek, upstream of RD7	This site is interpreted to be impacted by seepage from the NWBV, however a number of indicators of AMD impact have been reducing in concentration between 2016 and November 2020, based on the following water quality trends: _The EC level increased from ~3,000 µS/cm in 2011 to > 5,000 µS/cm in 2016, though the trend since that time has been for a reducing EC, with 2,110 µS/cm recorded in November 2020. _ The concentration of dissolved nickel increased from <0.004 mg/L in 2011 to ~0.02 mg/L in 2016 but has reduced to 0.007 mg/L in November 2020. _ The concentration of dissolved zinc increased from ~0.02 mg/L in 2011 to >0.1 mg/L in 2016 but has reduced again to 0.025 mg/L in November 2020. _The sulfate concentration has decreased from 326 mg/L in May 2015 and has been consistently below 50 mg/L since March 2018.
GW34	Coal Measures Below Queen Seam	Western haul road, upgradient of Bullgang Drain	It is interpreted that this site is potentially impacted by seepage from NW spoil dump based on water quality data, though data is inconclusive. It is noted that: _ Sulfate concentration is relatively high, generally >400 mg/L _ The dissolved iron concentration is sporadic at this site, though the concentration tends to be >20 mg/L.
GW36	Coal Measures Below Queen Seam	West of NW spoil dump, Down-gradient of Ramp 4 hydrocarbon dump, East of RD10	It is interpreted that this site is impacted by AMD based on water quality indicators. It is noted that: _ The sulfate concentration has increased from < 50 mg/L in 2011 to 612 mg/L in November 2020 and May 2021. _ The dissolved iron concentration is generally >70 mg/L _ The dissolved manganese concentration is within the range of 2.1 to 3.6 mg/L.

Assessment of bore water quality in the area within and around Hitachi Hill indicates that the AMD seepage appear to be limited to an area north and northwest of the NWBV, on the eastern side of Meandu Creek. Preferential pathways appear to be associated with pre-mining drainage channels. The EE conducted by WSP (2018) states that "*The North-West Backfilled Pit is the only known mine domain currently seeping AMD. Groundwater flow to the west of Meandu Creek is assessed to be unlikely*."

The area affected by seepage expressions and preferential pathways are show on **Figure 34**. Since late 2021 the amount seepage been significantly reduced as a result of groundwater dewatering from NWBV and ongoing water quality analyses from the dewatering bores shows continual improvement (e.g. pH 5.5 to 6.8 and SO_4^{2-} in the range of ~ 800 mg/L).

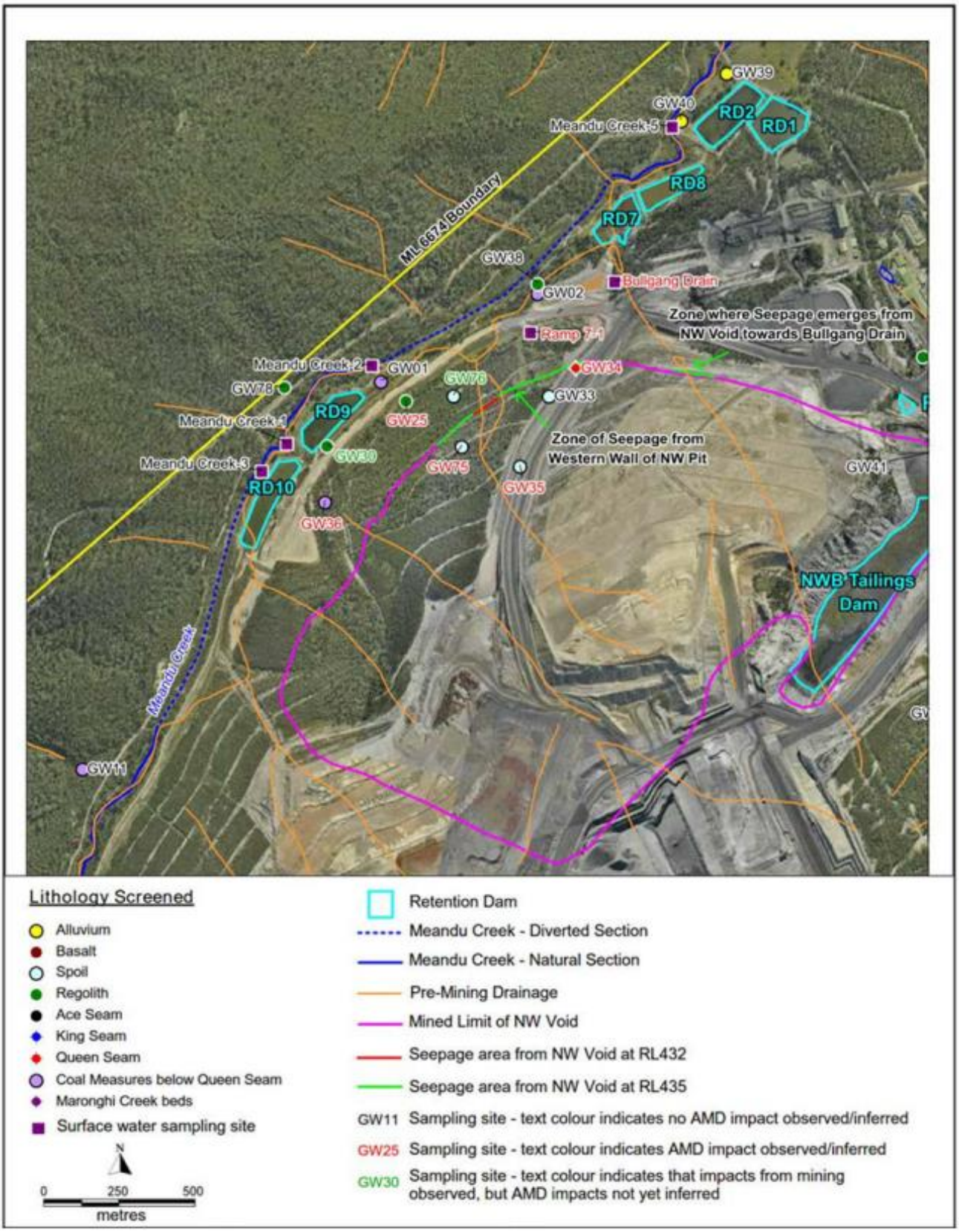

Figure 34 AMD Impacted Sites and Seepage Areas (WSP, 2018)

4.3.3.2 Queen West Backfilled Void (QWBV) Saline Plume

Water quality investigations for the EE (WSP, 2018) identified the presence of a salinity plume extending from the QWBV (located in the centre of the site) towards Meandu Creek to the north. The significantly lower EC of the QWBV sump water indicates that this is not the source of the salinity in the area. A review of the lithological data for impacted groundwater monitoring bores in the area indicates that the plume is relatively confined to shallow regolith material (**Table 12**). Bore locations are shown on **Figure 40**.

Table 12 QWBV Saline Plume Characterisation – Potentially Impacted Bores

Bore	Aquifer	Location	Comments (Updated from JBT, 2021a)
GW41	Spoil	Down-gradient of Tailings Storage area	This bore is located adjacent to the NWB tailings storage facility which at January 2022 is in process of having an initial 2m capping layer installed over the northern area. This site is assessed to be within the high EC plume that is downgradient of the QWBV. It is noted that at this bore: _ The EC is elevated (> 12,000µS/cm) _ The sulfate concentration is generally > 600mg/L _ Dissolved iron concentration is generally > 10mg/L
GW68	Regolith	Down-gradient of QW void	This bore is located adjacent to the north of RD3A and RD3B and ~300m to the east of NWB tailings storage facility. The EC at this bore is consistently >12,000µS/cm, with a sulfate concentration >600mg/L. This bore is located within the high EC plume that is interpreted to be emanating from the area of the QW spoil dump/K2W void.
GW69	Regolith	Down-gradient of QW void	This bore is located ~350m north of GW41 and the NWB tailings storage facility. It is further down-gradient than bore GW68 and GW41 (discussed above). The EC at this bore is consistently >11,000µS/cm, with a sulfate concentration ~600 mg/L. This bore is located within the high EC plume that is interpreted to be emanating from the area of the QW spoil dump/ K2W void.
GW80	Regolith	Downgradient of King 2 West North (K2WN) Embankment	This bore is located adjacent to the southeast of RD3A. It shows elevated concentrations of sulfate compared to baseline data in all other units (range 611 to 763 mg/L), iron (>100 mg/L) and manganese (>5 mg/L).
GW81	Regolith	Adjacent RD3	This bore is located between the rehabilitated RD16 tailings storage facility and RD3A. It shows elevated concentrations of EC compared to baseline data in all other units (>10,000µS/cm) and sulfate (866mg/L in May 2021), but has relatively low concentrations in AMD indicator metals such as cobalt, iron, manganese, nickel and zinc.
GW82	Regolith	Southern end of QW Sump	This bore is located adjacent and to the west of the rehabilitated RD16 tailings storage facility. Groundwater at this site is elevated with respect to the following parameters: _ EC (range from 25,900 to 28,100µS/cm), noting that the EC range in the QW sump is generally <6,000µS/cm) _ Sulfate (range from 1,320 to 1,600mg/L) _ Dissolved cobalt (range from 0.57 to 0.74mg/L) _ Dissolved manganese (range from 29.6 to 37.4mg/L) _ Dissolved nickel (range from 0.36 to 0.51mg/L) _ Dissolved zinc (range from 4.13 to 5.55mg/L)
GW85D	Regolith	Below K2WN Embankment	This bore is located downgradient of the K2WN embankment and adjacent to the rehabilitated RD16 tailings storage facility (capping completed April 2020). Water quality observations of note include: _ The EC at this site is elevated (>10,000µS/cm). _ Sulfate concentration rose from 692 to 900mg/L between November 2020 and May 2021. _ Dissolved iron concentration rose from 0.26 to 10.6mg/L between November 2020 and May 2021.

Bore	Aquifer	Location	Comments (Updated from JBT, 2021a)
GW53	Regolith	Between K2W and K2N voids	Water quality at this site is indicative of seepage from the K2W ash storage, as the bore was dry prior to the water level within the ash rising above the base of the bore (the site is located within the K2W ash facility, within natural ground between the K2W void and the K2N void). _ The EC at this site has reduced from >8,000µS/cm in November 2014 to 4,690 µS/cm in November 2020. The high initial EC may have been related to the soil salinity as the sediments became initially saturated, with the more recent EC values reflecting the EC of the seepage water; _ The sulfate concentration has increased from ~500mg/L in November 2014 to 872mg/L in November 2020; _ GW53 records concentrations of the ash indicator parameters selenium and vanadium at concentrations that are above the Limit of reporting (LOR). _ GW53 is the only ash monitoring bore to record concentrations of selenium and vanadium above the LOR, which is taken to be indicative of seepage from the K2WN ash storage to this site. As noted above, GW53 is located on the ash dam side of the raised K2W/K2N embankment and the emergence of seepage at this site is not unexpected.
GW84	Queen Seam	Downgradient of K2WN Embankment	This site is located adjacent and to the north of RD3A. Groundwater at this site is elevated with respect to the following parameters: _ EC (range 11,270 to 12,157µS/cm) _ Sulfate (range 584 to 678mg/L) _ Dissolved iron (range from 13.9 to 21.5mg/L) _ Dissolved manganese (range from 3.08 to 3.99mg/L)
GW09	Coal Measures Below Queen Sean	Unmined area between QW dump and Tailings void	The EC at GW09 increased significantly between July 2003 and January 2005, from ~1,700µS/cm to ~4,300µS/cm. The rise in EC corresponded to a period when the water level decreased from ~456mAHD to ~449mAHD between January 2003 and January 2005 (7m water level decrease over a period of approximately 2 years). From review of historic aerial photos, it is evident that the period between July 2003 and January 2005 corresponded with the development of both the QWBV and the NWB pit. Therefore, it is likely that the reduction in water level is related to mining of either or both of the QWBV and NWB pit. GW09 is screened from 31.3 to 44. m below ground level in sandstone interburden below the Queen Seam and it is possible that the increase in EC is related to downward seepage of higher EC groundwater from overlying units as the water level in the coal seams and interburden units decreased due to mining.
GW94	Coal Measures Below Queen Sean	Downgradient of QW void and upgradient of Meandu Creek	The EC for the first sample was 11,527µS/cm and: _ Sulfate concentration rose from 615 to 647mg/L from November 2020 to May 2021 _ Dissolved iron rose from 10.3 to 11.9mg/L from November 2020 to May 2021 _ Dissolved manganese rose from 3.28 to 3.56mg/L from November 2020 to May 2021.

The area of elevated salinity is present in the vicinity of GW82 (adjacent to rehabilitated RD16 tailings storage facility) in the south of the site, with values generally decreasing down hydraulic gradient to the north. EC is variable within the plume. **Figure 35** shows a simplistic bore fence line showing EC concentration variations between data collected in February 2020 and May 2021 from the regolith bores shown. An arrow above each bore indicate if the concentration has increased (upward) or decreased (downward) during the recording period. **Figure 36** is an aerial map showing the locations of these bores.

The fence line figure shows that maximum EC of 28,470 µS/cm was observed at GW82 (adjacent to the rehabilitated RD16 tailings storage facility and in the vicinity of the QW void sump) in May 2021 in the north of the area. From this point concentrations generally decline along the groundwater flow path to 5,310 µS/cm (GW37 – May 2021). Alluvium bore GW40 has been included at the end of the cross section to represent concentrations at the potential discharge point of the plume. Bore GW53 has been decommissioned and no data was available for May 2021. However as indicated in **Table 12**, water quality is indicative of seepage from the K2W ash storage (and may not be relevant to salinity plume assessment).

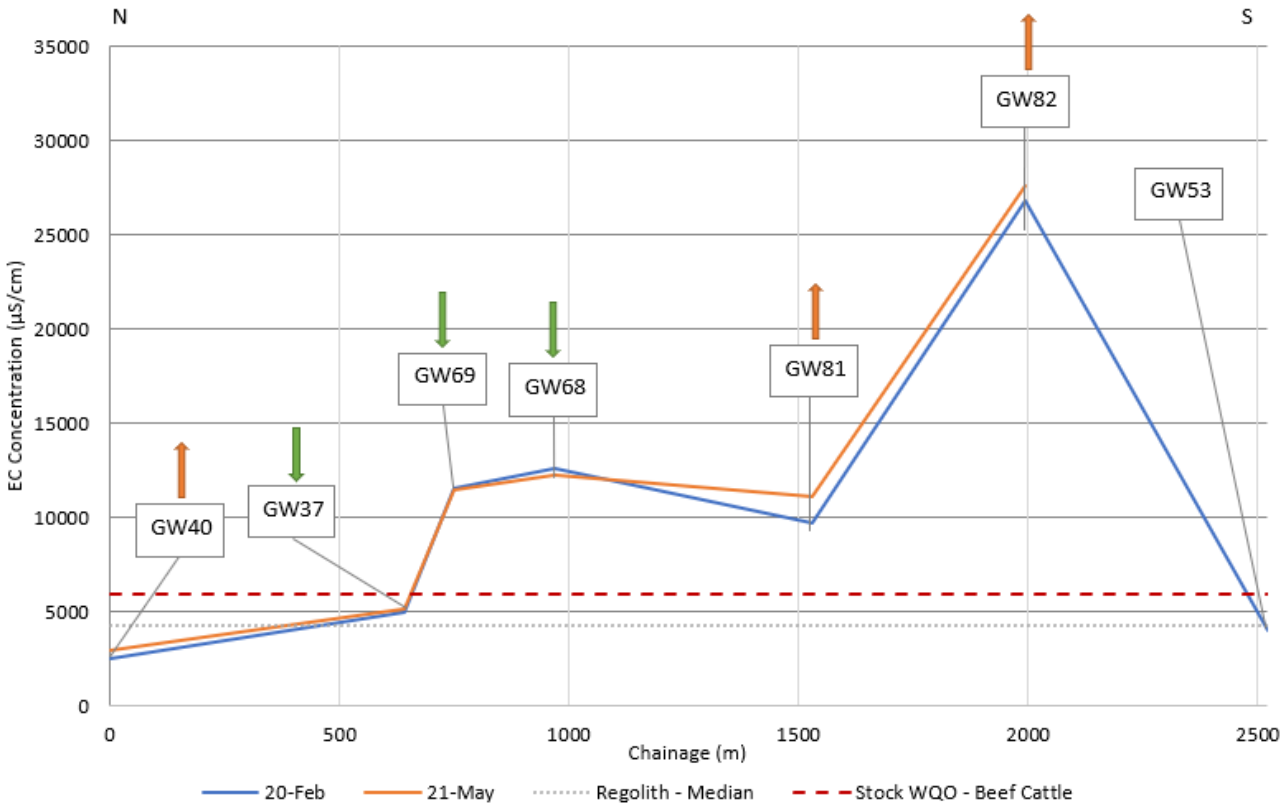

Figure 35 Fence Line with EC observations – Feb 2020 and May 2021

A Mann-Kendall trend analysis revealed that GW37 is the only regolith bores showing an increasing trend in EC over the recording history. The stability of the EC values indicate that the groundwater is relatively immobile. If groundwater was migrating down hydraulic gradient, increases in EC would generally be expected to be seen in the down hydraulic gradient bores.

Using a hydraulic gradient of 0.025 and based on an assumed porosity of 0.35 and an average hydraulic conductivity of 0.35m/d, SLR (2020) calculated the linear seepage velocity at 8.8m/year downgradient of QWBV. Considering that Meandu Creek is located approximately 1,600m down hydraulic gradient of the QW sump, in theory it would take 182 years for the elevated EC groundwater to reach the receptor. This indicates that the short-term potential risk to Meandu Creek from the plume is low.

The salinity plume extent was delineated by SLR (2020) based on the review of the historical water quality data, water level data and TEM airborne electromagnetics survey data (JBT Consulting, 2017). It should be noted that the delineation is approximate, as the extents are based on the spatial distribution of the available data. The interpreted plume extents are presented in **Figure 36**.

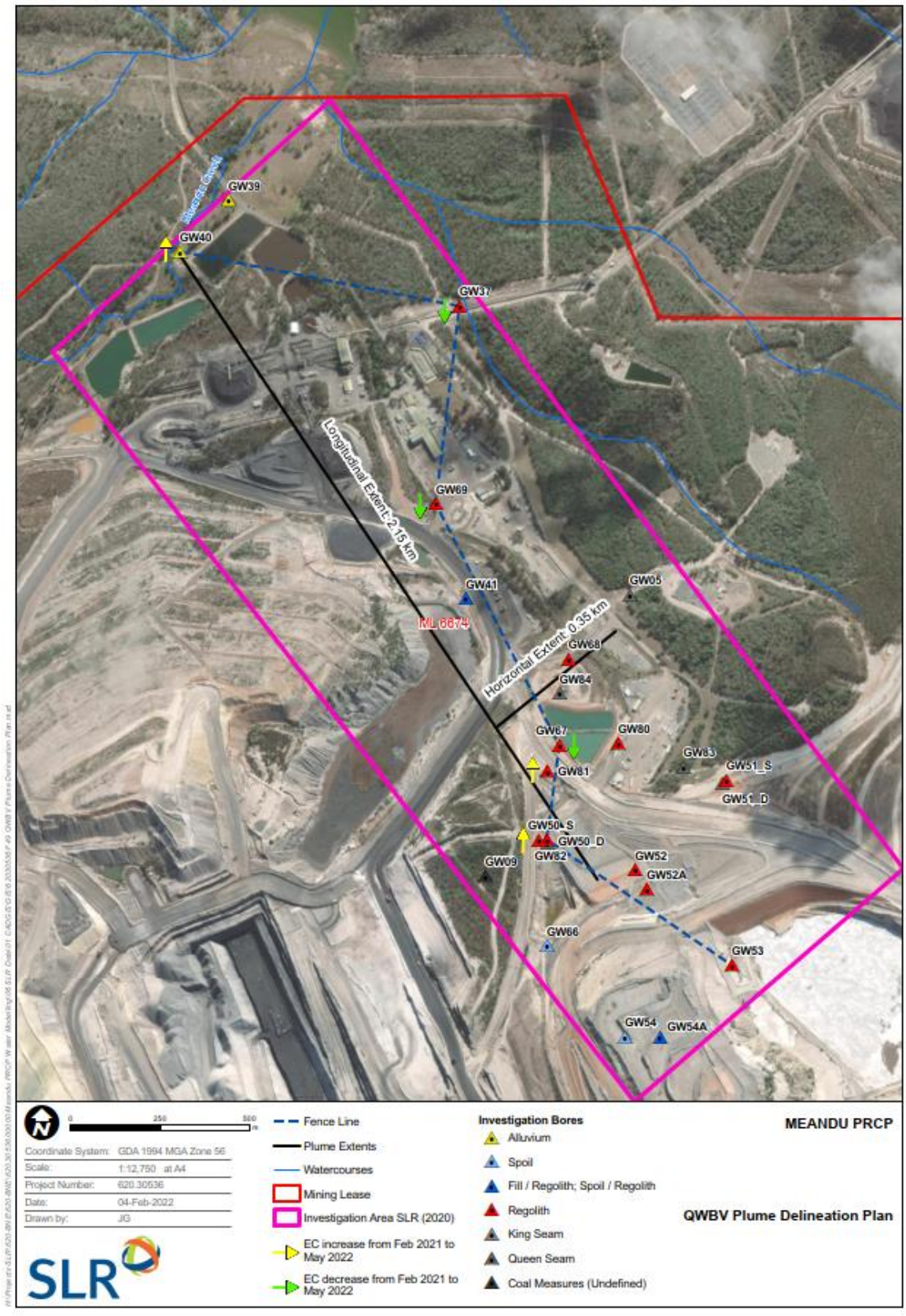

Figure 36 QWBV Plume Delineation Plan

4.3.3.3 K2E/RD17 Saline Plume

The K2E/RD17 saline plume was identified in an aerial (electromagnetic) geophysical survey undertaken as part of the EE investigations (WSP, 2018). The area identified comprises the spoil areas to the north of K2E Pit and bores within the Black Creek drainage channel (e.g. around bores GW61_s, GW61_d, GW73 and GW74).). A review of the lithological data for impacted groundwater monitoring bores in the area indicates that the plume is relatively confined to spoil and shallow regolith material (**Table 13**). The location of the bores is shown on **Figure 40**.

Table 13 K2E/RD17 Saline Plume Characterisation – Potentially Impacted Bores

Bore	Aquifer	Location	Comments (Updated from JBT, 2021a)
GW70	Spoil	Within K2E rehabilitated spoil	The EC in this bore is relatively high (>8,000 µS/cm), though the sulfate concentration is relatively low (~1 to 130 mg/L). Groundwater from this site records high concentrations of iron (>200 mg/L) as well as nickel and zinc, which are potential AMD indicator parameters.
GW71	Spoil	Within K2E rehabilitated spoil	GW71 is located up-gradient of GW70. This bore is at a depth of 35m and monitors at the interface of spoil and underlying clay. The EC at this site is relatively low (~3,500µS/cm) and the sulfate is also low (<200 mg/L). A notable feature at this site is that the pH is low (generally ~5.0) and the dissolved aluminium concentration is relatively high (>4 mg/L), which is interpreted to be related to dissolution of aluminium from the spoil due to the low pH. The site also regularly records dissolved vanadium at concentrations above the LOR, with all other groundwater bores (with the exception of GW53) generally recording concentrations that are below the LOR for this analyte. All metals associated with AMD are showing an upward trend at this bore.
GW72	Spoil	Within K2 tailings dump, overlain by K2E rehabilitated spoil	GW72 is screened within the K2 tailings storage area, which is overlain by K2E rehabilitated spoil. Observations of note include: _ The site records relatively low but consistent field EC (range 2,230 to 2,870 µS/cm); _ The bore has recorded a distinct reduction in sulfate concentration, from >500 mg/L between February 2017 and February 2019), reducing to 26 mg/L in November 2020; _ Over the same period, dissolved iron has reduced from a concentration generally >100 mg/L to 26.4 mg/L in November 2020.
GW73	Regolith	Black Creek catchment, down-gradient of GW61_s and GW61_d	The EC at this site is relatively high (>10,000 µS/cm) as is the sulfate concentration (>800mg/L). However, the site does record relatively low concentrations of AMD indicator metals/metalloids, e.g. cobalt, iron, manganese, nickel and zinc.
GW74	Regolith	Black Creek catchment, down-gradient of GW73	The EC at this site is relatively low (~3,500 µS/cm). However, the sulfate concentration is relatively high (>800 mg/L) as is the concentration of AMD indicator parameters including dissolved cobalt, iron, manganese, nickel and zinc.

Bores GW70, GW71 and GW72 are located within the rehabilitated K2E area (spoil) to the south and southwest of RD17A. This area includes the rehabilitated tailings storage facility (K2) which was operated as a valley fill tailings storage facility (TSF) from 1986 to 1995. Tailings were pumped via pipeline to the TSF from the CHPP. Investigations to date do not correlate the K2E/RD17 saline plume to AMD and the source of the plume has not yet been identified (WSP, 2018).

A Mann-Kendall trend analysis detected an upward trend in EC at bore GW71, located within the former K2E void at the northern periphery. In addition, GW71 display increasing trends in sulfate, cobalt, iron, manganese, nickel and zinc. Downward trends in EC have been detected for bores GW72 and GW74 located off the mining lease and to the north along Black Gully. This could suggest that the spoil area in the vicinity of GW71 is impacted by saline drainage. However, additional monitoring is required to better characterise the nature and extent of potential saline drainage and/or AMD within the K2E/RD7 area.

4.3.3.4 Metalliferous Drainage

Areas where metalliferous drainage may occur includes:

- A spoil area, central west of the mining area, adjacent to Meandu Creek diversion and monitored by GW42;
- A regolith area, in the northern area of the mine, down-gradient of workshop area and monitored by GW37; and
- Two areas adjacent to the K2W void tailings storage facility and/or K2N ash storage facility monitored by GW55-d and GW59B.

Groundwater quality related to potential metalliferous drainage in these bores is detailed in **Table 14**.

Table 14 Metalliferous Drainage Characterisation

Bore	Aquifer	Location	Comments (Updated from JBT, 2021a)
GW42	Spoil	Southwest area of mine, adjacent to Meandu Creek diversion	Groundwater at this site is assessed to be impacted by seepage generated from the spoil aquifer to the south of the bore, based on the following water quality parameters: _ The dissolved iron concentration is elevated, generally >15mg/L _ The dissolved manganese concentration is relatively consistent at >4mg/L
GW55_d	Queen Seam	~170 m west of the K2W void currently in use as a tailings storage facility	Water quality in GW55_d is interpreted to be impacted by seepage from the adjacent K2W void based on the following: _ The sulfate concentration rose from <200mg/L in 2009 to >800mg/L in 2015. However, since 2015 the sulfate concentration has been steadily reducing to a concentration in August 2020 of 399mg/L. _ GW55_d is high in concentrations of dissolved metals relative to other Queen Seam bores, including aluminium, cobalt, manganese, nickel and zinc. _ However, GW55_d is not elevated in metal/metalloid parameters that are specific to ash dam monitoring, including molybdenum, selenium or vanadium.
GW59B	King Seam	160 m east of K2W and south of K2N voids ; K2W currently in use as a tailings storage and K2N as an ash storage facility	It is interpreted that the water quality at GW59B is impacted by seepage from the adjacent K2W void, based on increasing and/or elevated concentrations of ash indicator parameters such as sulfate, boron and molybdenum.
GW37	Regolith	Northern area of mine, down-gradient of workshop area	The dissolved iron concentration is relatively high at this site (>40mg/L) and manganese (> 5mg/L). The site may be impacted by mining but is remote from areas of known AMD seepage.

4.3.4 Seeps

Groundwater seepage expression has been, and continues to be, monitored at Ramp 7 and Bullgang drain. Seepage data statistics for Ramp 7-1, 7-2 (i.e. Ramp 7) and Bullgang Drain from 2013-2017 (as presented in WSP, 2018) and 2020-2021 are presented in **Table 15**. The seepage waters are characterised by elevated levels of sulfate, aluminium, cobalt, manganese, nickel, zinc and iron. Major ions for seepage samples for 2020-2021 are presented on a piper diagram in **Figure 37**. The water type is Na-SO_4 dominant.

Comparison between the two time periods shows on-average there has been a significant decrease in all key analytes since the EE investigation.

Table 15 Ramp 7 and Bullgang Drain Seepage Water Quality Statistics 2013-2017 and 2020-2021

Parameter	Unit	2013-2017 (WSP, 2018)			2020-2021		
		Min	Average	Max	Min	Average	Max
pH	pH units	3.4	-	6.3	3.05	5.4	6.58
Electrical conductivity	µS/cm	1690	3199	4500	1380	2816	3520
Total Acidity	mg/L	12	277	490	10	108.2	179
Sulfate (SO_4)	mg/L	223	1113	1580	326	788	978
Aluminium (dissolved)	mg/L	0.005	0.84	4.52	0.01	0.1	0.31
Cobalt (dissolved)	mg/L	0.01	0.7	1.21	0.13	0.4	0.55
Manganese (dissolved)	mg/L	0.88	32.9	50.3	7.83	23	29.2
Nickel (dissolved)	mg/L	0.03	0.51	0.92	0.094	0.3	0.443
Zinc (dissolved)	mg/L	0.01	4.11	12.3	0.61	2.4	3.13
Iron (dissolved)	mg/L	0.33	91.6	181	3.46	46.5	89.3

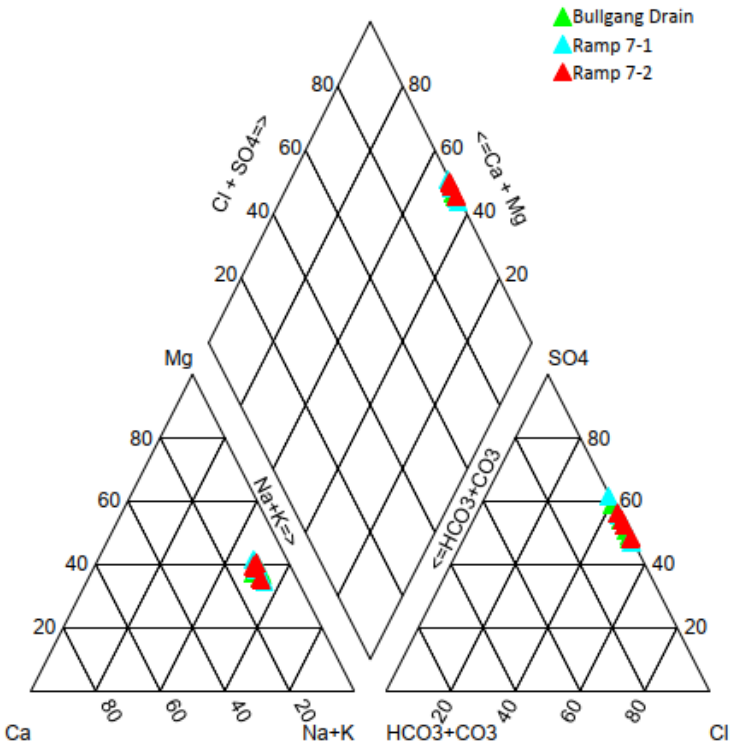

Figure 37 Piper Diagram Seepage

4.3.5 Springs

A search with Queensland's WetlandInfo Portal (WetlandInfo, 2019) showed that there are no registered springs within a 50 km radius of the Project Area.

4.4 Current and Potential Future Uses of Groundwater

4.4.1 Current

4.4.1.1 Landholder Bores

The location of existing landholder bores is shown in **Figure 38** and **Table 16**. Information on these bores is derived from the DOR database. The search was extended to a 5km radius from the Mine and 72 bores were identified within this area. Of these, 1 bore has its use listed as Stock, 43 as water supply and 28 are unknown. Groundwater in the region is used for the purposes of irrigation, stock watering and domestic use (JBT, 2021a).

As noted by JBT (2021a), a number of private bores are screened in the alluvium of Tanduringie Creek (a tributary of Barker Creek to the west of the Mining Lease). These bores are within a surface-water sub catchment isolated from Meandu Mine's mining lease.

Table 16 Landholder Bores within 5km from the Mine (DoR, 2021)

Registered Number	Easting (GDA94 z56)	Northing (GDA94 z56)	Use
26405	383470.5	7033723	Unknown
26407	383364.9	7033199	Unknown
26408	384783.3	7035089	Unknown
26412	385647	7037964	Water Supply
75078	390228.9	7027498	Water Supply
106901	393159.7	7027572	Water Supply
106954	397315.7	7036409	Water Supply
106955	397482.7	7034910	Water Supply
106958	396094.7	7038822	Water Supply
110975	398322.2	7030467	Water Supply
110976	398604.2	7030788	Water Supply
121578	386862.6	7028165	Water Supply
121743	387174.5	7029340	Water Supply
127006	385263.9	7037164	Water Supply
127810	386288.6	7027758	Water Supply
129166	392544.4	7026550	Water Supply
129344	392622.7	7026986	Water Supply
129435	397088.7	7028580	Water Supply
135000	385405.5	7027750	Water Supply
137189	398340.7	7032200	Unknown
143032	396962.7	7028620	Water Supply
143390	396708.7	7029018	Water Supply
143421	398464.7	7032300	Water Supply
144372	383631	7034236	Water Supply
150399	396993.7	7034897	Unknown
150426	397002.7	7033759	Unknown
154073	396501.7	7029729	Water Supply
154203	396204.7	7038393	Water Supply
154688	396558.7	7029265	Water Supply
156065	391172.9	7026385	Unknown
156328	397172.7	7029355	Unknown
159370	385573	7037990	Water Supply
159371	386255	7037237	Water Supply
159372	385333	7035749	Water Supply
159374	384572	7034870	Water Supply
159460	396553.7	7029571	Unknown
159461	396063.7	7038377	Unknown

Registered Number	Easting (GDA94 z56)	Northing (GDA94 z56)	Use
159769	386641	7027430	Water Supply
164821	383083	7033669	Unknown
164822	383984	7034472	Unknown
164823	383635	7034246	Unknown
164824	383376	7034276	Unknown
167096	386288.6	7027758	Unknown
167183^	389068	7036087	Unknown
167265	384407	7034957	Unknown
167266	384472	7034944	Unknown
173643	396990.7	7033597	Unknown
173644	397093.7	7033167	Water Supply
173828	397481.5	7032562	Water Supply
174189	396207.7	7039267	Water Supply
185245*	392318.2	7039317	Water Supply
185246*	392558.2	7039478	Water Supply
185248*	392500.9	7039633	Water Supply
185249*	392352.6	7039523	Water Supply
185304*	392614.8	7039400	Water Supply
185772	387087.6	7030330	Water Supply
185773	386529	7031241	Water Supply
185988	387008	7029508	Water Supply
189084	394830	7026047	Unknown
189293	397964.7	7034258	Water Supply
189295	397066.6	7034372	Water Supply
189651	399511.5	7034178	Water Supply
189817	395809	7035306	Stock
191357	387578	7038414	Water Supply
195645	384471	7034934	Unknown
13620313	385509.4	7036470	Unknown
13620316	385528.9	7036670	Unknown
13620320	385685	7038171	Unknown
13620355	384338	7034879	Unknown
Bore 2	397105.7	7034909	Unknown
Hilltop Bore	394929.7	7036964	Unknown
Nag's Bore	396845.7	7034052	Unknown
Sauer's Bore	398706.7	7036282	Unknown

*Bore Location falls within the Meandu Creek dam. Likely erroneous and removed from **Figure 38**.

^Bore location appears erroneous. Bore removed from **Figure 38.**

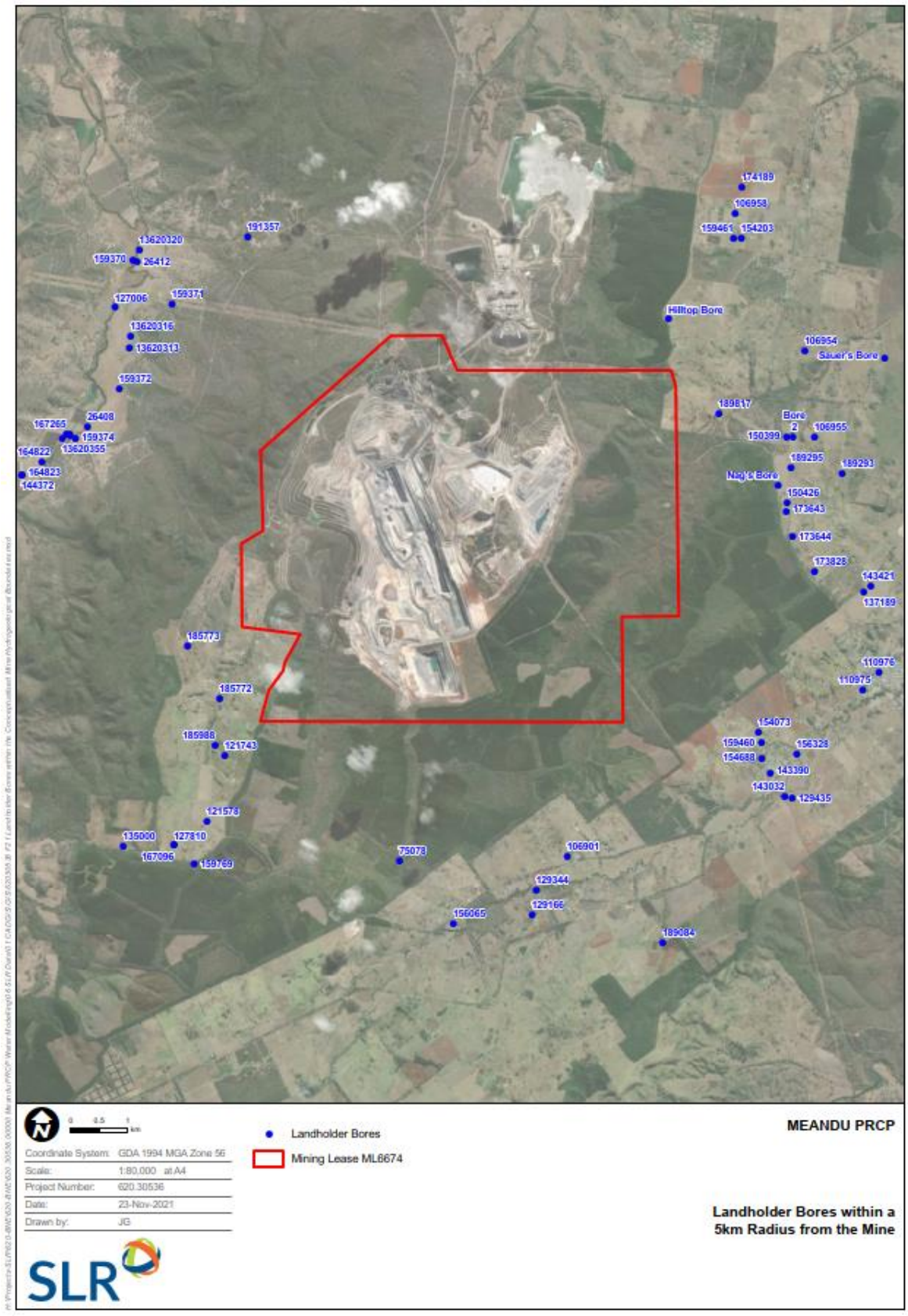

Figure 38 Landholder Bores within a 5km Radius from the Mine

4.4.1.2 Groundwater Dependent Ecosystems

Ecosystems that are dependent or partially dependent on groundwater, or that may be affected or impacted by change in groundwater quality and levels are referred to as groundwater dependant ecosystems (GDEs). Queensland GDE mapping is available from the QSpatial Portal (DES, 2018a). Site specific GDE studies have also been conducted by ESP (2021), cited in JBT, (2021a) for the K2E Project.

4.4.1.2.1 Regional Studies

The Queensland GDE mapping builds on existing information including wetland mapping, regional ecosystem mapping, spring and waterholes databases and drainage lines (Queensland Government, 2017).

The dataset contains shapefile data which can be grouped into the three categories of GDEs:

- Aquatic GDEs (and surface line expressions)
- Terrestrial GDEs
- Subterranean GDEs (including stygofauna).

The dataset contains information on both known and potential GDE areas. Known GDEs refers to areas that have been verified through field studies while potential GDEs refer to areas that have been mapped at a large scale primarily through analysis of GIS data. The dataset was queried to assess the presence of GDEs within a 10km buffer of the site. The search returned showed the following GDEs in the area and are shown on **Figure 39**:

- Terrestrial GDEs – Potential, derived with low and moderate confidence (outside of Meandu Mine's surface rights area, predominantly to the south and east of the Mining Lease);
- Aquatic GDEs – Potential, derived with low and moderate confidence (outside of Meandu Mine's surface rights area, in the southeast of the Mining Lease and surrounding);

The dataset for terrestrial GDE is presented as polygons with either up to 80% of the polygon being potentially groundwater dependent (01-80 Derived GDE, **Figure 39**) or 80 to 100% of the polygon being potentially groundwater dependent (81-100 Derived GDE, **Figure 39**). Site studies presented in **Section 4.4.1.2.2** did not find any potential for GDEs along Rocky Creek.

The search did not show any subterranean GDEs within a 10km buffer of the site. Field surveys have indicated that the mapped GDEs have a similar aquatic ecosystem value to unmapped areas (ESP 2018).

A search for wetlands within a 1km buffer of the Mining Lease was conducted using the Wetland data version 5 – wetland areas – Queensland dataset downloaded from the QSpatial portal (DES, 2015). The search showed that there were several wetlands in the area including lacustrine, palustrine, riverine and those that were not classified (**Figure 39**).

A search for springs was conducted using the Springs – Active – Queensland dataset downloaded from QSpatial (DES, 2018b). The search showed that there were no active springs within a 10km buffer of ML6674 and that the closest active spring is approximately 31km southwest of the Mining Lease.

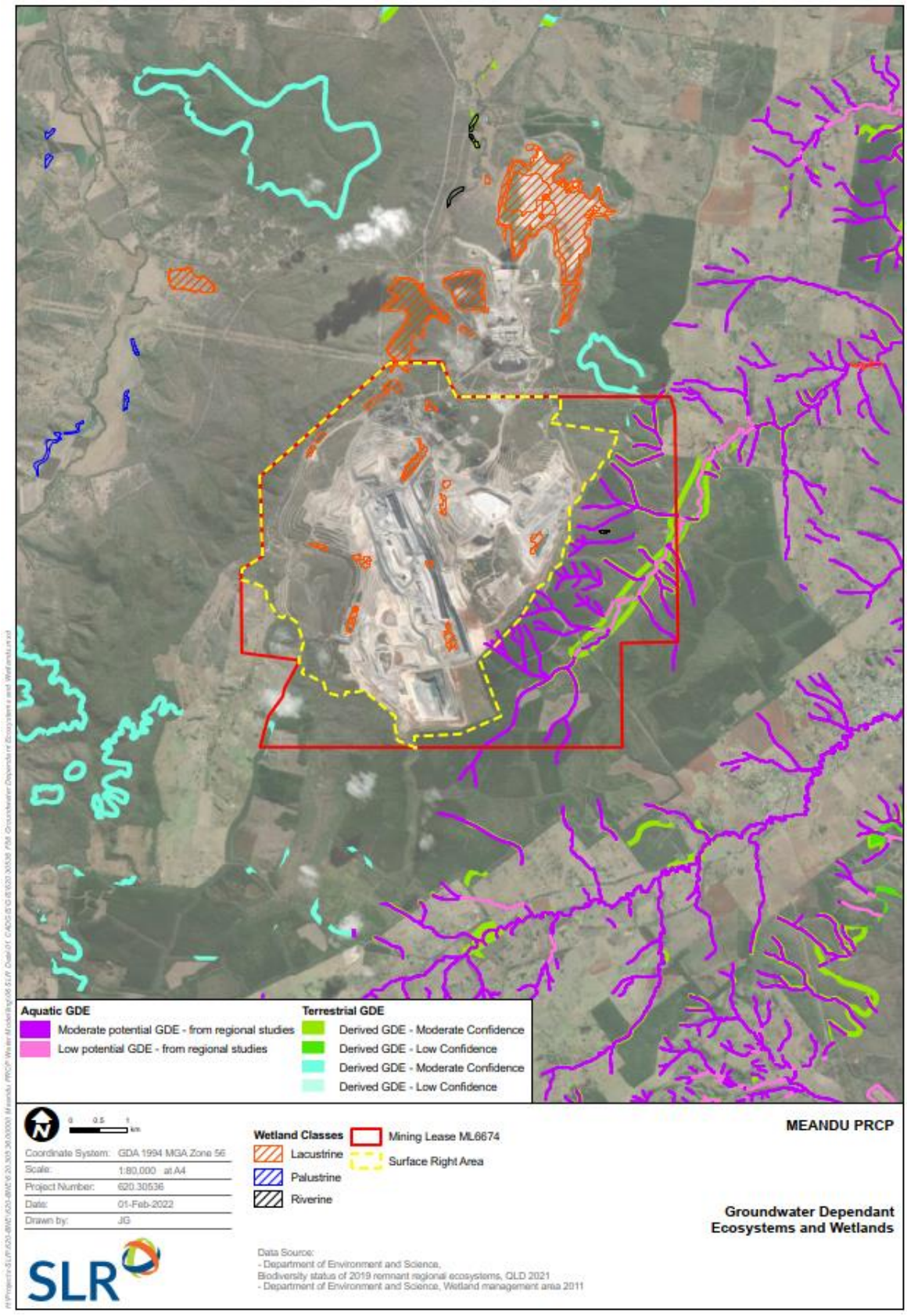

Figure 39 Groundwater Dependant Ecosystems and Wetlands

4.4.1.2.2 Site Studies

Site specific GDE studies, conducted for the K2E Project by ESP (2021), and cited in JBT, (2021a) indicates:

- The alluvium within Meandu Creek, Yarraman Creek and Rocky Creek are the only hydrogeological units with the potential habitat to host stygofauna in the vicinity of the K2E project area. No stygofauna specimens were recorded as part of the study.
- It is unlikely that the terrestrial GDEs mapped as low confidence (**Figure 39**) along Rocky Creek are reliant on groundwater. This is based on the depth to the groundwater table surrounding Rocky Creek which is estimated to be greater than 10mbgl.
- No evidence of surface expression GDEs were found as part of the aquatic ecology field surveys along Rocky Creek or its tributaries.

4.4.2 Future Local Groundwater Use

Future groundwater uses are anticipated to be similar to current uses previously described in **Section 4.4.1**.

4.4.3 Fate of Current Groundwater Extraction Bores

Two pumping wells are located in the Hitachi Hill area. Pumping at wells GW48 and GW49 started in November 2019. It is planned that the wells will be abandoned and decommissioned prior to closure (July 2045).

4.5 Potentiometric Maps and Hydro Stratigraphic Cross Sections

4.5.1 Groundwater Monitoring Network

A total of 81 groundwater monitoring bores are currently active according to the site groundwater monitoring bore register. A summary of monitoring bores and standing water level (SWL) in metres below ground level (mbgl) for each aquifer is provided in **Table 17** and the location of bores is shown on **Figure 40**. The bores assessed as not impacted by mining (control and background bores) in WSP (2018) and Stanwell (2020b) are highlighted (light blue shade). It is noted that the remaining bores have not all been assessed as impacted by mining and several bores are categorised as "potentially impacted". This is discussed in **Section 4.3**.

Table 17 Groundwater Monitoring Bores Network and Standing Water Level (SWL)

Bore Name	Coordinates AGD84		Top of Casing mRL	Total Depth mbgl	Screened Interval mbgl		Screened Geology	SWL May 2021 (mbgl)
	Easting	Northing			Upper	Lower		
GW02	389371	7035544	-	30.0	18.5	29.4	Coal Measures below Queen Seam	4.8
GW05	391056	7035094	462.0	29.0	-	-	Queen Seam	7.0
GW09	390653	7034308	480.1	44.9	33.3	44.3	Sandstone below Queen Seam	36.1
GW21	388411	7031771	534.8	74.2	57.6	>74	Coal Measures below Queen Seam	61.9
GW22	387834	7032483	470.1	54.6	37.3	54.2	Coal Measures below Queen Seam	12.9
GW25	388980	7035226	431.4	13.9	5.3	13.9	Regolith	2.9

Bore Name	Coordinates AGD84		Top of Casing mRL	Total Depth mbgl	Screened Interval mbgl		Screened Geology	SWL May 2021 (mbgl)
	Easting	Northing			Upper	Lower		
GW30	388747	7035093		9.9	5.5	9.5	Regolith	4.0
GW33	389405	7035240	448.8	26.0	14.0	21.0	Spoil	15.2
GW34	389484	7035322	442.3	42.0	35.0	42.0	Coal Measures below Queen Seam	10.2
GW36	388740	7034925	441.5	30.0	17.0	30.0	Coal Measures below Queen Seam	9.0
GW37	390580	7035904	432.0	36.0	29.0	36.0	Regolith	6.2
GW38	389370	7035573	426.7	24.0	17.0	24.0	Regolith	3.8
GW39*	389931	7036197	421.1	12.0	5.0	12.0	Meandu Creek alluvium	3.3
GW40	389797	7036057	421.7	12.0	5.0	12.0	Meandu Creek alluvium	3.6
GW41	390598	7035084	447.9	13.0	7.0	13.0	Interface between spoil/ underlying regolith	13.6
GW42	389156	7033103	468.0	37.0	29.0	37.0	Interface between spoil/ underlying regolith	35.6
GW42_s	389156	7033103	-	-	-	-	Spoil	Removed
GW43_d*	391373	7030177	555.1	145.5	-	-	Queen Seam	80.8
GW43_s	391367	7030176	555.4	66.3	-	-	Basalt	55.8
GW44_d*	393995	7031154	514.8	146.0	-	-	Queen Seam	31.5
GW44_s*	393998	7031154	514.7	97.5	-	-	Queen Seam	30.8
GW45_d*	393709	7031395	500.0	149.5	-	-	Queen Seam	21.8
GW45_s*	393707	7031395	499.5	78.5	-	-	King Seam	22.2
GW46_d*	394328	7033544	484.6	124.5	-	-	Queen Seam	26.7
GW46_s*	394330	7033546	484.5	67.0	-	-	King Seam	25.6
GW47	390848	7033926	518.4	85.8	67.8	79.8	Spoil	60.1
GW48	389007	7034417	488.7	103.7	82.0	94.0	Spoil	55.4
GW49	389210	7034794	484.4	100.6	76.7	88.7	Spoil (Production/ Dewatering Bore)	51.2
GW53	391365	7034040	491.8	20.1	16.5	19.5	Regolith	Removed
GW55_d	391081	7033151	522	78.5	69.5	78.5	Queen Seam	Removed
GW56_d	391957	7032143	588.5	148.0	136.0	148.0	Ace Seam	128.9
GW56B_d	391947	7032150	587.3	145.0	140.5	145.0	Ace Seam	127.2
GW56_s	392048	7032031	594.9	40.5	34.5	40.5	Basalt	Dry
GW58_d*	392595	7032686	570.1	170.0	149.0	161.0	King Seam	110.7
GW58_s	392574	7032680	569.7	61.0	49.0	61.0	Basalt	Dry
GW59B	391863	7033509	583.8	144.0	129.0	141.0	King Seam	102.4
GW60	393207	7034409	540.4	109.0	97.0	109.0	Queen Seam	82.3

Bore Name	Coordinates AGD84		Top of Casing mRL	Total Depth mbgl	Screened Interval mbgl		Screened Geology	SWL May 2021 (mbgl)
	Easting	Northing			Upper	Lower		
GW61_d	392708	7035417	467.0	53.5	41.5	53.5	Regolith	7.1
GW61_s	392708	7035407	467.0	18.2	12.2	18.2	Regolith	9.3
GW62_d	391092	7029145	598.4	501.9	-	-	Ace Seam	Dry
GW62_s	391090	7029146	598.5	550.0	-	-	Basalt	Dry
GW63_d*	393974	7032350	482.7	374.7	-	-	Queen Seam	22.8
GW63_s	393973	7032349	482.7	464.7	-	-	Regolith	Dry
GW64_d	394858	7033643	472.3	422.3	-	-	Maronghi Creek beds	19
GW64_s	394859	7033642	471.9	446.9	-	-	Maronghi Creek beds	24.8
GW65	394670	7034730	494.9	422.9	-	-	Maronghi Creek beds	30.1
GW67	390860	7034677	552	12	9	12	Regolith	Removed
GW68	390900	7034903	452.6	17.6	14.5	17.5	Regolith	4.2
GW69	390512	7035357	441.3	24.5	18.5	24.5	Regolith	6.0
GW70	392450	7035246	494.2	26.0	20.0	26.0	Interface between spoil/ underlying regolith	25.2
GW71	392559	7034977	509.4	35.0	29.0	35.0	Interface between spoil/ underlying regolith	31.3
GW72	391926	7035103	518.2	41.0	35.0	41.0	Interface between K2 tailings and regolith	35.3
GW73	392860	7035712	460.5	20.0	17.0	20.0	Regolith	7.0
GW74	392772	7036159	456.8	20.0	17.0	20.0	Regolith	8.2
GW75	389146	7035090	456.9	36.0	30.0	36.0	Spoil	23.2
GW76	389121	7035241	439.7	9.0	6.0	9.0	Spoil	9.3
GW78	388621	7035266	432.4	12.0	7.5	12.0	Regolith	4.9
GW79_d	391091	7033453	523.7	49.0	46.0	49.0	Regolith beneath spoil	Dry
GW79_s	391089	7033452	523.6	37.0	34.0	37.0	Spoil	Dry
GW80	391024	7034681	465.5	16.0	13.0	16.0	Regolith	10.0
GW81	390826	7034603	467.7	16.0	13.0	16.0	Regolith	9.9
GW82	390802	7034409	473.8	15.0	12.0	15.0	Regolith	12.1
GW83	391206	7034614	478.2	14.0	11.0	14.0	Queen Seam	14.7
GW84	390866	7034819	454.4	11.8	8.8	11.8	Queen Seam	1
GW85_d	391114	7034387	491.3	36.1	33.1	36.1	Regolith	22.8
GW85_s	391122	7034388	491.5	24.4	21.4	24.4	Regolith	Dry
GW86	389366	7035561	426.8	24.0	15.0	24.0	Replace GW01, Coal Measures below Queen Seam	3.3
GW87_d	388025	7034138	448.8	38.0	26.0	38.0	Replace GW11, Coal Measures - below Queen Seam	15.4

Bore Name	Coordinates AGD84		Top of Casing mRL	Total Depth mbgl	Screened Interval mbgl		Screened Geology	SWL May 2021 (mbgl)
	Easting	Northing			Upper	Lower		
GW87_s	388022	7034131	448.8	20.0	17.0	20.0	Regolith	15.8
GW88_d	388365	7034749	439.0	30.0	24.0	30.0	Regolith and coal measures below Queen Seam	9.5
GW88_s	388368	7034753	438.9	12.0	9.0	12.0	Regolith	8.2
GW89_s	388469	7035142	432.7	12.0	9.0	12.0	Regolith claystone and Regolith sandstone respectively	5.3
GW89_d	388471	7035145	432.6	30.0	24.0	30.0	Regolith claystone and Regolith sandstone respectively	5.0
GW90	388623	7035270	432.2	29.7	23.7	29.7	Regolith siltstone	4.6
GW91	389001	7035506	437.5	24.0	18.0	24.0	Regolith	12.3
GW92	389272	7035677	432.7	24.0	18.0	24.0	Coal measures below Queen Seam	10.2
GW93	389620	7035921	427.0	35.0	29.0	35.0	Coal measures below Queen Seam	5.5
GW94	390711	7035231	446.5	25.0	14.0	25.0	Coal measures below Queen Seam	2.7
GW95	390452	7035353	439.7	36.0	30.0	36.0	Coal measures below Queen Seam	6.8
GW96	390572	7035683	450.2	51.0	45.0	51.0	Coal measures below Queen Seam	20.9
GW97	390055	7035922	439.7	36.0	30.0	36.0	Regolith	6.8

* Control and Background Bores – Not impacted by mining

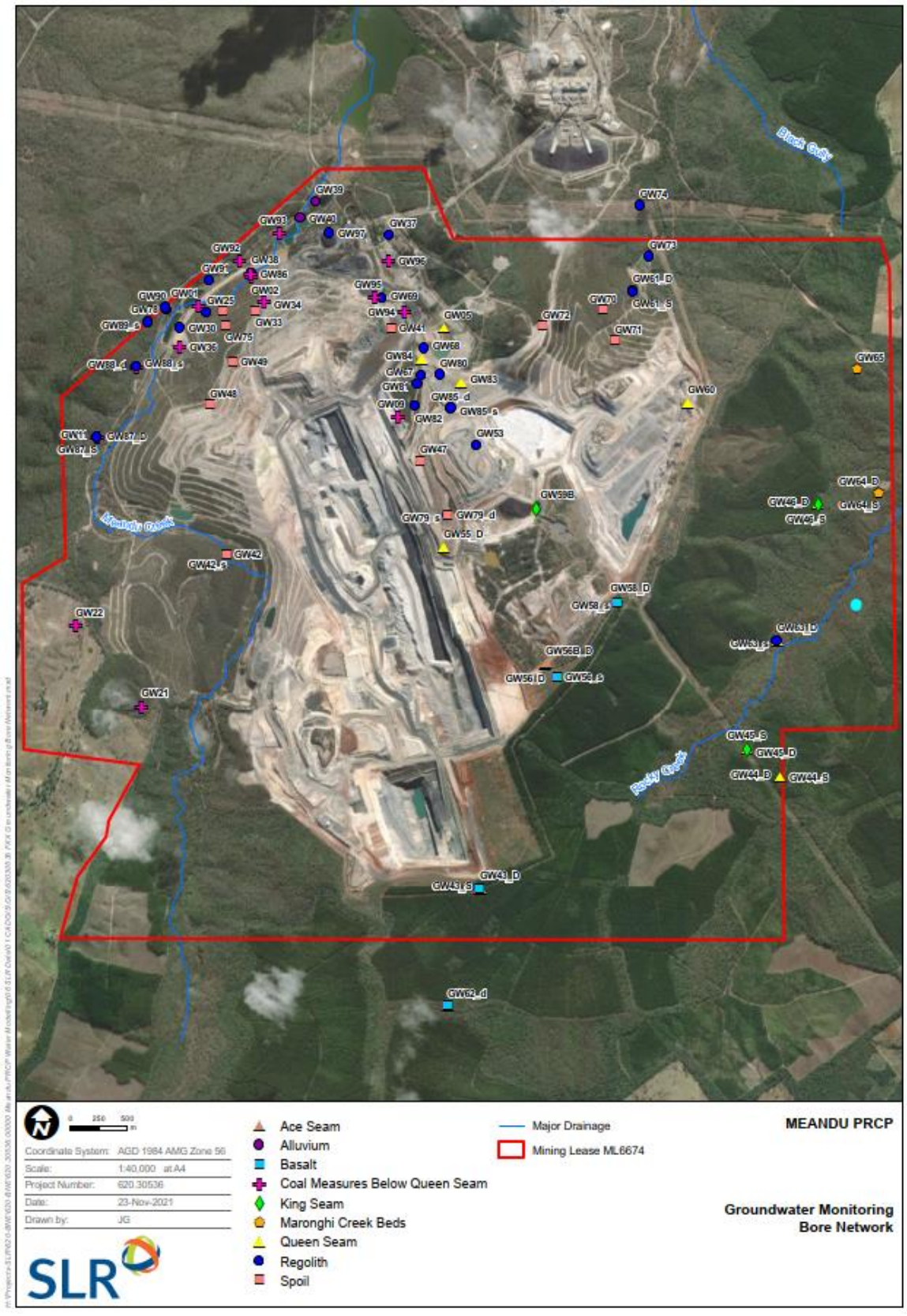

Figure 40 Groundwater Monitoring Bore Network

4.5.2 Potentiometric Maps

4.5.2.1 Unconfined Alluvium, Regolith and Spoil

Where saturated, the unconfined units are conceptualised as hydraulically connected. A groundwater elevation contour map for the groundwater table has been produced using groundwater levels (mAHD) in the alluvium, regolith and spoil recorded in May 2021 (**Figure 41**).

4.5.2.2 Basalt

Water level data is only available for one bore in the basalt (GW43s) and as such, groundwater flow direction cannot be interpreted. However, where saturated, flow in the basalt is expected to be primarily influenced by topography, and to a lesser degree, by fracture orientation.

4.5.2.3 Tarong Beds

As described in JBT (2018a and JBT 2021a), groundwater flow direction in the Tarong beds is complex and discontinuous. As such, potentiometric contour maps for the coal seams have not been produced.

4.5.2.4 Maronghi Creek Beds

Within the mining lease, water level data is only available for two bores in the Maronghi Creek Beds (GW64 and GW65) which is insufficient to develop a groundwater level contour map.

4.5.3 Hydro Stratigraphic Cross Sections

Hydro Stratigraphic cross sections have been developed for the study area and are presented in **Figure 42** through **Figure 47**.



Figure 41 Water Table Elevation Contours – Spoil, Alluvium and Regolith Bores

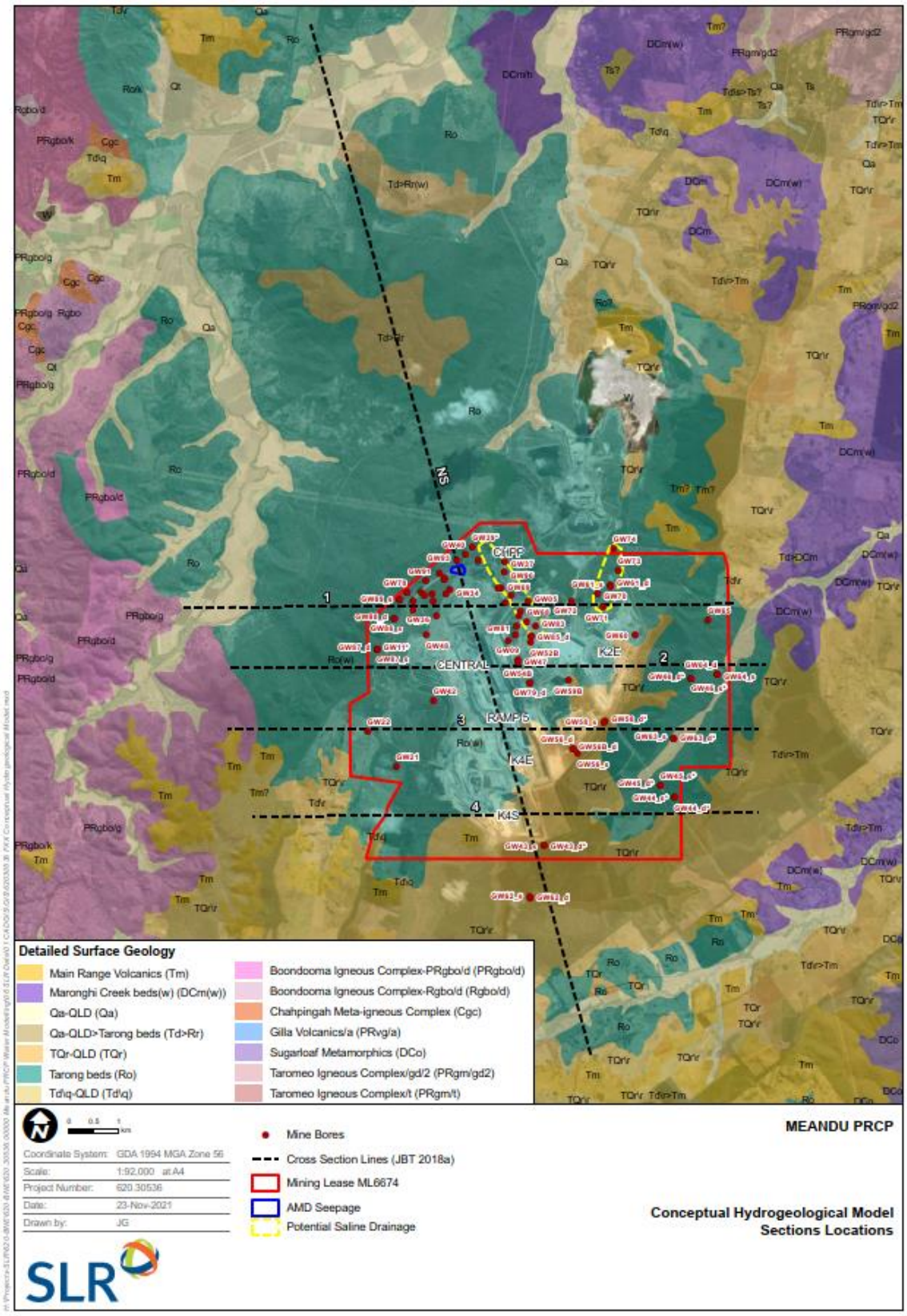

Figure 42 Conceptual Hydrogeological Model – Location of Hydrogeological Cross Section

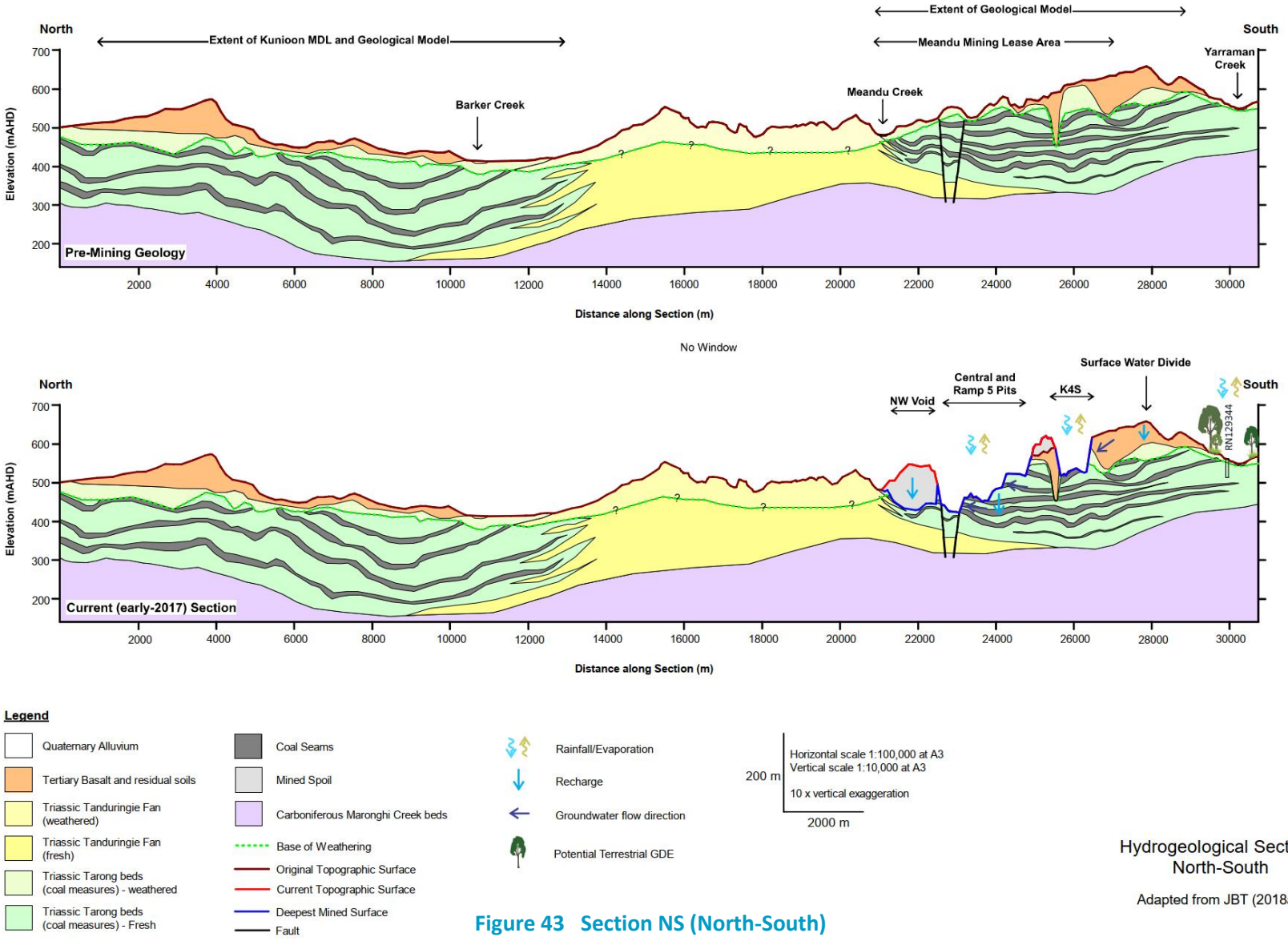

Figure 43 Section NS (North-South)

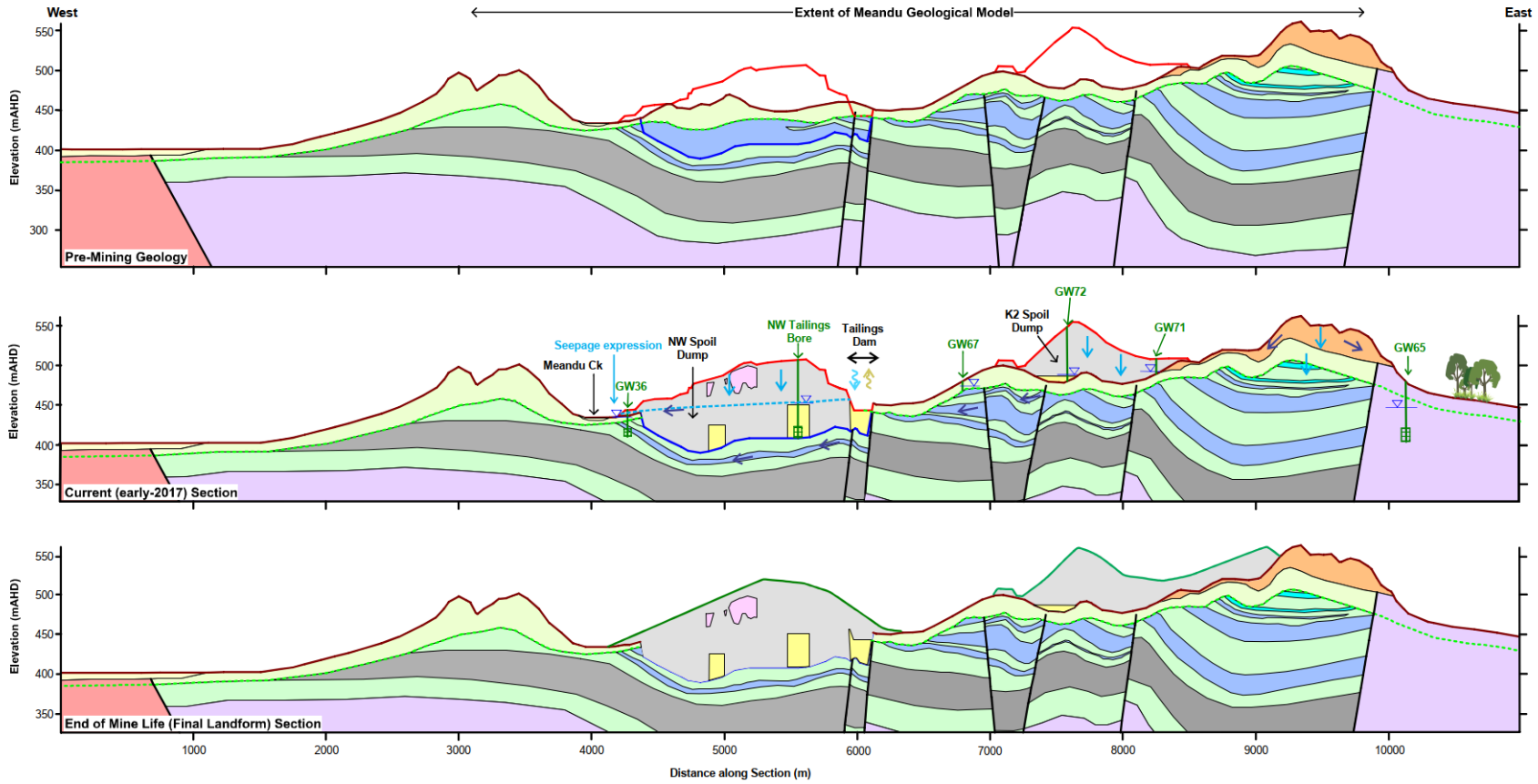

Figure 44 Section 1 (West-East)

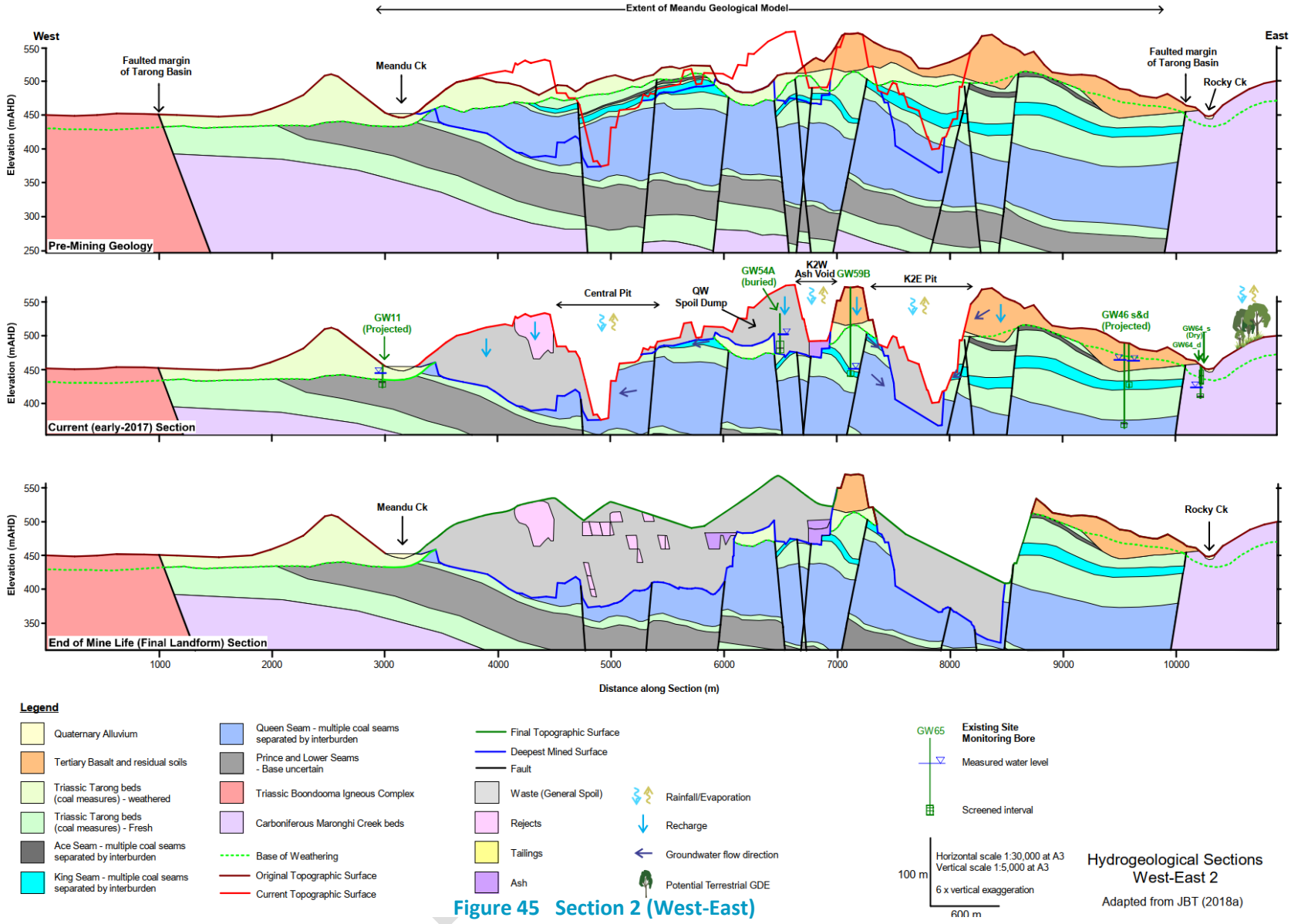

Figure 45 Section 2 (West-East)

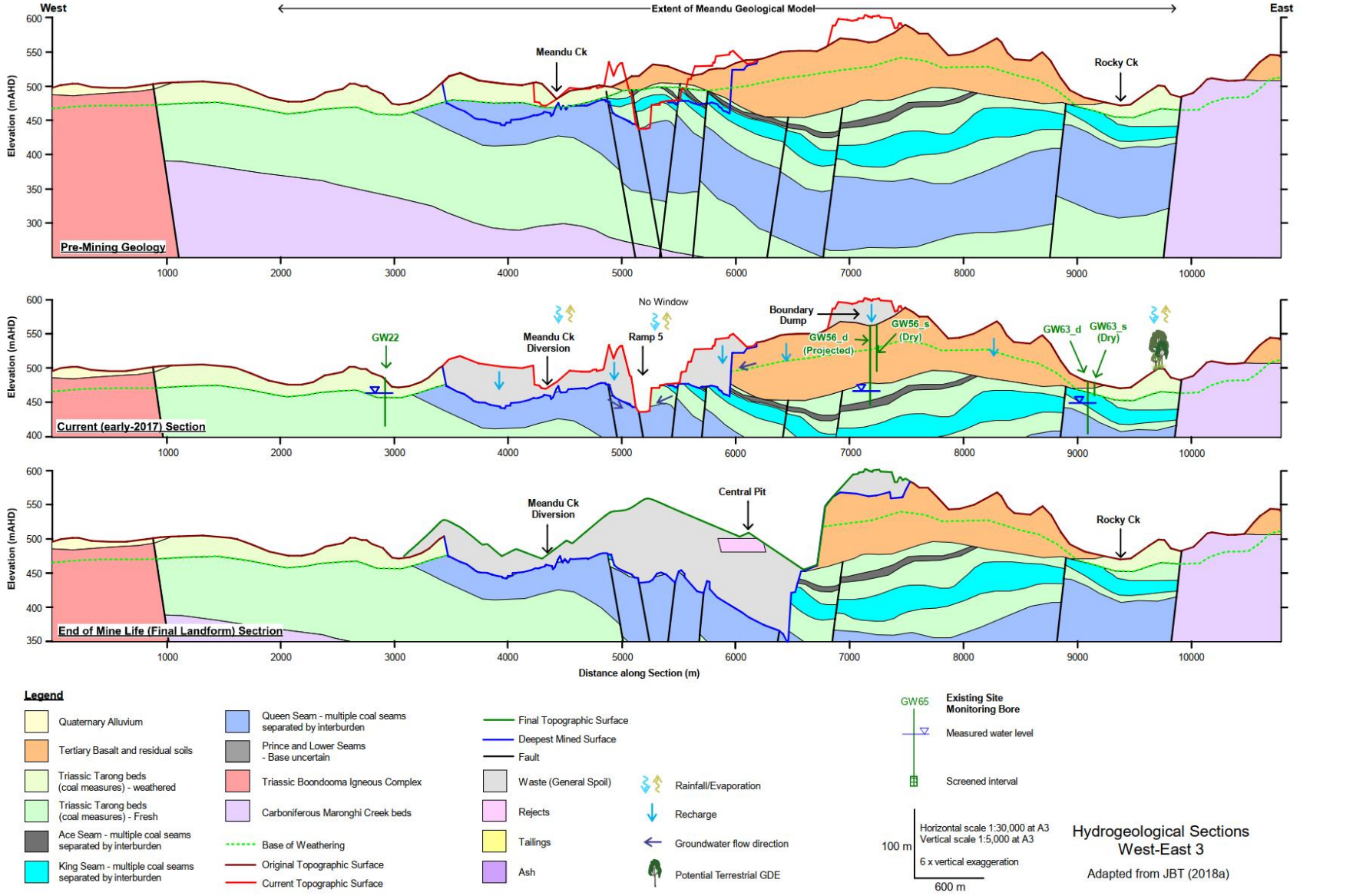

Figure 46 Section 3 (West-East)

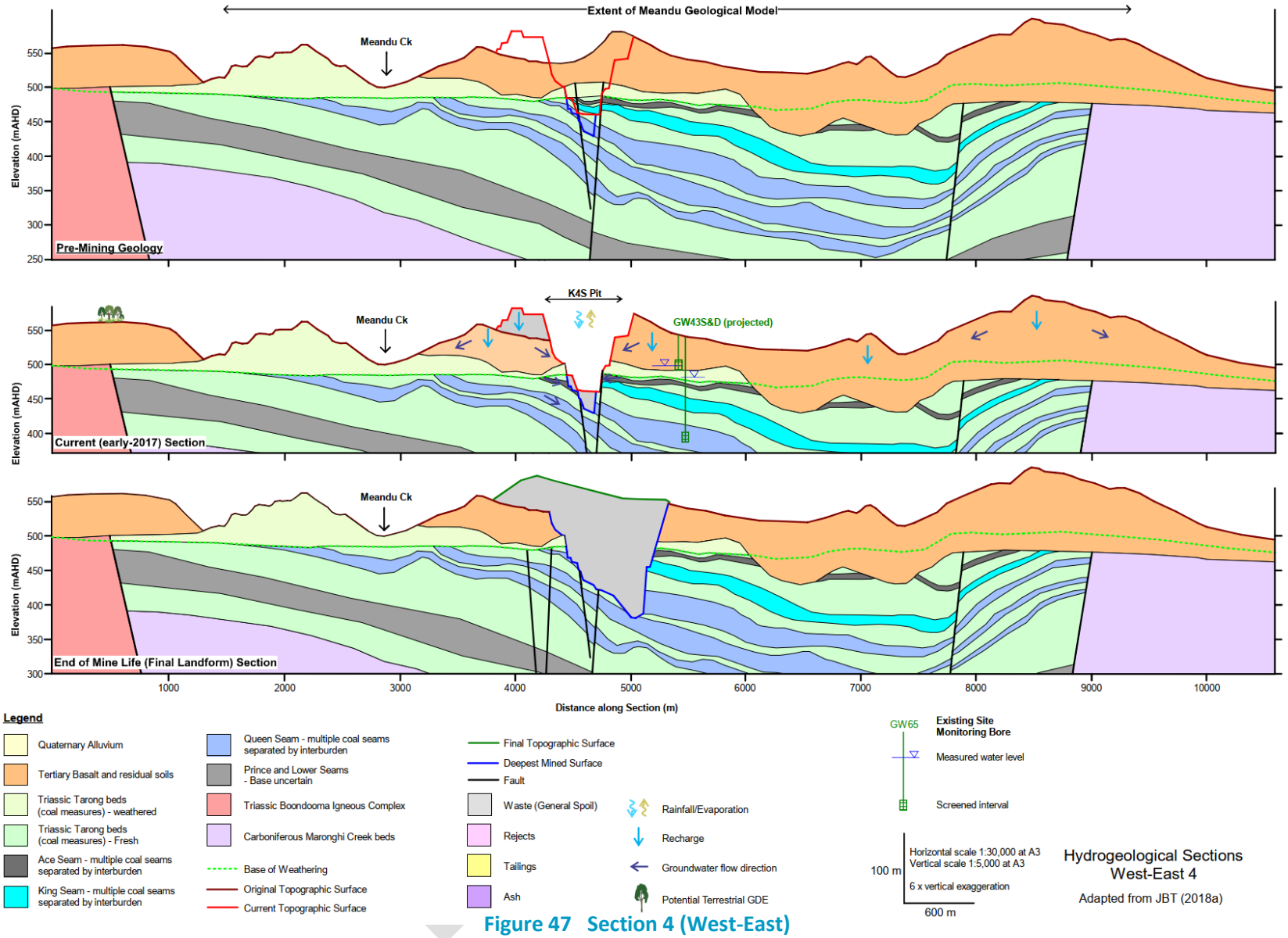

Figure 47 Section 4 (West-East)

4.6 Groundwater Flow Direction and Velocity

4.6.1 Regional Groundwater flow

Within the Tarong Basin, groundwater primarily occurs in the alluvium, basalt and coal seams of the Tarong beds. Groundwater recharge occurs via direct rainfall recharge to the surface geological units (i.e. alluvium, regolith and basalt). Recharge to the basalt occurs primarily through fractured zones. The coal seams of the Tarong beds are primarily recharged through downward seepage where the coal subcrop the regolith and alluvium. The alluvium is recharged via rainfall and seepage from the regolith. Ephemeral water flow in the creeks may also contribute to alluvial recharge.

Groundwater flow in the unconfined units (alluvium and shallow basalt) is inferred to mimic surface topography. In the coal seams, flow patterns are complex due to preferential recharge zones and structural controls (i.e. coal seams dip and faulting). However, the general groundwater flow is inferred to be in the direction of topography.

Groundwater may temporarily discharge in the form of baseflow from the alluvium (e.g. some waterholes in Rocky Creek) and via evapotranspiration, primarily along drainage channels where the water table is shallower and groundwater dependant vegetation exists. Groundwater may support some aquatic and terrestrial GDE along the main drainage channels. Groundwater is also extracted regionally for agricultural and domestic purposes (e.g. bore RN129344, **Figure 43**).

4.6.2 Localised Mine Groundwater Flow

Groundwater recharge at the mine is influenced by the spoil which is highly permeable and allows greater rainfall infiltration when compared with other geological units. Downward seepage from the spoil increases recharge to the regolith and allows for greater saturation of this unit within the mine site (**Figure 43** to **Figure 47**). The basalt is typically dry around the mine and groundwater primarily occurs within the coal seams and the unconfined alluvium and regolith, where saturated.

The general groundwater flow direction is in the direction of topography and Meandu Creek. Toward the east and southeast of the mining lease (i.e. outside of the SRA), groundwater flow is expected to be toward Yarraman Creek (**Figure 43**). However, in the coal seams, the groundwater divide does not coincide with the surface water divide and groundwater flow in the coal is expected to be primarily toward the mine. In the vicinity of the pit, groundwater flow is toward the pit where the groundwater is removed by evaporation and/or pumping. (**Figure 45**, **Figure 46** and **Figure 47**). Meandu Creek dam is inferred to exert control over the water table elevation in its vicinity.

4.6.3 Hydraulic Testing

Field tests have been conducted to obtain hydraulic conductivity estimates (as reported in JBT, 2021a):

- Slug testing - including 33 tests completed across monitoring bores screened within the Meandu Creek alluvium, regolith, basalt, coal measures (Ace, King and Queen Seams and interburden) and the Maronghi Creek beds (JBT, 2018b).
- Permeability testing of core samples – including testing of representative lithologies (siltstone, sandstone and conglomerate) from two cored boreholes, resulting in six interburden samples.
- Pumping tests - from three landholder bores in the Maronghi Creek beds.

The results of these are summarised below and presented in **Table 18**.

Data for the alluvium includes two bores with hydraulic conductivity estimates that are an order of magnitude different (0.97 vs. 9.09m/day). This is due to the presence of clay in one of the screened intervals (one of the bores was screened in sand and the other in sandy clay). A wide range of hydraulic conductivity is typical for alluvium due to differences in grain size.

Hydraulic conductivity estimates from 11 tests conducted in the regolith range from 0.08 to 1.62m/day (median 0.25m/day).

Only one test was conducted for the basalt as the majority of bores are dry. The estimated hydraulic conductivity from this test was 0.16m/day. The basalt is expected to have higher hydraulic conductivity around fracture zones, which are the principal mechanism for groundwater movement in fractured rock aquifers.

Four tests were conducted for the spoil, yielding hydraulic conductivity estimates of 0.01 to 0.97m/day (median 0.43m/day).

Field tests conducted for the Tarong Beds show that the coal seams have a significantly higher hydraulic conductivity than the interburden (coal seams 0.01 to 0.71m/day; interburden 0.000002 to 0.008m/day). The range of hydraulic conductivity values observed for the coal seams is likely due to variability of fractures which are the main factor that provide porosity to the unit.

Five tests were conducted for the Maronghi Creek Beds, yielding hydraulic conductivity estimates in the range of 0.000019 to 0.084m/day.

Table 18 Summary of Field Test Data Estimates for Hydraulic Conductivity; m/day (JBT, 2021a)

Aquifer	Sample Number	Min	Max	Arithmetic Mean	Harmonic Mean	Median	Standard Deviation
Spoil - Kh	4	0.01	0.97	0.36	0.03	0.23	0.43
Alluvium - Kh*	2	0.97	9.09	5.03	-	-	5.74
Regolith - Kh	11	0.08	1.62	0.54	0.23	0.25	0.52
Basalt - Kh	1	0.16	0.16	-	-	-	-
Ace Seam - Kh	1	0.71	0.71	-	-	-	-
King Seam - Kh	4	0.01	0.71	0.23	0.02	0.09	0.33
Queen Seam - Kh	9	0.1	0.27	0.18	0.17	0.17	0.05
All Coal Seams - Kh	14	0.01	0.71	0.22	0.05	0.17	0.21
Interburden - Kh	6	0.000002	0.008	0.0014	0.00001	0.0001	0.0031
Interburden – Kz*	6	0.000002	0.005	0.0018	0.00001	0.0011	0.0022
Maronghi Creek- Kh	5	0.000019	0.084	0.031	0.0001	0.0029	0.041

Kh: Horizontal hydraulic conductivity; Kz: Vertical hydraulic conductivity; "- " denotes no data available

4.6.4 Storage Properties

Site storage properties have not been measured. As indicated by JBT (2021a), the construction of pumping test bores was deemed inappropriate considering field test observations which indicated the bores would quickly be pumped dry. Storage properties were estimated by JBT (2021a) based on literature values (**Table 19**).

Table 19 Storage Properties - Estimated from Literature by (JBT, 2021a)

Groundwater Unit	Storage Coefficient (-)		Specific Yield (m^{-1})	
	Min	Max	Min	Max
Alluvium	0.00013	0.00013	0.05	0.2
Basalt	0.00007	0.00137	0.005	0.02
Regolith	0.01370	0.00128	0.01	0.02
Coal Seams (All)	0.00002	0.00012	0.01	0.06
Interburden (All)	0.00016	0.00341	0.001	0.01
Maronghi Creek beds	0.00033	0.00683	0.001	0.01
Granite - weathered	0.00102	20.00000	0.001	0.01
Granite - fresh	0.00033	0.00683	0.01	0.02
Spoil	0.00102	0.00205	0.01	0.15

4.6.5 Groundwater Velocities

Average linear groundwater velocities within the study area are likely to have a large range in values. The relatively higher hydraulic conductivities of the alluvium (**Table 18**) will result in velocities orders of magnitude greater than those within the Coal Measures and other consolidated aquifers. Estimated velocities based on field test data estimates for hydraulic conductivity and specific yield are provided in **Table 20**.

Table 20 Estimated Average Linear Groundwater Velocities

Groundwater Unit	Velocity (m/d)	
	Min	Max
Alluvium	4.9	45.5
Basalt	8.0	8.0
Regolith	4.0	81.0
Coal Seams (All)	0.2	11.8
Interburden (All)	0.0002	0.8
Maronghi Creek beds	0.002	8.4
Spoil	0.1	6.5

4.7 Groundwater Modelling

Groundwater modelling is required under Section 3.6.1 of the Guideline to estimate:

- Potential changes to groundwater levels due to dewatering, water and waste storages (**Section 6.5.1**);
- Long term recovery of groundwater levels post-mining (**Section 6.5.2**); and
- Potential contaminant seepage to groundwater (**Section 4.7.5**).

The primary objective of the PRCP groundwater model is to predict the post-mining water level across the entire mine site and associated impacts on environmental receptors. Predicted water levels are then used to assess potential contaminant transport in groundwater, including extent of contaminant transport and potential areas for surface expression.

The following sections provide a summary of the groundwater modelling setup, calibration, and predictive results.

4.7.1 Numerical Model Design

The K2E Model developed by JBT (2021a) was transferred from MODFLOW-SURFACT to MODFLOW-USG. No changes were made to the original model structure which is presented in **Section 4.7.1.1**.

4.7.1.1 Model Structure

4.7.1.1.1 Model Grid

The model grid is rectangular with axes oriented along the general strike and dip of the basin and predominant orientation of local geological structure. The grid size is 40 m x 40 m within the existing surface rights area (which includes the K4S Ash storage area) and K2E ASA, extending to 80 m x 80 m cell size in the outer areas of the model (**Figure 48**). The total number of cells per layer is 82,297 cells which, for a 15-layer model results in a total of 1,234,455 cells.

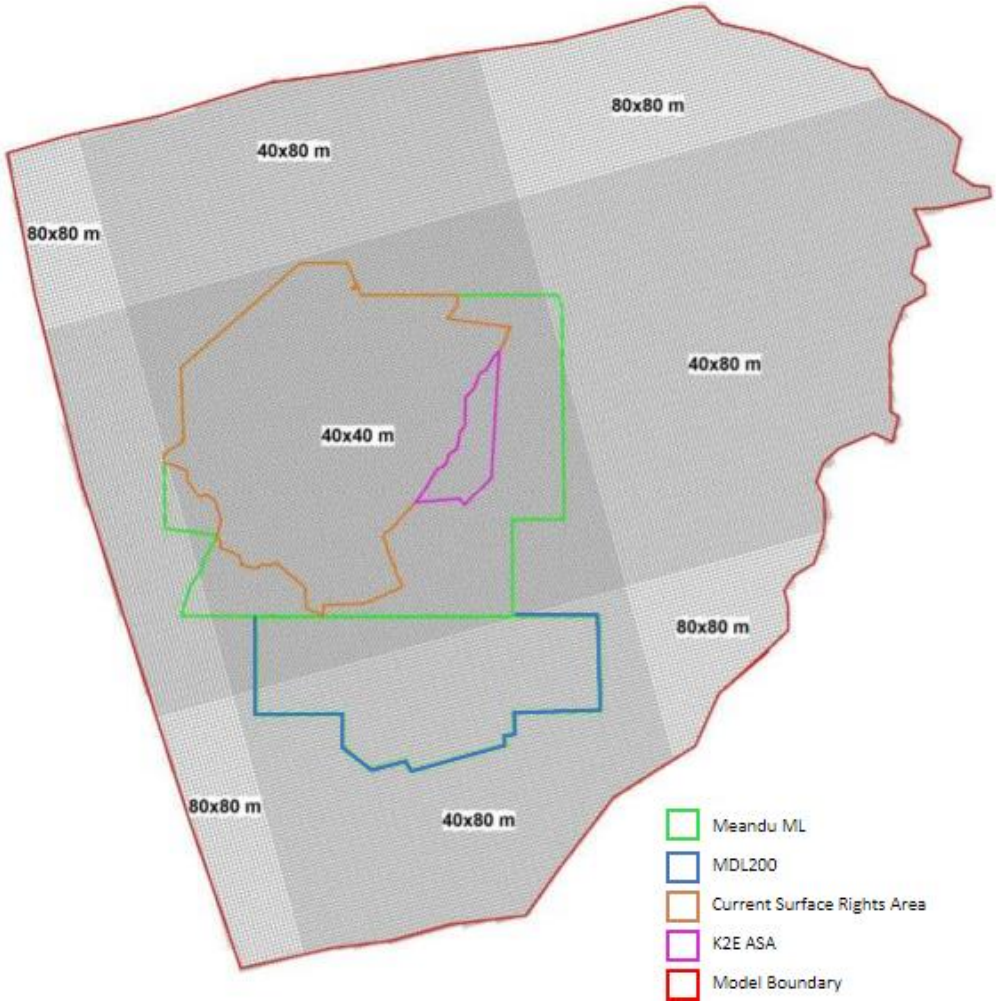

Figure 48 Model Grid (JBT, 2021)

The areas where a fine resolution is required is the surface right area and the K2E ASA. The model grid must be small enough in these areas to simulate stresses to the system from mining activities and contaminant transport, but also large enough to minimise model run time to allow a comprehensive calibration process. A 40 m by 40 m grid size satisfy these requirements.

4.7.1.1.2 Model Layers

The model is discretised vertically in 15 layers to represent the various Hydro Stratigraphic Units (HSU) encountered at site. These HSU's are shown in **Table 21**.

Table 21 Model Layers (Adapted from JBT, 2021)

Layer	Top of Layer	Base of Layer	Description
1	Topographic Surface	Top Triassic	Basalt, Quaternary alluvium, upper layers of Triassic regolith (within Tarong Basin)
2	Top Triassic	Base Regolith	Quaternary alluvium, Regolith (weathered coal measures)
3	Base Regolith	to Ace 1 Roof	Fresh Triassic coal measures below regolith but above Ace Seam; Top of Maronghi Creek beds

Layer	Top of Layer	Base of Layer	Description
	Ace 1 Roof	Ace 3 Floor	Package of Triassic sediments that includes Ace Seams
4	Ace 3 Floor	King 2 Roof	Interburden_1 (interburden between coal seams)
5	King 2 Roof	King 4 Floor	Package of Triassic sediments that includes King Seams
6	King 4 Floor	Queen A1 Roof	Interburden_2 (interburden between coal seams)
7	Queen A1 Roof	Queen A3 Floor	Package of Triassic sediments that includes Queen A Seam
8	Queen A3 Floor	Queen B1 Roof	Interburden_3 (interburden between coal seams)
9	Queen B1 Roof	Queen B3 Floor	Package of Triassic sediments that includes Queen B Seam
10	Queen B3 Floor	Queen C1 Roof	Interburden_4 (interburden between coal seams)
11	Queen C1 Roof	Queen C3 Floor	Package of Triassic sediments that includes Queen C Seam
12	Queen C3 Floor	Queen D1 Roof	Interburden_5 (interburden between coal seams)
	Queen D1 Roof	Queen D3 Floor	Package of Triassic sediments that includes Queen D Seam
	Queen D3 Floor	Queen E1 Roof	Interburden_6 (interburden between coal seams)
	Queen E1 Roof	Queen E3 Floor	Package of Triassic sediments that includes Queen E Seam
	Queen E3 Floor	Queen F1 Roof	Interburden_7 (interburden between coal seams)
	Queen F1 Roof	Queen F3 Floor	Package of Triassic sediments that includes Queen F Seam
	Queen F3 Floor	Queen G1 Roof	Interburden_8 (interburden between coal seams)
13	Queen G1 Roof	Queen G3 Floor	Package of Triassic sediments that includes Queen G Seam
14	Queen G3 Floor	Queen H1 Roof	Interburden_9 (interburden between coal seams)
	Queen H1 Roof	Queen H3 Floor	Package of Triassic sediments that includes Queen H Seam
	Queen H3 Floor	Queen J1 Roof	Interburden_10 (interburden between coal seams)
	Queen J1 Roof	Queen J3 Floor	Package of Triassic sediments that includes Queen J Seam
	Queen J3 Floor	Basement	Triassic below Queen Seam
15	Triassic Basement	Base of Maronghi Creek beds	Base of Maronghi Creek beds (occurs below Triassic in Tarong Basin, and is the only unit present east of the basin boundary fault

4.7.1.2 Boundary Conditions

4.7.1.2.1 No Flow

No flow boundary conditions are applied to the northern, southern and western boundary of the model, in accordance with the conceptual model (SLR, 2021a) and as per JBT (2021a):

- *"The northern boundary is the mid-way point of the Tanduringie Fan. It is interpreted that groundwater flow within the Triassic sediments is generally within the coal seams and that the Tanduringie Fan represents a low-permeability unit with a permeability similar to the coal measures interburden*
- *The southern boundary is the southern catchment divide of the Yarraman Creek catchment; and,*

- *The western boundary is the western limit of the Tarong Basin, with the rock type to the west comprising relatively impermeable granite."*

4.7.1.2.2 Recharge and Evapotranspiration

Diffuse rainfall recharge was simulated in MODFLOW USG using the recharge package (RCH). Recharge was distributed in laterally distinct zones within the model domain. Zones are based on surface geology and a portion of annual rainfall was assigned to each zone. Zoning was conserved from the K2E Model. The proportion of rainfall entering the model was defined through the calibration process and the calibrated recharge rates are discussed in **Section 4.7.2.5**.

Evapotranspiration was simulated in MODFLOW USG using the evapotranspiration package (EVT). EVT inputs are the maximum evapotranspiration rate and an extinction depth (i.e. depth at which the evapotranspiration is equal to 0 m). Evapotranspiration is represented in the highest active cells of the model domain and is calculated using a linear function with maximum evapotranspiration occurring where the water table is equal to ground elevation and 0 where the water table is at, or below, the extinction depth. In the model, the maximum rate of evapotranspiration was set from Scientific Information for Landowners (SILO) database (Queensland Government, 2021) pan evaporation data with an extinction depth of 2 m.

4.7.1.2.3 Meandu Creek Dam

Meandu Creek Dam, which continuously contains water due to discharges from the Meandu Mine as well as the Tarong and Tarong North Power Stations, is modelled in MODFLOW-USG using the River package (RIV). Required RIV inputs are the elevation of the riverbed, water stage (i.e. water level) and riverbed conductance.

Constant river inputs (i.e. not varying with time) as defined in JBT (2021a) were used in this model.

4.7.1.2.4 Meandu Creek (Downstream of Meandu Creek Dam)

Meandu Creek downstream of Meandu Creek Dam is perennial due to releases from Meandu Creek Dam. Meandu Creek downstream of Meandu Creek Dam is simulated using the River package (RIV). Constant river inputs (i.e. not varying with time) as defined in JBT (2021a) were used in this model.

4.7.1.2.5 Ephemeral Creeks

Ephemeral creeks are simulated using the River package (RIV) by setting the water depth equal to 0 m. Therefore, the river cells act like a drain (i.e., if the groundwater level reaches above the riverbed elevation, the water is removed from the model at the river node).

All creeks are ephemeral except for Meandu Creek downstream of Meandu Creek Dam during the period of mining and power generation operations. Ephemeral creeks also include the eastern model boundary which follows Yarraman Creek and a north-east unnamed tributary of Yarraman Creek.

4.7.1.2.6 Ash and Tailing Storages

Ash and tailing storages are simulated using the General Head Boundary package (GHB). The GHB inputs are the hydraulic head and a conductance term. For the calibration period, and where measured water level are available, these are used as the head value. For the predictive model, and where no measured water level is available, the GHB head is based on the deposition schedule, assuming that the water level in the storage is equal to the fill level. In the recovery model, the storages are assumed to be capped. Once capped, the GHB boundary is removed, and the cell remains with no boundary condition (i.e., no recharge or evaporation applied). The conductance values adopted by JBT (2021a) were conserved. For consistency with JBT (2021a), the conductance value adopted for King 2 West North (K2WN) was used for K4S considering that both voids will be filled with broadly similar proportions of ash and tailings material.

4.7.1.2.7 Mining

Representation of mining has been described by JBT (2021a) as follows:

"Two surfaces were created for the Meandu Mine area:

- *The current topographic surface, which includes mine voids, natural ground (unmined areas) and the surface of mined spoil, which is waste rock that has either been placed into voids behind the advancing mining face (in pit dumps), or placed onto the natural land surface (out of pit dumps). At Meandu Mine the majority of spoil is disposed of via in-pit dumping; and,*
- *The deepest mined surface, which is a surface that describes the deepest RL that has ever been observed at a particular location.*

The difference between the two surfaces (from grid to grid subtraction) is either:

- *Natural ground;*
- *A current mined void; or,*
- *Where there is a difference between current elevation and the deepest mined surface, the difference represents spoil that has been placed within a mined void.*

At the location of current voids, the water level is held at the base of mining via drain cells, with the locations of the drain cells altered dynamically according to the mine plan (i.e. as the location of the base of mined void advanced, the locations of drain cells were changed to represent the new location of the base of mining). The model included mine planning details for every financial year (i.e. 1 July to 30 June) from 2014 to 2039.

As mining advanced into new areas, the drain cells were turned off in the old mining areas and the layer properties above the old mining surface were changed to the hydraulic properties of spoil. This simulated the backfilling with spoil that occurs behind the advancing face of the mine." The recharge zones were also progressively changed to spoil as backfilling occurs. The drains active in 2039 (K2E and K4E) were left active for an additional six years (up to 2045). This assumption allows six years for post mining rehabilitation. The recovery period (i.e., final landform in place) starts in July 2045.

4.7.1.2.8 Pumping Wells

Two pumping wells are included in the model around the Hitachi Hill area. Pumping at wells GW48 and GW49 started in November 2019. A nominal extraction rate of 4L/s was selected for each well based on data provided by Stanwell. In the model the wells are active from November 2019 until the start of the post mining period (July 2045).

4.7.1.2.9 Horizontal Flow Barrier

The Boulevard Fault is represented as a Horizontal Flow Barrier (HFB) for the steady state calibration only. The assumption, which was formulated as part the calibration of the K2E Model (as detailed in JBT (2021a)), is that the fault acted as a hydraulic barrier to groundwater flow prior to mining on the edge of K2E. Mining on the edge of K2E (i.e., close to the Boulevard Fault) likely created conditions of enhanced permeability between the mine and the fault and "activated "the fault as a conduit. Thus, the HFB is only active in the steady state period and from 2014 onward, the fault is simulated as a "flow conduit."

The HFB package simulates a narrow, low conductivity barrier between two nodes. The HFB input includes the location of the barrier along the rectangular grid and a conductance term which is equal to the hydraulic conductivity of the barrier divided by its thickness (in units of days). For the Boulevard Fault prior to mining at K2E, a low conductance value of 0.000001 d^{-1} was used.

4.7.1.3 Timing

The timing and stress period setup was conserved from the K2E Model, including a steady state stress period followed by monthly transient stress periods starting from July 2014. The calibration period was extended to May 2021 (**Table 22**).

Table 22 Calibration Model Timing

Model Period	Interval	Stress Period	Date from	Date to
Initial		1	Steady State	
Calibration	Monthly	2 - 83	01-07-2014	01-05-2021

4.7.2 Model Calibration

The K2E Model was developed based on the MODFLOW-SURFACT code. Since 2013, MODFLOW-USG (the latest version of MODFLOW) has become the new standard for numerical groundwater flow modelling. MODFLOW-USG offers greater stability, which can improve the calibration process and run time. Thus, the model was transferred into MODFLOW-USG prior to calibration.

The observed water level dataset was updated to include all site bores and newly captured data (up till early-2021) including new bores installed since the last model calibration. The model was calibrated by adjusting aquifer parameters, stresses and boundary conditions to produce the best match between the observed and simulated water levels. The automated parameterisation software PEST++ (White et. al., 2020) was used to identify optimal hydraulic parameters and recharge rates to achieve the best statistical calibration of the groundwater model.

4.7.2.1 Calibration Targets

All bores with known screened lithologies and available water level data within the calibration period were included in the calibration target dataset. Overall, 82 bores and 1,390 datapoints were selected (**Table 23**). Spatially, the targets extend from the mining lease boundaries and covers key environmental receptors (e.g. Meandu Creek), the Boulevard Fault, the Maronghi Creek Beds, ash storages and the areas under groundwater quality investigation (i.e. Hitachi Hill, Queen West Backfilled Void - QWBV saline plume, Black Creek catchment) (**Figure 49**).

Table 23 Calibration Targets

Unit	Number of Bores	Number of Datapoints
Regolith	28	374
Coal Measures Below Queen Seam	16	196
Queen Seam	13	279
Spoil	13	248
King Seam	4	111
Ace Seam	2	27
Maronghi Creek Beds	3	72
Alluvium	2	56
Basalt	1	27
TOTAL	**82**	**1,390**

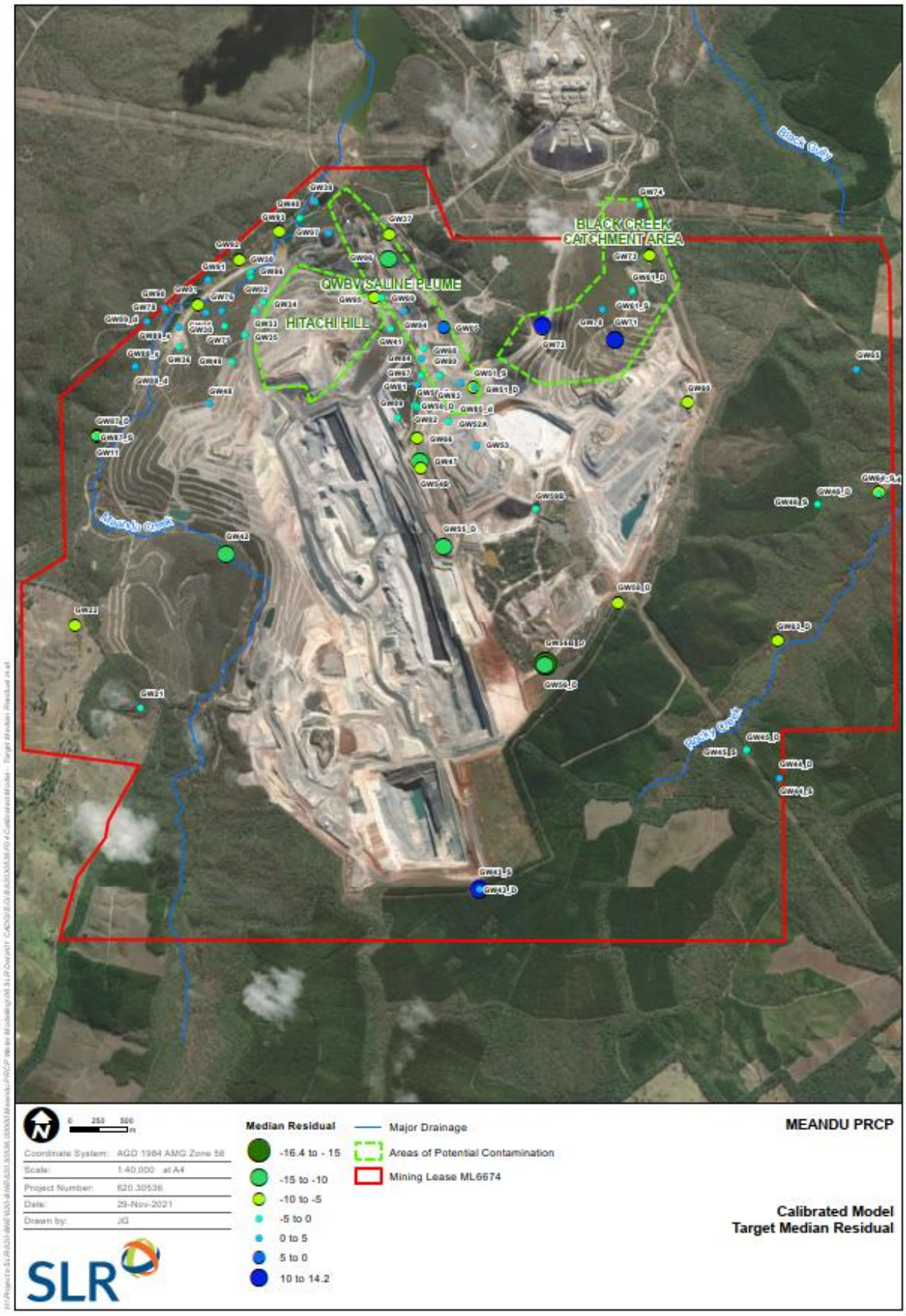

Figure 49 Calibration Targets

4.7.2.2 Groundwater Level Statistics

Transient calibration statistics are presented in **Table 24**. The industry standard method to evaluate the calibration of the model is to examine the statistical parameters associated with the calibration. This is done by assessing the error between the modelled and observed (measured) water levels in terms of the root mean square (RMS). A root mean square (RMS) is expressed as:

$$RMS = \left[1/n \sum (h_o - h_m)_i^2\right]^{0.5}$$

where: n = number of measurements

ho = observed water level

hm = simulated water level

RMS is considered to be the best measure of error if errors are normally distributed. The RMS error calculated for the calibrated model is 5.8m.

The acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS error, to the total head change in the system is small, the errors are considered small in relation to the overall model response(s). The total measured head change across the model domain is 84.9 m; therefore, the ratio of RMS to the total head loss (SMRS) is 6.8%. This indicates a reasonable calibration and is within the Australian Groundwater Modelling Guidelines of 10% Scaled RMS (Barnett et al., 2012). **Figure 50** presents the observed and simulated groundwater levels graphically as a scattergram for the transient calibration.

Table 24 Transient Calibration Statistics

Statistic	Value
Root Mean Square Error (m)	5.8
Scale Root Mean Square Error (%)	6.8
Sum of Residuals (m)	5869.4
Mean Sum of Residuals (m)	4.2
Scaled Mean Sum of Residuals (%)	5.0

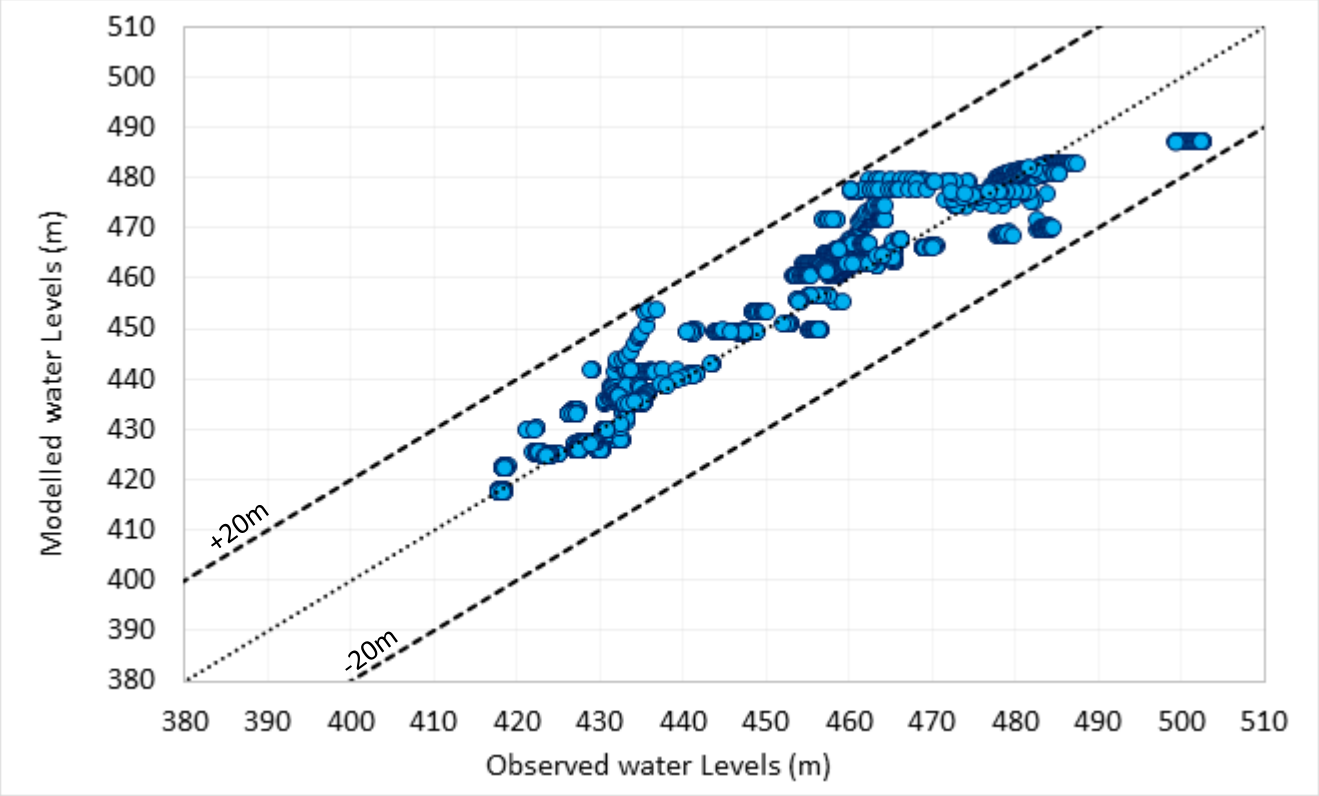

Figure 50 Transient Calibration – Modelled vs. Observed Groundwater Levels

4.7.2.3 Water Balance

The average water balance for the transient simulation is presented in **Table 25**. The mass balance error at the completion of the transient calibration is < 1%. This value indicates that the model is stable and achieves an accurate numerical solution.

The water balance indicates that recharge to the groundwater system within the model averages 1.6 Mega Litres (ML)/day. Approximately 0.03 ML/day is discharged via surface drainage, and 1.3 ML/day is lost to evapotranspiration in areas where the water table is within 2 m of the land surface. The largest component of the water balance is the water taken out of storage (5.5 ML/day) which is removed from the model through the pumping wells (0.7 ML/day) and sumps within the active mining areas (3.3 ML/day).

Table 25 Water Balance – Calibration Period Average

Water Balance Component	Average Inflow (ML/d)	Average Outflow (ML/d)
Storage	5.5	2.8
Recharge	1.6	0
River Leakage	0.03	0.03
GHB	0.4	0.03
Drain	0	3.3
ET	0	1.3
Wells	0	0.7
Total	7.53	7.46

Water Balance Component	Average Inflow (ML/d)	Average Outflow (ML/d)
In-Out	-0.6	
% Error	<1 %	

4.7.2.4 Calibrated Hydraulic Parameters

The calibrated hydraulic parameters are presented in **Table 26**. The zones have been conserved from the K2E transient calibration model. As discussed in JBT (2021a), the K2E Model includes additional zones to represent faulting and fracturing associated with the Boulevard Fault. Various zones have been implemented along the fault to represent the heterogeneity in hydraulic conductivity. The overall assumption that the Boulevard Fault becomes a conduit as mining approaches from the west was conserved from JBT (2021a). As described by Dr Noel Merrick in JBT (2021a), it is a "*conservative assumption that the enhanced permeability of the fault would be the same for its entire mapped extent. As this is unlikely, due to differential stress relief related to mining proximity, the extent of drawdown propagation* (and contaminant transport) *towards the south is probably overestimated.*"

All parameters are within the bounds of measured and/or estimated values for the site as presented in JBT (2021a).

Table 26 Calibrated Hydraulic Parameters

Zones	Layer / HSU	Kh* (m/d)	Kz* (m/d)	Sy* (-)	Sc* (-)
1	Interburden 1	6.1E-03	2.8E-04	3.2E-03	2.7E-03
2	Alluvium	10	4.2E-01	1.4E-01	2.1E-03
3	Basalt	1.0E-03	1.0E-05	1.2E-02	1.7E-04
4	King Seams	1.0E-02	1.1E-03	2.5E-02	4.6E-03
5	Regolith	1.0E-02	1.2E-04	1.0E-02	1.4E-02
6	Granite weathered	4.3	2.4E-01	3.7E-03	8.5E-04
7	Spoil	9.7E-01	2.4E-01	5.1E-02	5.2E-04
8	Maronghi Creek beds	1.3E-04	3.3E-05	3.2E-03	9.9E-04
9	Granite fresh	2.8E-03	4.1E-05	1.7E-02	1.9E-03
10	Ace seam	6.3E-03	1.6E-03	2.5E-02	1.3E-03
11	Interburden 2	7.8E-03	2.0E-03	3.2E-03	2.8E-03
12	Queen A seam	5.0E-03	9.0E-04	2.5E-02	3.3E-03
13	Interburden 3	2.7E-04	6.7E-05	3.2E-03	3.7E-03
14	Queen B, C, D-F and G seams	1.0E-03	9.9E-05	2.5E-02	4.7E-03
15	Interburden 4	2.2E-06	5.5E-07	3.2E-03	1.5E-03
16	Queen H-J seams	1.0E-04	1.8E-06	2.5E-02	3.7E-03
17 - 34	Fault zones	1.0E-02 - 4.3	1.3E-03 - 8.0E-01	2.0E-03 - 5.8E-02	1.3E-04 - 2.2E-02

*Kh: Horizontal Hydraulic Conductivity; Kz: Vertical Hydraulic Conductivity; Sy: Specific Yield; Sc: Storage Coefficient

4.7.2.5 Calibrated Recharge

Calibrated recharge values are presented in **Table 27**. As per the K2E Model, the greatest recharge was calibrated for the alluvium (4.8 % of rainfall), followed by the spoil (0.9 % of rainfall). The regolith and basalt were calibrated both at 0.13% of rainfall while the recharge input to the Maronghi Creek Bed is negligeable (<0.0001% of rainfall).

Table 27 Calibrated Recharge Values

Zone	Average Yearly Recharge (mm/d)	Recharge (% rainfall)
Alluvium	21.3	4.8
Regolith	0.6	0.13
Basalt	0.6	0.13
Maronghi Creek Beds	0	<0.0001
Spoil	4	0.9

4.7.3 Predictive Model Setup

Groundwater modelling is required under Section 3.6.1 of the Guideline to estimate:

- Potential changes to groundwater levels due to dewatering, water and waste storages (**Section 6.5.1**);
- Long term recovery of groundwater levels post-mining (**Section 6.5.2**); and
- Potential contaminant seepage to groundwater (**Section 4.7.5**).

The primary objective of the PRCP groundwater model is to predict the post mining water level across the entire mine site and associated impacts on environmental receptors. Predicted water levels are then used to assess potential contaminant transport in groundwater, including extent of contaminant transport and potential areas for surface expression. The contaminant transport modelling uses the results (i.e. groundwater flow gradients) of the hydrogeologic modelling results of the final void groundwater modelling described in **Section 6.5.2**.

4.7.4 Contaminant Transport Model Setup

A contaminant transport simulation was preformed using the transport functionality in MODLOW USG - Transport. The version of MODFLOW USG – Transport V1.4.0. was used, which includes two packages to simulate mass contaminant transport: The Block Centred Transport (BCT) package, which defines the transport parameters for the model (e.g., dispersion and porosity); and the Prescribed Concentration Boundary (PCB) package, which define the location (i.e. node) and mass concentration of the contaminant sources.

4.7.4.1 Transport Boundary Conditions

The constant source (i.e., no decay) is represented by a PCB condition, which is defined in MODFLOW-USG in the PCB package. Input to the PCB package are the nodes at which the boundary condition applies and the associated contaminant concentration.

A PCB condition applies a prescribed concentration to a node. Instead of calculating concentration as a simulation result, at these nodes the concentration is given by the boundary condition value. This can lead to an inflow of mass into the model when neighbouring nodes have a lower concentration, or to an outflow from the model when there is a concentration gradient from the neighbouring nodes towards the boundary condition.

The initial background concentration in the aquifer is assumed to be zero. The same is valid for the recharge flux concentration. The nodes, selected as potential contaminant sources, are shown in **Figure 51**.



Figure 51 Location of Prescribed Concentration Boundaries for Various Potential Sources

4.7.4.1.1 Spatial Representation of Sources

Selected nodes are based on the following areas (**Figure 51**):

- The Hitachi Hill and western reject area, which includes three large areas of potential contaminant, directly upstream of Meandu Creek. These are:
    - The north west rejects: An area adjacent to the road and Meandu Creek used to disposed reject waste material between 1986 and 2012;
    - The west overburden reject: An area on the western side of the mine where mine reject have been disposed from 2014 to present; and
    - Hitachi Hill: The Hitachi Hill dump was progressively formed over several legacy mine features including the North West Pit, which was used to store tailings (the NWA TSF) and backfilled with spoil and rejects up to 2015.
- Tailing dams:
    - The NWB TSF is located upgradient of the NWA TSF and was used for tailings deposition after the NWA TSF. The NWB TSF is currently undergoing decommissioning.
    - Historical tailings dams (excluding the one within Hitachi Hill) including the NWB TSF, the K2W TSF and the K2 TSF.
- Mixed ash and tailings dams which include:
    - existing K2W and K2WN.
    - planned future K4S.

The vertical extent for each 'constant source' was assigned based on the vertical extent of mining, assuming that the concentration at the source is uniform throughout the backfilled material (i.e., Mine reject, tailings, spoil or ash).

4.7.4.1.2 Source Concentration

To characterise CoC concentrations at the potential sources, laboratory Kinetic Leaching Colum (KLC) testing of deposited waste conducted by RGS (2020) was compared to measured groundwater quality within the spoil/mine waste.

KLC testing was conducted in 23 leach columns; where 22 columns were leached for approximately 15 months and, 12 columns were leached for approximately 32 months. The material placed in each column was selected to represent mine conditions, by testing either a single source material or, mixed materials disposed as waste within the mine as part of the mining process. The CoC concentration was generally found to be greater in the measured data compared to laboratory results. This is illustrated on **Figure 52** which show sulfate concentration over time in the KLCs relevant to the Hitachi Hill area (i.e. mixed waste) and in groundwater monitoring bores assessed to be impacted by mining and/or AMD around Hitachi Hill. For comparison purposes, the starting date for the KLC is set at 2015, which is the date when waste deposition ceased around the Hitachi Hill area. As shown on **Figure 52**, the concentration in the bores in generally constant over the past 6 years, which contrast with the strong decreasing trend observed with the KLCs. Additionally, sulfate concentrations in the bores after six years are mostly greater than observed after three years with the KLCs. Therefore, where available, measured groundwater data was used to define CoC source concentration. CoCs were selected based on being representative of potential sources as well as general water quality indicators. The representative data for each contaminant source, including how each value was calculated (i.e., 80th percentile or maximum value), is detailed in **Table 28**.

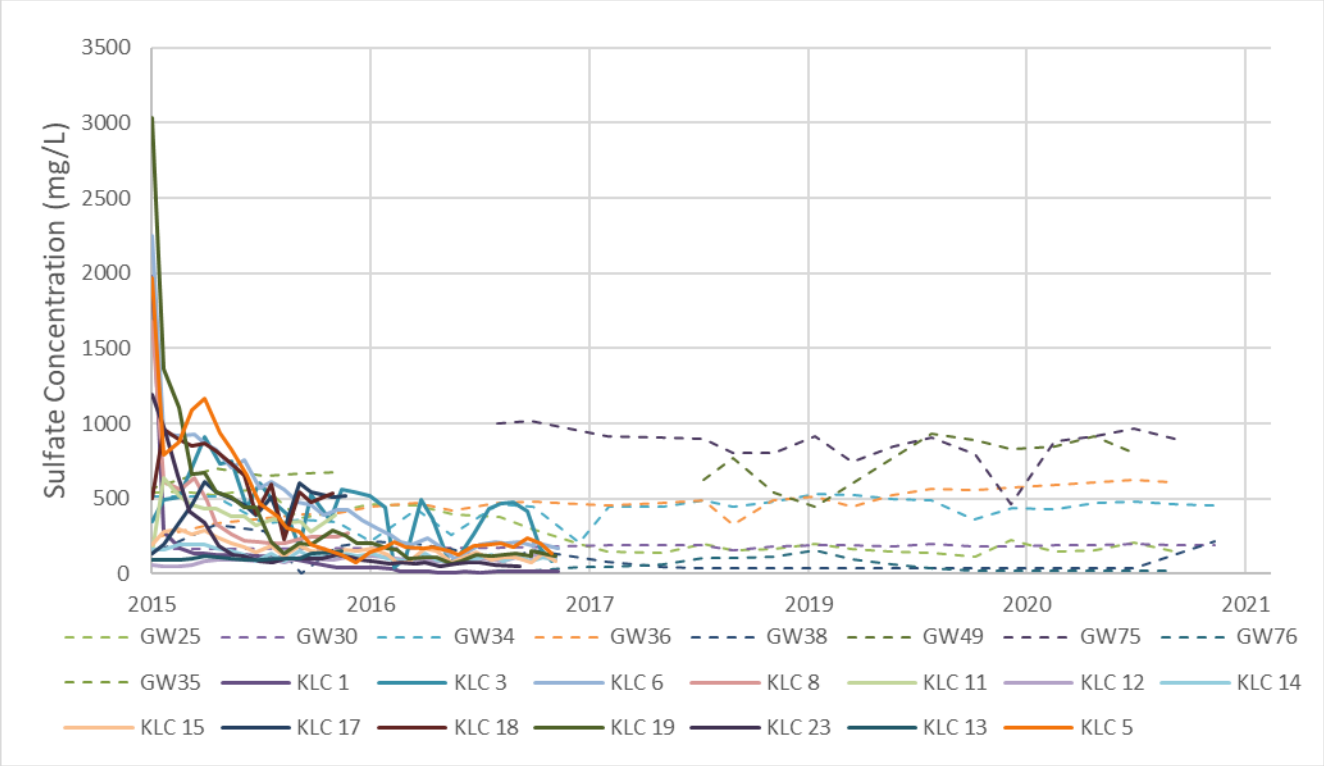

Figure 52 Sulfate Concentration for KLC Tests and Groundwater Monitoring Bores Around Hitachi Hill

Table 28 CoC Concentration Data for the Each Source Area

Contaminant Source	Northern Area	K2 TSF	K2W TSF	K2W, K2WN and K4S
Representative data	GW34, GW35, GW48, GW49, GW75 (80th percentile)	GW72 (80th percentile)	GW82 (80th percentile)	KLC#1^ (maximum value)
pH (-)	6.1	6.0	4.5	8
EC (µS/cm)	3,349	2,824	28,424	6,470
Sulfate (mg/L)	849	568	1,524	1,980
Aluminium (mg/L)	0.005*	0.02	9.24	1.9
Cobalt (mg/L)	0.32	0.086	0.715	0.079
Iron (mg/L)	48.8	146	9.8	0.11
Manganese (mg/L)	40.4	11.6	36.7	4.6
Nickel (mg/L)	0.22	0.086	0.5	0.067
Zinc (mg/L)	0.58	0.134	5.29	0.58
Selenium (mg/L)	0.005*	0.005*	0.01	0.08
Vanadium (mg/L)	0.005*	0.005*	0.005*	0.34
Molybdenum (mg/L)	0.0005*	0.0005*	0.0005*	0.46

^ RGS (2020), KLC test number 1; * Reported values are below the limit of reporting (LoR). 0.5 x LoR was used as source concentration.

To review potential for source decay overtime, KLC completed by RGS (2020) as well as previous leachate testing completed by Ward. *et. al*., (2007) was reviewed with a focus on the northern area.

As discussed in **Section 4.7.4.1.1**, the northern area includes a mix of material including rejects, tailings and spoil. A comparison between the groundwater quality measured within the spoil in the northern area and the various column test results for mixed waste (at the end of the testing period) show that the groundwater quality in the northern area best compares with KLC#11 for cobalt and nickel; KLC#15 for zinc; and KLC#18 for sulfate and aluminium. All four tests show small to non-detect concentrations for molybdenum, vanadium and selenium, in line with groundwater quality data (**Table 29**).

As detailed in RGS (2020), KLC#11 shows an increase over the 15-month period for cobalt and nickel. KLC#15 shows a slight increase and then a flattening for zinc. KLC#18 shows an initial decrease in sulfate concentration followed by a flattening. An increase in concentration overtime was also observed for cobalt, manganese, nickel and zinc during leachate tests conducted by Ward *et. al*., (2007).

It is acknowledged that decay and/or mass reduction (i.e., natural attenuation) of CoCs will occur over the ensuing decades to centuries. However, given that the available information did not quantify CoC decay, this was not considered further for this study.

Table 29 Measured Groundwater Quality VS Kinetic Leachate Testing for the Northern Area

Contaminant Source	Hitachi Hill and Western Reject Area - *GW34, GW35, GW48, GW49, GW75 (80th percentile)*	KLC#11*	KLC#15*	KLC#18*
pH (-)	6.1	4.82	4.4	7.6
EC (µS/cm)	3,349	807	207	1350
Sulfate (mg/L)	849	391	87	604
Aluminium (mg/L)	<0.01	6.9	0.05	<0.01
Cobalt (mg/L)	0.32	0.23	0.024	<0.01
Iron (mg/L)	48.8	<0.05	<0.05	<0.05
Manganese (mg/L)	40.4	7.3	4.6	0.01
Nickel (mg/L)	0.22	0.16	0.028	0.004
Zinc (mg/L)	0.58	3.29	0.53	0.076
Selenium (mg/L)	<0.01	<0.01	<0.01	<0.01
Vanadium (mg/L)	<0.01	<0.01	<0.01	<0.01
Molybdenum (mg/L)	<0.001	0.003	<0.001	0.004

*Shaded cell indicate KLC test that best matches observed groundwater quality data

4.7.4.2 Transport Parameters

Additional model parameters for the mass transport solution includes longitudinal dispersity, transverse dispersivity and effective porosity (**Table 30**).

The longitudinal dispersivity was estimated using the empirical power law proposed by Schulze-Makuch (2005):

$$\propto = c(L)^m$$

where: $\propto$ is the Longitudinal dispersivity;

c is a parameter characteristic of a geological medium;

L is the flow distance; and

m is the scaling component.

Schulze-Makuch (2005) suggest a value for ***c*** of 0.01 for sandstones, and 0.5 for **m**, regardless of the geological media. Using a distance of 1 km between the contaminant sources and the receptors, the calculated longitudinal dispersivity for the interburden is 0.3 m.

For unconsolidated sediments Schulze-Makuch (2005) suggest a value of 0.085 for **c,** and 0.5 for **m**, regardless of the geological media. Using a distance of 1 km between the contaminant sources and the receptors, the calculated Longitudinal dispersivity for the spoil is 2.5 m.

For basalts, Schulze-Makuch (2005) suggest a value of 0.15 for **c,** and 0.5 for **m**, regardless of the geological media. Using a distance of 1 km between the contaminant sources and the receptors, the calculated Longitudinal dispersivity for the basalt is 4.7 m.

In the absence of data for the coal seams, the longitudinal dispersivity of the sandstone was selected, effectively assigning a single longitudinal dispersivity value for the Permian coal measures. Considering the limited extent of the fault zones, no specific value of dispersivity was assigned to the fault.

Geological units away from the contaminant sources and with no risk of being affected by the contaminant sources have been assigned a default value for dispersivity equal to the sandstone.

The transverse dispersity was set at 30% of the longitudinal dispersivity and effective porosity values estimated based on ranges of values provided by Woessner *et. al.*, (2020).

Table 30 Transport Model Parameters

Zones	Layer / HSU	Sy* (-)	nE* (-)	Longitudinal dispersity (m)	Transverse dispersity (m)
1	Interburden 1	3.2E-03	0.2	0.3	0.09
2	Alluvium	1.4E-01	0.25	2.5	0.8
3	Basalt	1.2E-02	0.1	4.7	1.4
4	King Seams	2.5E-02	0.2	0.3	0.09
5	Regolith	1.0E-02	0.1	2.5	0.8
6	Granite weathered	3.7E-03	0.1	0.3	0.09
7	Spoil	5.1E-02	0.3	2.5	0.8
8	Maronghi Creek beds	3.2E-03	0.01	0.3	0.09
9	Granite fresh	1.7E-02	0.01	0.3	0.09
10	Ace seam	2.5E-02	0.2	0.3	0.09
11	Interburden 2	3.2E-03	0.2	0.3	0.09
12	Queen A seam	2.5E-02	0.2	0.3	0.09
13	Interburden 3	3.2E-03	0.2	0.3	0.09

Zones	Layer / HSU	Sy* (-)	nE* (-)	Longitudinal dispersity (m)	Transverse dispersity (m)
14	Queen B, C, D-F and G seams	2.5E-02	0.2	0.3	0.09
15	Interburden 4	3.2E-03	0.2	0.3	0.09
16	Queen H-J seams	2.5E-02	0.2	0.3	0.09
17 - 34	Fault zones	2.0E-03 - 5.8E-02	0.2	0.3	0.09

*Sy = Specific Yield; nE = Effective Posrosity

4.7.4.3 Model Timing

The model was initially run for 300 years, using the recovery timing set up shown on **Table 36** (**Section 6.4.1.5**). However, initial results showed that contaminant concentration did not reach equilibrium within this timeframe shown by concentrations at the bores downgradient of the sources presenting a steady increase. The model timing was progressively extended to 700 years post mining to achieve near equilibrium for the contaminant transport solution (**Table 31**). Both Scenario 1 and 2 models were run, as presented in **Section 6.4.1.2.**

The concentrations of CoCs at the source have been set up as constant over time (**Table 31**). The constant source approach is conservative from a risk perspective as it does not consider natural attenuation or decay which would likely occur over centuries of mobilisation.

Table 31 Transport Model Timing

Model Period	Interval	Stress Period	Date from	Date to	CoC sources active
Transport - Recovery	Yearly	186 - 190	01-07-2045	01-07-2050	✓
	Ten year	191 - 195	01-07-2050	01-07-2100	✓
	20 year	196	01-07-2100	01-07-2120	✓
	25 years	197	01-07-2120	01-07-2145	✓
	200 years	198	01-07-2145	01-07-2345	✓
	400 years	199	01-07-2345	06-02-2745	✓

4.7.5 Predictive Results

As reviewed in **Section 6.5.2**, resulting differences for water levels between Scenarios 1 and 2 are only visible in the immediate vicinity of the K2E void and do not have any notable impacts on water levels within the source areas and predicted CoC concentrations. Therefore, the results are only presented for Scenario 1 but can be assumed by the reader to be same for Scenario 2.

Predicted concentrations of CoCs with time shows that that near equilibrium is reached after 700 years, as illustrated for sulfate on **Figure 53**. Although some bores are still showing increasing concentration after 700 years, this is attributed to the modelling assumption that sources of potential contamination have a constant concentration (still active at 100% potential after 700 years) and assumes no natural attenuation or decay is occurring. It is acknowledged that this is highly unlikely to occur.

The spatial distribution of CoCs concentration after 700 years is presented on concentration contours maps for each CoC in **Appendix D**. The maps show that migration of CoCs within the site aquifers is likely to be mostly contained within the mining lease. As shown for Sulfate on **Figure 54**:

- CoC migration from K2W and K2WN is limited in extent and moves toward (but does not reach) final void K2E.
- CoC migration from K4S is approximately 1km from the source toward the K4E final void and in direction of the K2E final void.
- CoC migration from K2W TSF is approximately 700m from the source toward the northern mine lease boundary.
- CoC migration from K2 TSF is approximately 700m from the source toward Black Creek and 500m toward the northern mine boundary.
- CoC migration from the northern area is approximately 400 m toward Meandu Creek.

CoC concentrations above source concentration are shown within area previously identified as “Shallow Water Table” (refer to **Section 6.5.2 Figure 92**). This is due to evaporation simulated in the model where the groundwater level is within 2 m of the surface. Evaporation “removes” water from the model but not mass, leading to an accumulation of CoC mass in these areas.

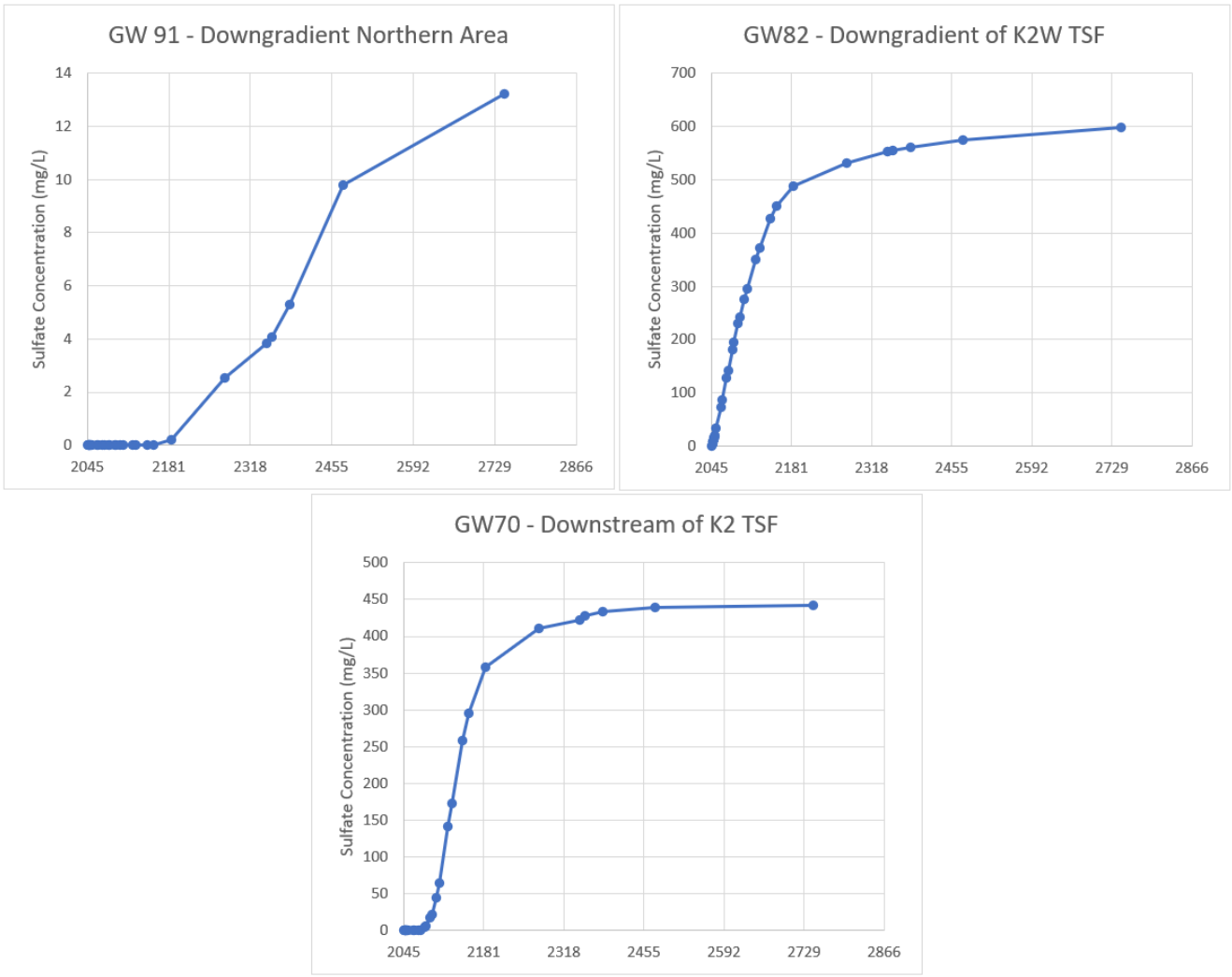

Figure 53 Sulfate Concentration Time Series for GW91, GW82 and GW70



Figure 54 Sulfate Concentration 700 Years Post Closure

The model indicates that some mass will be transferred to surface water through baseflow at Meandu Creek adjacent to the mine from the toe of Hitachi Hill. Baseflow contaminant concentrations equal to approximately 90% of source concentration are predicted for each CoC (**Table 32**). Baseflow to Meandu Creek is estimated at a constant level of 0.01 ML/d (3.65 ML/annum).

Table 32 Estimated Baseflow Concentration (Meandu Creek Adjacent to Mine)

Contaminant Source	Estimated Baseflow Concentration
EC (µS/cm)	3,014
Sulfate (mg/L)	764.10
Aluminium (mg/L)	<0.01
Cobalt (mg/L)	0.29
Iron (mg/L)	43.90
Manganese (mg/L)	36.40
Nickel (mg/L)	0.20
Zinc (mg/L)	0.52
Selenium (mg/L)	<0.01
Vanadium (mg/L)	<0.01
Molybdenum (mg/L)	<0.001

4.7.6 Limitations

The following limitations have been identified in relation to the contaminant transport modelling:

- There is inherent uncertainty around the location, spatial extent and CoC concentrations of current and future contaminant sources. In the model, large areas have been used as potential sources to assess potential risk of CoC migration. However, sources are likely to be more localised and smaller in size.
- The contaminant transport boundary conditions and parameters are conservative from a risk to Environmental Values (EVs) perspective. They do not account for source decay or natural attenuation. Source decay and natural attenuation will vary based on the CoC, the characteristics of sources and the contaminant flow pathway. Additional studies on individual source areas could be undertaken to assess potential decay and attenuation.
- Background concentration of CoC have not been included in the model. It is assumed that source concentrations for CoC are greater than background concentrations enough such that background concentration may be ignored. In some situations, this assumption may underestimate final concentrations by overestimating dilution of source concentrations.

5 Water Management

5.1 Description of Contaminants of Concern

5.1.1 Groundwater

Metals and metalloids indicative of AMD or ash seepage were evaluated by WSP (2018). The dissolved metal contaminants of concern due to mining activities that were identified are arsenic, boron, cobalt, iron, manganese, molybdenum, nickel selenium vanadium and zinc.

Specific areas of concern associated with potential contaminants are shown in **Figure 55** and are described as follows:

- The North-West Backfilled pit is the only area where AMD impacted seepage expresses at the surface. Surface expression occurs at Bullgang Corner and Ramp 7 (JBT, 2018a). The sources of AMD have been identified in WSP (2018) as likely from "*the oxidation of sulfide minerals placed (predominantly) into RSA1 from circa 1986 to 1995"* and *"the oxidation of sulfide minerals in rejects that have been emplaced (and left open to atmospheric conditions for more than six months) into the North-West Backfilled Pit".*
- The salinity plume extending from the QWBV towards Meandu Creek has been assessed by SLR (2020). Contamination sources are unclear at this stage and may be linked to natural conditions and/or saline discharge from water infiltrating through the spoil.
- An area within the Black Creek catchment in the northern area of the Mining Lease recorded elevated EC, aluminium, zinc and low pH (WSP, 2018). The potential source of contaminants within the Black Creek catchment may be derived from mine impacted areas (i.e. spoil or tailings of the K2E area), from areas that are unimpacted by mining to the east (i.e. natural drainage lines that drain the ridgetop basalt) or from the area of the Tarong Power Station (JBT, 2018a). This area is under further monitoring and investigation.

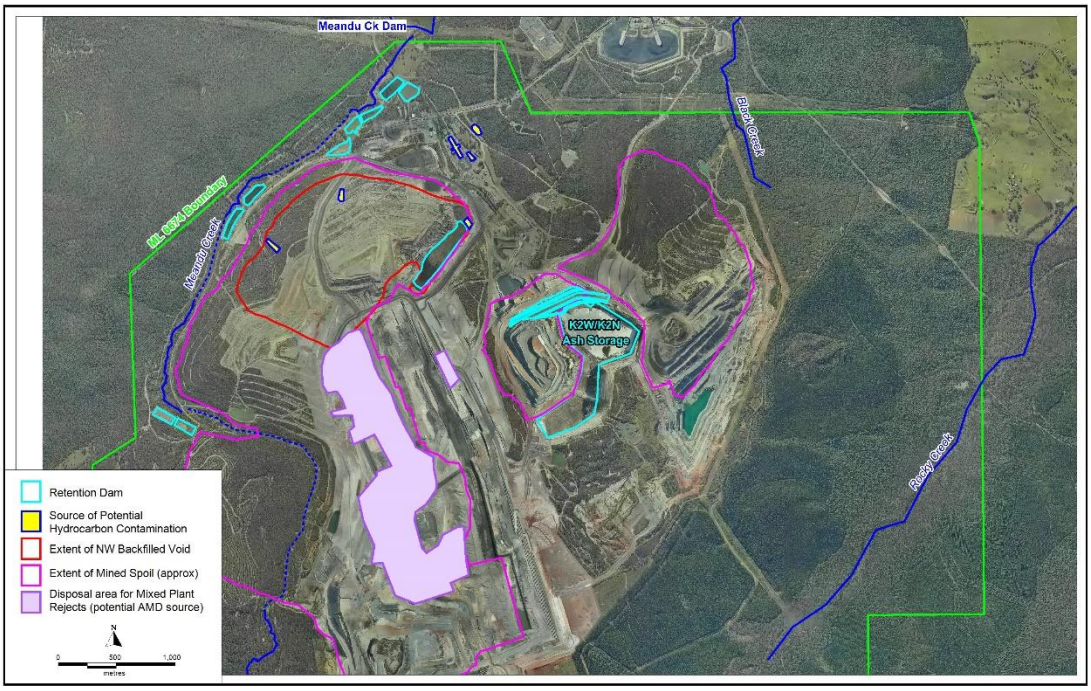

Figure 55 Sources of Potential Contaminants to Groundwater (Stanwell, 2020)

5.1.2 Seepage

Contaminants of concern measured at the groundwater seepage expressions monitored at Ramp 7 and Bullgang drain are sulfate as well as the following dissolved metals: aluminium, cobalt, manganese, nickel, zinc and iron.

5.1.3 Surface Water

5.1.3.1 Background

Predicted concentrations of contaminants of concern (CoC) in surface water was assessed in the Integrated Water Balance Model (IWBM) that was developed for the PRCP. The purpose of the IWBM was to represent the surface water system of the mine and to be used to characterise the long-term water levels and water quality of surface water discharged from site.

5.1.3.2 Modelling Basis

The IWBM was based on the model developed by Golder (2018) and was updated for use in the PRCP IWBM to reflect conditions at closure. Australian Water Balance Model (AWBM) parameters that were calibrated in WSP (2021) were adopted in the IWBM. The IWBM catchments were based on the final landform designs. Catchments were classified as either spoil rehab (rehabilitated spoil), or natural. Catchments and receiving environment monitoring points are shown in **Figure 56.** The IWBM was run to simulate a period of 120 years.

CoCs were selected based on being representative of potential sources as well as general water quality indicators. Concentrations of CoC adopted for each contaminant source used the 80th percentile or maximum value of groundwater data as detailed **Table 28**.

5.1.3.3 Scope of Modelling Task

The IWBM task included the following tasks:

- Updated the IWBM developed to represent the surface water system at and after the closure Meandu Mine to include the predicted seepage from groundwater modelling;
- Developed probabilistic climate data for the WBM based on daily time series climate data. Probabilistic rainfall data was produced for 500 replicates of 120 year rainfall data (60,000 years of probabilistic data), allowing for a wide range of climatic conditions to be simulated. The assessment yields percentiles which are interpreted as a percentage exceedance probability (i.e. the risk of an event occurring). The results of the WBM focus on 10th/50th/90th percentile. This is for the dry, median and wet climatic conditions.
- Characterised the long-term water levels and quality of the proposed final voids K2E and K4E for the 10%, 50% and 90% climate; and
- Identified and reported on the predicted water quality and water quantity at compliance points CP1, CP2 and CP3 (**Figure 56**) as well as at the proposed final voids K2E and K4E for the 10th, 50th and 90th percentiles.

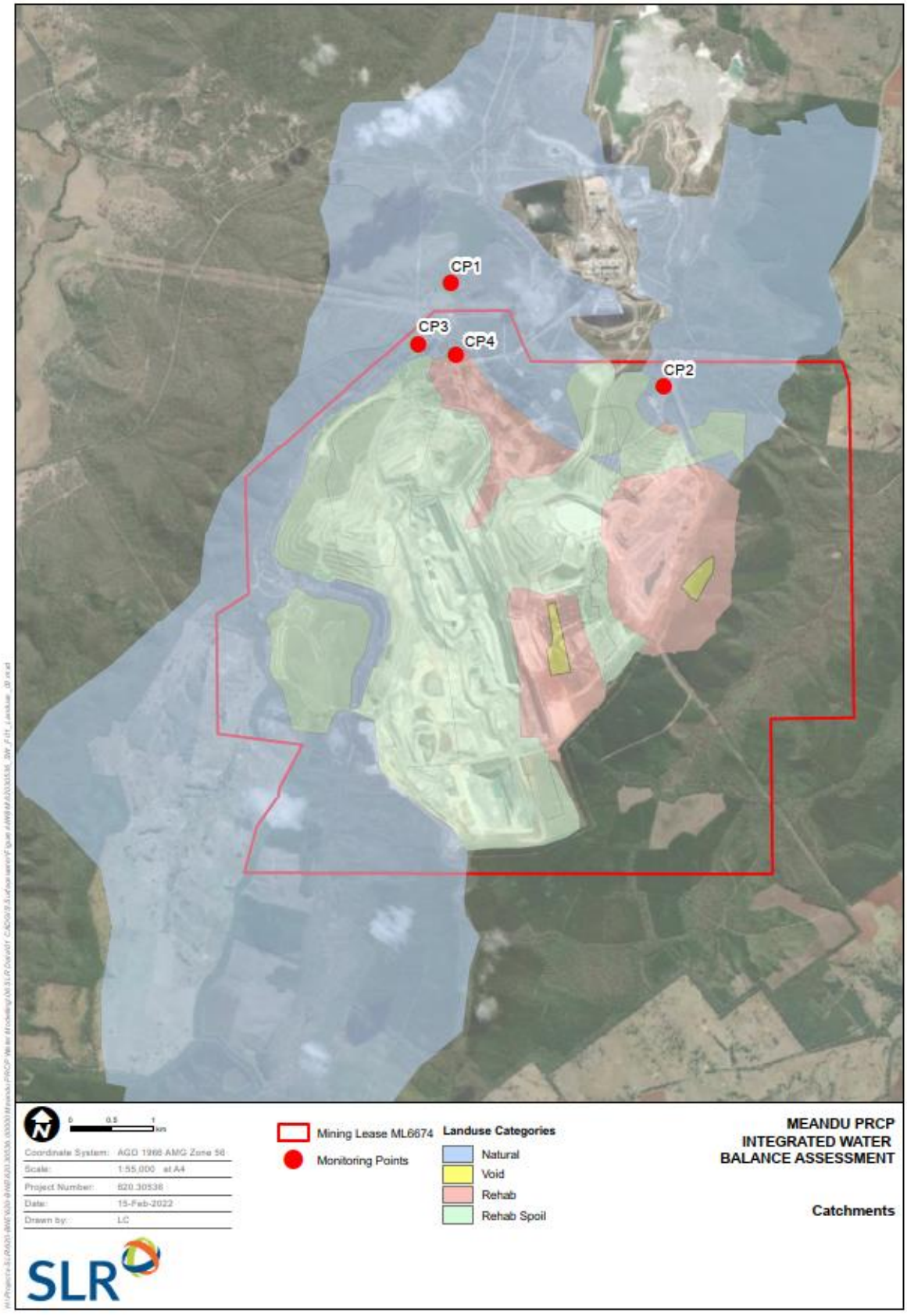

Figure 56 IWBM Catchments

5.1.3.4 Contaminants of Concern

The predicted concentrations of CoC at key points of interest are shown on **Figure 57** through to **Figure 66**. The water quality results showing the 10th, 50th and 90th percentile results for each analyte over the 120-year simulation are summarised in the following graphs with full tabulated results provided in **Appendix E**. Where available, trigger values for slightly to moderately disturbed and highly disturbed aquatic ecosystems (ANZECC/ARMCANZ, 2000) are indicated on the graphs for context of contaminant levels.

The results show that concentrations for all analytes are typically highest at CP3 and lowest at Meandu Creek Dam. This is predominately due to seepage which occurs from the Northwest Backfilled Void (NWBV). Seepage to a lesser degree occurs upstream of CP2 and therefore has a lesser impact on elevated contaminant concentrations. Although elevated concentrations are modelled for CP2 and CP3, they are diluted once they enter Meandu Creek Dam, where concentrations are considerably less.

Whilst contaminant concentrations are input to the model at a constant rate, the highest concentration of CoC (90%) occurs during periods of very low flow when there is minimal dilution of baseflow groundwater seepage from NWBV. Specific behaviour of changes in concentration at monitoring locations CP2 and CP3 and Meandu Creek Dam are provided below.

- Meandu Creek Dam – peaks in concentration of CoC occur at a similar time to the peak volumetric inflow into Meandu Creek Dam as a result of a flushing effect of the concentrated pooled water.
- CP2 – less direct relationship to flow. Baseflow from groundwater expressing to surface dominates concentration generally, however flow events can result in an initial spike (due to creek “flushing” of accumulation) and then dilution of CoC.
- CP3 – the base flow seepage dominates the concentration of CoC with surface water runoff events resulting in a dilution of CoC.

Importantly it is noted that the loading of CoC from runoff (including surface and baseflows) is assumed static over the entire 120-year simulation period. This is a conservative assumption as the concentration of many of these contaminates would be expected to decay as they are leached from the material and rehabilitation improves overall water quality. Future modelling could be undertaken to consider this in the predictions. Data from water quality drainage studies of rehabilitated land would be required to support development of such decay relationships.

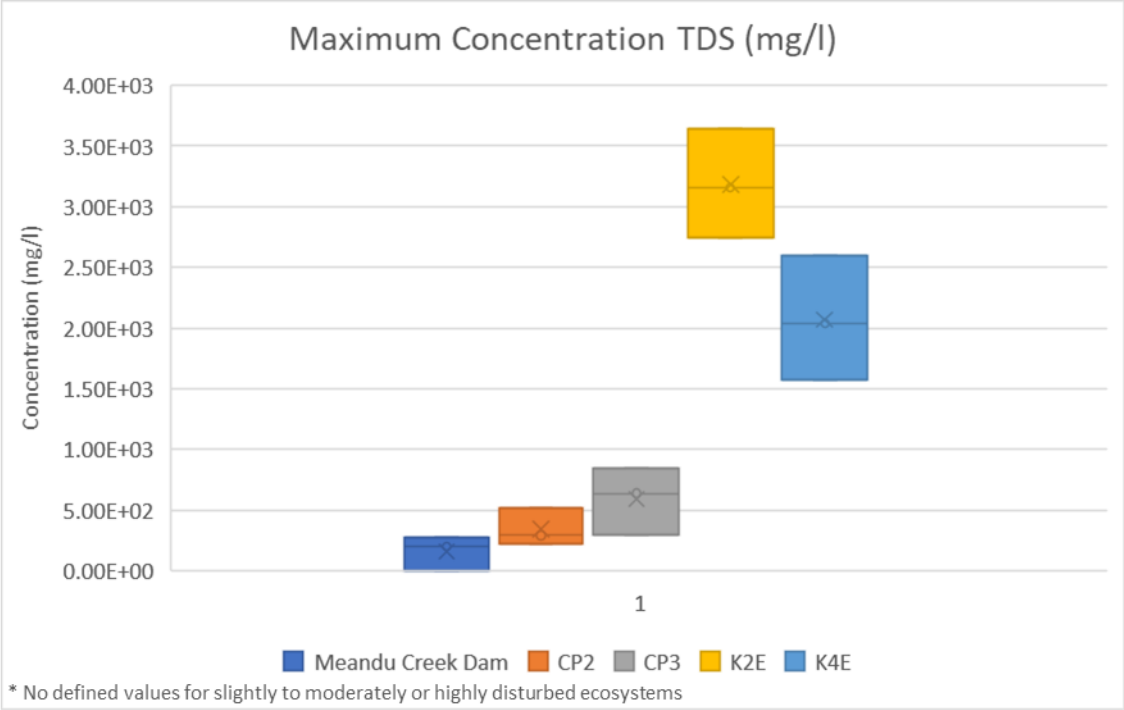

Figure 57 10th, 50th, 90th Percentile results for Total Dissolved Solids

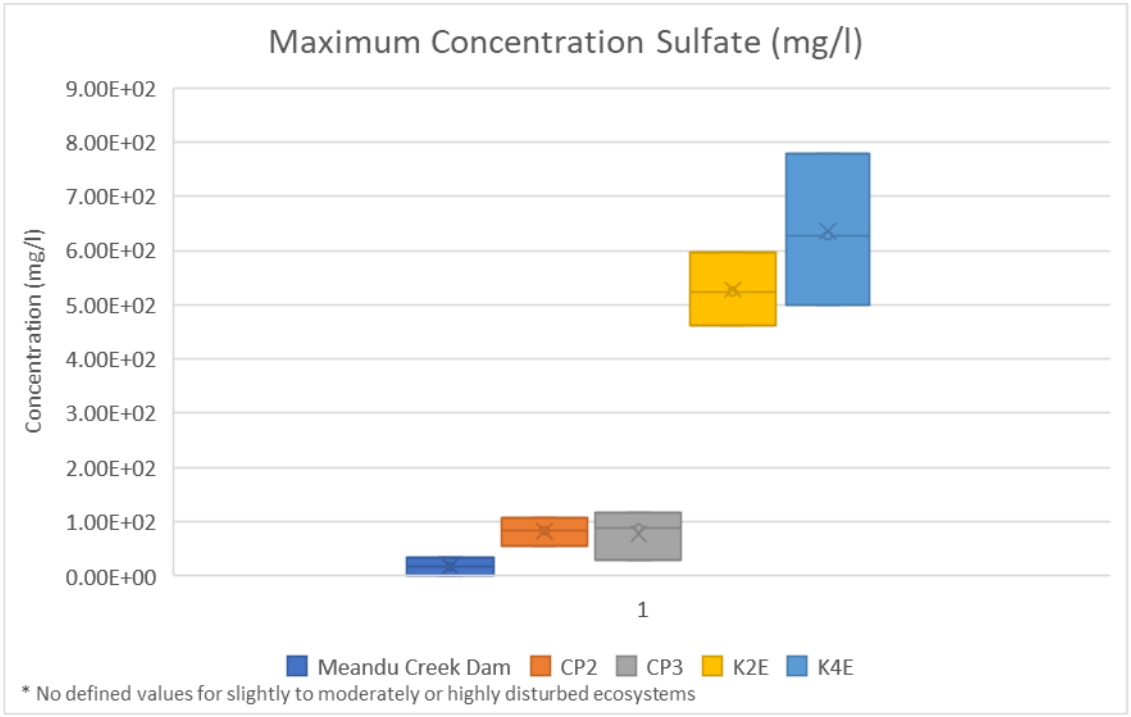

Figure 58 10th, 50th, 90th Percentile results for Sulfate

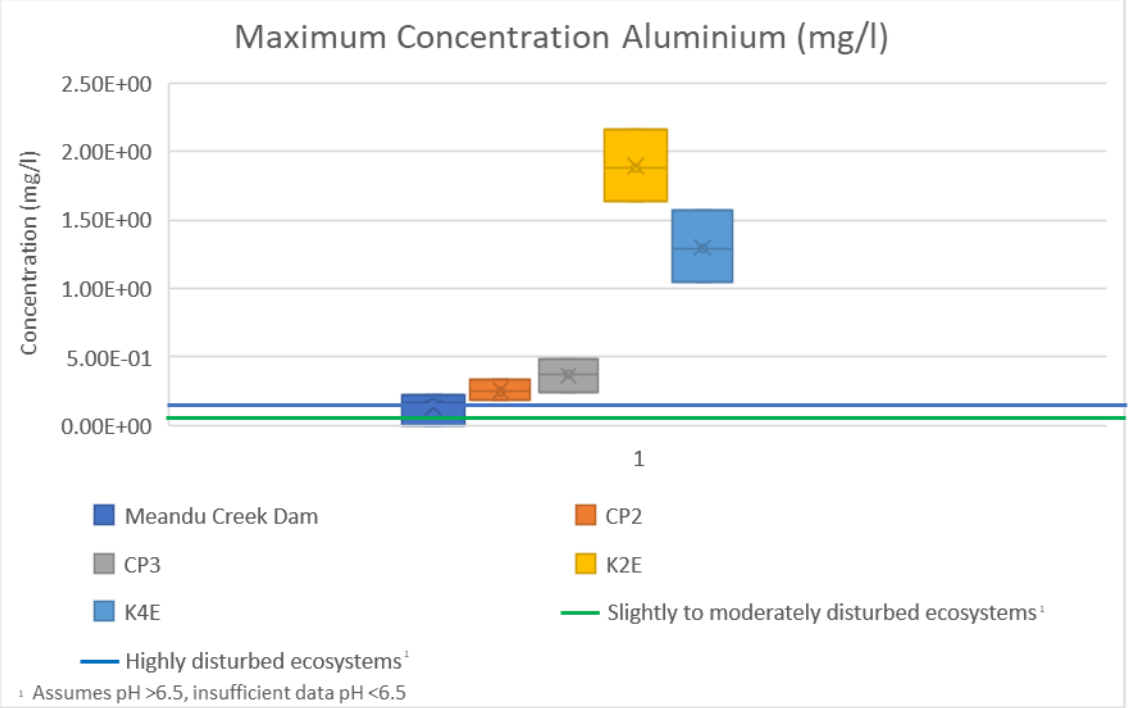

Figure 59 10th, 50th, 90th Percentile results for Aluminium

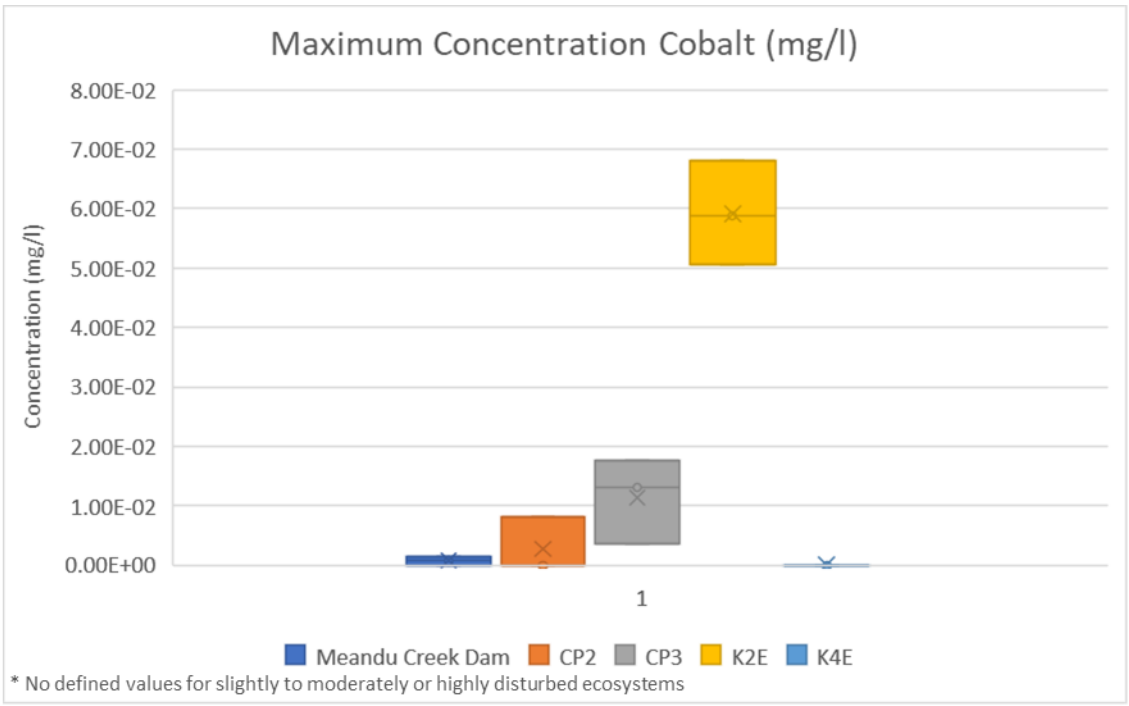

Figure 60 10th, 50th, 90th Percentile results for Cobalt

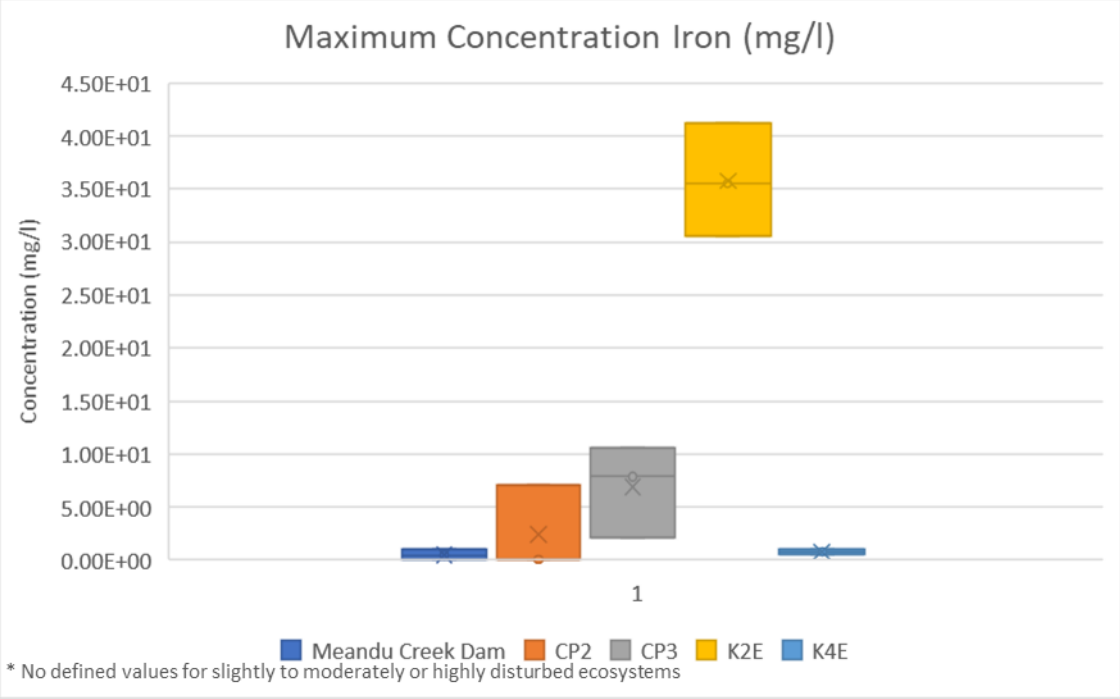

Figure 61 10th, 50th, 90th Percentile results for Iron

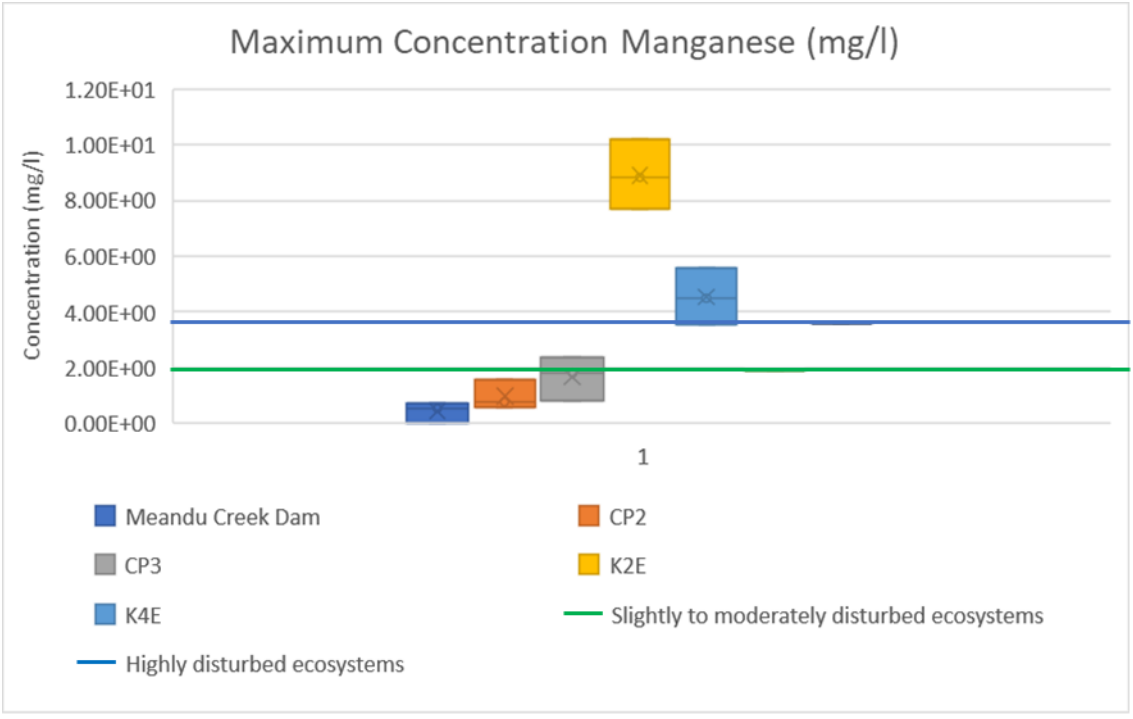

Figure 62 10th, 50th, 90th Percentile results for Manganese

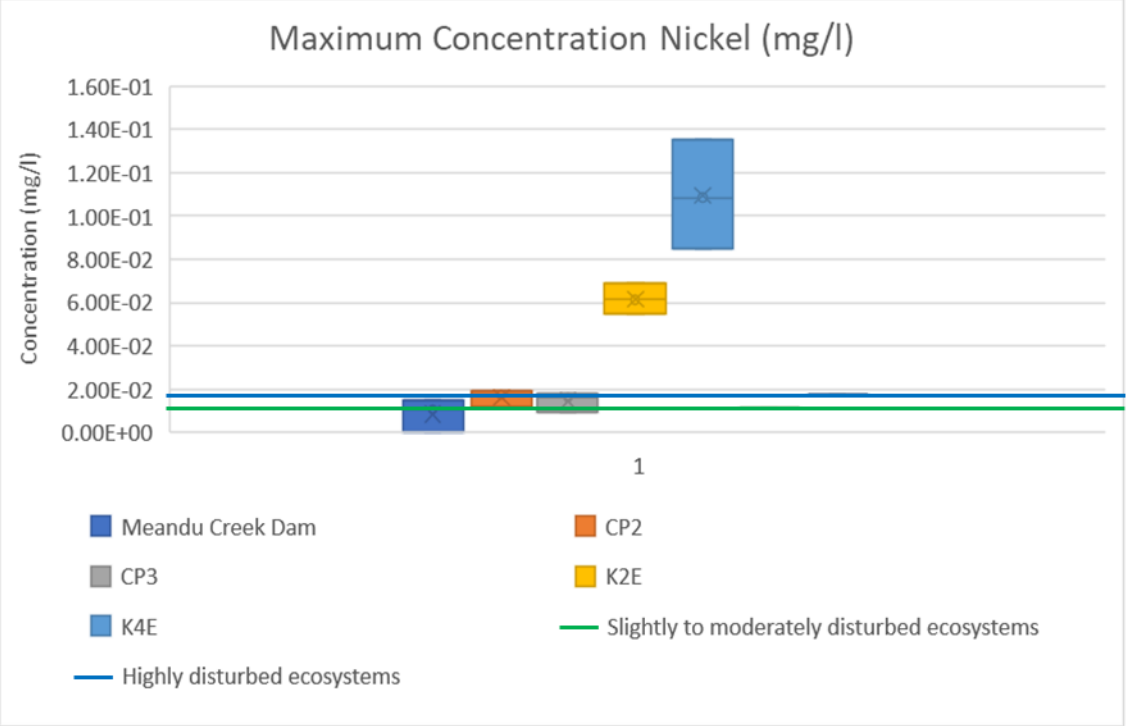

Figure 63 10th, 50th, 90th Percentile results for Nickel

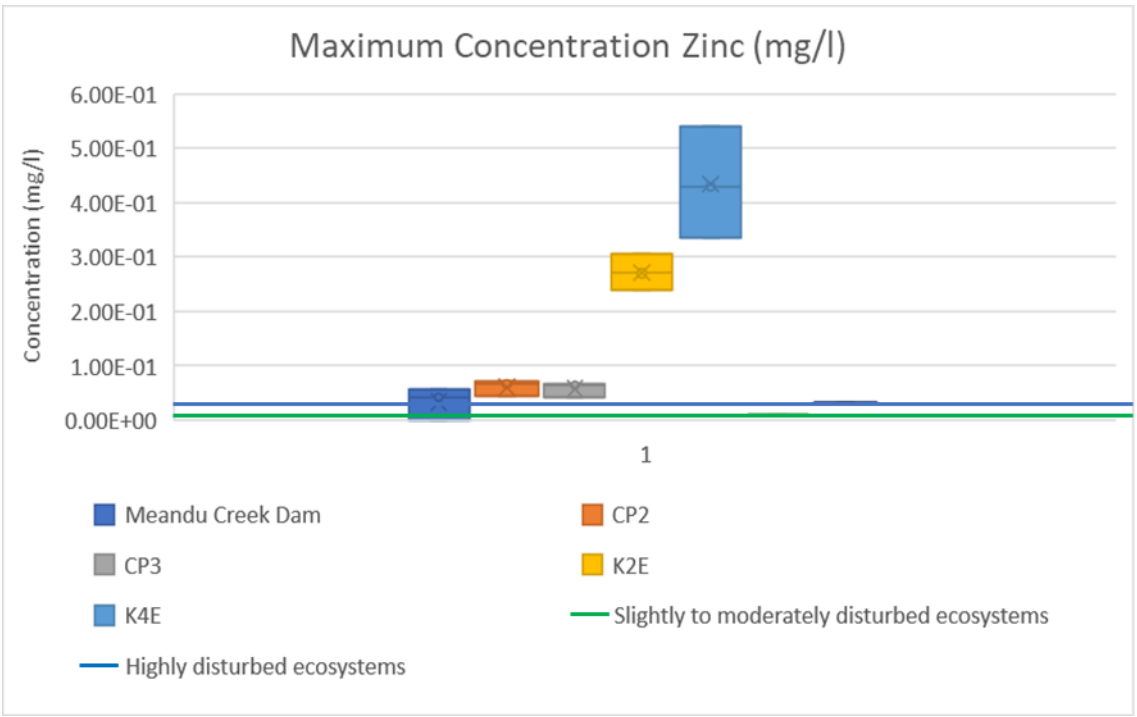

Figure 64 10th, 50th, 90th Percentile results for Zinc

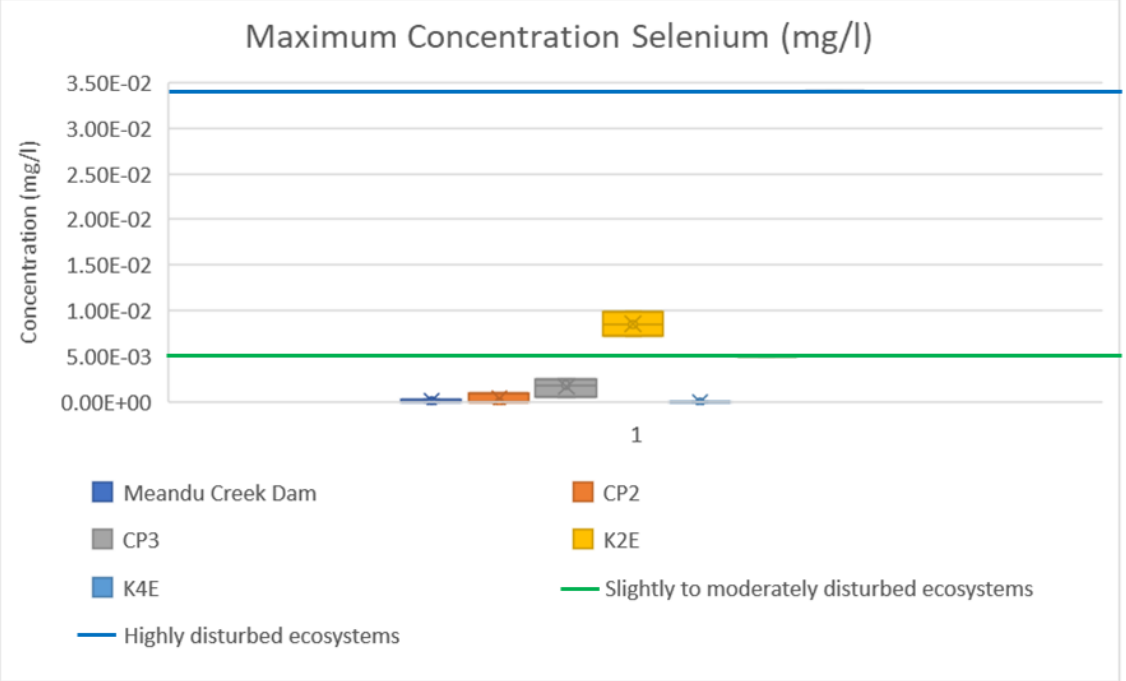

Figure 65 10th, 50th, 90th Percentile results for Selenium

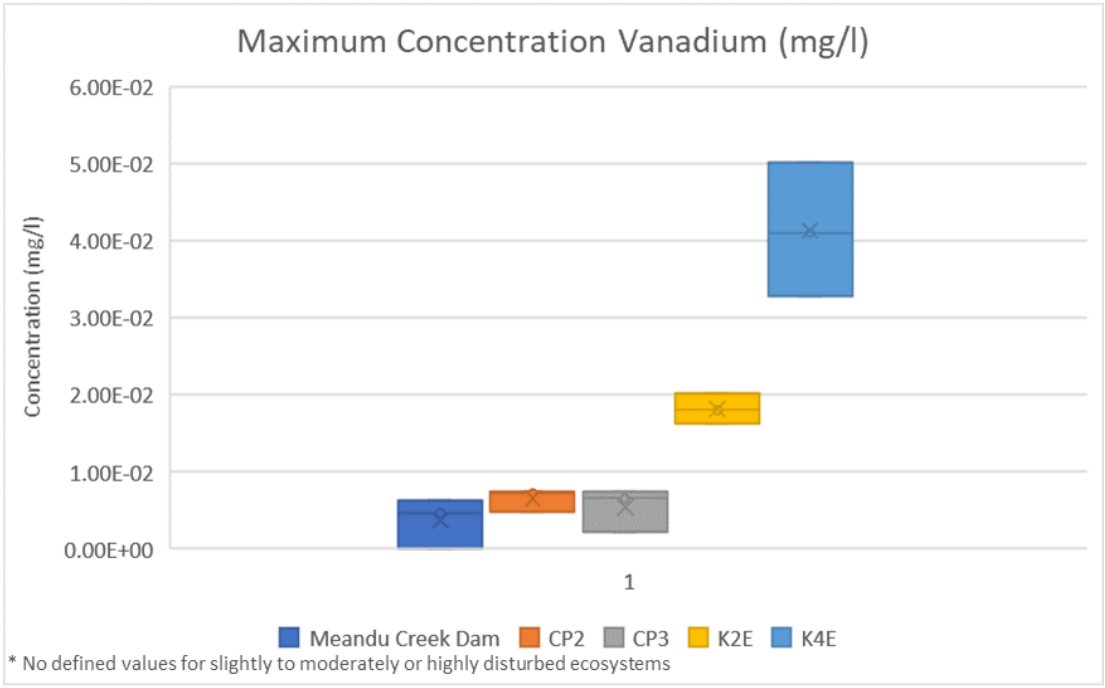

Figure 66 10th, 50th, 90th Percentile results for Vanadium

5.1.3.5 Limitations

The purpose of the IWBM is to integrate the modelling the hydrogeological and surface water modelling to provide an integrated prediction of water quality and quantity to support further assessment by others. The model provides predictions of potential concentrations of CoCs reporting to the surface water runoff and void waterbodies.

In preparing this report, SLR has relied upon and assumed accurate information which was received from the client and other sources. Except where noted, no verification of accuracy of the information has been carried out. In the event that some of the information which was relied upon for this assessment is found to be inaccurate, then some or all of the findings may change.

This report has been prepared to provide information which can be used to support a Progressive Rehabilitation and Closure Report. This report should be read in full and no excerpts are to be taken as representative of the findings. This report has been prepared on behalf of SCL and we accept no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

A number of assumptions have been made to inform the development of the IWBM. These assumptions are generally considered conservative. Further studies are required to refine the model inputs, assumptions and improve model accuracy. In particular it is noted that the generation of contaminants from rainfall runoff over different AWBM Surface land uses types as well as groundwater baseflow was assumed to be constant over the entire 120 year simulation. This is a conservative assumption as the concentration of many of these contaminates would be expected to decay as they are leached from the material and rehabilitation improves overall water quality. This is due to lack of data to support any assumptions around decay of materials and reduced concentrations over time. This differs from modelling in the Operational IWBM which considered changes to the concentration load due to progressive dumping.

5.2 Source, Pathway and Fate of Contaminants

5.2.1 Potential Sources of Contaminants

The Meandu Mine Receiving Environment Monitoring Program (REMP) has been reviewed to identify potential sources of contamination from mining activities. Potential contaminant source locations are shown on **Figure 67** and summarised in **Table 33**.

Table 33 Potential Sources of Contamination, Contaminants of Concern and Receiving Waters (Adapted from Stanwell, 2020b)

Source Location	Potential contamination issue	Contaminant of concern	Receptor locations	Receiving Waters
K2W/K2N ash storage facility	Ash-impacted seepage from the storage facility	Sulfate, fluoride, arsenic, boron, molybdenum, selenium, vanadium	Underlying and adjacent groundwater systems	Groundwater
NW backfilled void	AMD	EC, pH, sulfate, cobalt, iron, manganese, nickel and zinc.	Underlying and adjacent groundwater system, particularly the area to the west of NWBV adjacent to Meandu Creek	Groundwater
NWB tailings storage facility	Saline drainage; metalliferous drainage	EC, TSS (Total Suspended Solids), minerals, metals	Underlying and adjacent groundwater systems	Groundwater

Source Location	Potential contamination issue	Contaminant of concern	Receptor locations	Receiving Waters
Mixed Plant Rejects	Saline drainage; metalliferous drainage; AMD	EC, TSS, minerals, metals	Underlying and adjacent groundwater systems; Meandu Creek Diversion; dams via runoff.	Groundwater / Surface Water
Areas of waste rock (spoil) dumps, both in-pit and out-of-pit storage	Saline drainage; metalliferous drainage	EC, TSS, minerals, metals/metalloids	Underlying and adjacent groundwater systems; Meandu Creek Diversion; dams via runoff.	Groundwater / Surface Water
Current and former hydrocarbon storage facilities (including historic in-pit hydrocarbon dumps and current bioremediation areas)	Hydrocarbon impacted seepage	Hydrocarbon	Underlying and adjacent groundwater systems; Meandu Creek Diversion; dams via runoff	Groundwater / Surface Water
In proximity to QW backfilled void	Saline drainage	EC	Shallow regolith along a natural drainage line towards retention dams RD1 and RD2	Groundwater
Area within the Black Creek catchment	Saline drainage; metalliferous drainage; AMD	EC, TSS, minerals, metals/metalloids	Shallow regolith along natural drainage lines toward RD17	Groundwater
Coal and coal rejects stockpiles	Runoff and leachate	pH, metals/metalloids and dissolved salts such as sulfate, chloride and major cations	CP2 - located on Black Creek CP3 - Meandu Creek channel; CP4 - located on a tributary that runs into Meandu Creek dam;	Surface Water
Tailings	Runoff and leachate	Metals/metalloids and dissolved salts such as sulfate, chloride and major cations		
Ash storage and ash slurry pipelines	Runoff and leachate	Sulfate, fluoride, metals/metalloids		
Pit water (accumulate from storm activity and groundwater seepage)	Runoff and leachate	EC, pH, metals/metalloids		
Haul roads and mine access roads	Runoff and leachate	TSS, hydrocarbons, coal fines.		
Retention dams, dirty water diversion channels/pipes	Uncontrolled releases	metals/metalloids, oil and grease, surfactants, petroleum hydrocarbons and dissolved salts such as sulfate, chloride and major cations.		
Spoil areas, stripped topsoil and newly rehabilitated areas	Runoff and leachate	May result in sediment-laden and/or saline runoff.		

Source Location	Potential contamination issue	Contaminant of concern	Receptor locations	Receiving Waters
Industrial (machinery workshops, large hardstand areas and the coal preparation plant)	Runoff and leachate	Hydrocarbons		
Explosives storage facility	Runoff	Ammonium nitrate	Orica Dam or Tip Dam	Surface Water

5.2.2 Identified Sources/Area of Concerns

Identified sources of contamination are shown on **Figure 67** and are summarised in the following sections.

5.2.2.1 AMD Seepage from NWBV

The North-West Backfilled Void is the only area where AMD impacted seepage has historically expressed at the surface. Surface expression occurred at Bullgang Corner and Ramp 7 (JBT, 2018a). The sources of AMD have been identified in WSP (2018) as likely from "*the oxidation of sulfide minerals placed (predominantly) into RSA1 from circa 1986 to 1995"* and *"the oxidation of sulfide minerals in rejects that have been emplaced (and left open to atmospheric conditions for more than six months) into the North-West Backfilled Pit".* Seepage has, since late 2021, been significantly reduced as a result of groundwater dewatering from NWBV to achieve target water RL of 432.7m. Additionally, ongoing water quality analyses, from the dewatering bores, shows continual improvement (e.g. pH 5.5 to 6.8 and SO_4^{2-} in the range of ~ 800 mg/L).

5.2.2.2 QWBV Salinity Plume

A salinity plume extending from the QWBV, towards Meandu Creek, has been assessed by SLR (2020). Contamination sources are unclear at this stage and may be linked to natural conditions and/or saline discharge from water infiltrating through the spoil. Ongoing monitoring of additional groundwater monitoring bores has shown that the plume is relatively static.

5.2.2.3 Black Creek Catchment Salinity Plume

An area within the Black Creek catchment, in the northern area of the Mining Lease, recorded elevated EC, aluminium, zinc and low pH (WSP, 2018). The potential source of contaminants within the Black Creek catchment may be derived from mine impacted areas (e.g. spoil or tailings of the K2E area), from areas that are unimpacted by mining to the east (i.e. natural drainage lines that drain the ridgetop basalt, or plantation forestry activities to the east)). This area is under ongoing monitoring and investigation.

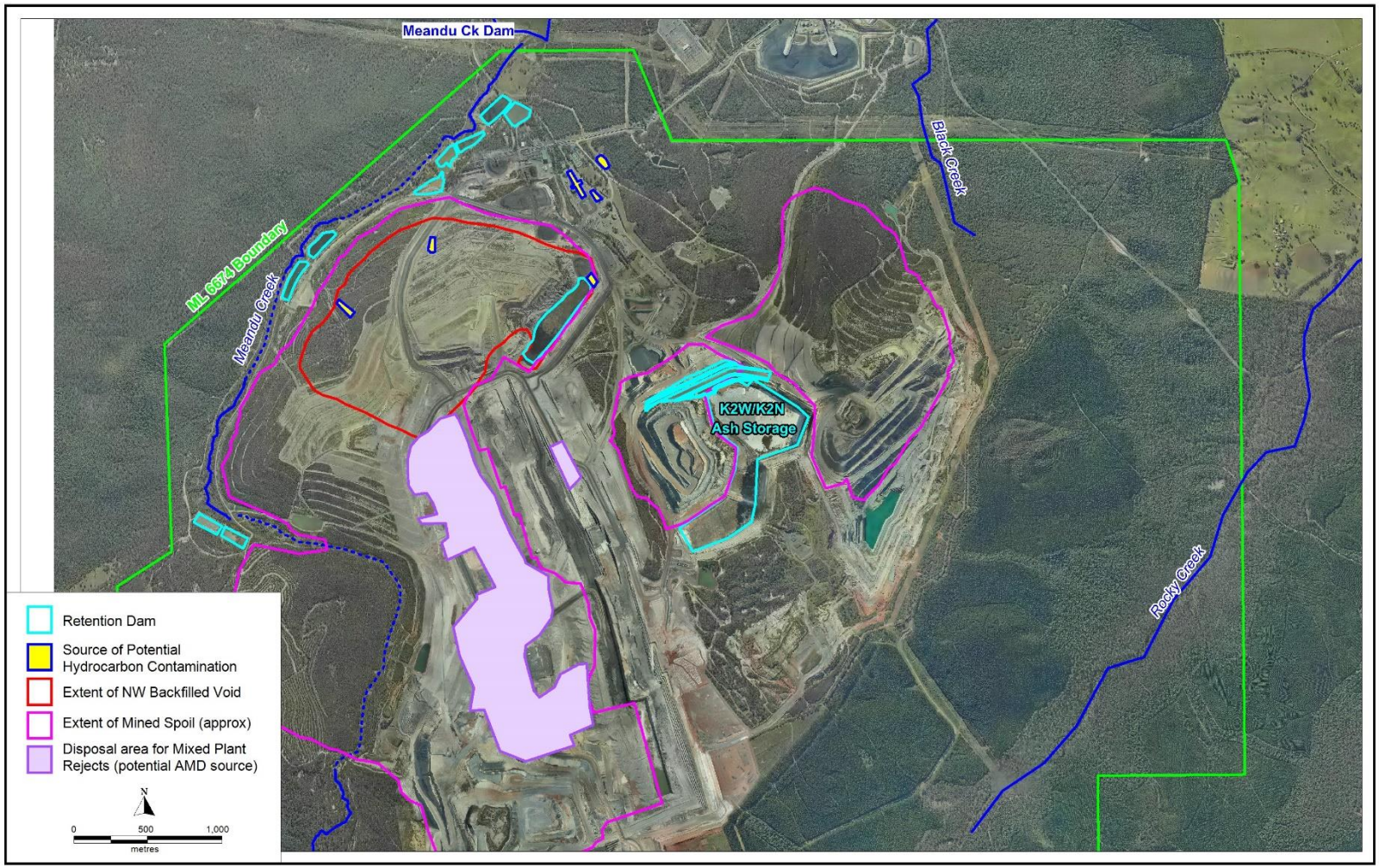

Figure 67 Sources of Potential Contaminants to Groundwater (Stanwell, 2020)

5.2.3 Receptors and Pathways

5.2.3.1 Receptors and Potential Seepage Pathways

Meandu Creek (adjacent to Meandu Mine) and Meandu Creek dam are the main ecological receptors at the Mine. It is noted that these receptors are differentiated from Meandu Creek upstream of the surface right area (upgradient of the mine) and Meandu Creek downstream of Meandu Creek dam (hydraulically separated from the mine waters by Meandu Creek dam).

The likely seepage pathways identified at the Mine are:

- Groundwater seepage via voids from either the natural ground surface or the deepest mined surface (WSP, 2018).
- Seepage from spoil filled voids that occurs when the water level in the spoil rises to a level where seepage from the void is possible via topographic low points (e.g. pre mining drainage channels or haul roads into the pit) (WSP, 2018).
- Seepage from spoil that has been dumped out of the pit, which tends to follow topography (WSP, 2018).

5.2.3.2 AMD Seepage from NWBV

Meandu Creek (upstream of Meandu Creek dam) is the receiving environment/receptor of concern for waters to be (potentially) impacted by seepage waters originating from the NWBV (JBT, 2018a). As shown on **Figure 68**, the Queen Seam (the lowest seam mined at Meandu Mine) does not exist beneath Meandu Creek to the west of the mining area and the sediments of the Tarong beds cease upstream of Meandu Creek dam. This limits the hydraulic connectivity between the mined seams and Meandu Creek alluvium. Groundwater gradients are toward Meandu Creek dam, which exert control onto water levels in the surrounding alluvium. It is thus inferred that shallow groundwater seepage in the regolith entering Meandu Creek alluvium will report to Meandu Creek dam. It is noted that no evidence of adverse impacts from seepage waters from the NWBV to Meandu Creek were found as part of the EE (WSP, 2018).

Specific pathways, related to the seepage waters from the NWBV, are identified on **Figure 34**. They have been reported by WSP (2018) as:

- Prior drainage channels (e.g. at Bullgang Corner) underneath filled areas. Seepage has been observed at the base of the spoil at Bullgang Corner.
- Western NWBV area. Diffuse seepage where the remnant natural material forms a relatively thin barrier to seepage (**Figure 69**).

The spoil saturation is inferred to originate from direct rainfall infiltration and seepage from the NWB tailings void. Remediation efforts are ongoing with initial 2m capping commenced in November 2021 and expected to be completed within approximately two years.

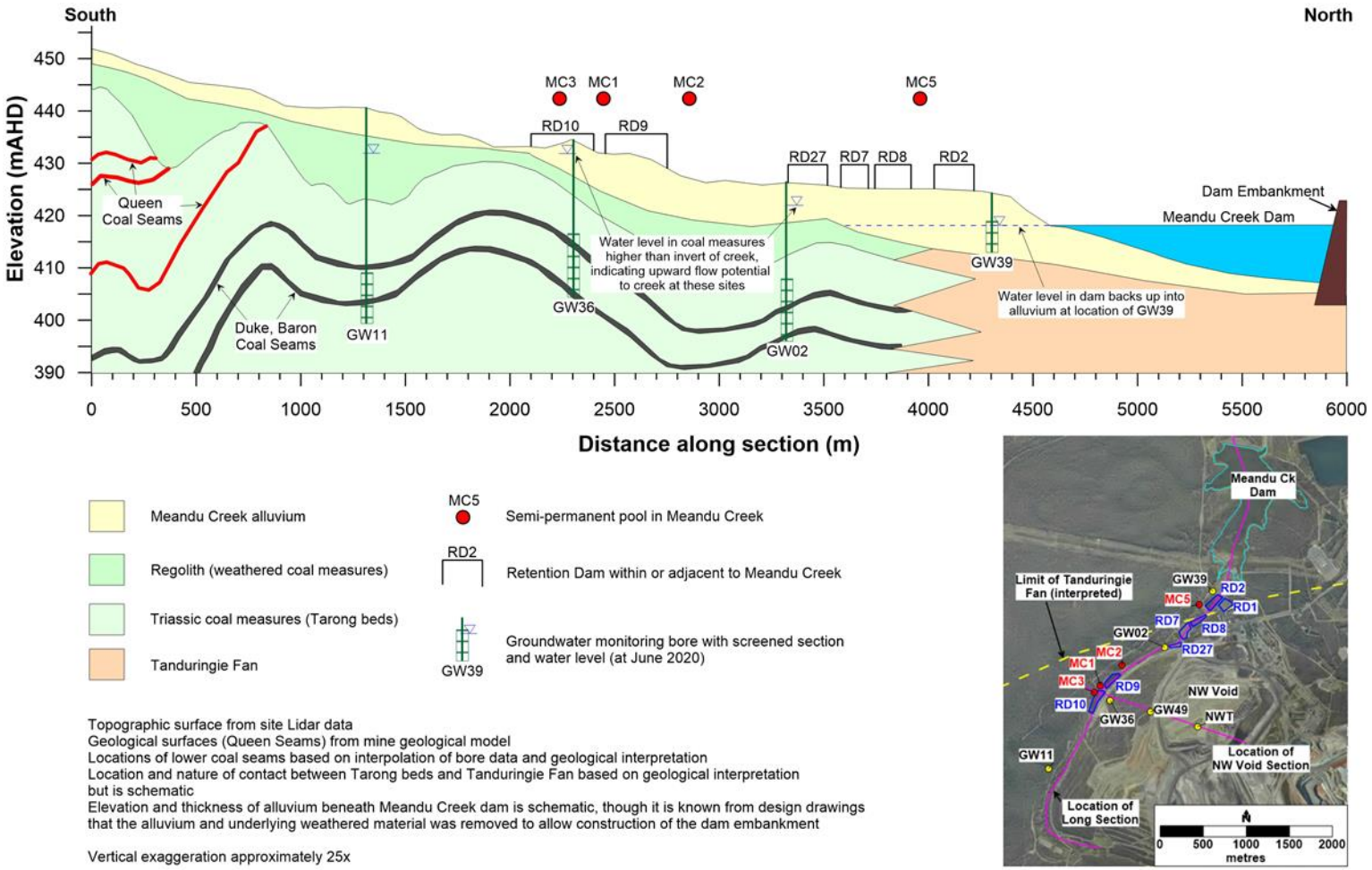

Figure 68 South -North (Long) Section along Meandu Creek to Meandu Creek dam (Stanwell, 2020b)

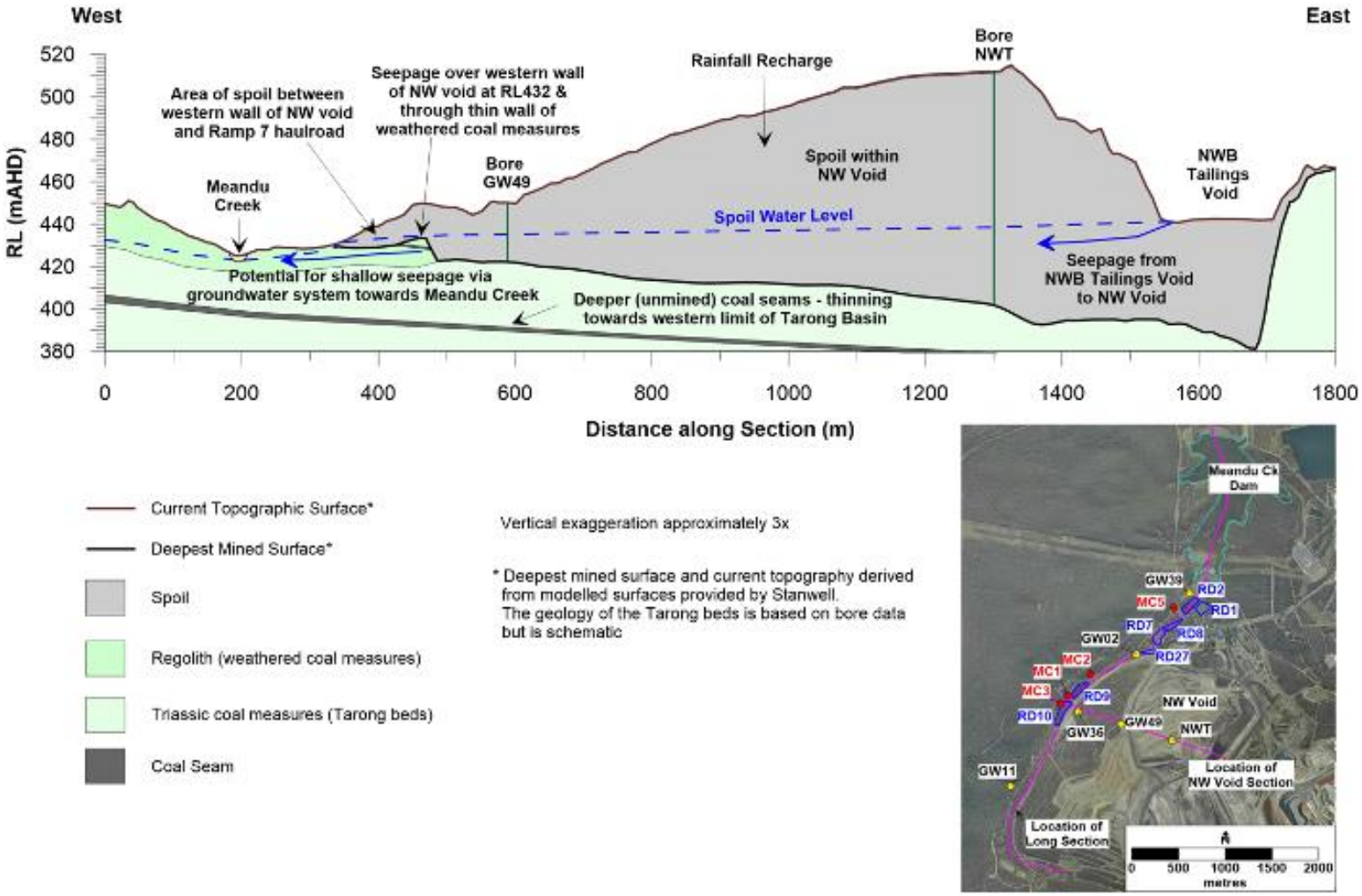

Figure 69 West - East Section through NW Backfilled Void (Stanwell, 2020b)

5.2.3.3 QWBV Salinity Plume

Meandu Creek (adjacent to Meandu Mine) is also the receiving environment/receptor for the saline plume, originating in the vicinity of the QWBV, if the plume were to ever reach Meandu Creek. Specific pathways related to the QWBV salinity plume have been reported by SLR (2020) as regolith associated with a natural drainage channel running south to north towards retention dam RD4 in the direction of Meandu Creek. The migration pathway is also south to north in direction of groundwater flow (**Figure 70**).

As described in Section **5.2.3.2**, it is inferred that shallow groundwater seepage in the regolith entering Meandu Creek alluvium will report to Meandu Creek dam. The risk of harm to EVs from the saline plume have been identified as extremely low as the plume has been interpreted to move very slowly (SLR, 2020) and of which may never reach Meandu Creek dam. This is being monitored routinely.

5.2.3.4 Black Creek Catchment Salinity Plume

Black Creek is the receiving environment receptor for the saline plume identified around K2E and RD17. Specific pathways related to the salinity plume and area within Black Creek catchment have been reported by WSP (2018) as likely regolith associated with a natural drainage channel running south to north towards RD17.

During the operational life of the mine and power stations, the surface water from Black Creek dam is captured and used at the power stations and hence the EV identified for this catchment is “industrial use”. The waterway has been de-gazetted. At closure (following mine rehabilitation), the discharge from Black Creek will continue to report to the Black Creek dam and to Meandu Creek (only) during significant surface water flow events. The functionality of this final surface water system will be determined following completion of the Tarong Power Stations rehabilitation and closure plan). At this point in time, the WQOs would need to meet the aquatic ecosystem EV for the downstream receiving environment.

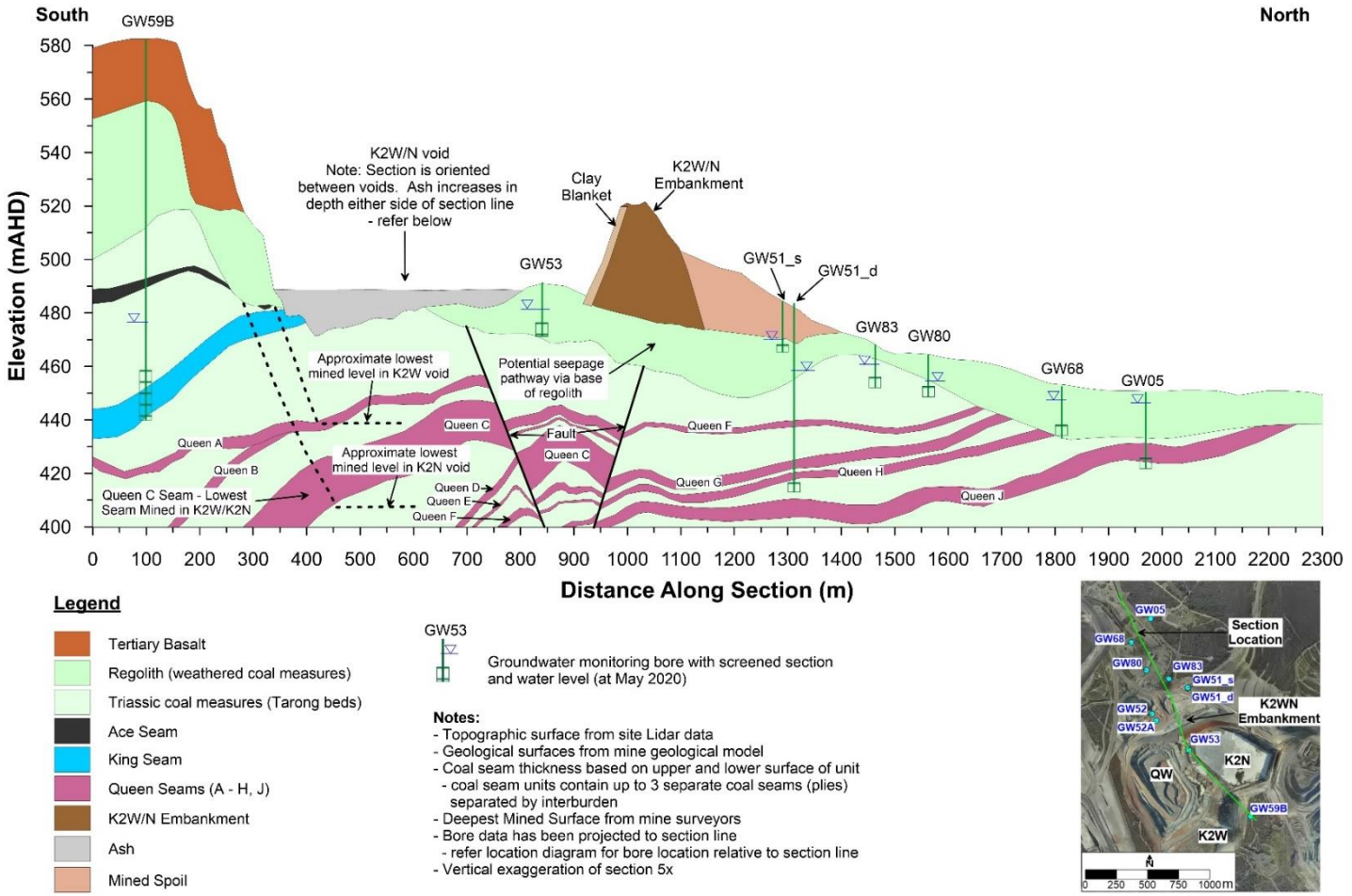

Figure 70 West - East Section through K2W/N Ash Storage (Stanwell, 2020b)

5.2.3.5 Surface Water Runoff

Surface water runoff can leave the site either to the north into the Black Creek catchment, to the northwest into the Meandu Creek dam catchment or in the future, to the southeast into the Rocky Creek Catchment. A summary of the catchments and their discharge pathways is provided below (as reported in the Meandu Mine Water Management Plan, Downer, 2020). The catchments extents are provided in **Figure 71**.

- **RD01, RD02 and RD04 Catchments** – This catchment collects runoff from the industrial area and the area directly to the west of the central Haul Road. Runoff from the ROM coal stockpile, Fixed Plant Maintenance (FPM) workshop and CHPP is diverted into the dirty water drain (DWD), which reports to a preliminary settling pond RD01A before flowing into RD01. The tailings pipeline which discharges tailings from the CHPP to the K2W tailings storage reports to this DWD. Potential sources of contamination in this drain include tailings (in the event of a spill) and coal fines washed from the ROM stockpile and CHPP area. RD01A allows settling of suspended particles prior to water entering RD01.

  Runoff from the small RD04 catchment in the mining area, the Mobile Equipment Maintenance (MEM) hardstand and areas containing the admin buildings enters a separate drain below RD03. A high flow diversion transfers low flows to RD01A, while high flows resulting from extreme rainfall events are diverted to the Clean Water Drain (CWD), which discharges to Meandu Creek dam via CP4. Minimal erosion is expected to occur from the industrial area; however, overflow from RD03 may exhibit higher turbidity.

  RD01 spills into RD02, from where water overflows to Meandu Creek and discharges from site to Meandu Creek dam via CP3. The only runoff which enters RD02 originates from a small undisturbed area – the majority of water enters from other retention dams.

- **RD03 and RD26 Catchment** - RD26 receives runoff from the Boundary Dump at K2E and a large area of undisturbed vegetation. Erosion from the Boundary Dump area can contribute to sedimentation and elevated turbidity in RD26. Controlled releases from RD26 can be directed to the K2WN ash storage, to supplement the return water pumped back to the TPS ash dam that is re-used in the ash sluicing process. RD26 receives pumped inflows from RD27.

  RD26 overflows to a drainage system which reports to RD03, via the Ramp 5 highwall ("Beatson's") haul road and culverts beneath the K2E haul road. Also reporting to RD03 is runoff from K1, K2W and K2E rehabilitation areas, K2W and K2E spoil dumps, the dragline shutdown area and undisturbed vegetation. Effective drainage has been maintained in this catchment area with minimal erosion evident due to the competent material, although RD03 receives suspended solids in the catchment runoff which can lead to sedimentation.

  Detention Bunds (DBs) have been constructed on the ash pipelines to collect potential pipe dumps from the ash pipeline. Runoff water diverted to the DBs from the bunded pipeline area is released to drainage channels under supervision. Water from DB2 and DB4 can be released to a drainage channel which reports to RD03.

- **RD06 and RD18 Catchment** - The catchment reporting to RD18 consists primarily of undisturbed vegetation and rehabilitation established prior to 2001, 2003, 2005 and 2006. The ash pipeline upper catchment dam DB1 spills to a drain, which flows to RD18. Erosion in this catchment is minimal.

  RD18 discharges to a drain, which flows beneath the BC13 coal conveyor, through a highly vegetated catchment with some grassed areas, before discharging to Meandu Creek dam. A weir and Rising Stage Sampler (RSS) have been installed to monitor releases from site via this clean water drain. RD06 was constructed to capture runoff from the BC13 coal conveyor and PLO bin area. Contaminants include coal fines and some sediment from erosion of exposed surfaces along access roads, which settle in the dam prior to discharge of water to the drain downstream of RD18.

- **RD07, RD08 and RD27 Catchment** - A water drain separates the mining area on the western side of the lease from the Meandu Creek. RD27 receives runoff water from rehabilitation established prior to 2001, 2005, 2006, 2016 and 2018, in addition to areas impacted by mine spoil, rejects, haul roads, the ROM coal stockpile and raw coal stockpile. The rejects conveyor, and rejects stockpile are located within this catchment, and rehabilitation in the NW area was established over a number of rejects dumps. Leachate or runoff from these areas has the potential to affect water quality by altering pH and EC. Coal fines from the western side of the ROM coal stockpile and raw coal stockpile may become mobilised and contribute to sedimentation of RD27. Some erosion is evident along the drain and spoil that borders the Western LV and haul roads – runoff from this area enters a culvert beneath Ramp 7 haul road before entering RD27 and may contribute to sedimentation. RD27 also receives return water pumped from the NWB tailings storage.

  RD07 receives water from RD09 and surface water flows from heavy rainfall (which are diverted away from RD27 via high flow structures). While freeboard is routinely maintained in RD27 via pumping to RD26, during heavy rainfall events RD27 can overflow to RD07 via a spillway.

  RD07 overflows into RD08, which has a minimal catchment area. Water from RD08 overflows to Meandu Creek directly below the RD02 spillway via the RD02/RD08 weir or can be diverted to RD02 by opening connecting valves. Water supply for CHPP operations is primarily sourced from either RD08 or RD02.

- **RD09, RD10 and RD21 Catchment** – The RD21 catchment consists of an area of established (2009/ 2010 and more recent) rehabilitation, in addition to spoil that is being progressively dumped, profiled and rehabilitated. Erosion may contribute to turbidity in runoff water and sedimentation of the dams/ drains below this catchment. RD21 also receives overflow water from RD24.

  Water from RD21 reports to a drain that flows to RD10. Runoff water from this catchment is from areas at various stages of rehabilitation (prior to 2001, 2005, 2009, 2010 and more recent) and spoil in the process of being profiled. Water quality is affected by suspended particles, which result in increased turbidity and sedimentation. RD10 overflows directly to RD09, which receives runoff water from a small catchment at various stages of rehabilitation, in addition to a small section of the Ramp 7 haul road (disused for production purposes). In extreme rainfall events, high flows can be diverted to Meandu Creek via high flow diversions constructed on the channel between RD10/RD21 and RD07/RD09, which then discharge from site through CP3.

- **RD24 and RD25 Catchment** – These dams were primarily constructed to capture runoff and sediment from the western spoil dump areas through their rehabilitation. A mine water drainage channel reporting to these dams has been constructed from the southern extent of the mine, to provide clean water/ dirty water separation between active areas and Meandu Creek.

  The catchment reporting to RD24 includes the Central and Ramp 5 spoil dumps and rehabilitation areas of different ages. RD25 overflows to RD24 and its catchment consists of the K4E and K4S spoil dump areas that are undergoing rehabilitation. Both RD24 and RD25 have low flow spillways that report to the downstream dams, and high flow spillways that can report to the Meandu Creek diversion during high rainfall events. Erosion and sediment load in runoff water from these catchments can lead to elevated turbidity and sedimentation in these dams.

- **RD14, RD22 and Meandu Creek Diversion Catchment** – RD14 consists of three dams (RD14A, RD14B, and RD14C) which overflows via spillway to Meandu creek upstream of CP3. RD14 west catchment consist of rehabilitated areas as well as significantly undisturbed vegetation and grassed areas. It also has a Topsoil stockpile with runoff that is diverted to RD14C.

  RD22 is constructed within the original Meandu Creek channel. Its consists of a small area of undisturbed riparian vegetation the rehabilitated south-west spoil dump areas and 200-2005 Meandu Creek diversion, with some runoff from access roads.

- **RD15 and RD19** – RD19 is located within the Meandu Creek channel and receives ephemeral flows from upstream Meandu Creek, before overflowing to the rehabilitated 2000-2005 Meandu Creek diversion. The catchment consists of large undisturbed vegetation and some rehabilitated catchment. RD15B receives runoff from undisturbed vegetation and rehabilitated catchments in addition to runoff from grassed areas. RD15B spills to Meandu creek upstream of RD19.
- **RD17A and RD17B Catchment** – The RD17 catchment consist of rehabilitated areas established between 2001 and 2016. Runoff reporting from the catchment may contain elevated suspended solids, which is captured and routinely desilted from the upper RD17A to maintain suitable water quality in RD17B. A pump-back system is maintained from RD17B to RD1 to provide sufficient freeboard in RD17B if required.
- **Orica dam and Tip dam** – The catchment reporting to the Orica dam consists of undisturbed vegetation and rehabilitated catchment whilst the Orica Evaporation Pond captures the runoff from within the Orica explosives compound. This Evaporation Pond runoff is potentially contaminated with ammonium nitrate. Overflows from the pond is captured by the Orica dam (either through a controlled pipe discharge or emergency spillway). The Orica dam spills to the Tip dam. The direct catchment for the Tip dam consists of rehabilitated catchment, grassed areas and undisturbed vegetation.
- **Meandu Creek Catchment –** Three creek diversions were completed along the Meandu Creek. These were completed during the mid-1980's (1.0km), early 1990's (0.8km) and early 2000's (2.4km) and are located along the western boundary of the mine site. The two earlier diversions are utilised as part of the mine water management system, while the latest diversion has been rehabilitated and reinstated in accordance with licensing requirements.

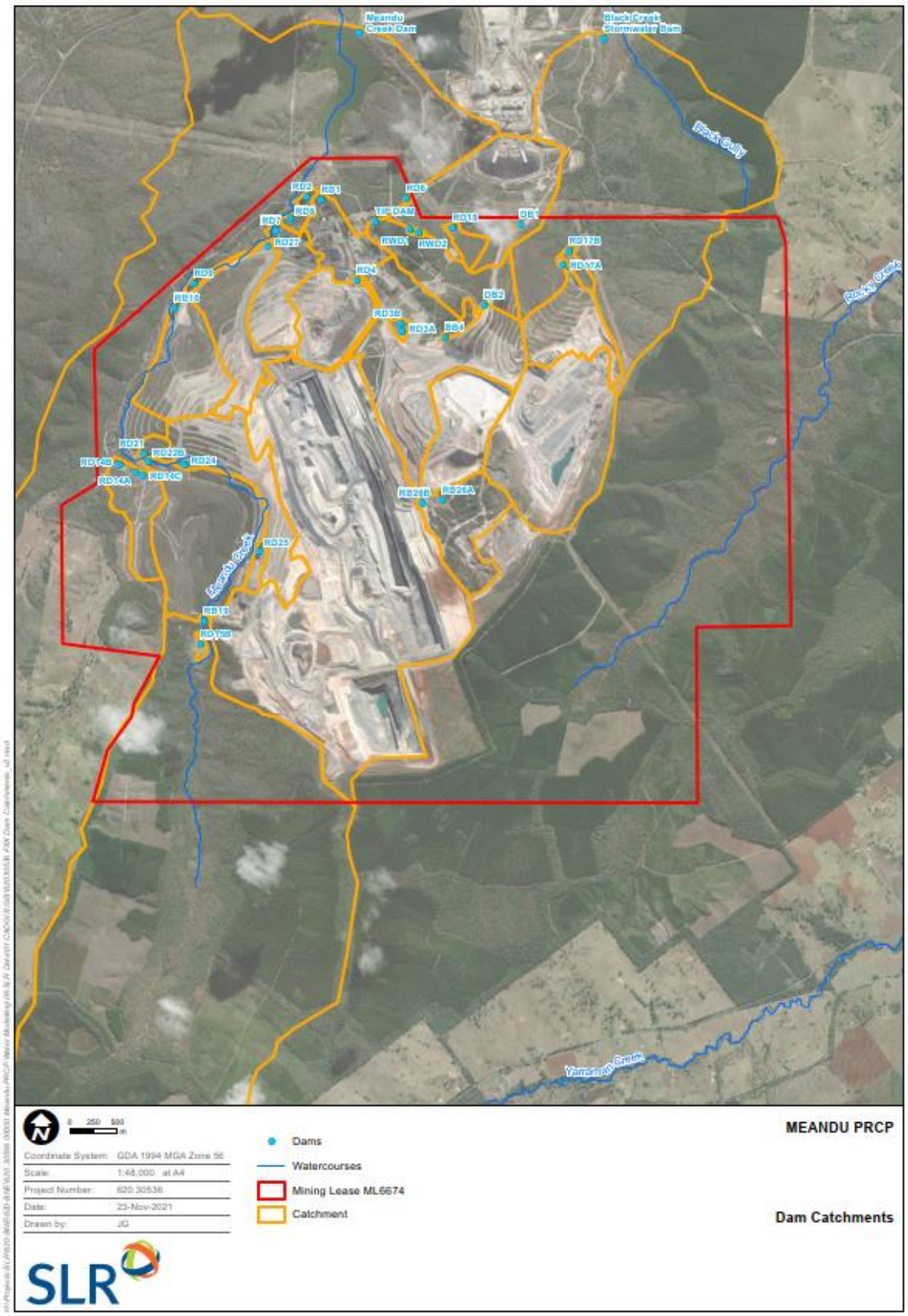

Figure 71 Catchment Map

5.2.4 Fate of Contaminants

5.2.4.1 Groundwater

The fate of a contaminant refers to where the contaminant will settle with consideration given to chemical reactions along the groundwater flow path which reduces the concentration of the contaminants and their risk to EVs. The fate of contaminants for the three potential seepages of note, as identified from groundwater monitoring, are outlined in the following sub-sections.

5.2.4.1.1 AMD Seepage from NWBV

Based on the chemical reactions that occur within spoil producing AMD it is expected that groundwater would exhibit a low pH, elevated sulfate and increases in metal/metalloid concentrations (including high iron) at the initial site of seepage. Although high iron can result from AMD chemical reactions, it is not regarded as a good indicator (of AMD) due to the high concentration of iron in groundwater at site (i.e. where basalt occurs). Other metal/metalloid indicators of AMD that have been highlighted from the monitoring of seepage waters in the local environment include cobalt, manganese, nickel and zinc. Groundwater quality indicative of AMD has been recorded at Bullgang Drain and Ramp 7 (refer to **Section 4.3.3.1**), however, there have been improvements in water quality since first identified. No evidence of adverse impacts from AMD to Meandu Creek was found as part of the EE (WSP, 2018).

5.2.4.1.2 QWBV saline plume

Monitoring data for impacted regolith monitoring bores shows that EC values and water levels are generally stable, with values generally declining northwards towards Meandu Creek (refer to **Figure 35**). This indicates that the migration of the plume is very slow. Hydraulic parameter values support this observation with the regolith material showing a shallow hydraulic gradient and relatively low hydraulic conductivity.

5.2.4.1.3 Black Creek catchment saline plume

High EC and low pH were measured in groundwater bores located within the Black Creek catchment saline plume. The source and total extent of the plume have not been assessed yet and investigations are underway. Any groundwater seepage is expected to express as surface water in Black Creek dam which is then diluted in the Tarong ash dam

5.2.4.2 Surface Water

Surface water runoff is directed to the on-site erosion and sediment control and mine-affected water capture dams. In the event that rainfall/runoff events exceed the capacity of the water management system, overflow is directed to Meandu Creek dam and Black Creek dam. Releases from Meandu Creek dam occur to downstream waterways in accordance with the EA controlled release conditions. Therefore, contaminants such as oil and grease, surfactants, petroleum hydrocarbons can persist further downstream, along with dissolved contaminants.

Although the fate where these contaminants end up is considered to be Meandu Creek dam, Black Creek dam and their downstream creek systems, the impact on these systems is materially reduced due to the capture of contaminated runoff in onsite detention/retention dams. Furthermore, as the discharges from Meandu Mine are diluted with runoff from surrounding clean catchments prior to discharge from Meandu Creek dam or Black Creek dam, it is unlikely that contaminants would be at concentrations that would impact the downstream environment from Meandu Creek Dam.

6 Voids

6.1 Number And Location of Final Voids

Following closure of the Mine, two final voids are expected to remain at K2E and K4E. K2E has a catchment area of 332 ha whilst K4E has a catchment area of 184 ha. The direct catchment area reporting to the voids are based on a 3D topographic model representing the final landform. The catchment extent and final landform topography is shown in **Figure 72**.

The stage-storage-surface area curves were also produced based on the final landform topography. This allows the model to assess the capacity, and pit lake surface area that influences the evaporation and direct rainfall footprint. **Figure 73** and **Figure 74** show stage-storage-surface area curves for the K2E and K4E voids.

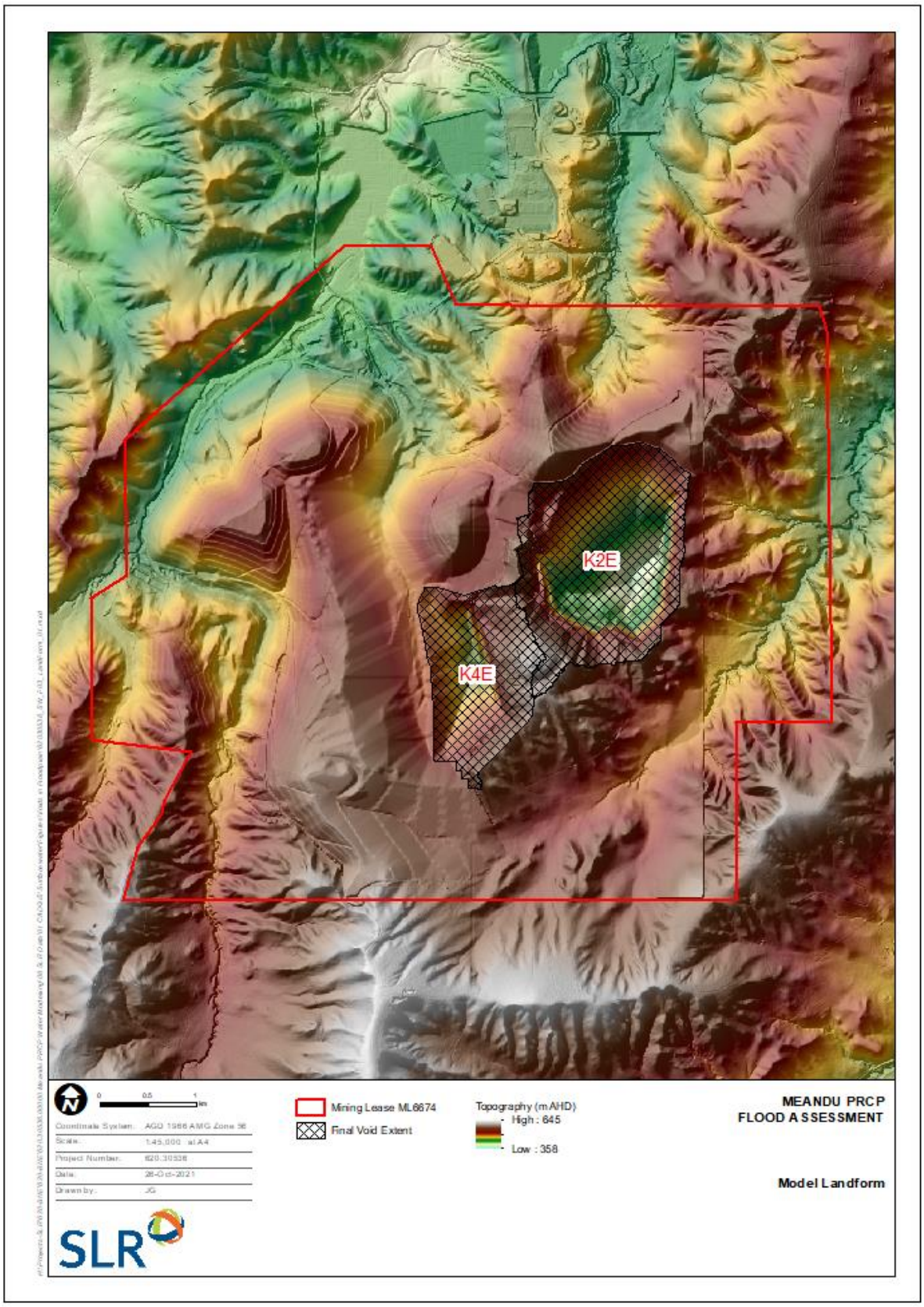

Figure 72 Void Catchment Area

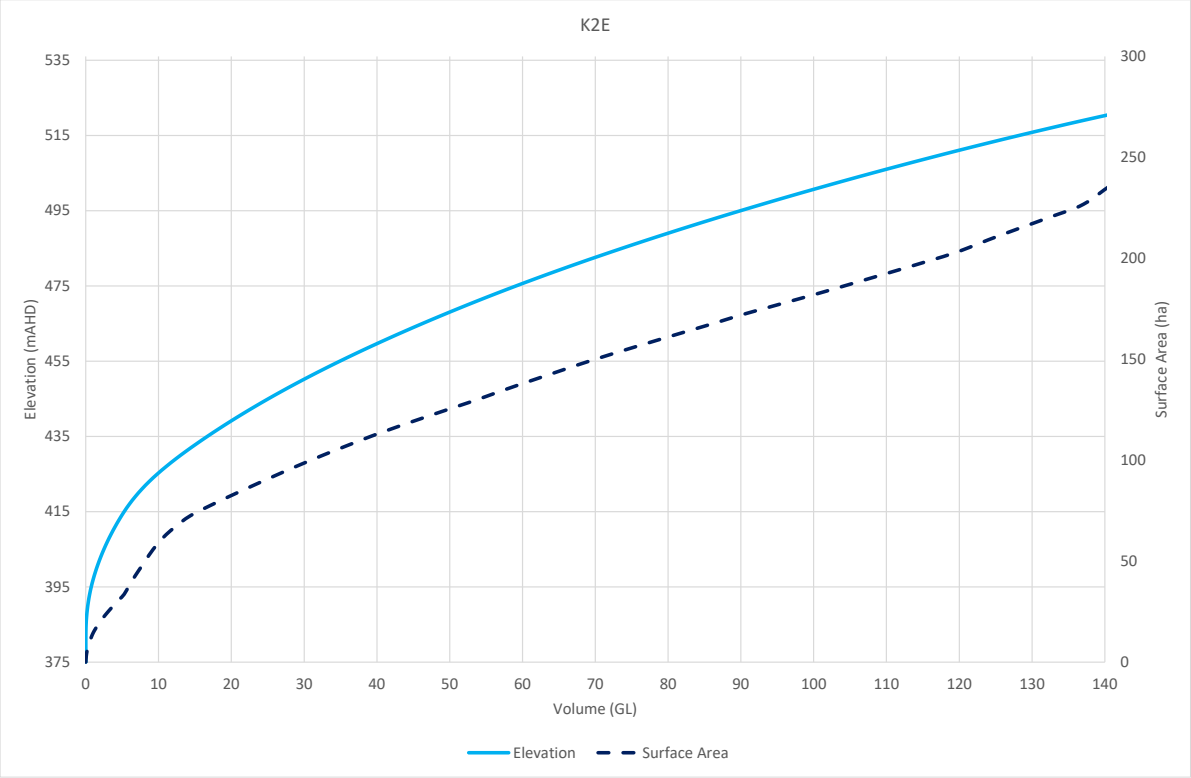

Figure 73 K2E Storage Curves

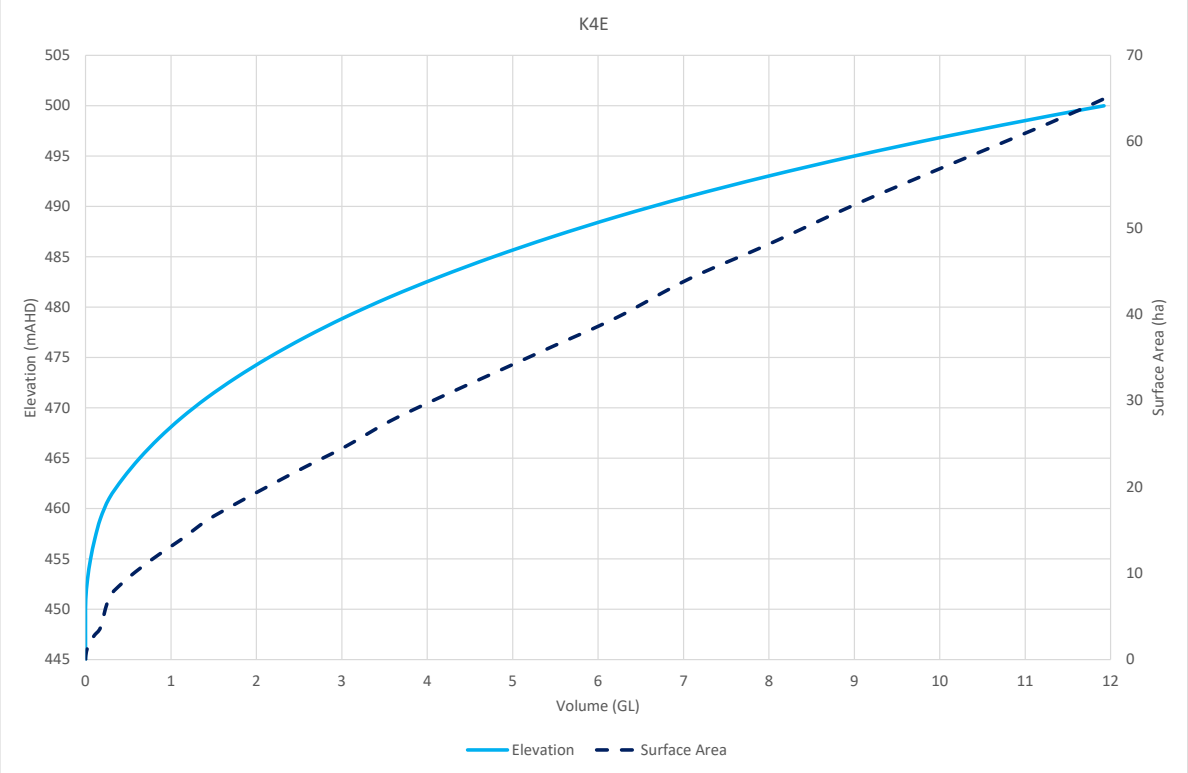

Figure 74 K4E Storage Curves

6.2 Final Void PMLUs And Adopted AWBM Parameters

The WBM utilises the Australian Water Balance Model (AWBM) rainfall runoff module to calculate the rainfall and runoff inflows in each catchment. The adopted AWBM parameters were based on the calibration exercises developed by WSP for the King 2 East (K2E) Project; based off two Barker Creek catchment calibrations and other calibrations from four mine-affected catchments in Central Queensland.

A summary of the AWBM parameters used for different catchment types are presented in **Table 34**. It should be noted that the final void WBM utilised only two land use types in the model, which are the Hardstand/Pit (representing Steep Rocky Ecosystem and Water Storage PMLUs) and Rehab (representing Native Ecosystem and Beef Cattle Grazing PMLUs). These two AWBM categories for land use are believed to best represent the four land use types reporting to the two final voids. The PMLUs within approved surface rights and outside of approved surface rights are shown in

Table 34 Adopted AWBM Parameters

Parameter	Hardstand/Pit	Rehab
A1	0.134	0.134
A2	0.433	0.433
A3	0.433	0.433
C1	1	25
C2	3	240
C3	5	480
BFI	0	0.2
Ks	0.1	0.1
Kb	0.7	0.7

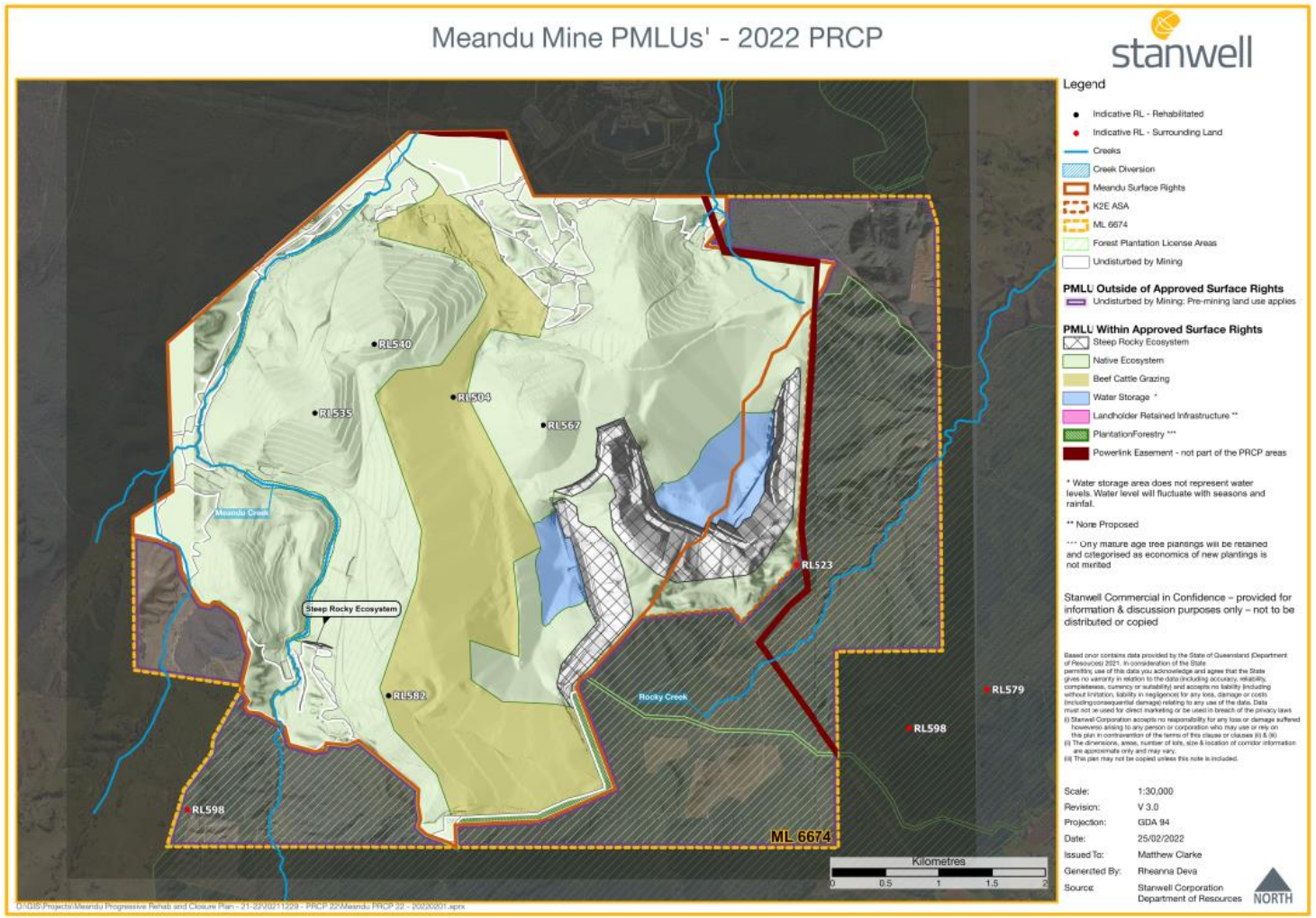

Figure 75 PLMUs within and outside of approved surface right areas (provided by Stanwell)

6.3 Void Hydrology

6.3.1 Long-Term Water Balance

Estimated long-term average water balance fluxes for scenarios 1 and 2 are provided in **Table 35** for the long-term average void water level.

Table 35 Long-Term Average Water Balances

Scenario	Inflow (m^3/day)		Outflow (m^3/day)		
	Rainfall\Runoff	Groundwater	Evaporation	Pumping	Groundwater
Scenario 1 – K2E	1,585	10	1,590	5	0
Scenario 1 – K4E	723	160	617	5	260
Scenario 2 – K2E	1,006	190	186	999	10
Scenario 2 – K4E	727	100	617	0	210

6.3.2 Long-Term Water Level

The modelling of different water input and output scenarios to assess pit capacity showed that neither of the pits overtopped over the 120 year period simulated.

6.3.2.1 Scenario 1 – Limited stock water extraction from both voids

6.3.2.1.1 K2E

The model was simulated with 2.08 ML/y extracted for stock water from K2E. The modelled results in **Figure 76**. **Figure 76** show the void is expected to be in equilibrium at approximately 416 m AHD during median conditions which is approximately 36 m deep. During dry climatic conditions, this is approximately 2 m lower whilst wet climatic conditions shows that the level is 2 m higher at 418 mAHD. This is approximately 100 metres below the spillway level and the void is not expected to overtop.

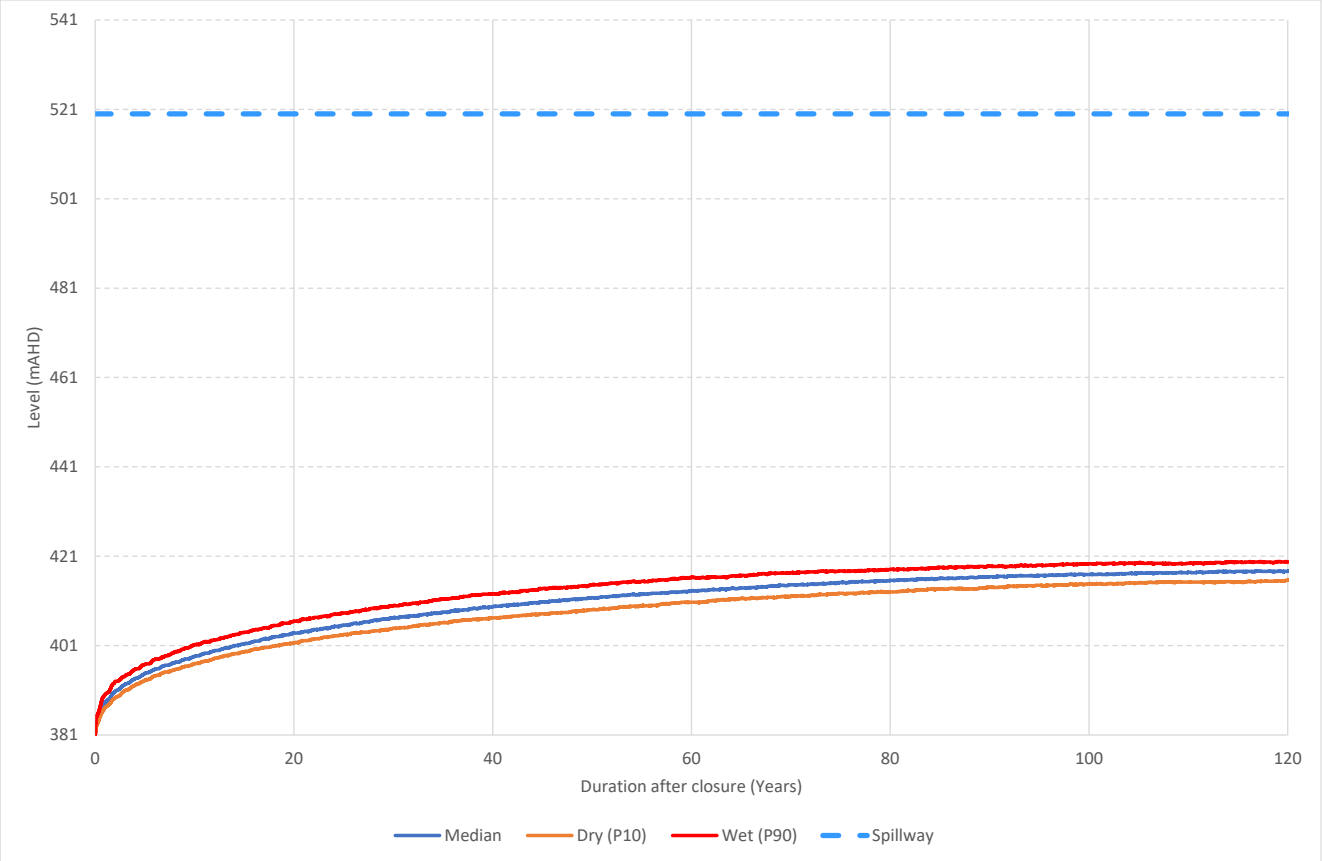

Figure 76 K2E – Scenario 1 Final Void Levels

6.3.2.1.2 K4E

The final void levels for K4E are shown in **Figure 77**. This shows that the void is expected to be in equilibrium at approximately 469 m AHD during median climatic conditions. Similar to the K2E results, the wet climatic condition water levels is approximately 2 m higher than median conditions at 471 mAHD whilst dry climatic conditions showed the final void water level sat 467 mAHD. This is approximately 30 m below the spillway level allowing significant capacity to prevent the void from overtopping.

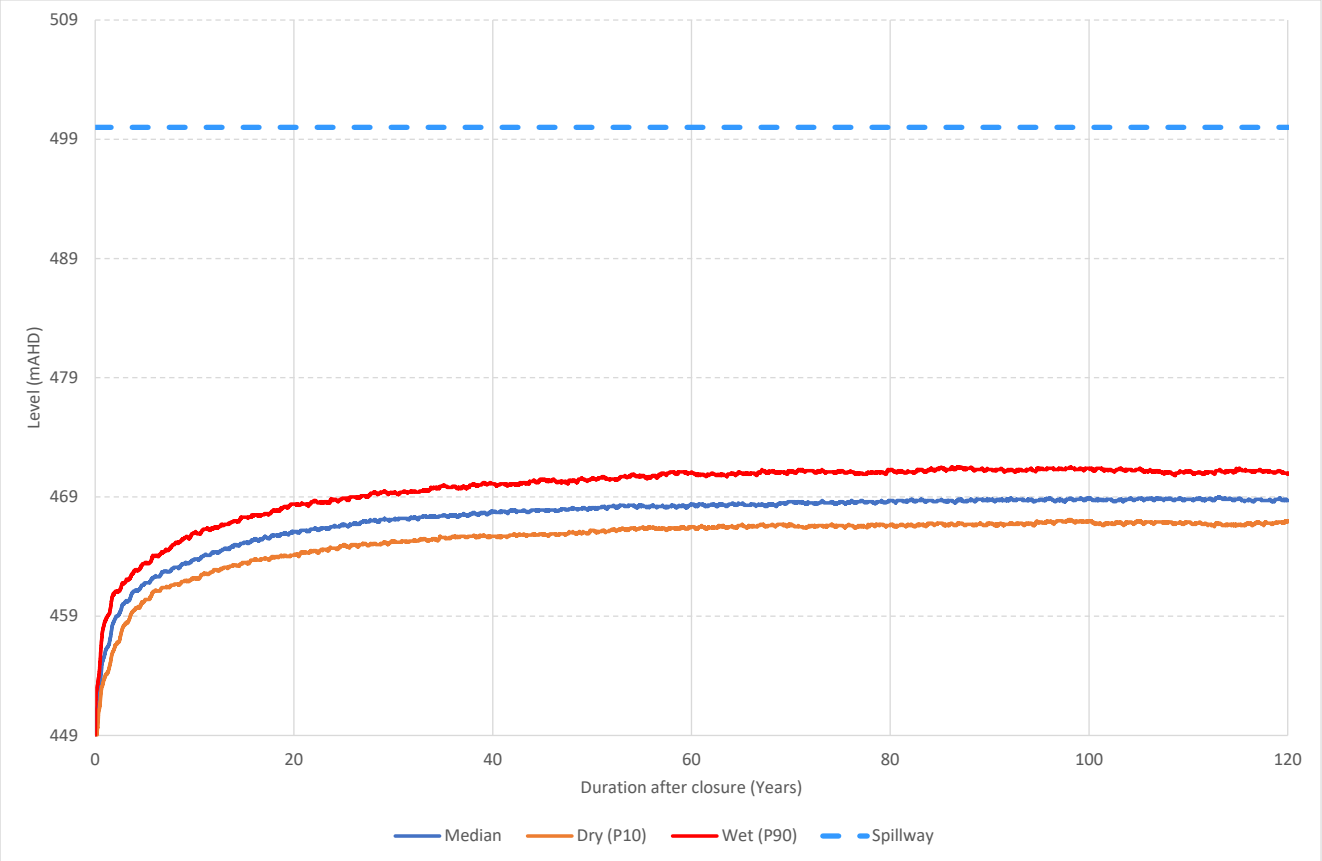

Figure 77 K4E – Scenario 1 Final Void Levels

6.3.2.2 Scenario 2 - Maximum stock water extraction from K2E void only.

6.3.2.2.1 K2E

The final void levels for K2E are shown in **Figure 78**. This shows that for the second scenario, where 1ML/d is extracted from K2E, the void is expected to be in equilibrium at approximately 387 m AHD during median conditions. The assessment showed that the void typically maintains depths of between 5 m and 7 m during the dry and wet climatic conditions.

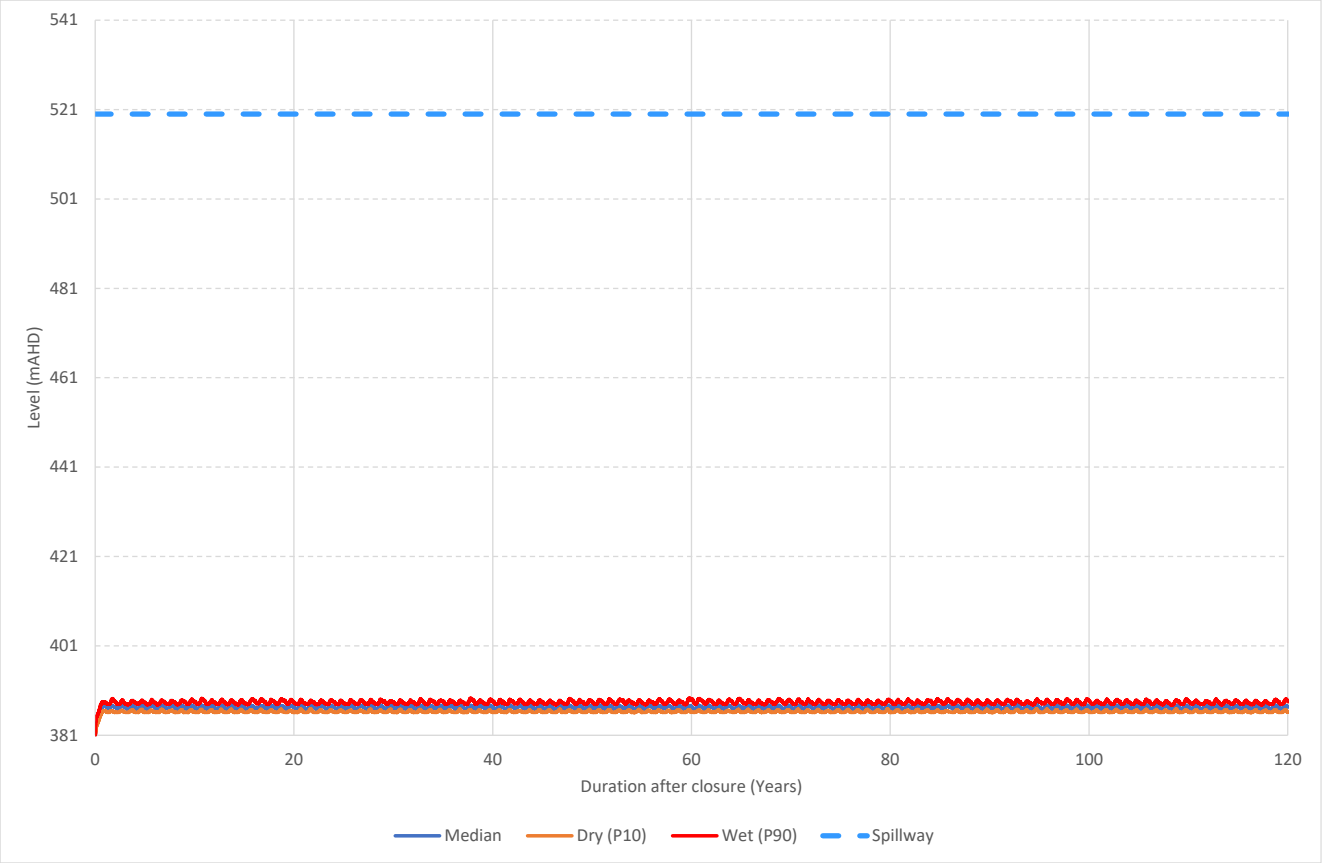

Figure 78 K2E – Scenario 2 Final Void Levels

6.3.2.2.2 K4E

The final void levels for K4E are shown in **Figure 79**. While there is no stock water demand from K4E in Scenario 2, these results show negligible difference to the K4E results from Scenario 1. This is due to the minimal impact of the 2.08 ML/y extraction in the first scenario. As such, the results showed median final void water level of 469 mAHD.

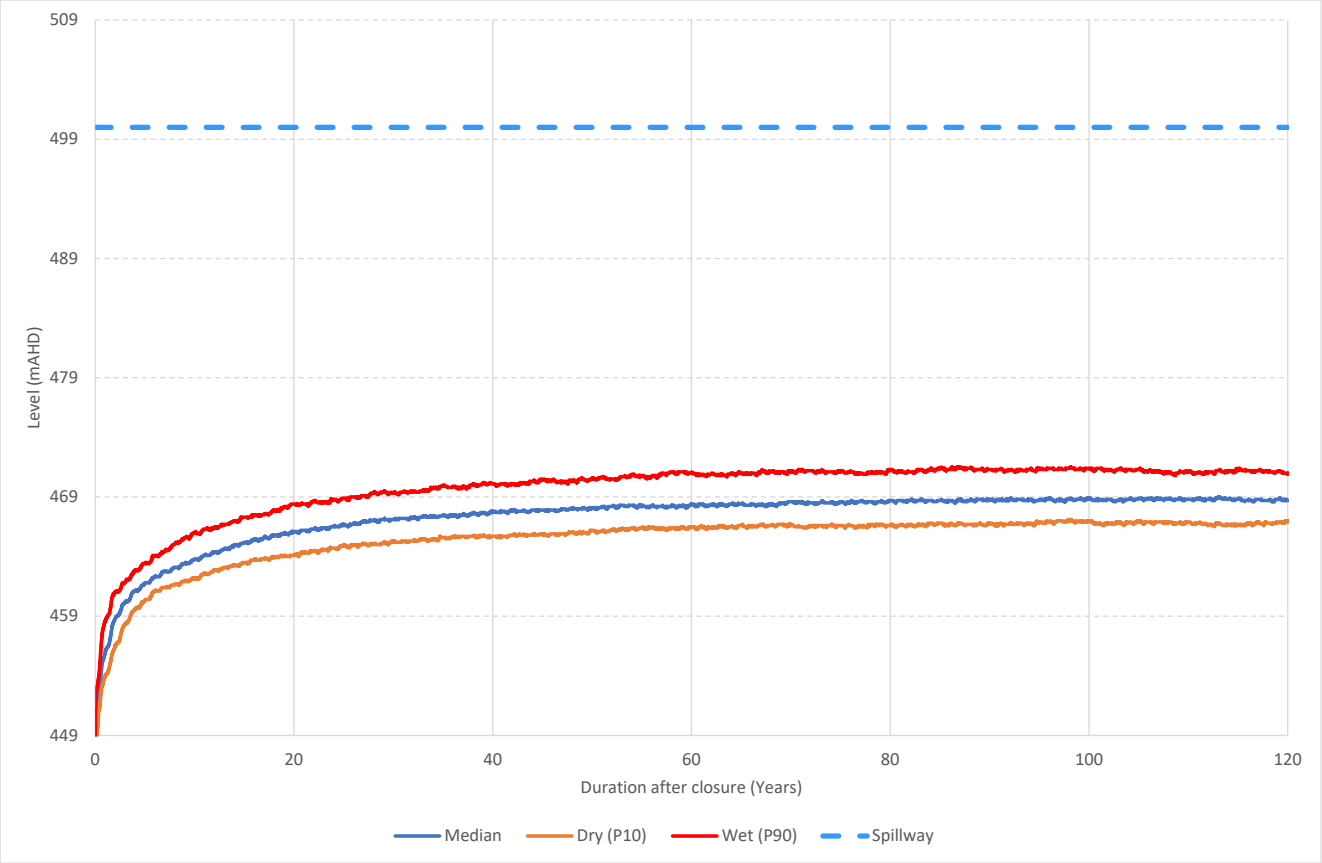

Figure 79 K4E – Scenario 2 Final Void Levels

6.3.2.3 Climate Change Sensitivity Scenario 1 – 20% increase in rainfall depth.

This scenario is based on the assumption of 4.16 ML/y of stock water is extracted from both voids (2.08 ML/y per void). **Figure 80** and **Figure 81** shows the void water levels for K2E and K4E, respectively. The results show an increase of 15 m water level in K2E and 14 m in K4E compared to the results from Scenario 1. This suggests that the results are sensitive to the 20% increase in rainfall although voids maintained a very low risk of overflow.

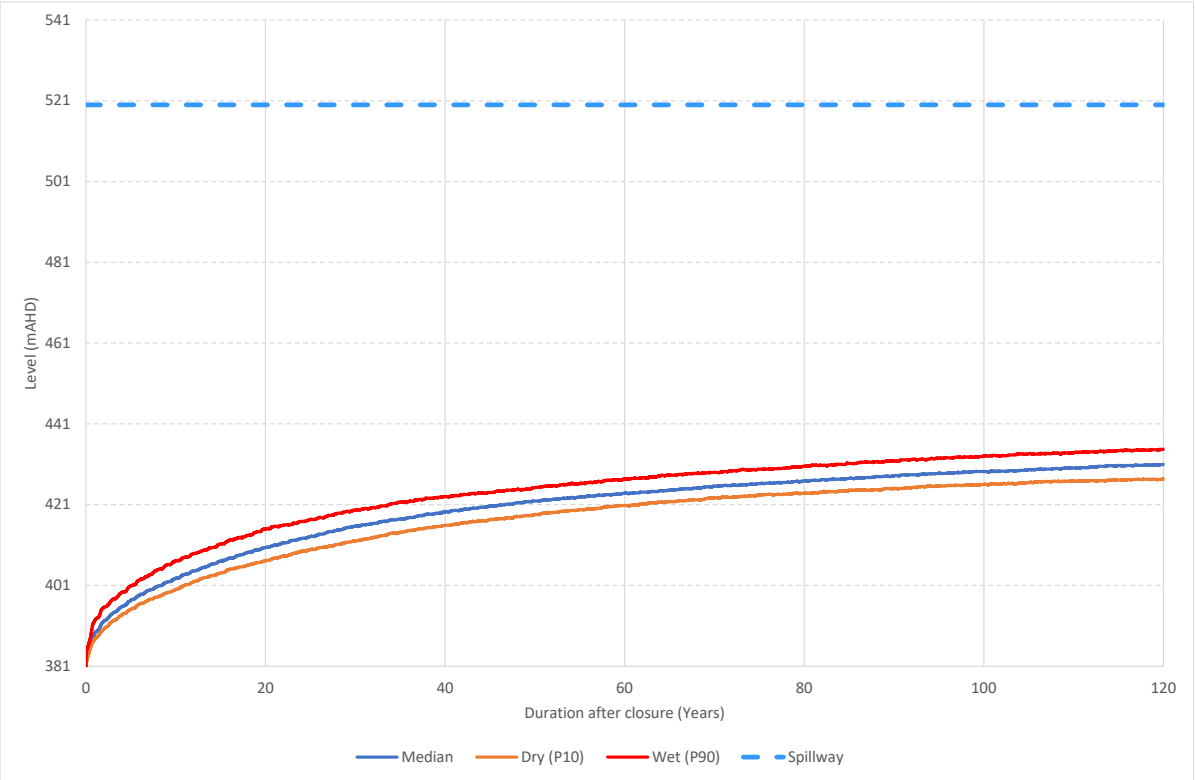

Figure 80 K2E – Climate Change Scenario 1 Final Void Levels

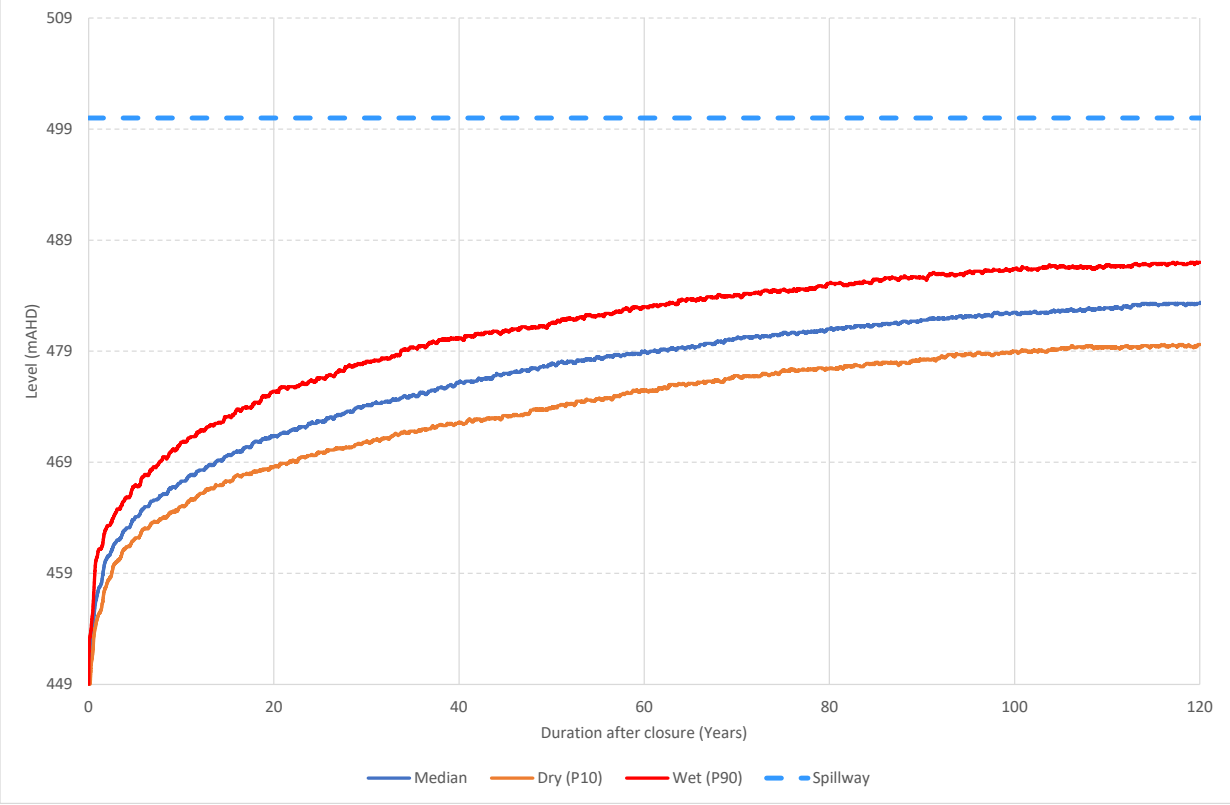

Figure 81 K4E – Climate Change Scenario 1 Final Void Levels

6.3.2.4 Climate Change Sensitivity Scenario 2 – 20% decrease in rainfall depth.

This scenario is based the assumption of 4.16 ML/y of stock water is extracted from both voids (2.08 ML/y per void). **Figure 82** to **Figure 83** shows the void water levels for K2E and K4E. These show significant differences to the results from non-climate change Scenario 1.

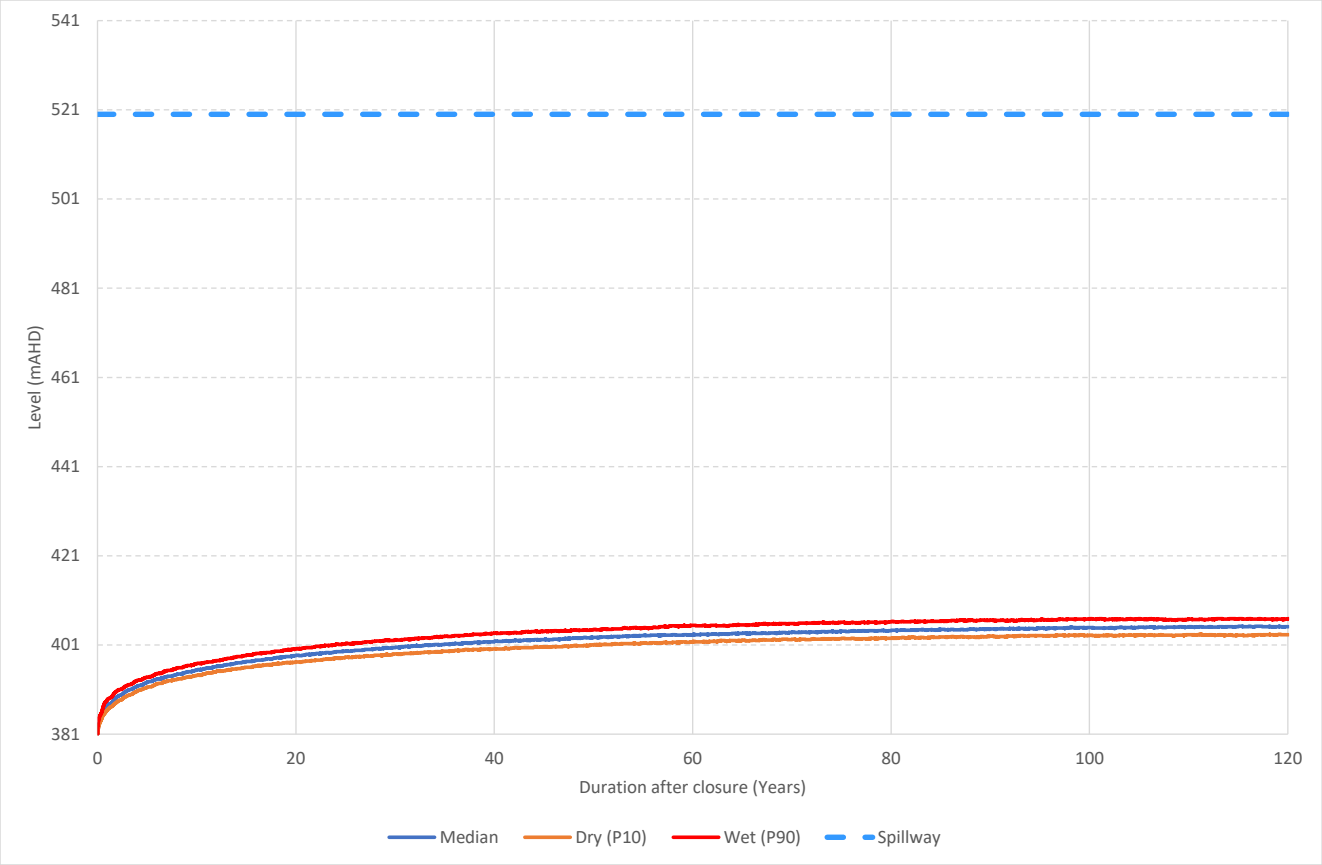

Figure 82 K2E – Climate Change Scenario 2 Final Void Levels

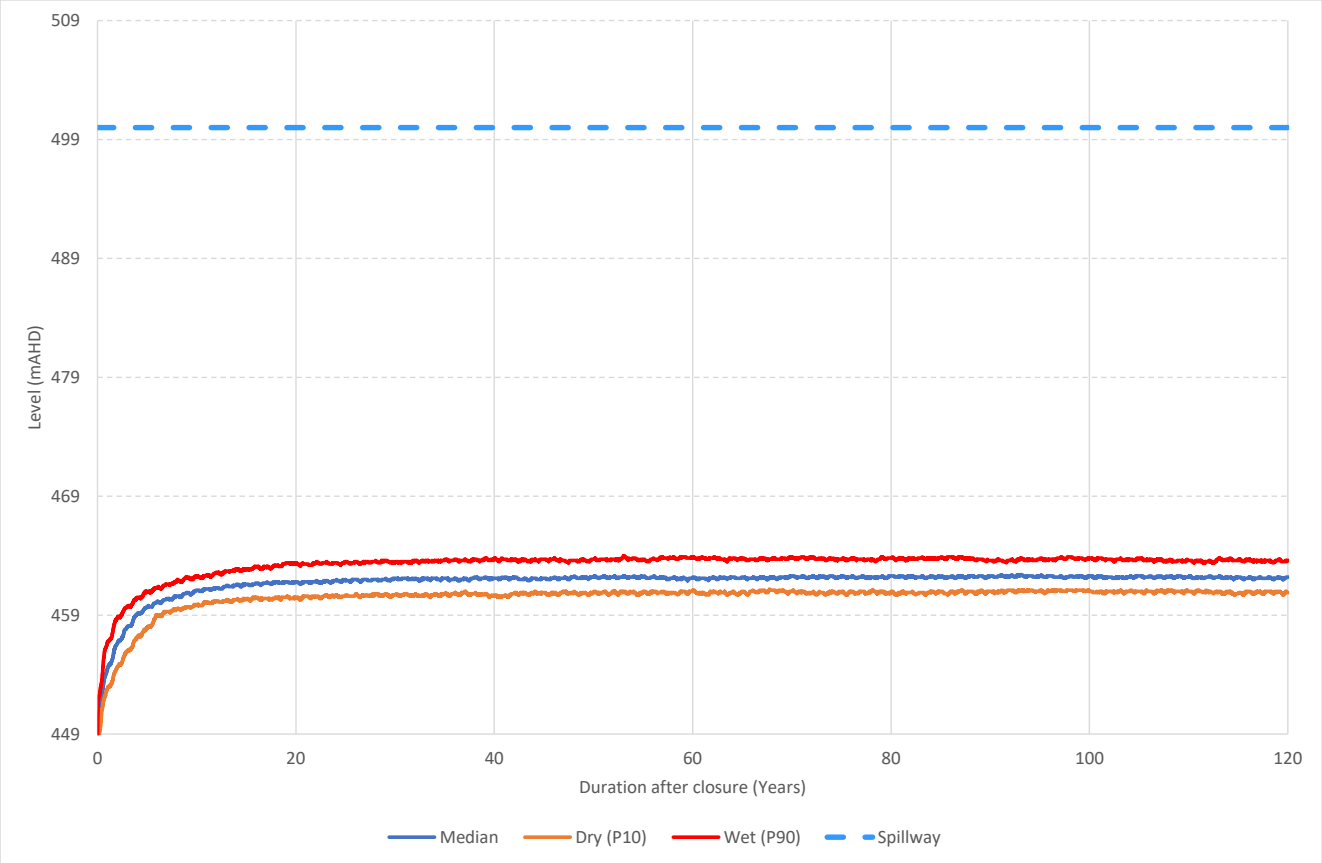

Figure 83 K4E – Climate Change Scenario 2 Final Void Levels

6.3.3 Stratification Connections to Groundwater Resources

The WBM carried out for the project showed that a completely mixed water column was not expected to exceed ANZECC/ARMCANZ (2000) guidelines for TDS for stock water for scenarios where stock water extraction occurred. Therefore, it is considered that stratification modelling is not required to assess risk to groundwater resources and has not been completed.

6.3.4 Potential for Overflow

Two versions of the WBM were developed to represent two stock water extraction plans. The first scenario represented a total of 0.0114 ML/d (4.16 ML/y) extraction rate which is distributed evenly from both voids. The second scenario represented a 1 ML/d (365 ML/y) extraction rate from K2E void. The modelling shows for all scenarios and climatic conditions that the stored water within the void will not be released to the environment (**Section 6.3.2**).

6.3.5 Limitations

This assessment was focused on water balance modelling of the proposed final voids in accordance with the requirements of the EP Act and EP Regulation. The following assumptions and limitations apply to this assessment.

- The accuracy of the assessment is reliant on the accuracy of the utilised data. SLR has assumed all source data to be fit for purpose and sufficiently accurate for the purpose of this assessment. Except where noted, no verification of accuracy of the information has been carried out. In the event that some of the information which was relied upon for this assessment is found to be inaccurate, then some or all of the findings may change.
- Although the analyses undertaken as detailed in this report were done so with the appropriate care and professionalism, this report shall only be used for the purposes intended. The analyses detailed in this report were undertaken solely for the purpose of addressing the requirements for the final voids water balance modelling for Meandu Mine in accordance with the relevant documentation.
- The range of potential stock watering utilisation from Water Storage PMLU is estimated and utilised to illustrate the potential range of water withdrawal for this purpose only. Firm water utilisation estimates are not currently available.
- This report should be read in full and no excerpts are to be taken as representative of the findings. This report has been prepared on behalf of Stanwell and SLR accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

6.4 Final Void Groundwater Modelling – Source/Sink

6.4.1 Predictive Model Setup

Two predictive models were simulated to assess the long-term impact of the mine on the groundwater:

- Model 1: Null (no mining)
  - All mining features in the existing calibration and predictive model were removed and the model was run transiently for the same time period and under the same natural stresses (i.e. rainfall recharge and evapotranspiration); and
- Model 2: Long-Term Closure Scenario
  - In order to establish initial conditions for the post mining recovery simulation, the approved and foreseeable (i.e. K2E Project) mining scenario were updated to include the progressive filling of the King 4 South (K4S) void with coal combustion products (e.g. ash) (Financial Year (FY)s 2028 – 2037).
  - The top of layer 1 in the recovery model was updated to include the final landform elevation.
  - Closure simulations include:
    - An initial recovery simulation to assess the groundwater inflows to the final voids. The initial estimate is used as an input to the final voids water balance model; the water balance model provides the final lake elevation in the voids. An iterative process between the surface water and groundwater models is then carried out so that the groundwater inflows that are provided as an input to the surface water model matches the groundwater inflows simulated using the final lake elevation output from the surface water model.
    - A predictive mining (up to Life of Mine - LOM) and post closure model using the voids lake elevations provided by the water balance model. Two final void level scenarios, with different assumptions on water usage, are included and are further discussed in **Section 6.4.1.2**.

6.4.1.1 Null (no mining)

A null run was developed to estimate groundwater levels with no mining at the site. The null run allows for the estimation of cumulative impact (i.e., from the start of mining to the end of recovery) by comparing it with the mining and recovery scenarios. All mining features in the existing calibration and predictive models are removed. This includes all mine related boundary conditions (i.e., model four packages with GHB and RIV representing the surface water features; Drains (DRN) representing mining and TVM representing spoil placement) and recharge and hydraulic parameter zones associated with spoil and fault zones (i.e., the Boulevard Fault is assumed to remain a hydraulic barrier to groundwater flow, in accordance with previous investigations reported in JBT (2021a)). The model is then run for the same time and under the same natural stresses (i.e., rainfall recharge and evapotranspiration).

6.4.1.2 Recovery (post mining)

The recovery model includes the approved and foreseeable mining and deposition activities (i.e., K2E Project and K4S ash and tailing dam) up to the year of 2045. An initial recovery simulation is used to assess the groundwater inflows to the final voids. The initial estimate is used as an input to the final voids water balance model (SLR, 2021b); and the water balance model provides the final lake elevation in the voids. An iterative process between the surface water and groundwater model is then carried out so that the groundwater inflows provided as an input to the surface water model match the groundwater inflows simulated using the final lake elevation output from the surface water model. The final predictive mining (up to LOM) and post recovery model is run using the lake elevations provided by the water balance model.

The following assumptions have been made for the post recovery model:

- The final voids (K4E and K2E) levels are estimated by the surface water study (SLR, 2021b):
    - The final voids are represented by a constant head (CHD) boundary condition. The CHD input is the hydraulic head for each of the model stress period. CHD heads are set up based on the median condition from the surface water study which provide the final void lake elevation with time for K2E and K4E. Two scenarios of final void elevation have been assessed, based on stock water extraction rates from the voids.
    - As the CHD defines the water level in each final void, the recharge (RCH) and evapotranspiration (EVT) boundary conditions are set to 0 mm/y above the voids (i.e., effectively inactive).
    - Hydraulic parameters of “air” are assigned to the final void footprint (e.g. Kx = 100 m/d).
- Meandu Creek Dam remains active post mining:
    - The RIV boundary condition representing the dam and downstream Meandu Creek remain as described in **Sections 4.7.1.2.3** and **4.7.1.2.4**.
- All existing and foreseeable tailing and ash dams are capped following the end of mining (i.e., historical dams that have been rehabilitated prior to 2014 are not assumed to be capped):
- The RCH and EVT boundary conditions above the tailing and ash dams are set to 0 mm/y; assuming that capping prevents rainfall infiltration and evapotranspiration in these areas.
- The top of layer 1 is changed to the final landform elevation for the recovery prediction.

6.4.1.3 Scenario 1

The first scenario is based on extraction of stock water from both K2E and K4E voids at a rate of 2 ML/yr. Under this scenario the level of the final voids have been estimated, under median conditions, at 418 mAHD for K2E (**Figure 76**) and 469 mAHD for K4E (**Figure 77**). Further detail on the final void water levels are provided in **Section 6.3.2**.

6.4.1.4 Scenario 2

The second scenario is based on extraction of stock water from K2E only at a rate of 365 ML/yr. Under this scenario the final void levels have been estimated, under median conditions, at 387 mAHD for K2E (**Figure 78**) and 469 mAHD for K4E (**Figure 79**).

6.4.1.5 Predictive Timing

The predictive model timing comprises the mining period of 2022 to 2045 and a 300-year recovery period (i.e., 2045 – 2345). Stress periods set up are presented in **Table 36**.

Table 36 Predictive Model Timing

Model Period	Interval	Stress Period	Date from	Date to
Prediction - Mining	Monthly	84 - 91	01-05-2021	01-01-2022
	Quarterly	92 - 185	01-01-2022	01-07-2045
Prediction - Recovery	Yearly	186 - 190	01-07-2045	01-07-2050
	Ten year	191 - 195	01-07-2050	01-07-2100
	20 year	196	01-07-2100	01-07-2120
	25 years	197	01-07-2120	01-07-2145
	200 years	198	01-07-2145	01-07-2345

6.4.2 Predictive Results – Scenario 1

6.4.2.1 K2E Final Void

The average groundwater inflow to the K2E void over the recovery period is 0.1 ML/d while the void contribution to the surrounding groundwater is 0.01 ML/d (**Table 37**). K2E is thus primarily a sink to the surrounding groundwater. Groundwater flow toward K2E primarily originate from K4E, as shown by the "K2E capture Zone" on **Figure 84**

Table 37 Recovery Simulation Average Water Balance – K2E Final Void – Scenario 1

Average Groundwater Inflow to K2E(ML/d)	Average Seepage from K2E to Groundwater (ML/d)	Average K2E Net Flow (ML/d)
0.12	0.01	0.11

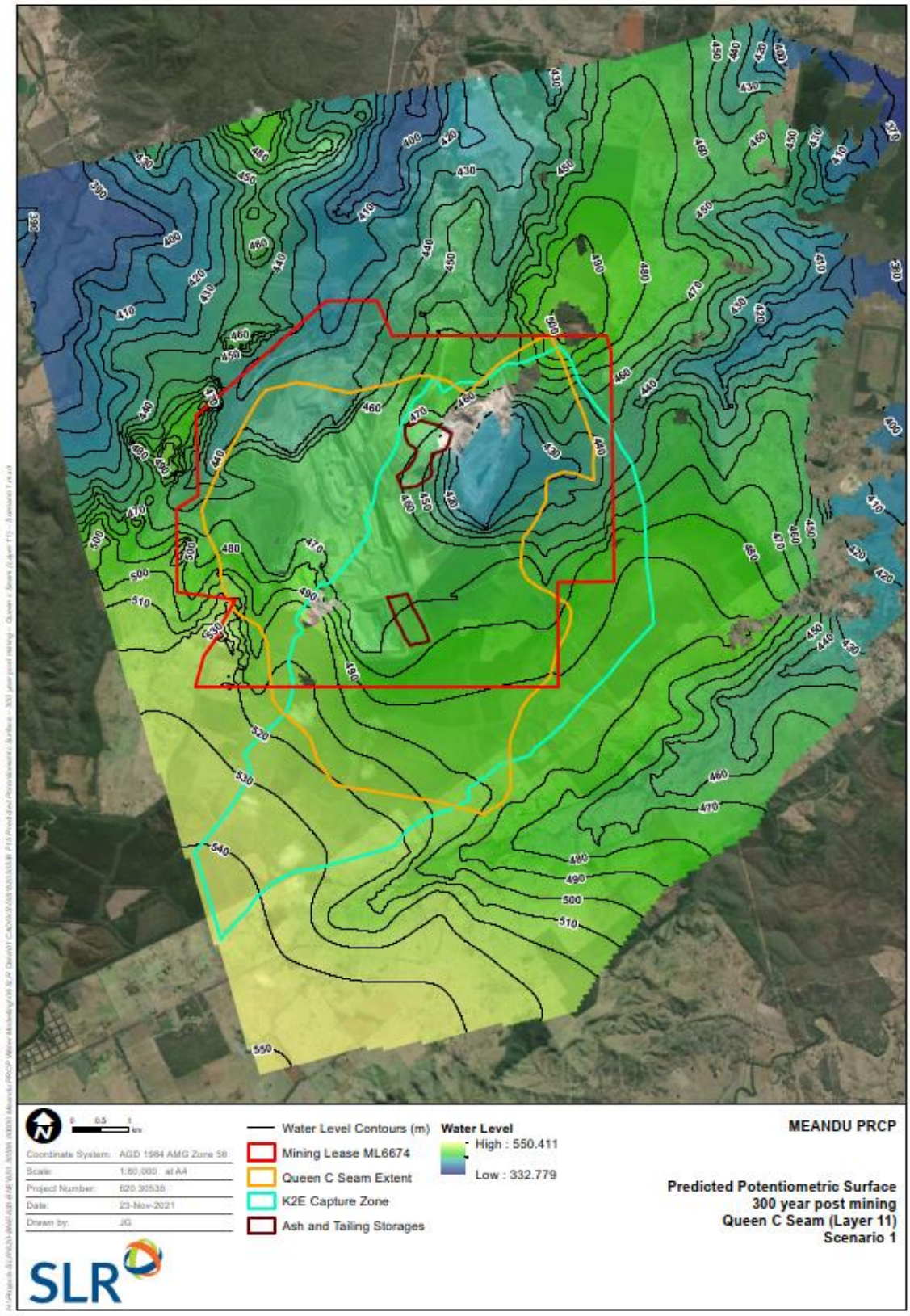

Figure 84 Predicted Potentiometric Surface – 300 Year Post Mining – Queen C Seam (Layer 11) – Scenario 1

6.4.2.2 K4E Final Void

The average groundwater inflow to the K4E void over the recovery period is 0.2 ML/d while the void contribution to the surrounding groundwater is 0.3 ML/d (**Table 38**). K4E is thus a flow through system, primarily a source. K4E seepage to groundwater flows primarily toward K2E and, to a smaller extent, Ramp 5 backfilled void. As presented in **Section 6.5.2**, the hydraulic gradient between K4E and K2E is significantly greater than between K4E and Ramp 5.

Table 38 Recovery Simulation Average Water Balance – K4E Final Void – Scenario 1

Average Groundwater Inflow to K4E(ML/d)	Average Seepage from K4E to Groundwater (ML/d)	Average K4E Net Flow (ML/d)
0.16	0.26	-0.1

6.4.3 Predictive Results – Scenario 2

6.4.3.1 K2E Final Void

The average groundwater inflow to the K2E void over the recovery period is 0.18 ML/d while the void contribution to the surrounding groundwater is 0.01 ML/d (**Table 39**). K2E is thus primarily a sink to the surrounding groundwater. Groundwater flow toward K2E primarily originates from K4E, as shown by the "K2E capture Zone" on **Figure 85**.

Table 39 Recovery Simulation Average Water Balance – K2E Final Void – Scenario 2

Average Groundwater Inflow to K2E(ML/d)	Average Seepage from K2E to Groundwater (ML/d)	Average K2E Net Flow (ML/d)
0.19	0.01	0.18

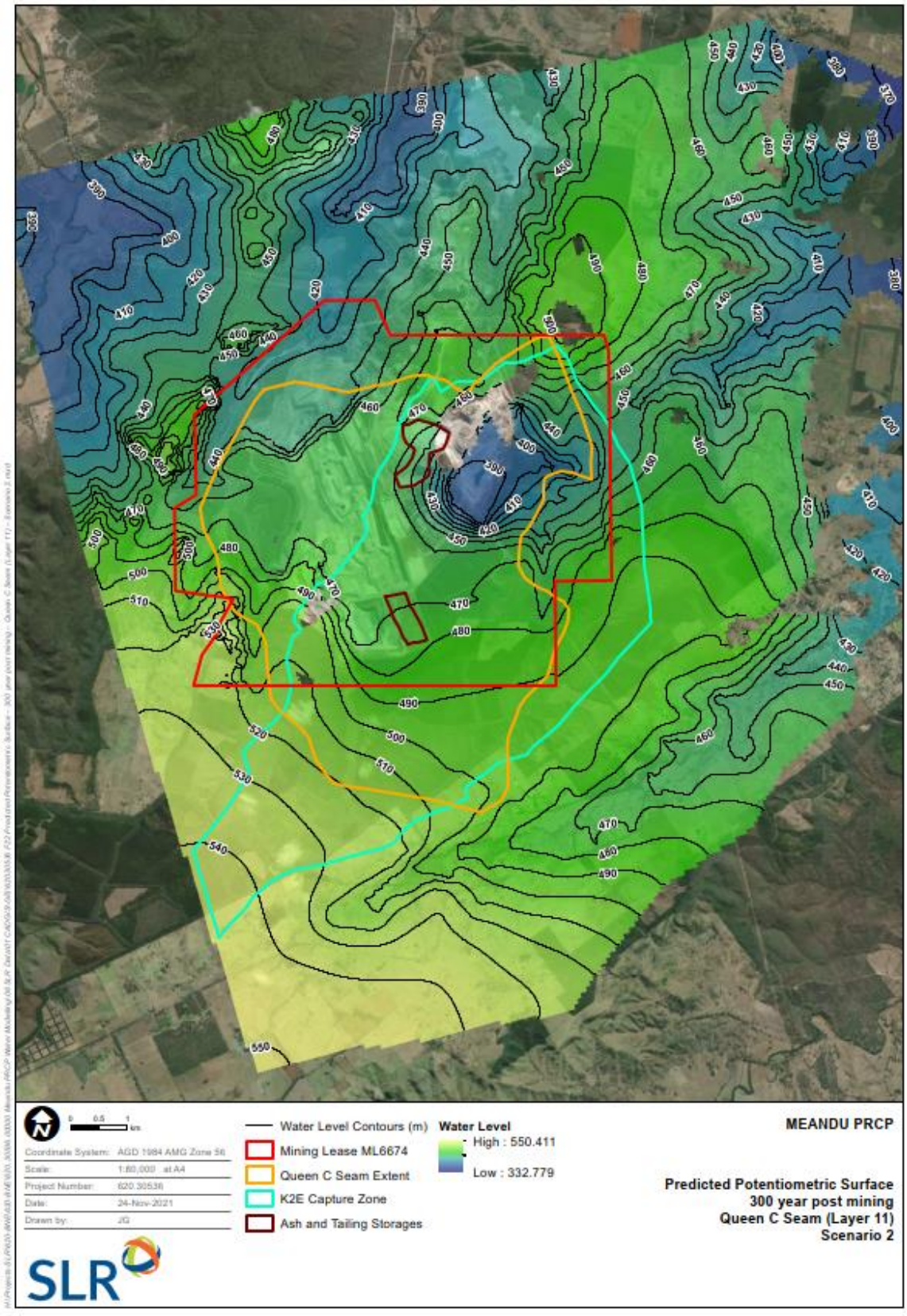

Figure 85 Predicted Potentiometric Surface – 300 Year Post Mining – Queen C Seam (Layer 11) – Scenario 2

6.4.3.2 K4E Final Void

The average groundwater inflow to the K4E void over the recovery period is 0.1 ML/d while the void contribution to the surrounding groundwater is 0.21 ML/d (**Table 40**). K4E is thus primarily a source to the surrounding groundwater. Seepage from K4E into the surrounding groundwater flows primarily toward K2E and, to a lesser extent, ramp 5 backfilled void. As shown in **Figure 84** for Scenario 1, there is a greater hydraulic gradient between K4E and K2E than K4E and Ramp 5. In Scenario 2, the gradient between K4E and K2E is furthermore increased (**Figure 85**).

Table 40 Recovery Simulation Average Water Balance – K4E Final Void – Scenario 2

Average Groundwater Inflow to K4E(ML/d)	Average Seepage from K4E to Groundwater (ML/d)	Average K4E Net Flow (ML/d)
0.10	0.21	-0.11

6.4.4 Limitations

The following limitations were identified for the groundwater flow model:

- The alluvium, basalt and regolith are represented as homogenous units. Although this simplification is considered appropriate over the regional extent of the model, there is inherent uncertainty in the model results associated with the actual heterogenous distribution of hydraulic parameters in these units.
- During the calibration period, recharge is applied as a percentage of monthly measured rainfall. Although this is appropriate for the modelling objective which looks at long term predicted groundwater levels, a more accurate representation of recharge could be achieved using a soil moisture model.

6.5 Water Balance Study (Assessment of Void Surface and Groundwater Interactions)

6.5.1 Groundwater Lowering/Reduction in Hydraulic Head

6.5.1.1 Predictive Results – Scenario 1

The cumulative drawdown at the end of the recovery period (i.e., 300 years after mining ends) was estimated by comparing the water level simulated for the Null run with no mining activities at Meandu to the water level simulated for the recovery run.

In the basalt, the cumulative drawdown reaches a maximum of 30 m in 300 years after mining ends. The greatest drawdown is limited to the mining lease with a maximum drawdown estimated <15 m outside of the mining lease, toward the south. The 1 m drawdown contour (i.e., the distance at which the cumulative drawdown is <1 m) extend to a maximum of 3 km from the south of the mining lease (**Figure 86**).

In the alluvium, the maximum drawdown is observed along Rocky Creek alluvium, directly south of the mine. The maximum drawdown is predicted where the Boulevard Fault crosses the Rocky Creek alluvium (**Figure 87**). As observed by peer reviewer Noel Merrick in JBT (2021a), it is likely for the drawdown south of the mining lease to be overestimated due to the simplified assumption that the Boulevard fault act as a conduit for its entire length.

The Queen seam C ply is the lowest mined seam at K4E while the Queen seam D ply is the lowest mined seam at K2E. In the Queen seam (Queen seam D ply), a maximum drawdown of approximately 65 m is estimated in the vicinity of the K2E final void (**Figure 88**).

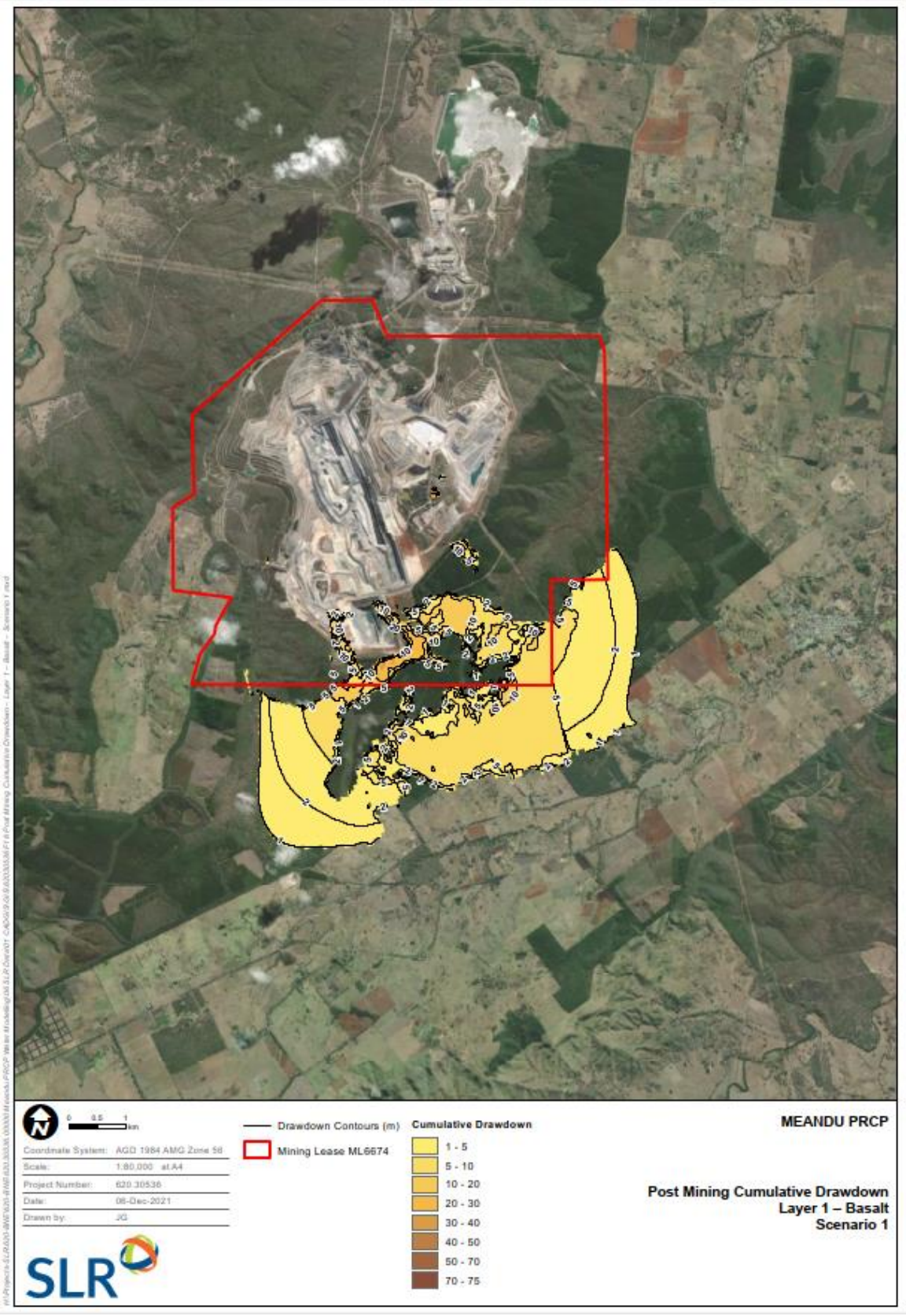

Figure 86 Post Mining Cumulative Drawdown – Layer 1 – Basalt – Scenario 1

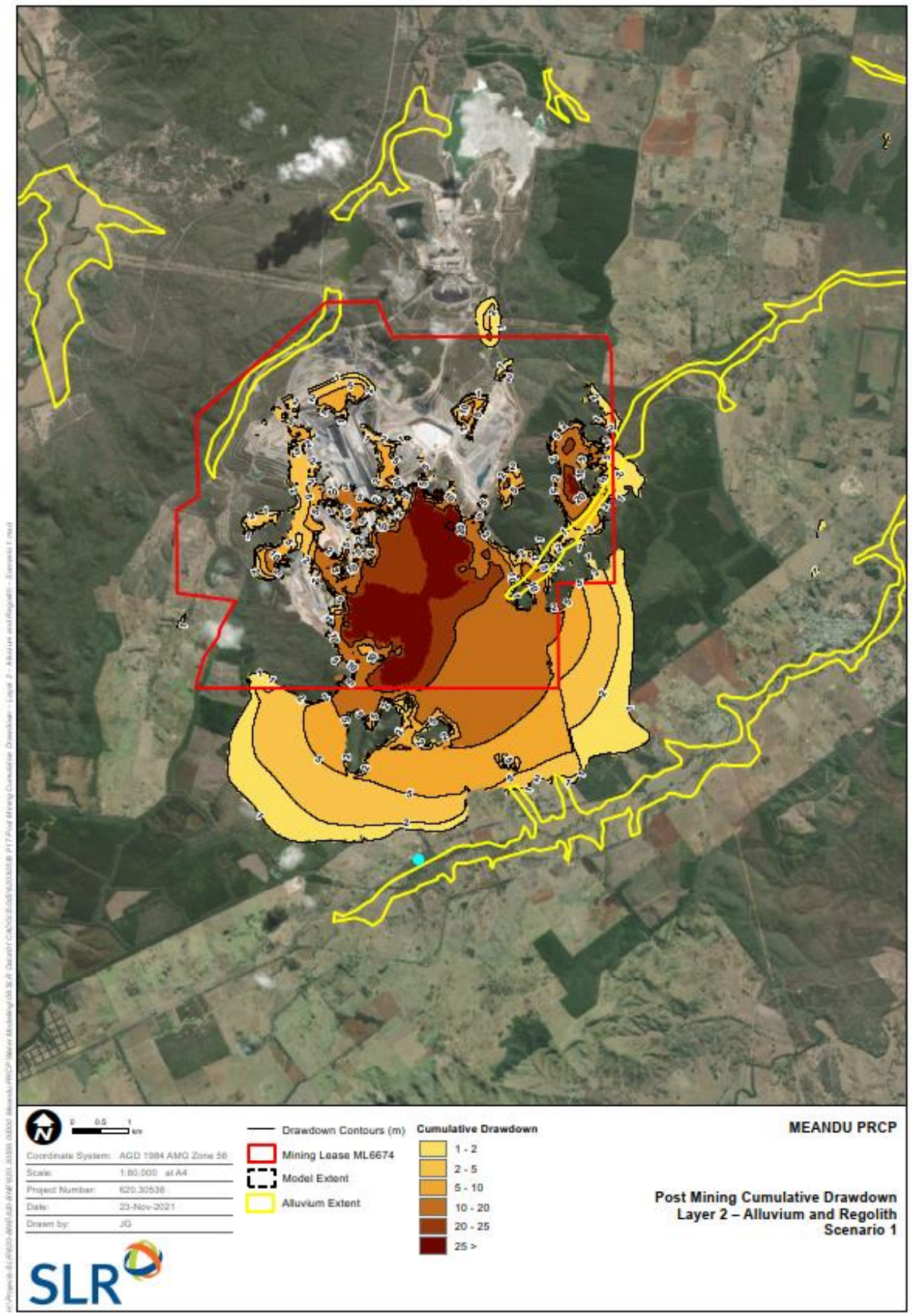

Figure 87 Post Mining Cumulative Drawdown – Layer 2 – Alluvium and Regolith – Scenario 1

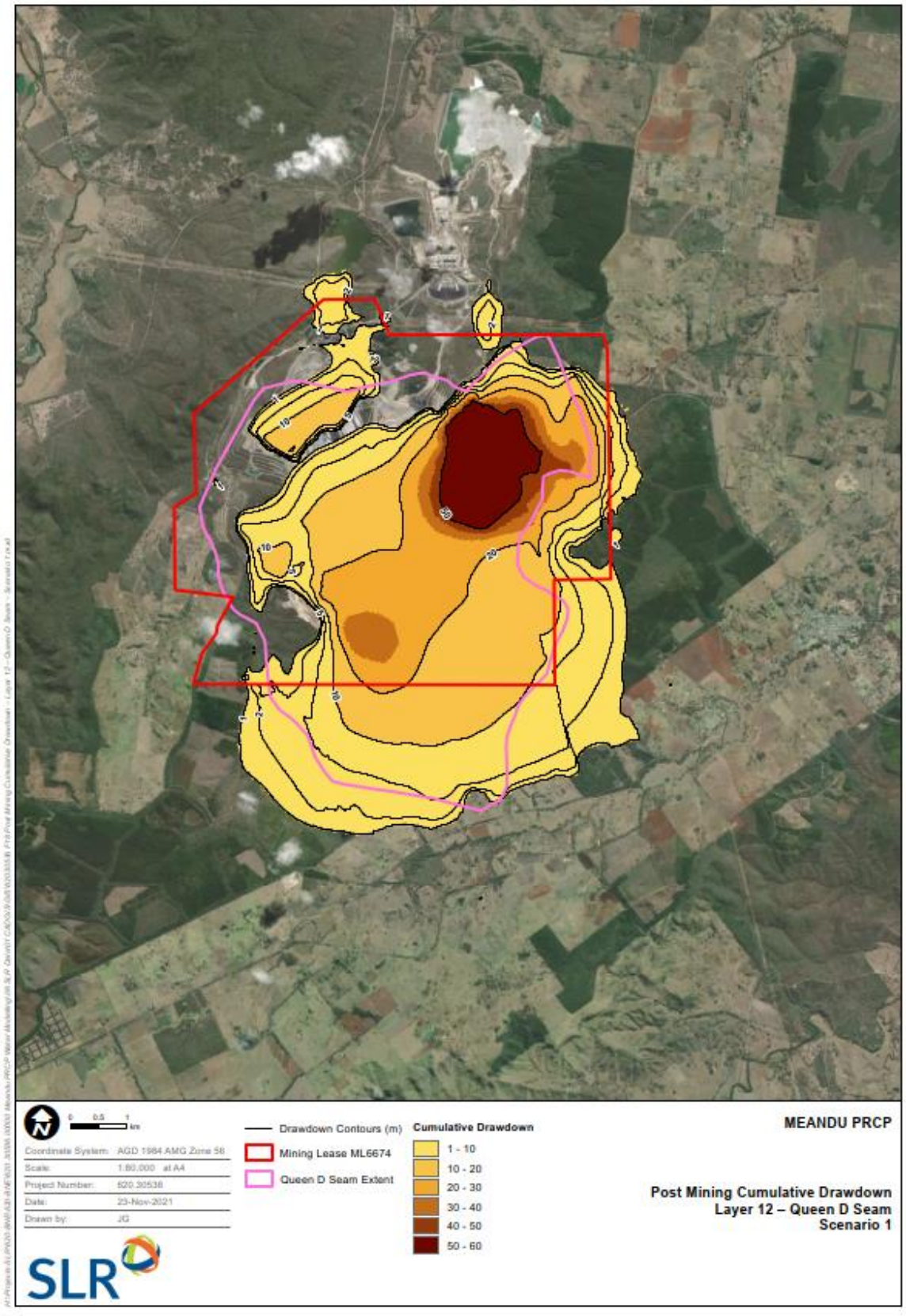

Figure 88 Post Mining Cumulative Drawdown – Layer 12 – Queen D Seam – Scenario 1

6.5.1.2 Predictive Results – Scenario 2

The cumulative drawdown at the end of the recovery period (i.e., 300 years after mining ends) was estimated by comparing the water level simulated for the Null run (i.e., no mining activities at Meandu) to the water level simulated for the recovery run.

In the basalt, the cumulative drawdown reaches a maximum of 30 m at 300 years after mining ends. The greatest drawdown is limited to the mining lease with a maximum drawdown estimated <15 m outside of the mining lease, toward the south. The 1 m drawdown contour (i.e., the distance at which the cumulative drawdown is <1 m) extend to a maximum of 3 km from the south of the mining lease (**Figure 89**).

In the alluvium, the maximum drawdown is observed along Rocky Creek alluvium, directly south of the mine. The maximum drawdown is predicted where the Boulevard Fault crosses the Rocky Creek alluvium (**Figure 90**). As observed by peer reviewer Noel Merrick in JBT (2021a), it is likely for the drawdown south of the mining lease to be overestimated due to the simplified assumption that the Boulevard fault act as a conduit for its entire length.

In the Queen seam (Queen D Seam), a maximum drawdown of approximately 95 m is estimated in the vicinity of the K2E final void (**Figure 91**).

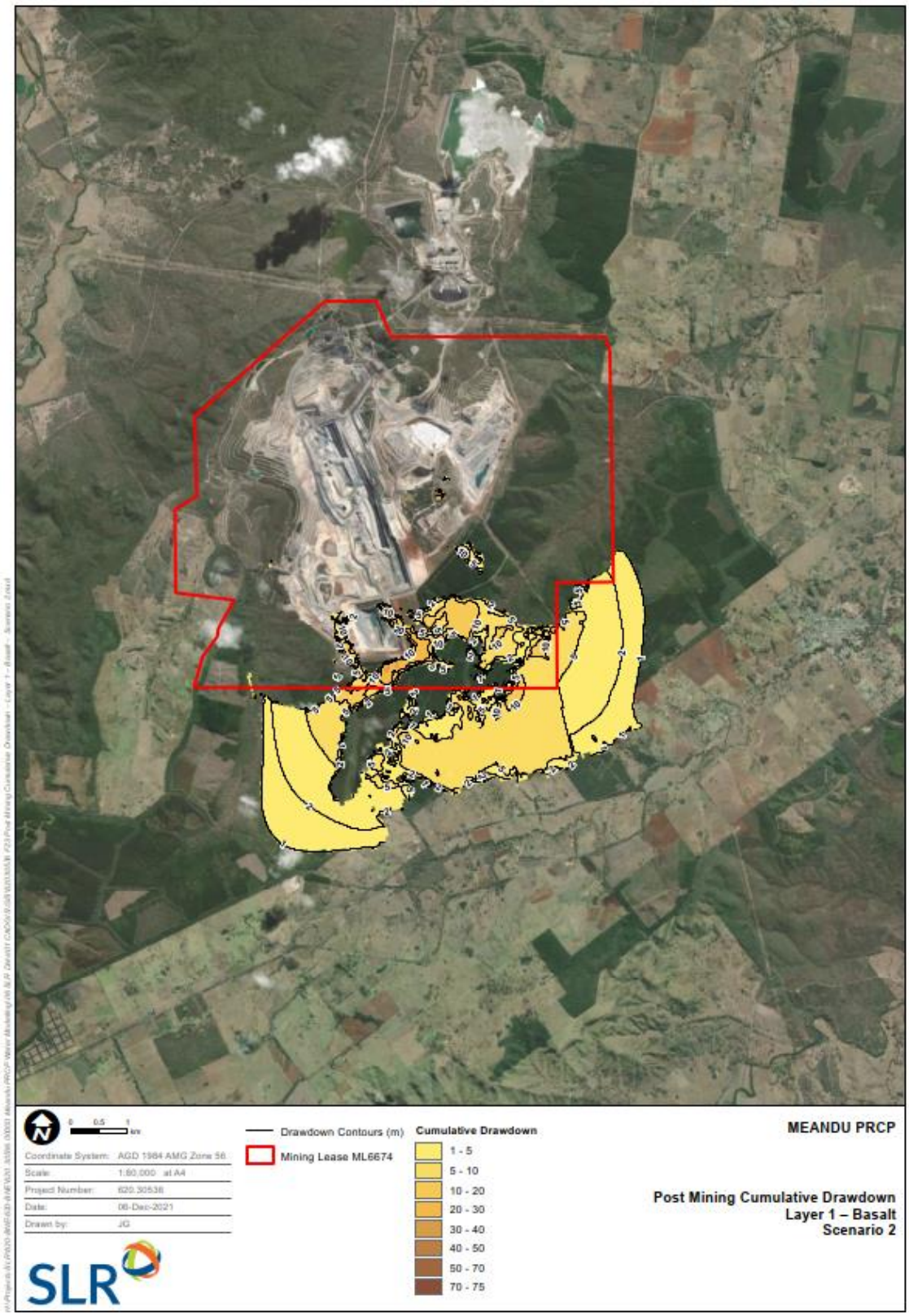

Figure 89 Post Mining Cumulative Drawdown – Layer 1 – Basalt – Scenario 2

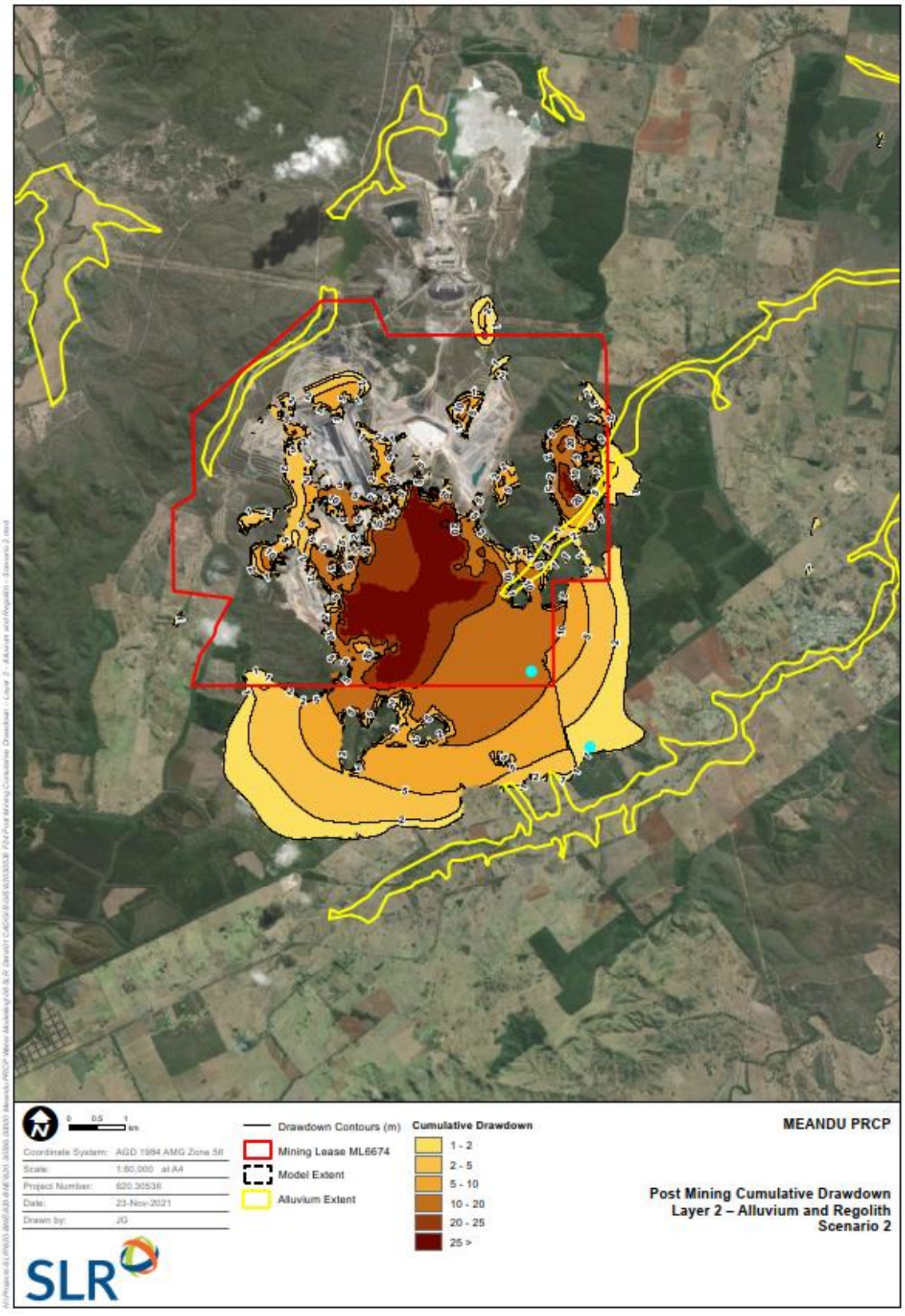

Figure 90 Post Mining Cumulative Drawdown – Layer 2 – Alluvium and Regolith – Scenario 2

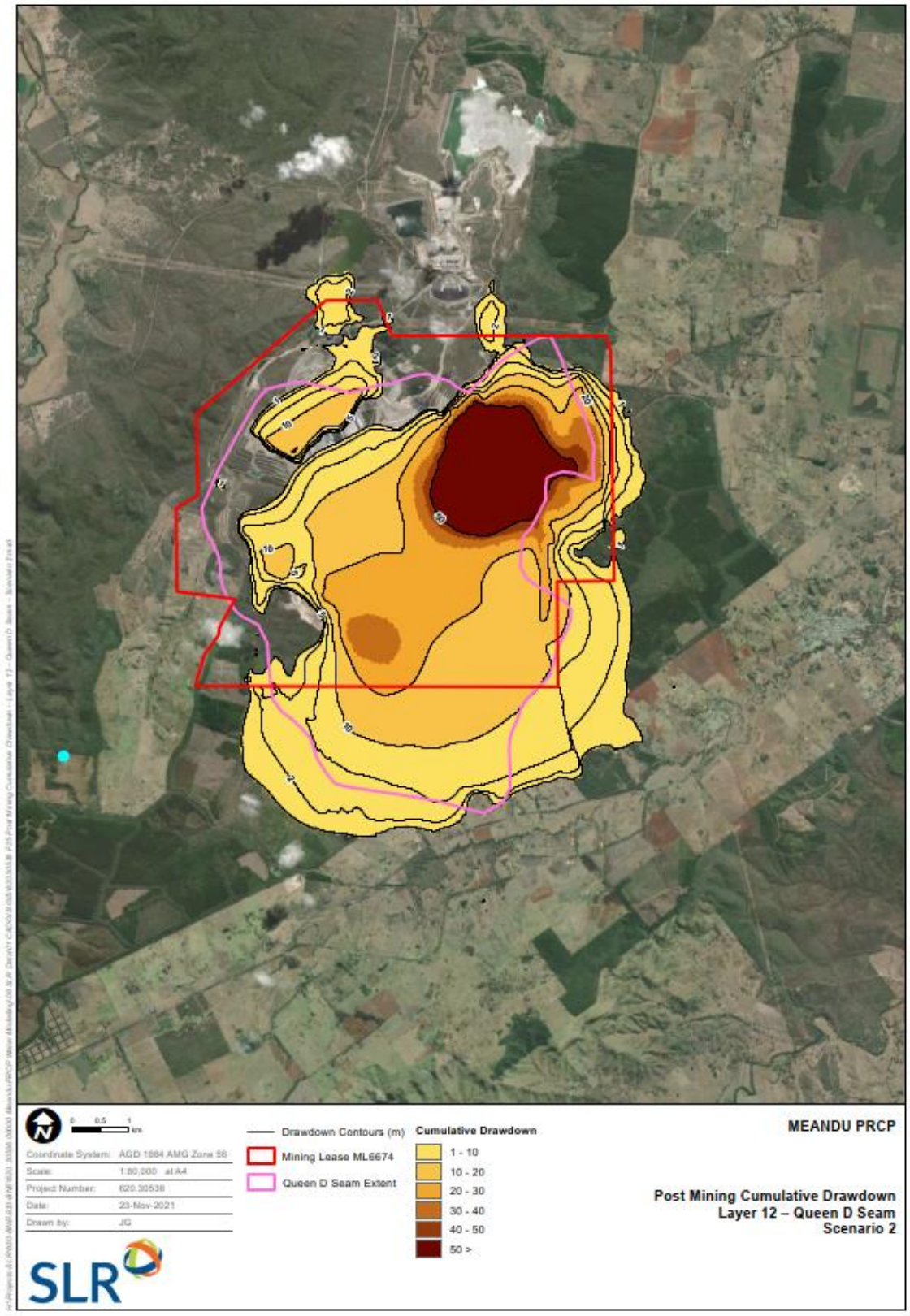

Figure 91 Post Mining Cumulative Drawdown – Layer 12 – Queen D Seam – Scenario 2

6.5.2 Cones of Depression and Associated Impacts

6.5.2.1 Predictive Results – Scenario 1

In the regolith, saturated areas are expected to flow toward Meandu Creek upstream of Meandu Creek Dam. In the alluvium, groundwater flow directions are with the alignment of drainage (**Figure 92**).

Post mining conditions in the basalt remains variably saturated with groundwater flow directions primarily toward the east (**Figure 93**).

Groundwater flow direction in the coal seams and the spoil (i.e., where the seams have been mined) is toward the final voids and Meandu Creek upstream of Meandu Creek Dam. This is best visualised in the lowest mined seams at the site, Queen D (Layer 12) and as presented on **Figure 94**.

Potential surface water expression was assessed by comparing the top of the model layer 1 (i.e., ground surface) to the water table elevation. Areas where the water table elevation is within 1 m of the surface (or above the surface) are shown as “Shallow Water Table” on **Figure 92**.

These are:

- An area of approximately 2 km along the degazetted Black Creek;
- Several areas along the north of the mining lease boundary associated with drainage lines;
- The majority of the Meandu Creek Dam surface area:
    - The groundwater is conceptualised to be hydraulically connected with the dam waters;
- Four areas associated with the AMD seepage around Hitachi Hill (at the interface between Spoil and Regolith); and
- A 1km section of Meandu Creek upstream of Meandu Creek Dam (adjacent to the Mine).

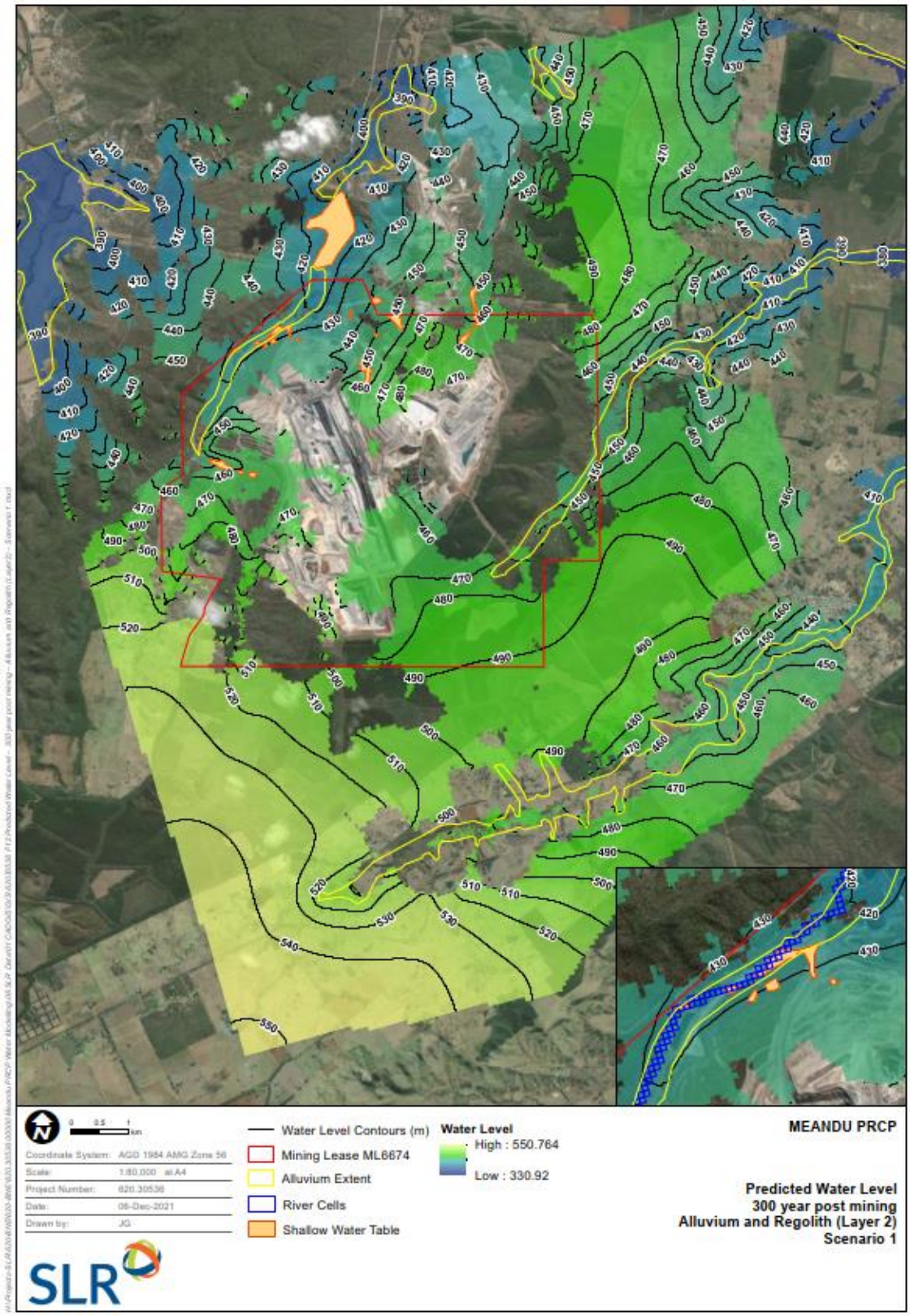

Figure 92 Predicted Water Level – 300 Year Post Mining – Alluvium and Regolith (Layer 2) – Scenario 1

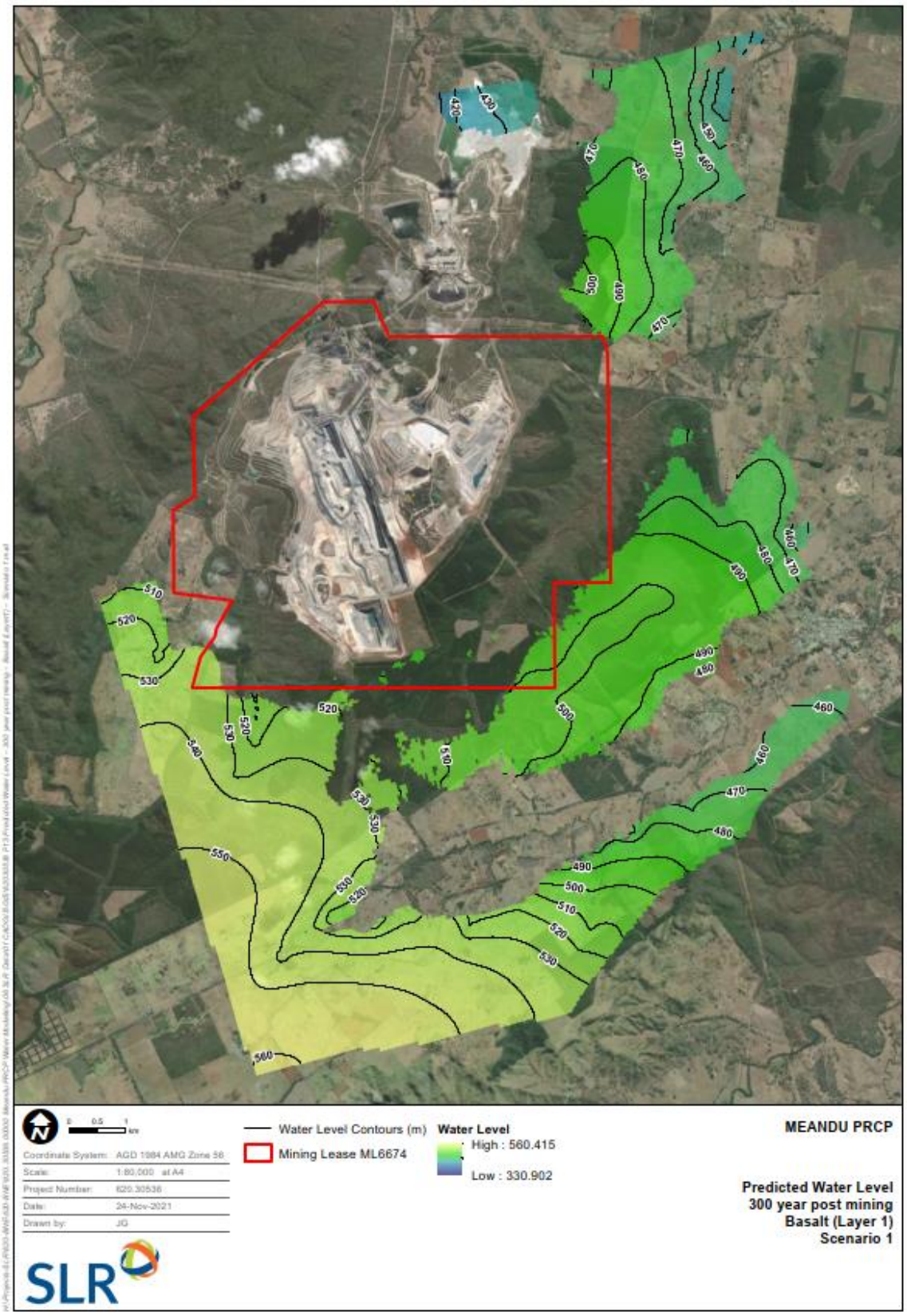

Figure 93 Predicted Water Level – 300 Year Post Mining – Basalt (Layer 1) – Scenario 1

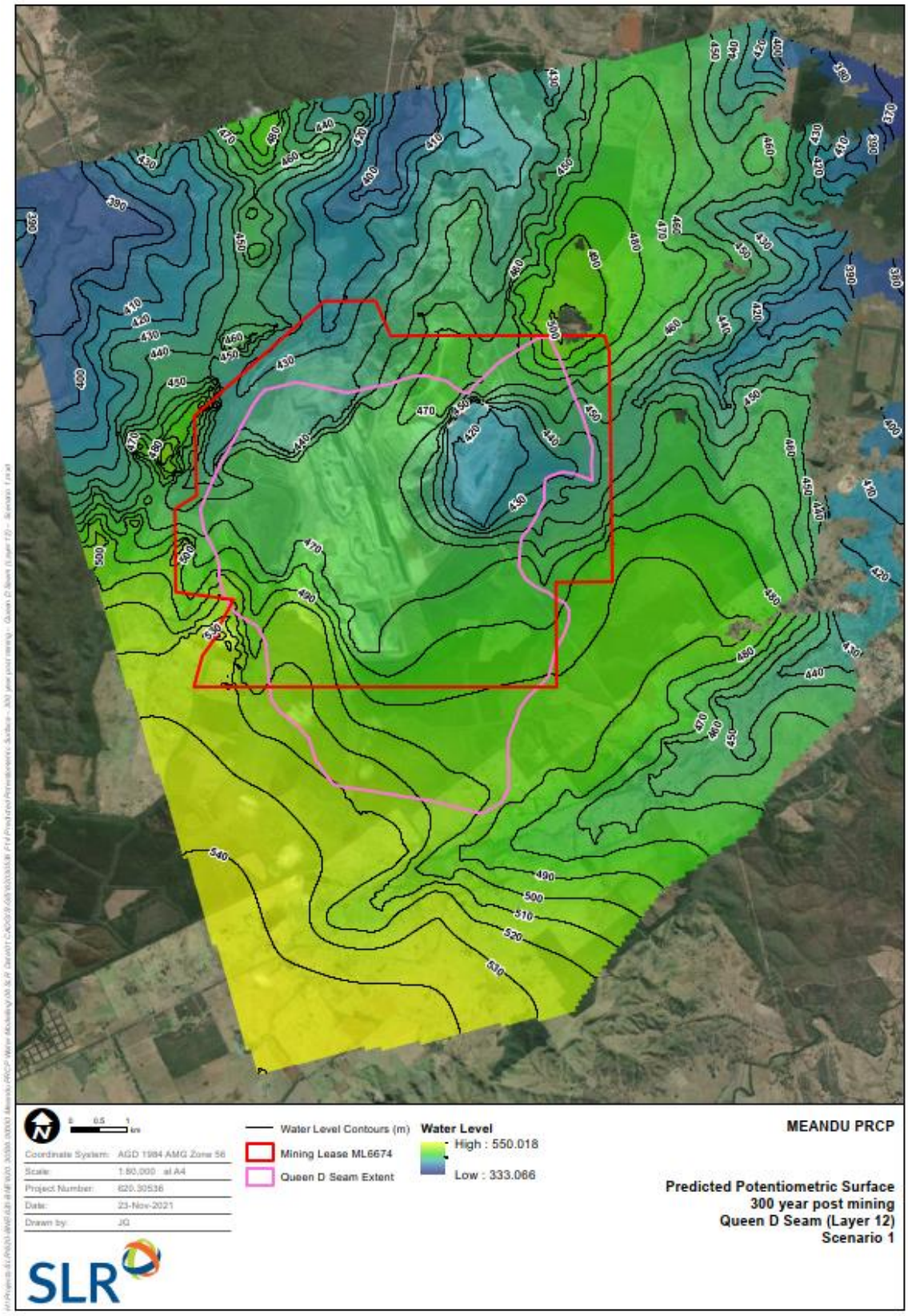

Figure 94 Predicted Potentiometric Surface – 300 Year Post Mining – Queen D Seam (Layer 12) – Scenario 1

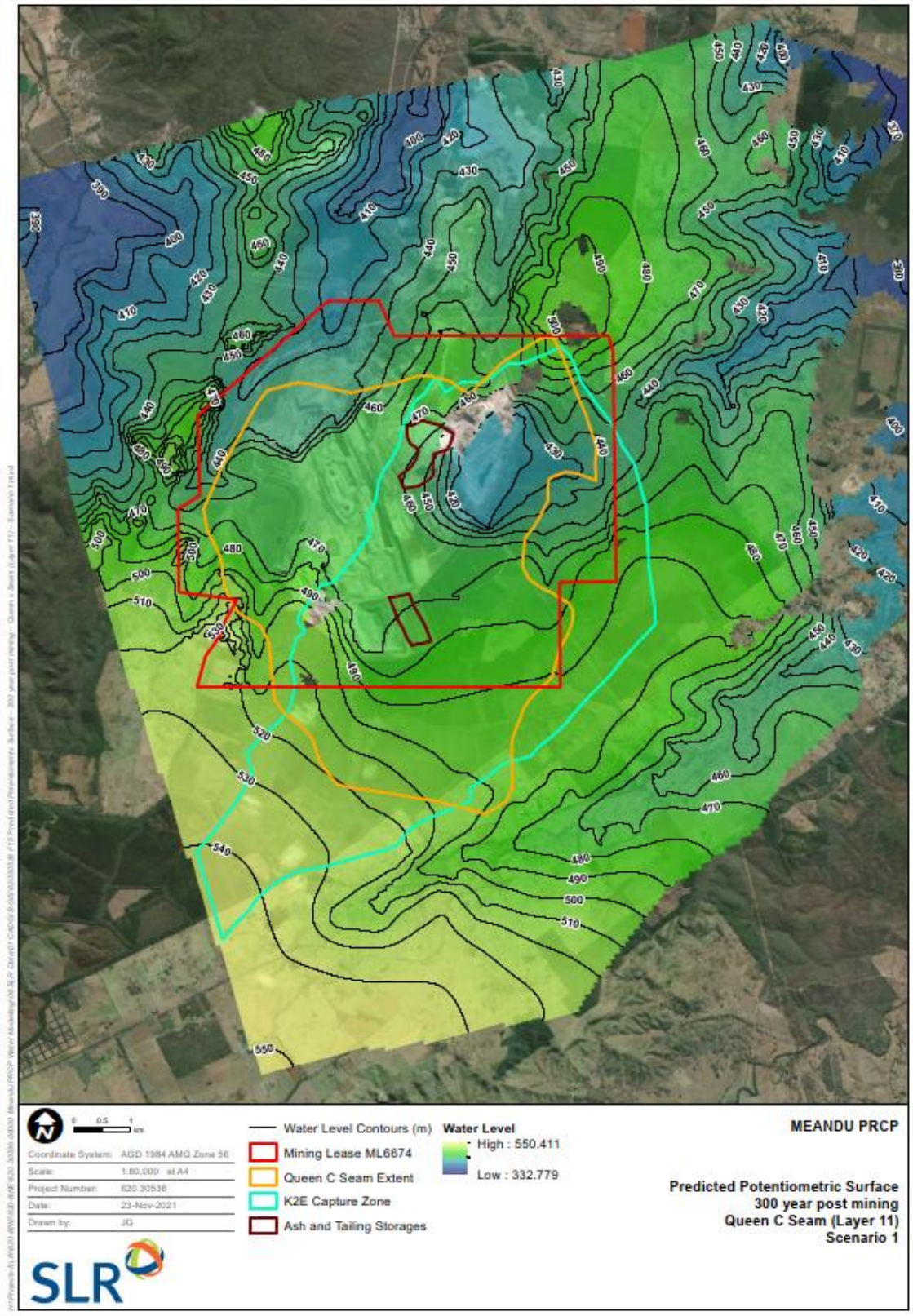

Figure 95 Predicted Potentiometric Surface – 300 Year Post Mining – Queen C Seam (Layer 11) – Scenario 1

6.5.2.2 Predictive Results – Scenario 2

Post mining conditions in the basalt remains variably saturated with groundwater flow directions primarily toward the east (**Figure 96**).

In the regolith, saturated areas are expected to flow toward Meandu Creek upstream of Meandu Creek Dam. In the alluvium, groundwater flow directions are with the alignment of drainage (**Figure 97**).

The groundwater flow direction in the coal seams and the spoil (i.e., where the seams have been mined) is toward the final voids and Meandu Creek upstream of Meandu Creek Dam. This is best visualised in the lowest mined seams at the site, Queen D (Layer 12), as presented on **Figure 98**.

Potential surface water expression was assessed by comparing the top of the model Layer 1 (i.e., ground surface) to the water table elevation. Areas where the water table elevation is within 1 m of the surface (or above the surface) are shown as “Shallow Water Table” on **Figure 97**. Identified areas of potential surface water expression are the same as Scenario 1 and are detailed in **Section 6.5.2.1**.

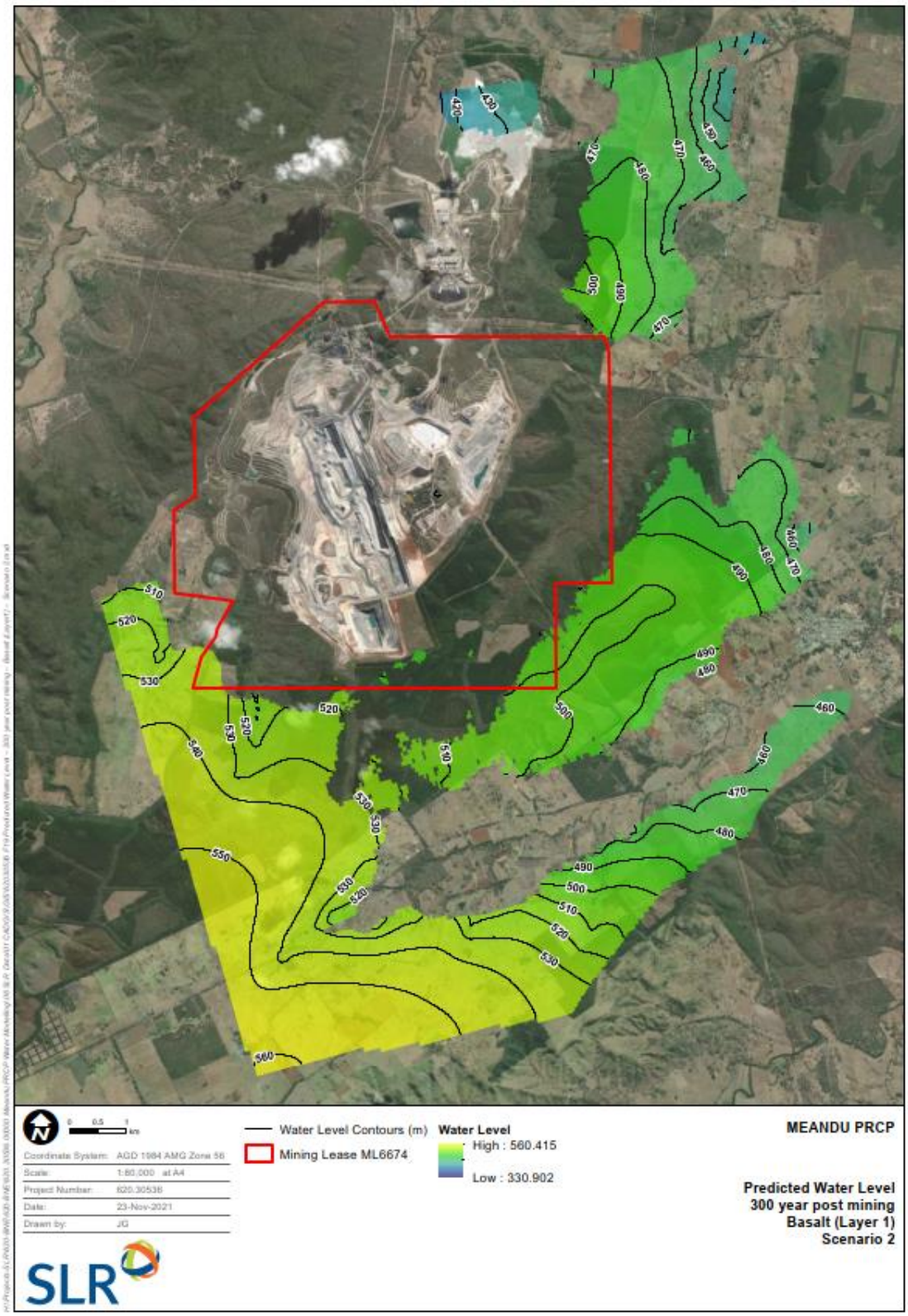

Figure 96 Predicted Water Level – 300 Year Post Mining – Basalt (Layer 1) – Scenario 2

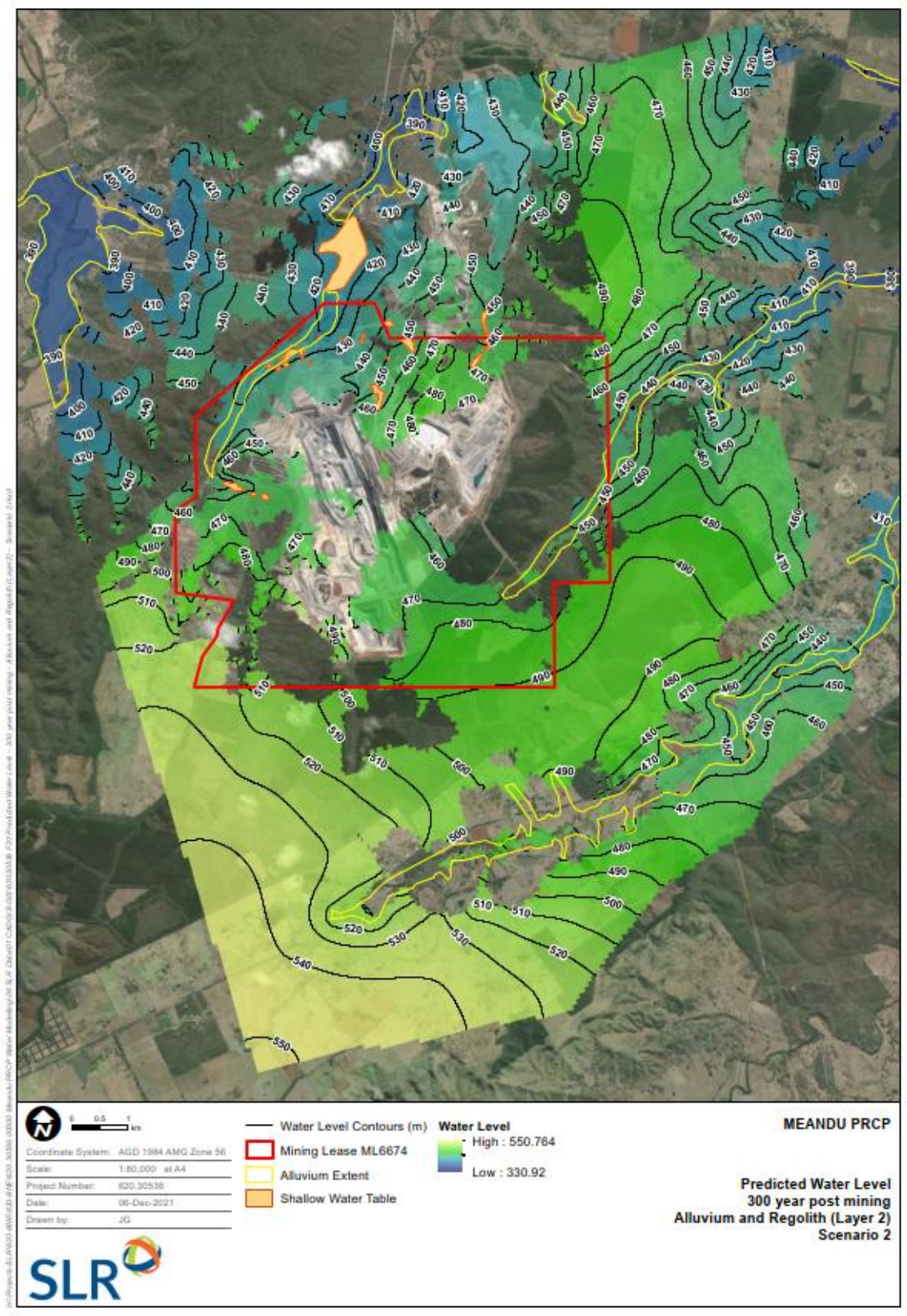

Figure 97 Predicted Water Level – 300 Year Post Mining – Alluvium and Regolith (Layer 2) – Scenario 2

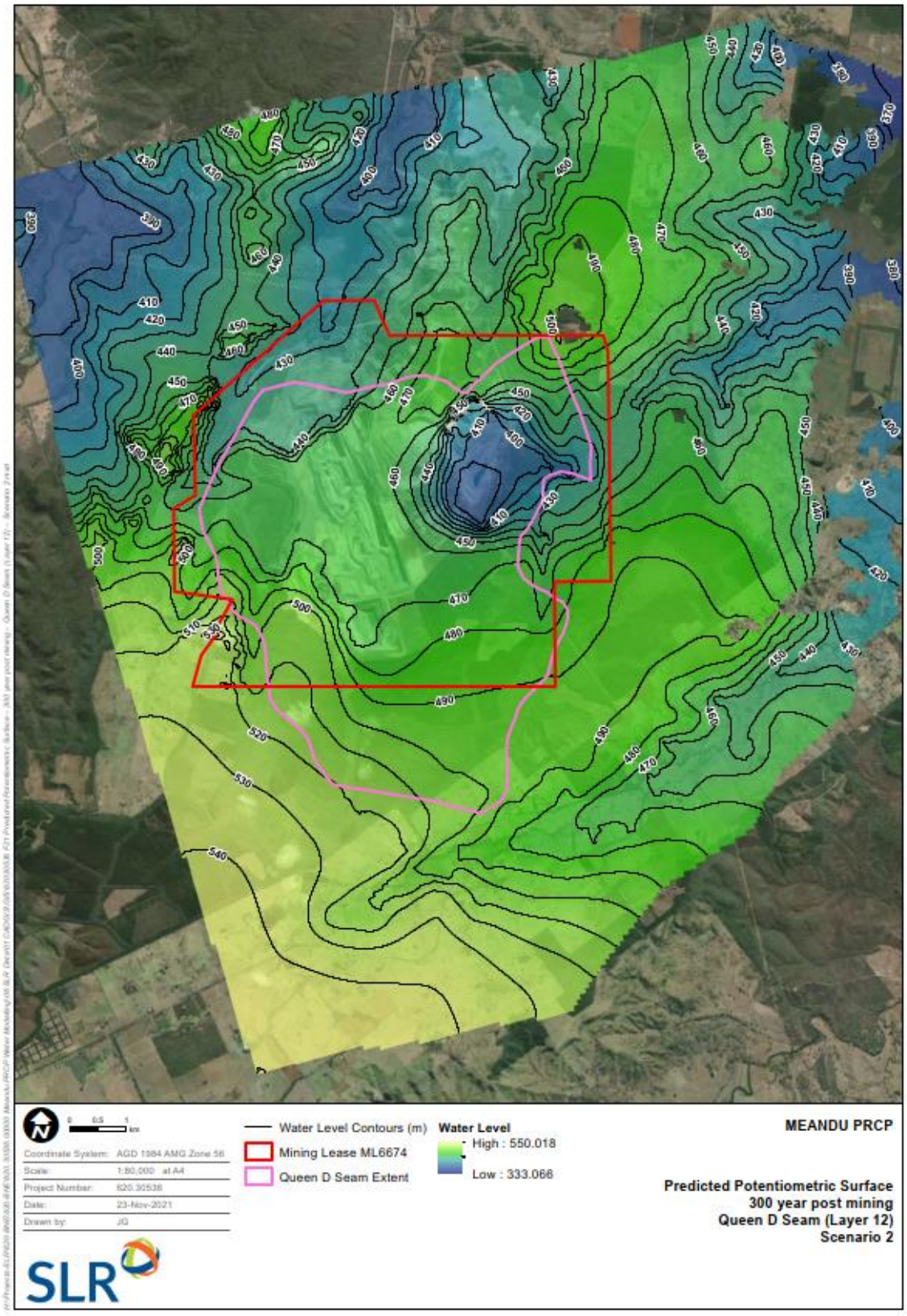

Figure 98 Predicted Potentiometric Surface – 300 Year Post Mining – Queen D Seam (Layer 12) – Scenario 2

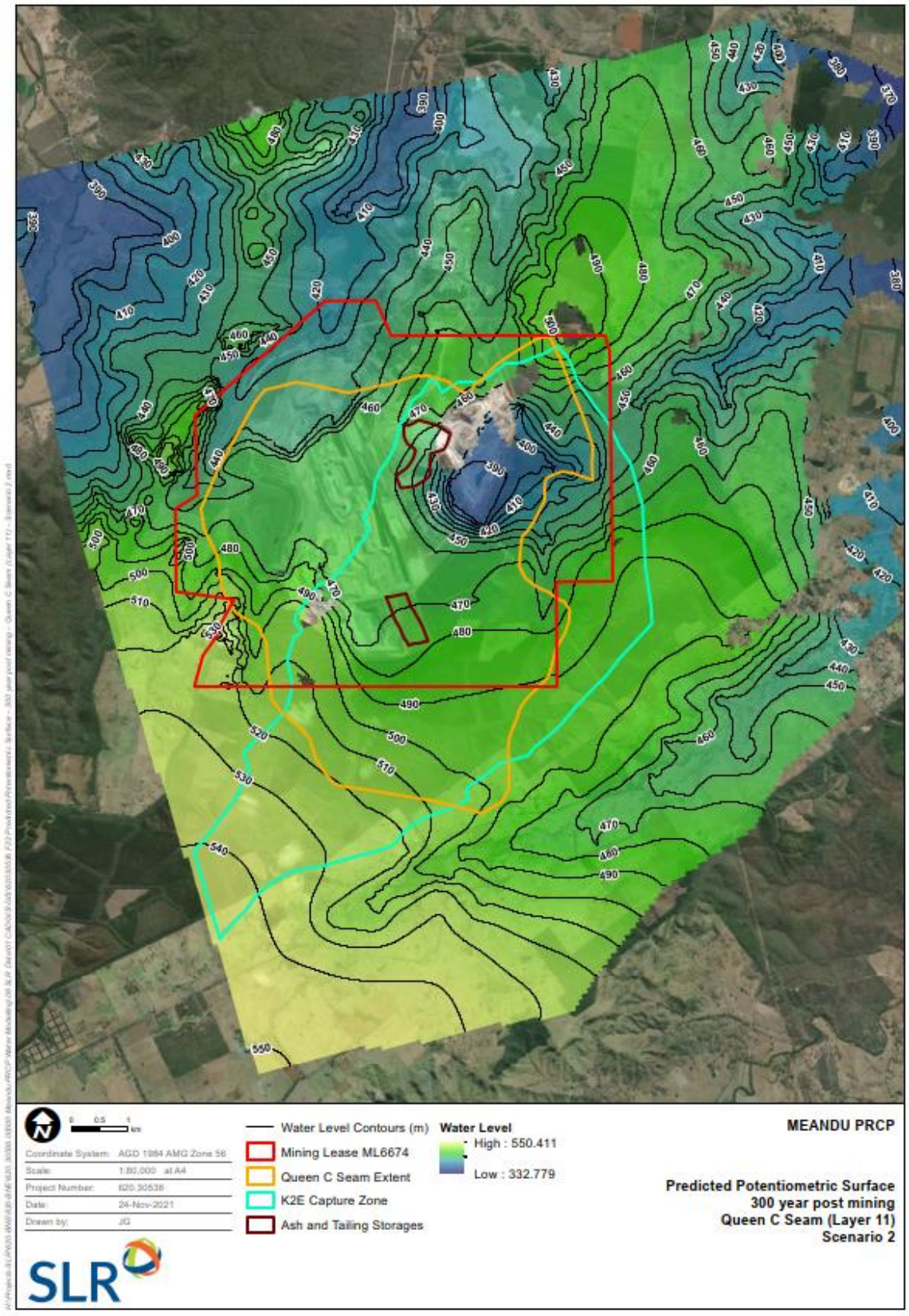

Figure 99 Predicted Potentiometric Surface – 300 Year Post Mining – Queen C Seam (Layer 11) – Scenario 2

6.5.3 Drainage and Flooding Behaviours of Surface Waters in the Vicinity of the Void

A review of the watercourses in the vicinity of the project showed that two relevant watercourses exist under the classification system outlined in the PRCP Guideline, i.e. Meandu Creek and Rocky Creek. Therefore, in accordance with the requirements of the PRCP Guideline, flood modelling was undertaken for both relevant watercourses.

A model landform was developed for the project, which was based on the post-mining final landform surface provided by Stanwell and included the proposed final voids and rehabilitated dump areas. LiDAR data dated 2007, also provided by Stanwell, was used to supplement the model landform for areas outside the project extents.

Using the model landform, hydrologic models were developed for both the Meandu Creek and Rocky Creek catchments. The results of the models were verified against results of empirical flow estimation methods. The hydrologic models were simulated for a suite of design storm events including a range of temporal patterns, storm durations and annual exceedance probability (AEP) events including the 0.1% AEP and probable maximum flood (PMF).

A hydraulic model covering both the Meandu Creek and Rocky Creek catchments was developed. The model topography was based on the model landform for the purpose of assessing the post-mining flooding conditions in accordance with Section 3.6.1 of the PRCP Guideline. Flow hydrographs produced by the hydrologic models were utilised as inflows for the hydraulic model.

The results of the hydraulic model showed the proposed voids are located outside of the flood inundation footprint of both Meandu Creek and Rocky Creek for the modelled flood events up to and including the PMF. The hydraulic model results also illustrated that the integrity of the rehabilitated waste rock dumps that form part of the stable landform (i.e. post-mining landform) are not located within the floodplain extent of Meandu Creek or Rocky Creek.

Based on the above, the outcome of the assessment indicates that the post-mining flood risk profile for the project is of negligible risk.

6.5.4 Potential Extent of Flooding and Implications of Interactions with the Void

The results of the hydraulic modelling (SLR, 2021) showed the proposed voids are located outside of the flood inundation footprint of both Meandu Creek and Rocky Creek for the modelled flood events up to and including the PMF. The hydraulic model results also illustrated that the integrity of the rehabilitated waste rock dumps that form part of the stable landform (i.e. post-mining landform) are not located within the floodplain extent of Meandu Creek or Rocky Creek.

6.5.5 Conceptual Model that Incorporates all Projected Inflows, Outflows, and Recharge Rates

6.5.5.1 Inflows\Recharge

The WBM utilises the Australian Water Balance Model (AWBM) rainfall runoff module to calculate the rainfall and runoff inflows in each catchment (**Figure 100**). Rainfall was included in the water balance using historically-recorded information and probabilistic rainfall generated values as discussed in **Section 6.5.7**. The rainfall is converted to runoff using the AWBM, illustrated in **Figure 100**. This runoff can be split into two forms:

- Surface runoff which travels overland to the destination; or

- Sub-surface which travels through the ground to reach the destination.

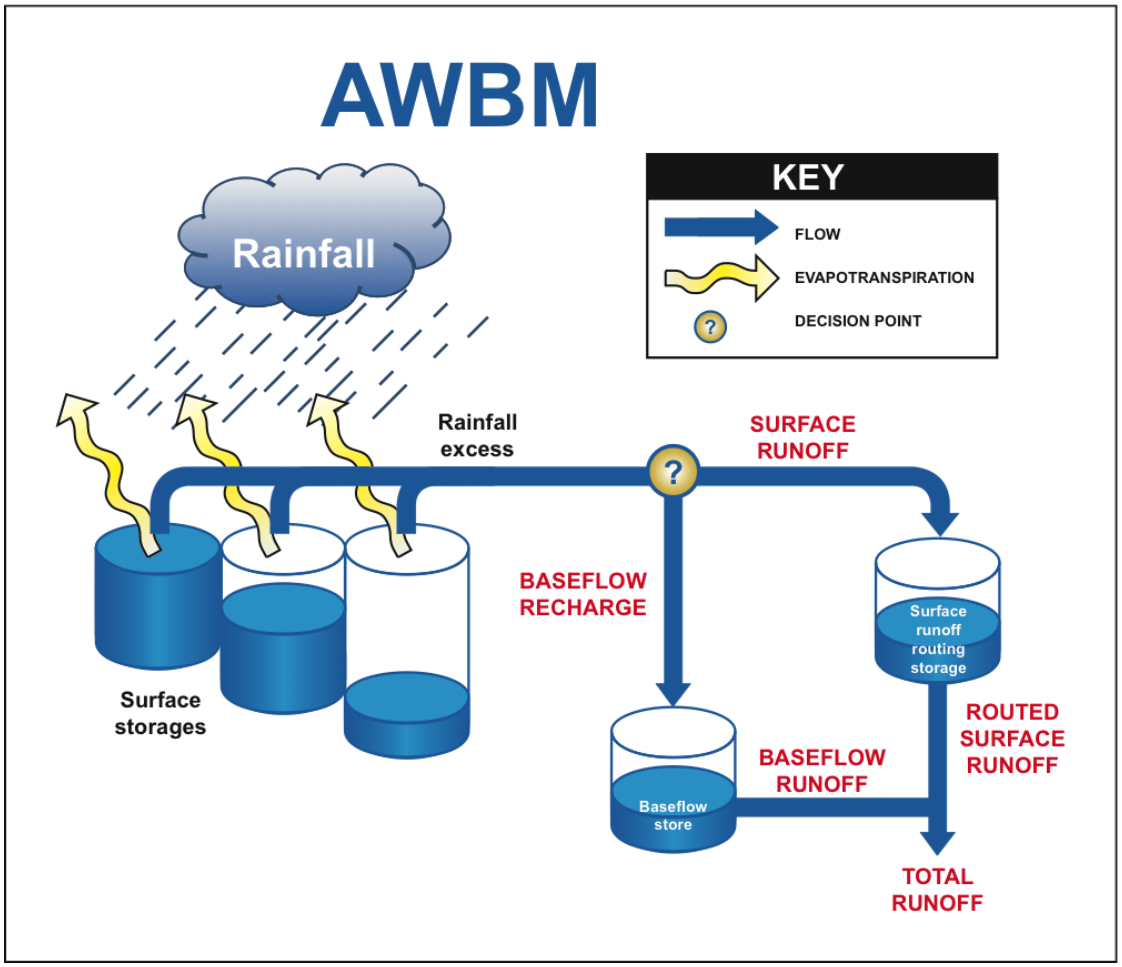

Figure 100 AWBM Rainfall Runoff Model (Source: www.ewater.org.au)

Groundwater inflows to the final void WBM were derived from the groundwater model developed for the PRCP. The groundwater model showed that 0.1 to 0.2 ML/d (36.5 – 73.0 ML/y) of ground water enters the K2E void. This was modelled as a constant inflow as 0.2 ML/d (73.0 ML/y) in the WBM.

Initial final void results (which assumed no groundwater inflow nor outflow) were supplied for the groundwater model. The groundwater model showed that the K4E void acted as a source with seepage rates between 0.0 ML/d to 0.1ML/d (0.0 ML/y to 36.5 ML/y). The latter is reached by the time K4E void reaches equilibrium. The groundwater model also did not show seepage loss for K2E void. As such, the final void model assumed no seepage losses for both voids.

6.5.5.2 Losses

Water is lost from the system to evaporation. Evaporation was included in the water balance using historically-recorded information and the long-term monthly averages as discussed in **Section 6.5.7**. These loss rates were applied to surface water areas through the period of the water balance. Other losses include the water extracted for stock water (2 ML/yr and 365 ML/yr).

6.5.6 Water Storage and Long-Term Water Balance

Estimated long-term water storage for scenarios 1 and 2 are provided in **Table 41** for the long-term average void water level.

Table 41 Long-Term Average Water Storage

Scenario	Storage (GL)
Scenario 1 – K2E	6.4
Scenario 1 – K4E	1.1
Scenario 2 – K2E	0.1
Scenario 2 – K4E	1.1

Estimated long-term average water balance fluxes for scenarios 1 and 2 are provided in **Table 35** for the long-term average void water level.

6.5.7 Major Water Fluxes Into and Out of the Void

6.5.7.1 Climate

Historical rainfall data was sourced for the Meandu Mine from the Scientific Information for Land Owners (SILO) database (**Figure 101**). The SILO database is a database hosted by the Queensland Department of Environment and Science (DES) developed in collaboration with the Bureau of Meteorology (BoM). The SILO database provides a continuous daily time series of data at either recording stations or grid points across Australia. The data consists of observational records with missing data interpolated from surrounding gauges. The grid consists entirely of interpolated estimates based on a 0.05° × 0.05° grid. The gridded data point for SILO data was selected due to its correlations with nearby gauges and the length and quality of the gauged record. The centroid of the SILO grid selected was -26.80, 151.90.

A comparison was undertaken between the gridded data and BoM historical rainfall records in the surrounding area including rainfall gauges at:

- Tarong (station number 040199, located 8 km north west),
- Yarraman Upper (Station number 040259, located 10 km south); and
- Yarraman Post Office (station number 040258 located 9 km south east).

Only minor variability in the monthly and annual rainfall totals were found, with the record at Tarong being slightly lower. The SILO record was therefore utilised as it provided a complete infilled record which was representative of the historical rainfall for the area.

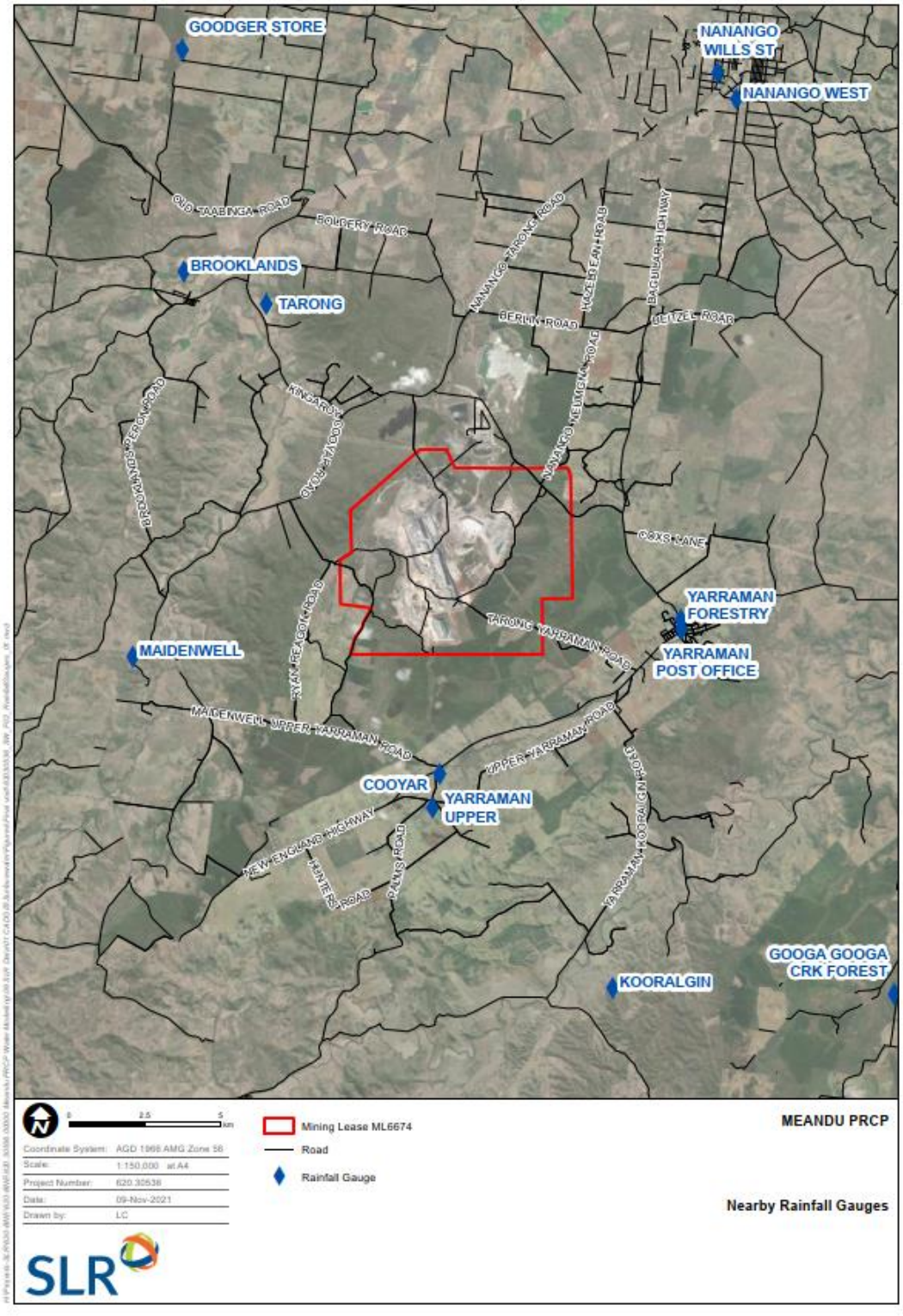

Figure 101 Nearby Rainfall Gauges

6.5.7.1.1 Probabilistic Rainfall Generation

Probabilistic climate data for the WBM was used to predict the rainfall at the site using the retrieved SILO rainfall data and the Stochastic Climate Library program (eWater CRC).

The purpose of the probabilistic rainfall generation is to develop a wide range of climate sequences based on the recorded rainfall data of the area. These sequences have the same statistical characteristics of the historical data set for a range of parameters, including mean, variance, skew, and number of wet days or dry days. Each sequence has an order in which the rainfall has occurred. For example, one sequence may have wetter years at the start of the sequence, where another sequence may have the wetter years towards the end of the sequence. Some sequences may be wetter or dryer than others in order to account for the variability of the climate which may occur after the mine is rehabilitated. The probabilistic rainfall data replicates the seasonality of the rainfall data.

Probabilistic rainfall data was produced for 500 replicates of 120 year rainfall data (60,000 years of probabilistic data). This allows a wide range of climatic conditions to be simulated, which then gives the mean and median of the assessment. The assessment also yields percentiles which are interpreted as a percentage exceedance probability (i.e. the risk of an event occurring).

The outputs of the stochastically generated rainfall were compared to the historically recorded rainfall data as shown in **Figure 102** for the full rainfall record. The comparison showed a good correlation for the majority of the exceedances.

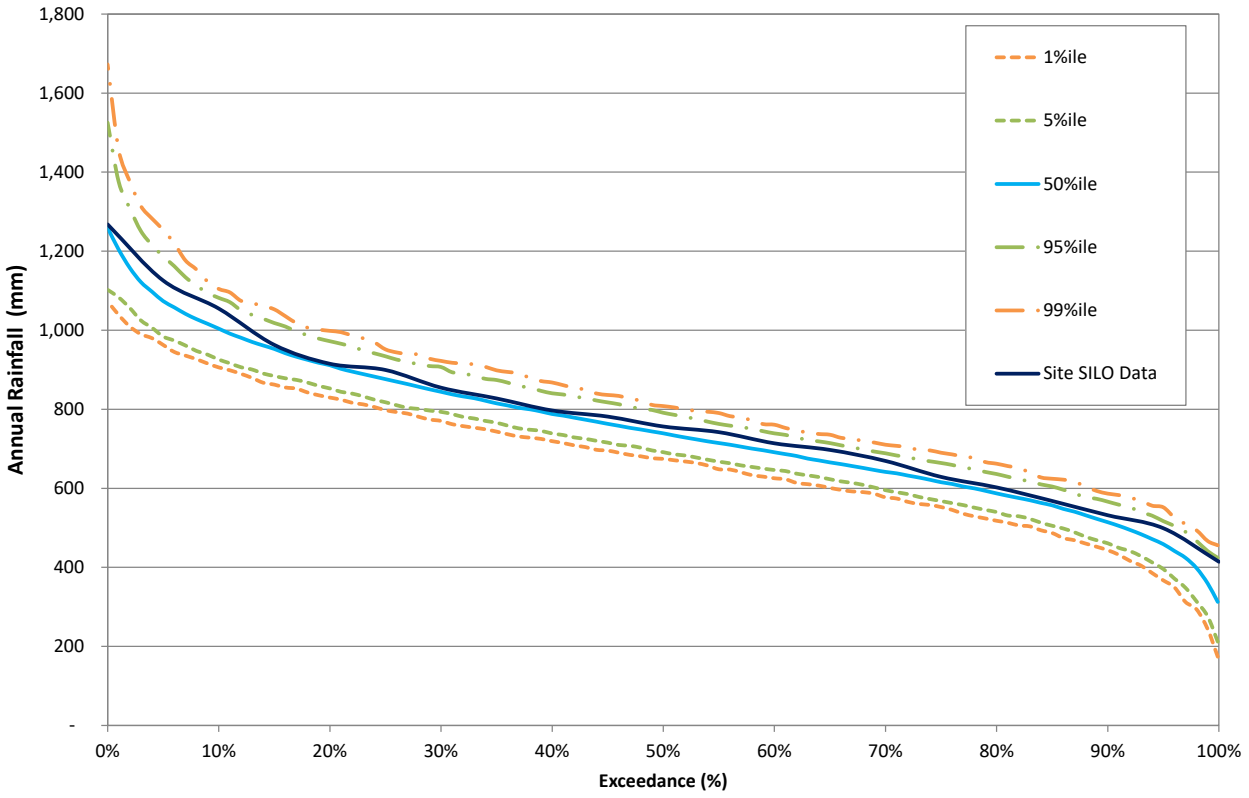

Figure 102 Stochastic and Historical Data Comparison – Annual Rainfall

6.5.7.1.2 Evaporation

The evaporation rates in the model were downloaded from SILO and were generated based on interpolative methods using available BoM stations in the region. Due to the limited number of stations in the region, long term average values were used in the WBM as opposed to probabilistic evaporation data. SLR did consider the opportunity to also utilise probabilistic evaporation data but the initial development of a combined rainfall and probabilistic evaporation data set showed poor correlation with the historical data in addition to impacting the rainfall probabilistic data fit. As a result, the monthly average data was adopted based on long term average values. **Table 42** shows the adopted evaporation rates.

Table 42 Adopted Evaporation Rates

Month	Evaporation (mm/d)
January	6.4
February	5.5
March	5
April	3.8
May	2.6
June	2.1
July	2.3
August	3.1
September	4.4
October	5.4
November	6.2
December	6.5

6.5.7.2 Groundwater Consideration

Groundwater inflows to the final void WBM were derived from the groundwater model developed for the PRCP (SLR, 2021a). The groundwater model showed that 0.1 to 0.2 ML/d of ground water enters the K2E void. This was modelled as a constant inflow as 0.2 ML/d in the WBM.

Initial final void results (which assumed no groundwater inflow nor outflow) were supplied for the groundwater model. The groundwater model showed that the K4E void acted as a source with seepage rates between 0.0 ML/d to 0.1ML/d. The latter is reached by the time K4E void reaches equilibrium. The groundwater model also did not show seepage loss for K2E void. As such, the final void model assumed no seepage losses for both voids.

6.5.8 Sources of Surface Water Within the Mine Catchment that are Likely to Influence the Water Quality in the Void

The WBM incorporates a coupled water balance with water quality for the runoff from catchment areas in the model for Electrical Conductivity (EC) calculated as Total Dissolved Salts (TDS) in the WBM.

The WBM includes modelling of salt to represent the general salt in the final voids. The salt loading is based on modelled TDS values used in the K2E Project. Each land use type was represented by a specific TDS value which is then applied to the runoff for each land use type that reports to the void. In addition to this, the groundwater inflow to the voids also contribute to the salt loading. The groundwater TDS is based on the median historical samples of the spoil and coal seam that is in contact with the void face. The adopted TDS are:

- Pit/Hardstand: 1,000 mg/L;
- Rehab: 200 mg/L; and
- GW Inflow: 1,364 mg/L.

It is noted that the Pit/Hardstand area in the model are defined as the bottom 10 m area of the void where highly turbid water settles long term. When runoff approaches this area, a higher TDS is applied. Due to the proposed final pit and highwall treatment post mining, the remainder of the catchment are represented as rehab.

An Electrical Conductivity (EC) factor of 0.5346 was adopted to convert the TDS to EC. This is based on the Integrated WBM developed by Golder (2018) and is based on laboratory analysis of over 1,350 samples from Meandu Mine.

6.6 Predicted Water Quality in the Long-Term Including Potential Stratification

6.6.1 Scenario 1 – Limited stock water extraction from both voids

6.6.1.1 K2E

Figure 103 shows the expected salinity in the void over the modelled 120-year period. The model shows that the EC levels increases up to 5,500 µS/cm. This is significantly below the ANZECC/ARMCANZ (2000) guidelines' of 9,350 µS/cm; suggesting that the water is of suitable quality for stock water demands for at least 120 years based on modelled EC levels as an indicator for water quality.

It is noted that there is a slight upward trend in EC. This is understood to be due to the minimal clean/rehabilitated catchment runoff entering the void that can offset groundwater inflows and evaporation that increases the salinity. However, extrapolation of the trend shows that it is unlikely to breach the ANZECC/ARMCANZ (2000) guideline for at least 200 years and is considered acceptable.

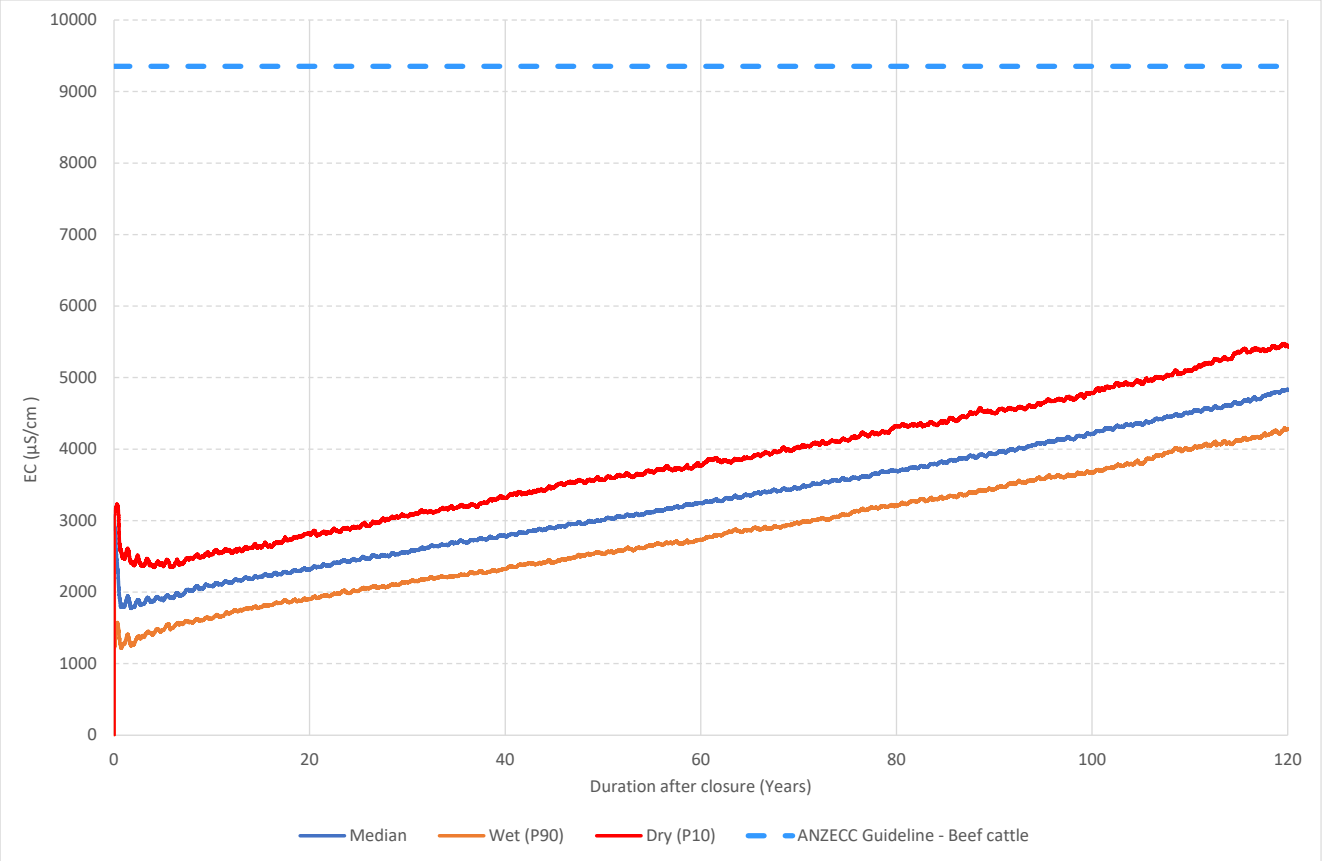

Figure 103 K2E – Scenario 1 Water Quality

6.6.1.2 K4E

Figure 104 shows the expected EC in the K4E void at 120 years. This shows that the EC levels increases to up to 4,000 µS/cm. This is significantly below the ANZECC/ARMCANZ (2000) guideline suggesting that the water is of suitable quality for stock water demands (based on EC) for at least 120 years. Similar to K2E results, there is an upward trend to the EC due to the minimal clean/rehabilitated catchment runoff entering the void to offset evaporation that increases the EC. However, the trend shows that it is unlikely to breach the ANZECC/ARMCANZ (2000) guideline for at least 400 years and is considered acceptable.

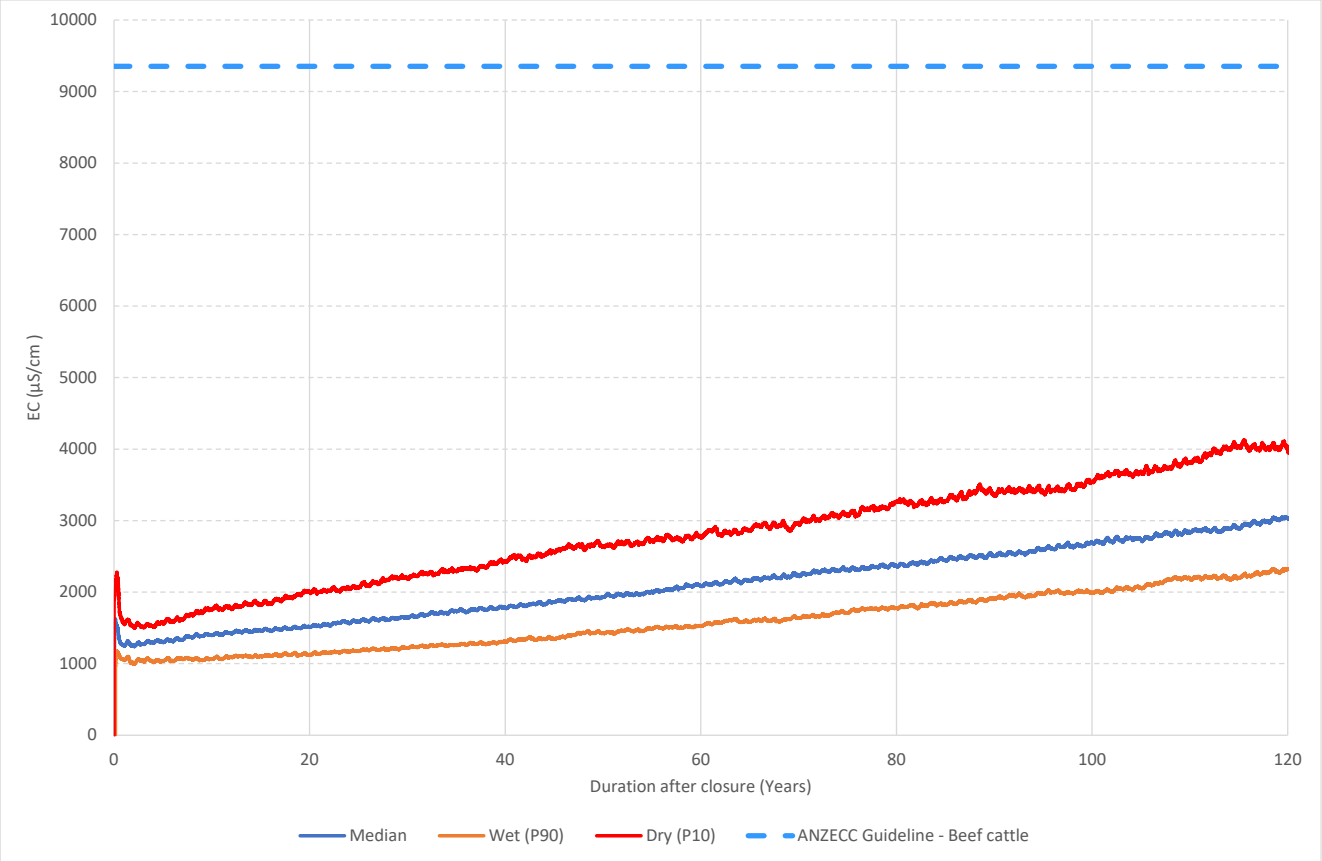

Figure 104 K4E – Scenario 1 Water Quality

6.6.2 Scenario 2 - Maximum stock water extraction from K2E void only.

6.6.2.1 K2E

Figure 105 shows the expected salinity levels in the void over 120 years. This showed that the void will maintain an EC of below 3,000 µS/cm. This suggests that stock water extraction is required to reduce salinity and the upward trend observed in Scenario 1.

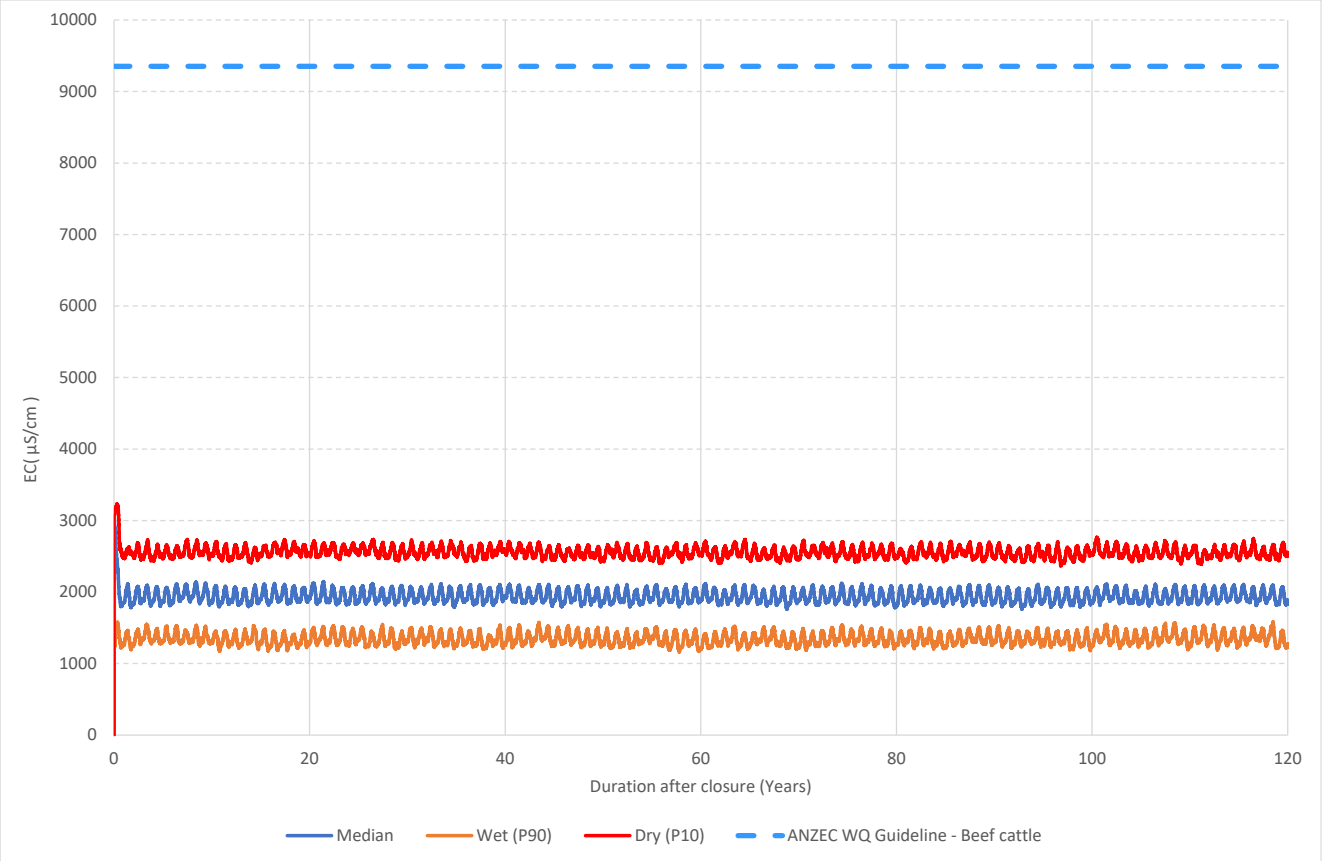

Figure 105 K2E – Scenario 2 Water Quality

6.6.2.2 K4E

The final void water quality for K4E is shown in **Figure 106**. While there is no stock water demand from K4E in Scenario 2, these results show negligible difference to the K4E results from Scenario 1. This is due to the minimal impact of the 2.08 ML/y extraction in the first scenario. As such, the results showed median final void EC levels of 4,000 µS/cm.

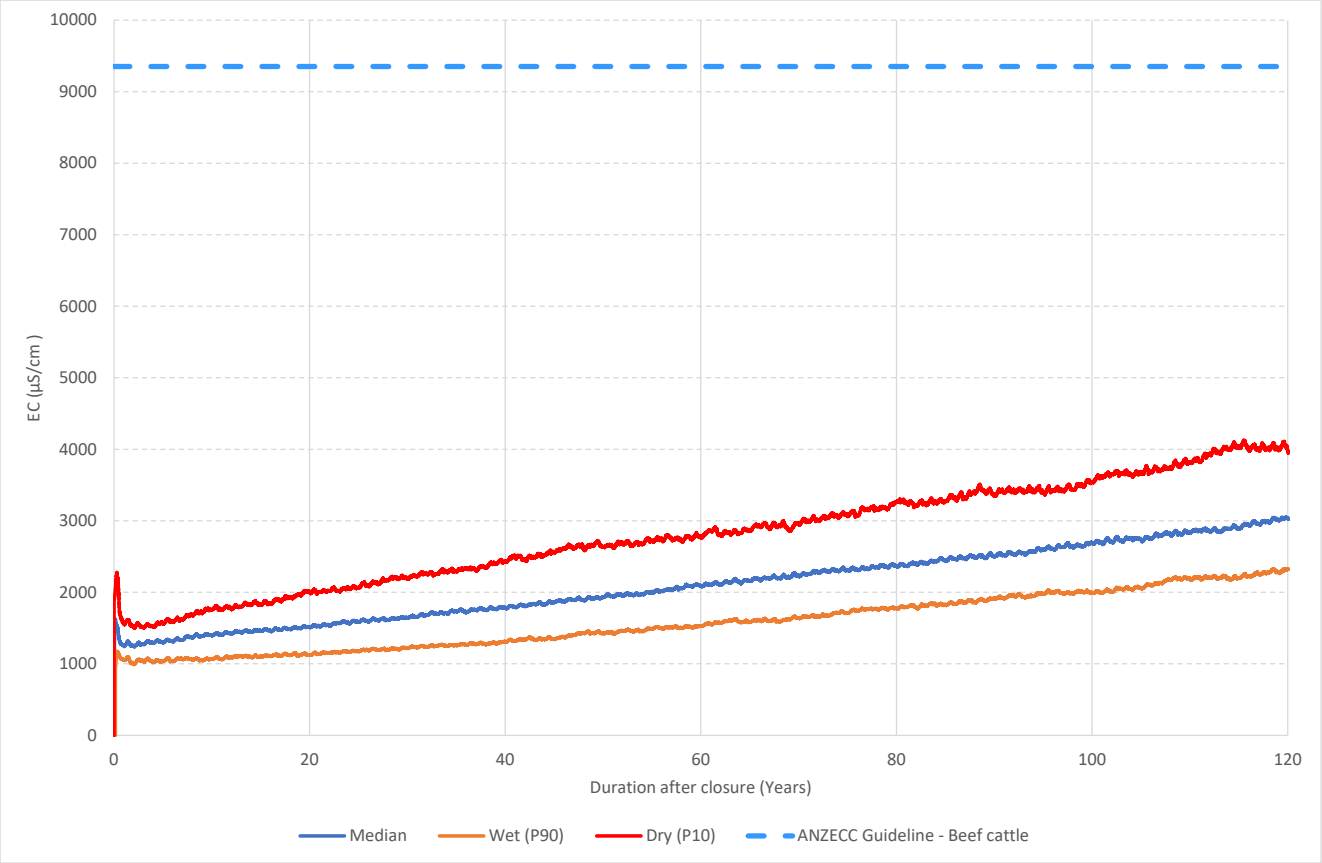

Figure 106 K4E – Scenario 2 Water Quality

6.6.3 Climate Change Sensitivity Scenario 1 – 20% increase in rainfall depth.

This scenario is based on the assumption of 4.16 ML/y of stock water is extracted from both voids (2.08 ML/y per void). **Figure 107** to **Figure 108** shows the void water quality for K2E and K4E. The salinity levels within the voids also improved with the additional rainfall received in each catchment. This suggests that the results are sensitive to the 20% increase in rainfall although voids maintained low salinity levels.

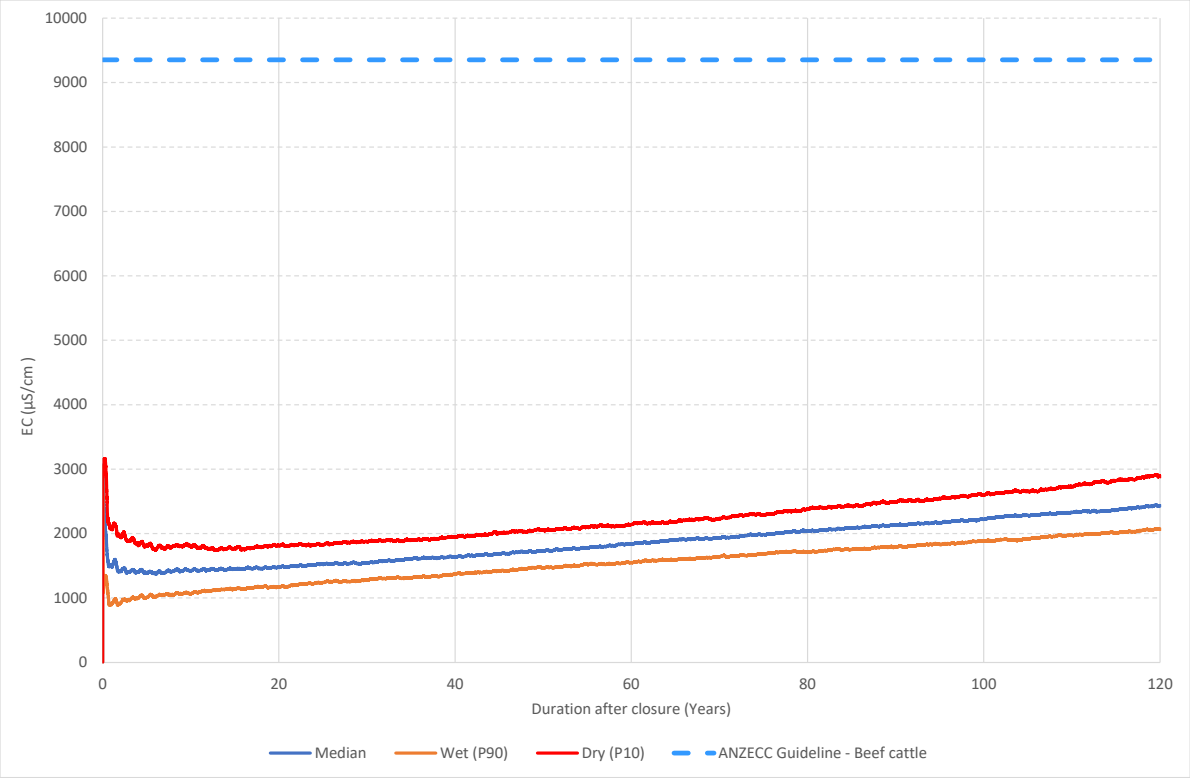

Figure 107 K2E – Climate Change Scenario 1 Water Quality

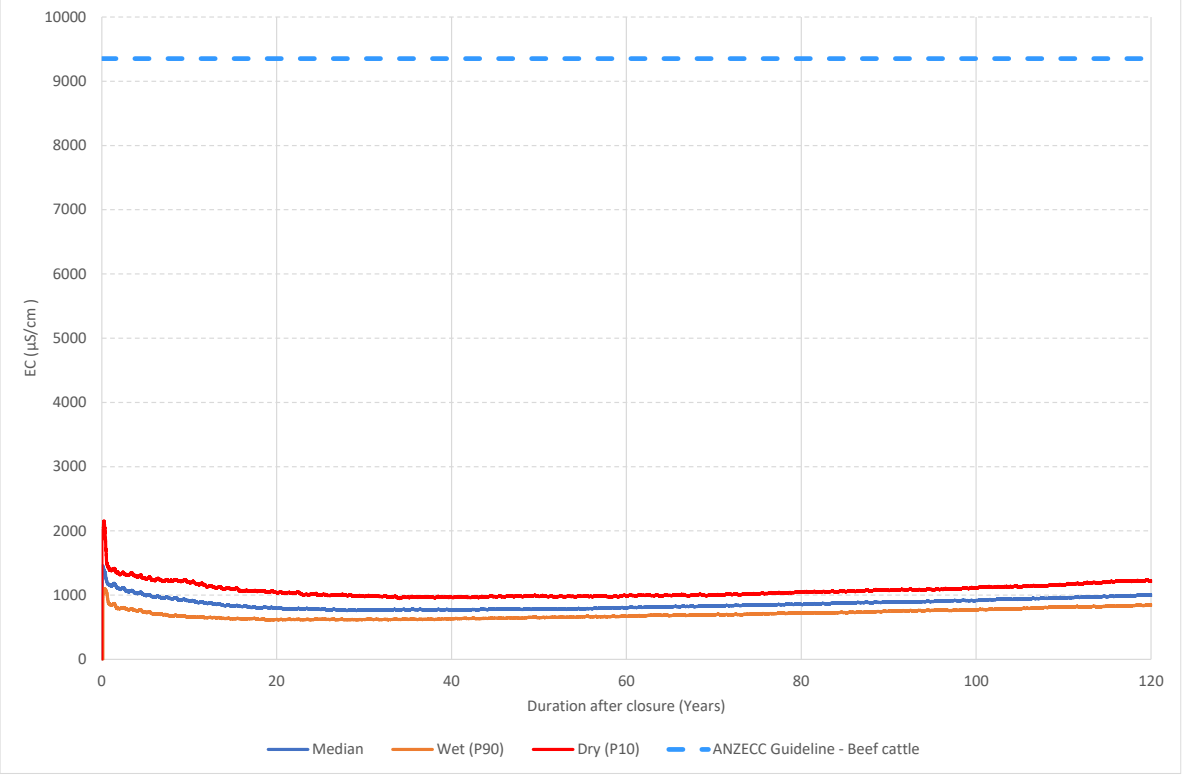

Figure 108 K4E – Climate Change Scenario 1 Water Quality

6.6.4 Climate Change Sensitivity Scenario 2 – 20% decrease in rainfall depth.

This scenario is based the assumption of 4.16 ML/y of stock water is extracted from both voids (2.08 ML/y per void). **Figure 109** to **Figure 110** shows the void water quality for K2E and K4E. These show significant differences to the results from non-climate change Scenario 1. While the overflow risk did not increase, the salinity levels within the pit increased due to the decrease in the rainfall and runoff entering the voids. The assessment showed that during the median case, the salinity levels within the void will breach the ANZECC/ARMCANZ (2000) salinity level after 100 years.

The increase in salinity is a function of reduced rainfall depths and high evaporation rates. This is a pattern which is observed for regions with high evaporation rates and is exacerbated by the reduction in rainfall depths.

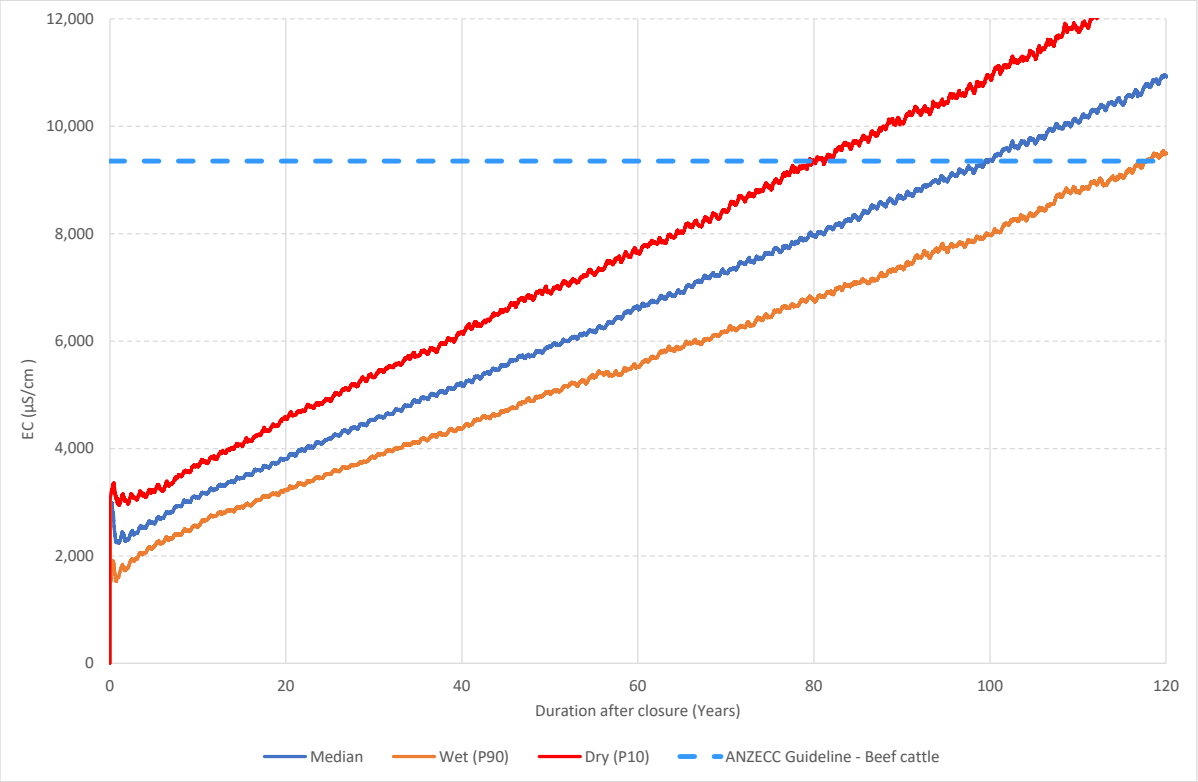

Figure 109 K2E – Climate Change Scenario 2 Water Quality

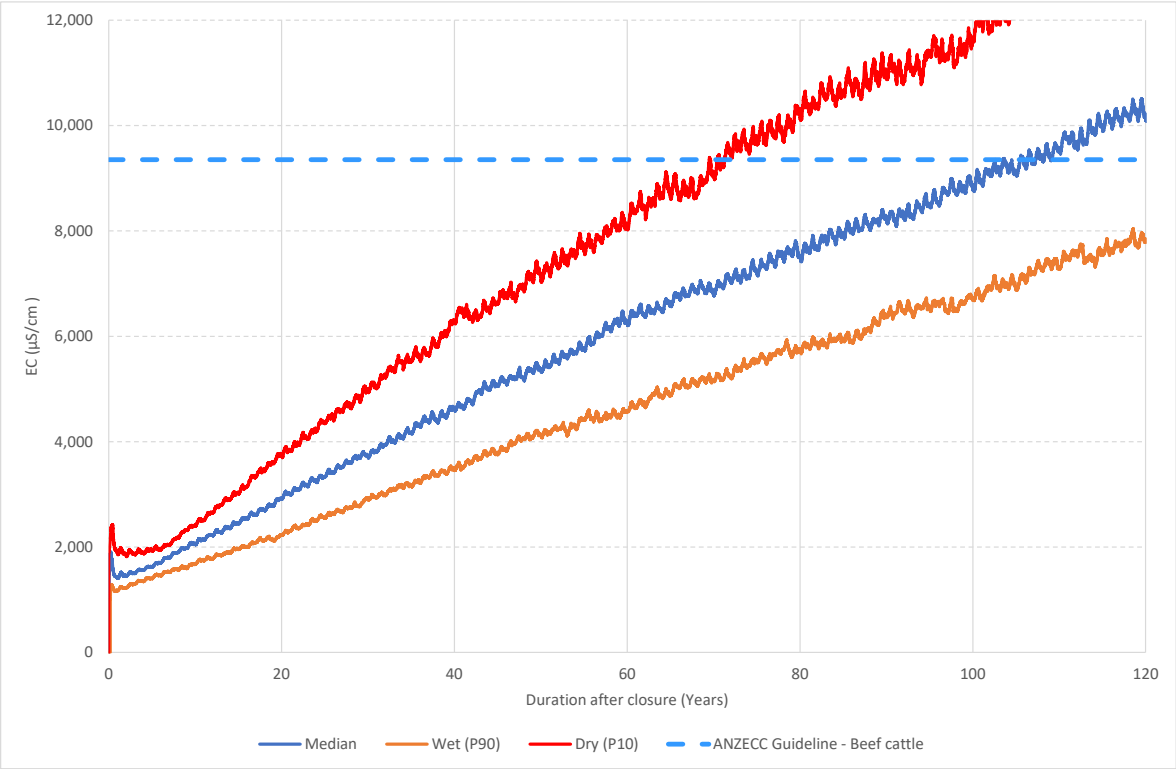

Figure 110 K4E – Climate Change Scenario 2 Water Quality

7 Stratification

Stratification modelling in the voids was considered to assess whether seasonal stratification occurs in the warmer months and the effect of annual mixing in the upper water column and lake turnover. The concern associated with stratification is the water quality which forms within the hypolimnion layer at depths below 20 m. During a lake turnover event, this water is fully mixed throughout the water column which can lead to a decline in water quality at the surface.

The modelling typically shows the change of water quality within the water column, typically with better quality freshwater at the surface. This modelling is helpful in understanding whether the better-quality water at the surface is appropriate to support a land-use, as well as quantifying the probability of a turnover event, and length of time where water quality may not be suitable for use.

The WBM carried out for the project showed that a completely mixed water column was not expected to exceed ANZECC/ARMCANZ (2000) guidelines for TDS for stock water for scenarios where stock water extraction occurred. Therefore, it is considered that stratification modelling is not required to support the post-mining land use and has not been completed.

8 Identification of Risk Areas

The purpose of this report is to address various sub-sections of Section 3 of the PRCP guideline that are primarily focused on water modelling and assessment of post mining conditions.

The hydrogeological environment of Meandu Mine is a complex system, but it is well understood in relation to geology, mine operation and final landform expectation. This scope of work has built on a detailed history of assessments into the hydrogeological environment and includes the use of the peer reviewed numerical groundwater model of Meandu Mine that was established 2018.

The primary objective of the PRCP groundwater model, as presented in this report, is to predict the post mining water level across the entire mine site and associated impacts on environmental receptors. Predicted water levels are then used to assess potential contaminant transport in groundwater, including extent of contaminant transport and potential areas for surface expression. The flow and contamination transport components of the groundwater modelling undertaken has provided confidence in key areas of risk. Where appropriate, a refinement of modelling grid size at key areas of concern was undertaken to further understand risk.

Consistent with previous observations, key areas identified as identified by the Mine site numerical groundwater model that will be carried forward to the PRCP risk assessment are:

- Seepage expression downgradient of the NWBV, which is predicted to report to Meandu Creek noting that seepage water quality has shown a decrease in the concertation of key analytes since the EE investigation;
- A salinity plume extending from the QWBV towards Meandu Creek to the north, relatively confined to shallow regolith material;
- CoC migration through groundwater toward Black Creek, with potential for surface expression.

A Final Void water balance model and IWBM water quality modelling were conducted in conjunction with the groundwater model to provide further assessment of likely final void and water quality conditions. Based upon the modelling undertaken herein, the areas of risk previously identified and identified within this scope of work that are to be carried forward in the PRCP assessment are summarised in Table 43.

Table 43 Findings to carry forward to PRCP assessment

Risk areas identified from SLR assessment		Assessment history	Assessment methodology	Findings	
Voids	Two proposed voids: King 4 East (K4E) and King 2 East (K2E).	This report	3D topographic model established. Stage-storage surface area curves developed based on final landform topography. Water balance model established.	***Short term impact*** ***(i.e. Post mining run up to year 2045)***	***Long term impact*** ***(i.e. 300yr recovery)***
				K2E void: Average groundwater inflow to K2E void is 0.1ML/d while void contribution to the surrounding groundwater is 0.01ML/d.	K2E void: Average groundwater inflow to K2E void is 0.18ML/d while void contribution to the surrounding groundwater is 0.01ML/d.
				K4E void: Average groundwater inflow to K4E void is 0.2ML/d while void contribution to the surrounding groundwater is 0.3ML/d.	K4E void: Average groundwater inflow to K4E void is 0.1ML/d while void contribution to the surrounding groundwater is 0.21ML/d.
				(K4E, K2E) at closure. No void is within floodplain. For both modelled scenarios: K4E is a flow through system towards east (i.e. K2E), therefore primarily a source. K2E primarily a sink to surrounding environment.	

Risk areas identified from SLR assessment		Assessment history	Assessment methodology	Findings
NWBV	Seepage expression occurred at Bullgang Corner and Ramp 7. Only site of historical expression of seepage (WSP, 2018).	WSP 2018 This report	Numerical Groundwater Model (MODFLOW-SURFACT) Numerical Groundwater Model (MODFLOW-USG) IWBM predicted concentrations of CoC at key points of interest	As outcome of WSP, 2018, management actions and data collected has demonstrated that seepage has for the time being been eliminated as a result of pumping out from NWBV to achieve target water RL. Comparison between the two time periods shows on-average there has been a significant decrease in all key analytes since the WSP (2018) study.

Risk areas identified from SLR assessment		Assessment history	Assessment methodology	Findings
QWBV	Identification of salinity plume extending from the QWBV (located in the centre of the Mine) towards Meandu Creek to the north.	WSP, 2018 JBT 2018 SLR (2020) This report	Numerical Groundwater Model (MODFLOW-SURFACT) Groundwater Data Review and Conceptual Groundwater Model Meandu Creek Saline Plume Investigation Numerical Groundwater Model (MODFLOW-USG) IWBM predicted concentrations of CoC at key points of interest	Contamination sources are unclear at this stage and may be linked to natural conditions and/or saline discharge from water infiltrating through the spoil. Monitoring of groundwater bores is continuing to confirm whether the plume is relatively static. The significantly lower EC of the QWBV sump water indicated that this is not the source of salinity in the area. A review of the lithological data for impacted groundwater monitoring bores indicates that the plume is relatively confined to shallow regolith material. It is inferred that shallow groundwater seepage in the regolith entering Meandu Creek alluvium will report to Meandu Creek dam. The risk of harm to EVs from the saline plume have been identified as low and the plume has been interpreted to move very slowly (SLR, 2020).

Risk areas identified from SLR assessment		Assessment history	Assessment methodology	Findings
Black Creek catchment salinity plume	CoC migration through groundwater toward Black Creek, with potential for surface expression.	WSP (2018) This report	Numerical Groundwater Model (MODFLOW-SURFACT) Numerical Groundwater Model (MODFLOW-USG) IWBM predicted concentrations of CoC at key points of interest	The potential source of contaminants within the Black Creek catchment may be derived from mine impacted areas (e.g. spoil or tailings of the K2E area), from areas that are unimpacted by mining to the east (i.e. natural drainage lines that drain the ridgetop basalt, or plantation forestry activities to the east) or from the area of the Tarong Power Station, including the coal stockpile which drains to this area (JBT, 2018a). This area is under ongoing monitoring and investigation. Determination of source yet to be established. Contaminant Transport model (MODFLOW USG – Transport (v1.4.0)) applied.

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APPENDIX A

Summary Statistic of Bore Groundwater Quality

Bore	Statistic	pH_Field	pH_Lab	EC_Field	EC_Lab	Fluoride	SO4	Al_diss	As_diss	B_diss	Cd_diss	Cr_diss	Co_diss	Cu_diss	Fe_diss	Pb_diss	Mn_diss	Mo_diss	Ni_diss	Se_diss	V_diss	Zn_diss	Al_total	As_total	B_total	Cd_total	Cr_total	Co_total	Cu_total	Fe_total	Pb_total	Mn_total	Mo_total	Ni_total	Se_total	V_total	Zn_total
GW01	Total Number	39	45	39	44	19	25	16	19	16	18	16	16	16	16	16	16	16	16	16	16	16	19	21	18	23	24	20	25	22	25	22	17	25	23	17	25
GW01	from	16-08-1993	16-08-1993	16-08-1993	16-08-1993	06-06-2002	16-08-1993	08-03-2017	16-08-1993	08-03-2017	25-11-2008	08-03-2017	08-03-2017	08-03-2017	08-03-2017	08-03-2017	08-03-2017	08-03-2017	08-03-2017	08-03-2017	08-03-2017	08-03-2017	16-08-1993	02-09-1999	15-10-2002	16-08-1993	16-08-1993	02-09-1999	16-08-1993	16-08-1993	16-08-1993	16-08-1993	28-10-2010	16-08-1993	16-08-1993	28-10-2010	16-08-1993
GW01	to	27-05-2021	22-02-2021	27-05-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021
GW01	Min	6.1	5.8	4589	4630	0.1	115	0.005	0.0005	0.025	0.00005	0.0005	0.0005	0.0005	5.13	0.0005	0.314	0.0005	0.0005	0.005	0.005	0.0025	0.24	0.0005	0.025	0.00005	0.0005	0.0005	0.0005	0.81	0.0005	0.204	0.0005	0.0005	0.005	0.005	0.0025
GW01	5th %ile	6.1	6.1	5071	4941	0.19	134.2	0.005	0.00095	0.05125	0.00005	0.0005	0.0005	0.0005	5.715	0.0005	0.332	0.0005	0.0005	0.005	0.005	0.006625	0.276	0.0005	0.025	0.00005	0.001	0.0005	0.0005	5.6175	0.0005	0.34355	0.0005	0.0006	0.005	0.005	0.0052
GW01	20th %ile	6.2	6.3	5386	5360	0.2	172	0.005	0.001	0.07	0.00005	0.0005	0.002	0.0005	7.75	0.0005	0.511	0.0005	0.0005	0.005	0.005	0.016	0.72	0.002	0.064	0.00005	0.002	0.0018	0.0038	9.572	0.0038	0.523	0.0005	0.002	0.005	0.005	0.0136
GW01	Median	6.3	6.7	5690	5678	0.2	183	0.005	0.002	0.08	0.00005	0.0005	0.002	0.0025	8.275	0.0005	0.541	0.0005	0.002	0.005	0.005	0.0535	1.78	0.004	0.08	0.00005	0.005	0.004	0.011	11.8	0.006	0.564	0.0005	0.005	0.005	0.005	0.063
GW01	80th %ile	6.5	7.0	6431	6322	0.2	203.4	0.005	0.003	0.09	0.00005	0.0005	0.003	0.007	9.02	0.0005	0.564	0.0005	0.005	0.005	0.005	0.07	4.974	0.005	0.09	0.0005	0.0092	0.004	0.0282	17.4	0.0442	0.7652	0.0005	0.008	0.005	0.018	0.0772
GW01	95th %ile	6.7	7.3	7363	7141	0.21	208.8	0.00875	0.005	0.1	0.0001175	0.0005	0.00425	0.022	9.76	0.0005	0.88575	0.0005	0.00625	0.005	0.005	0.1105	224.427	0.006	0.13	0.02255	0.016	0.005	0.0476	19.48	0.0746	0.9149	0.002	0.009	0.005	0.03	0.1772
GW01	Max	6.9	8.0	9610	8920	0.3	242	0.02	0.005	0.1	0.0005	0.0005	0.005	0.04	9.82	0.0005	0.987	0.0005	0.007	0.005	0.005	0.157	2190	0.006	0.3	0.025	0.05	0.005	0.063	39.4	0.1	2.3	0.002	0.05	0.01	0.03	0.749
GW01	Tau	-0.0421783	0.488848	0.21245	0.0849265	0.271448	-0.33445	-0.259272	0.0536562	-0.0365148	-0.333333	1	0.518711	0.432428	0.116667	1	0.35	1	0.741179	1	1	0.548567	0.22807	0.341369	-0.00695805	-0.749457	0.130907	0.369503	0.15962	0.0780913	-0.406971	0.100001	-0.156556	0.158715	-0.241269	-0.135929	0.382559
GW01	2-sided-p	0.71641	2.5034E-06	0.0590587	0.424069	0.185005	0.0207004	0.278076	0.796027	0.889156	0.123078	1	0.0113958	0.0276377	0.558351	1	0.0649034	1	0.0001752	1	1	0.00384951	0.183699	0.0437779	1	1.03615E-05	0.395866	0.0360129	0.280963	0.631543	0.00555717	0.534699	0.502335	0.290003	0.200045	0.526518	0.00823021
GW01	Trend	No	Yes-Upward	No	No	No	Yes-Downward	No	No	No	No	No	No	No	Yes-Upward	Yes-Upward	No	No	No	No	No	Yes-Upward	No	No	Yes-Upward	No	Yes-Downward	No	Yes-Upward	No	No	Yes-Downward	No	No	No	No	No	Yes-Upward
GW02	Total Number	38	43	38	43	18	23	15	18	15	15	15	15	15	15	15	15	15	15	15	15	15	18	20	18	21	23	21	24	20	23	21	17	24	22	17	24
GW02	from	16-08-1993	16-08-1993	16-08-1993	16-08-1993	06-06-2002	16-08-1993	28-02-2017	16-08-1993	28-02-2017	26-11-2008	28-02-2017	28-02-2017	28-02-2017	28-02-2017	28-02-2017	28-02-2017	28-02-2017	28-02-2017	28-02-2017	28-02-2017	28-02-2017	16-08-1993	02-09-1999	15-10-2002	16-08-1993	16-08-1993	02-09-1999	16-08-1993	16-08-1993	16-08-1993	16-08-1993	10-08-2010	16-08-1993	16-08-1993	10-08-2010	16-08-1993
GW02	to	27-05-2021	22-02-2021	27-05-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021	22-02-2021
GW02	Min	6.3	6.1	2080	2060	0.05	39	0.005	0.0005	0.025	0.00005	0.0005	0.0005	0.0005	0.025	0.0005	0.002	0.0005	0.0005	0.005	0.005	0.0025	0.005	0.0005	0.025	0.00005	0.0005	0.0005	0.0005	0.02	0.0005	0.004	0.0005	0.0005	0.005	0.005	0.0025
GW02	5th %ile	6.4	6.4	2107	2084	0.05	42	0.005	0.0005	0.025	0.00005	0.0005	0.0005	0.0005	0.025	0.0005	0.002	0.0005	0.0005	0.005	0.005	0.00705	0.01775	0.0005	0.025	0.00005	0.0005	0.0005	0.001	0.153	0.00055	0.01	0.0005	0.0005	0.005	0.005	0.00575
GW02	20th %ile	6.5	6.6	2331	2340	0.05	44.2	0.005	0.0005	0.025	0.00005	0.0005	0.0005	0.0005	0.094	0.0005	0.0942	0.0005	0.0005	0.005	0.005	0.0108	0.04	0.0005	0.025	0.00005	0.0005	0.0005	0.002	0.492	0.002	0.046	0.0005	0.0008	0.005	0.005	0.0132
GW02	Median	6.8	7.1	2725	2865	0.05	57	0.005	0.0005	0.025	0.00005	0.0005	0.0005	0.002	1.85	0.0005	0.218	0.0005	0.001	0.005	0.005	0.018	0.08	0.001	0.06	0.00005	0.0005	0.0005	0.004	2.26	0.006	0.2	0.0005	0.0025	0.005	0.005	0.025
GW02	80th %ile	6.9	7.4	3062	3076	0.1	66.2	0.005	0.001	0.06	0.00005	0.0005	0.0006	0.0062	2.504	0.0005	0.2502	0.0005	0.0032	0.005	0.005	0.04	0.256	0.0052	0.07	0.0005	0.0026	0.001	0.01	4.592	0.0212	0.276	0.0005	0.0068	0.005	0.005	0.0518
GW02	95th %ile	7.1	7.7	3308	3345	0.1	75.7	0.005	0.00515	0.063	0.001285	0.0005	0.0013	0.015	4.88	0.00065	0.3258	0.0005	0.008	0.005	0.005	0.0859	33.935	0.01205	0.098	0.0005	0.005	0.005	0.0157	6.597	0.0402	0.43	0.0012	0.008	0.005	0.005	0.0697
GW02	Max	7.3	8.3	4660	4330	0.1	138	0.005	0.006	0.07	0.008	0.0005	0.002	0.029	7.47	0.001	0.47	0.0005	0.008	0.005	0.005	0.179	220	0.013	0.2	0.0025	0.069	0.005	0.046	8.44	0.046	0.474	0.002	0.161	0.01	0.005	0.201
GW02	Tau	0.191568	0.17886	-0.304626	-0.354052	0.156624	-0.0521158	1	0.101144	0.250373	-0.0140733	1	0.252399	0.0321357	0.267466	-0.312984	0.363641	1	0.7074413	1	1	0.456397	0.171626	0.464531	-0.0150126	-0.636607	-0.371228	-0.0707838	0.0458671	0.364117	-0.292321	0.352381	-0.44663	0.122312	-0.227796	1	0.0182823
GW02	2-sided-p	0.09426	0.0939307	0.00740572	0.00087242	0.468738	0.75057	1	0.630628	0.268237	1	1	0.282334	0.916397	0.180964	0.203017	0.0667622	1	0.000621557	1	1	0.0220486	0.342627	0.00705957	0.968152	0.00017056	0.0250391	0.716503	0.781984	0.027288	0.0564783	0.027498	0.0374134	0.436133	0.156016	1	0.920828
GW02	Trend	No	No	Yes-Downward	Yes-Downward	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes-Upward	No	No	No	Yes-Downward	Yes-Downward	No	No	Yes-Upward	No	Yes-Upward	Yes-Downward	No	No	No	No	No
GW05	Total Number	62	68	51	68	45	48	22	43	41	21	19	20	20	22	20	22	41	20	41	41	20	23	41	45	22	21	20	23	23	23	23	44	23	46	45	23
GW05	from	16-08-1993	16-08-1993	16-08-1993	16-08-1993	05-06-2009	16-08-1993	15-09-2015	16-08-1993	22-06-2010	25-11-2008	28-02-2016	28-02-2016	28-02-2016	15-09-2015	28-02-2016	15-09-2015	22-06-2010	28-02-2016	22-06-2010	22-06-2010	28-02-2016	16-08-1993	22-06-2010	05-06-2009	16-08-1993	16-08-1993	28-02-2016	16-08-1993	16-08-1993	16-08-1993	16-08-1993	05-06-2009	16-08-1993	05-06-2009	16-08-1993
GW05	to	24-05-2021	24-05-2021	24-05-2021

Bore	Statistic	pH_Field	pH_Lab	EC_Field	EC_Lab	Fluoride	SO4	Al_diss	As_diss	B_diss	Cd_diss	Cr_diss	Co_diss	Cu_diss	Fe_diss	Pb_diss	Mn_diss	Mo_diss	Ni_diss	Se_diss	V_diss	Zn_diss	Al_total	As_total	B_total	Cd_total	Cr_total	Co_total	Cu_total	Fe_total	Pb_total	Mn_total	Mo_total	Ni_total	Se_total	V_total	Zn_total
GW35	5th %ile	5.8	6.6	NA	2153	0.215	521.2	0.005	0.0023	0.025	0.00005	0.0005	0.06675	0.0005	4.8045	0.0005	23.725	0.00115	0.03105	0.005	0.005	0.071	0.31	0.0033	0.025	0.00005	0.002	0.07745	0.0023	5.3645	0.000575	26.715	0.00115	0.0335	0.005	0.005	0.08125
GW35	20th %ile	5.9	6.7	NA	2162	0.26	544.6	0.005	0.0032	0.025	0.00005	0.0005	0.069	0.0005	6.258	0.0005	24.4	0.0016	0.0342	0.005	0.005	0.08	0.4	0.0042	0.025	0.00005	0.002	0.0788	0.0032	6.098	0.0008	26.76	0.0016	0.038	0.005	0.005	0.097
GW35	Median	6.1	6.8	NA	2170	0.3	609	0.005	0.0055	0.025	0.00005	0.0005	0.0725	0.0005	10.375	0.0005	27.6	0.0025	0.038	0.005	0.005	0.1055	0.765	0.0055	0.025	0.00005	0.002	0.0805	0.0045	8.675	0.0015	26.9	0.0025	0.043	0.005	0.005	0.1125
GW35	80th %ile	6.6	7.3	NA	2238	0.3	661.4	0.007	0.007	0.039	0.00005	0.0005	0.0752	0.0027	13.6	0.0005	31.08	0.003	0.039	0.005	0.005	0.1378	1.13	0.0068	0.039	0.00005	0.0028	0.0818	0.0058	12.56	0.0036	30.68	0.0034	0.0444	0.005	0.005	0.1288
GW35	95th %ile	6.9	7.8	NA	2315	0.3	684	0.00925	0.007	0.05475	0.00005	0.0005	0.07655	0.005175	14.05	0.0005	32.07	0.003	0.039	0.005	0.005	0.15445	1.22	0.0077	0.05475	0.00005	0.0037	0.0827	0.0067	14.765	0.0054	34.82	0.00385	0.04485	0.005	0.005	0.14545
GW35	Max	7.3	7.9	NA	2340	0.3	700	0.01	0.007	0.06	0.00005	0.0005	0.077	0.006	14.2	0.0005	32.4	0.003	0.039	0.005	0.005	0.16	1.25	0.008	0.06	0.00005	0.004	0.083	0.007	15.5	0.006	36.2	0.004	0.045	0.005	0.005	0.151
GW35	Tau	0.450188	0.666667	NA	0.182574	-0.707107	0.441177	0.235702	-0.547723	-0.707107	1	1	-0.333333	-0.707107	-0.333333	1	-0.666667	-0.547723	0.182574	1	1	0	0.333333	-0.333333	-0.707107	1	0.707107	0	0	0.333333	0.666667	-0.333333	-0.333333	0	1	1	0
GW35	2-sided-p	0.0133737	0.308179	NA	1	0.371093	0.0150837	1	0.470101	0.371093	1	1	0.734095	0.371093	0.734095	1	0.308179	0.470101	1	1	1	1	0.734095	0.734095	0.371093	1	0.371093	1	1	0.734095	0.308179	0.734095	0.734095	1	1	1	1
GW35	Trend	Yes-Upward	No	NA	No	No	Yes-Upward	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
GW36	Total Number	29	25	17	25	25	37	25	25	25	25	24	25	25	25	25	25	25	25	24	25	25	25	25	25	25	23	25	25	25	25	25	25	25	25	25	25
GW36	from	05-08-2011	27-05-2015	27-08-2016	27-05-2015	27-05-2015	05-08-2011	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015
GW36	to	26-05-2021	26-05-2021	26-05-2021

Bore	Statistic	pH_Field	pH_Lab	EC_Field	EC_Lab	Fluoride	SO4	Al_diss	As_diss	B_diss	Cd_diss	Cr_diss	Co_diss	Cu_diss	Fe_diss	Pb_diss	Mn_diss	Mo_diss	Ni_diss	Se_diss	V_diss	Zn_diss	Al_total	As_total	B_total	Cd_total	Cr_total	Co_total	Cu_total	Fe_total	Pb_total	Mn_total	Mo_total	Ni_total	Se_total	V_total	Zn_total
GW43_S	95th %ile	7.1	8.0	2365	2375	0.11	70.9	0.0105	0.0005	0.15	0.000105	0.000575	0.00205	0.0011	1.911	0.0005	0.21615	0.000575	0.0104	0.005	0.005	0.0604	2.911	0.0005	0.16	5.75E-05	0.0072	0.004	0.01225	7.1225	0.002	0.2372	0.0005	0.0152	0.005	0.00525	0.07665
GW43_S	Max	7.1	8.1	2400	2420	0.2	88	0.02	0.0005	0.15	0.0002	0.002	0.003	0.003	1.93	0.0005	0.219	0.002	0.018	0.005	0.005	0.068	3.5	0.0005	0.16	0.0002	0.009	0.004	0.017	8.31	0.002	0.241	0.0005	0.019	0.005	0.01	0.222
GW43_S	Tau	-0.117108	0.0707992	-0.278859	-0.363153	-0.043259	-0.0769285	0.0298955	1	-0.198883	-0.368712	0.282941	0.253278	0.132947	0.221053	1	0.592601	0.282941	0.530156	1	1	0.523991	0.253972	1	-0.0499307	0.0499307	0.336584	0.349548	0.509852	0.39578	0.0896866	0.560854	1	0.443498	1	0.0166436	0.524389
GW43_S	2-sided-p	0.583571	0.69983	0.164819	0.0350525	0.867362	0.673859	0.916012	1	0.258743	0.0576637	0.165327	0.189621	0.510681	0.183447	1	0.000311971	0.165327	0.00188649	1	1	0.00193751	0.126888	1	0.792521	0.86232	0.0604343	0.0621128	0.00302124	0.0162994	0.673147	0.000649095	1	0.00946677	1	1	0.00221705
GW43_S	Trend	No	No	No	Yes-Downward	No	No	No	No	No	No	No	No	No	No	No	Yes-Upward	No	Yes-Upward	No	No	Yes-Upward	No	No	No	No	No	No	Yes-Upward	Yes-Upward	No	Yes-Upward	No	Yes-Upward	No	No	Yes-Upward
GW44_D	Total Number	16	26	17	26	26	26	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	26	27	27	27	27	27	27	27	27
GW44_D	from	19-08-2016	24-02-2014	24-02-2014	24-02-2014

Bore	Statistic	pH_Field	pH_Lab	EC_Field	EC_Lab	Fluoride	SO4	Al_diss	As_diss	B_diss	Cd_diss	Cr_diss	Co_diss	Cu_diss	Fe_diss	Pb_diss	Mn_diss	Mo_diss	Ni_diss	Se_diss	V_diss	Zn_diss	Al_total	As_total	B_total	Cd_total	Cr_total	Co_total	Cu_total	Fe_total	Pb_total	Mn_total	Mo_total	Ni_total	Se_total	V_total	Zn_total
GW54B	Trend	No	No	No	Yes-Upward	No	Yes-Upward	NA	No	No	NA	NA	NA	NA	NA	NA	NA	No	No	No	No	NA	NA	No	No	NA	NA	NA	NA	NA	NA	No	NA	No	No	No	NA
GW55_D	Total Number	40	41	30	41	41	41	19	37	37	17	16	17	17	19	17	19	37	17	37	37	17	19	37	41	17	15	17	17	19	17	19	41	17	41	41	17
GW55_D	from	03-06-2009	03-06-2009	03-06-2009	03-06-2009	03-06-2009	03-06-2009	14-09-2015	21-06-2010	21-06-2010	26-02-2016	26-02-2016	26-02-2016	26-02-2016	14-09-2015	26-02-2016	14-09-2015	21-06-2010	26-02-2016	21-06-2010	21-06-2010	26-02-2016	14-09-2015	21-06-2010	03-06-2009	26-02-2016	26-02-2016	26-02-2016	26-02-2016	14-09-2015	26-02-2016	14-09-2015	03-06-2009	26-02-2016	03-06-2009	03-06-2009	26-02-2016
GW55_D	to	25-08-2020	25-08-2020	25-08-2020

Bore	Statistic	pH_Field	pH_Lab	EC_Field	EC_Lab	Fluoride	SO4	Al_diss	As_diss	B_diss	Cd_diss	Cr_diss	Co_diss	Cu_diss	Fe_diss	Pb_diss	Mn_diss	Mo_diss	Ni_diss	Se_diss	V_diss	Zn_diss	Al_total	As_total	B_total	Cd_total	Cr_total	Co_total	Cu_total	Fe_total	Pb_total	Mn_total	Mo_total	Ni_total	Se_total	V_total	Zn_total
GW64_S	Min	6.5	6.8	4787	504	0.05	47	0.005	0.002	0.025	0.00005	0.0005	0.0005	0.0005	0.025	0.0005	0.013	0.0005	0.0005	0.005	0.005	0.006	0.11	0.002	0.025	0.00005	0.0005	0.001	0.002	1.86	0.0005	0.058	0.0005	0.003	0.005	0.005	0.018
GW64_S	5th %ile	6.5	6.8	4809	1228	0.05	58	0.005	0.002	0.025	0.00005	0.0005	0.0005	0.001325	0.025	0.0005	0.0207	0.0005	0.0005	0.005	0.005	0.0071	0.66	0.00805	0.025	0.00005	0.001875	0.00155	0.0064	1.959	0.002425	0.1119	0.0005	0.0041	0.005	0.005	0.0246
GW64_S	20th %ile	6.5	7.0	4986	4850	0.05	69.2	0.005	0.003	0.025	0.00005	0.0005	0.0005	0.002	0.025	0.0005	0.0376	0.0005	0.0012	0.005	0.005	0.0088	1.484	0.0186	0.025	0.00005	0.0042	0.0022	0.0104	2.798	0.0054	0.2074	0.0005	0.0062	0.005	0.005	0.0352
GW64_S	Median	6.5	7.1	5054	5000	0.05	75.5	0.005	0.004	0.025	0.000075	0.0005	0.0005	0.002	0.025	0.0005	0.0535	0.0005	0.0025	0.005	0.005	0.0145	2.735	0.0275	0.025	0.000075	0.008	0.005	0.017	5.025	0.0115	0.397	0.0005	0.0125	0.005	0.005	0.0555
GW64_S	80th %ile	6.7	7.5	5246	5254	0.05	82.8	0.026	0.004	0.025	0.0001	0.0005	0.0005	0.0038	0.093	0.0005	0.0694	0.0005	0.006	0.005	0.005	0.025	5.886	0.0404	0.025	0.0002	0.0146	0.0126	0.0376	7.786	0.03	0.5624	0.0005	0.0214	0.005	0.018	0.1096
GW64_S	95th %ile	6.9	7.6	5265	5278	0.05	84.45	0.1475	0.006	0.13525	0.0002	0.000725	0.002525	0.0049	1.1025	0.003425	0.12815	0.000725	0.00925	0.005	0.005	0.0316	10.1835	0.0924	0.1715	0.00029	0.02715	0.024	0.05505	16.745	0.0848	1.5381	0.001175	0.0383	0.005	0.03	0.19345
GW64_S	Max	6.9	7.7	5280	5290	0.05	85	0.23	0.006	0.27	0.0002	0.001	0.005	0.006	1.2	0.007	0.143	0.001	0.012	0.005	0.005	0.036	11.3	0.11	0.32	0.0004	0.031	0.024	0.06	22.3	0.131	2.34	0.002	0.046	0.005	0.03	0.227
GW64_S	Tau	-0.345455	0.141938	-0.587181	-0.48718	1	-0.636364	-0.199681	-0.430906	0.0371135	-0.0371135	0.408248	0.11134	-0.298936	0	0.334021	-0.272727	0.408248	0.299445	1	1	0.137409	-0.0606061	-0.181818	0.241747	-0.161593	0.0775403	-0.0465242	0.0307729	-0.151515	0	-0.121212	0.11134	0.0152676	1	-0.131399	0.030303
GW64_S	2-sided-p	0.161125	0.541049	0.0154909	0.0239875	1	0.0049315	0.45841	0.0819262	1	0.939686	0.147501	0.772059	0.236051	1	0.246566	0.243722	0.147501	0.210903	1	1	0.582405	0.837011	0.45067	0.392871	0.550616	0.782021	0.890143	0.945071	0.537134	1	0.631222	0.772059	1	1	0.641771	0.94533
GW64_S	Trend	No	No	Yes-Downward	Yes-Downward	No	Yes-Downward	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
GW65	Total Number	16	20	16	20	20	20	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
GW65	from	19-08-2016	23-02-2016	19-08-2016	23-02-2016	23-02-2016	23-02-2016	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015	28-11-2015
GW65	to	26-05-2021	26-05-2021	26-05-2021

Bore	Statistic	pH_Field	pH_Lab	EC_Field	EC_Lab	Fluoride	SO4	Al_diss	As_diss	B_diss	Cd_diss	Cr_diss	Co_diss	Cu_diss	Fe_diss	Pb_diss	Mn_diss	Mo_diss	Ni_diss	Se_diss	V_diss	Zn_diss	Al_total	As_total	B_total	Cd_total	Cr_total	Co_total	Cu_total	Fe_total	Pb_total	Mn_total	Mo_total	Ni_total	Se_total	V_total	Zn_total
GW76	80th %ile	6.7	7.0	2307	2368	0.1	101.6	0.005	0.0116	0.025	0.00005	0.0005	0.0552	0.0048	46.92	0.0005	13.12	0.0005	0.0158	0.005	0.005	0.0816	7.306	0.0156	0.025	0.00009	0.018	0.0656	0.0524	71.36	0.0138	13.54	0.0005	0.0232	0.005	0.02	0.1634
GW76	95th %ile	6.9	7.4	2562	2483	0.1	123	0.076	0.016	0.03	0.00005	0.0005	0.0628	0.017	69.36	0.0058	14	0.0005	0.0228	0.005	0.0396	0.1448	384.48	0.025	0.025	0.00012	0.0293	0.0722	0.2258	78.34	0.1052	15.58	0.0005	0.0316	0.005	0.03	0.265
GW76	Max	7.0	7.4	2740	2502	0.1	159	0.1	0.02	0.05	0.00005	0.0005	0.066	0.029	70.8	0.025	15.2	0.0005	0.03	0.005	0.178	0.328	1870	0.029	0.025	0.0002	0.03	0.073	0.253	80.5	0.334	15.9	0.0005	0.034	0.005	0.03	0.429
GW76	Tau	-0.05	0.393445	-0.583333	-0.743437	-0.10249	-0.192598	-0.3707	-0.49111	0.257248	1	1	0.414826	0.10249	-0.548163	0.477432	-0.450188	1	0.483188	1	-0.342997	0.214024	0	-0.6518	1	0.219686	0	0.397059	0.352122	-0.735294	0.165456	-0.558824	1	0.376036	1	-0.166439	0.161765
GW76	2-sided-p	0.821892	0.0253263	0.00189282	2.15301E-05	0.660549	0.302275	0.0799217	0.0093034	0.261572	1	1	0.023241	0.642842	0.00259381	0.0257553	0.0133738	1	0.00972152	1	0.125786	0.248347	1	0.00371249	1	0.312026	1	0.0290204	0.0569054	0.000045411	0.384311	0.00200529	1	0.0423613	1	0.427323	0.387014
GW76	Trend	No	Yes-Upward	Yes-Downward	Yes-Downward	No	No	No	Yes-Downward	No	No	No	Yes-Upward	No	Yes-Downward	Yes-Upward	No	No	No	No	No	No	No	Yes-Downward	No	No	No	Yes-Upward	No	Yes-Downward	No	Yes-Upward	No	No	No	No	No
GW78	Total Number	17	18	17	18	17	17	17	17	17	17	16	17	17	17	17	17	17	17	17	17	17	17	17	17	17	15	17	17	17	17	17	17	17	17	17
GW78	from	29-11-2016	29-11-2016	29-11-2016	29-11-2016	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	17-05-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017	07-03-2017
GW78	to	27-05-2021	23-02-2021	27-05-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021	23-02-2021
GW78	Min	5.8	5.9	12409	1350	0.2	383	0.005	0.0005	0.025	0.00005	0.0005	0.037	0.0005	0.16	0.0005	10	0.0005	0.012	0.005	0.005	0.019	0.005	0.0005	0.025	0.00005	0.0005	0.036	0.0005	0.42	0.0005	10.4	0.0005	0.013	0.005	0.005	0.018
GW78	5th %ile	5.8	6.3	12567	10573	0.2	387	0.005	0.0005	0.025	0.00005	0.0005	0.0386	0.0005	0.176	0.0005	10.16	0.0005	0.0128	0.005	0.005	0.019	0.005	0.0005	0.025	0.00005	0.0005	0.0392	0.0005	0.428	0.0005	10.48	0.0005	0.0138	0.005	0.005	0.018
GW78	20th %ile	5.8	6.4	12684	12880	0.2	400	0.005	0.0005	0.062	0.0001	0.0005	0.04	0.0005	0.282	0.0005	10.62	0.0005	0.013	0.005	0.005	0.0296	0.128	0.0005	0.07	0.00012	0.0005	0.042	0.0068	0.62	0.0005	11.12	0.0005	0.014	0.005	0.005	0.0522
GW78	Median	5.9	6.6	13240	13100	0.2	409	0.005	0.0005	0.07	0.0002	0.0005	0.041	0.006	0.41	0.0005	11	0.0005	0.015	0.005	0.005	0.098	0.43	0.0005	0.08	0.0003	0.0005	0.044	0.018	0.78	0.001	11.9	0.0005	0.016	0.005	0.005	0.102
GW78	80th %ile	6.1	6.8	13531	13360	0.2	427	0.005	0.0005	0.088	0.0003	0.0005	0.0464	0.0262	0.614	0.0005	11.58	0.0005	0.0168	0.005	0.005	0.133	3.76	0.0009	0.088	0.00072	0.0046	0.0478	0.0324	1.612	0.002	12.5	0.0005	0.0188	0.005	0.005	0.153
GW78	95th %ile	7.0	7.8	13966	13913	0.3	453	0.012	0.001	0.09	0.00052	0.000875	0.0496	0.0406	0.7	0.001	12.38	0.0005	0.0194	0.005	0.005	0.215	438.312	0.002	0.092	0.0013	0.0083	0.054	0.0424	3.588	0.004	12.8	0.0005	0.0228	0.005	0.01	0.2124
GW78	Max	7.2	8.1	14550	14550	0.3	453	0.02	0.001	0.09	0.0006	0.002	0.052	0.047	0.78	0.001	12.7	0.0005	0.025	0.005	0.005	0.239	2170	0.002	0.1	0.0017	0.009	0.058	0.056	4.34	0.004	12.8	0.0005	0.026	0.005	0.01	0.222
GW78	Tau	0.118522	0.211231	-0.199263	-0.298513	0.344423	-0.119416	-0.261817	-0.0331112	-0.250065	-0.289122	-0.353553	0.263955	0.344423	-0.361626	0.187867	-0.432884	1	0.459928	1	1	0.385196	0.228784	-0.114587	-0.23603	-0.341589	0.0895547	0.173645	0.245368	-0.0516609	0.131965	-0.328395	1	0.415828	1	-0.0626224	0.405907
GW78	2-sided-p	0.539956	0.239298	0.283757	0.0998151	0.117525	0.53526	0.234333	0.940584	0.202594	0.137013	0.128885	0.16616	0.0692046	0.0478244	0.412278	0.0184068	1	0.0150371	1	1	0.0353438	0.216151	0.614144	0.231515	0.0716916	0.705047	0.361668	0.186324	0.804625	0.532748	0.0753484	1	0.0269544	1	0.823063	0.0259947
GW78	Trend	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes-Downward	No	Yes-Downward	No	Yes-Upward	No	No	Yes-Upward	No	No	No	No	No	No	No	No	No	No	No	Yes-Upward	No	Yes-Upward
GW80	Total Number	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
GW80	from	26-02-2019	26-02-2019	26-02-2019

Bore	Statistic	pH_Field	pH_Lab	EC_Field	EC_Lab	Fluoride	SO4	Al_diss	As_diss	B_diss	Cd_diss	Cr_diss	Co_diss	Cu_diss	Fe_diss	Pb_diss	Mn_diss	Mo_diss	Ni_diss	Se_diss	V_diss	Zn_diss	Al_total	As_total	B_total	Cd_total	Cr_total	Co_total	Cu_total	Fe_total	Pb_total	Mn_total	Mo_total	Ni_total	Se_total	V_total	Zn_total
GW88_D	2-sided-p	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GW88_D	Trend	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GW88_S	Total Number	3	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
GW88_S	from	25-11-2020	25-11-2020	25-11-2020

Bore	Statistic	pH_Field	pH_Lab	EC_Field	EC_Lab	Fluoride	SO4	Al_diss	As_diss	B_diss	Cd_diss	Cr_diss	Co_diss	Cu_diss	Fe_diss	Pb_diss	Mn_diss	Mo_diss	Ni_diss	Se_diss	V_diss	Zn_diss	Al_total	As_total	B_total	Cd_total	Cr_total	Co_total	Cu_total	Fe_total	Pb_total	Mn_total	Mo_total	Ni_total	Se_total	V_total	Zn_total
GW97	to	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021	24-05-2021
GW97	Min	8.2	7.9	1400	1260	0.4	70	0.005	0.002	0.025	0.00005	0.0005	0.0005	0.0005	0.025	0.0005	0.0005	0.01	0.0005	0.005	0.005	0.0025	0.15	0.003	0.025	0.00005	0.0005	0.0005	0.002	0.15	0.0005	0.029	0.012	0.002	0.005	0.005	0.02
GW97	5th %ile	8.2	8.0	1402	1274	0.4	72.5	0.0125	0.0021	0.025	0.00005	0.0005	0.0005	0.0005	0.025	0.0005	0.00185	0.0101	0.00055	0.005	0.005	0.0025	0.341	0.0031	0.025	0.00005	0.00055	0.00055	0.0032	0.201	0.0005	0.0292	0.0122	0.0021	0.005	0.005	0.0201
GW97	20th %ile	8.3	8.1	1410	1316	0.4	80	0.035	0.0024	0.025	0.00005	0.0005	0.0005	0.0005	0.025	0.0005	0.0059	0.0104	0.0007	0.005	0.005	0.0025	0.914	0.0034	0.025	0.00005	0.0007	0.0007	0.0068	0.354	0.0005	0.0298	0.0128	0.0024	0.005	0.005	0.0204
GW97	Median	8.5	8.3	1424	1400	0.4	95	0.08	0.003	0.025	0.00005	0.0005	0.0005	0.0005	0.025	0.0005	0.014	0.011	0.001	0.005	0.005	0.0025	2.06	0.004	0.025	0.00005	0.001	0.001	0.014	0.66	0.0005	0.031	0.014	0.003	0.005	0.005	0.021
GW97	80th %ile	9.9	8.4	1488	1454	0.46	97.4	0.23	0.0036	0.04	0.00005	0.0005	0.0005	0.0005	0.025	0.0005	0.0146	0.0122	0.001	0.005	0.005	0.0025	2.834	0.0118	0.025	0.00005	0.0046	0.0016	0.0182	0.696	0.0005	0.0658	0.0146	0.0036	0.005	0.005	0.0222
GW97	95th %ile	10.5	8.5	1519	1481	0.49	98.6	0.305	0.0039	0.0475	0.00005	0.0005	0.0005	0.0005	0.025	0.0005	0.0149	0.0128	0.001	0.005	0.005	0.0025	3.221	0.0157	0.025	0.00005	0.0064	0.0019	0.0203	0.714	0.0005	0.0832	0.0149	0.0039	0.005	0.005	0.0228
GW97	Max	10.8	8.5	1530	1490	0.5	99	0.33	0.004	0.05	0.00005	0.0005	0.0005	0.0005	0.025	0.0005	0.015	0.013	0.001	0.005	0.005	0.0025	3.35	0.017	0.025	0.00005	0.007	0.002	0.021	0.72	0.0005	0.089	0.015	0.004	0.005	0.005	0.023
GW97	Tau	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GW97	2-sided-p	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
GW97	Trend	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

APPENDIX B

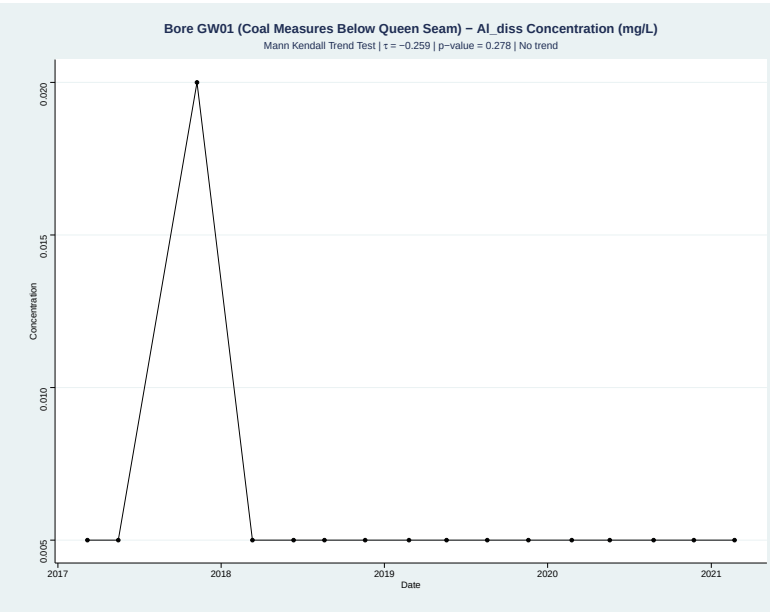
Summary Statistic of Hydrogeological Unit Groundwater Quality

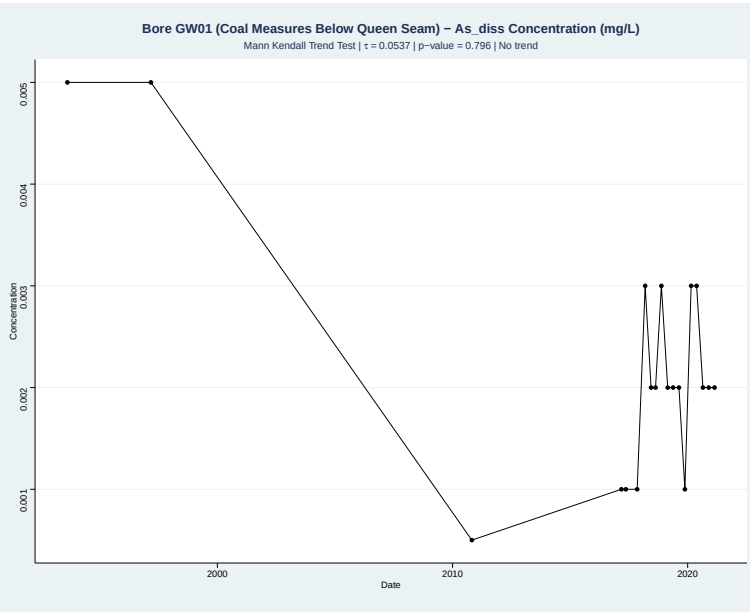
Aquifer	statistic	pH_Field	pH_Lab	EC_Field	EC_Lab	Fluoride	SO4	Al_diss	As_diss	B_diss	Cd_diss	Cr_diss	Co_diss	Cu_diss	Fe_diss	Pb_diss	Mn_diss	Mo_diss	Ni_diss	Se_diss	V_diss	Zn_diss	Al_total	Sb_total	As_total	Ba_total	Be_total	B_total	Cd_total	Cr_total	Co_total	Cu_total	Fe_total	Pb_total	Mn_total	Mo_total	Ni_total	Se_total	V_total	Zn_total
Spoil	Total Number	151	167	134	167	162	175	157	162	162	156	148	156	156	157	156	157	162	156	161	162	156	157	135	162	137	94	162	156	142	156	156	157	156	157	162	156	162	156
Spoil	from	05-08-2011	05-08-2013	28-05-2014	05-08-2013	05-08-2013	05-08-2011	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	12-05-2016	12-05-2016	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	05-08-2013	41491	41491	05-08-2013
Spoil	to	27-05-2021	26-05-2021	27-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	25-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	26-05-2021	44342	44342	26-05-2021
Spoil	Min	4.3	4.5	1373	1580	0.05	0.5	0.005	0.0005	0.025	0.00005	0.0005	0.0005	0.0005	0.025	0.0005	0.049	0.0005	0.0005	0.005	0.0005	0.0025	0.005	0.0005	0.0005	0.004	0.0005	0.025	0.00005	0.0005	0.0005	0.0005	0.47	0.0005	0.054	0.0005	0.0005	0.005	0.005	0.0
Spoil	5th %ile	4.4	4.6	1724	1683	0.05	5	0.005	0.0005	0.025	0.00005	0.0005	0.0005	0.0005	1.55	0.0005	0.394	0.0005	0.002	0.005	0.0005	0.00875	0.01	0.0005	0.0005	0.02	0.0005	0.025	0.00005	0.0005	0.00275	0.0005	3.75	0.0005	0.4338	0.0005	0.004	0.005	0.005	0.0
Spoil	20th %ile	5.6	6.0	2441	2178	0.05	105.4	0.005	0.0005	0.025	0.00005	0.0005	0.004	0.0005	12.54	0.0005	1.308	0.0005	0.006	0.005	0.005	0.032	0.152	0.0005	0.002	0.0482	0.0005	0.025	0.00005	0.001	0.011	0.003	19.72	0.0005	1.416	0.0005	0.01	0.005	0.005	0.1
Spoil	Median	5.9	6.4	3241	2990	0.1	197	0.005	0.002	0.08	0.00005	0.0005	0.06	0.0005	26.4	0.0005	8.58	0.0005	0.034	0.005	0.005	0.104	1.78	0.0005	0.005	0.104	0.0005	0.08	0.0001	0.006	0.0065	0.011	36.8	0.005	9.09	0.0005	0.043	0.005	0.005	0.2
Spoil	80th %ile	6.3	6.8	8101	8164	0.3	749.2	0.04	0.01	0.3	0.0002	0.002	0.199	0.0005	153.8	0.0005	15.52	0.0005	0.142	0.005	0.005	0.284	7.89	0.0005	0.014	0.3864	0.001	0.308	0.0004	0.0218	0.0214	0.03	168.2	0.013	16.14	0.001	0.156	0.005	0.03	0.5
Spoil	95th %ile	6.9	7.6	12938	12970	0.8	914	5.81	0.015	0.4995	0.0004	0.06665	0.39175	0.00725	222.6	0.0005	43.8	0.001	0.28525	0.005	0.0995	0.71425	21.12	0.004	0.024	1.91	0.007	0.519	0.001325	0.09895	0.4085	0.09425	248.6	0.042	47.72	0.003	0.29825	0.005	0.13	0.9
Spoil	Max	9.7	9.3	13350	14100	1	1020	10	0.02	0.59	0.0005	0.089	0.532	0.048	249	0.025	54.8	0.004	0.322	0.005	0.178	1.56	23000	0.007	0.05	3.06	0.009	0.61	0.012	0.449	0.568	0.717	329	0.334	56.2	0.009	0.541	0.01	0.48	3.8
Alluvium	Total Number	34	50	50	50	50	76	50	50	48	50	50	50	50	50	50	50	50	50	50	50	50	40	50	50	42	30	50	50	46	50	50	50	50	50	50	50	50	50
Alluvium	from	28-08-2016	27-05-2015	28-08-2016	27-05-2015	27-05-2015	05-08-2011	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	28-08-2016	27-05-2015	14-05-2016	14-05-2016	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	27-05-2015	42151	42151	27-05-2015
Alluvium	to	25-05-2021	25-05-2021	25-05-2021

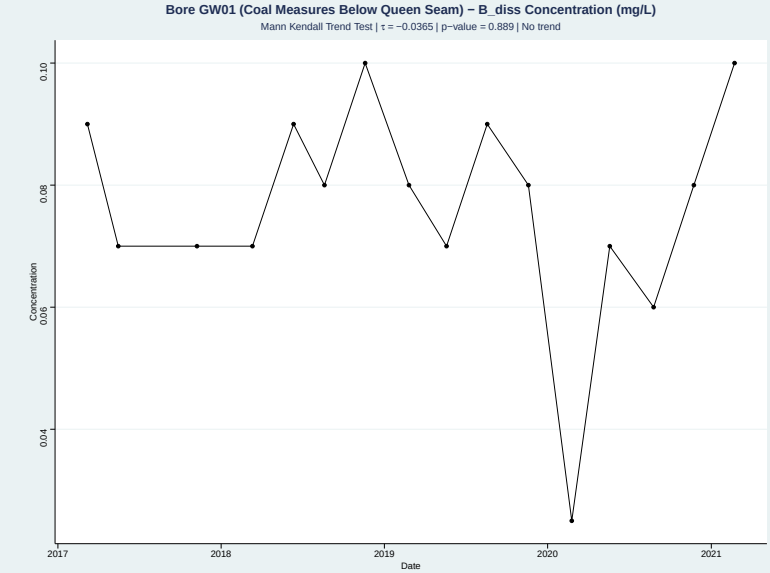
APPENDIX C

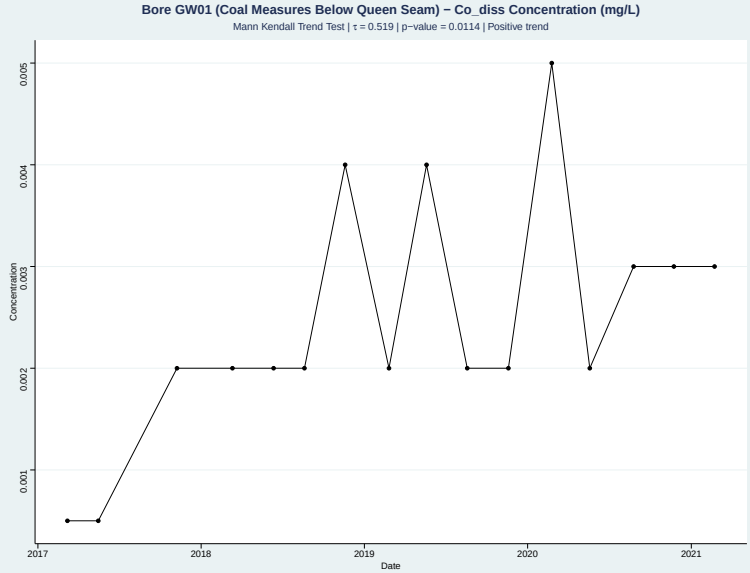
Groundwater Quality Time Series

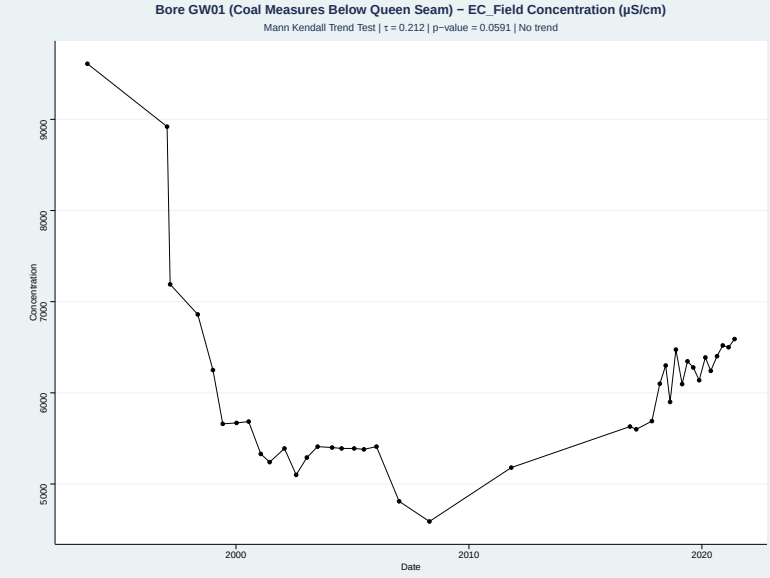
Appendix C Groundwater Quality Time Series

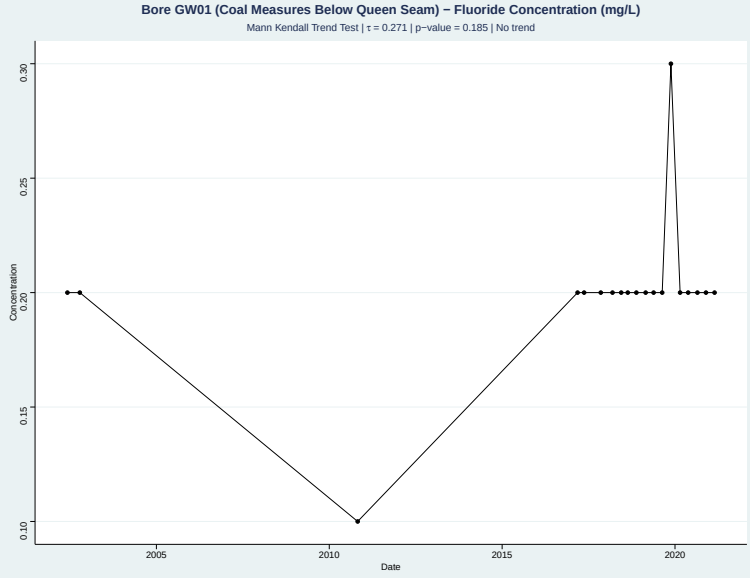




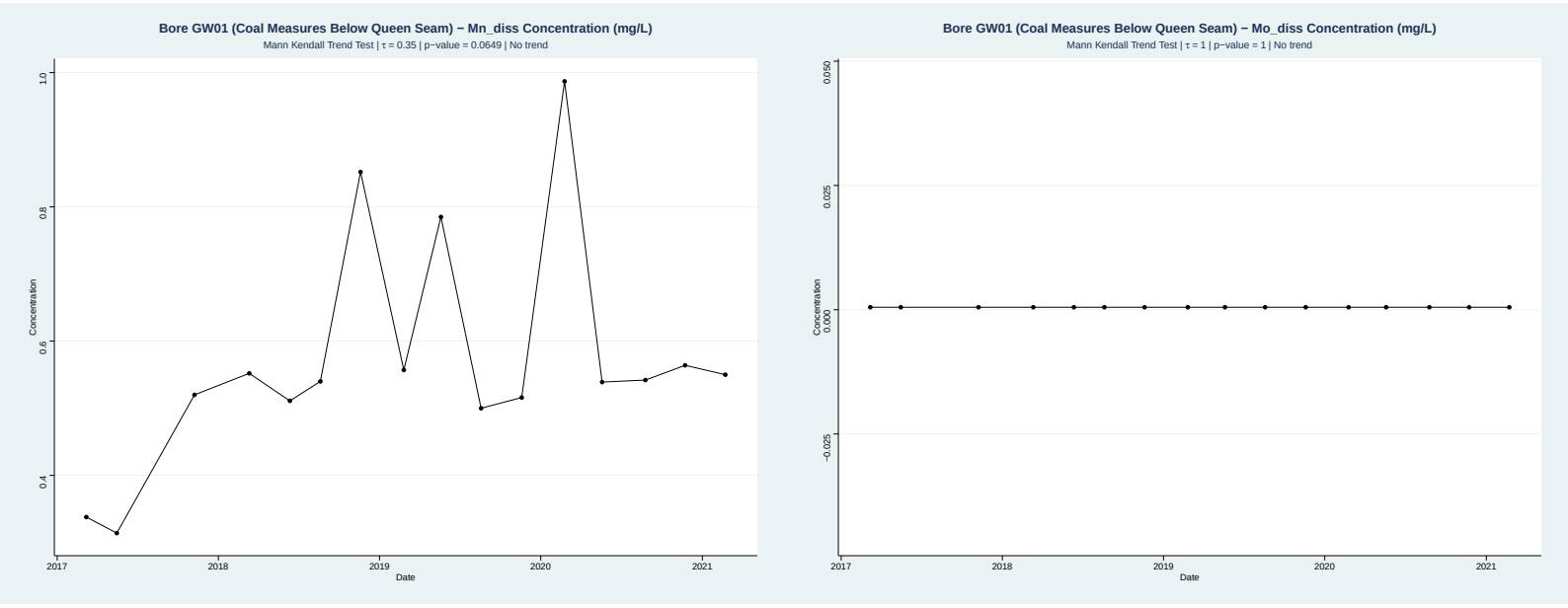


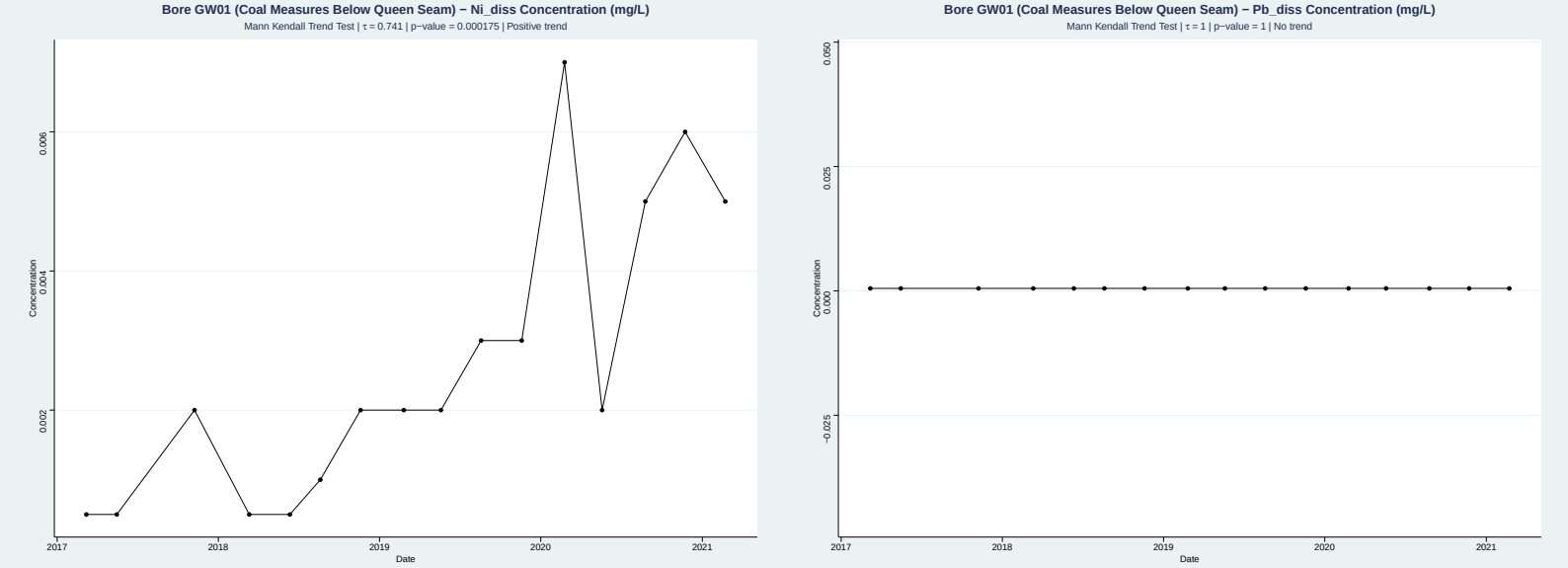


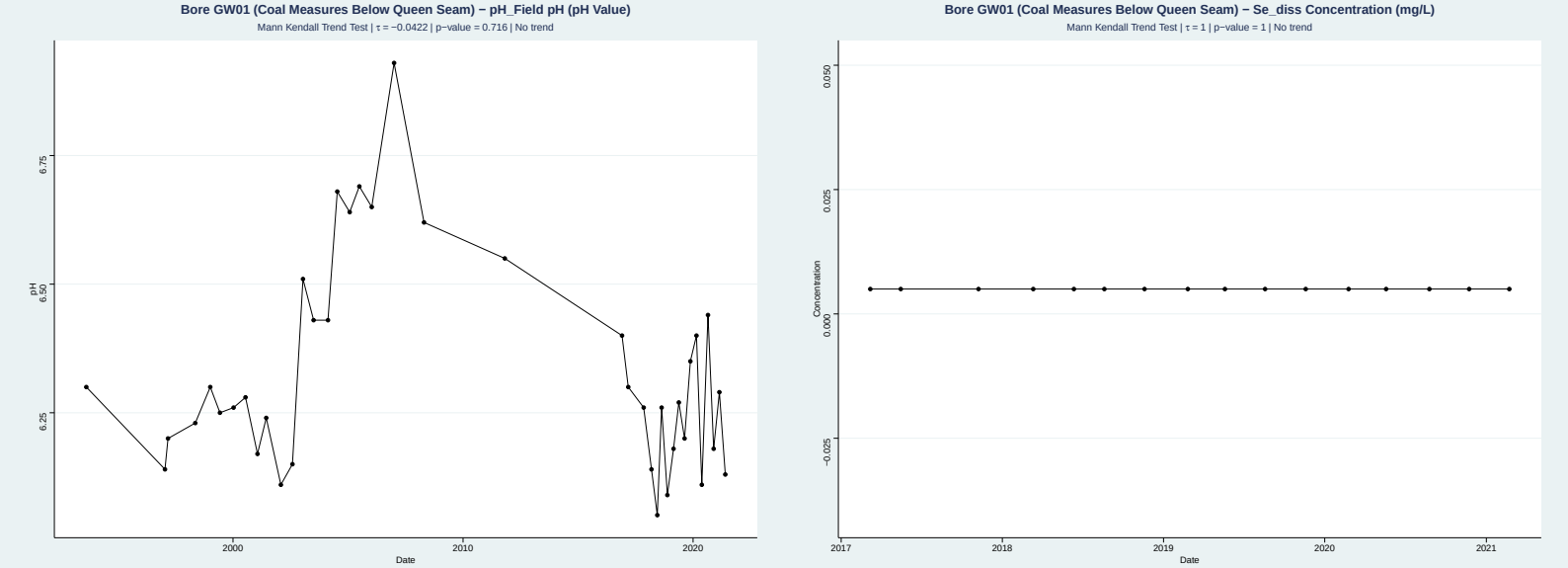




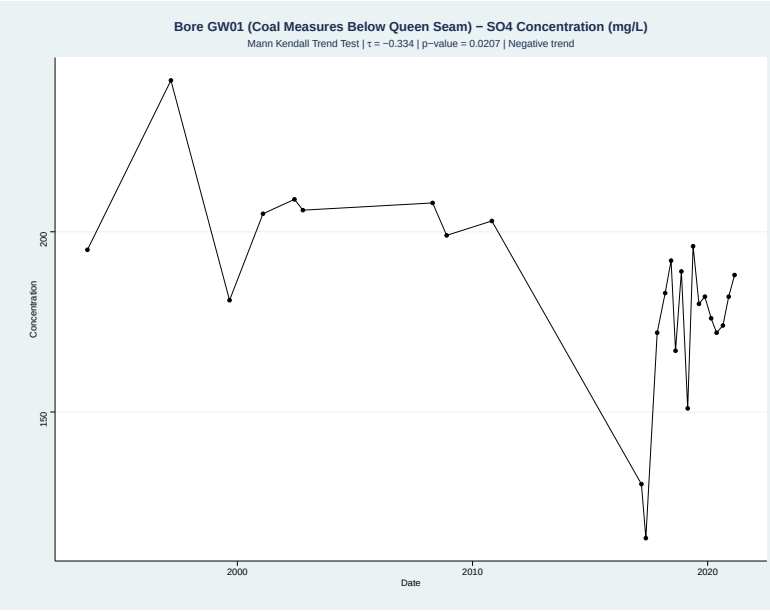
Appendix C Groundwater Quality Time Series

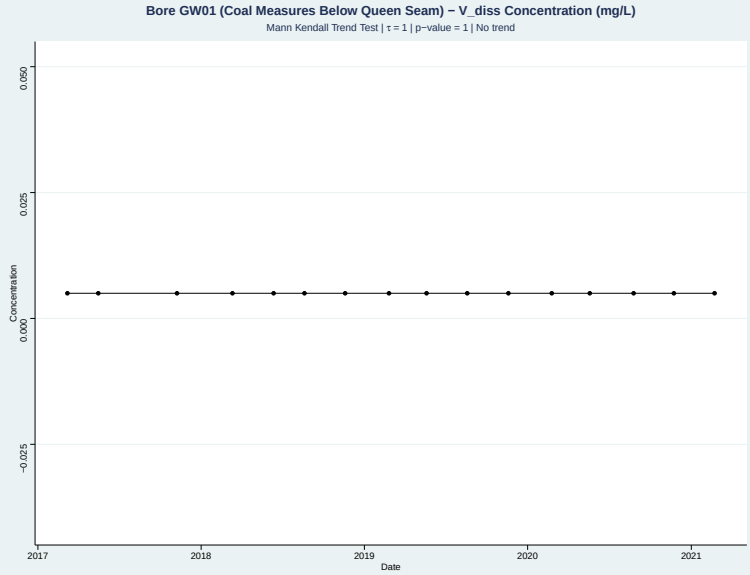


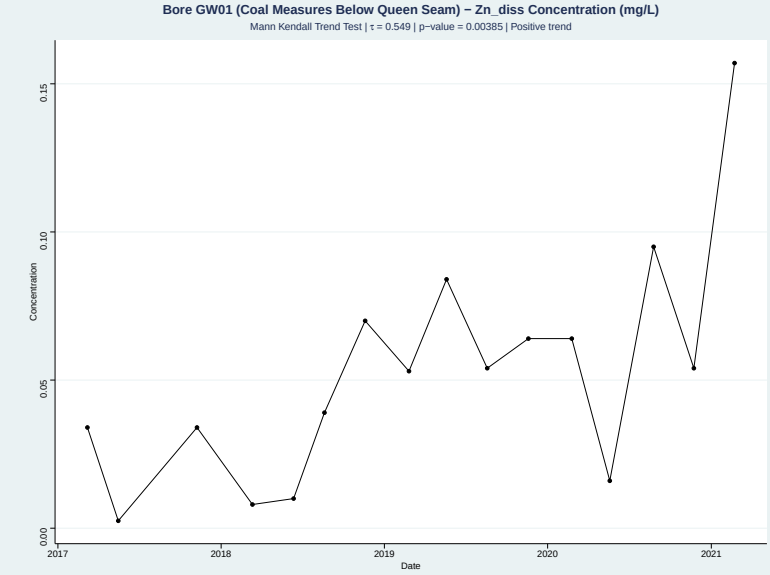


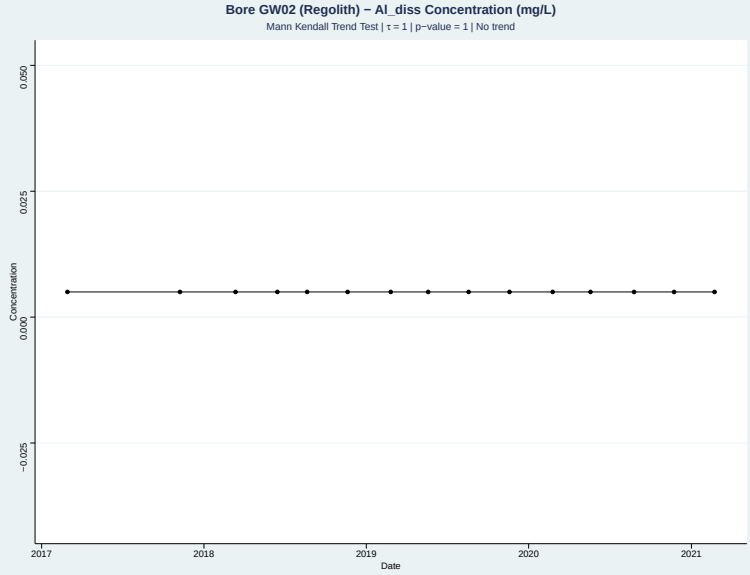


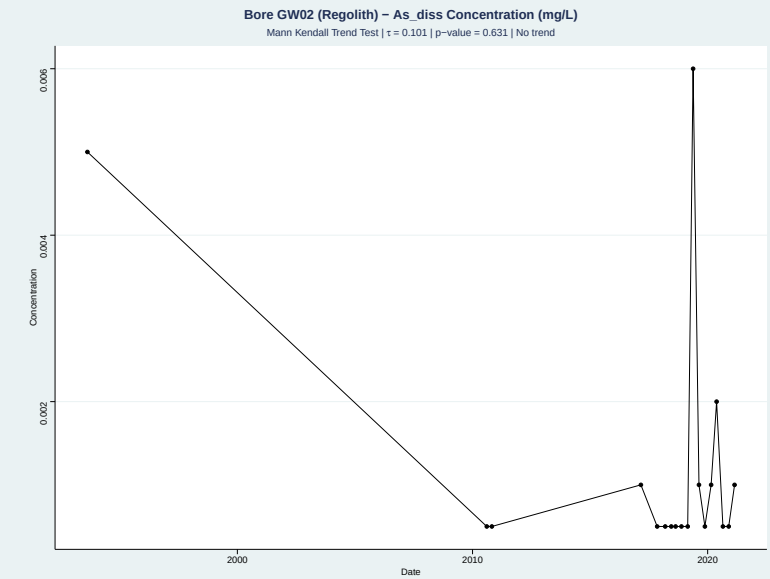
Appendix C Groundwater Quality Time Series

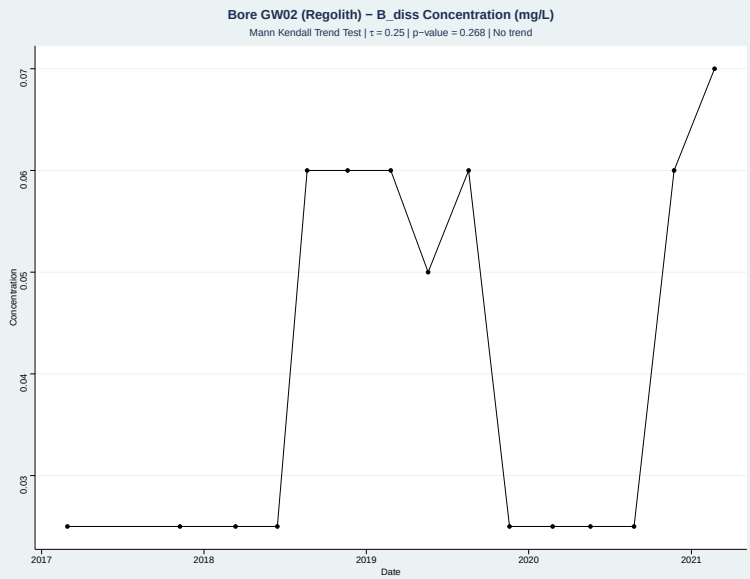








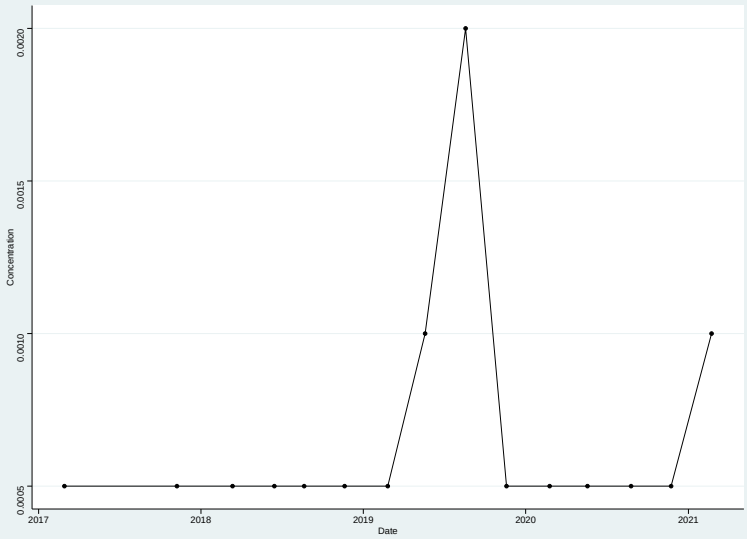




Appendix C Groundwater Quality Time Series

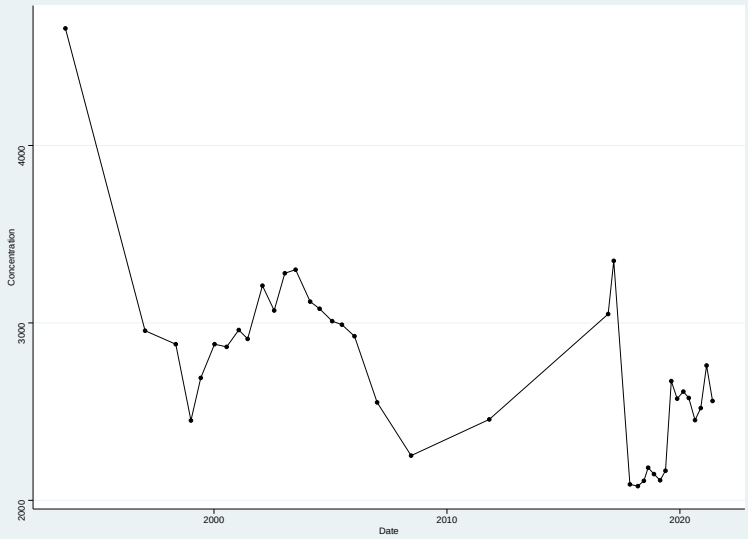
Bore GW02 (Regolith) – Co_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.253 | p−value = 0.282 | No trend



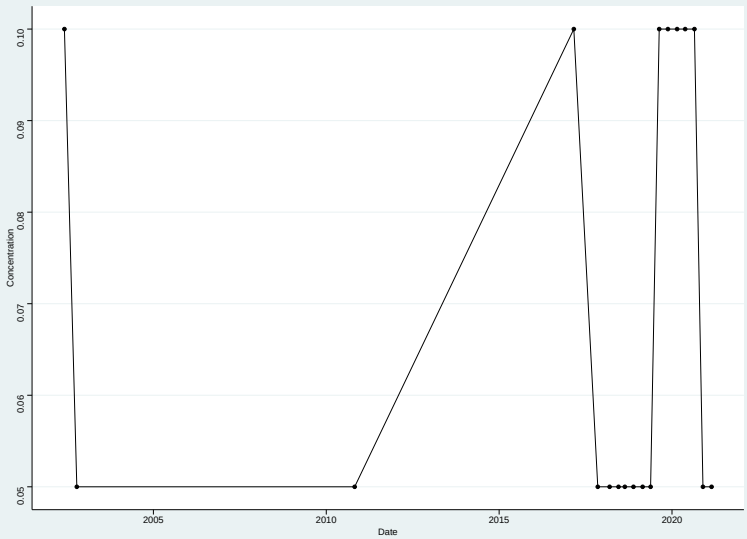
Bore GW02 (Regolith) – EC_Field Concentration (µS/cm)

Mann Kendall Trend Test | τ = −0.305 | p−value = 0.00741 | Negative trend



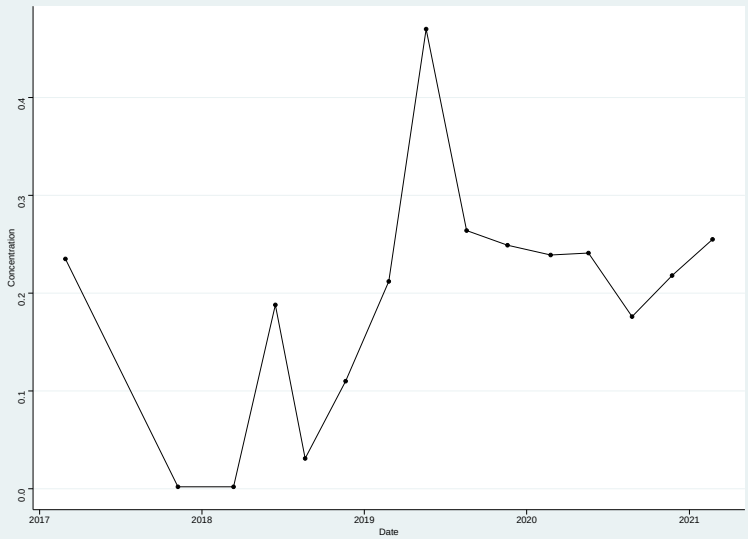
Bore GW02 (Regolith) – Fluoride Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.157 | p−value = 0.469 | No trend



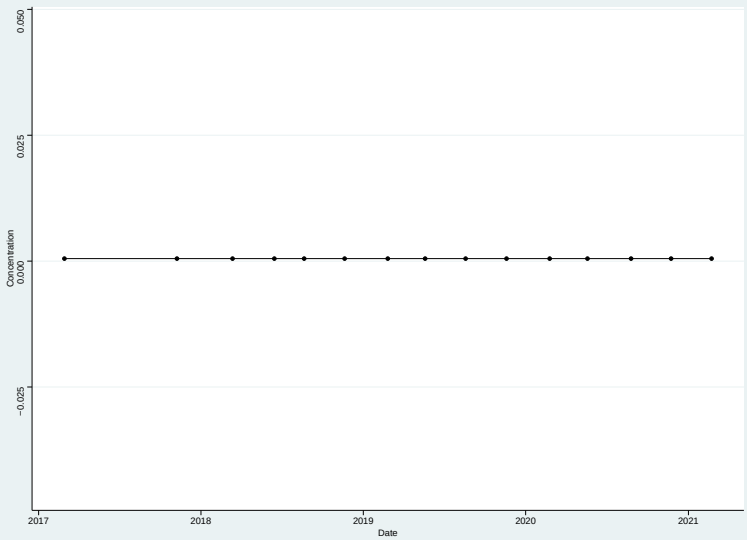
Bore GW02 (Regolith) – Mn_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.364 | p−value = 0.0668 | No trend



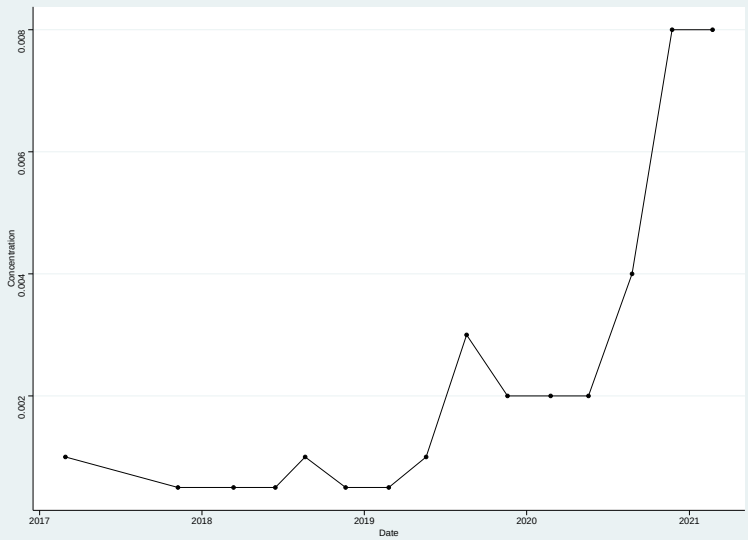
Bore GW02 (Regolith) – Mo_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 1 | p−value = 1 | No trend

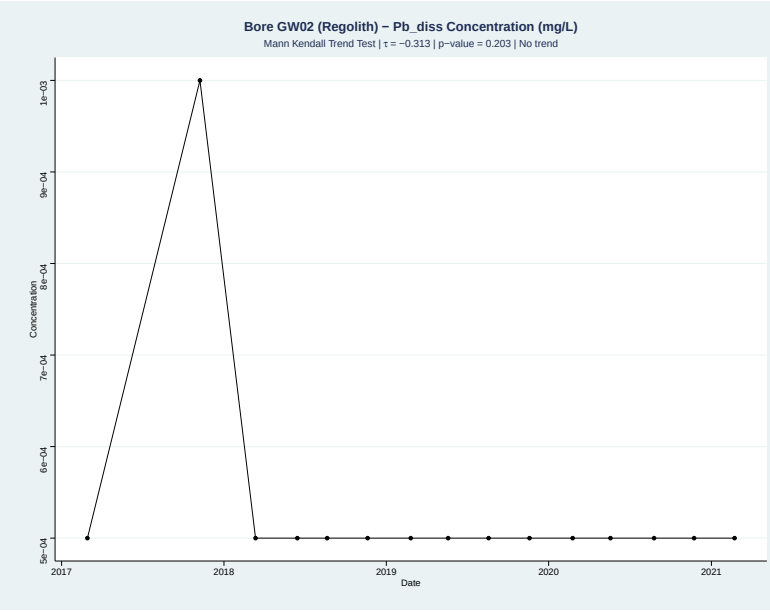


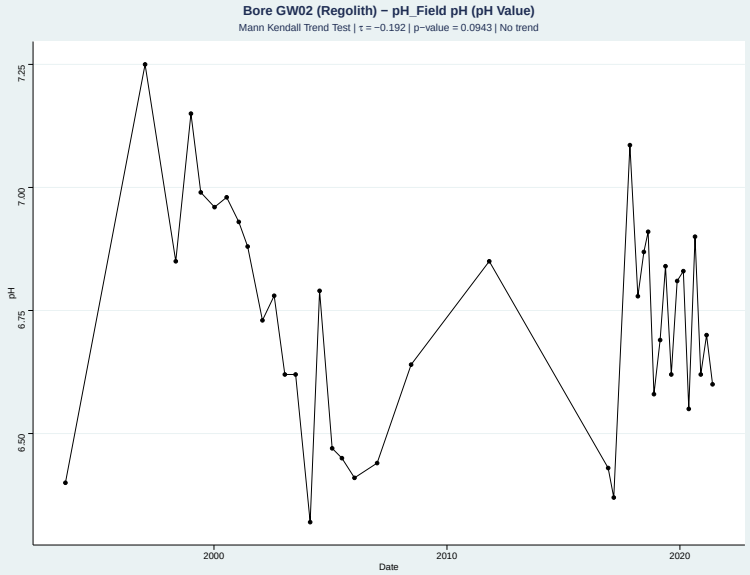
Bore GW02 (Regolith) – Ni_diss Concentration (mg/L)

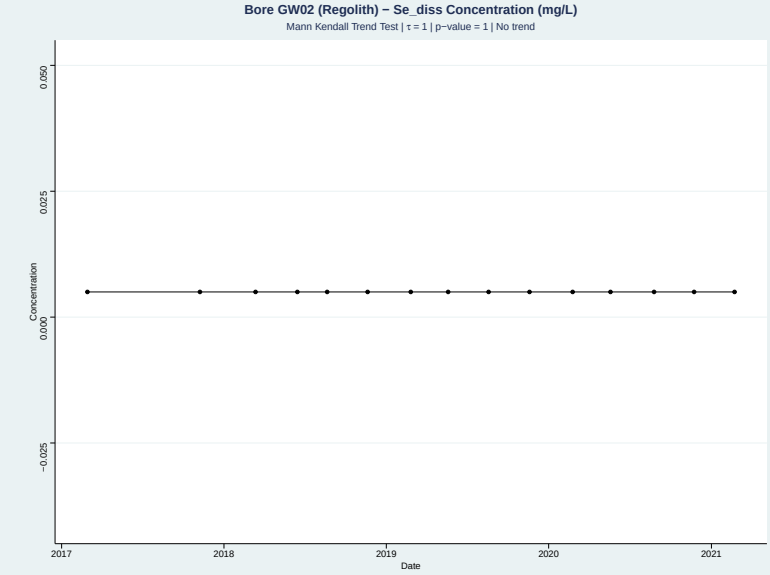
Mann Kendall Trend Test | τ = 0.707 | p−value = 0.000622 | Positive trend

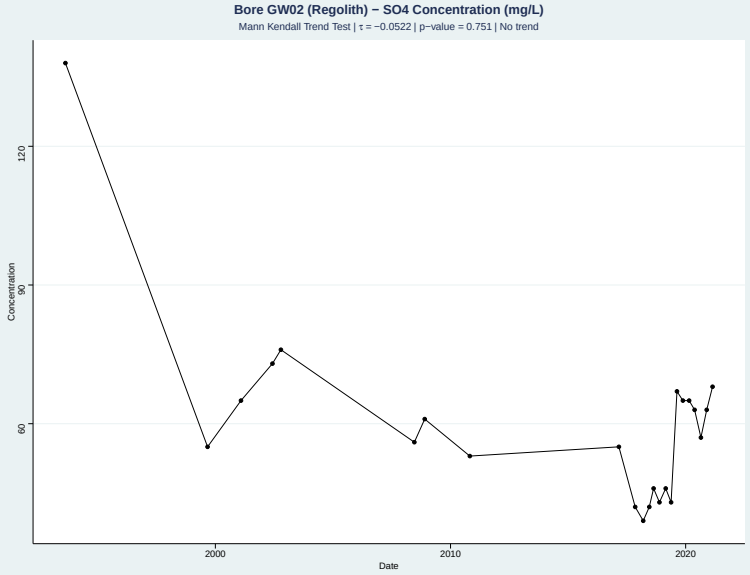


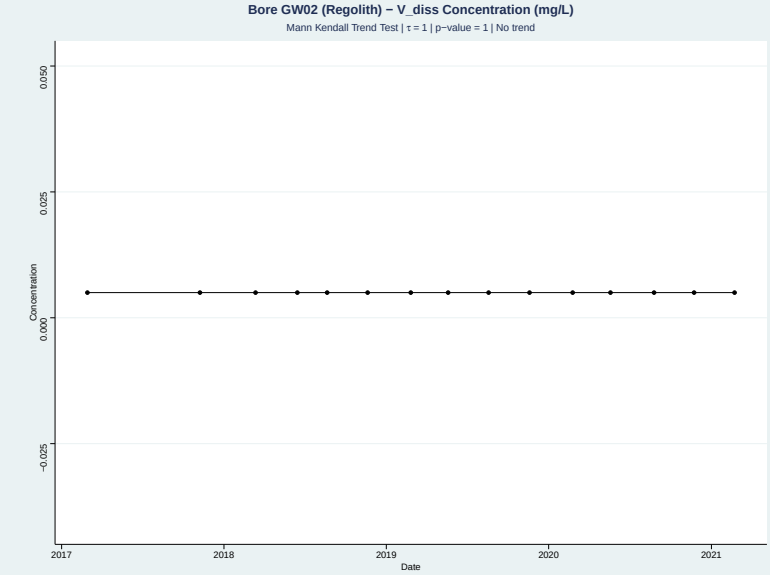
Appendix C Groundwater Quality Time Series

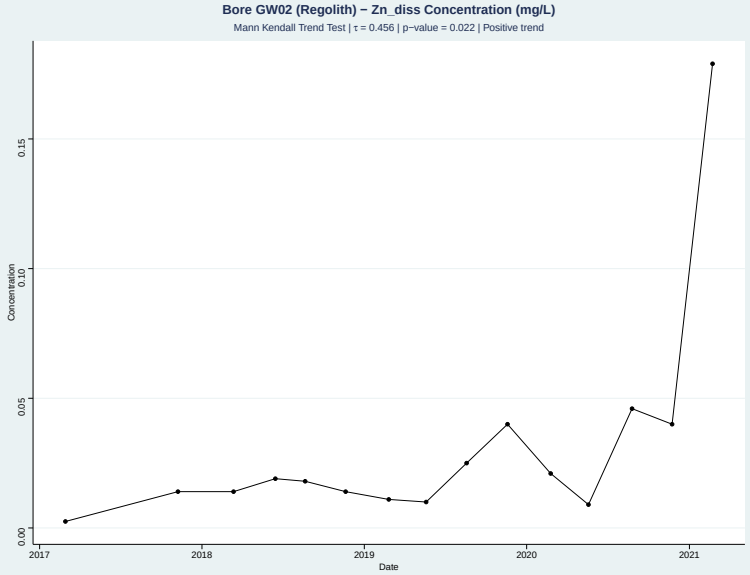




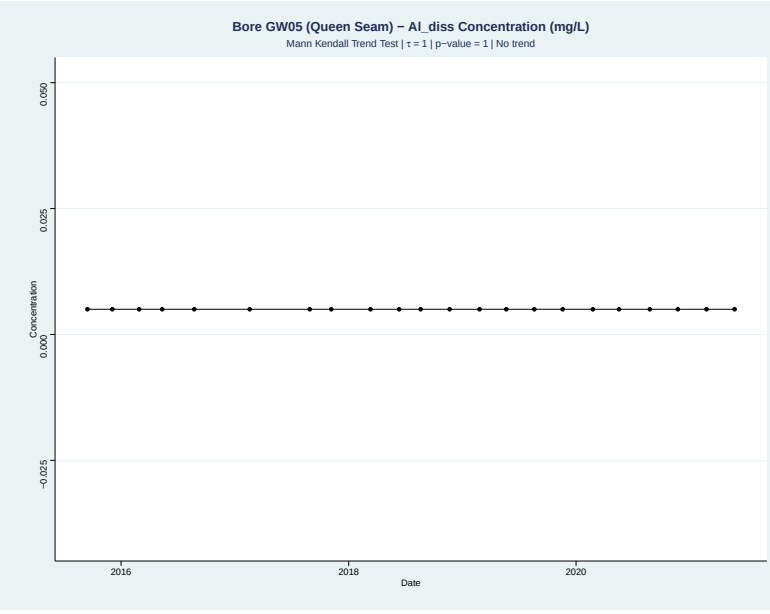


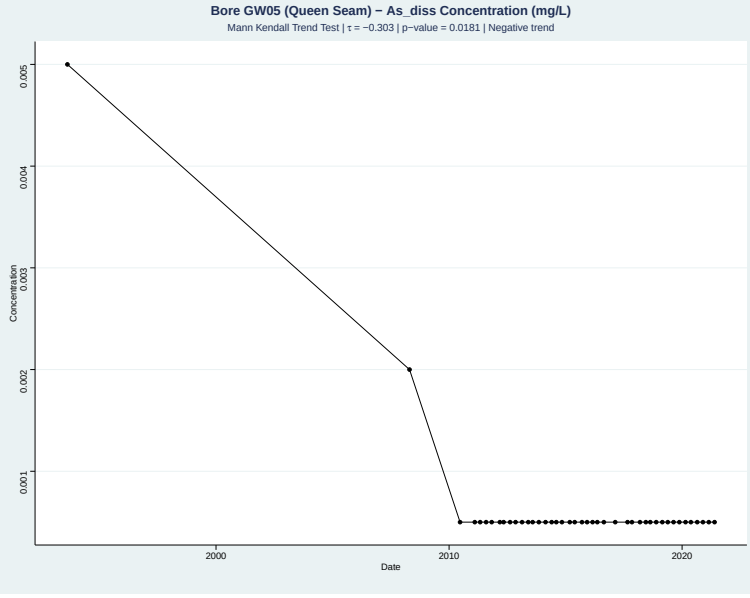


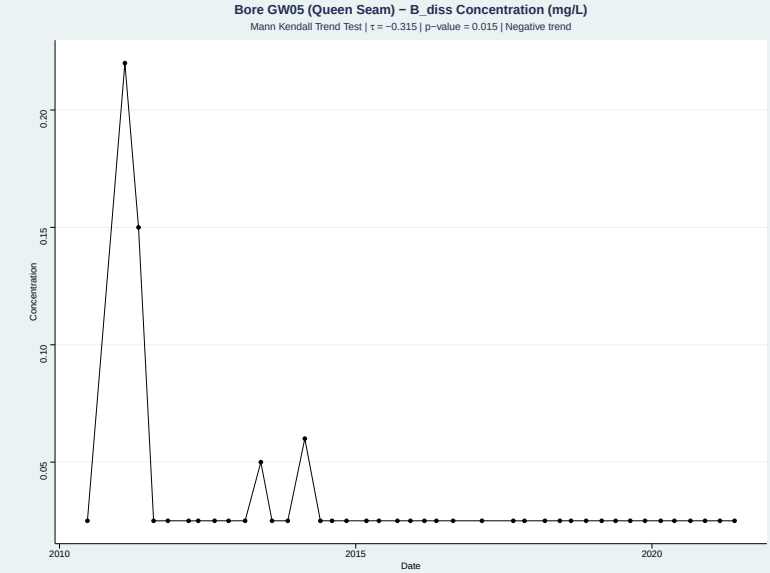


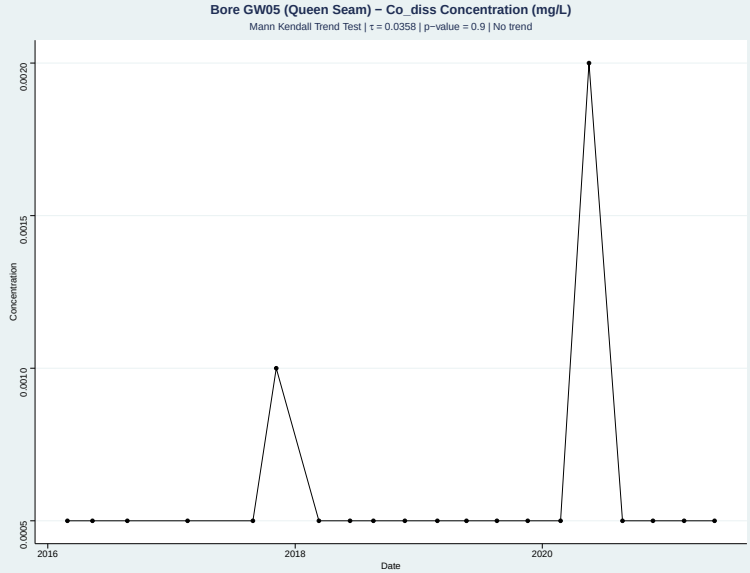


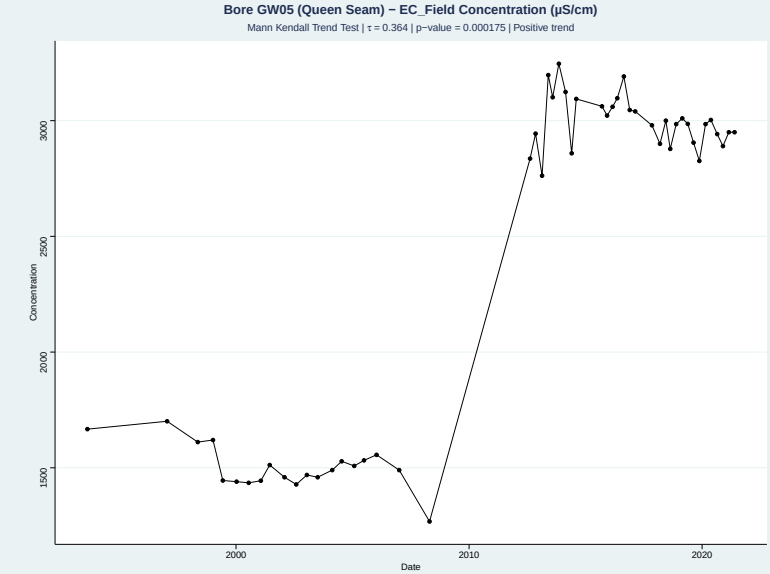
Appendix C Groundwater Quality Time Series

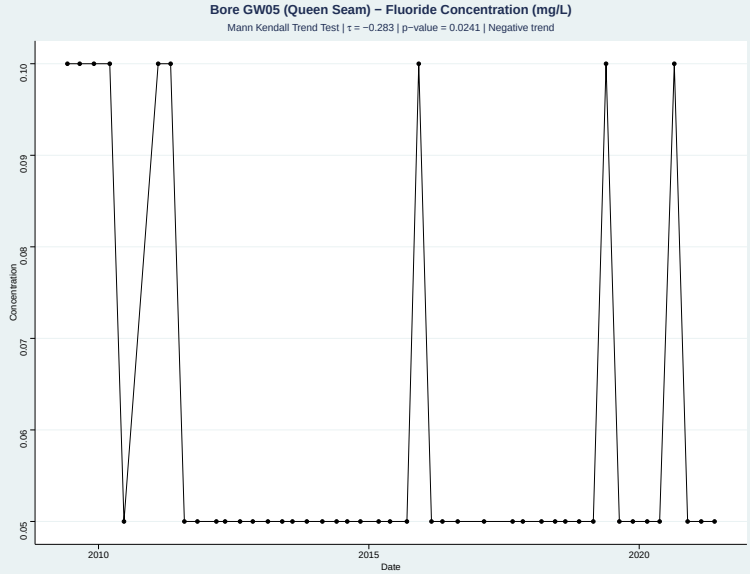




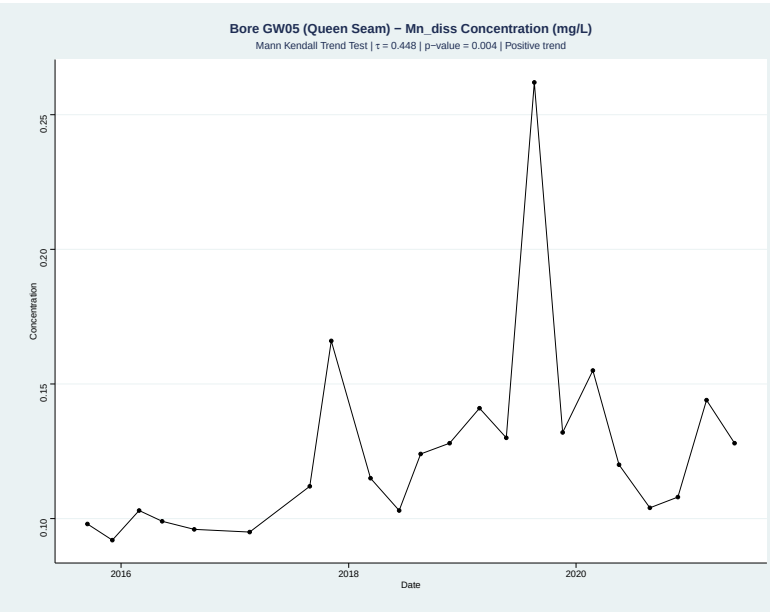


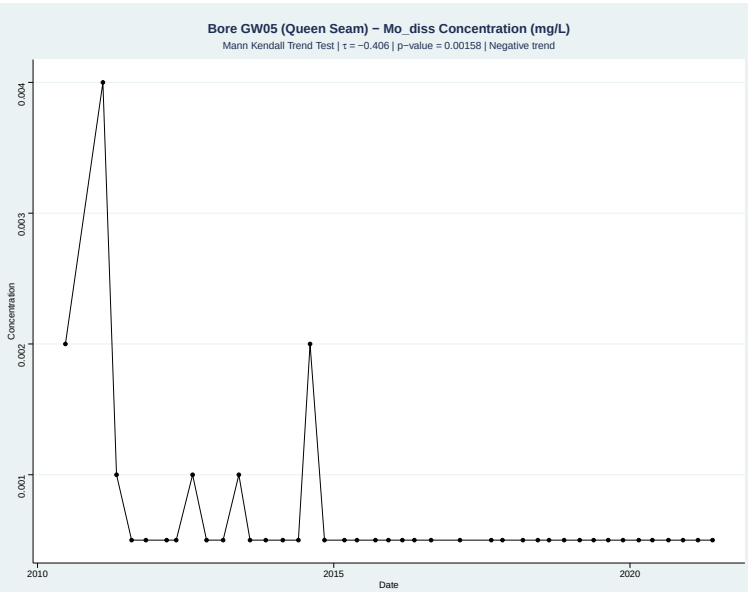


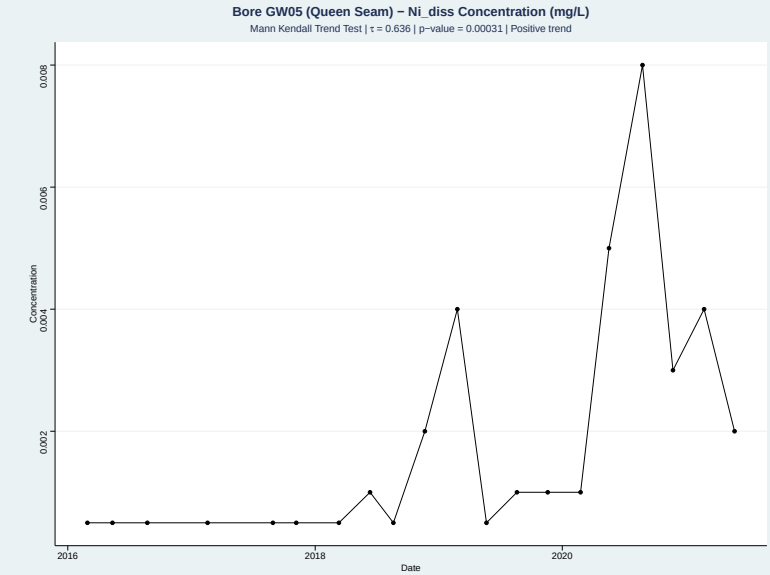


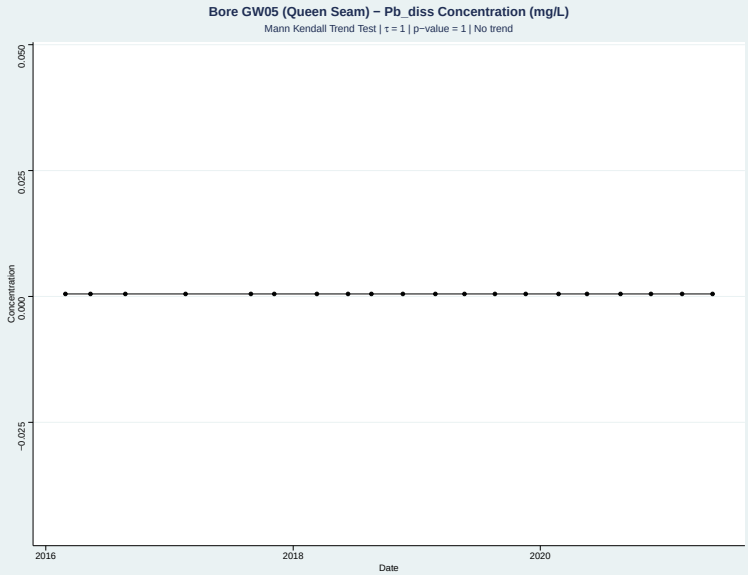


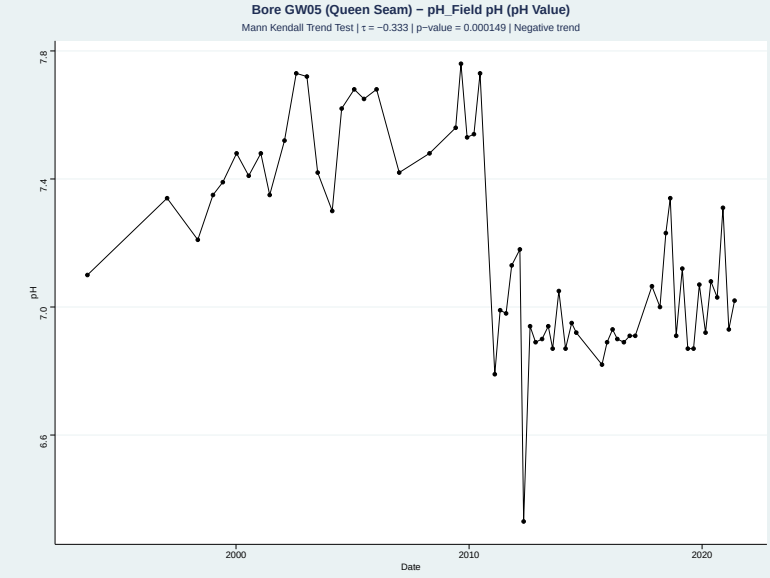
Appendix C Groundwater Quality Time Series

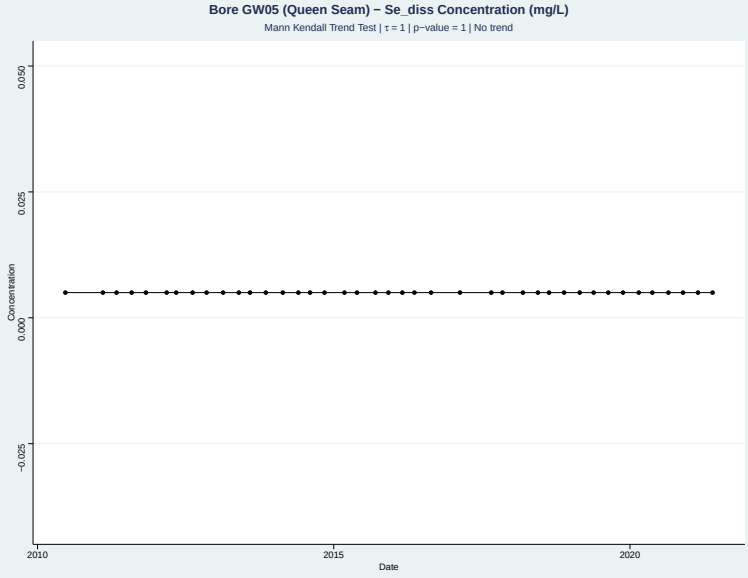




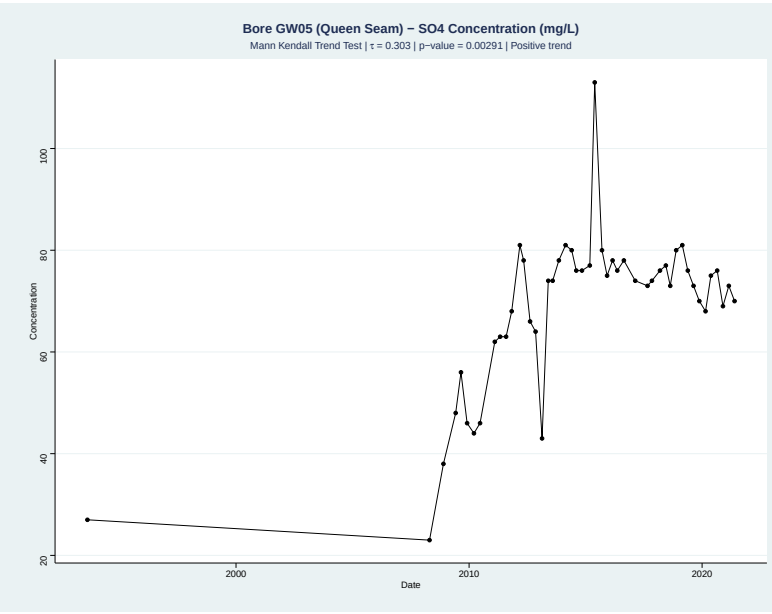


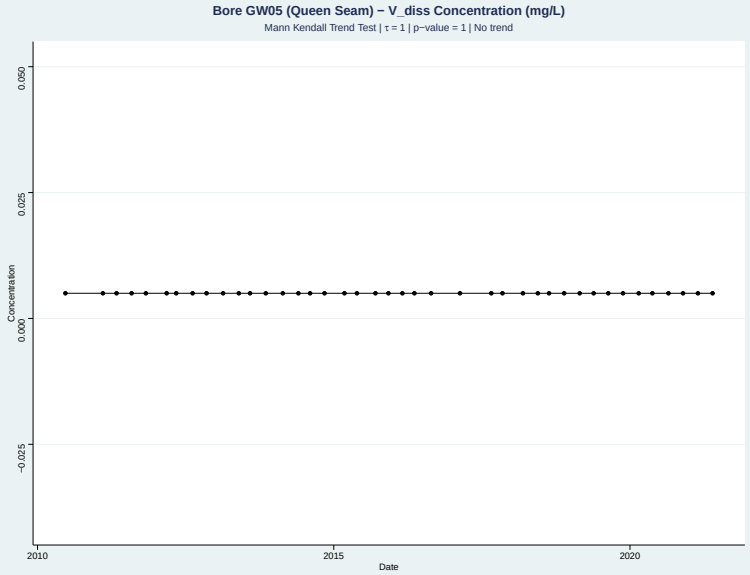


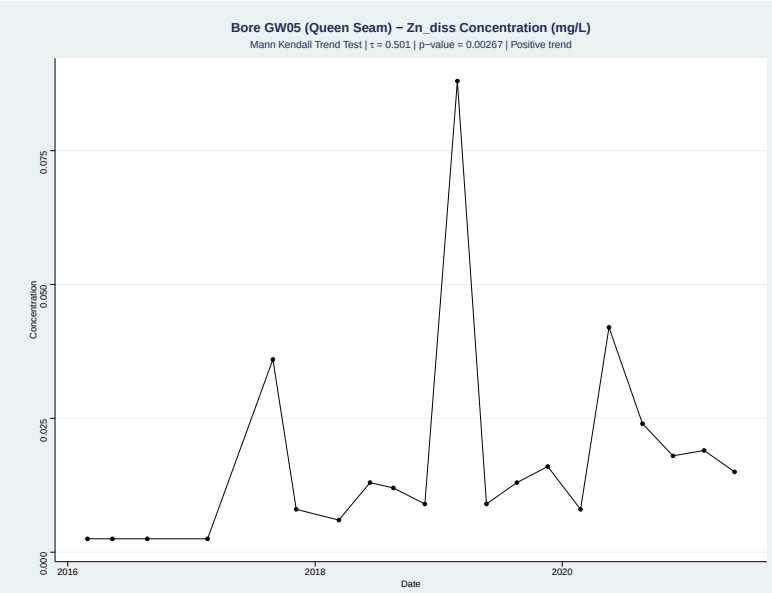


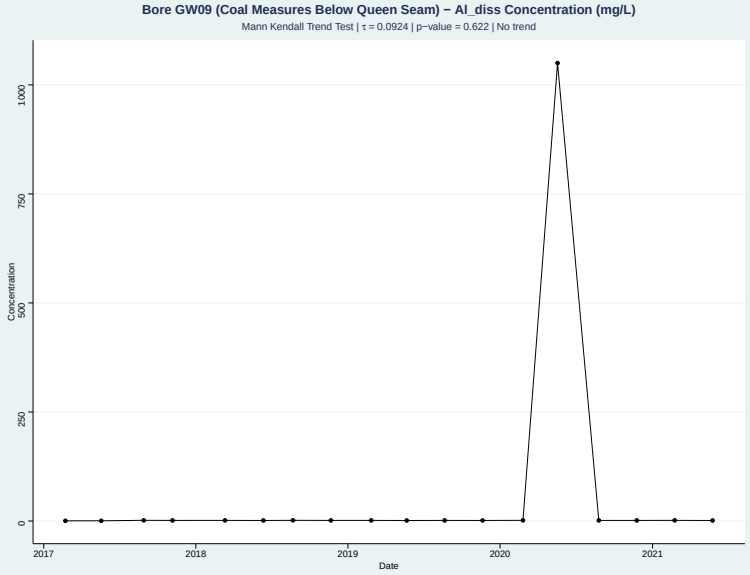


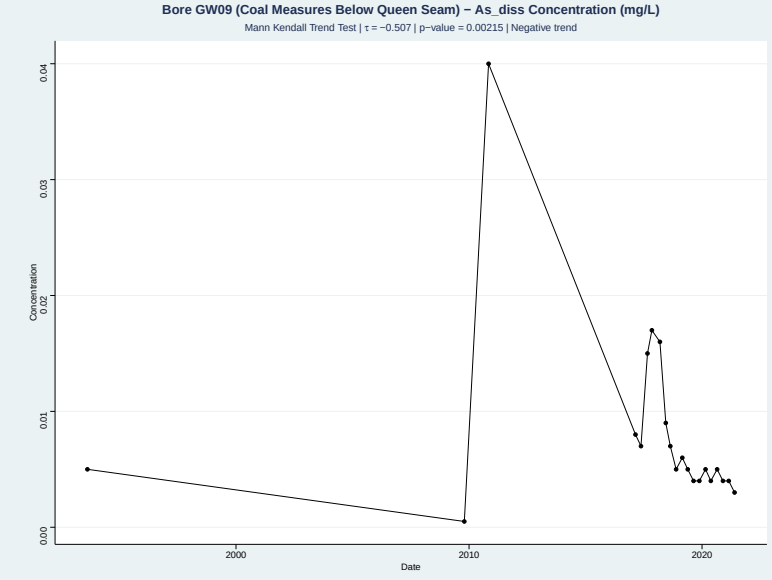
Appendix C Groundwater Quality Time Series

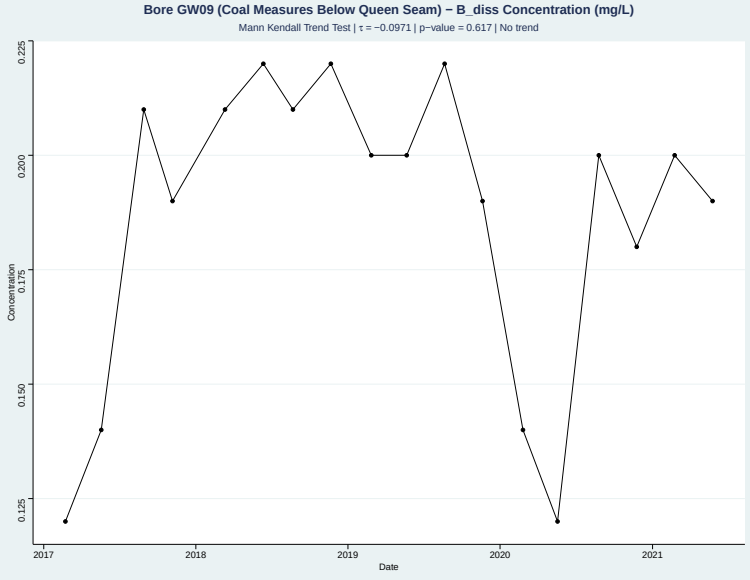




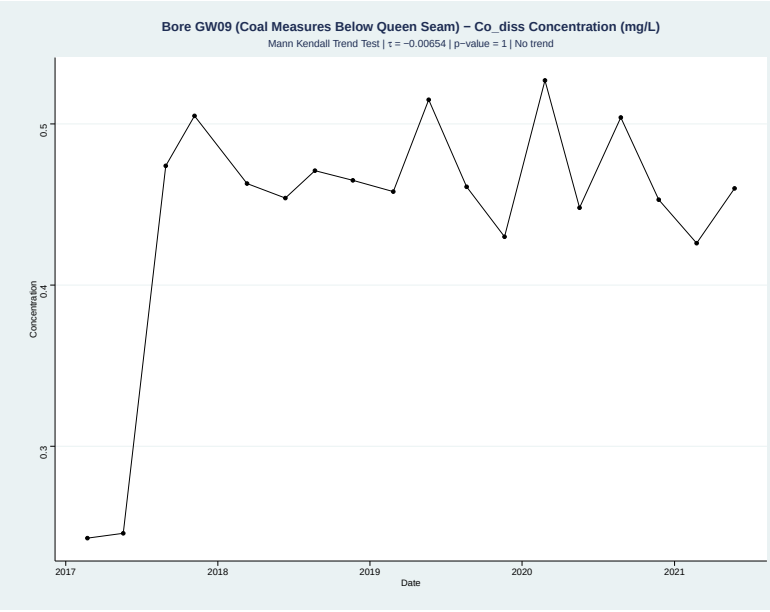


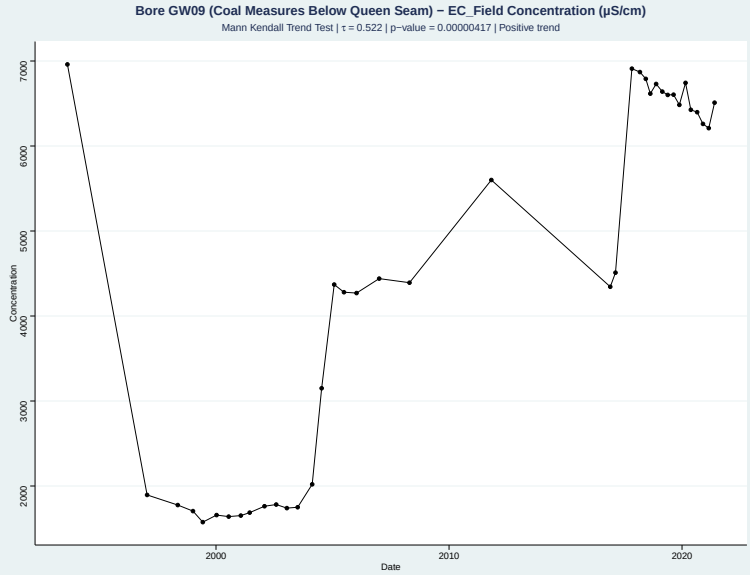


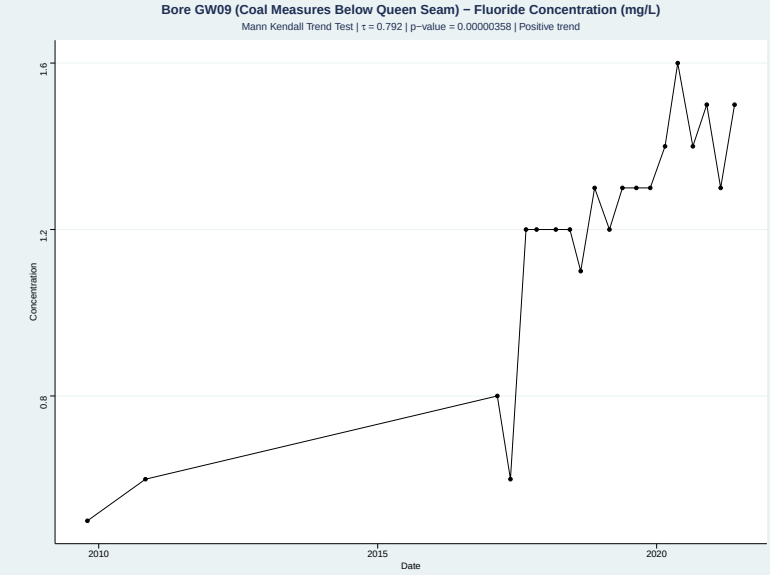


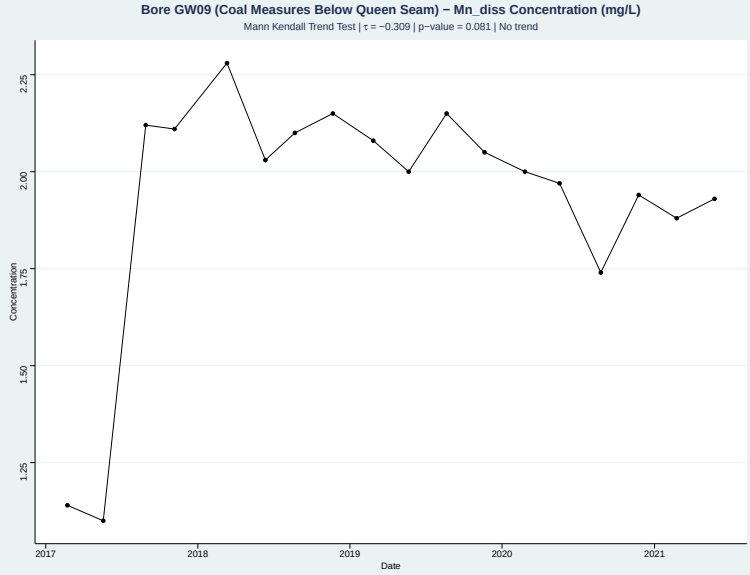


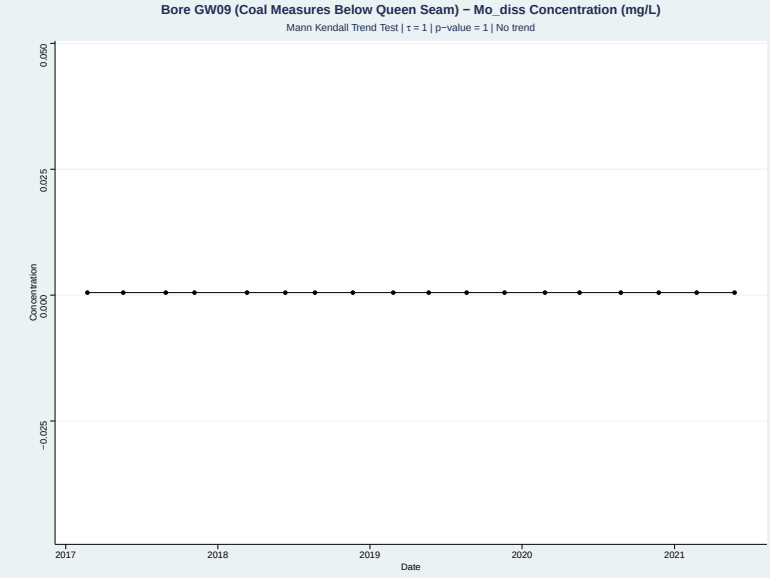
Appendix C Groundwater Quality Time Series

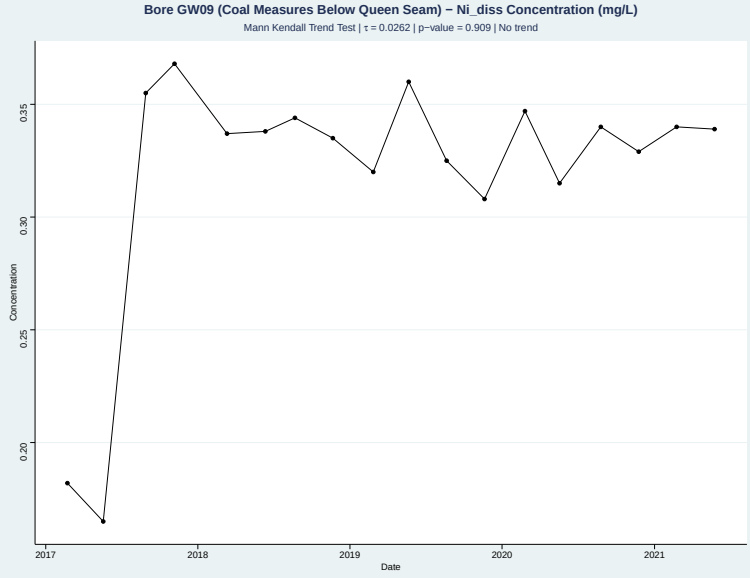




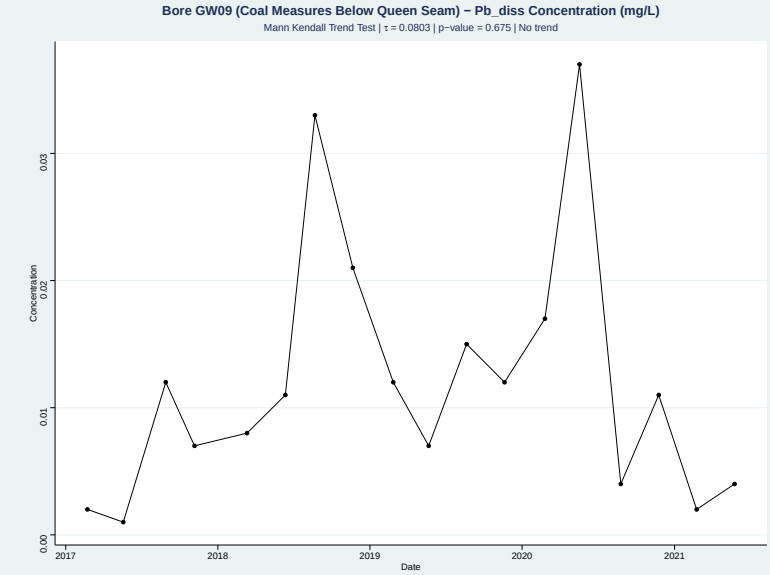


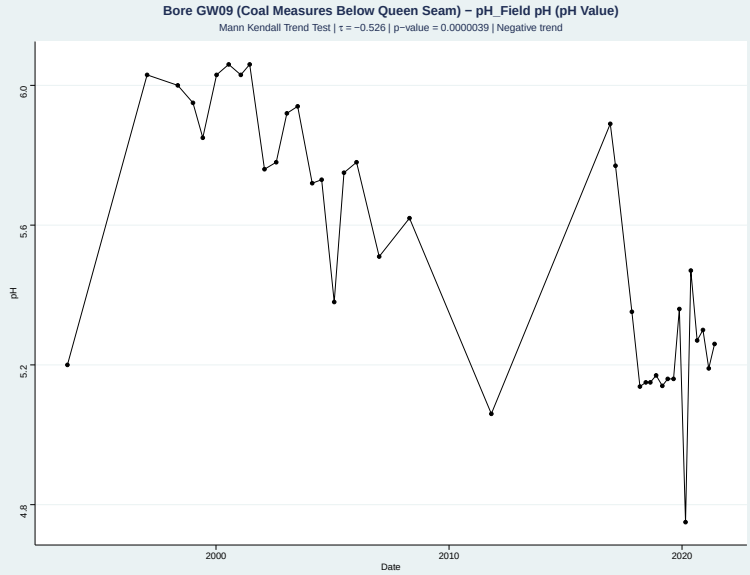


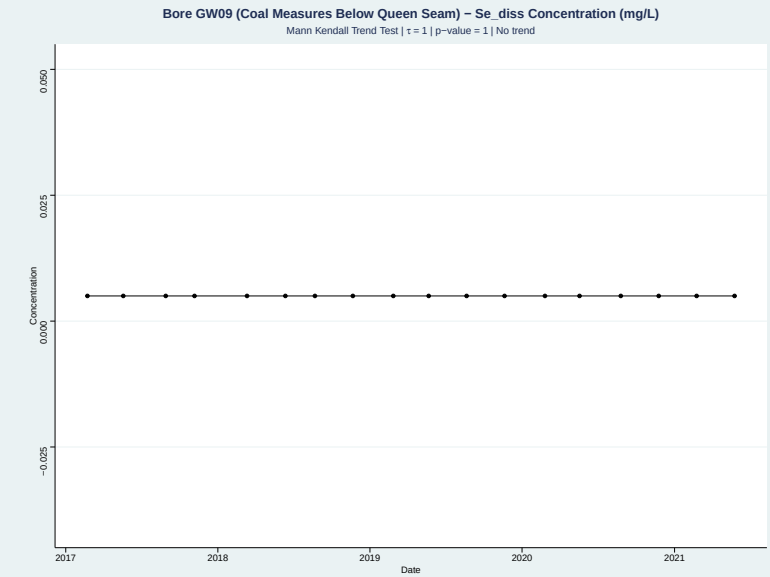


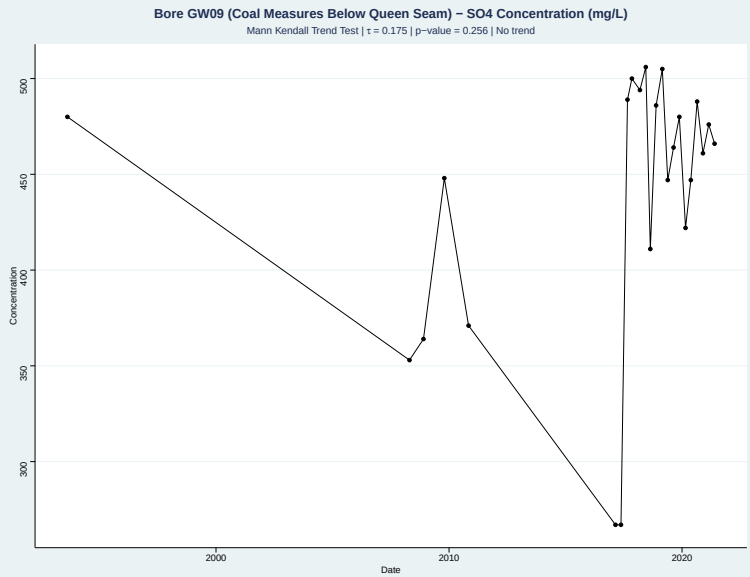


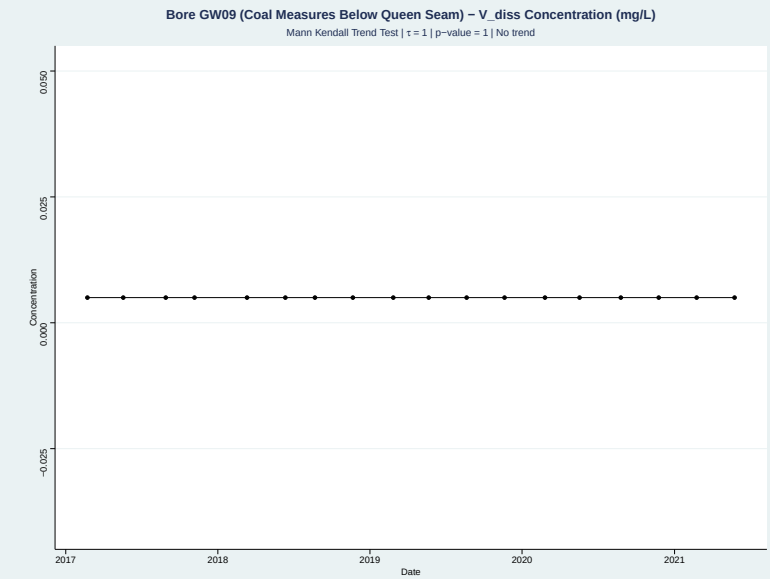
Appendix C Groundwater Quality Time Series

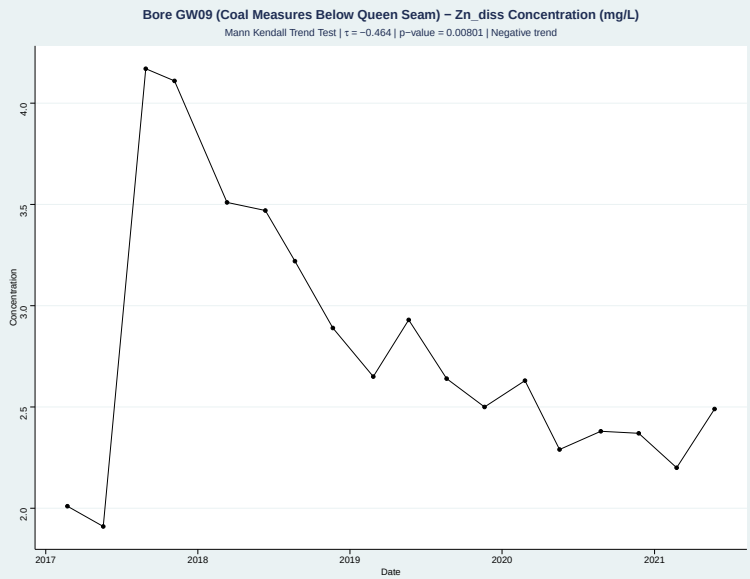




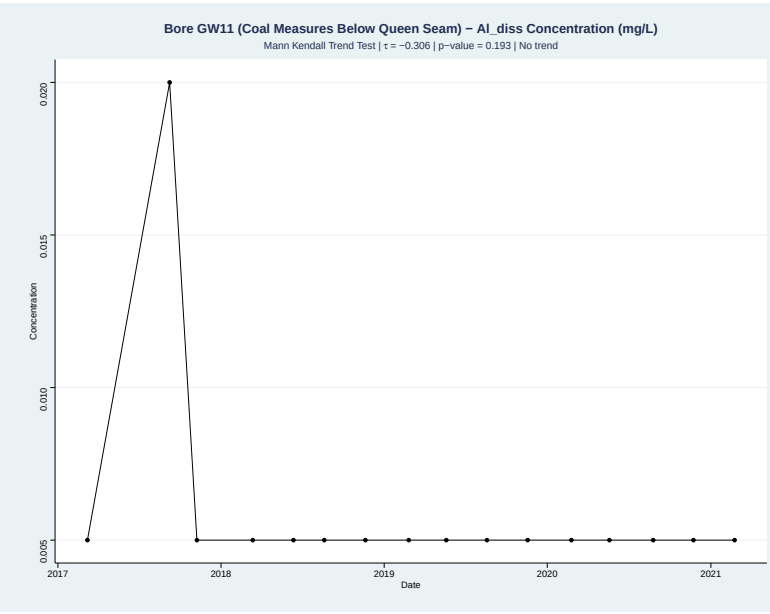


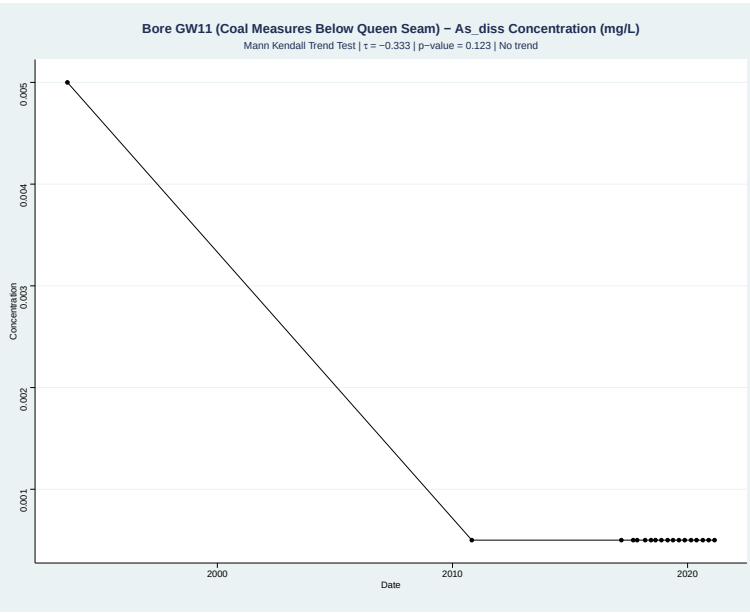


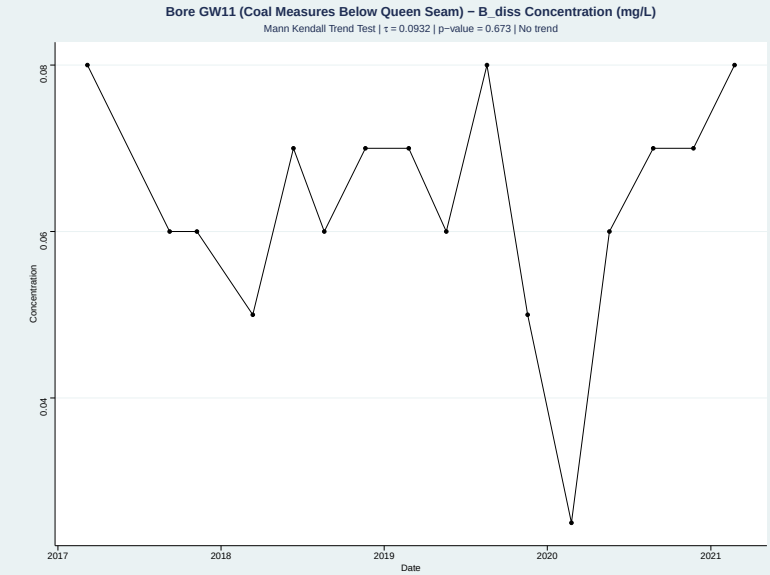


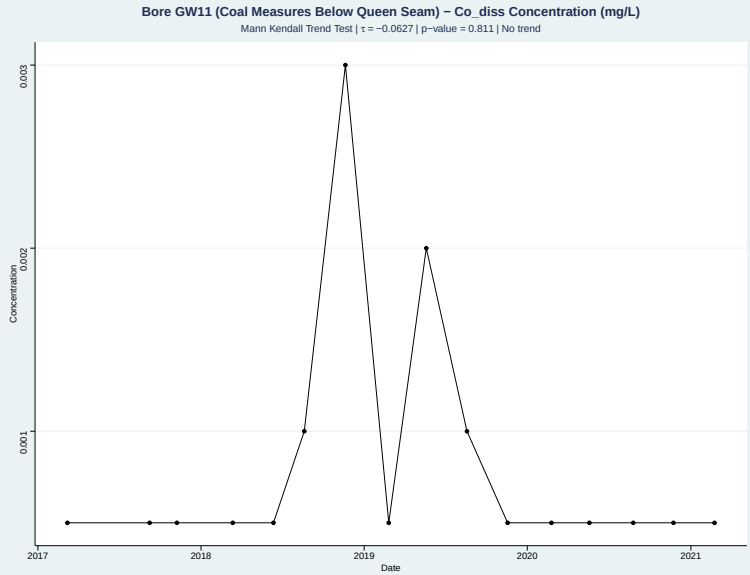


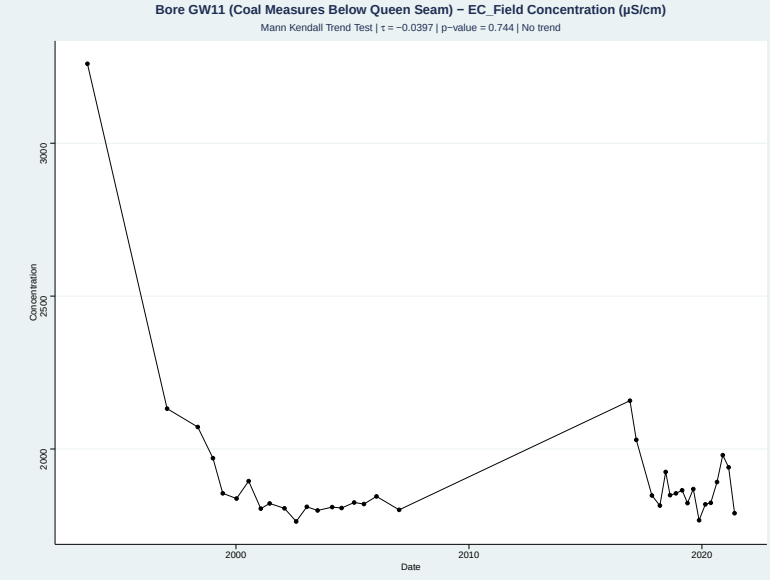
Appendix C Groundwater Quality Time Series

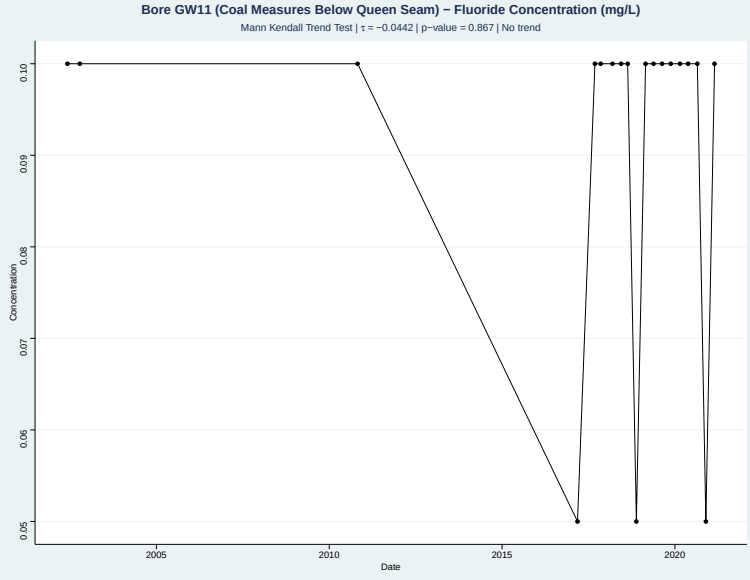




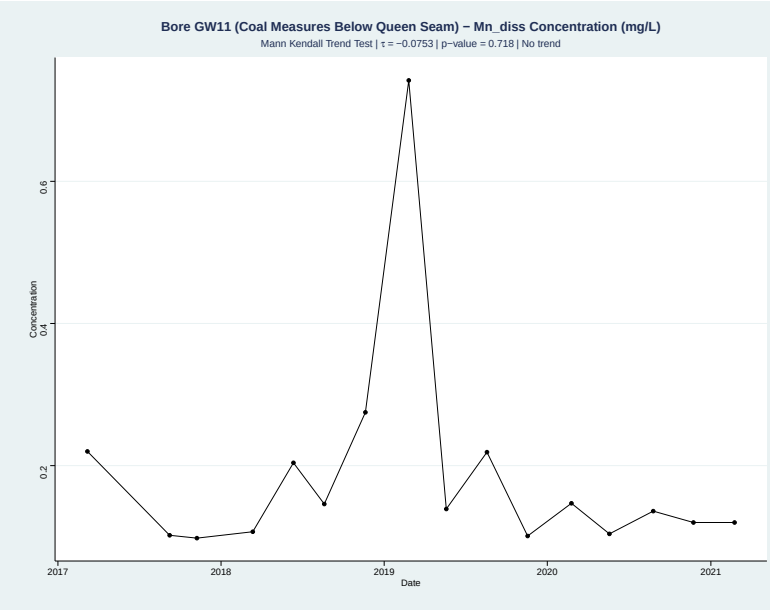


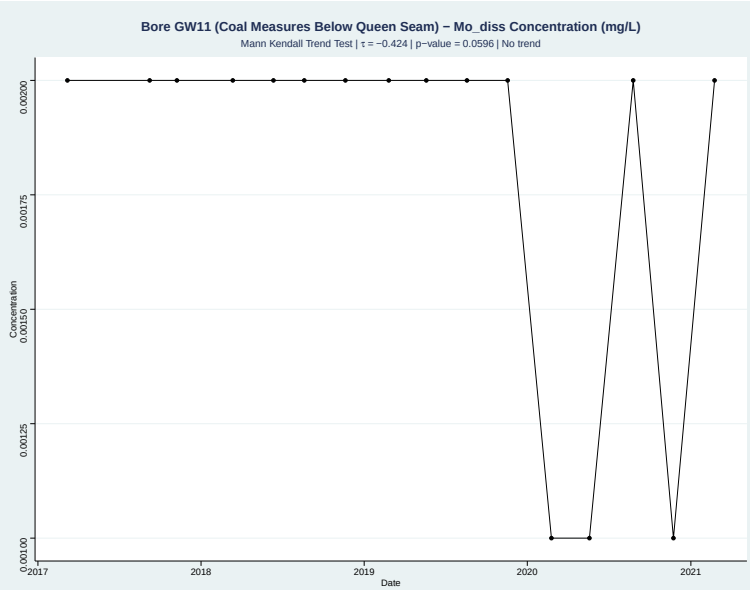


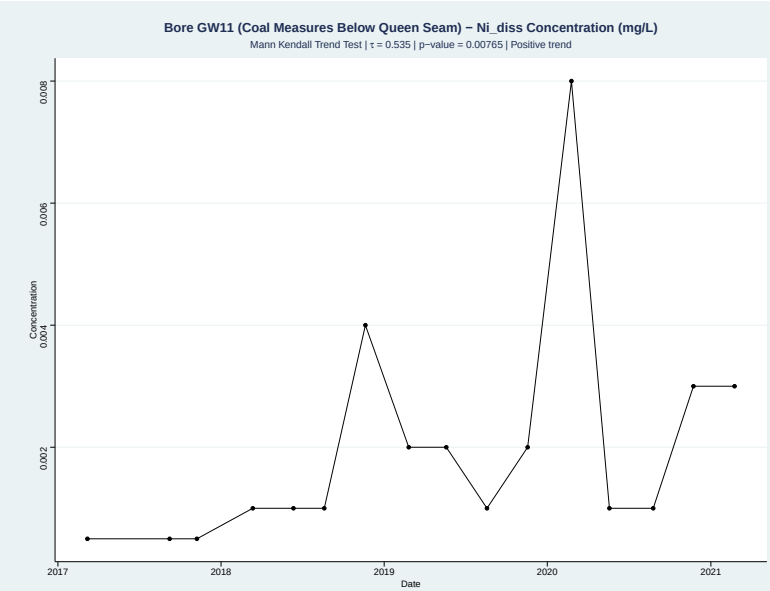


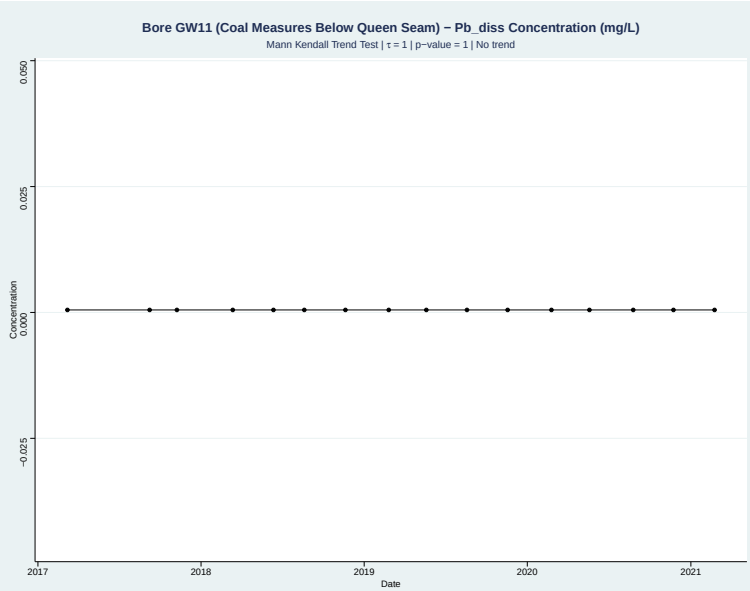


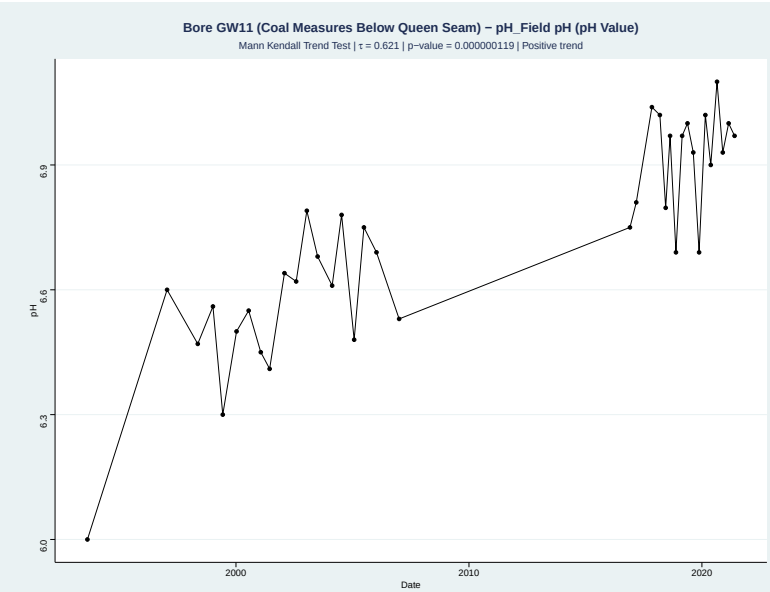
Appendix C Groundwater Quality Time Series

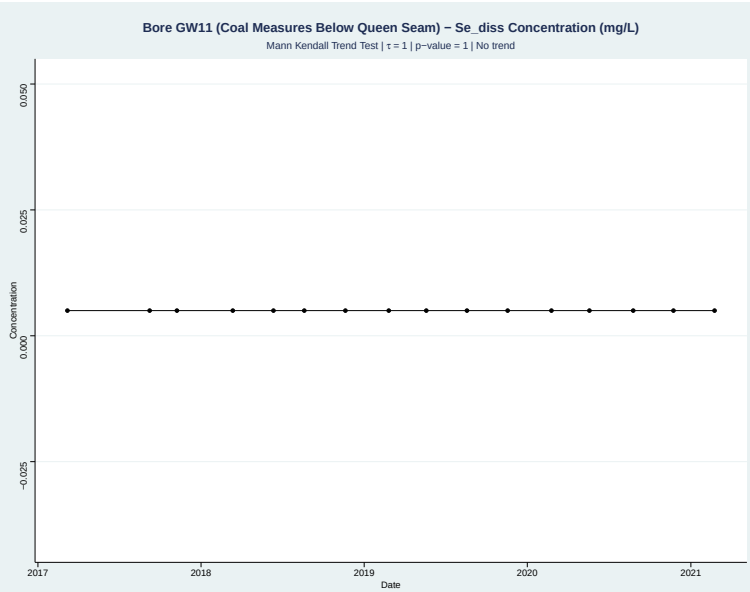




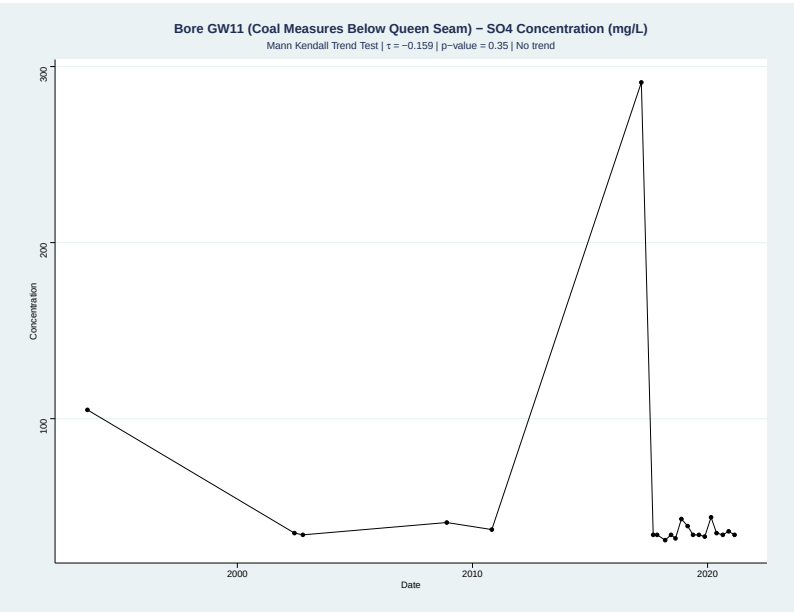


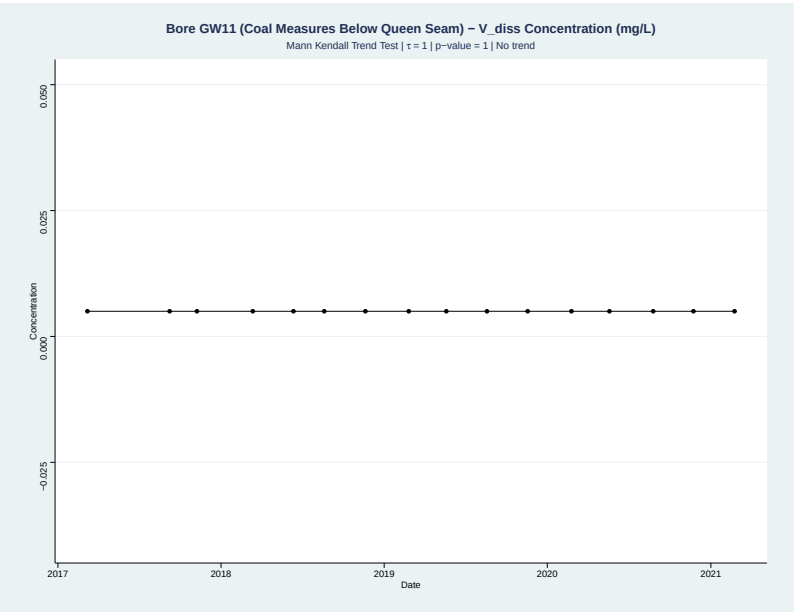


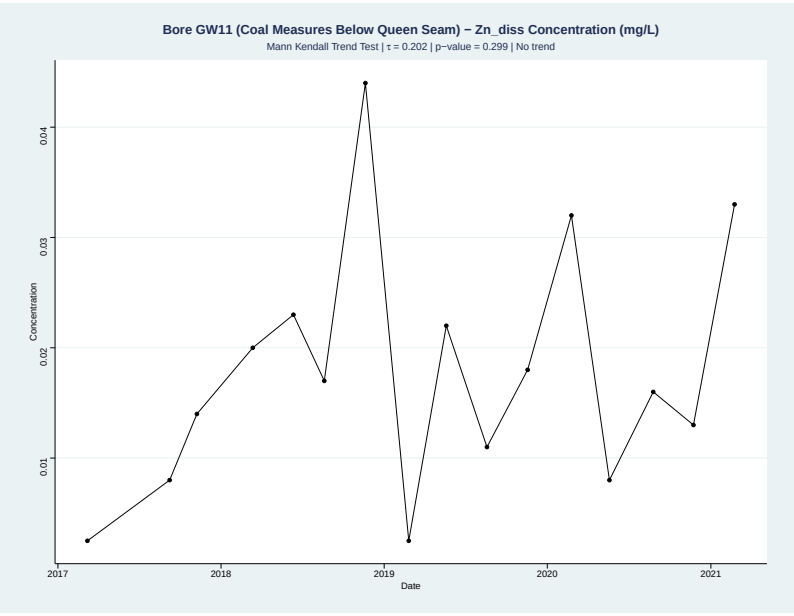


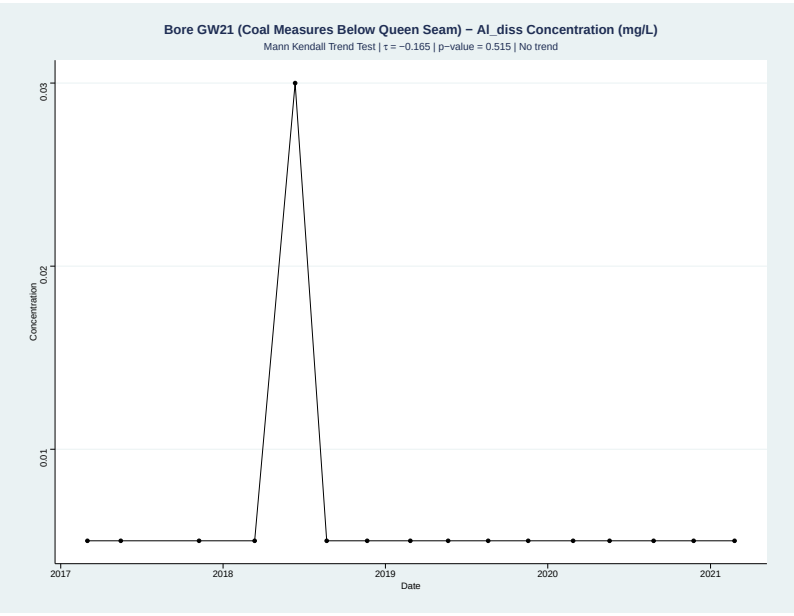


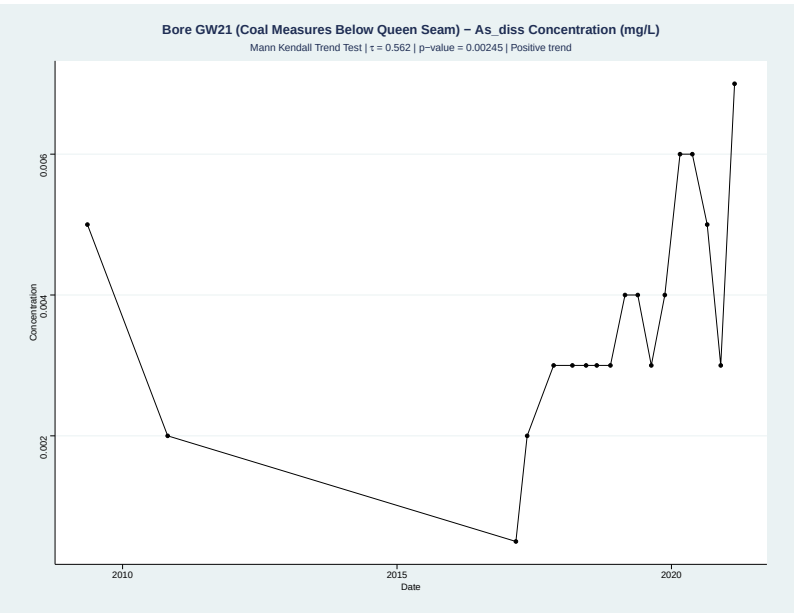
Appendix C Groundwater Quality Time Series

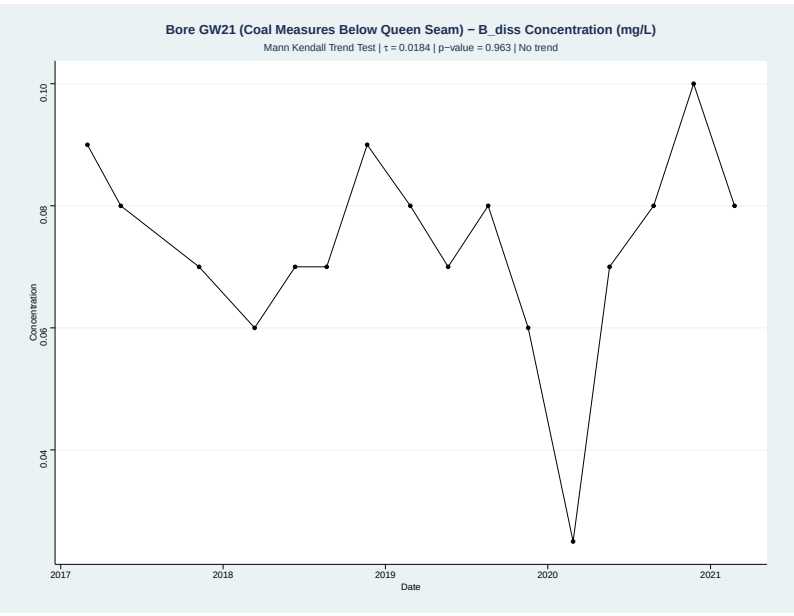




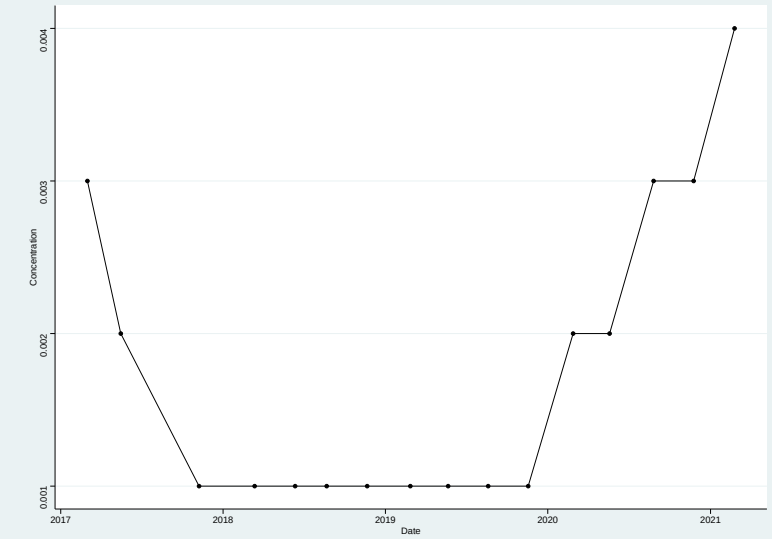


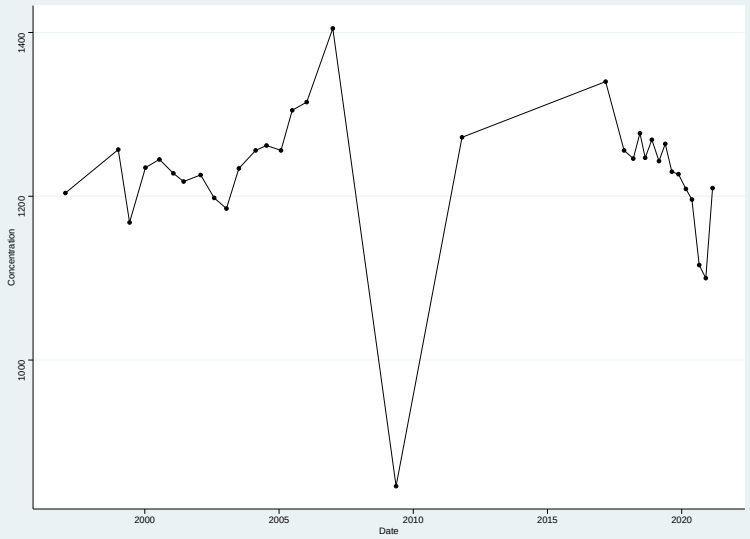


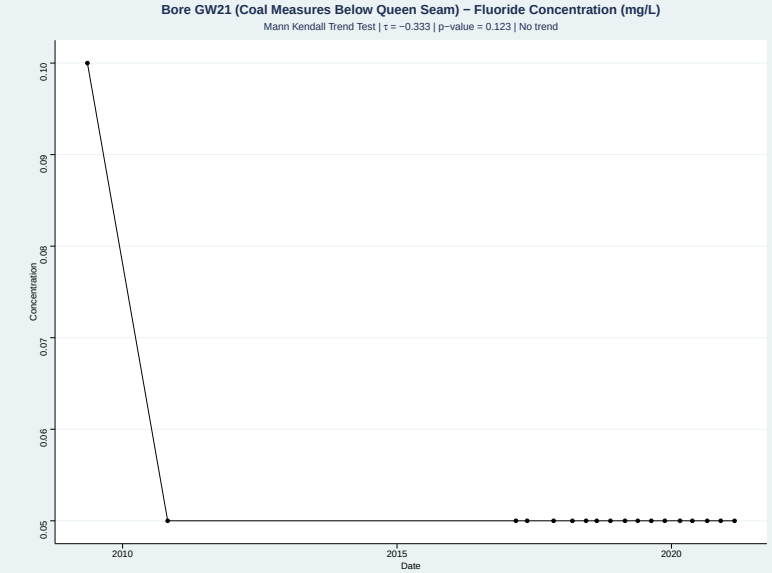


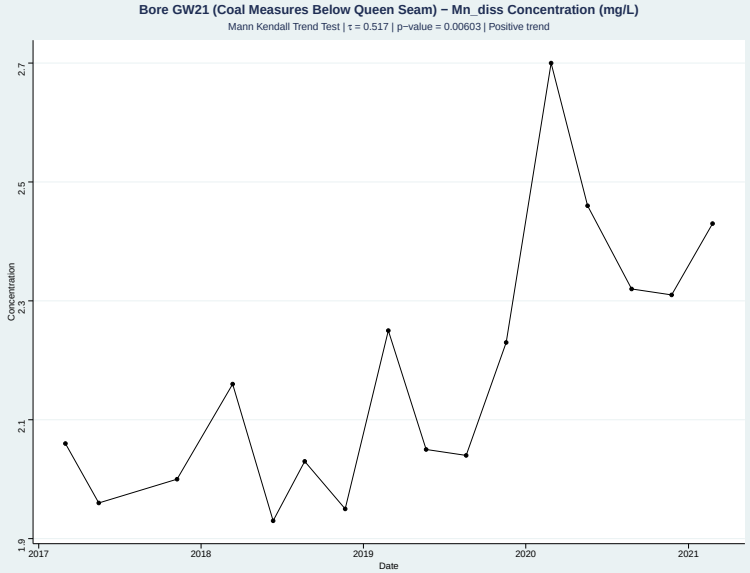


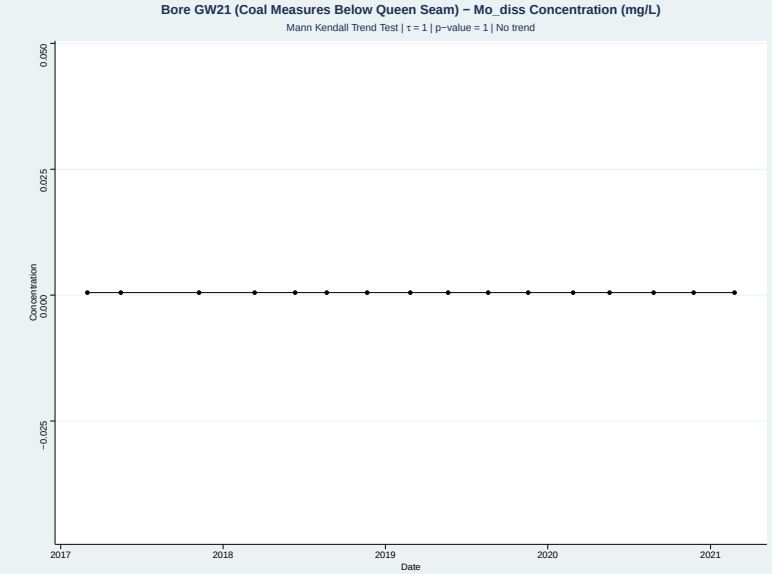
Appendix C Groundwater Quality Time Series

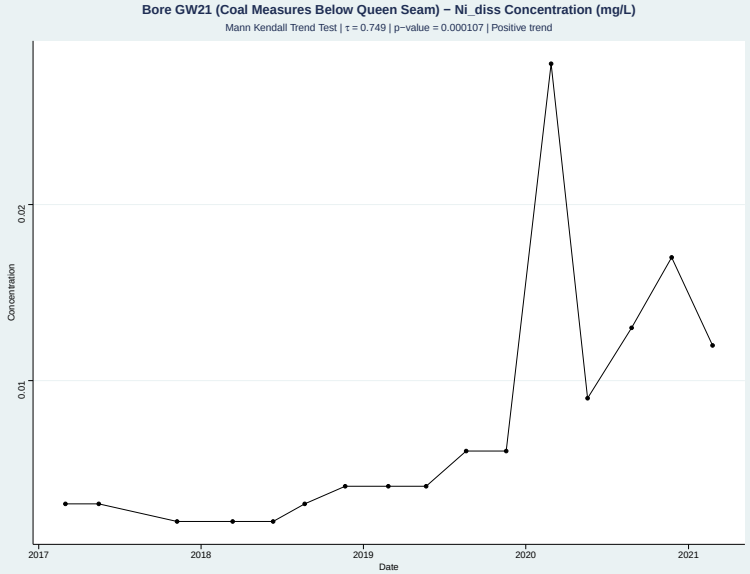




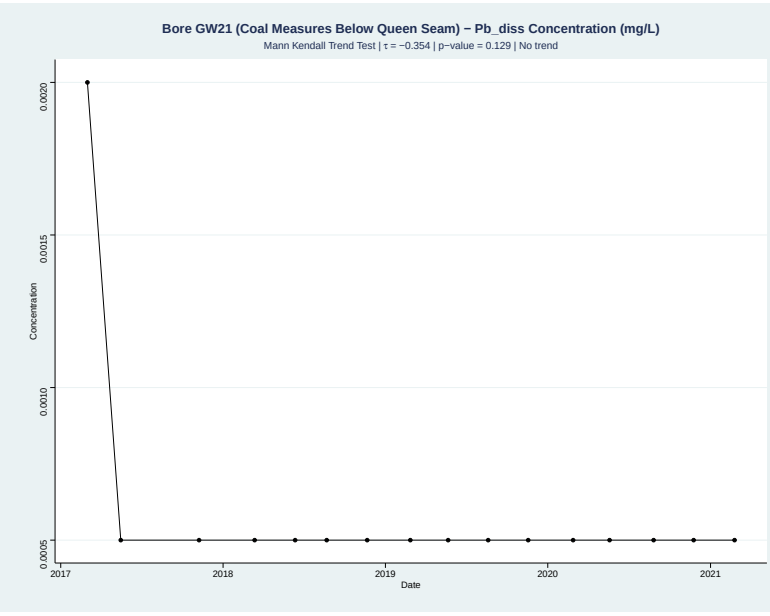


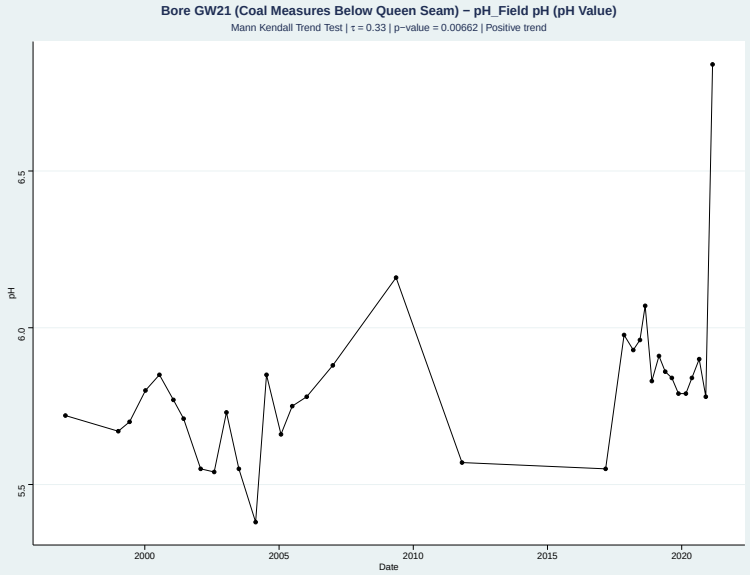


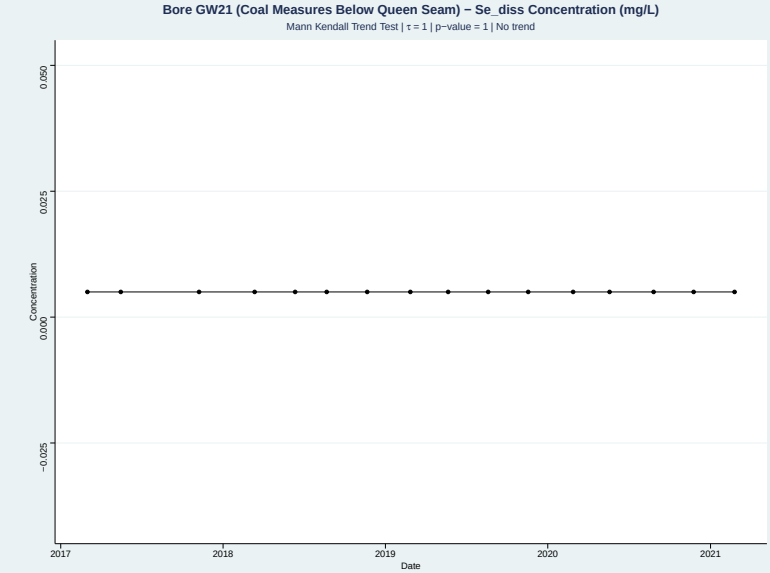


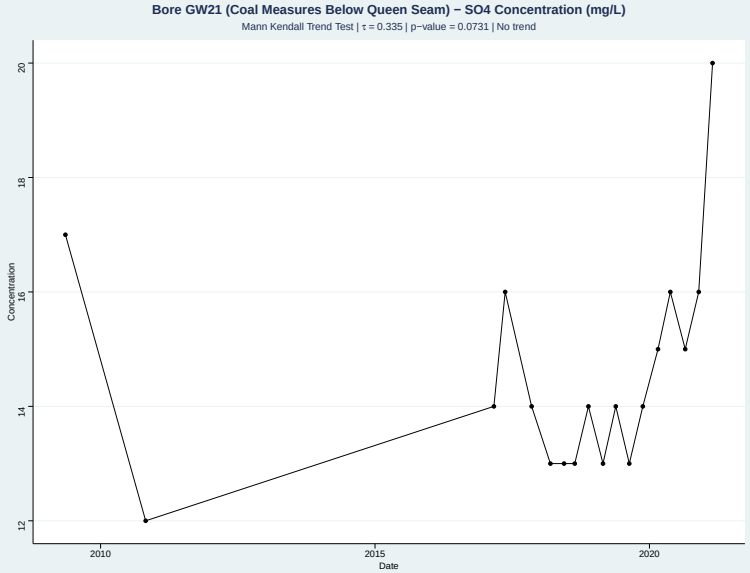


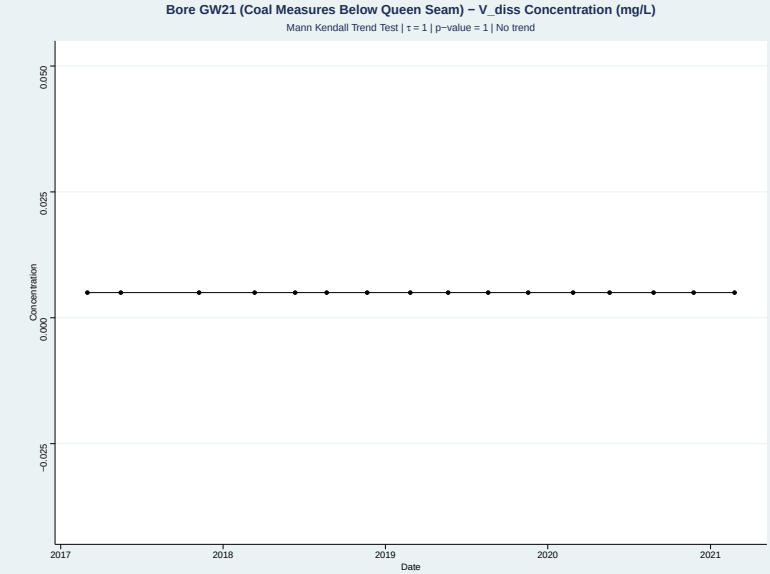
Appendix C Groundwater Quality Time Series

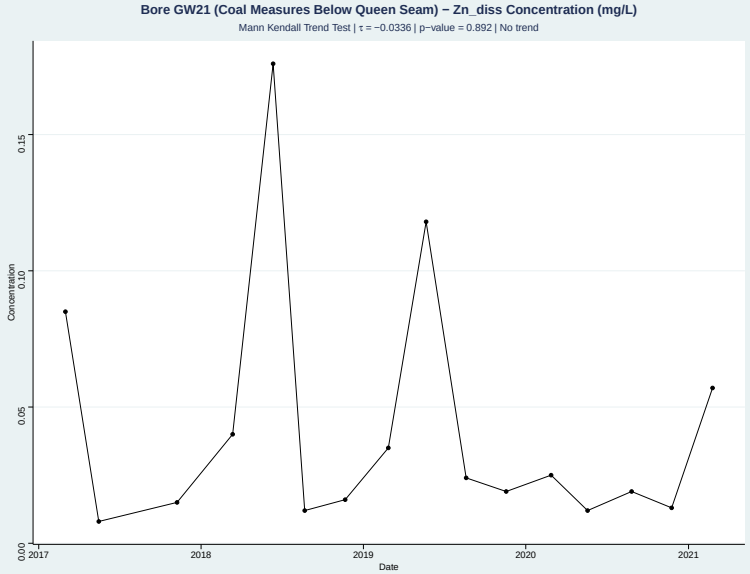




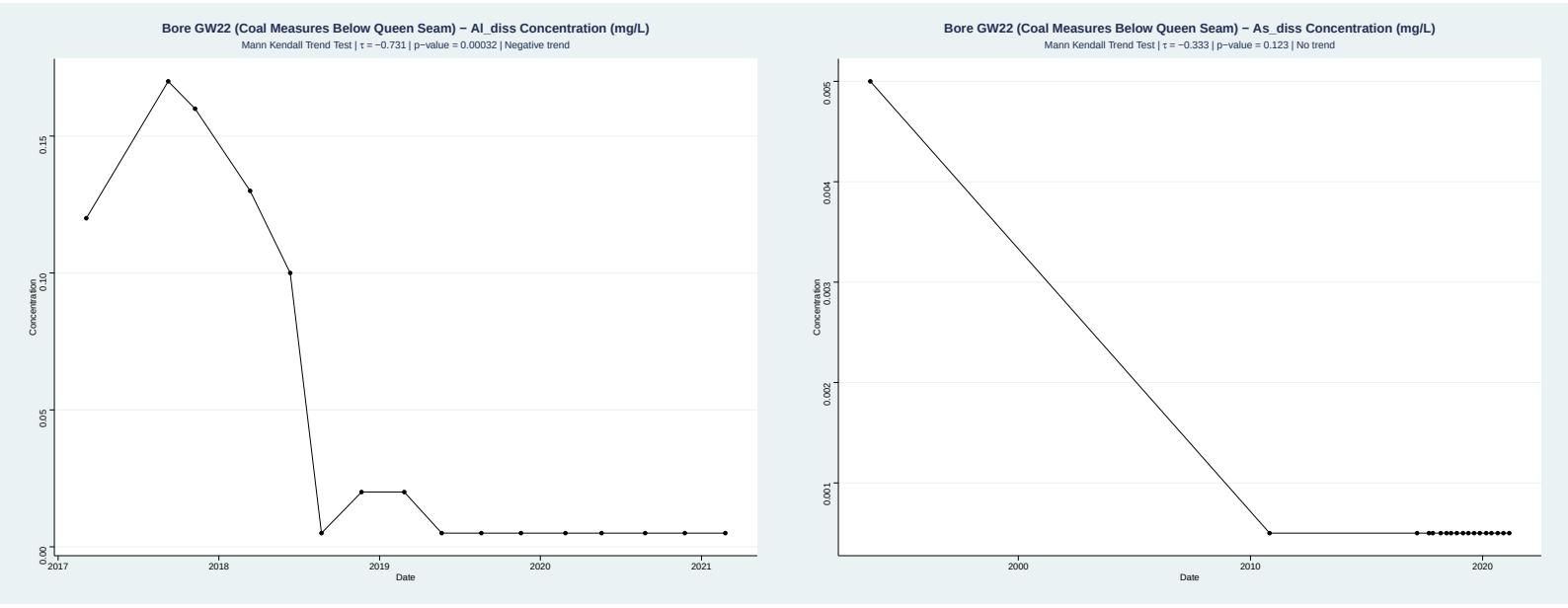


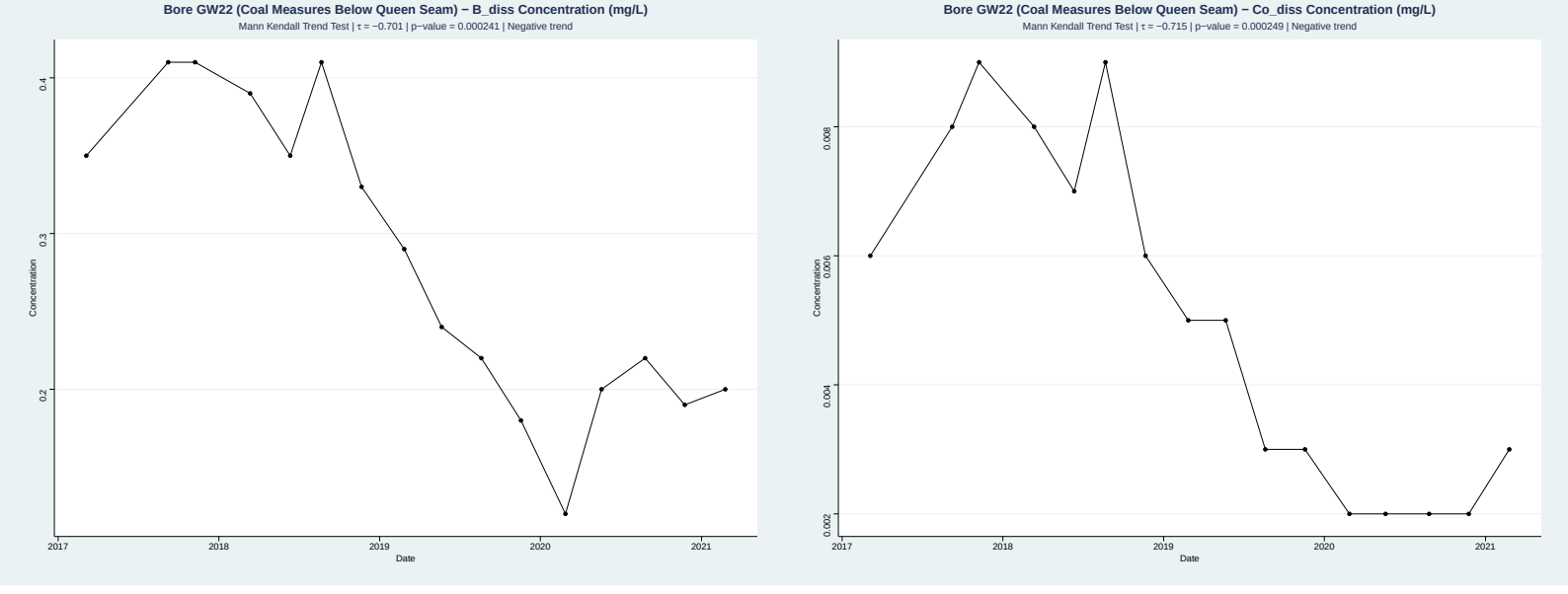


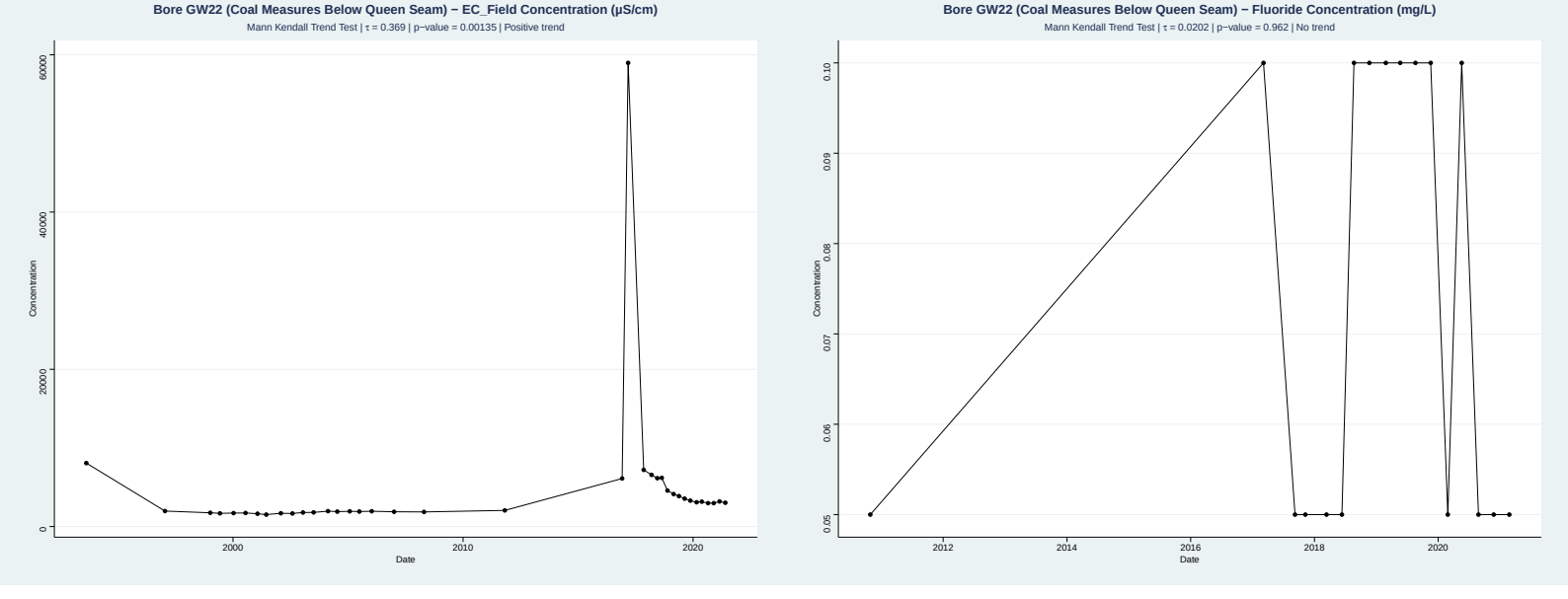




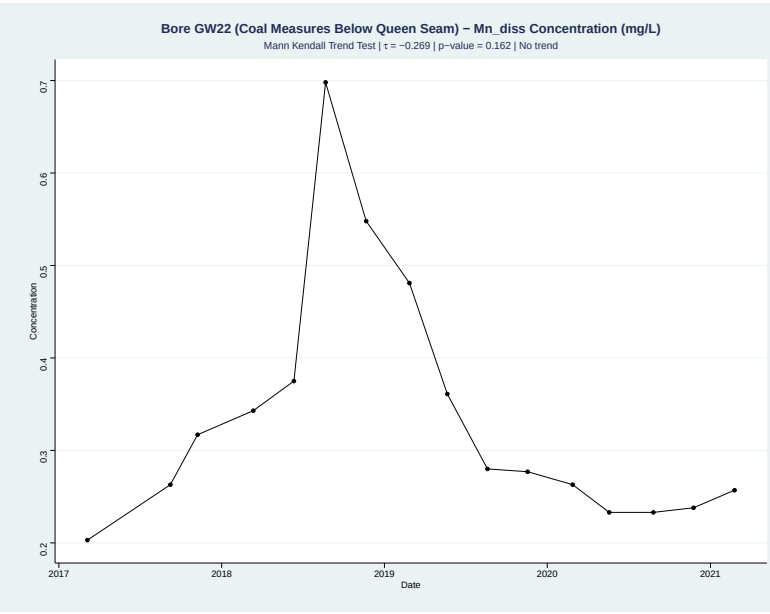
Appendix C Groundwater Quality Time Series

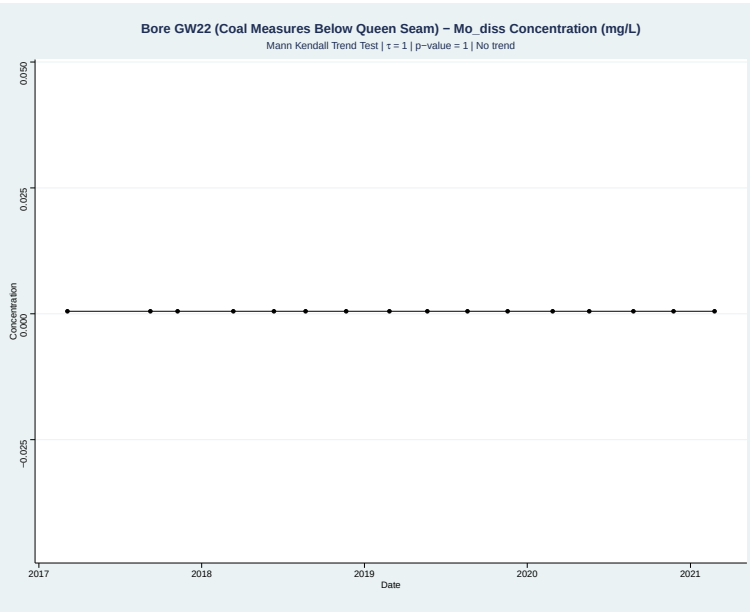


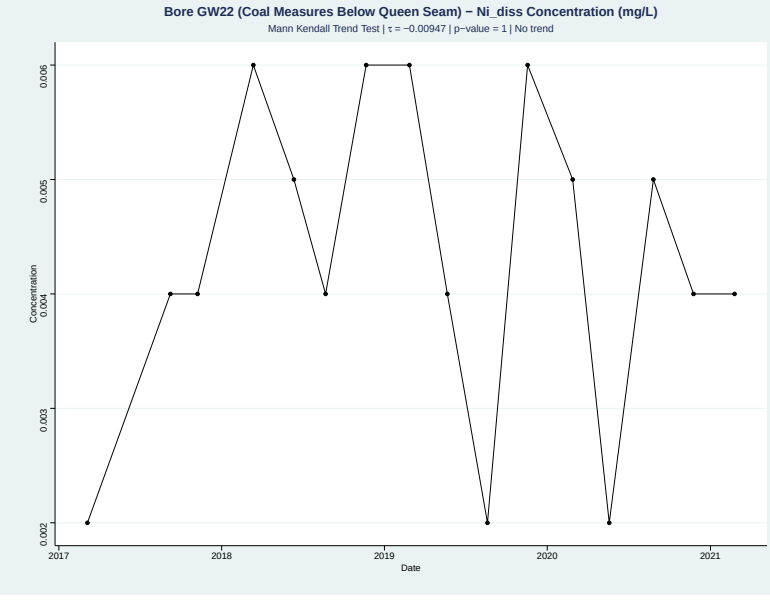


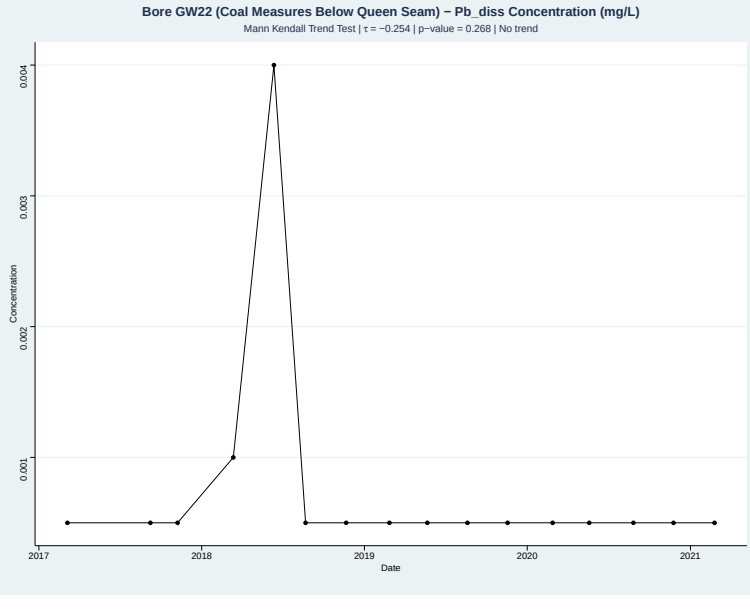


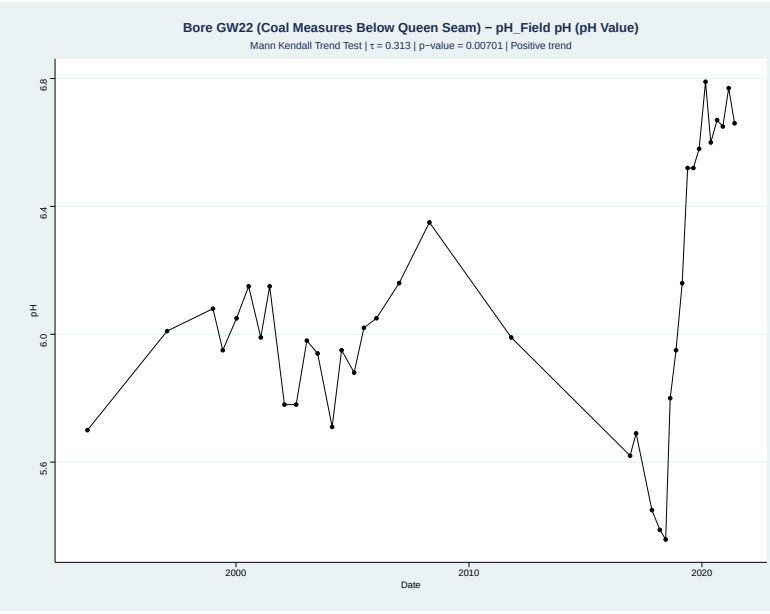
Appendix C Groundwater Quality Time Series

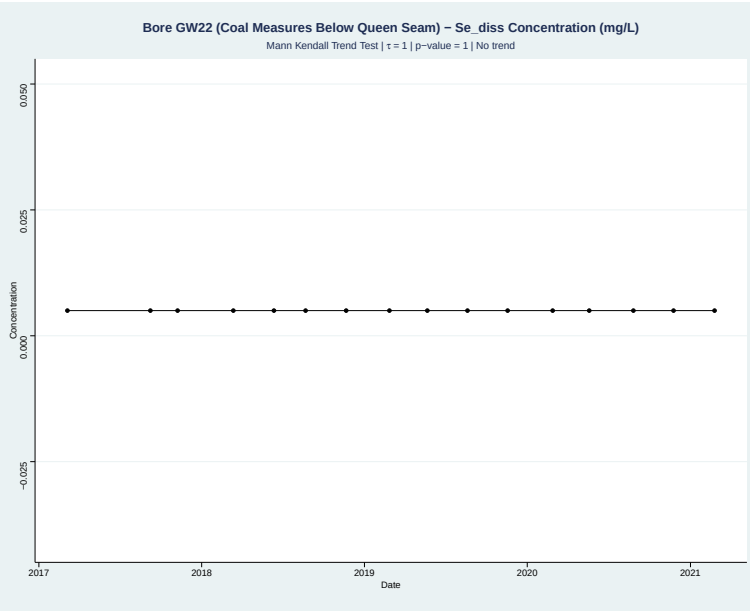




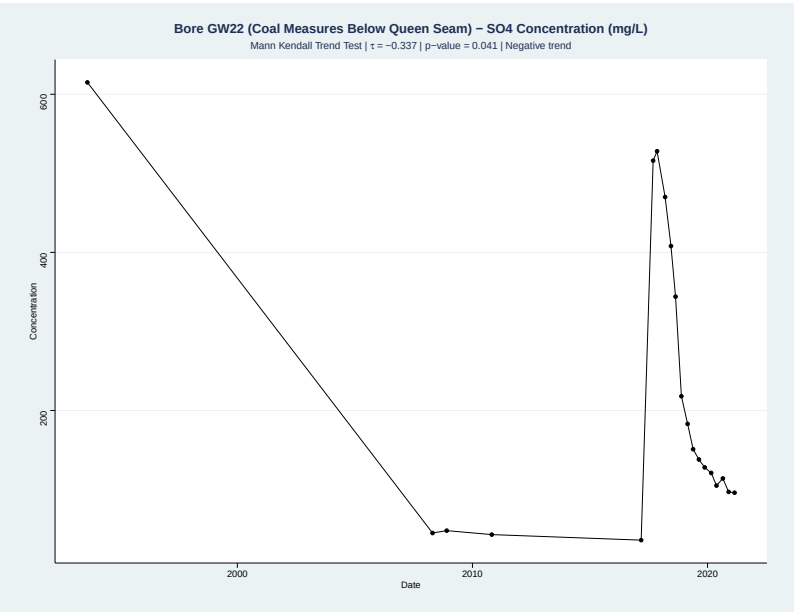


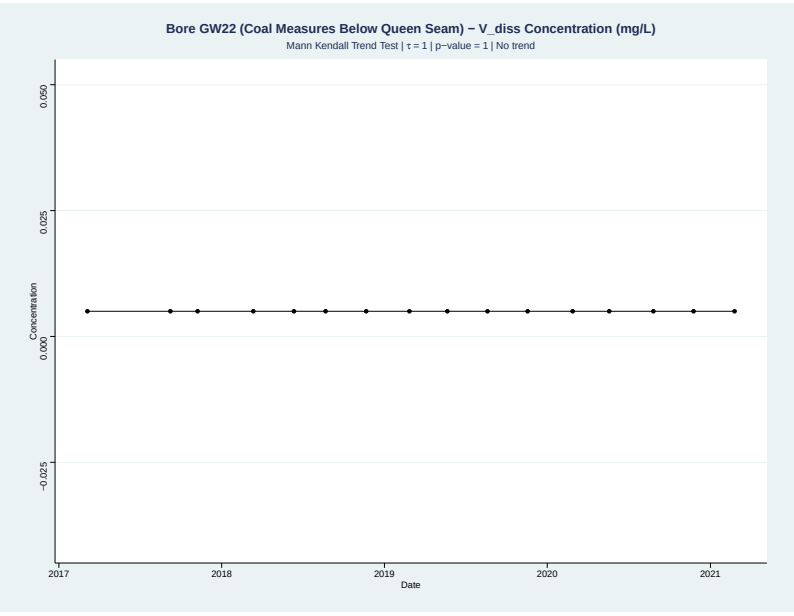


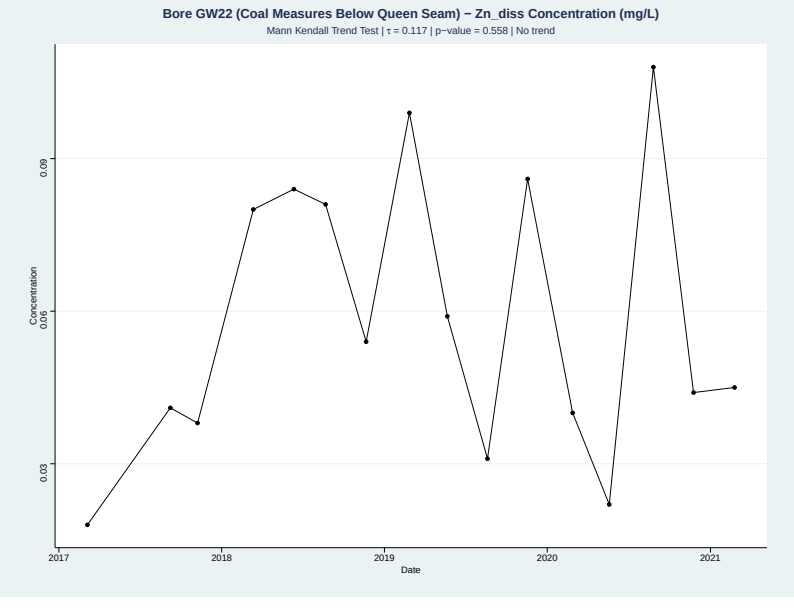


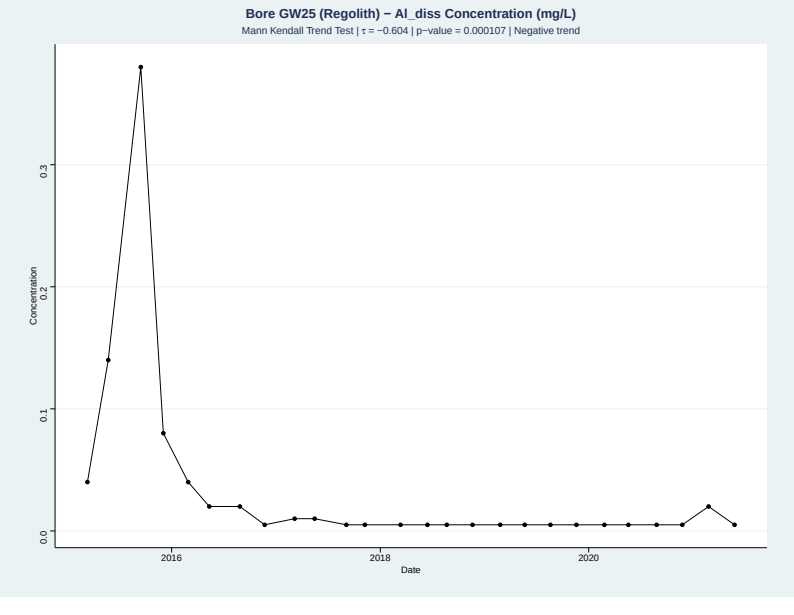


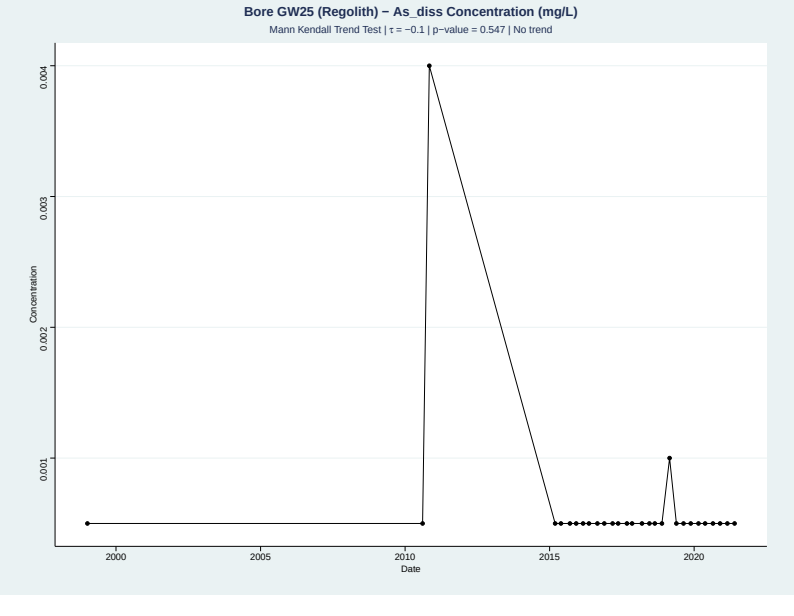
Appendix C Groundwater Quality Time Series

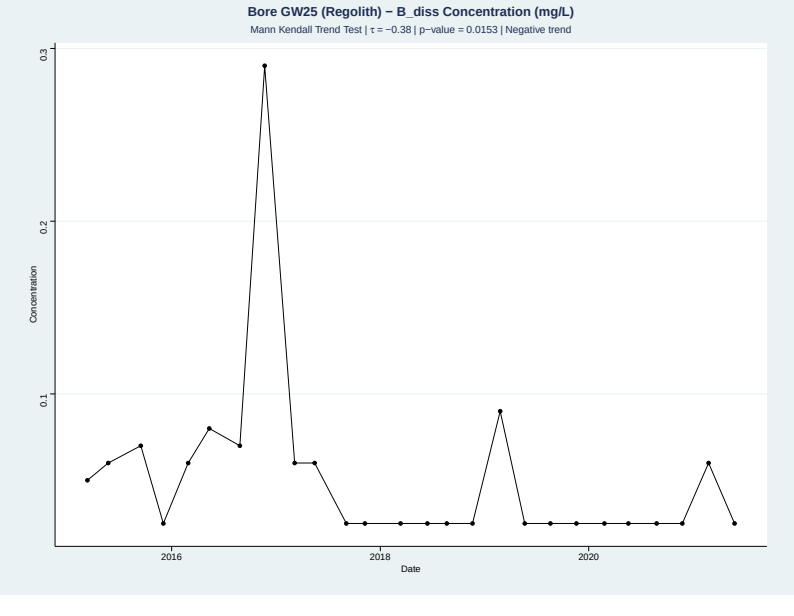




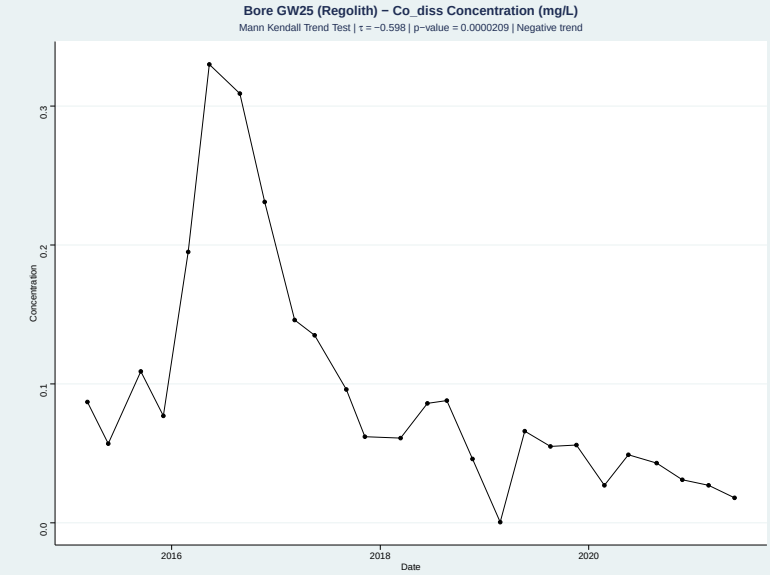


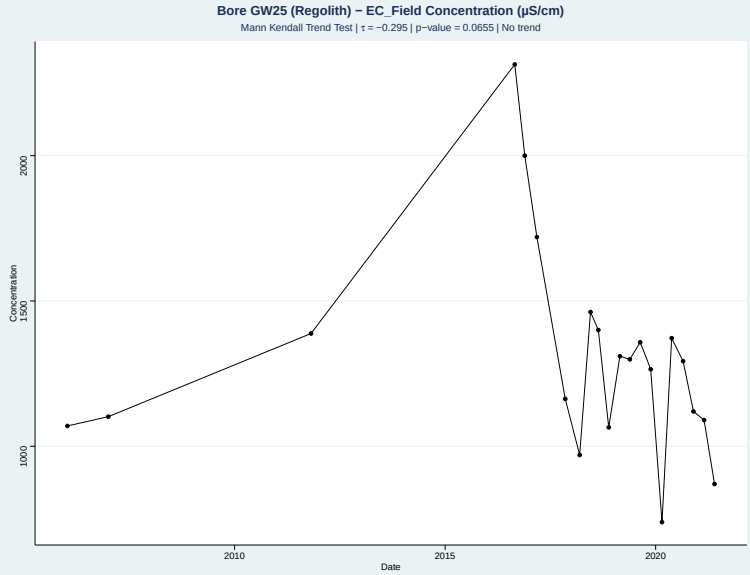


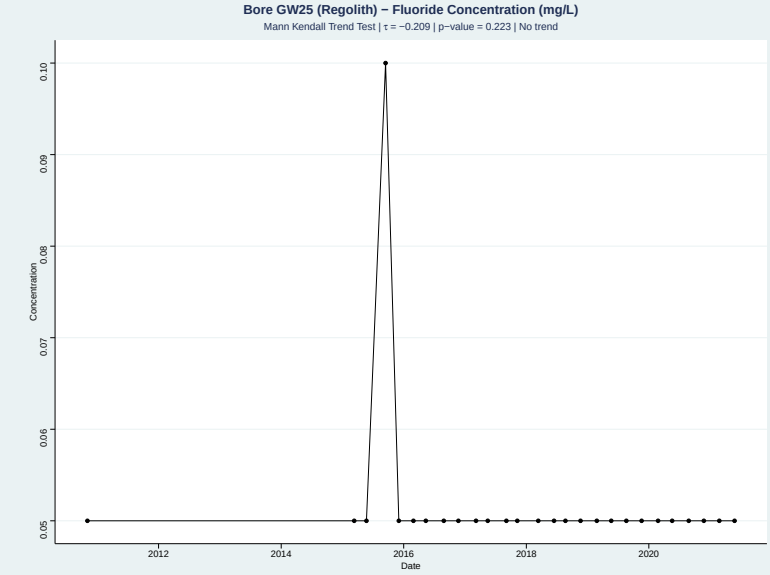


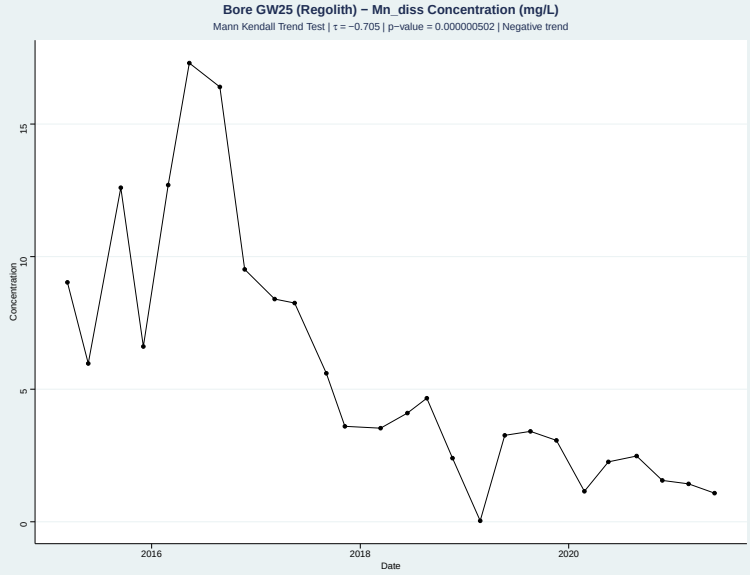


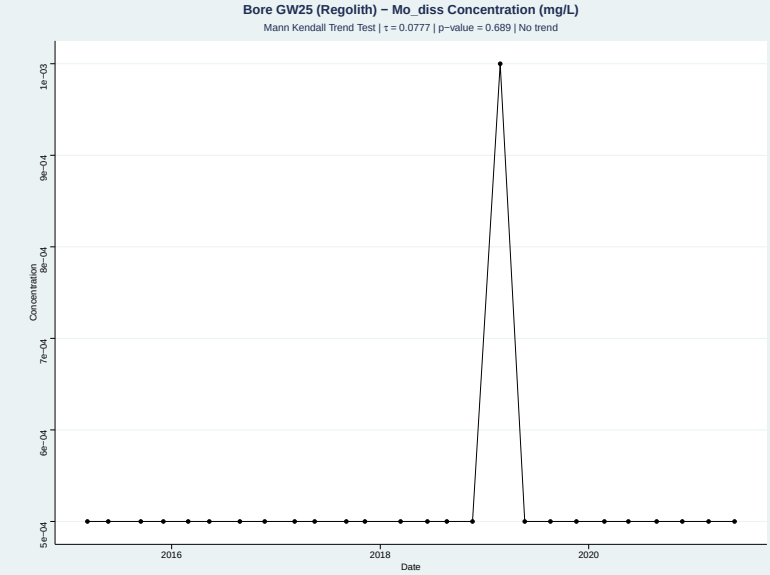
Appendix C Groundwater Quality Time Series

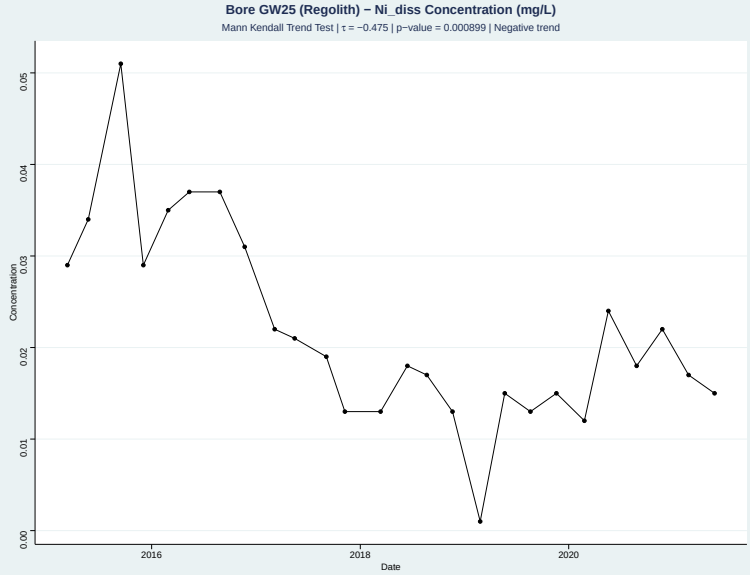




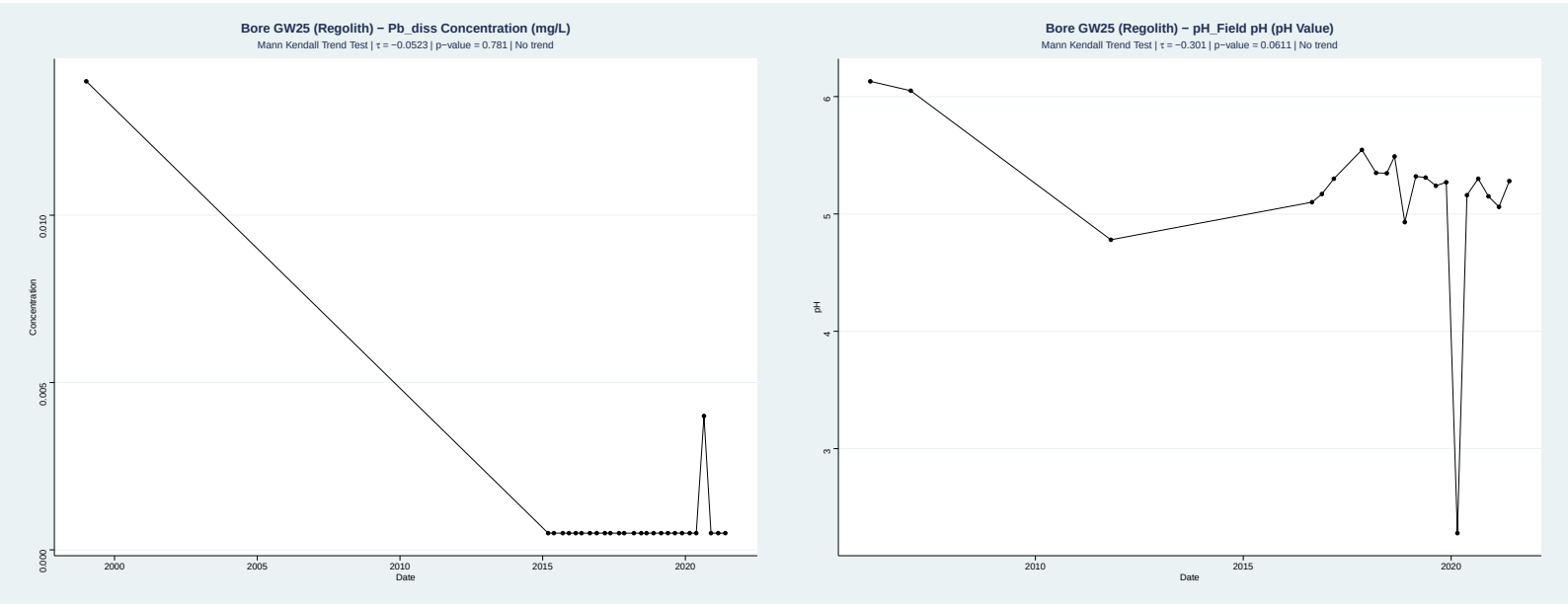


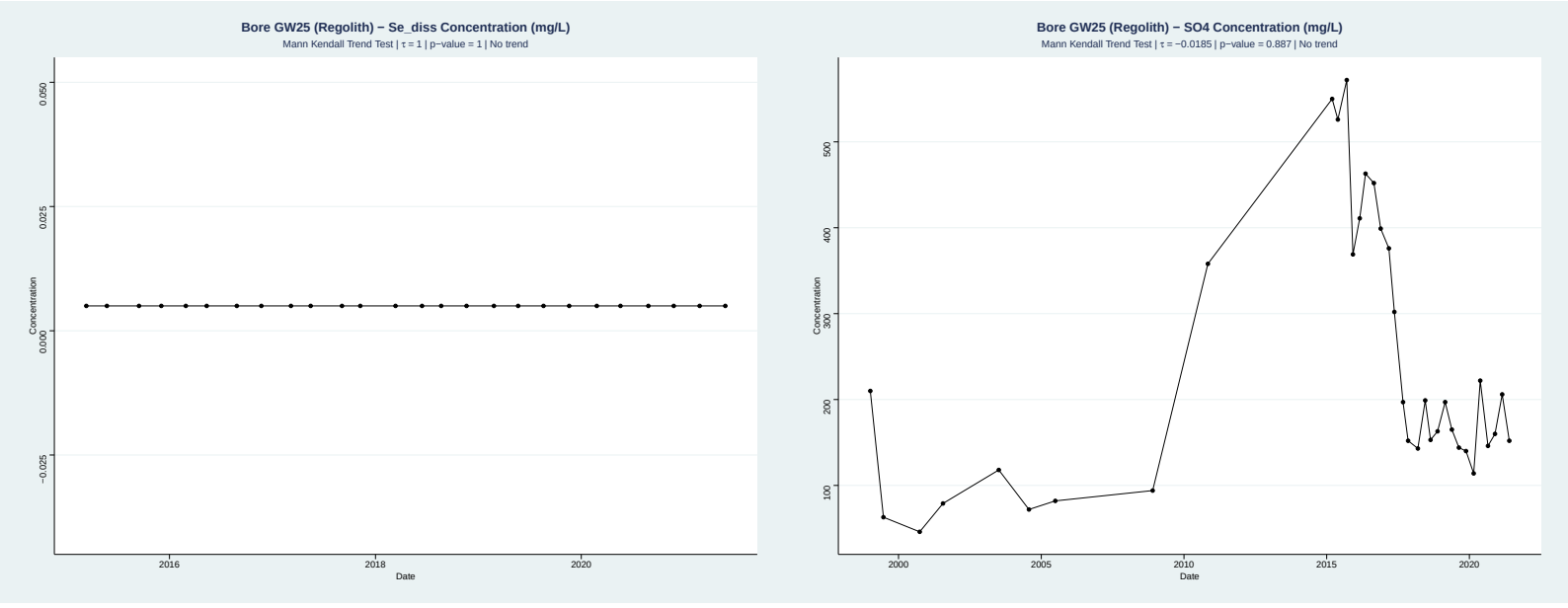


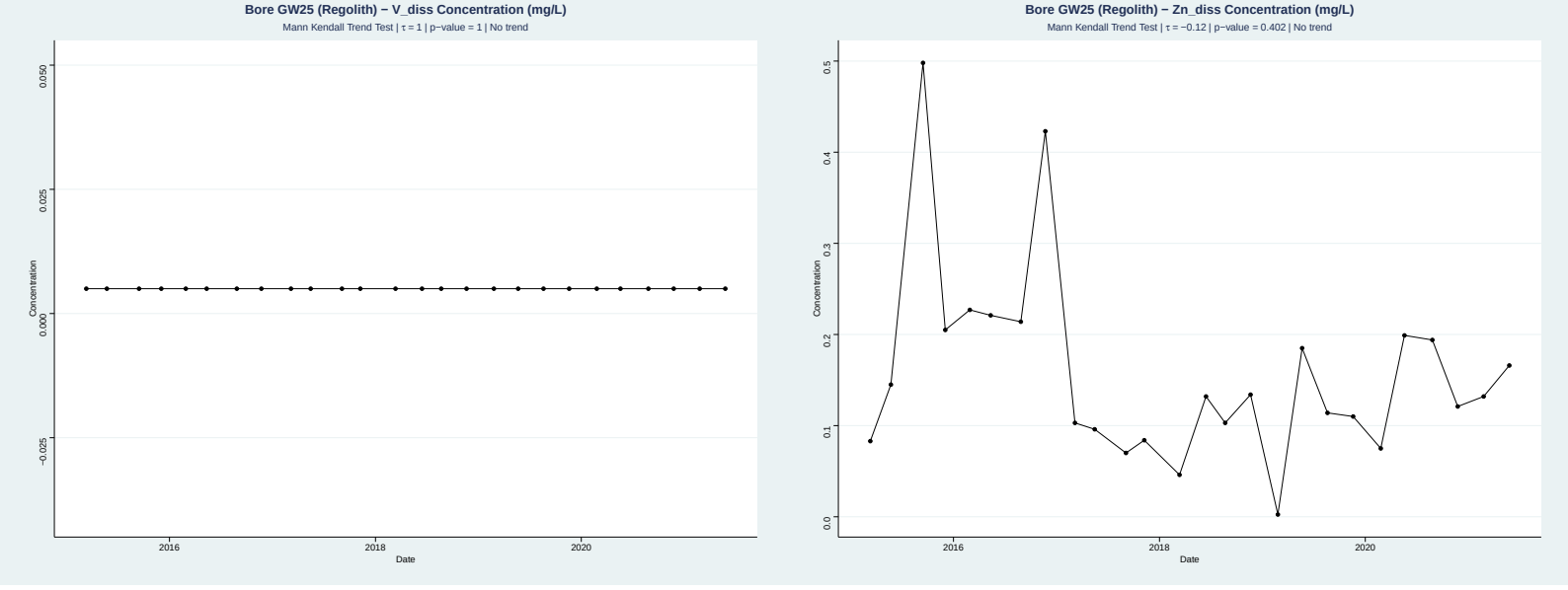




Appendix C Groundwater Quality Time Series



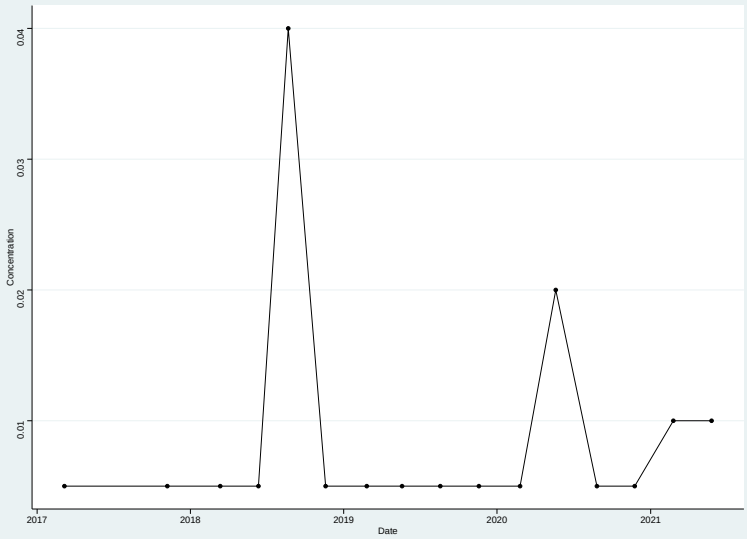




Appendix C Groundwater Quality Time Series

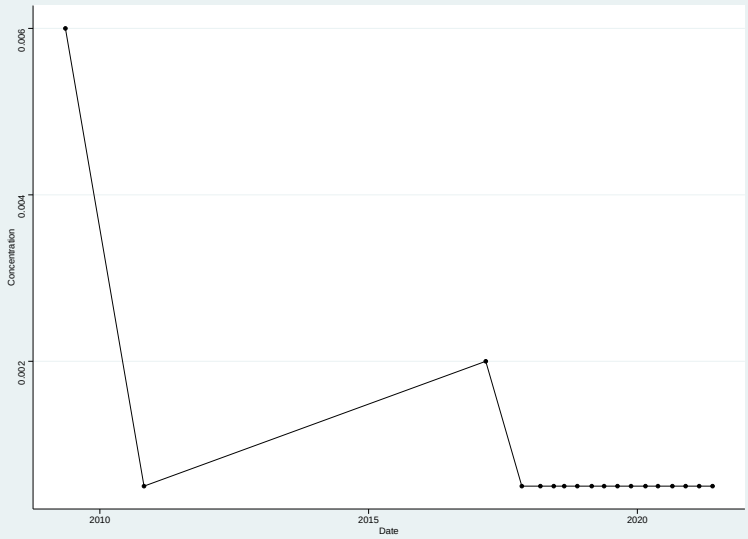
Bore GW30 (Regolith) – Al_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.288 | p−value = 0.188 | No trend



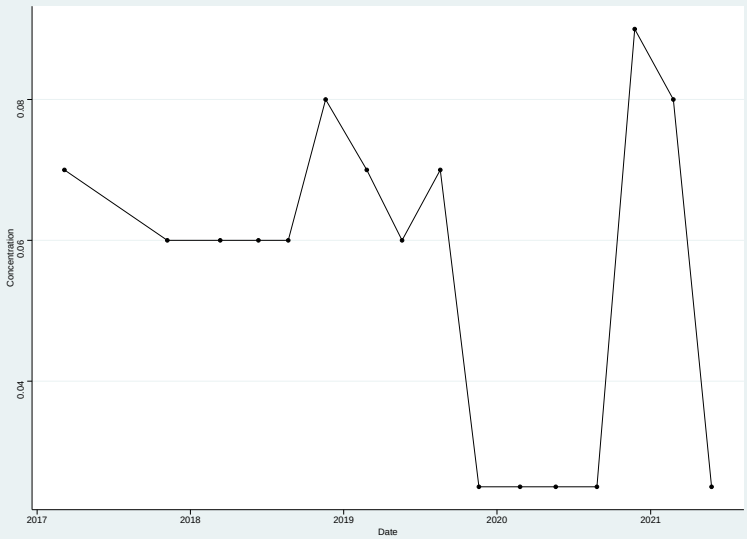
Bore GW30 (Regolith) – As_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.436 | p−value = 0.0355 | Negative trend



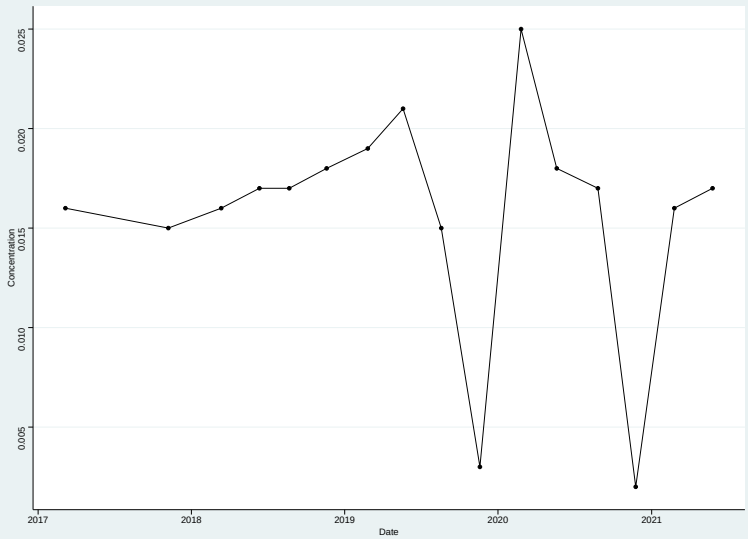
Bore GW30 (Regolith) – B_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.168 | p−value = 0.426 | No trend



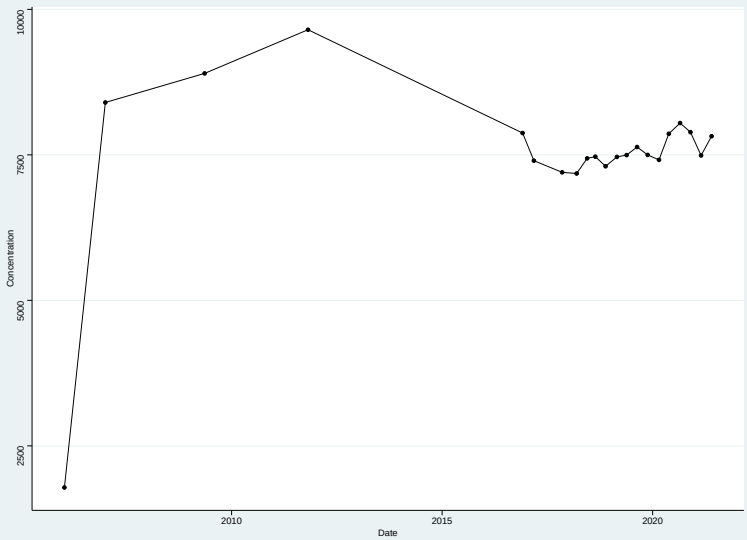
Bore GW30 (Regolith) – Co_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.0612 | p−value = 0.784 | No trend



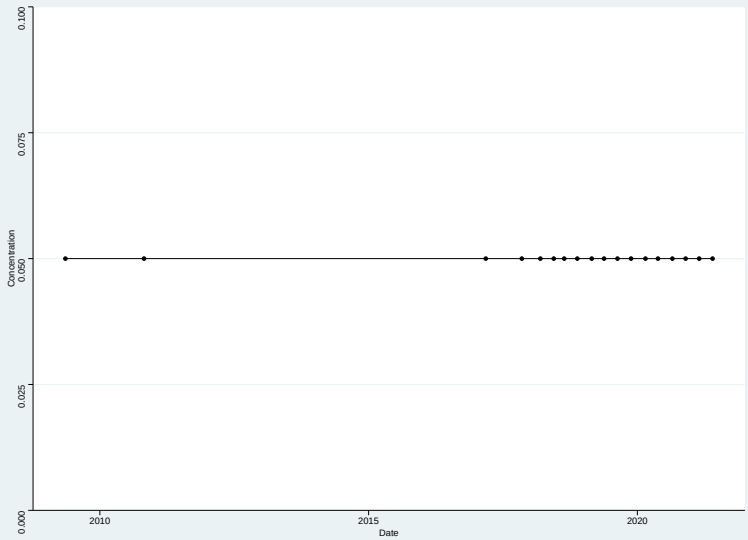
Bore GW30 (Regolith) – EC_Field Concentration (µS/cm)

Mann Kendall Trend Test | τ = 0.152 | p−value = 0.349 | No trend

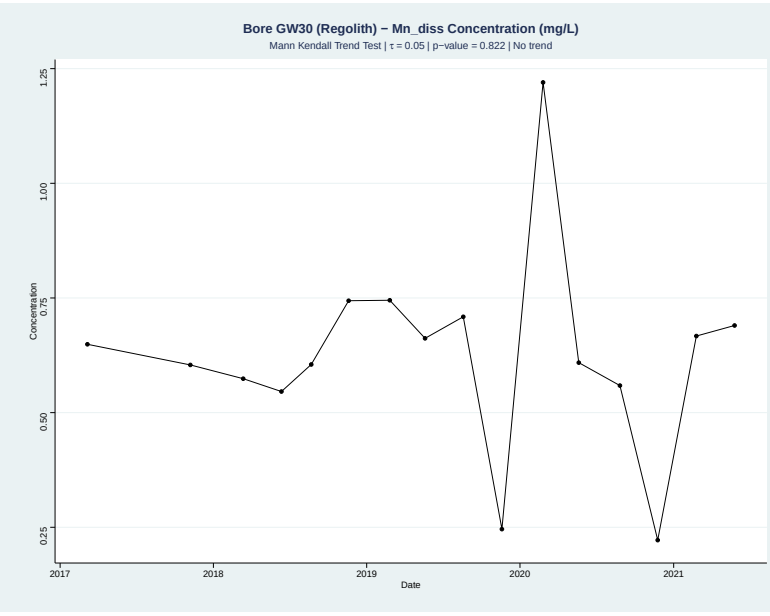


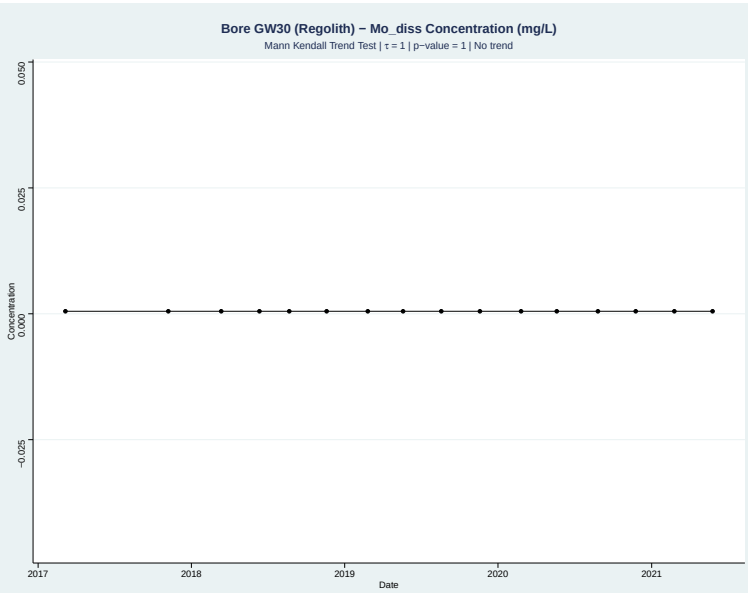
Bore GW30 (Regolith) – Fluoride Concentration (mg/L)

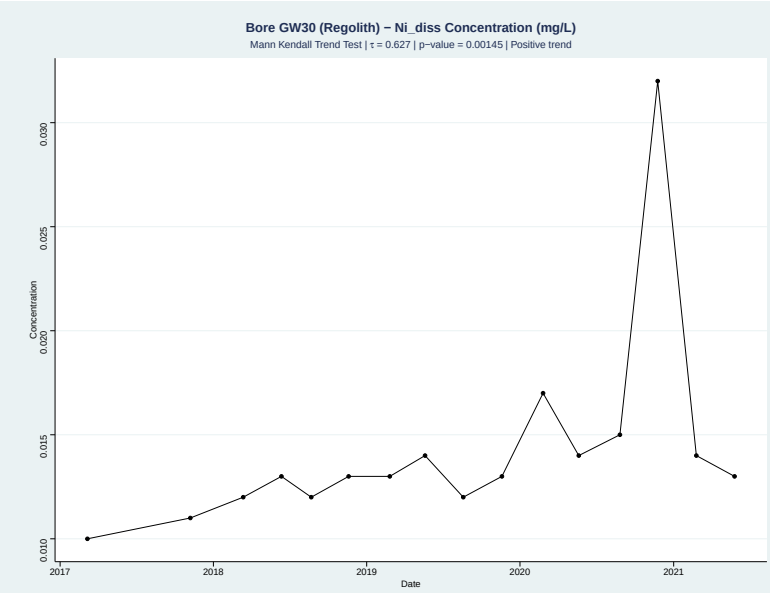
Mann Kendall Trend Test | τ = 1 | p−value = 1 | No trend

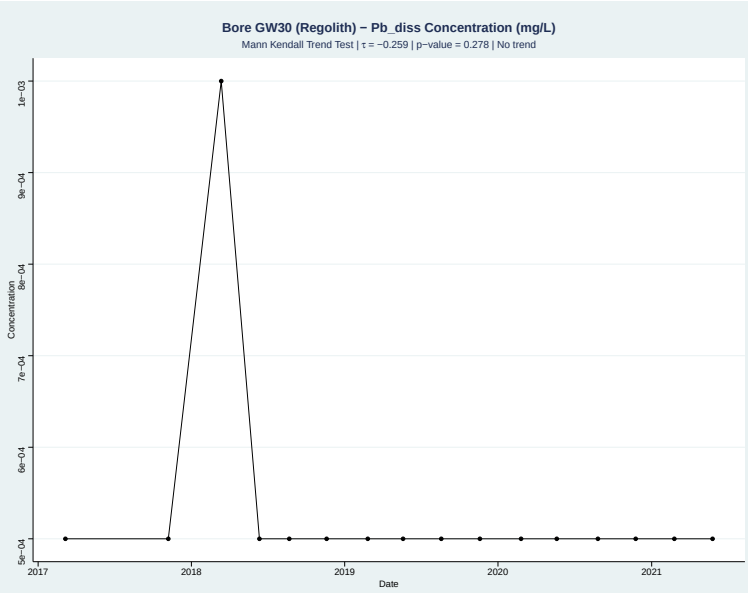


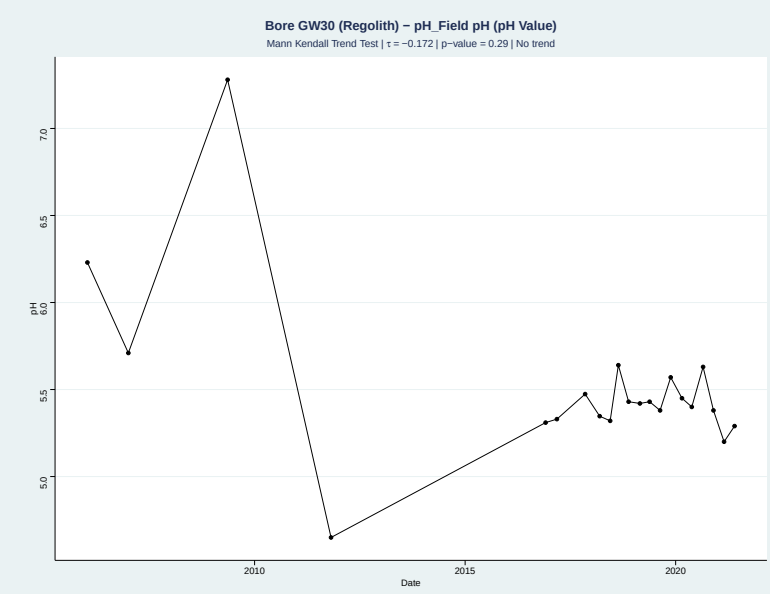
Appendix C Groundwater Quality Time Series

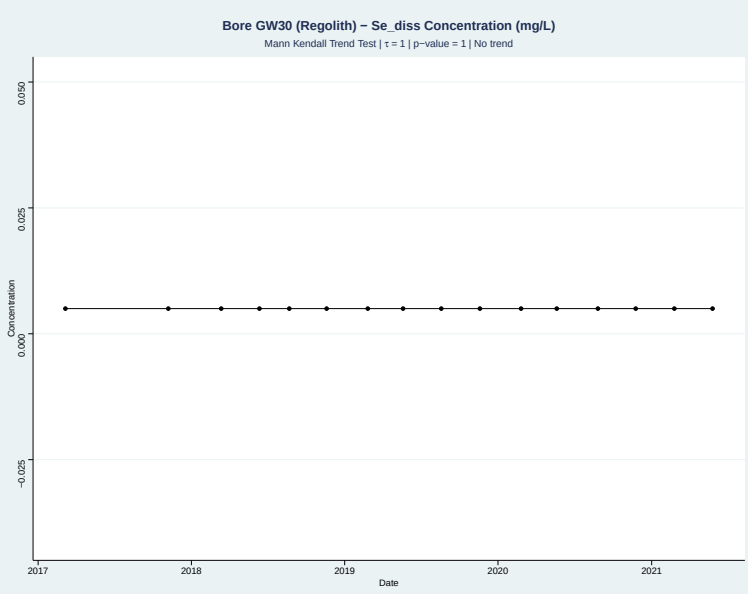




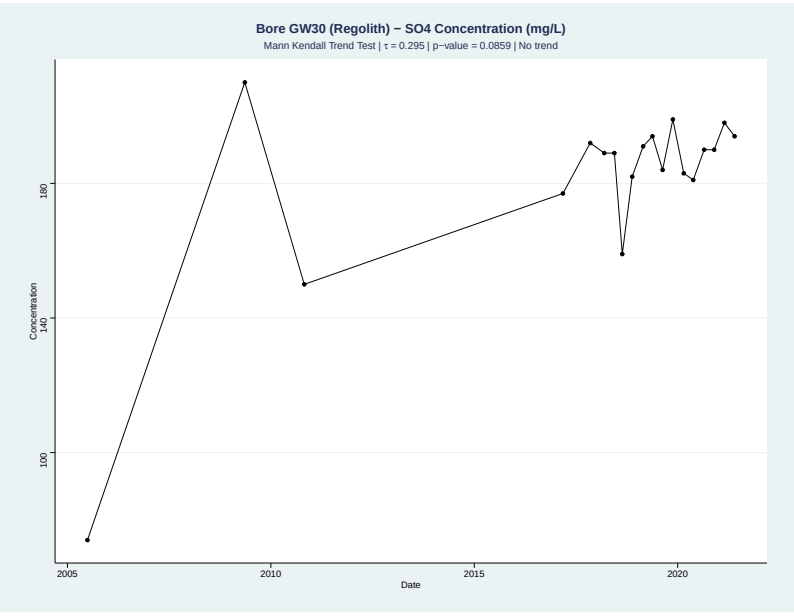


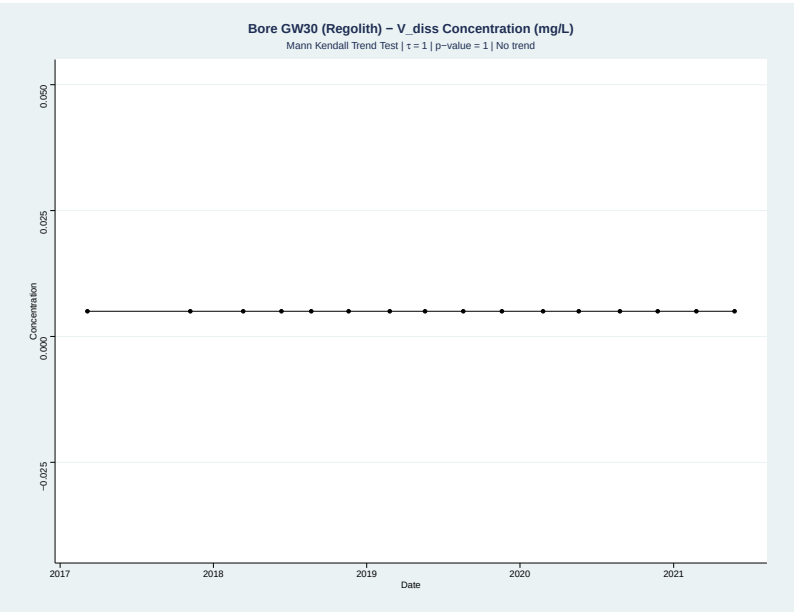


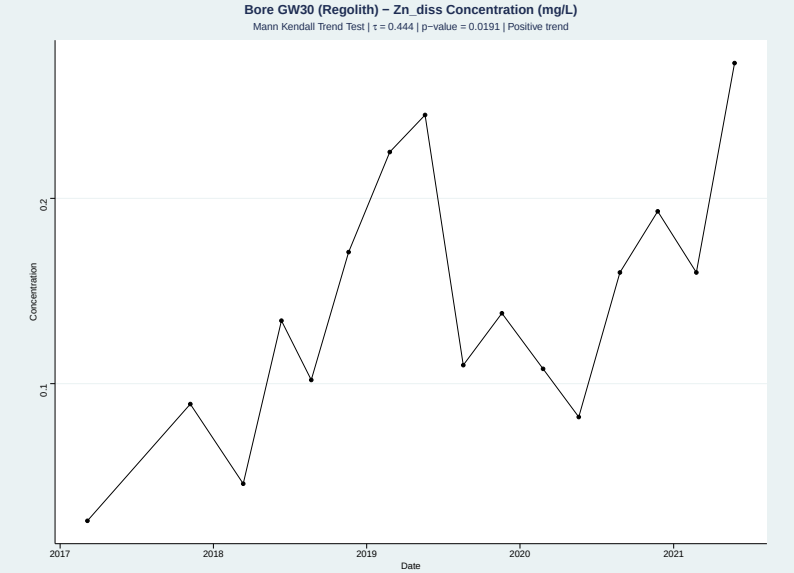


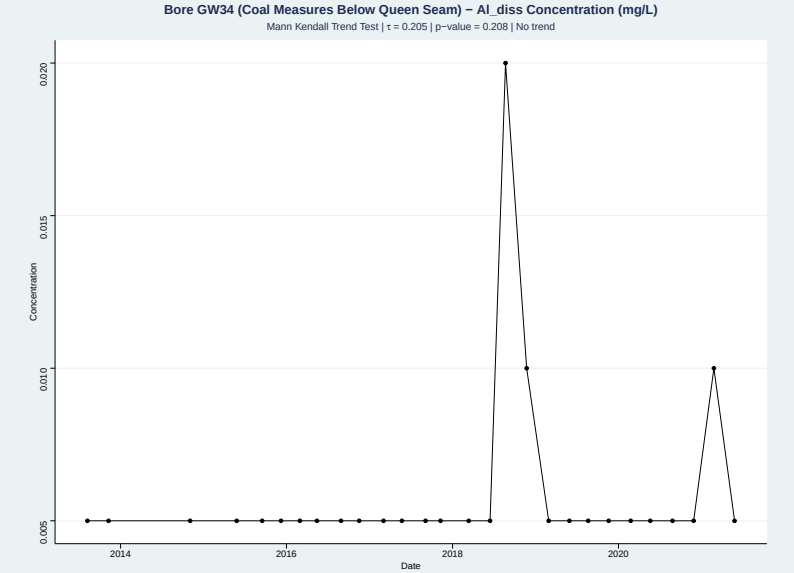


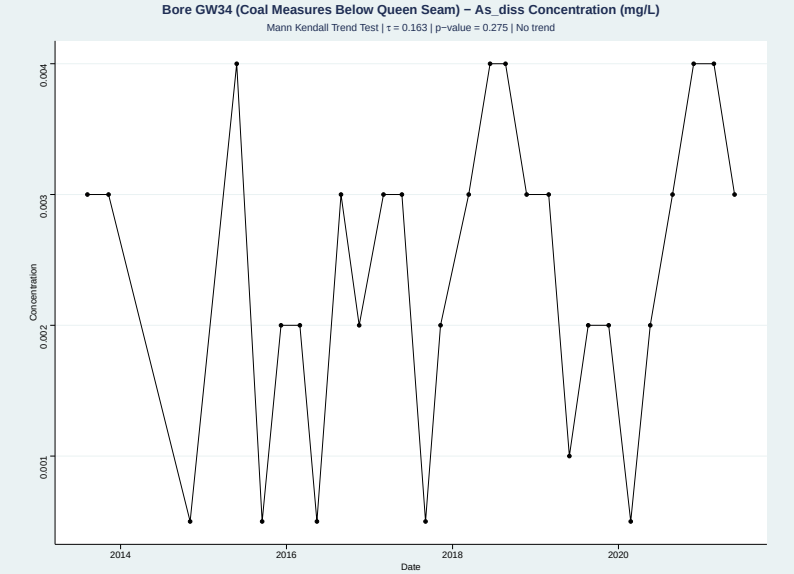
Appendix C Groundwater Quality Time Series

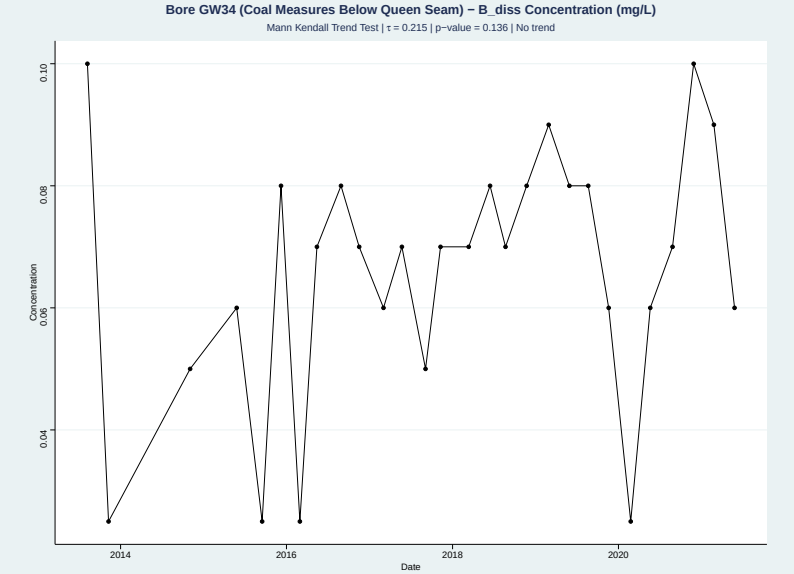




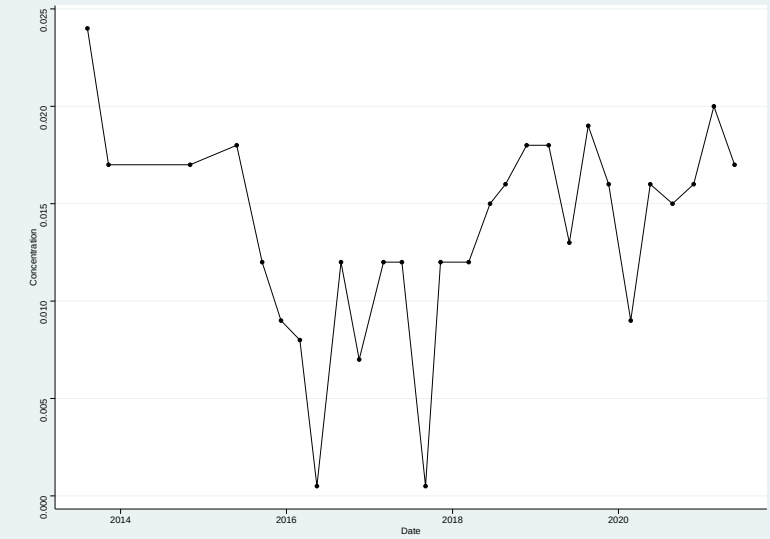


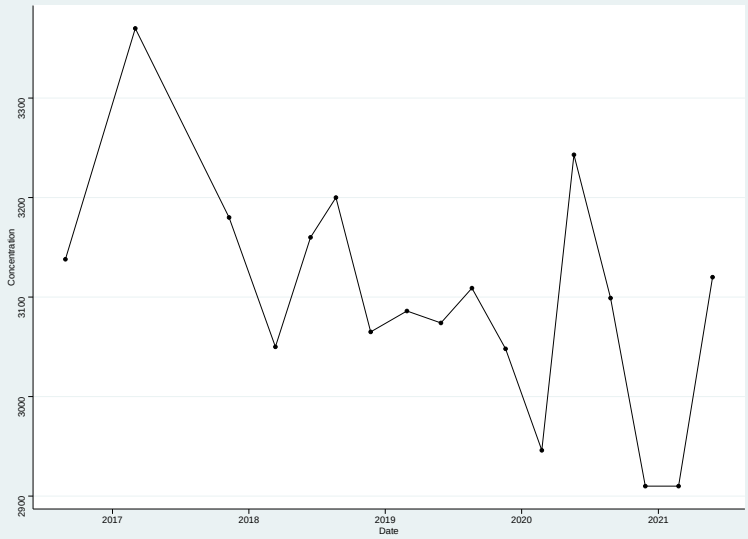


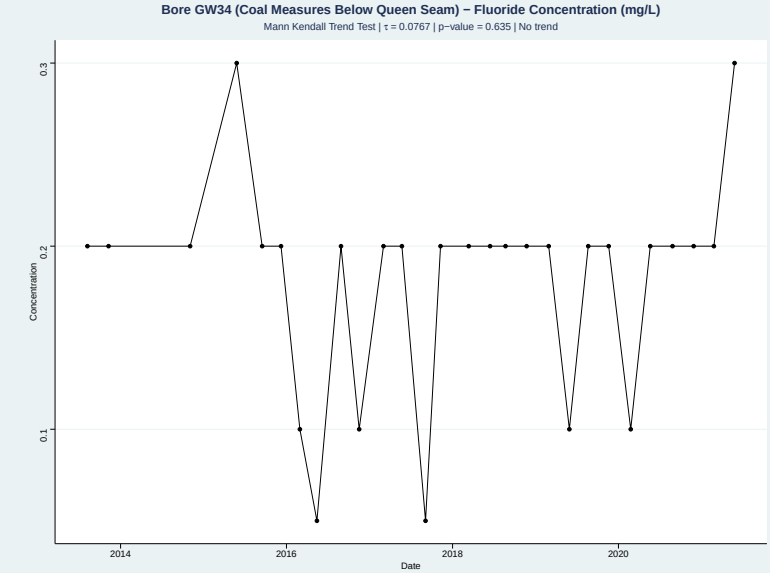


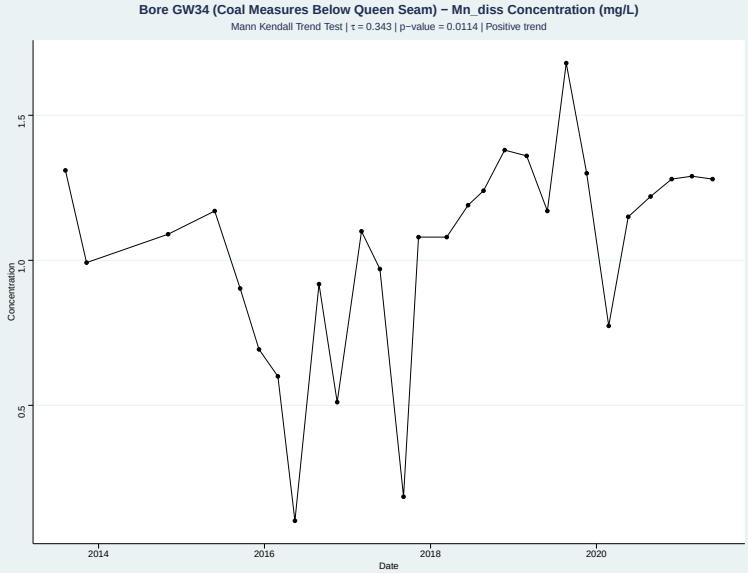


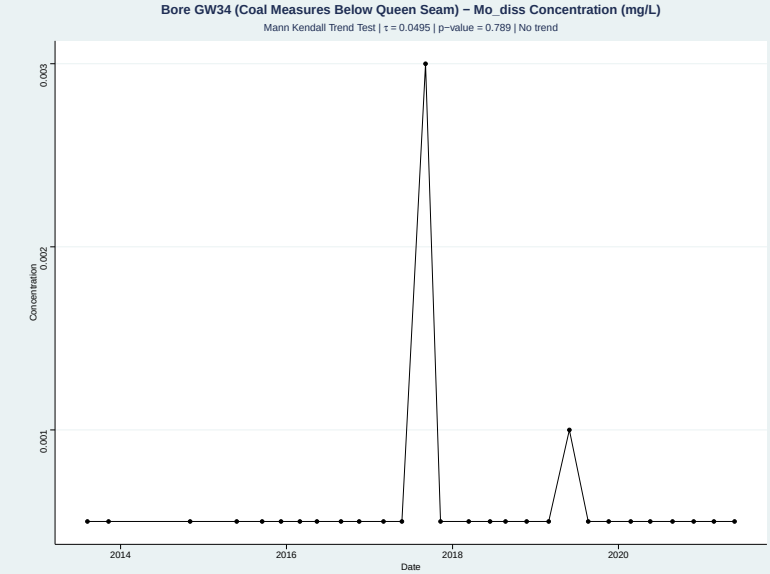
Appendix C Groundwater Quality Time Series

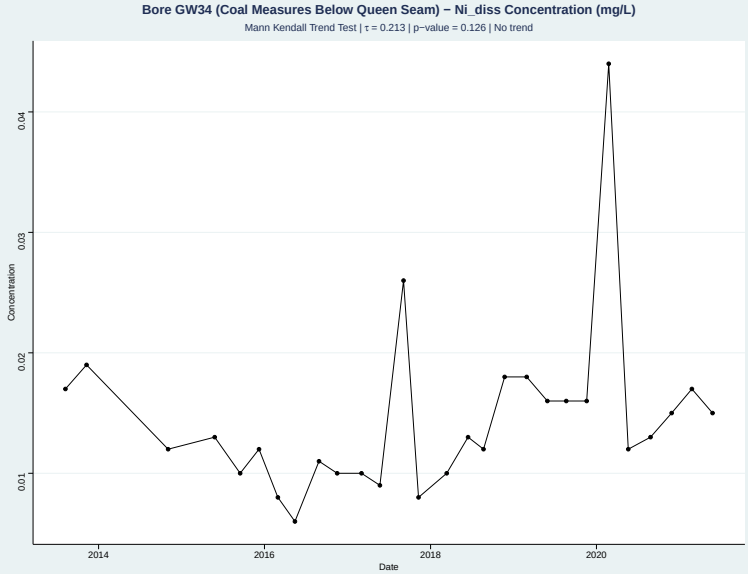




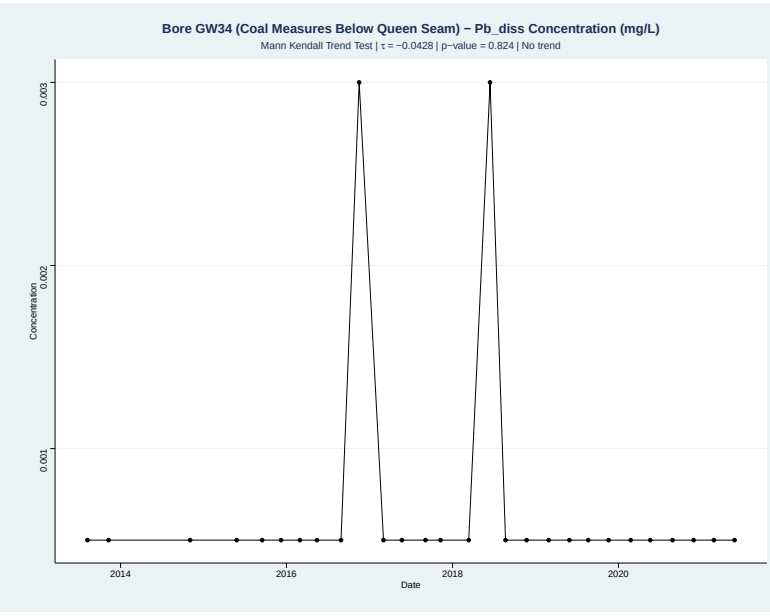


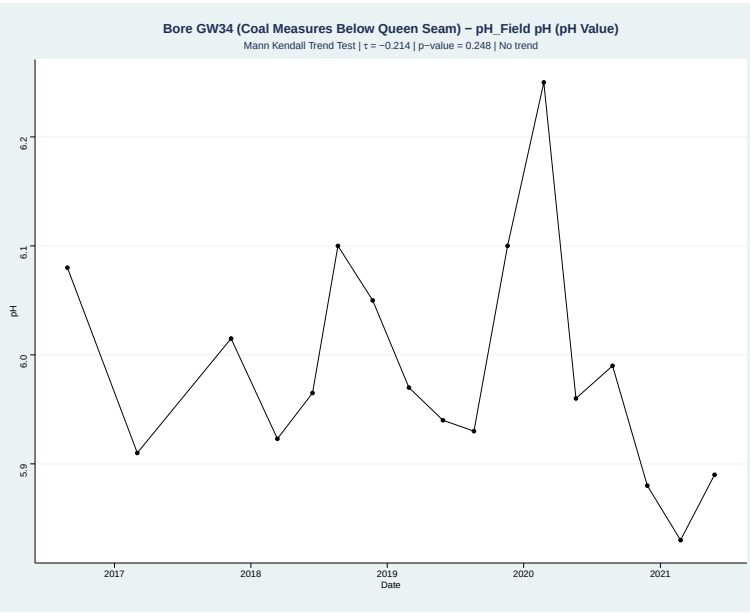


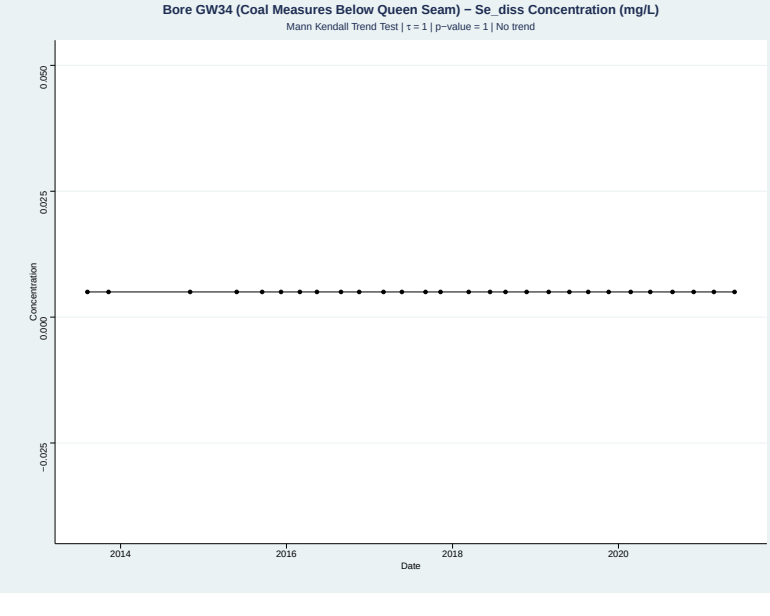


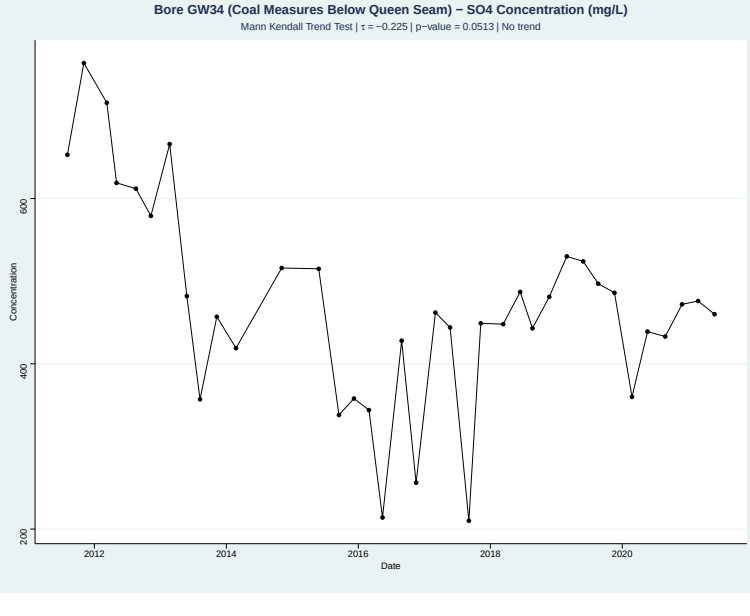


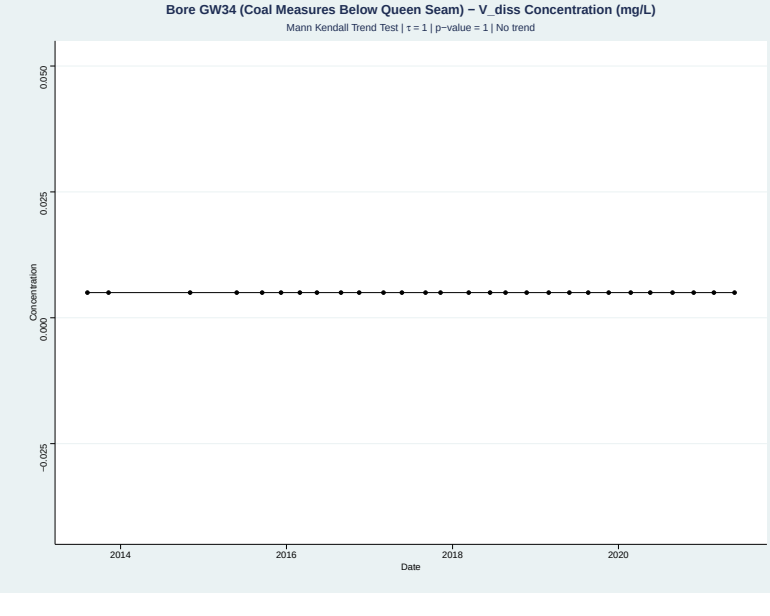
Appendix C Groundwater Quality Time Series

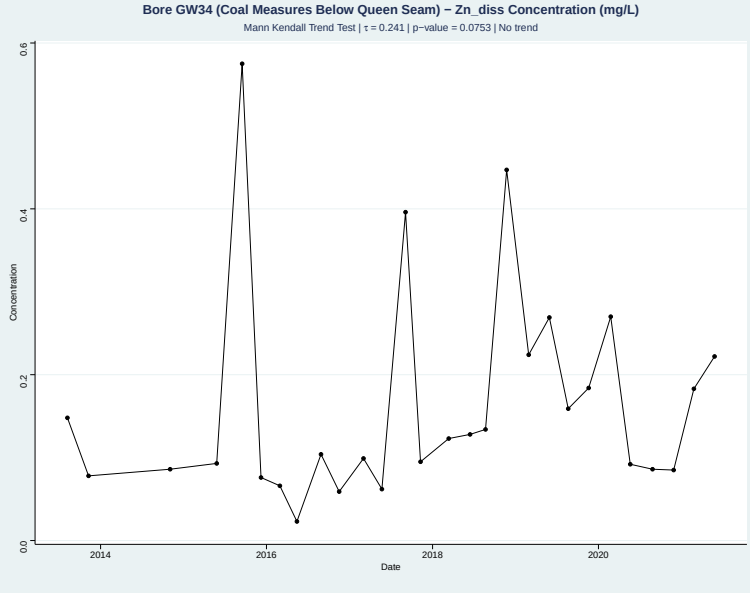




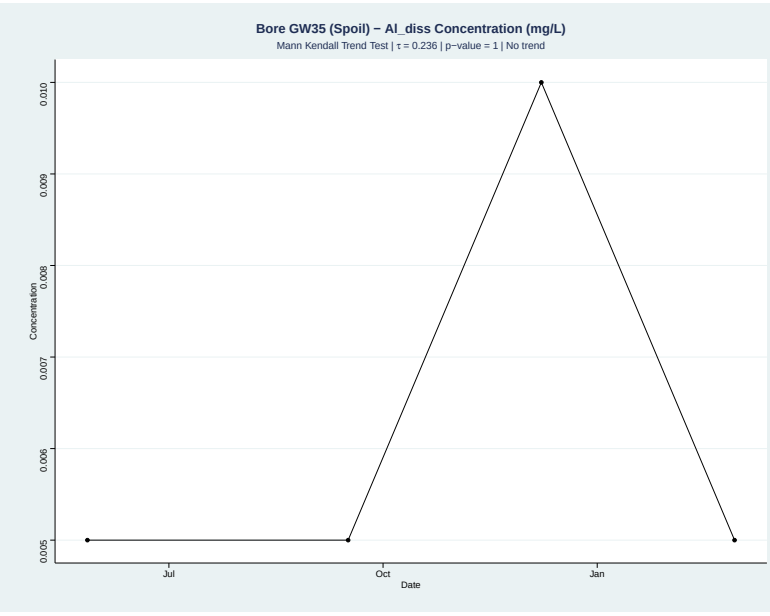


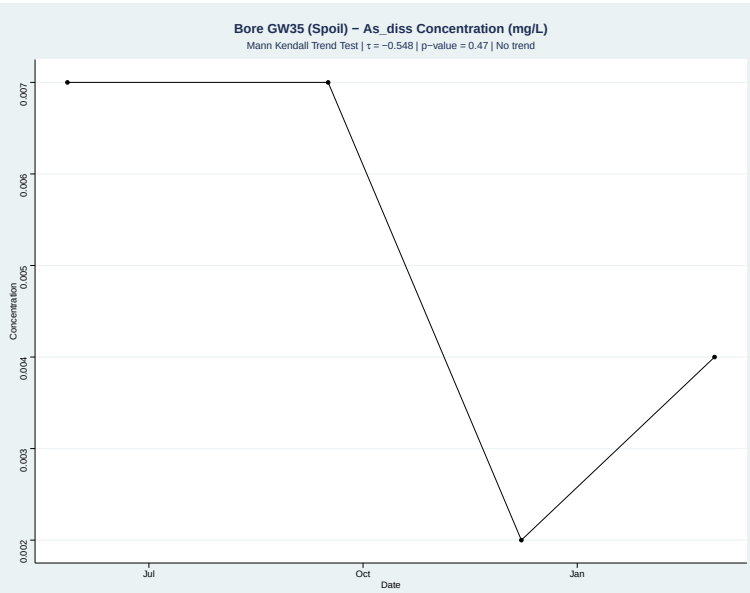


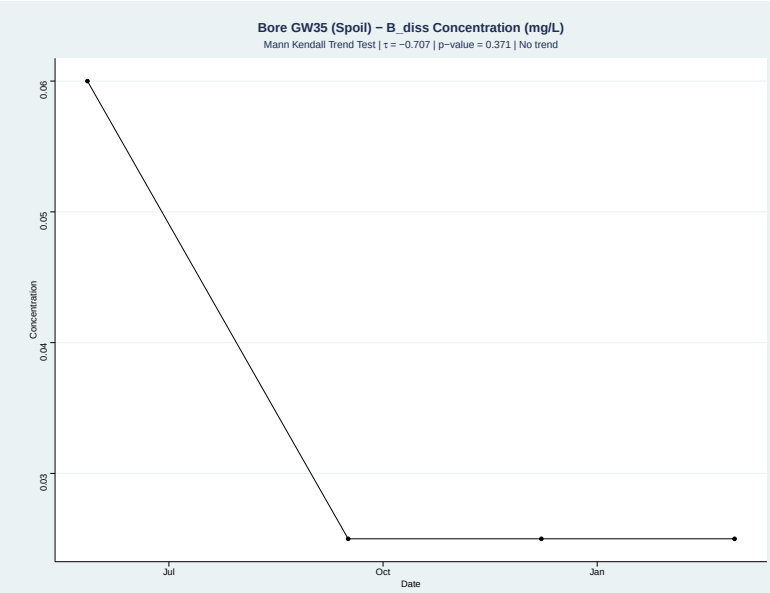


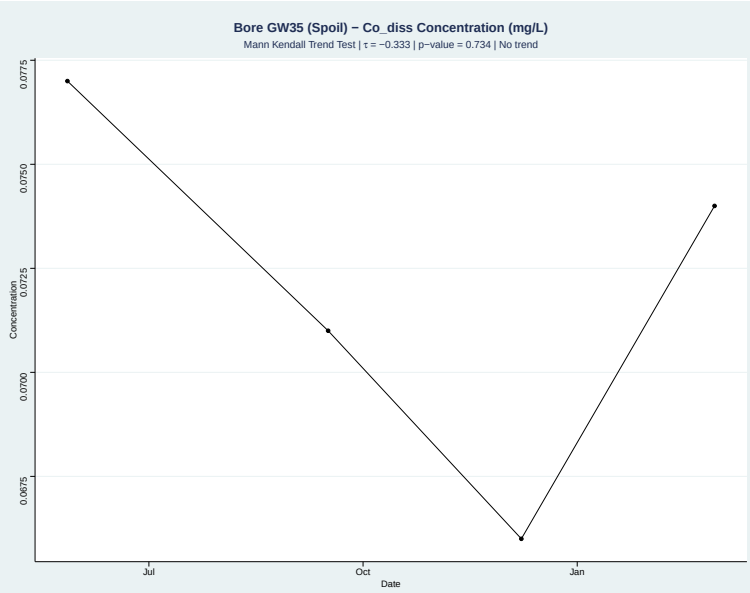


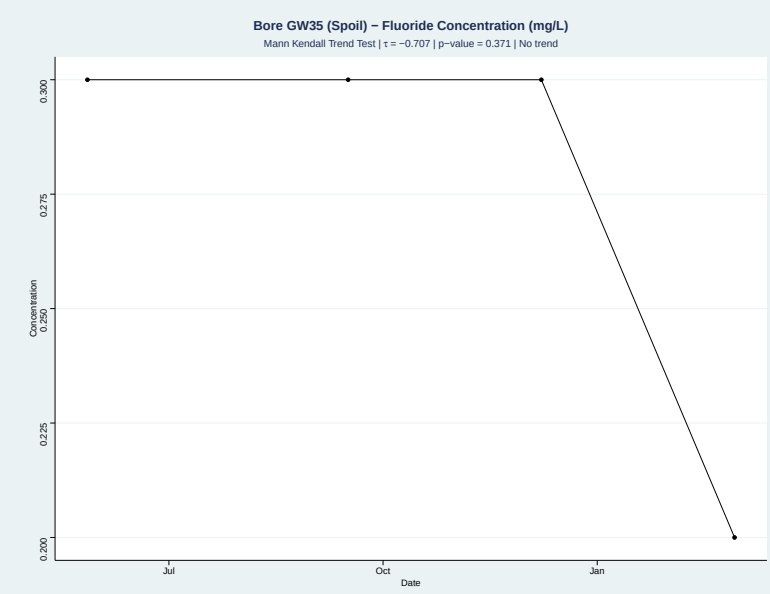
Appendix C Groundwater Quality Time Series

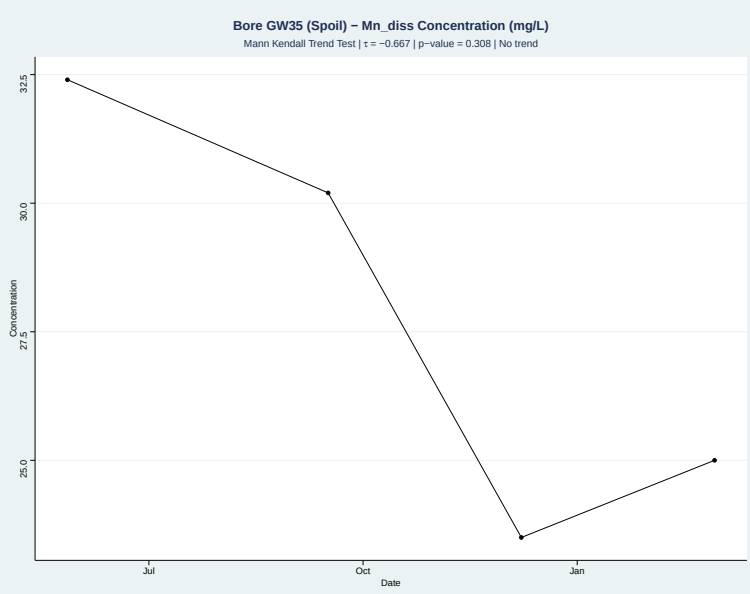




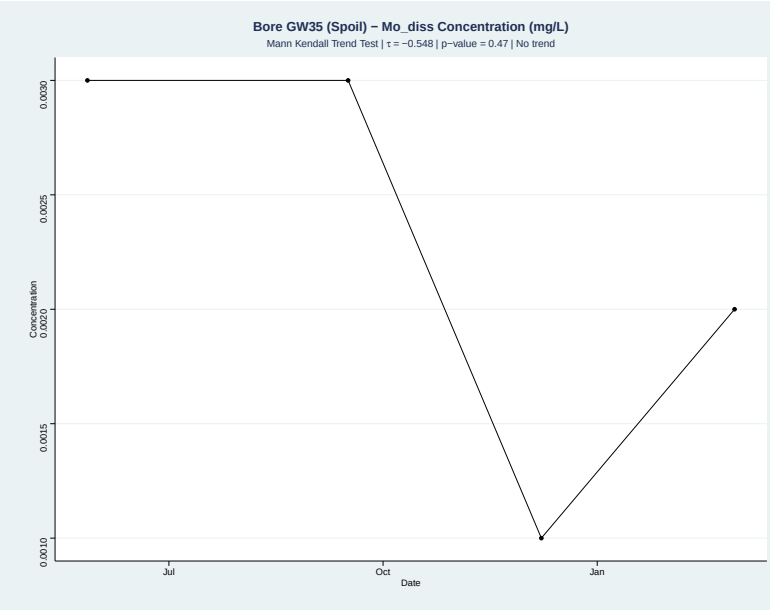


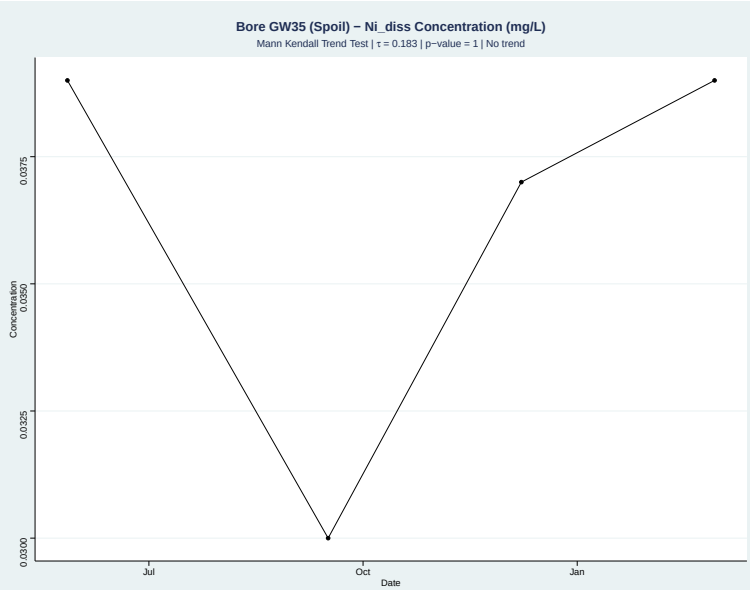


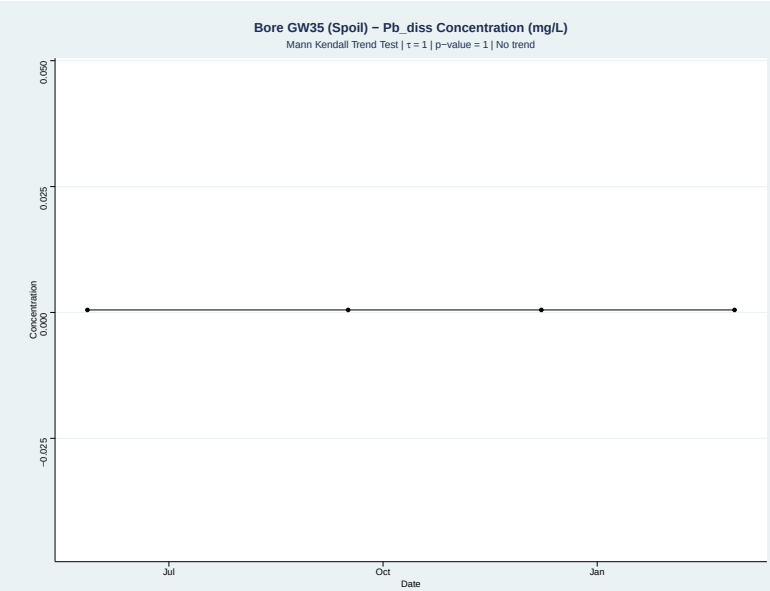


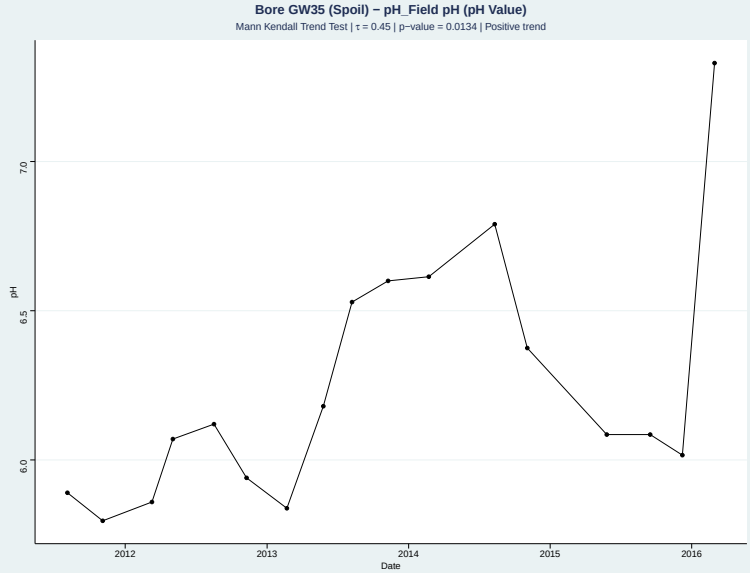


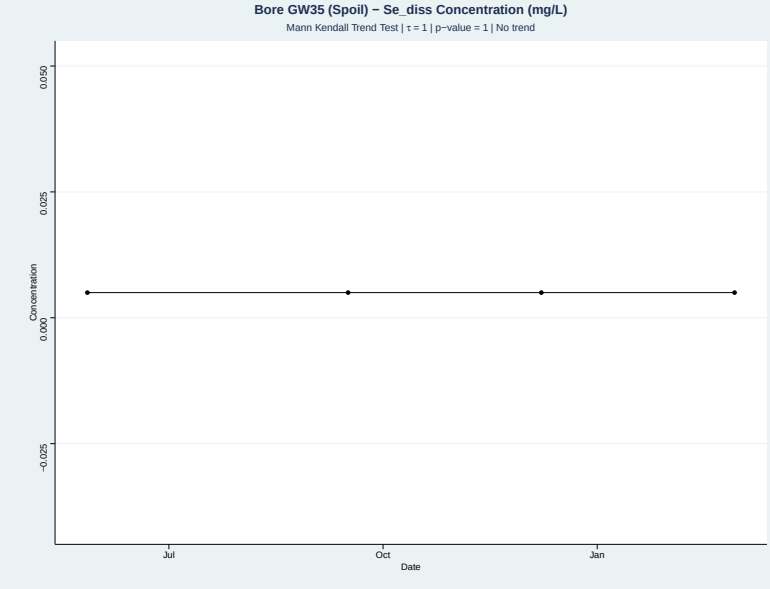
Appendix C Groundwater Quality Time Series

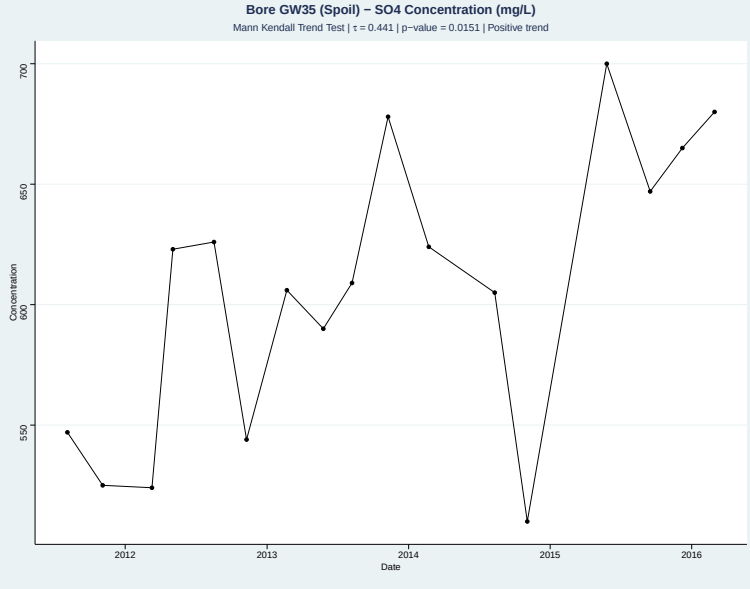












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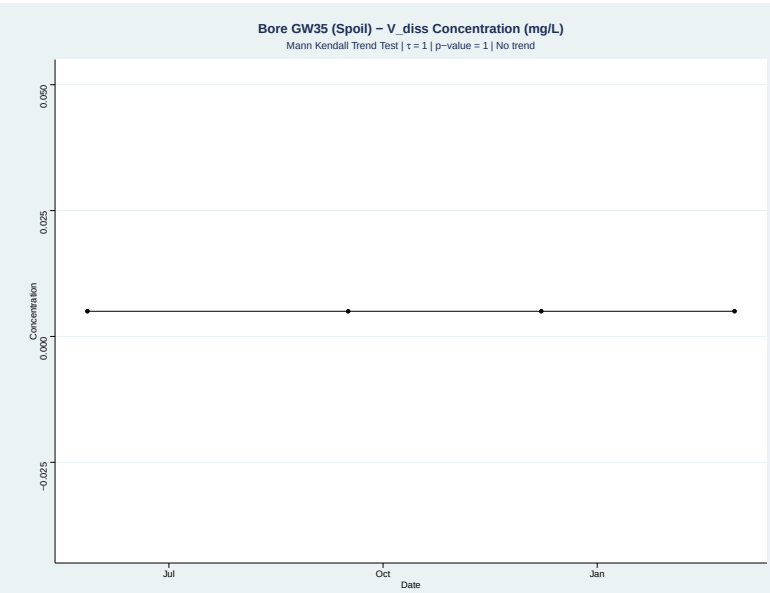
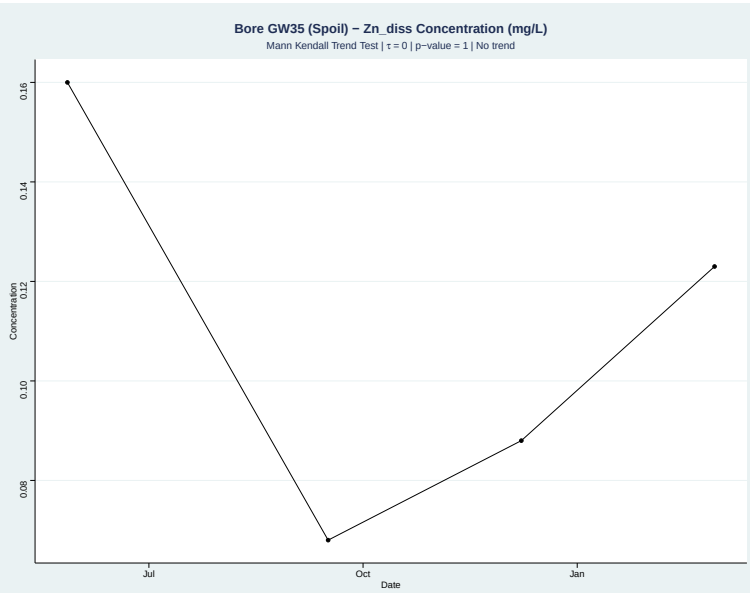
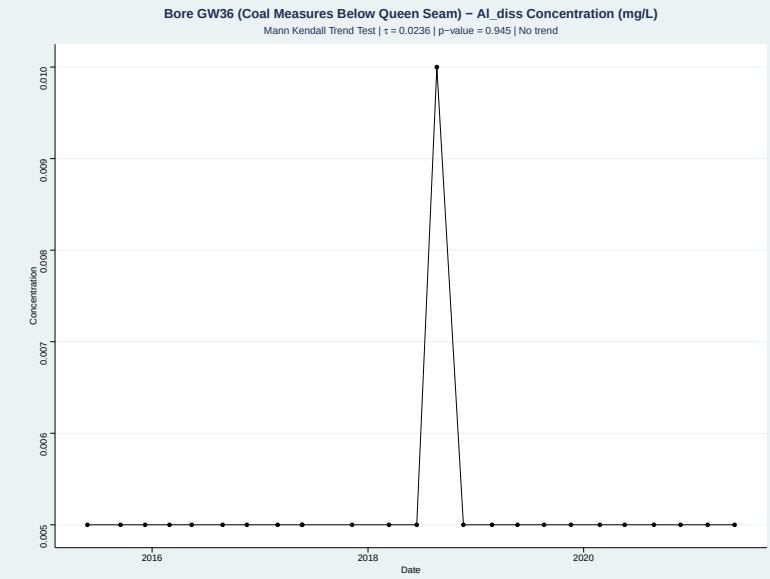
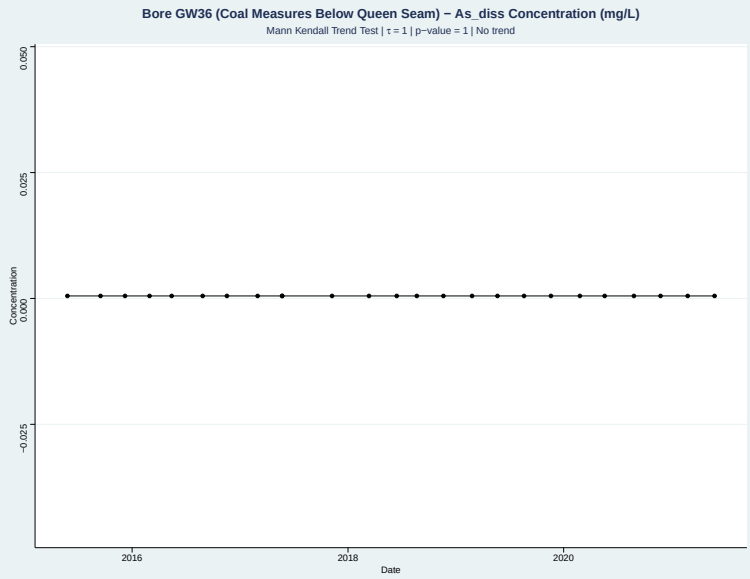
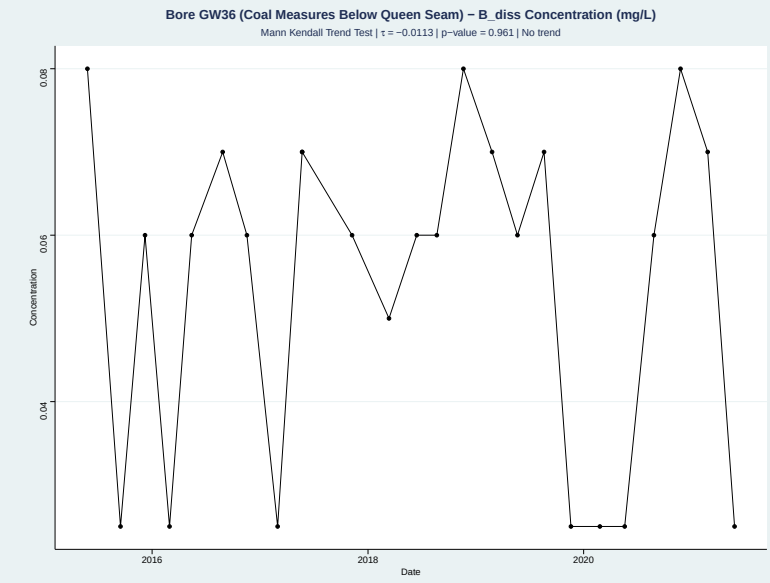
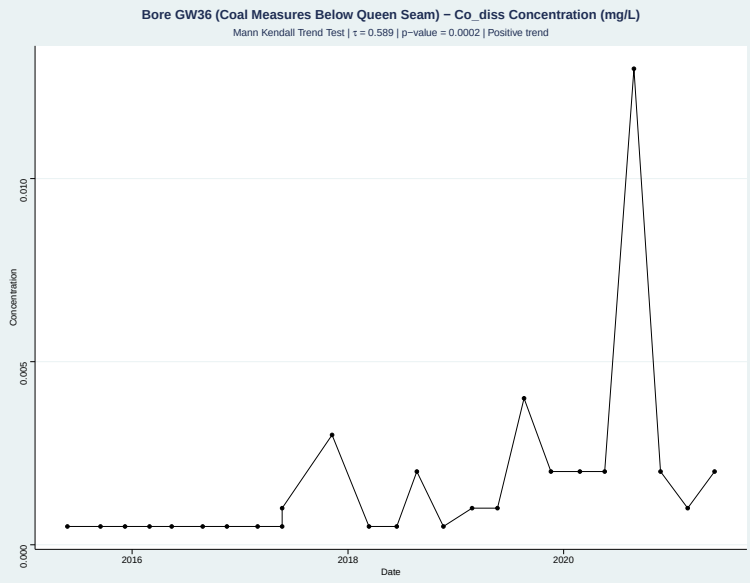




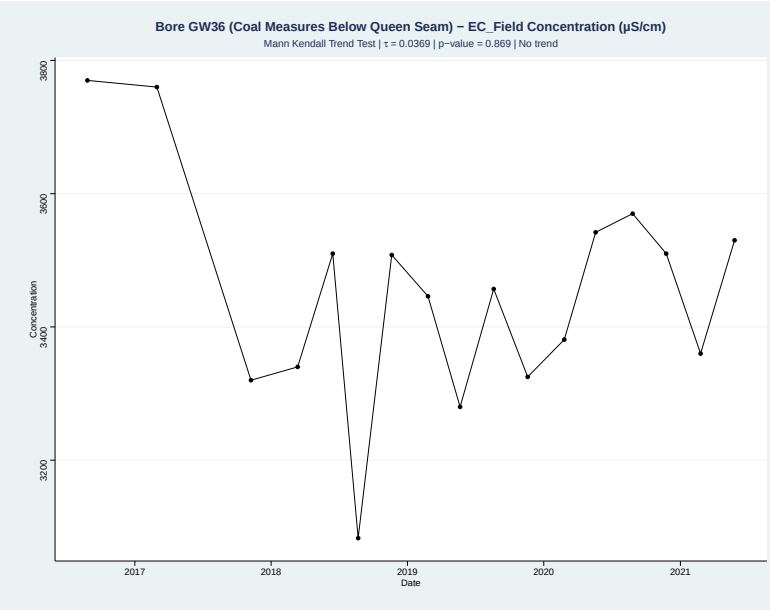


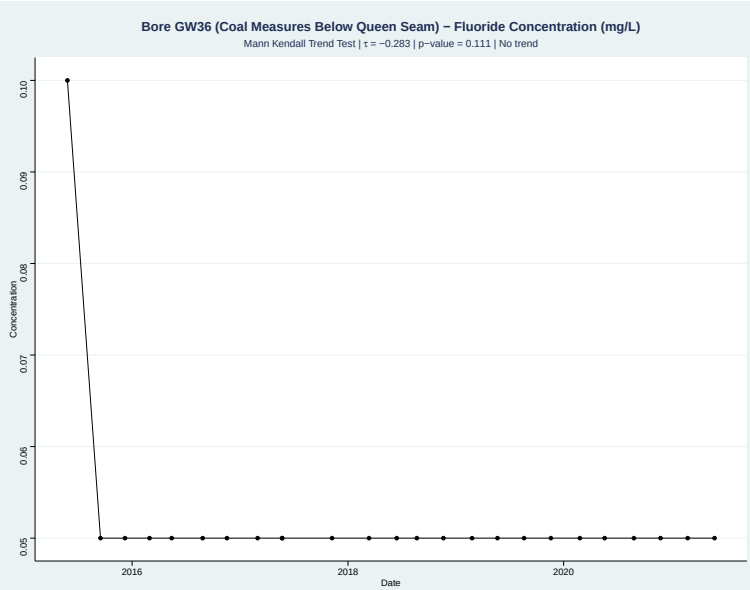


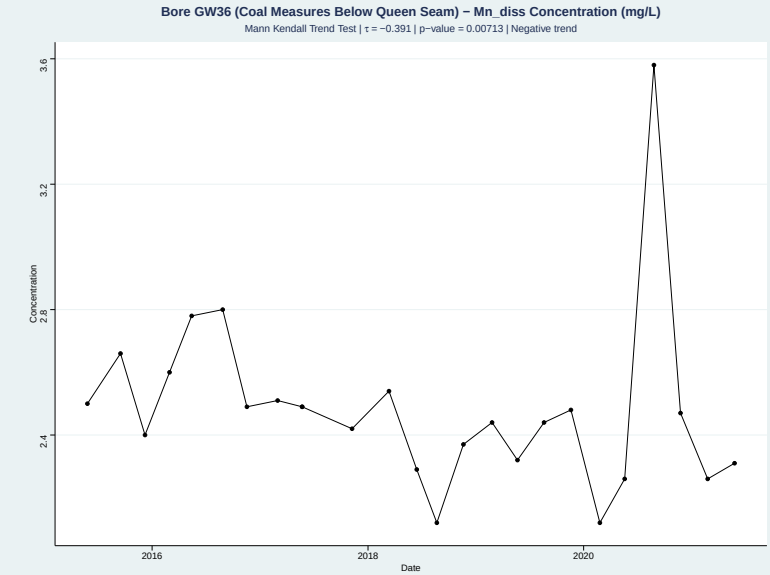


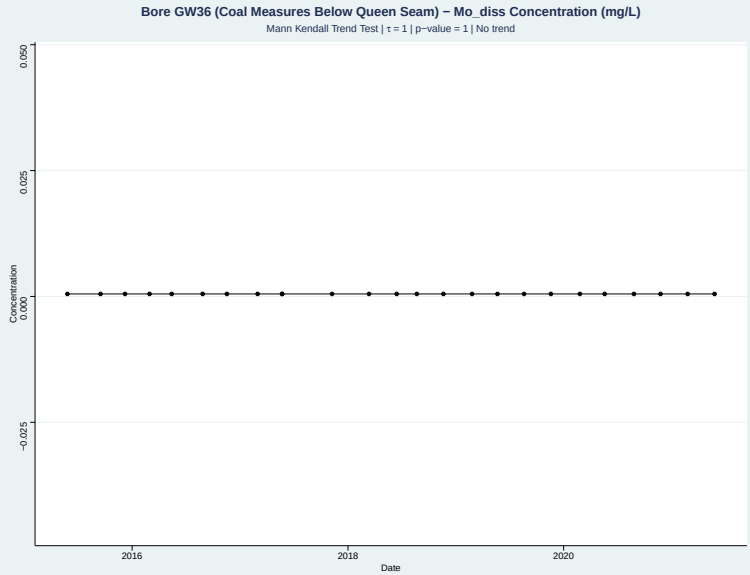


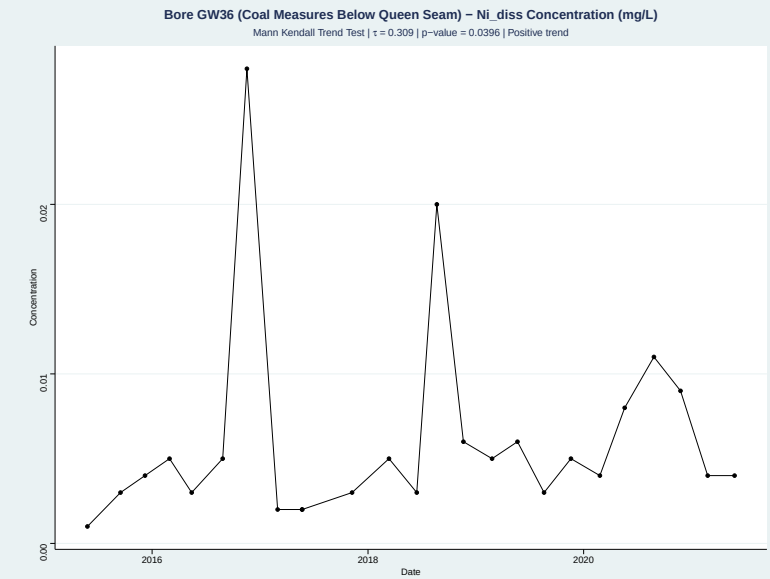
Appendix C Groundwater Quality Time Series

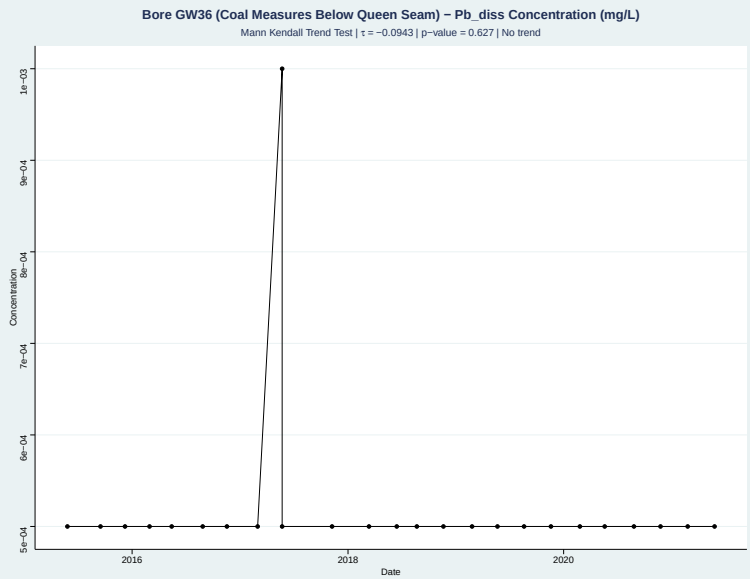




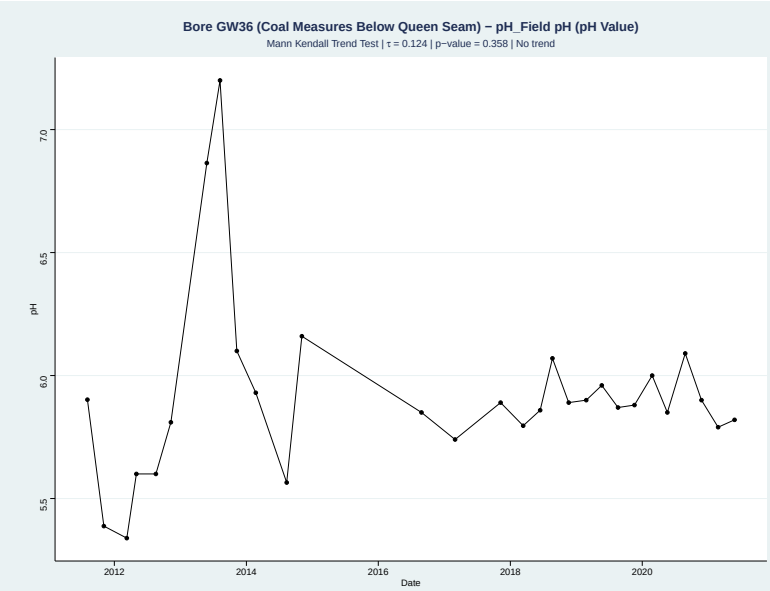


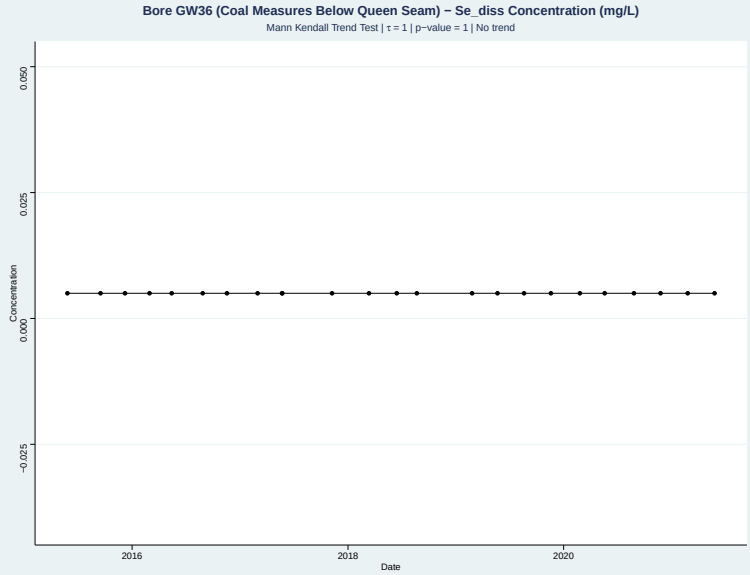


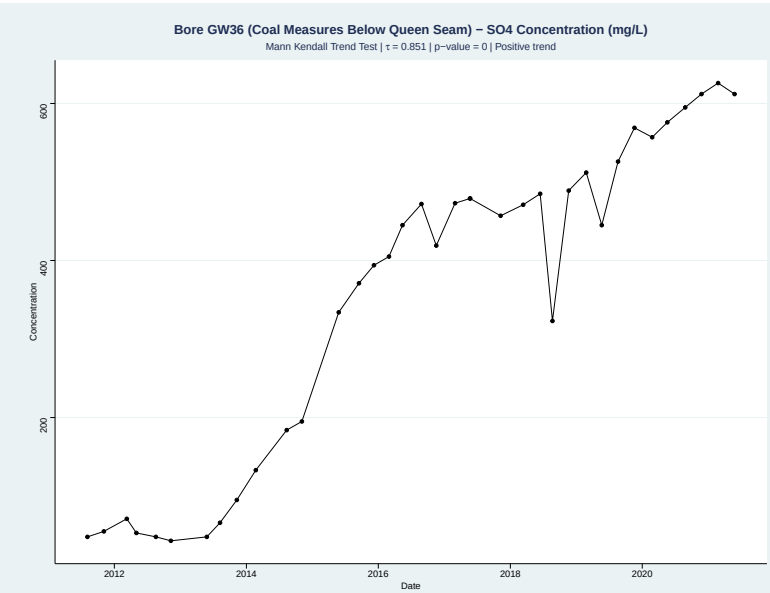


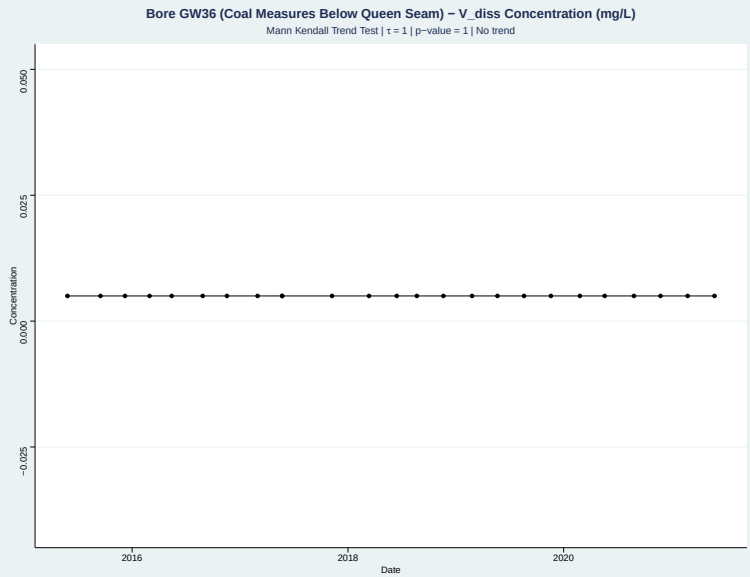


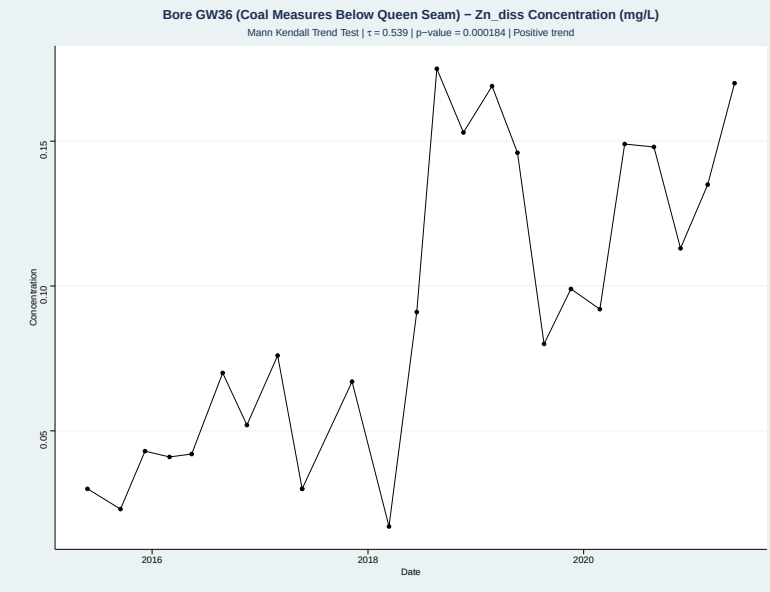
Appendix C Groundwater Quality Time Series

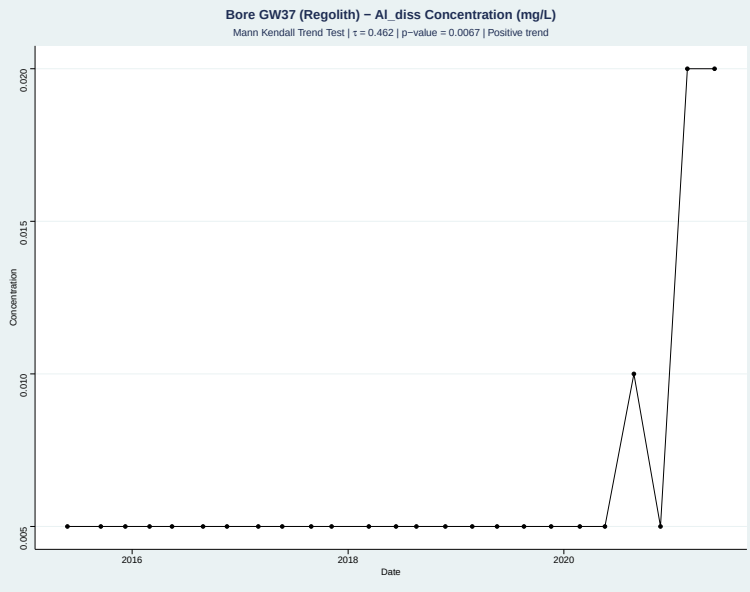




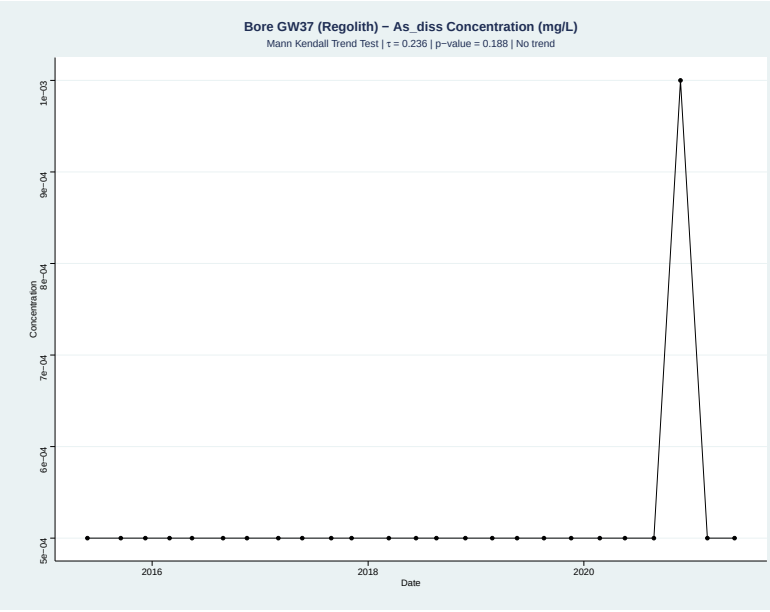


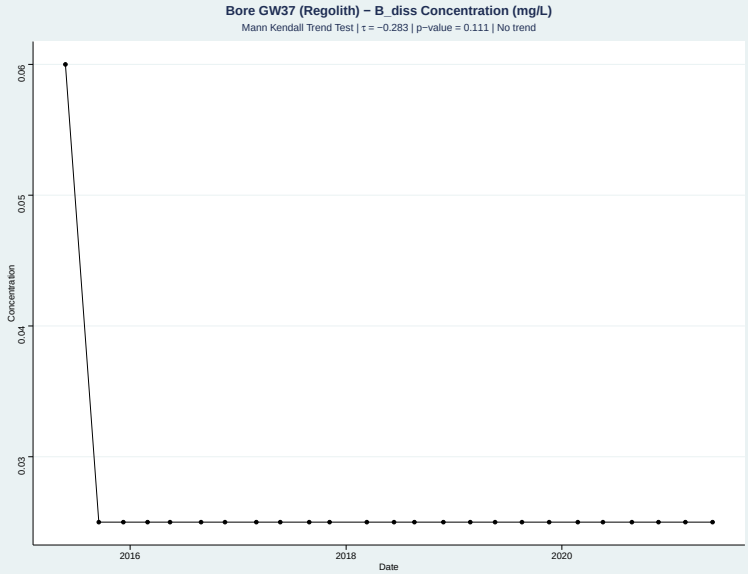


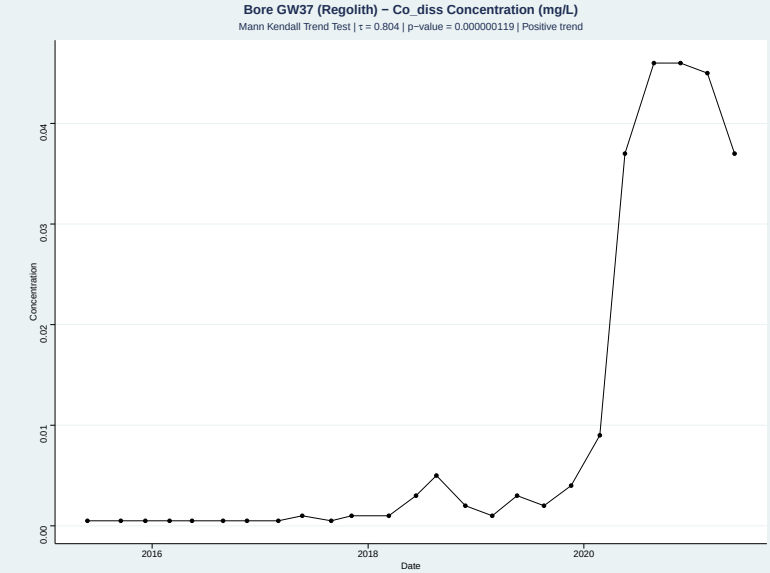


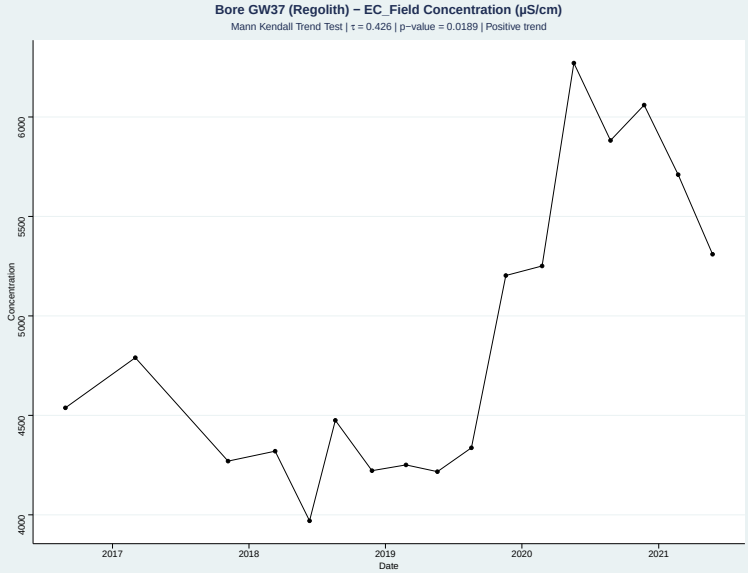


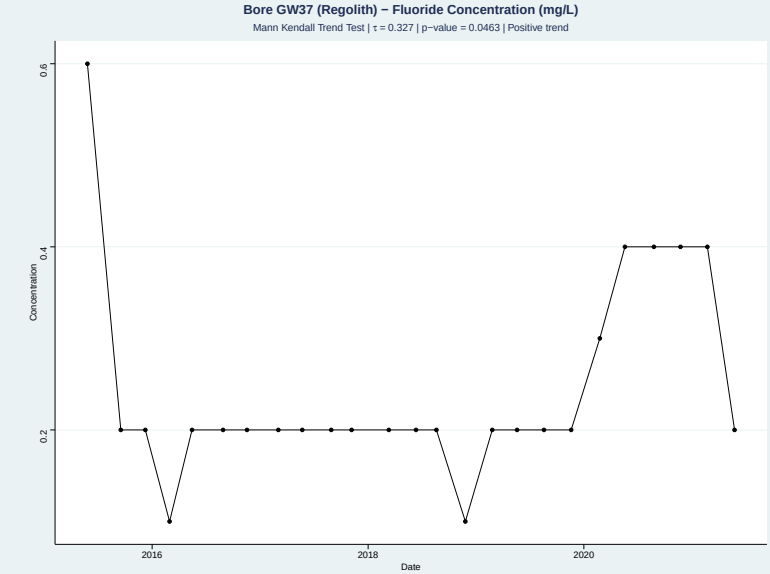
Appendix C Groundwater Quality Time Series





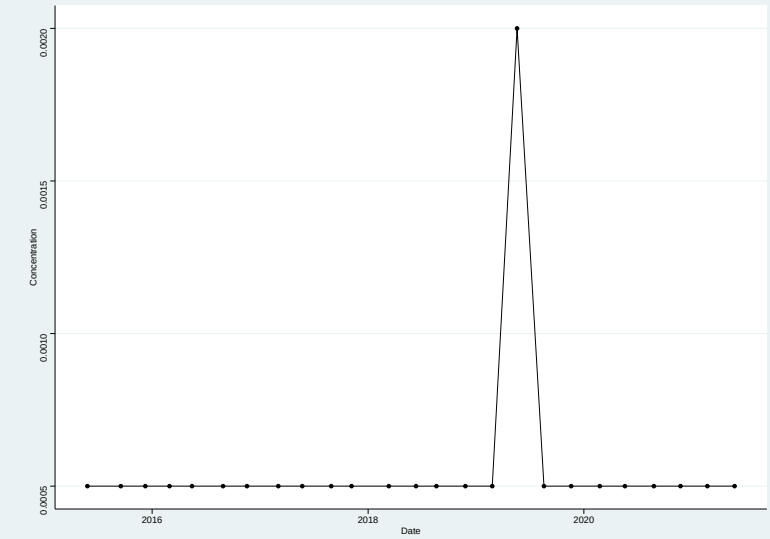


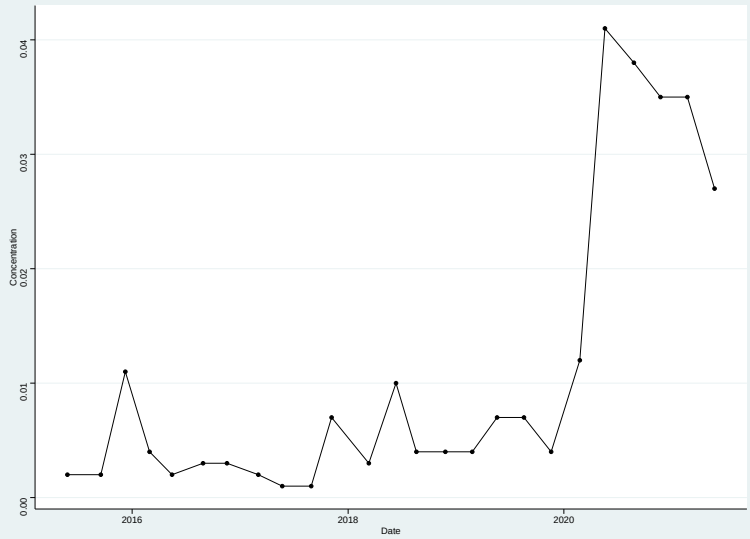


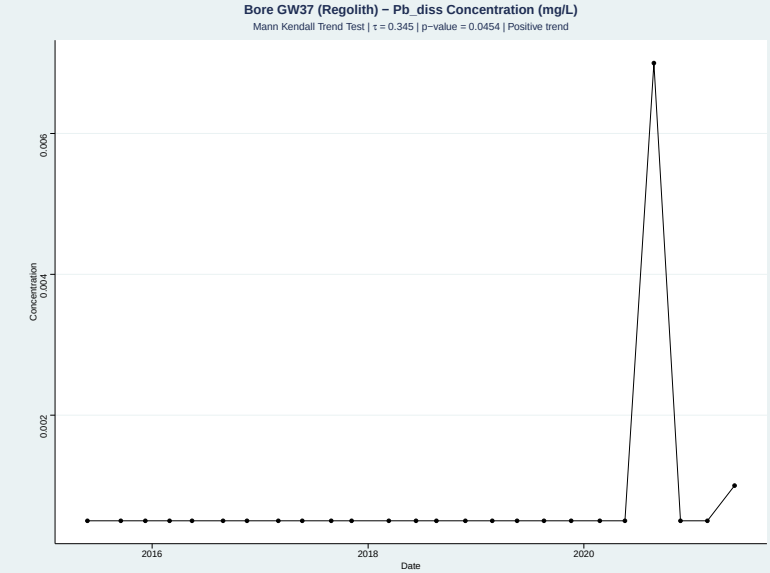


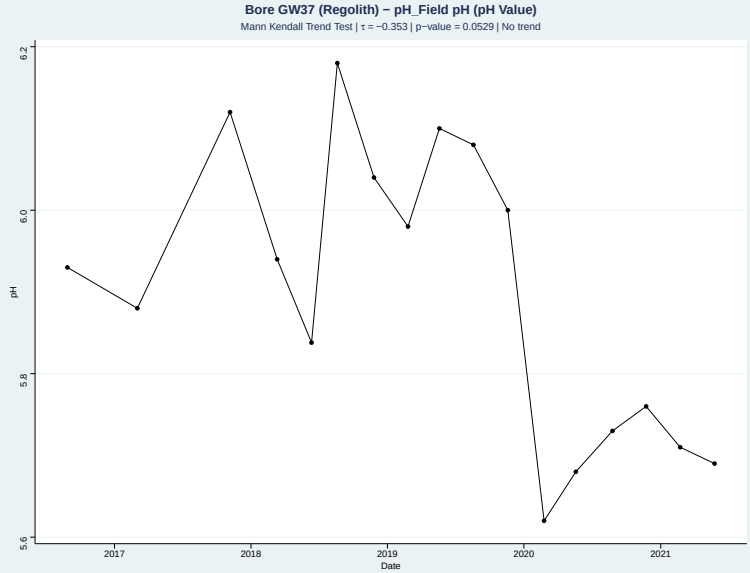


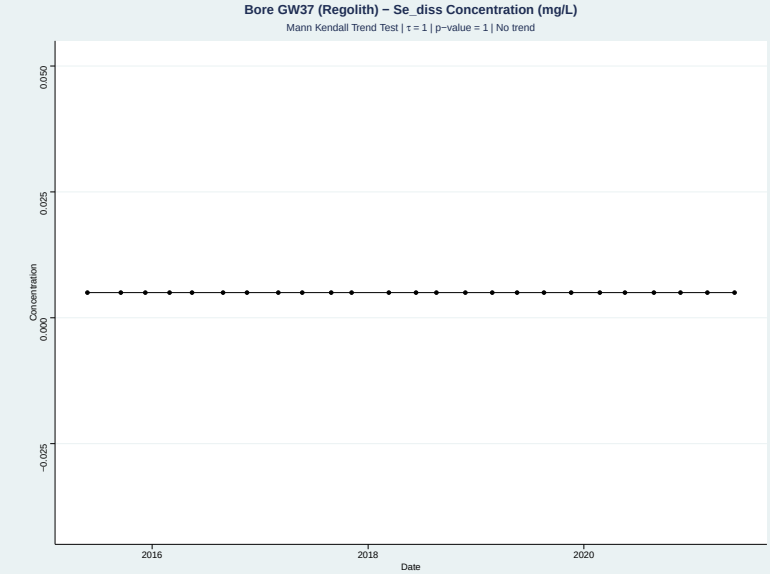
Appendix C Groundwater Quality Time Series

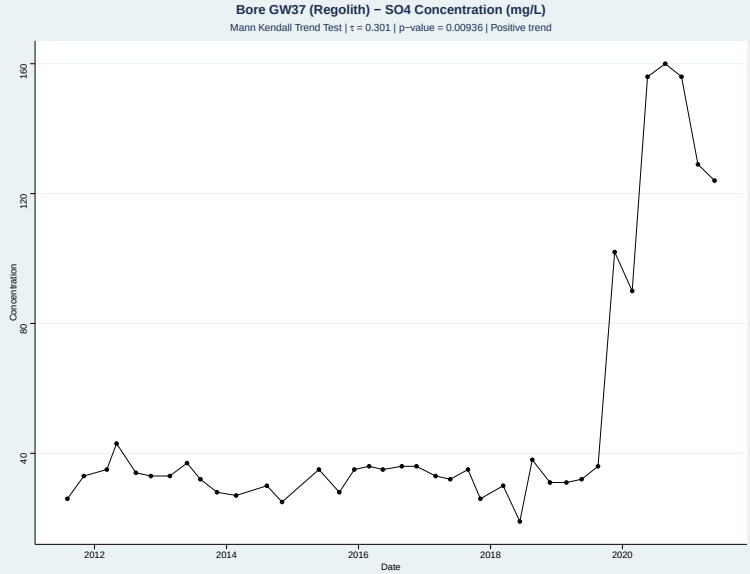




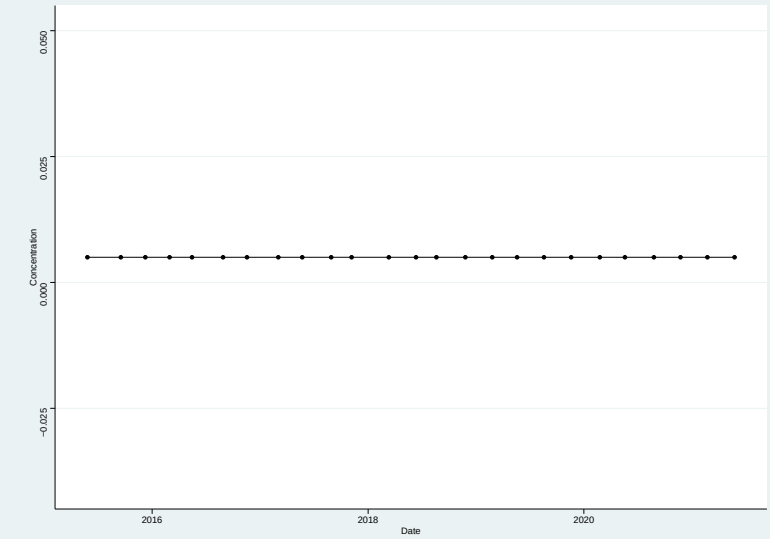


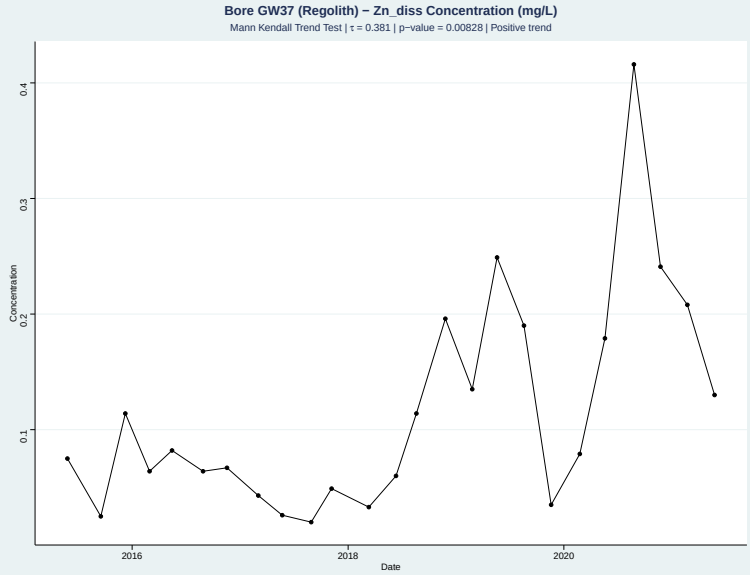


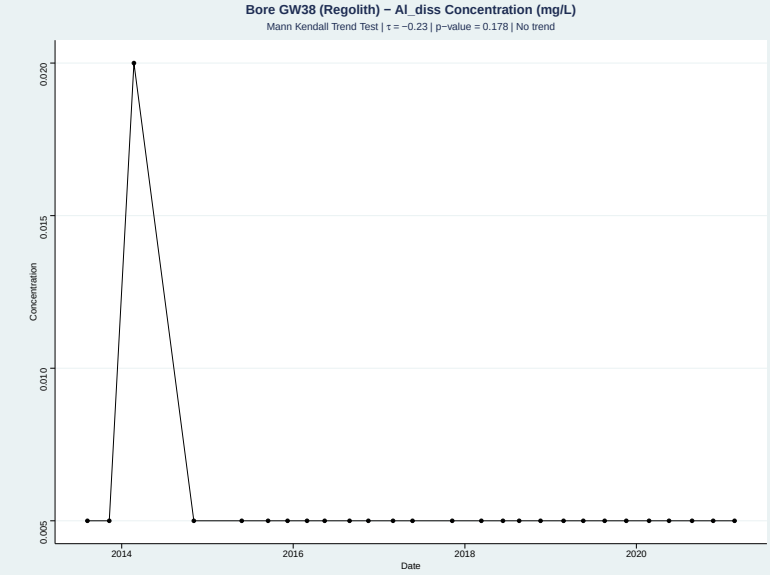


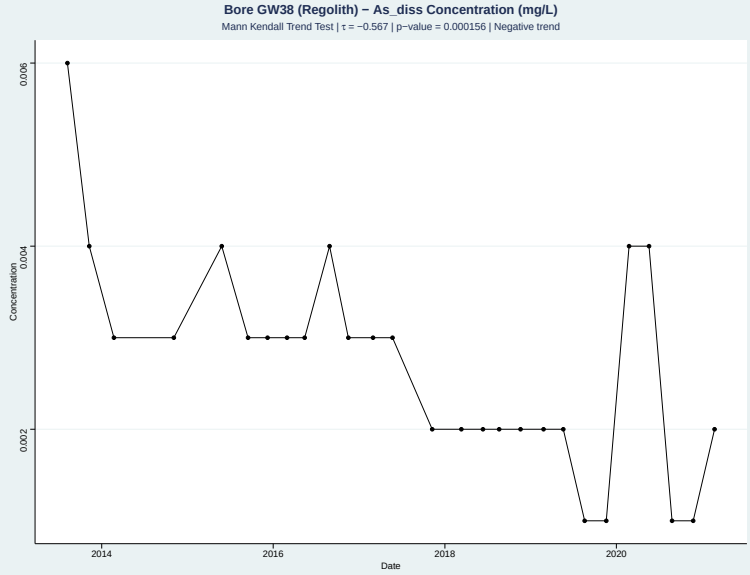


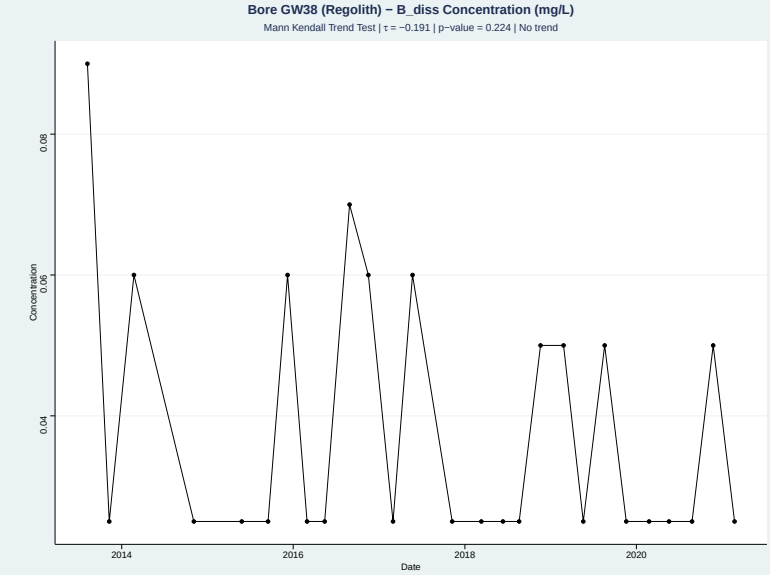
Appendix C Groundwater Quality Time Series

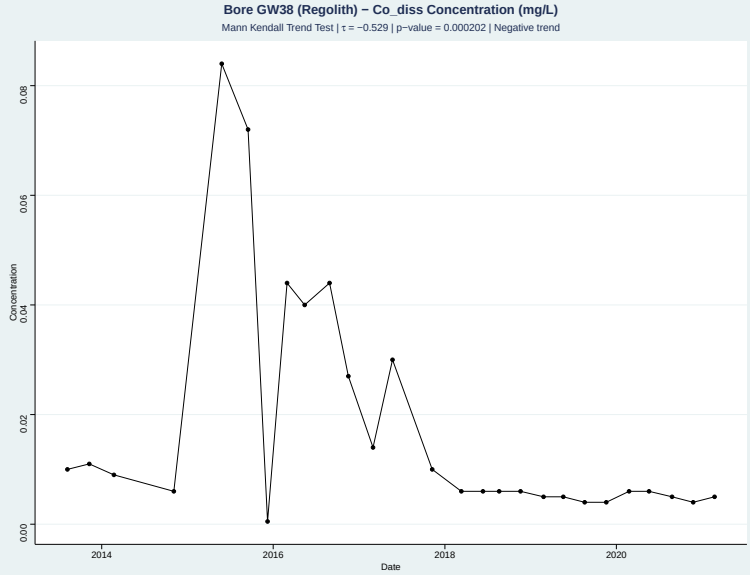


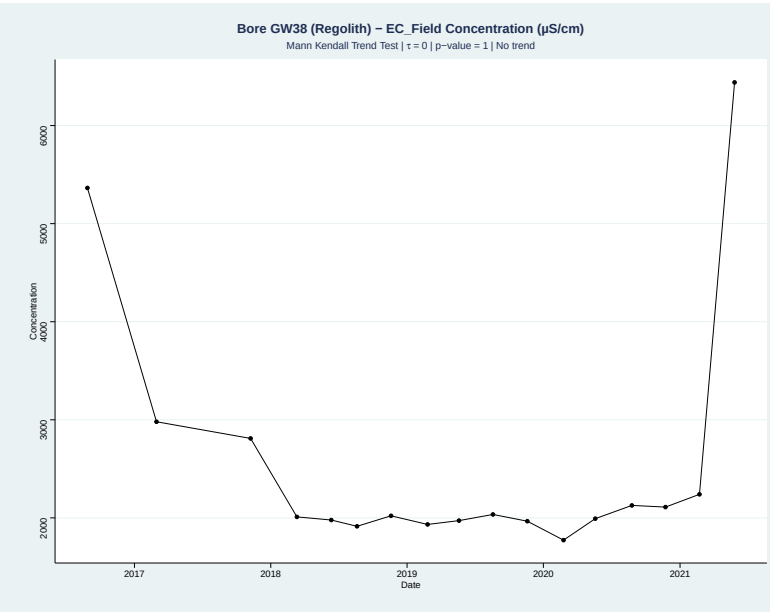


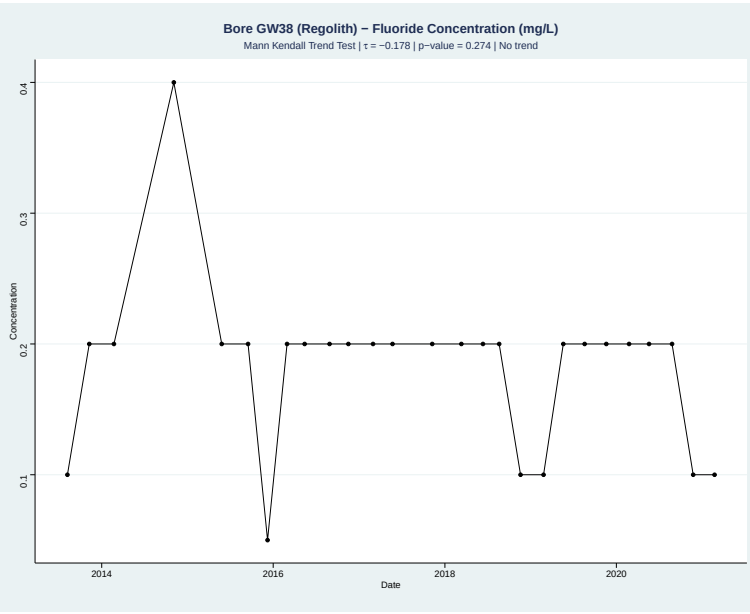


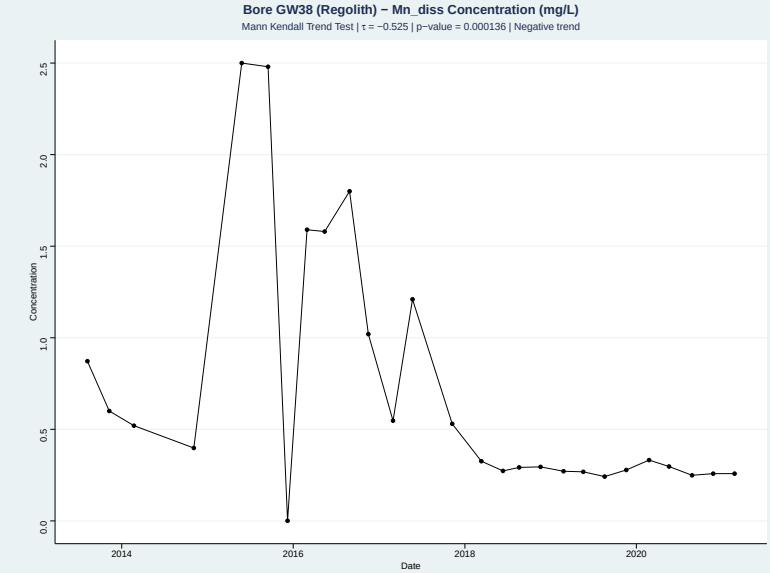


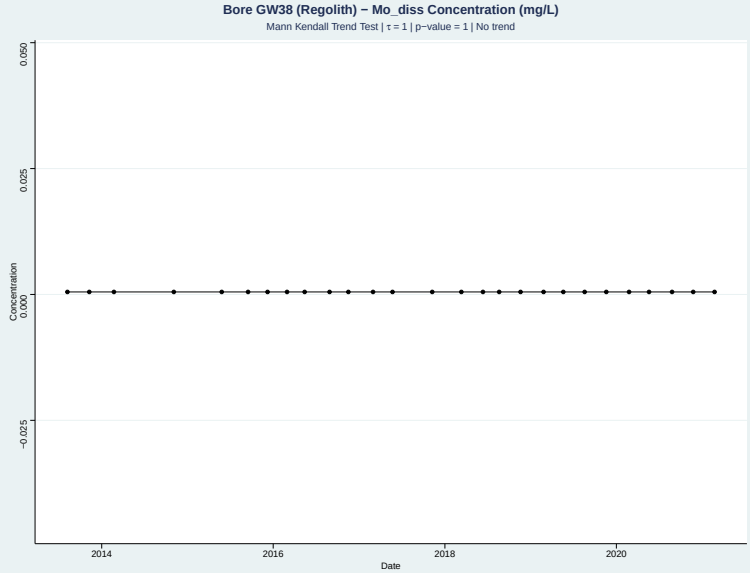


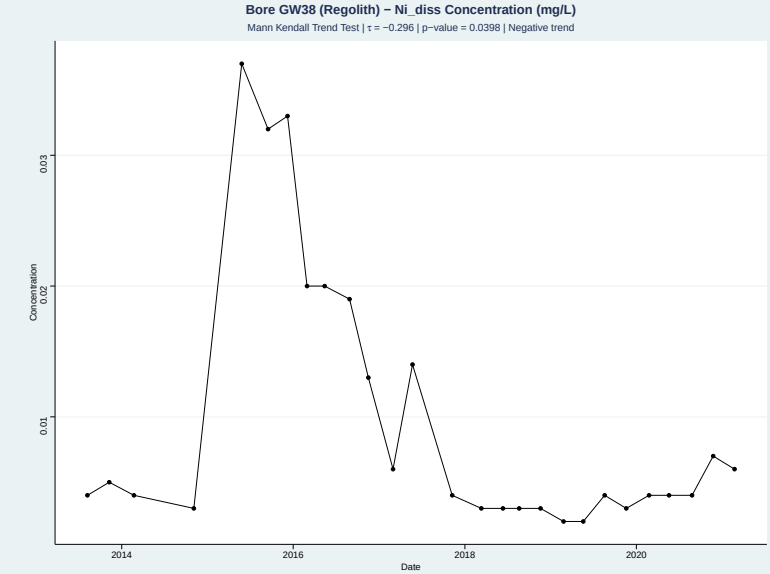


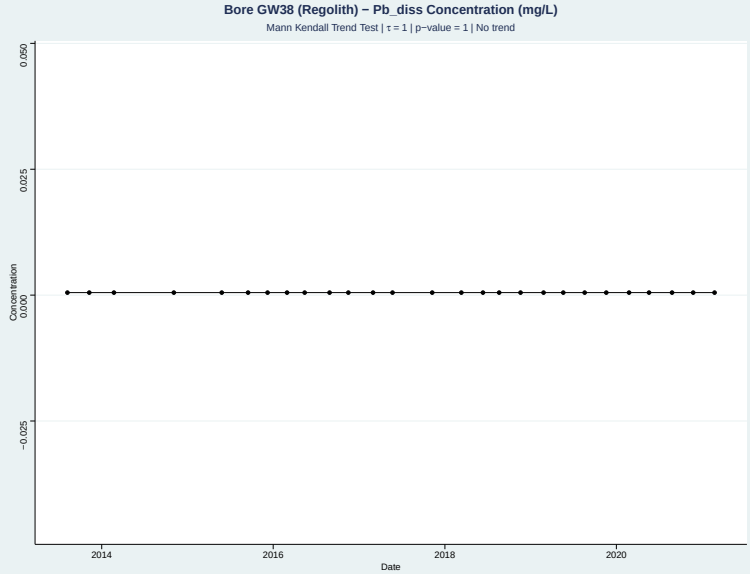

Bore GW38 (Regolith) − EC_Field Concentration (µS/cm)
Mann Kendall Trend Test | τ = 0 | p−value = 1 | No trend
Concentration
Date


Bore GW38 (Regolith) − Fluoride Concentration (mg/L)
Mann Kendall Trend Test | τ = −0.178 | p−value = 0.274 | No trend
Concentration
Date

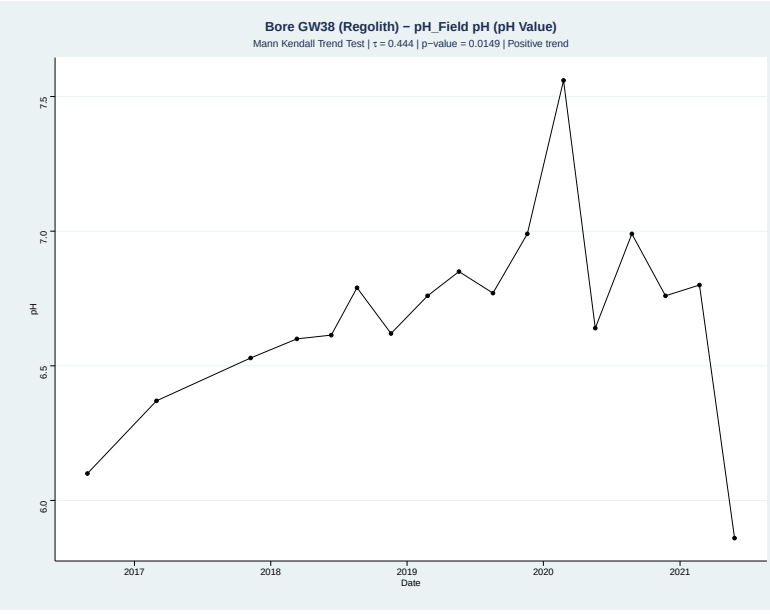

Bore GW38 (Regolith) − Mn_diss Concentration (mg/L)
Mann Kendall Trend Test | τ = −0.525 | p−value = 0.000136 | Negative trend
Concentration
Date

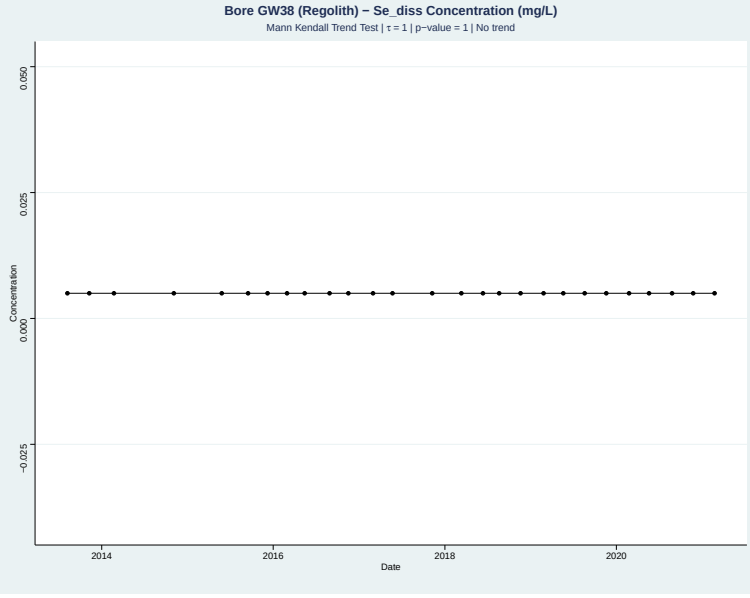

Bore GW38 (Regolith) − Mo_diss Concentration (mg/L)
Mann Kendall Trend Test | τ = 1 | p−value = 1 | No trend
Concentration
Date

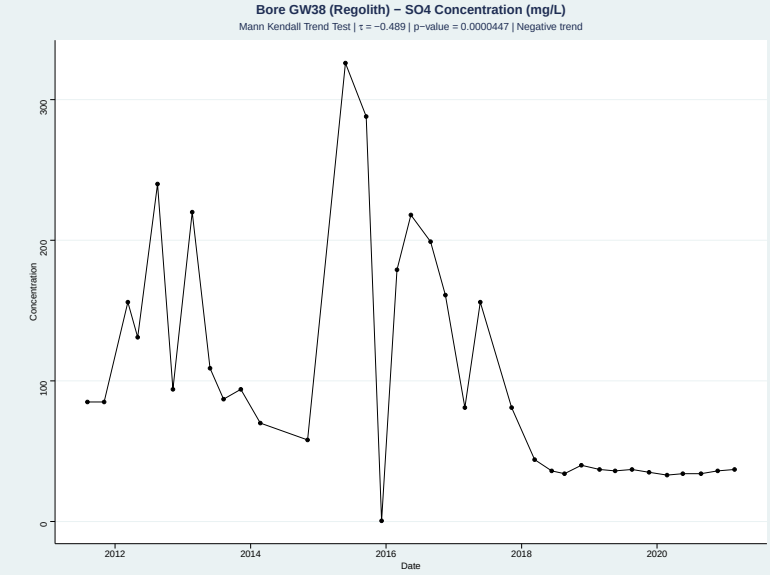

Bore GW38 (Regolith) − Ni_diss Concentration (mg/L)
Mann Kendall Trend Test | τ = −0.296 | p−value = 0.0398 | Negative trend
Concentration
Date

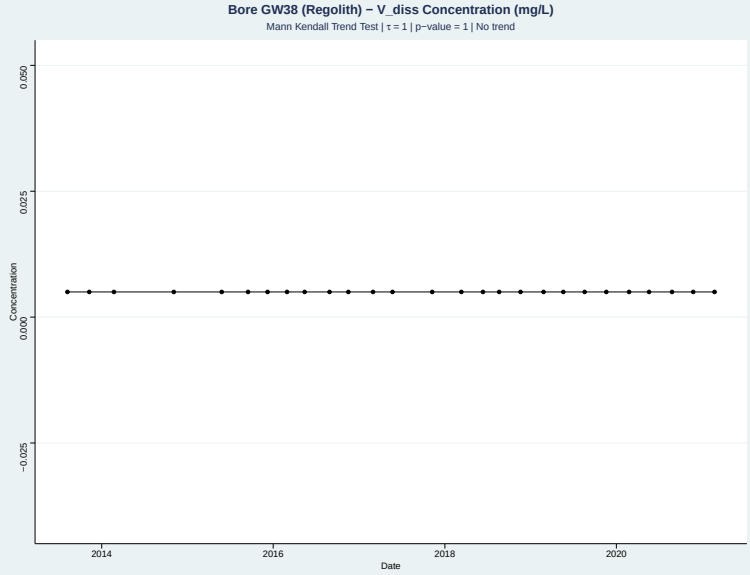

Bore GW38 (Regolith) − Pb_diss Concentration (mg/L)
Mann Kendall Trend Test | τ = 1 | p−value = 1 | No trend
Concentration
Date

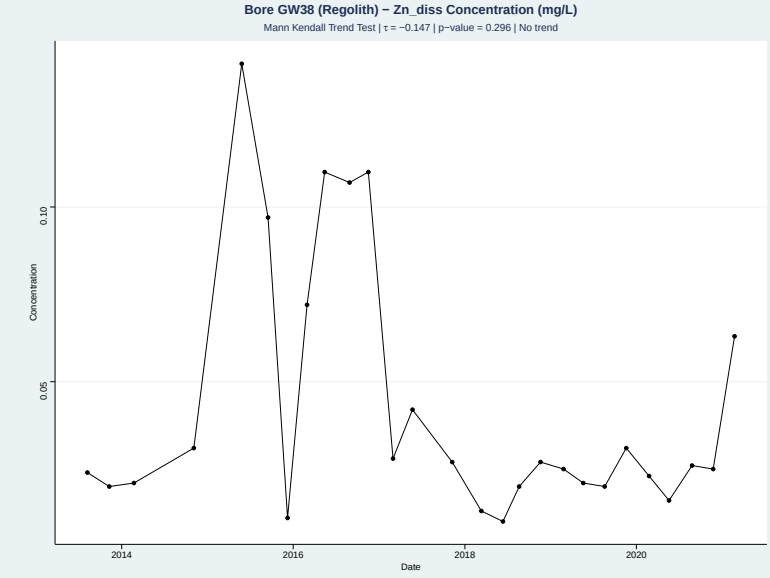
Appendix C Groundwater Quality Time Series

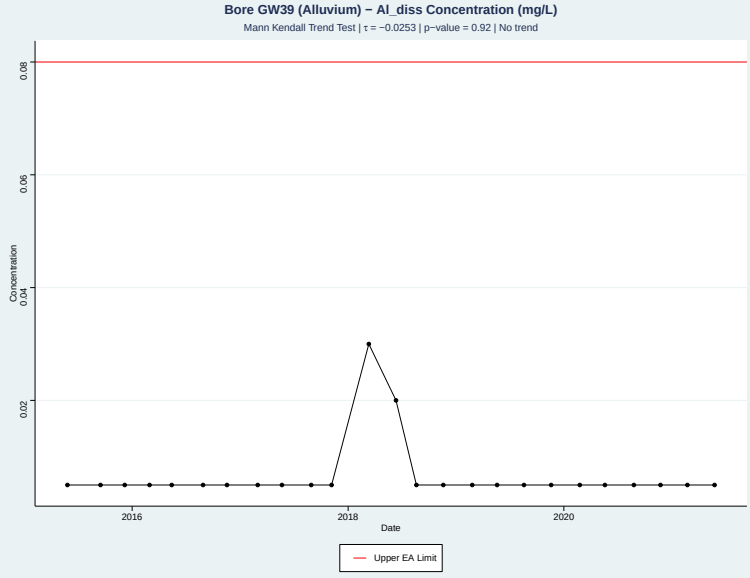




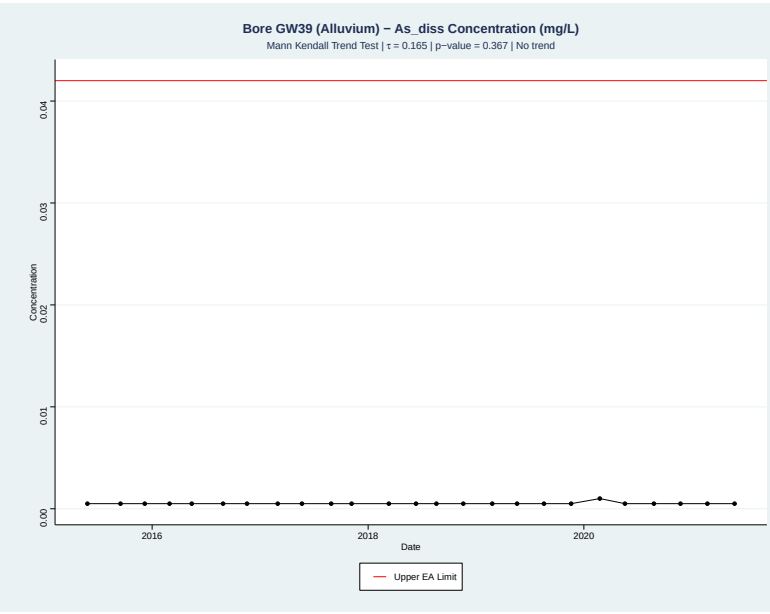


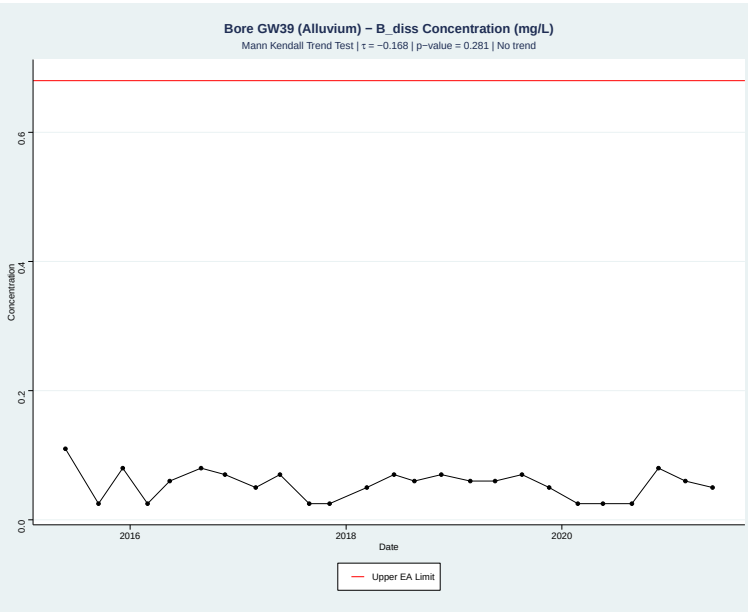


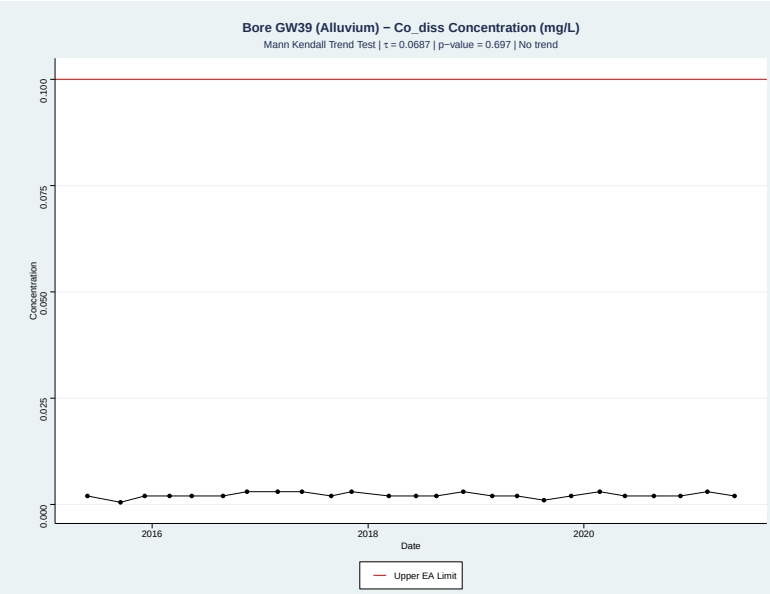


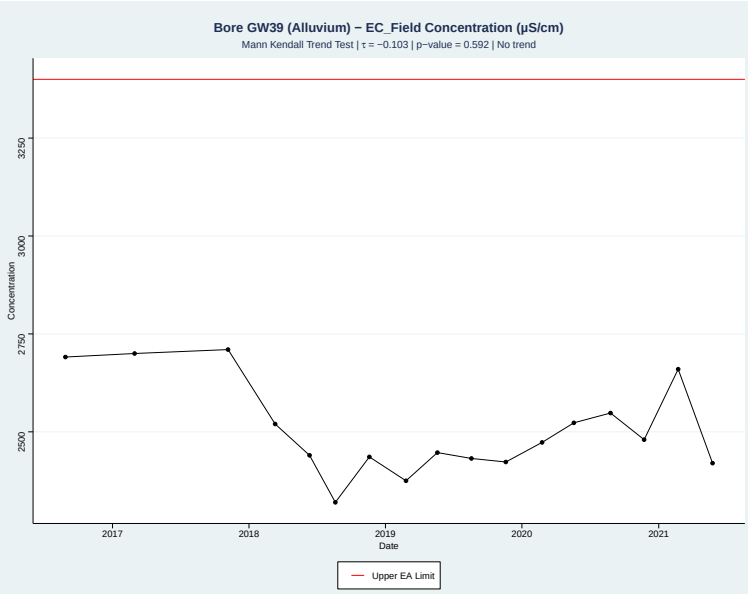


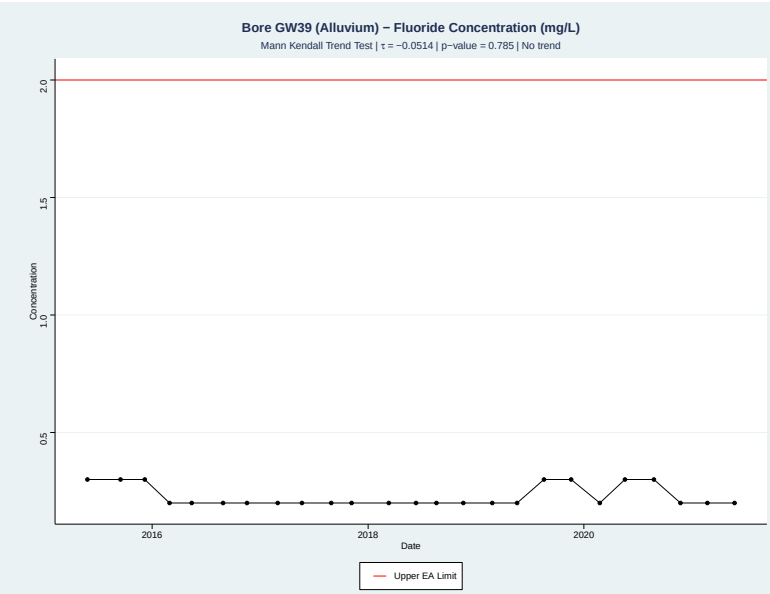
Appendix C Groundwater Quality Time Series

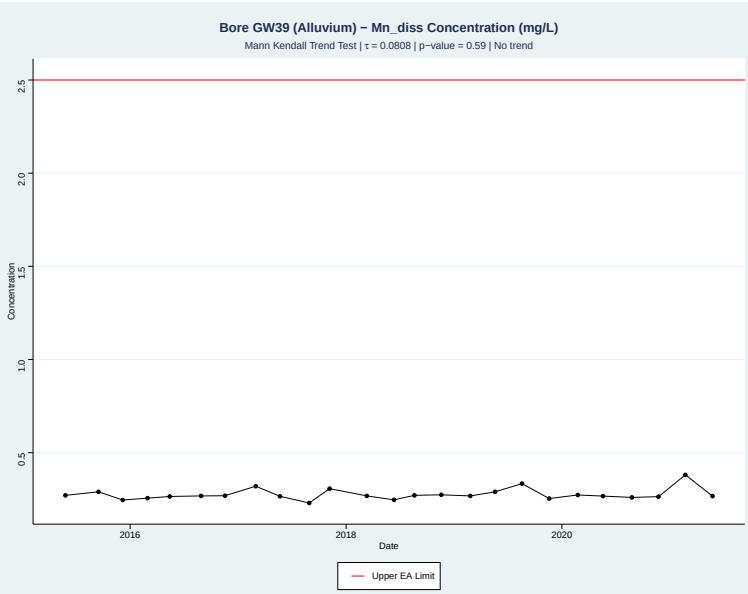




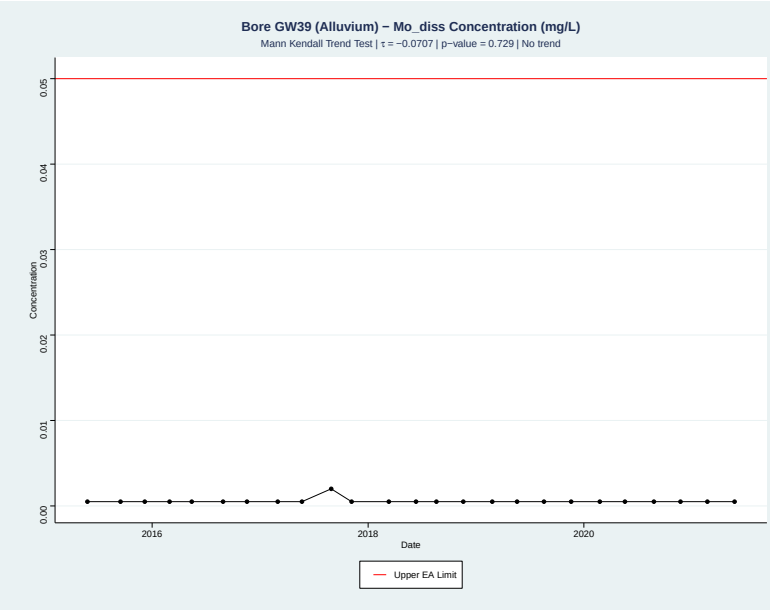


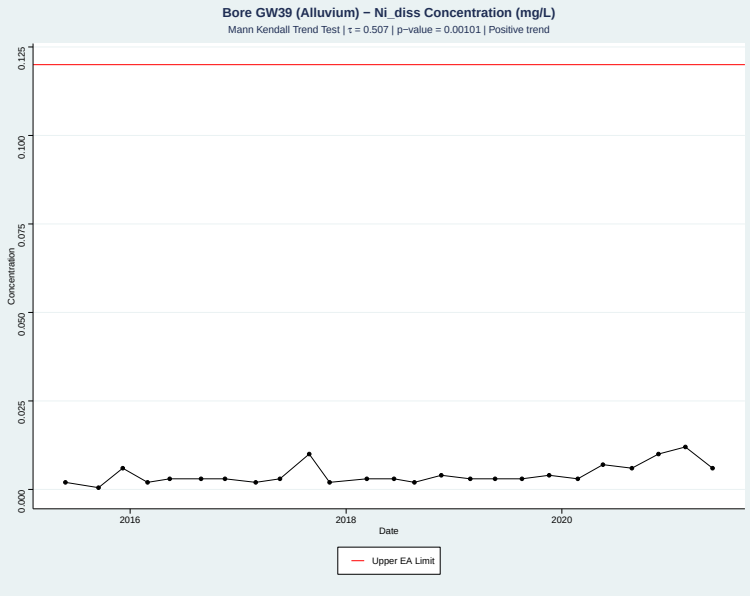


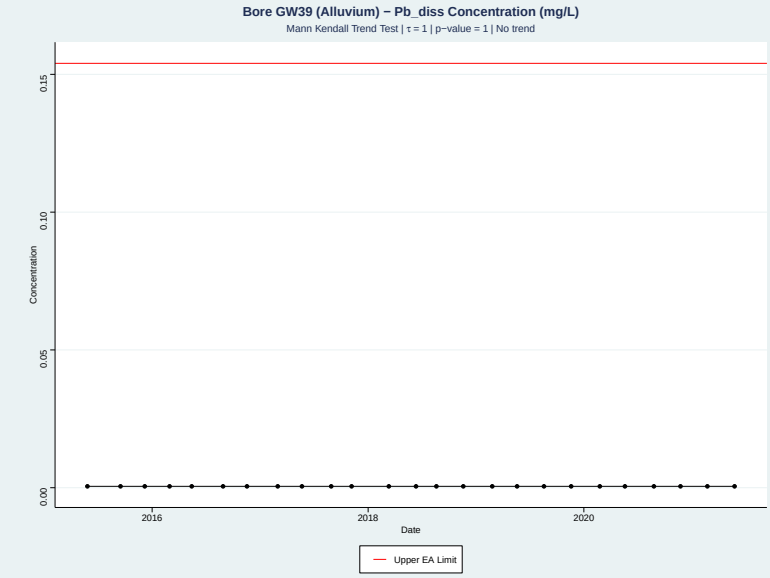


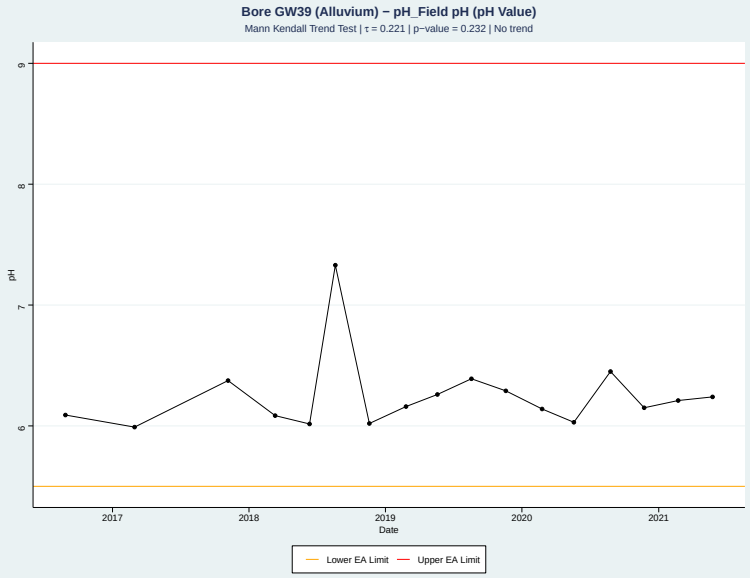


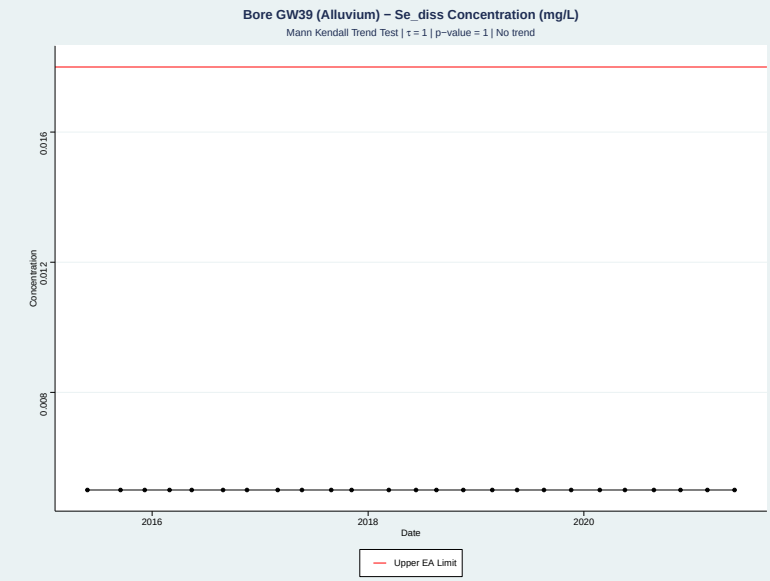
Appendix C Groundwater Quality Time Series

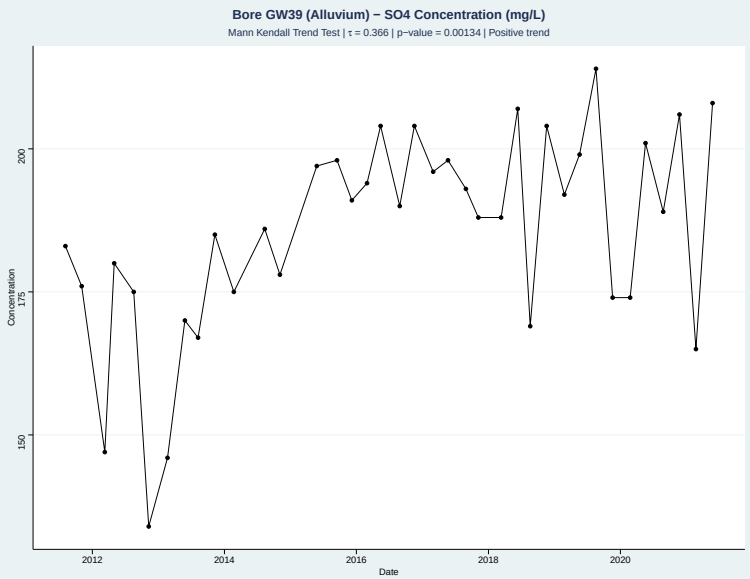




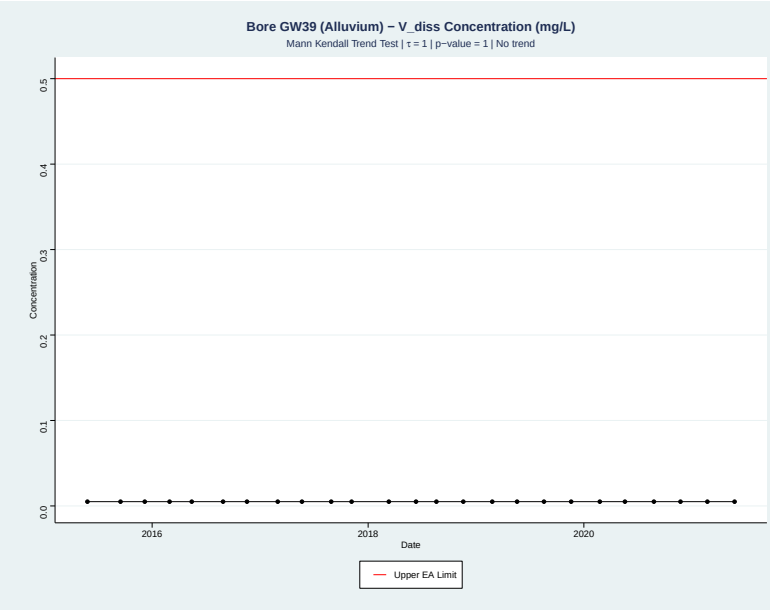


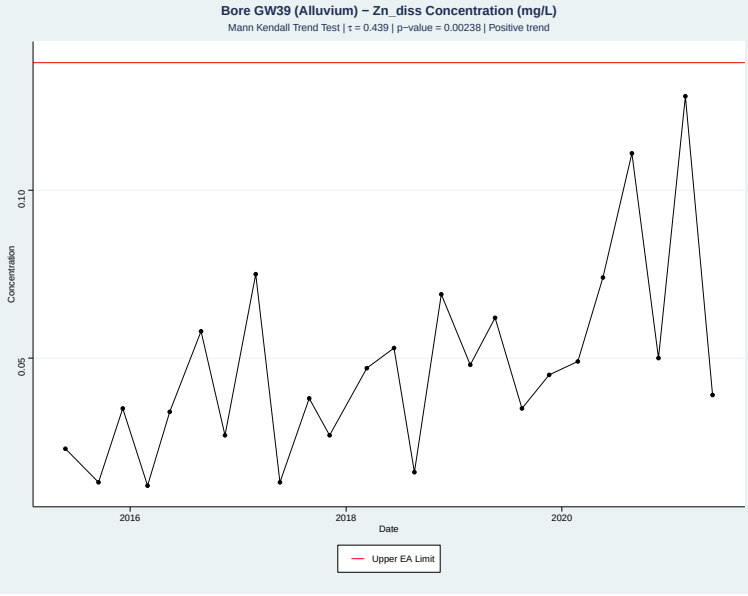


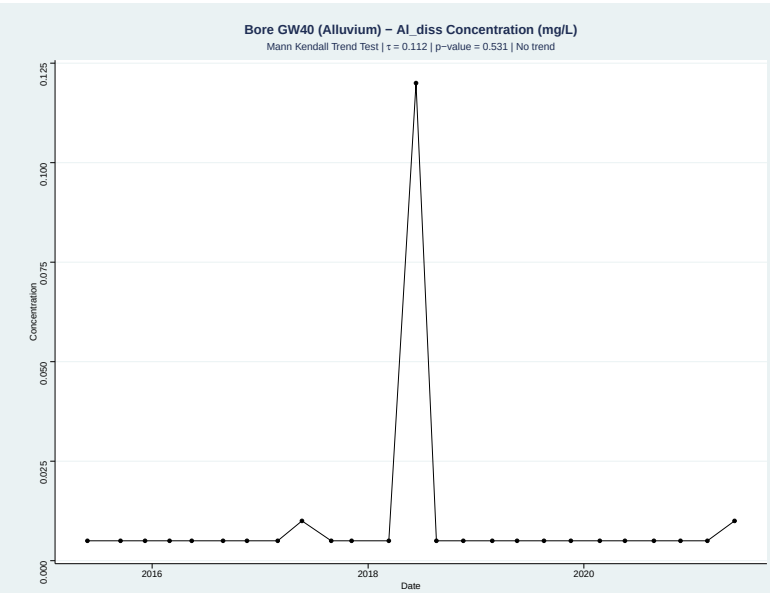


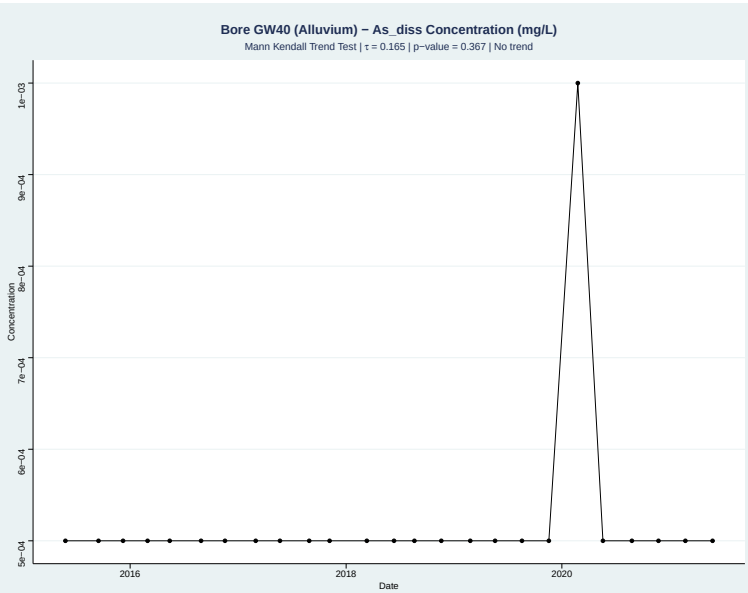


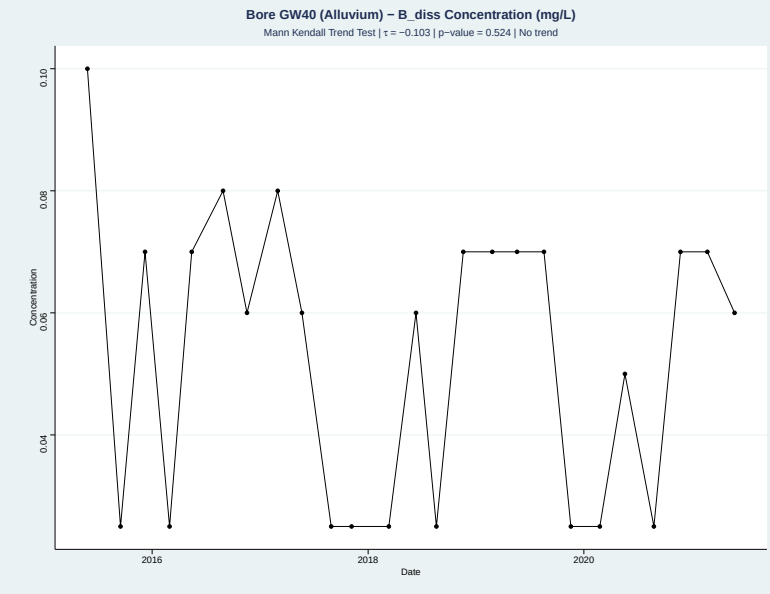
Appendix C Groundwater Quality Time Series

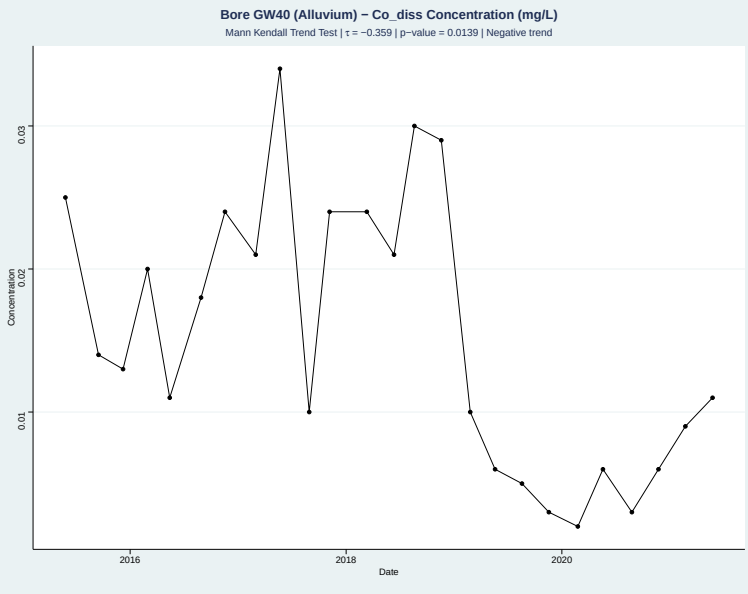




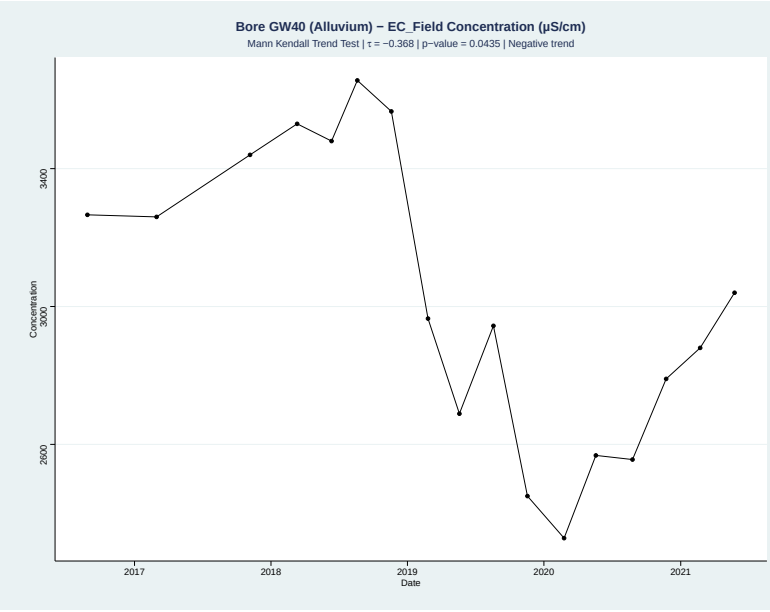


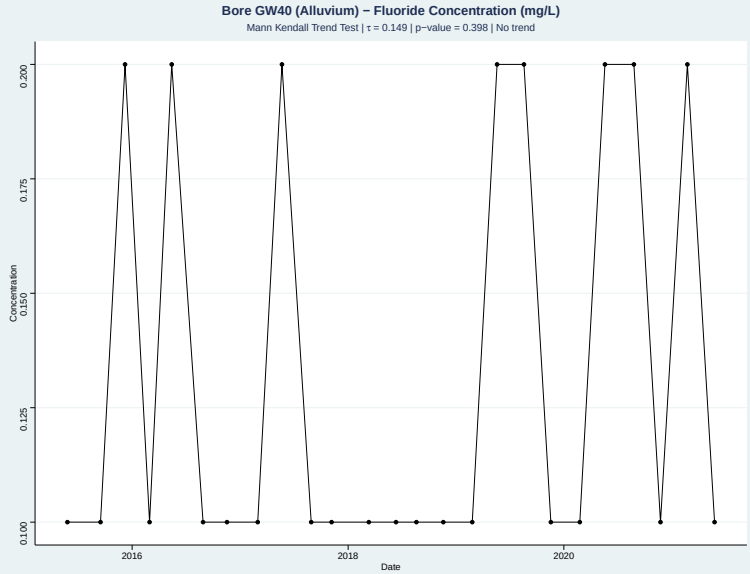


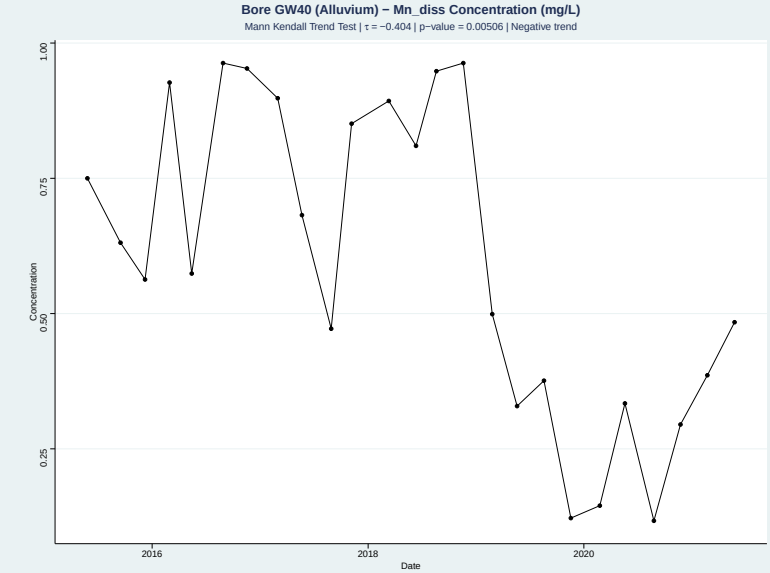


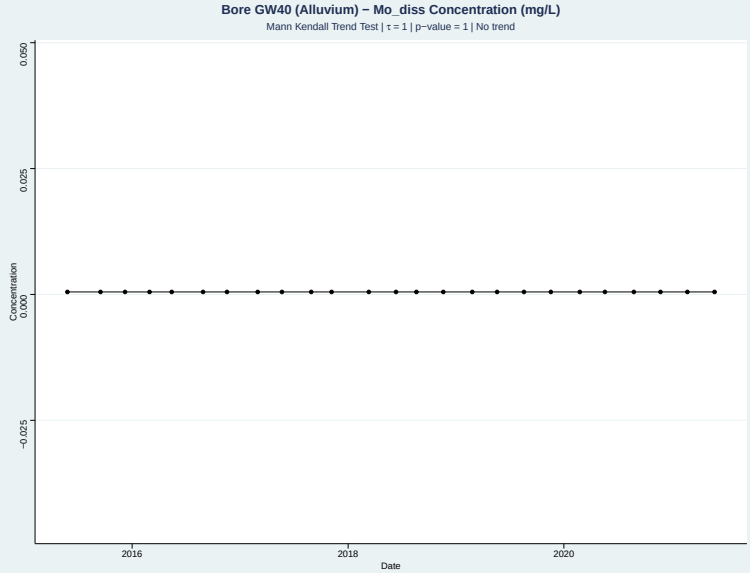


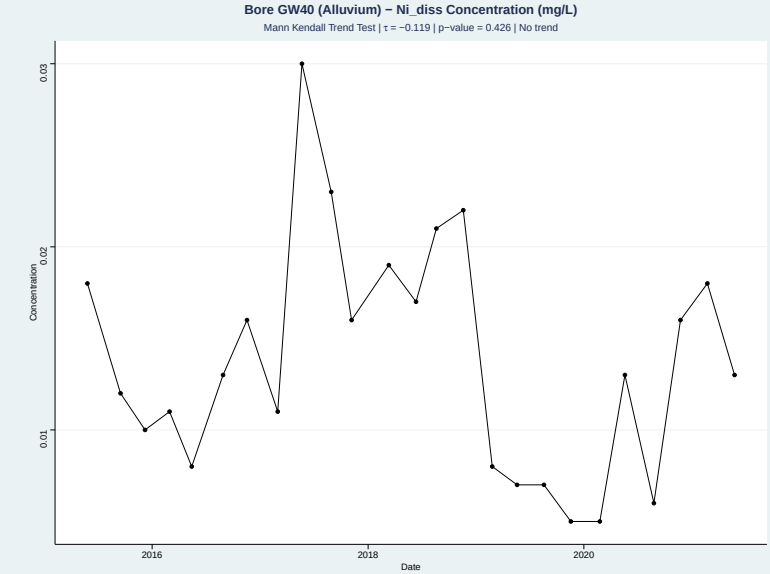
Appendix C Groundwater Quality Time Series

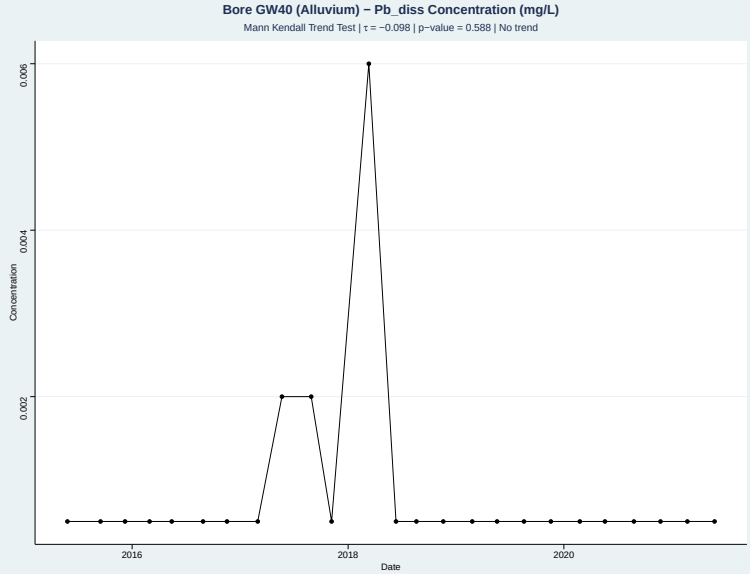




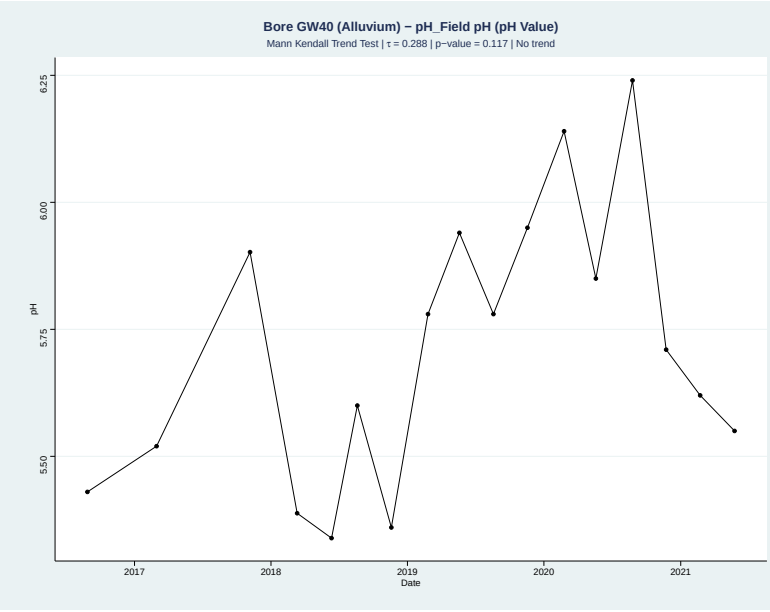


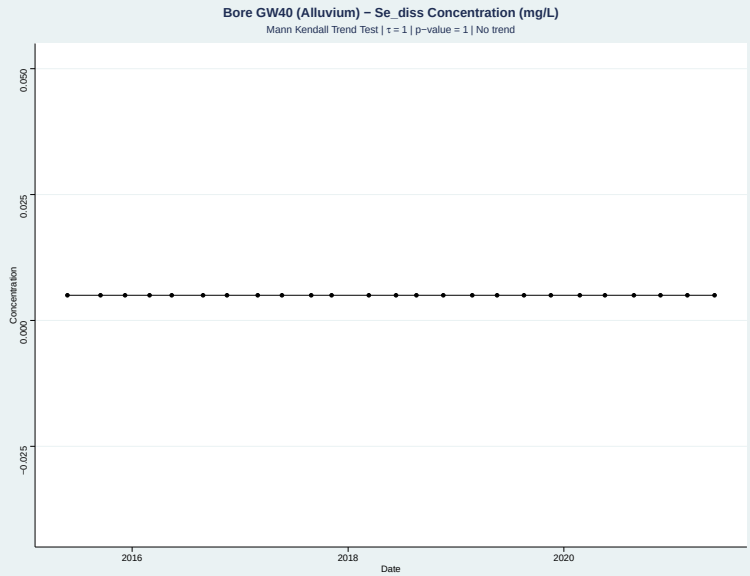


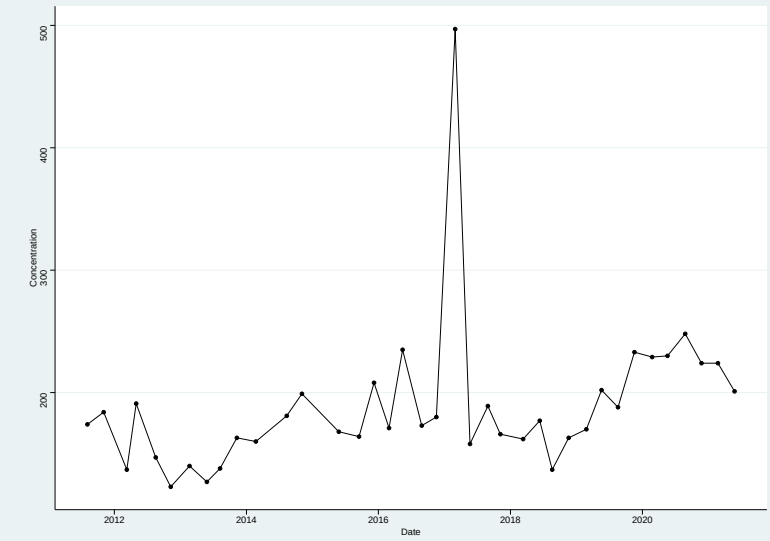


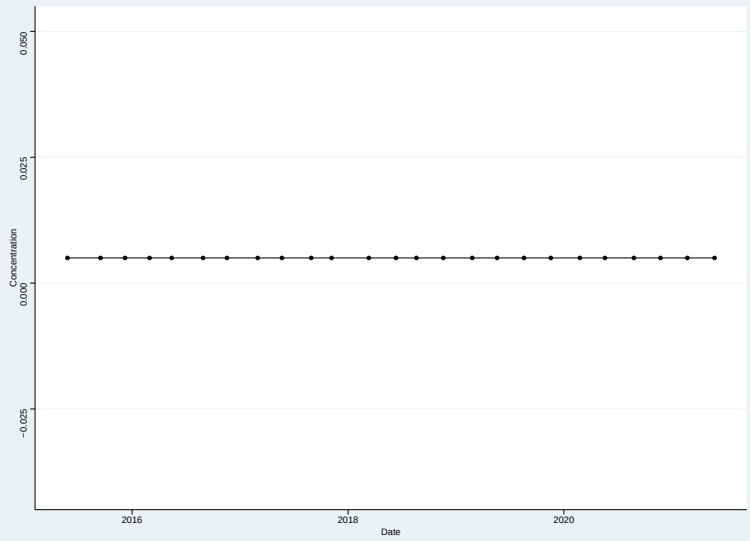


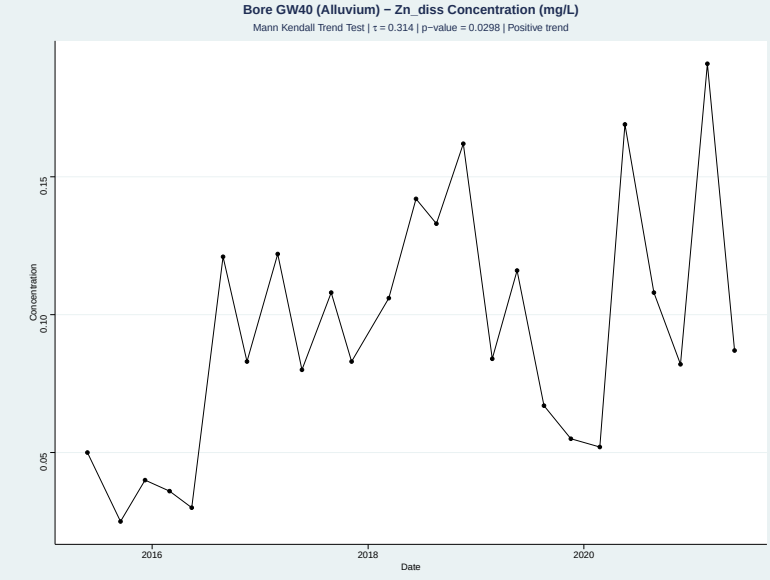
Appendix C Groundwater Quality Time Series

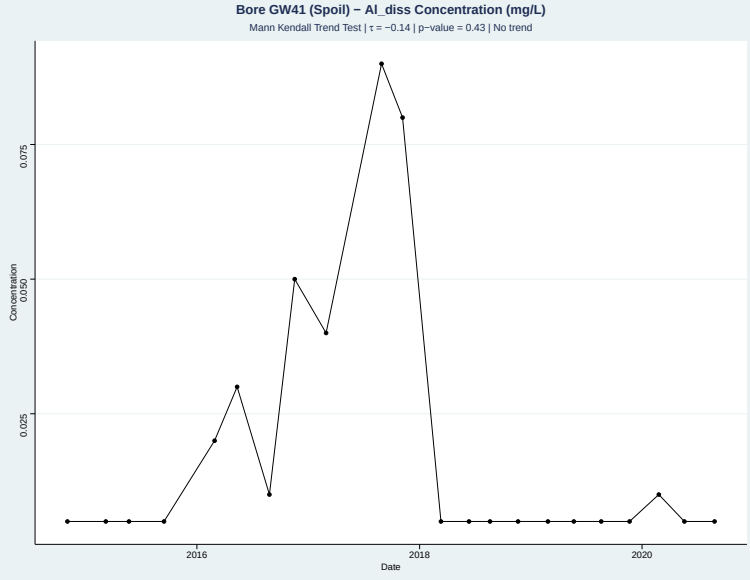








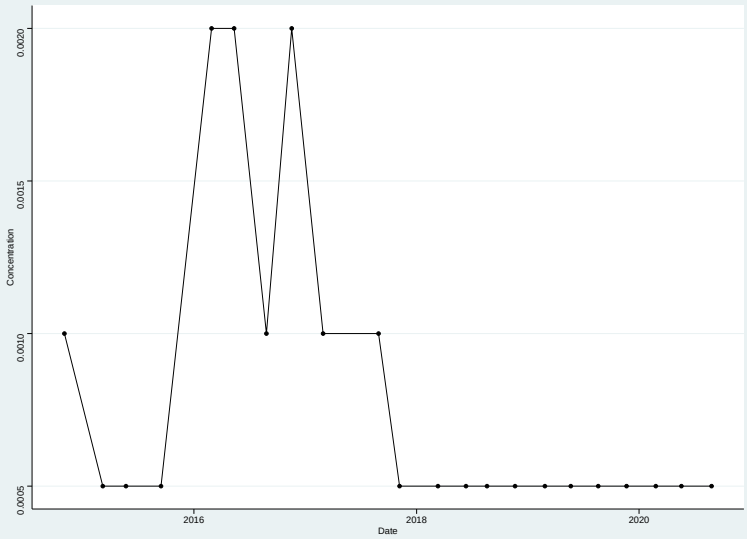




Appendix C Groundwater Quality Time Series

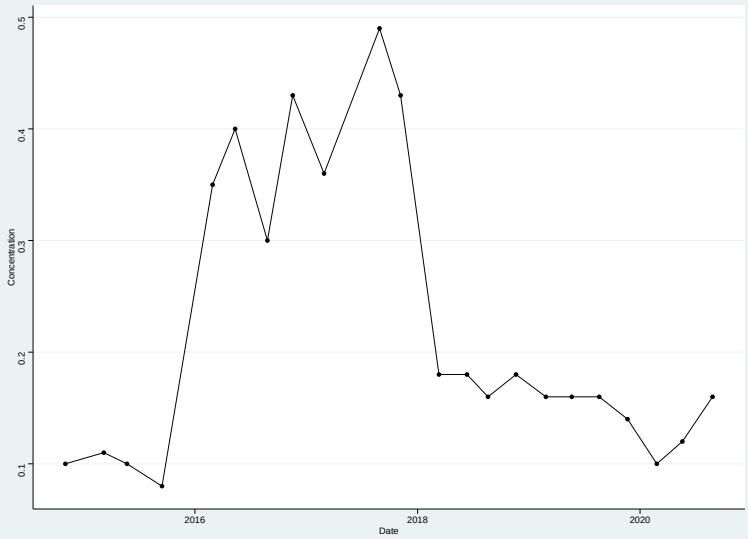
Bore GW41 (Spoil) – As_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.444 | p−value = 0.0128 | Negative trend



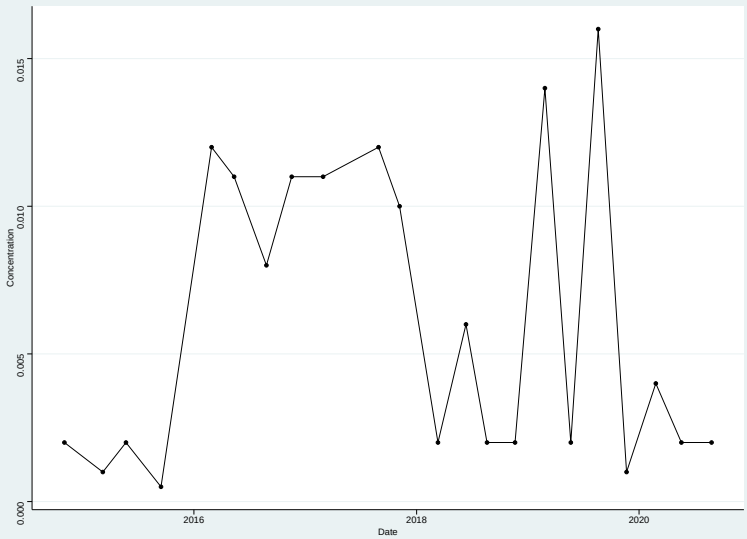
Bore GW41 (Spoil) – B_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.153 | p−value = 0.347 | No trend



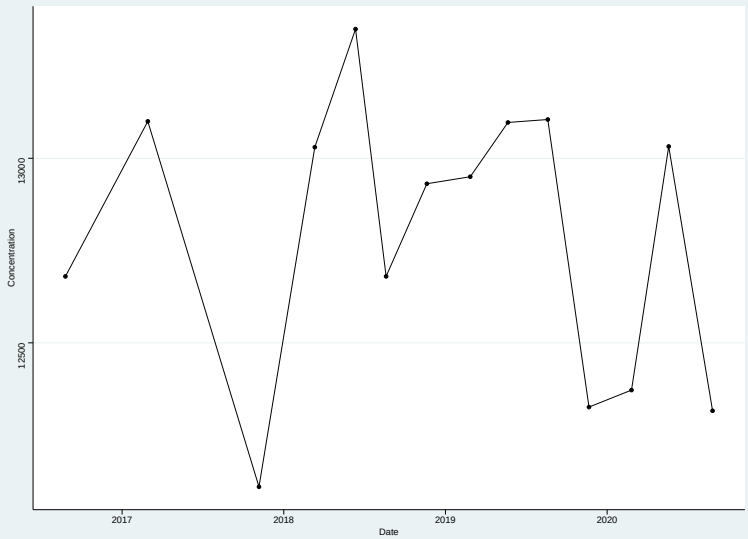
Bore GW41 (Spoil) – Co_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.0187 | p−value = 0.931 | No trend



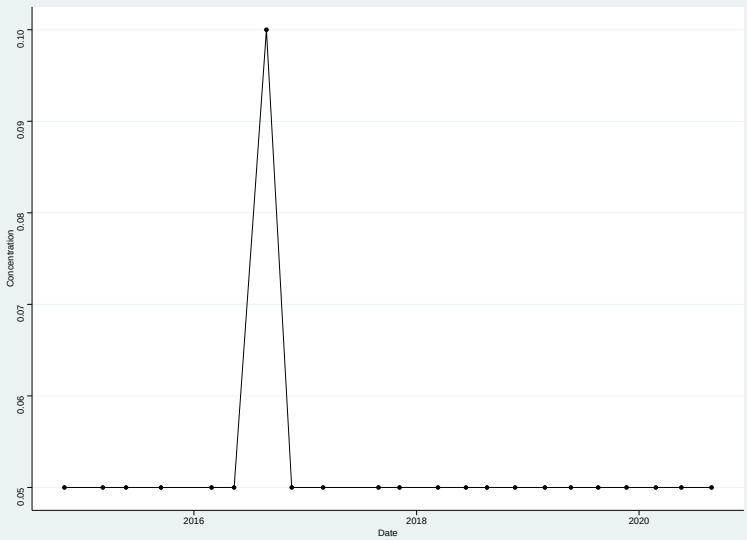
Bore GW41 (Spoil) – EC_Field Concentration (µS/cm)

Mann Kendall Trend Test | τ = −0.0884 | p−value = 0.701 | No trend



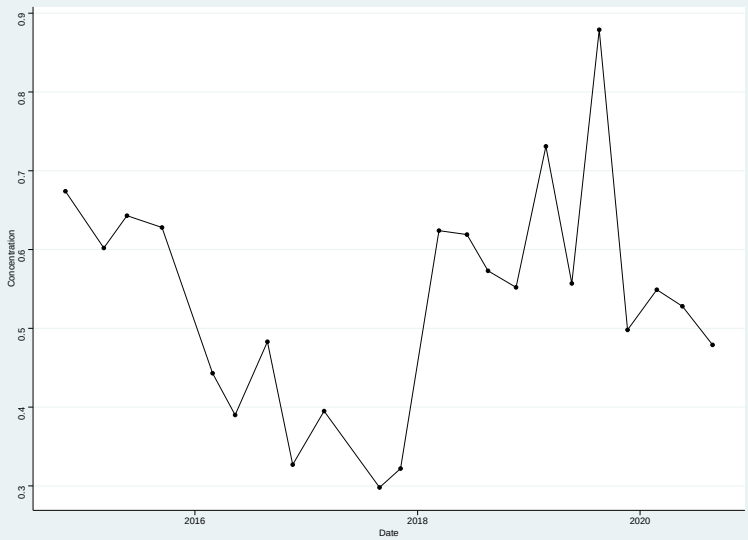
Bore GW41 (Spoil) – Fluoride Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.129 | p−value = 0.528 | No trend

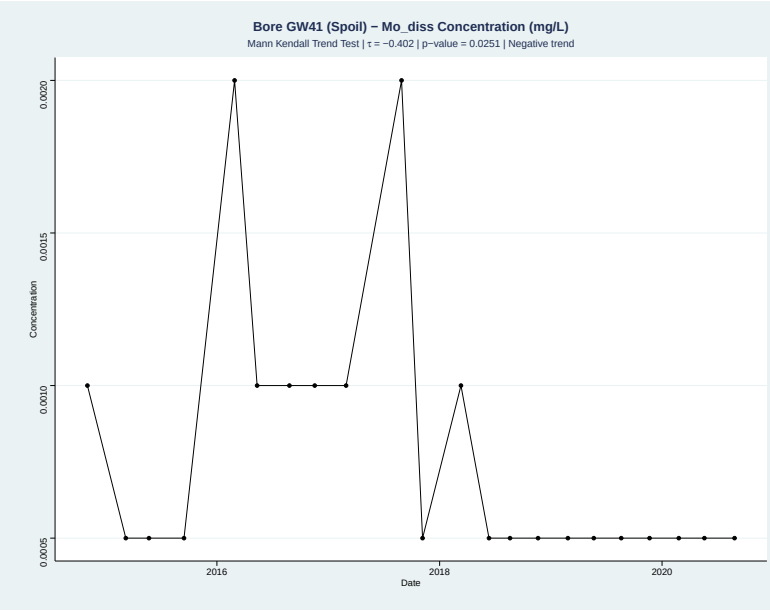


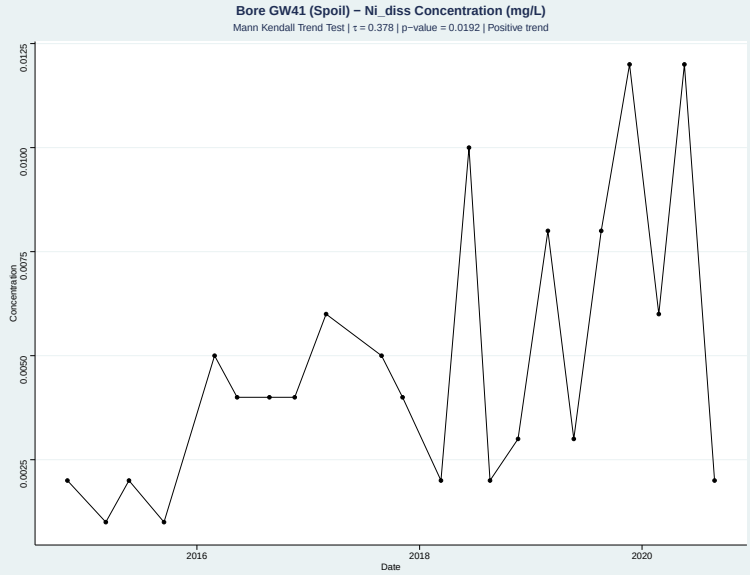
Bore GW41 (Spoil) – Mn_diss Concentration (mg/L)

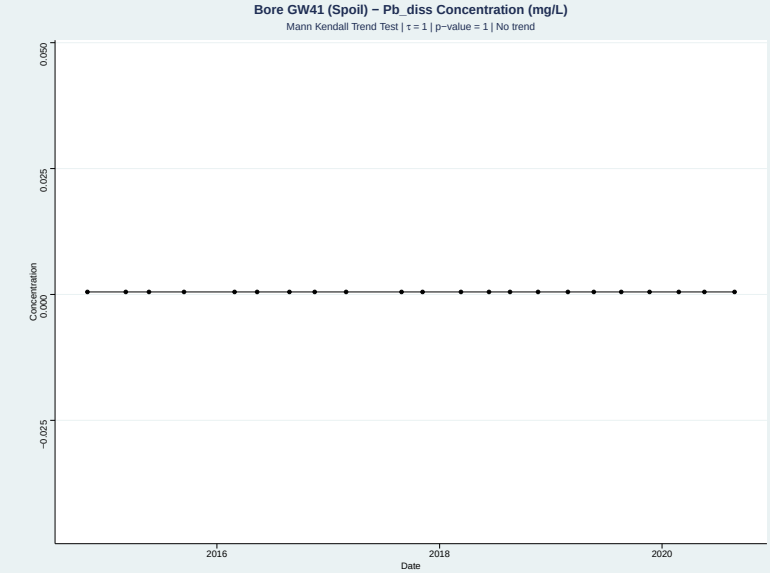
Mann Kendall Trend Test | τ = −0.0823 | p−value = 0.612 | No trend

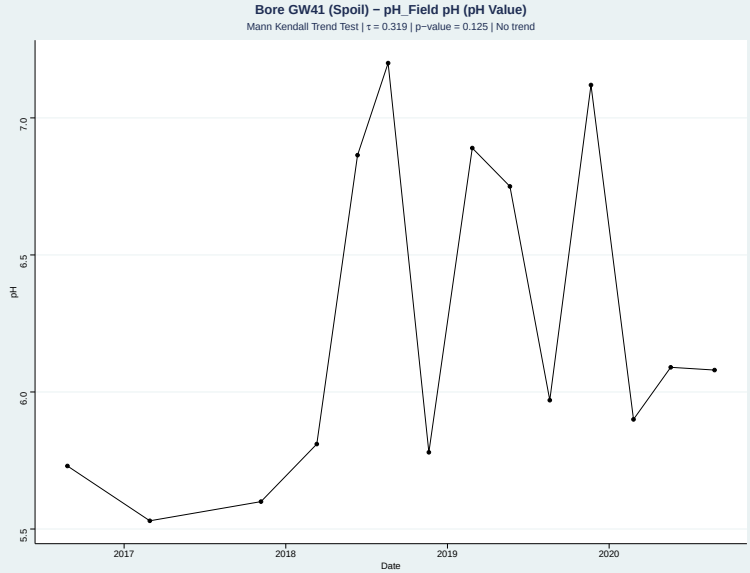


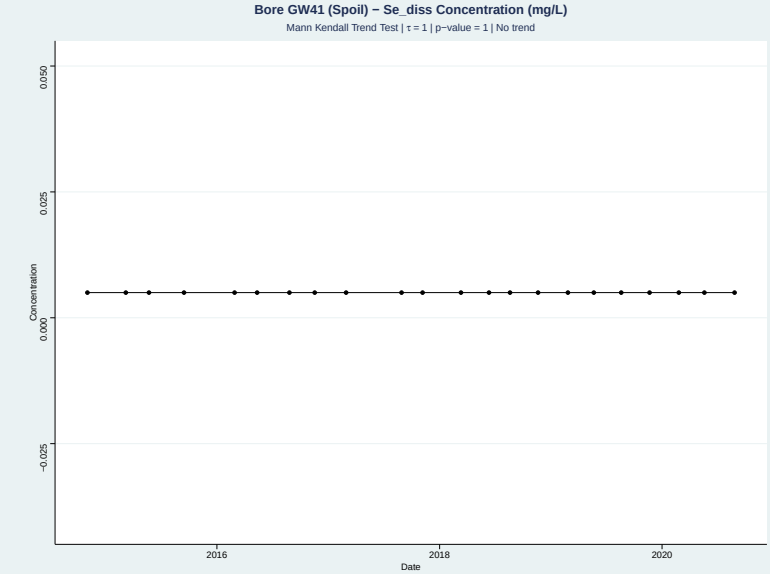
Appendix C Groundwater Quality Time Series

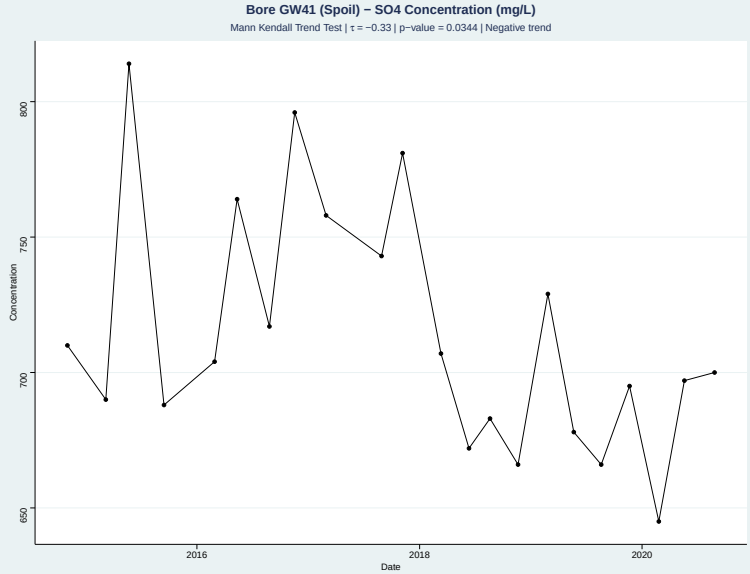




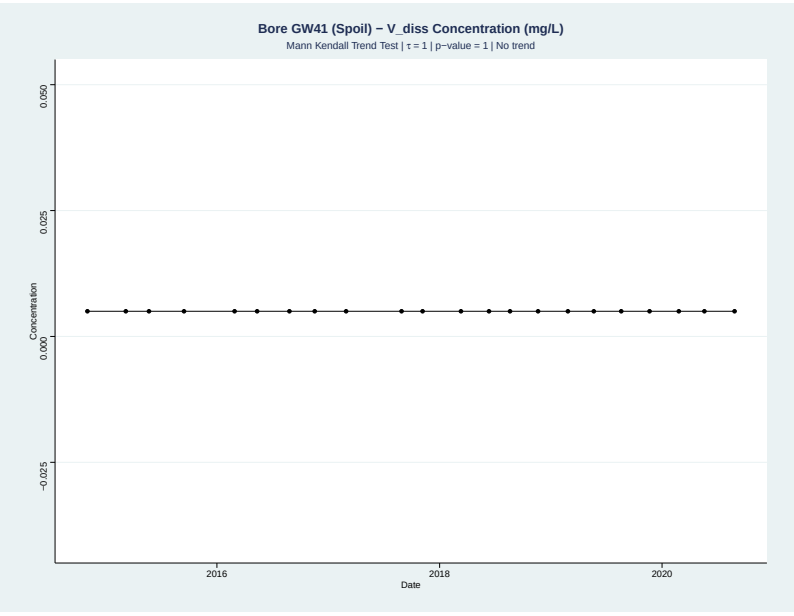


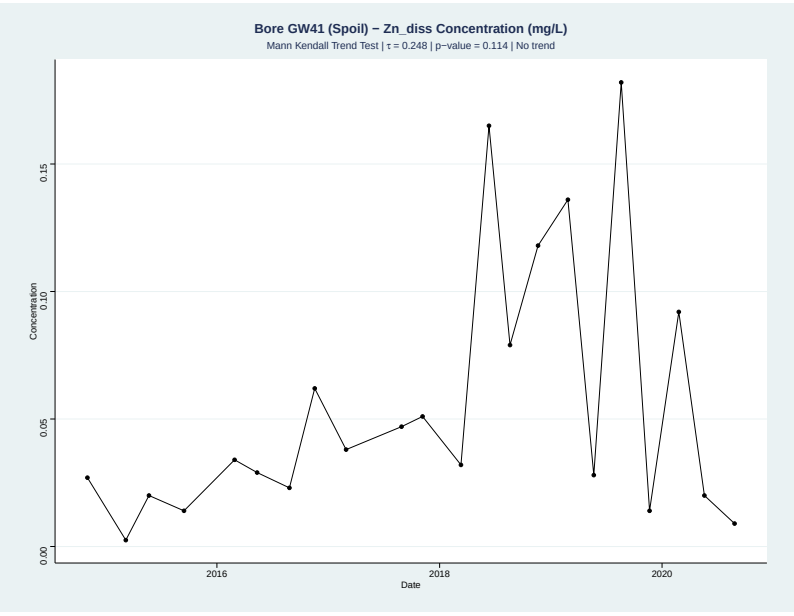


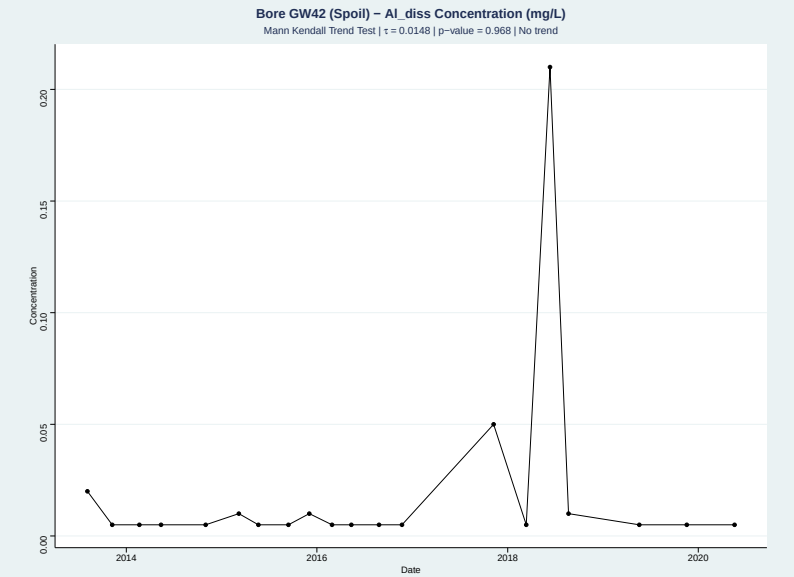


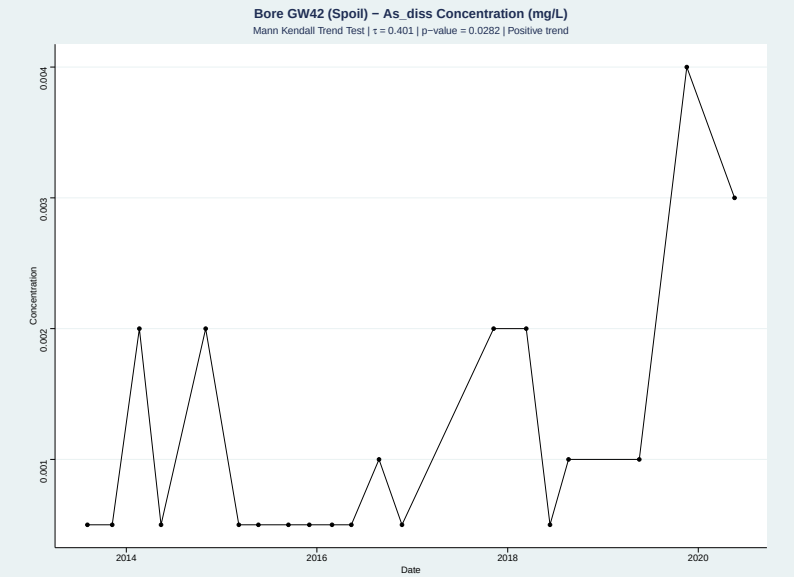


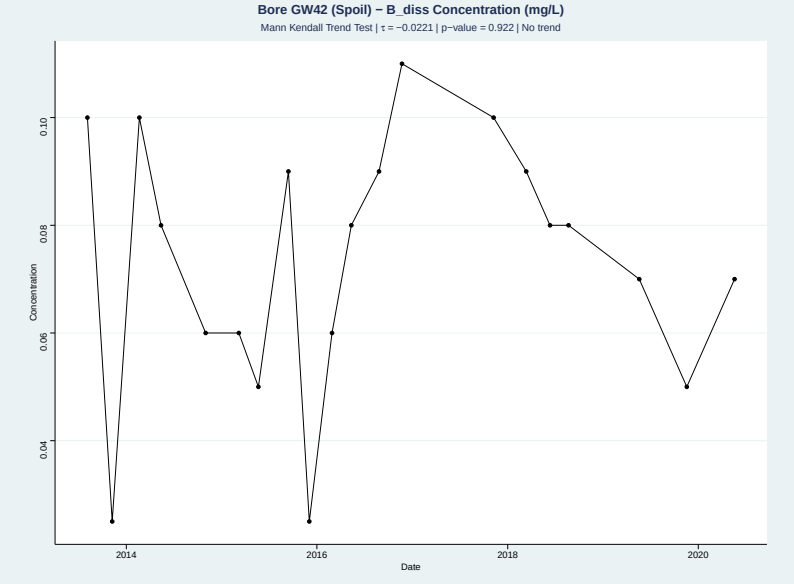
Appendix C Groundwater Quality Time Series

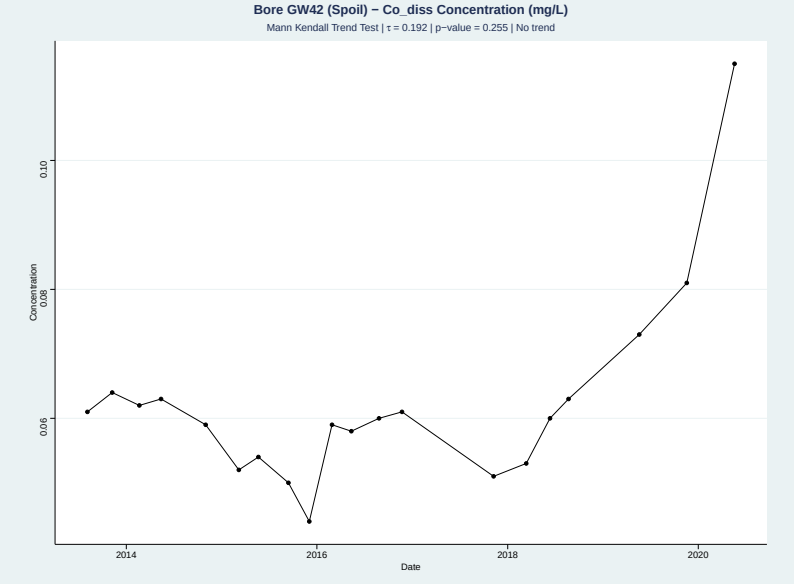




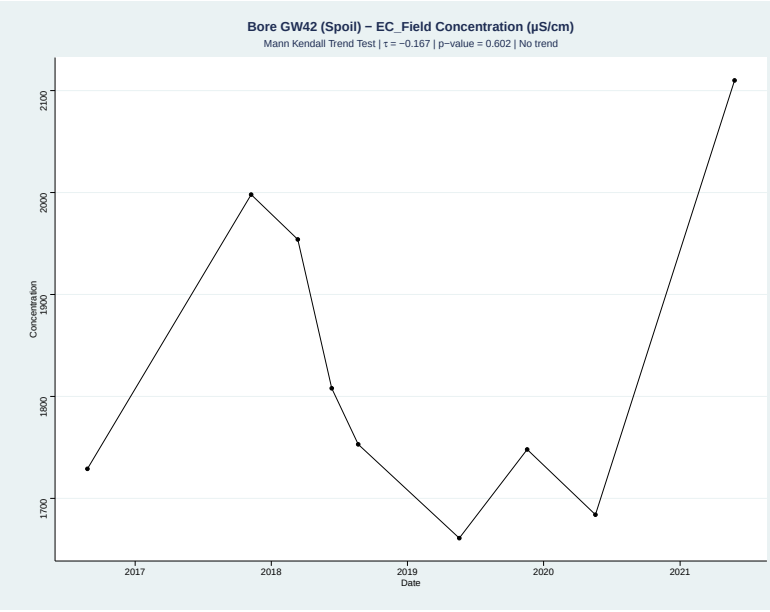


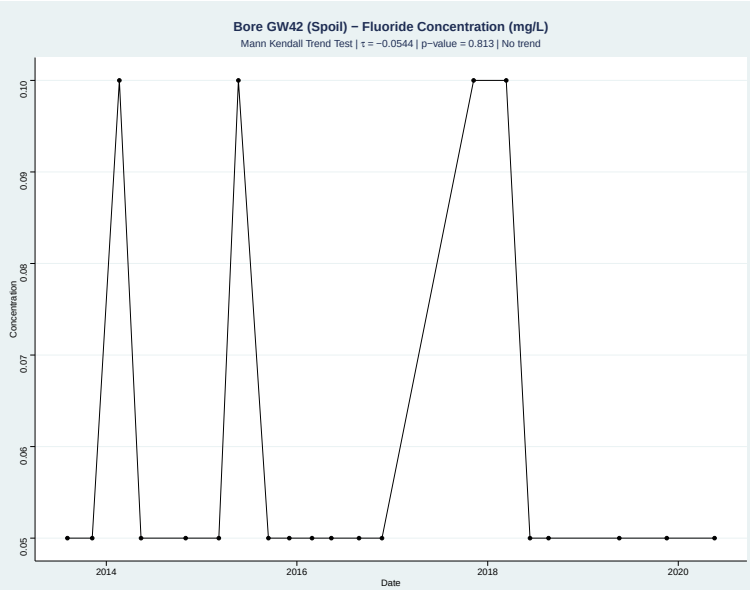


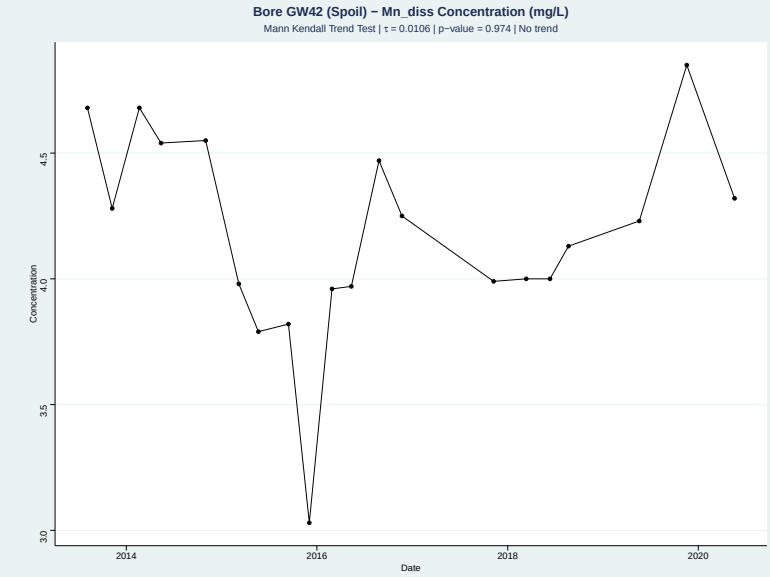


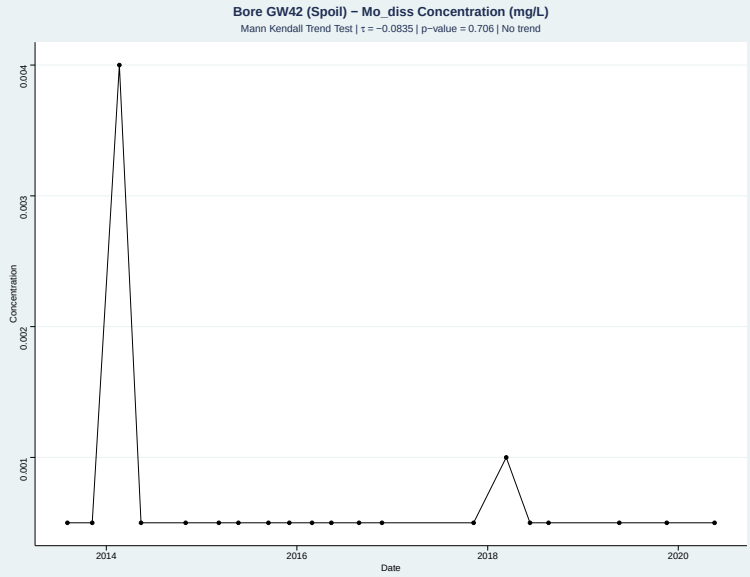


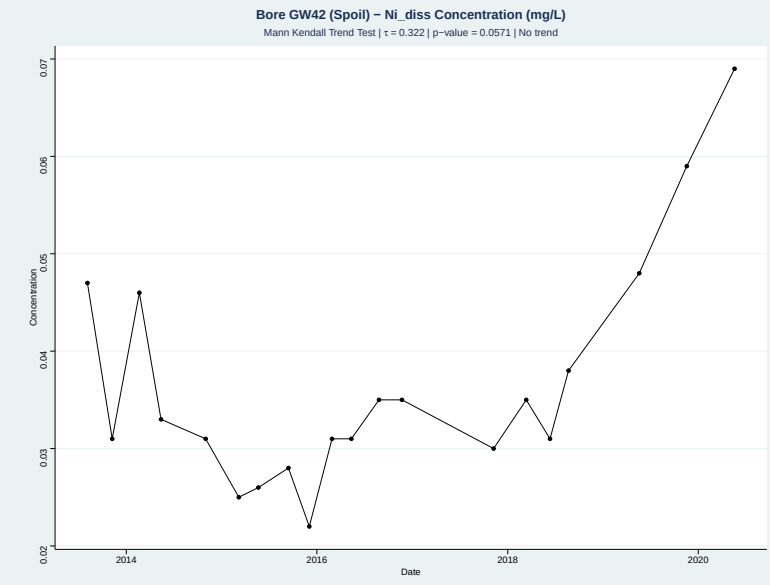
Appendix C Groundwater Quality Time Series

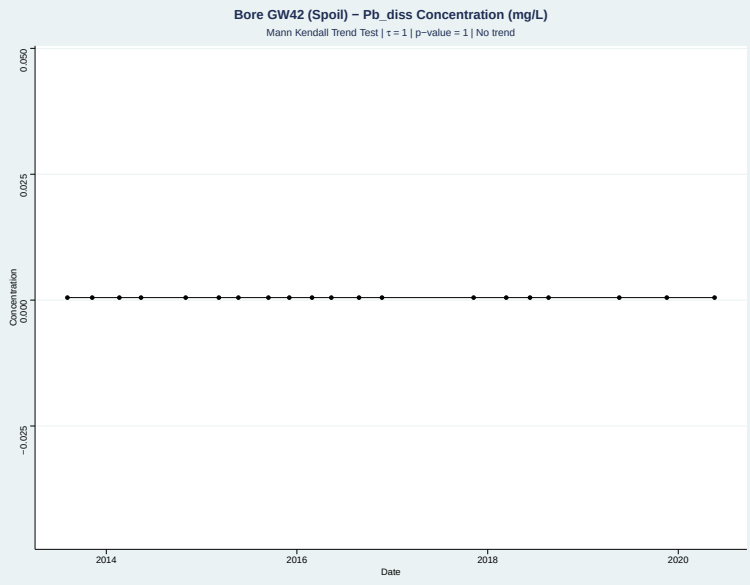


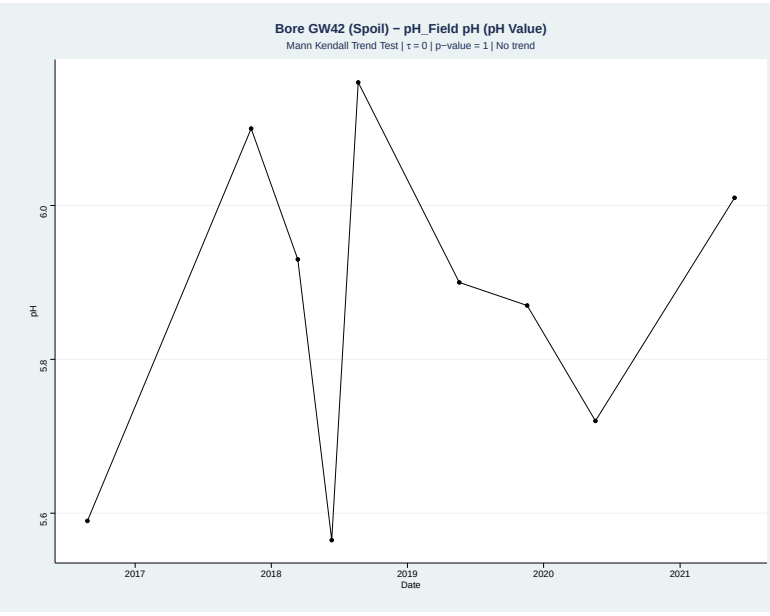


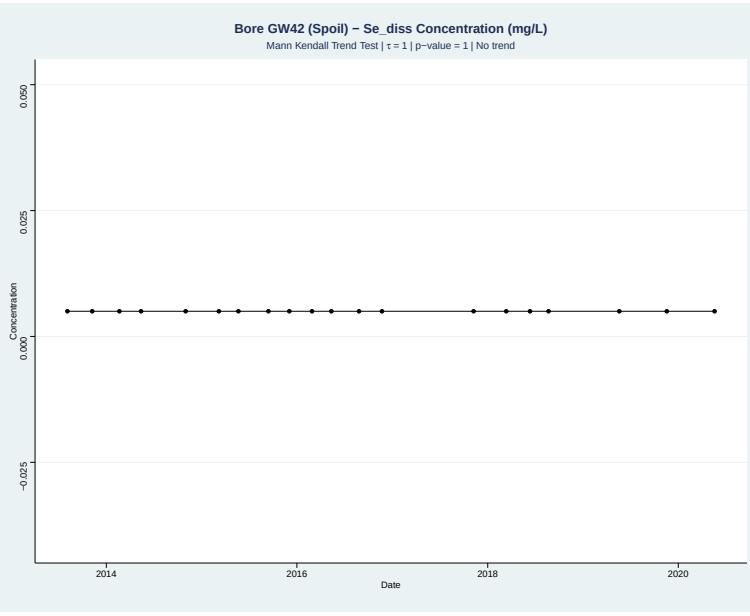


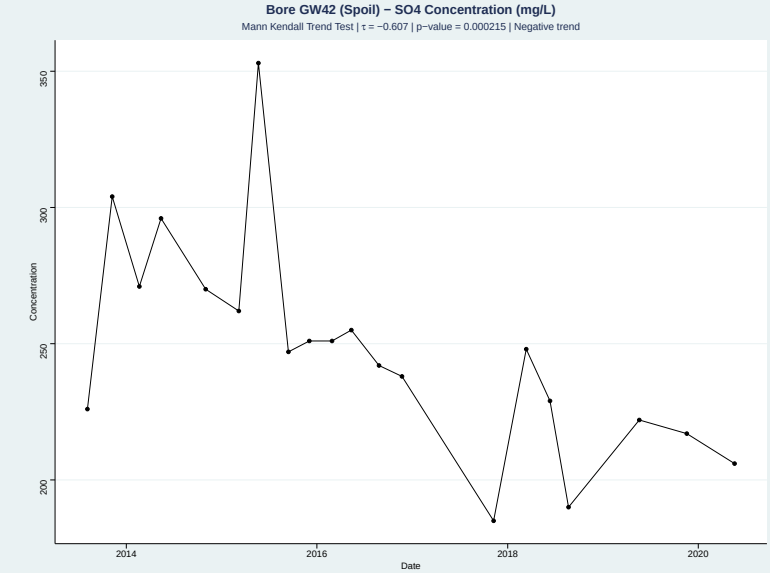


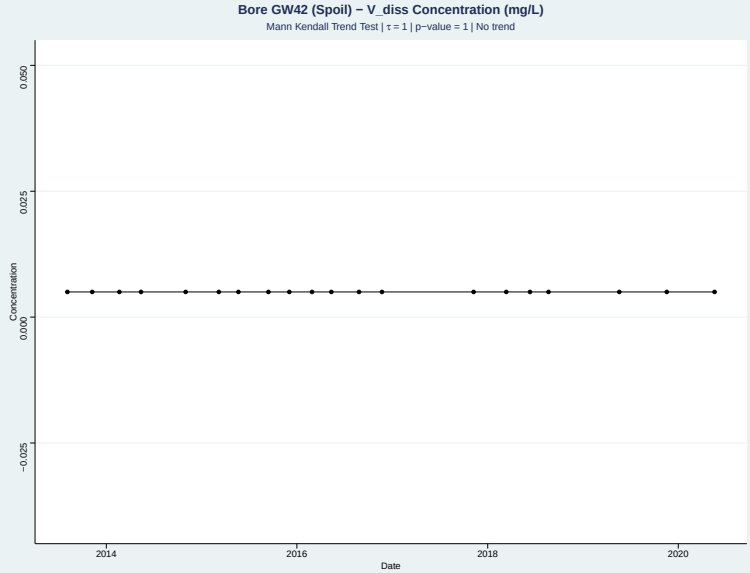


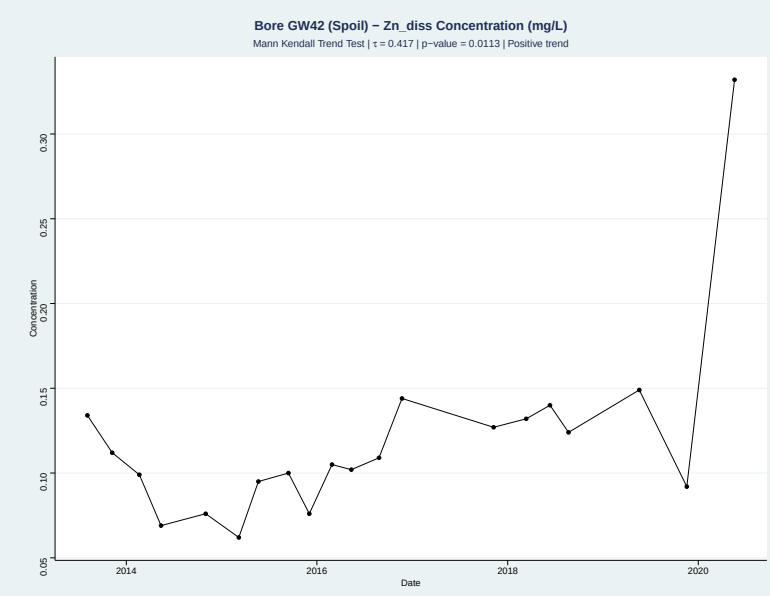


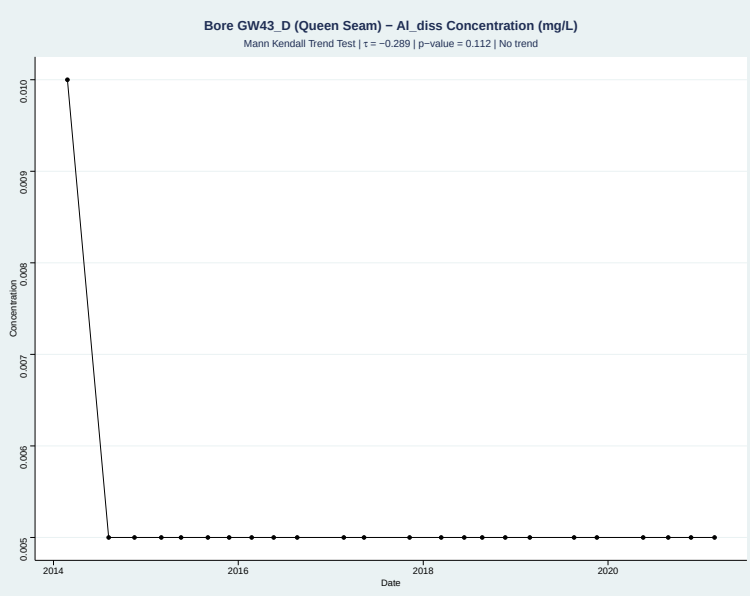

Bore GW42 (Spoil) − pH_Field pH (pH Value)
Mann Kendall Trend Test | τ = 0 | p−value = 1 | No trend
pH
5.6
5.8
6.0
2017
2018
2019
2020
2021
Date


Bore GW42 (Spoil) − Se_diss Concentration (mg/L)
Mann Kendall Trend Test | τ = 1 | p−value = 1 | No trend
Concentration
−0.025
0.000
0.025
0.050
2014
2016
2018
2020
Date

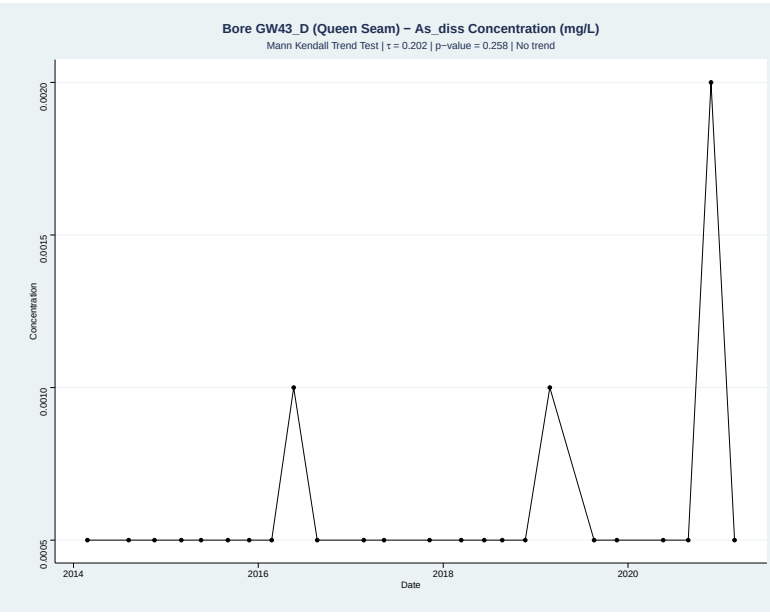

Bore GW42 (Spoil) − SO4 Concentration (mg/L)
Mann Kendall Trend Test | τ = −0.607 | p−value = 0.000215 | Negative trend
Concentration
200
250
300
350
2014
2016
2018
2020
Date

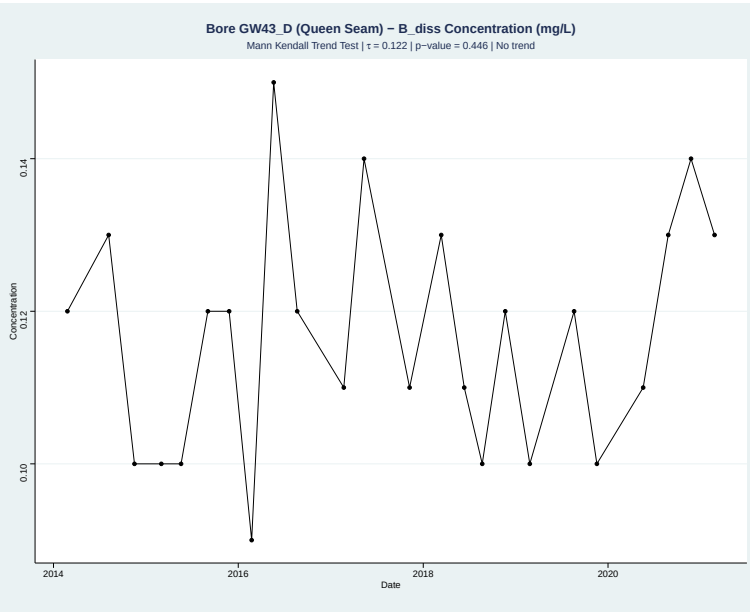

Bore GW42 (Spoil) − V_diss Concentration (mg/L)
Mann Kendall Trend Test | τ = 1 | p−value = 1 | No trend
Concentration
−0.025
0.000
0.025
0.050
2014
2016
2018
2020
Date

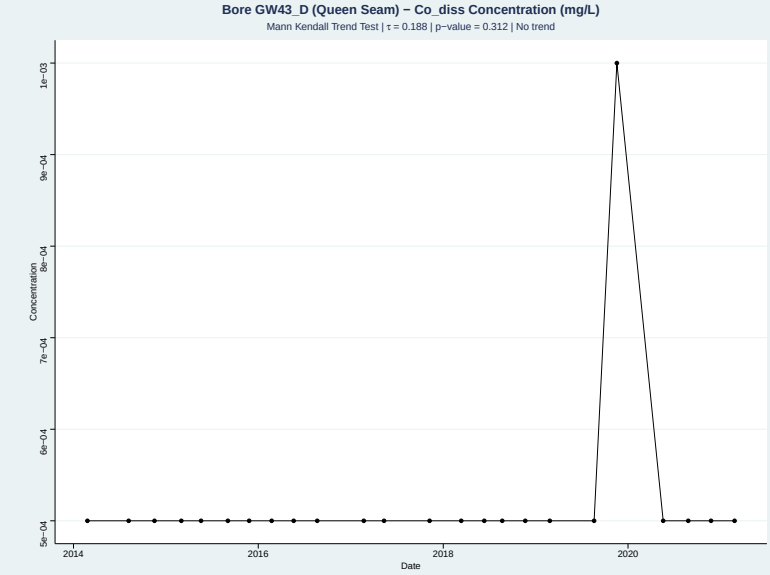

Bore GW42 (Spoil) − Zn_diss Concentration (mg/L)
Mann Kendall Trend Test | τ = 0.417 | p−value = 0.0113 | Positive trend
Concentration
0.05
0.10
0.15
0.20
0.25
0.30
2014
2016
2018
2020
Date

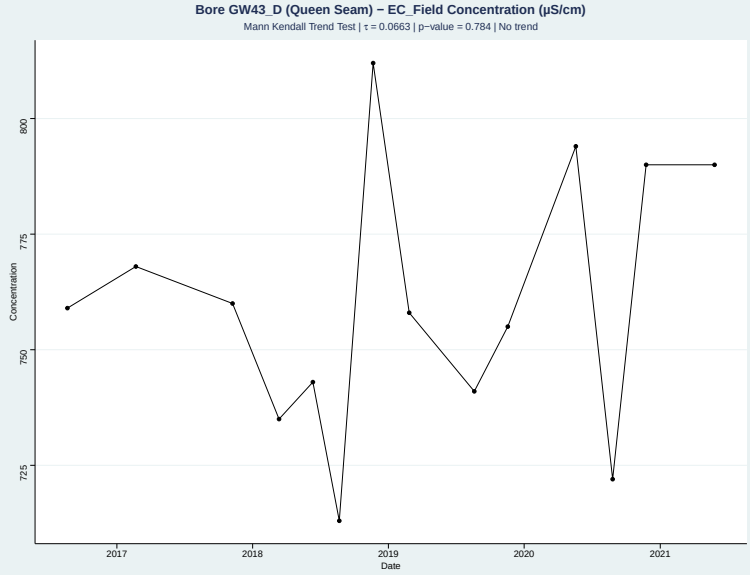

Bore GW43_D (Queen Seam) − Al_diss Concentration (mg/L)
Mann Kendall Trend Test | τ = −0.289 | p−value = 0.112 | No trend
Concentration
0.005
0.006
0.007
0.008
0.009
0.010
2014
2016
2018
2020
Date

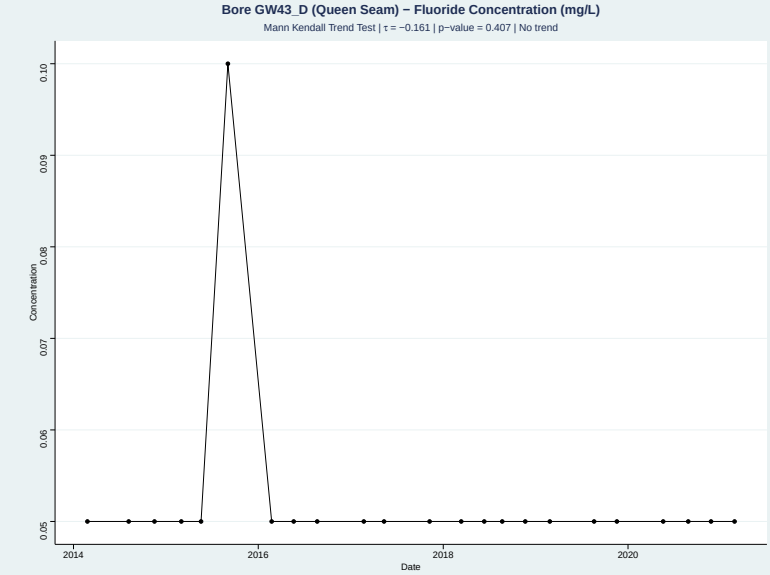
Appendix C Groundwater Quality Time Series

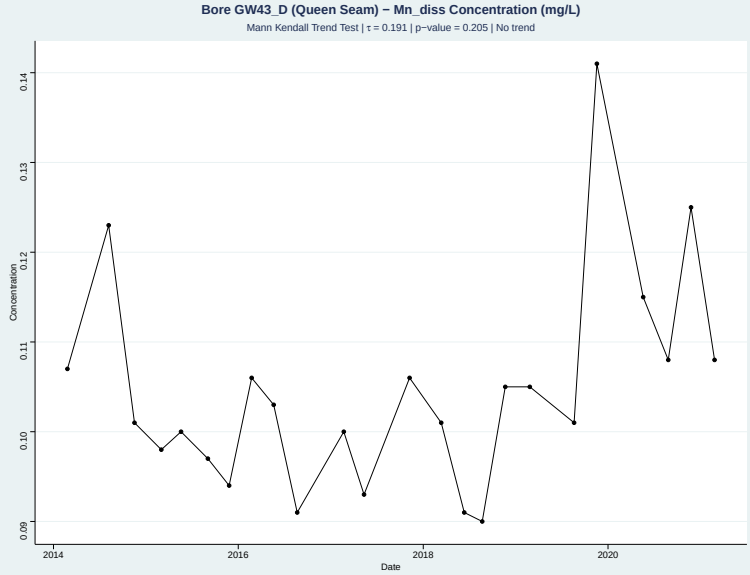




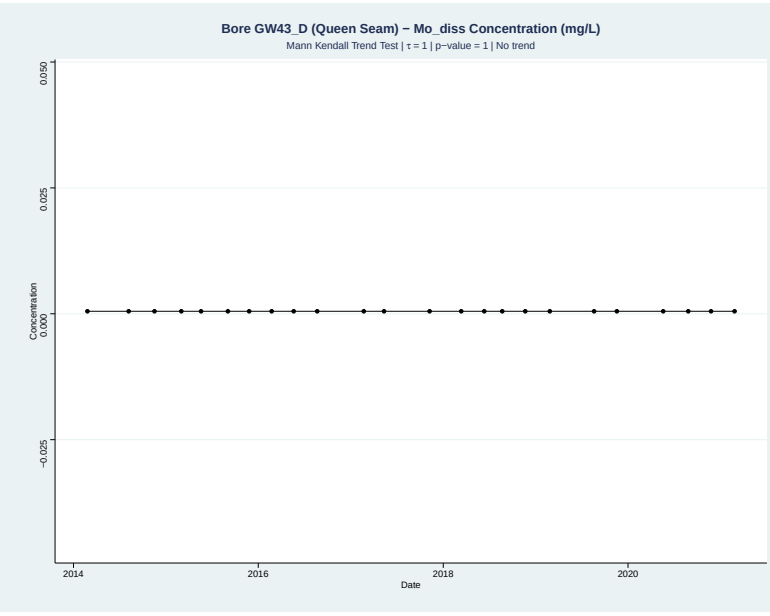


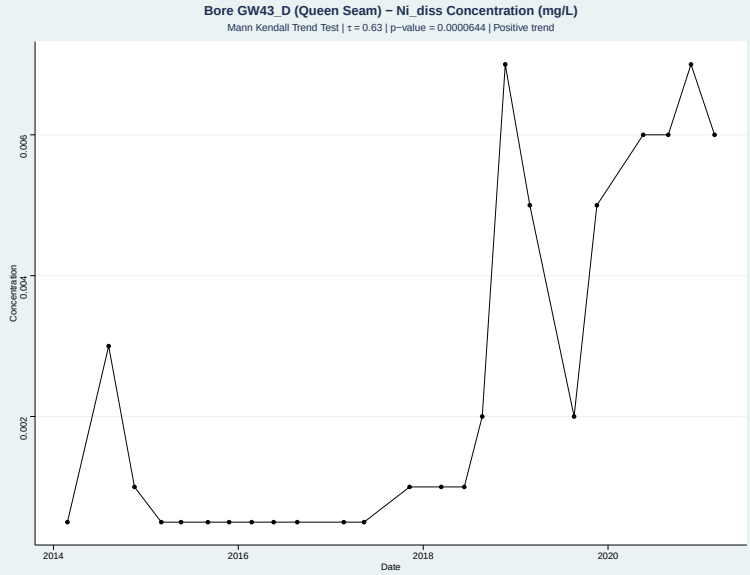


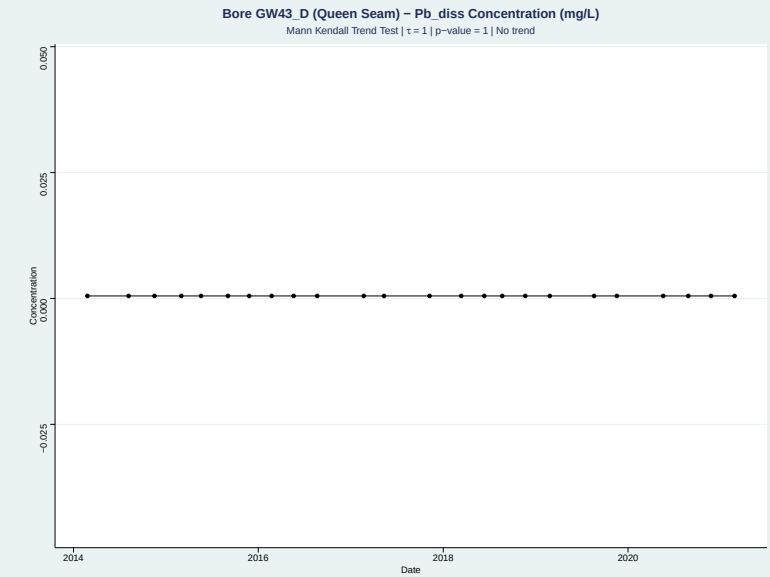


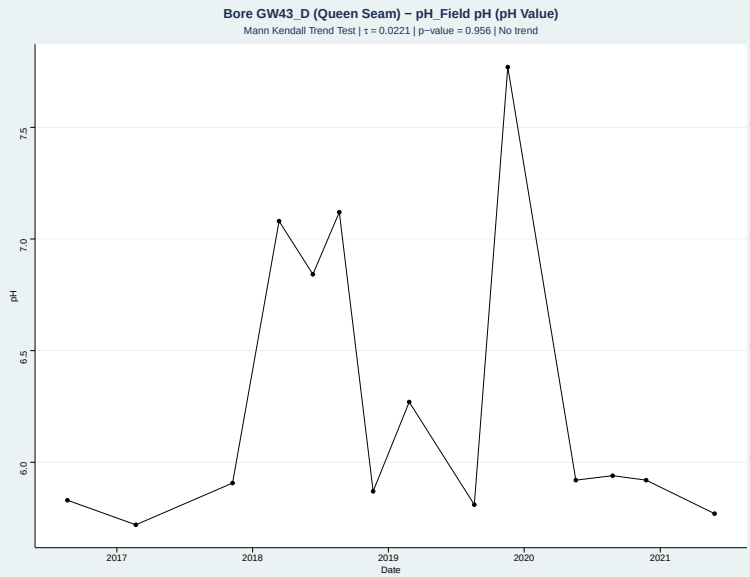


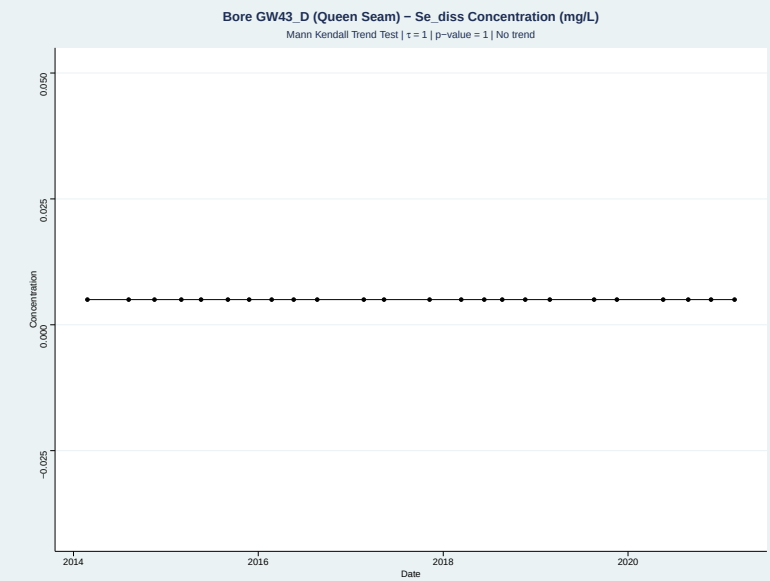
Appendix C Groundwater Quality Time Series

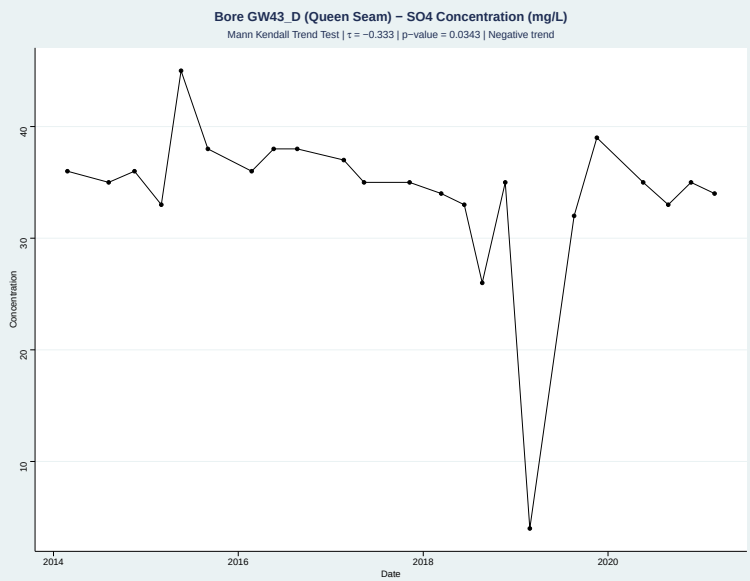




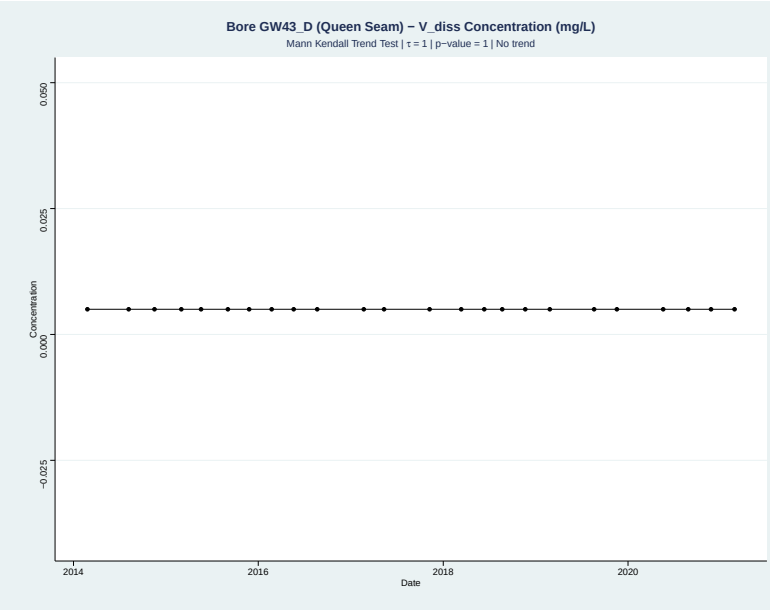


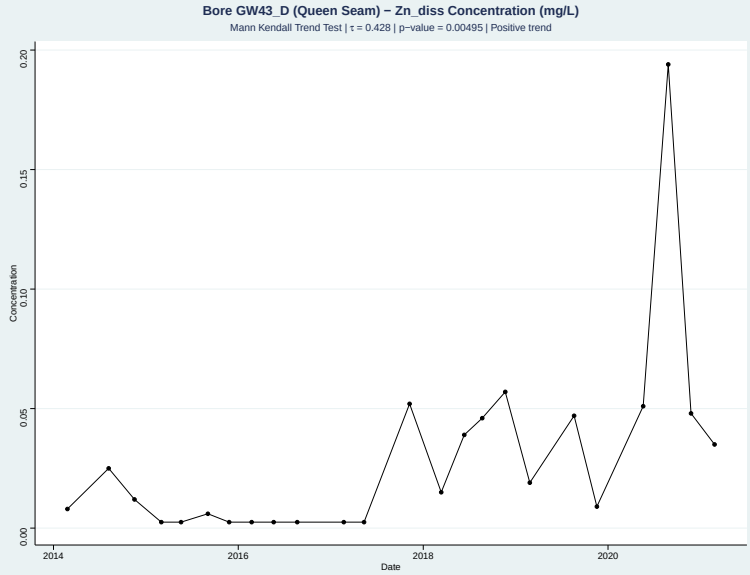


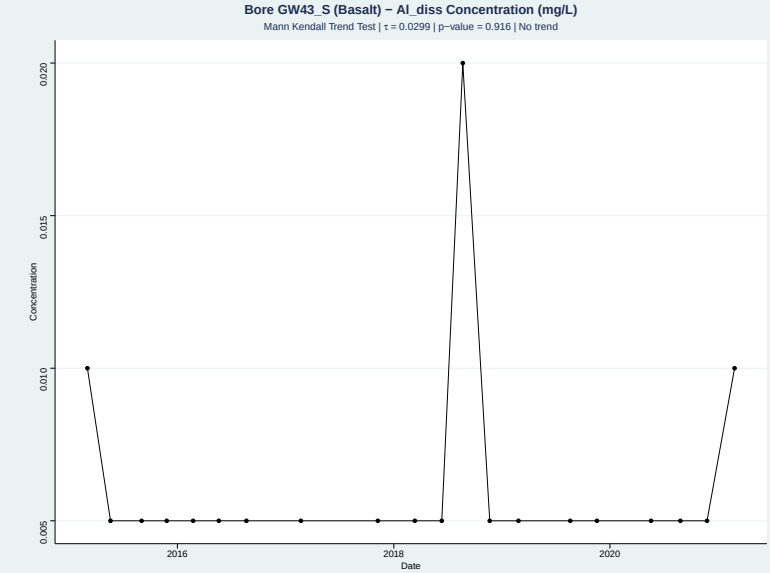


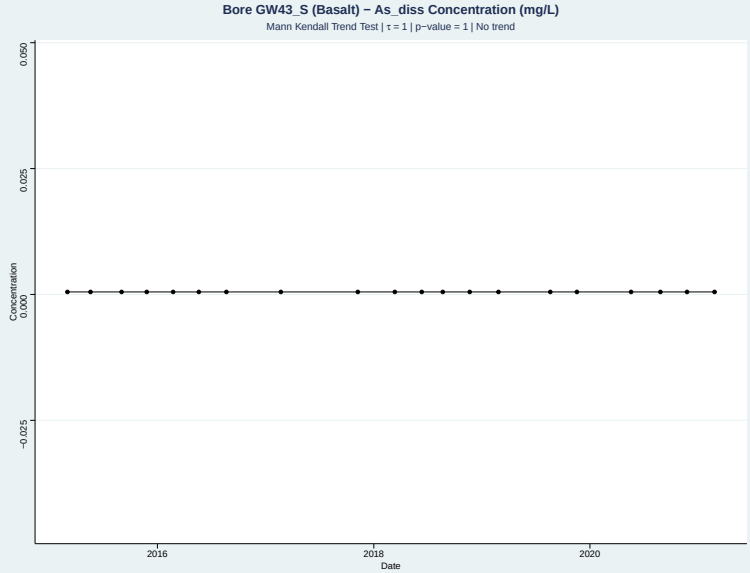


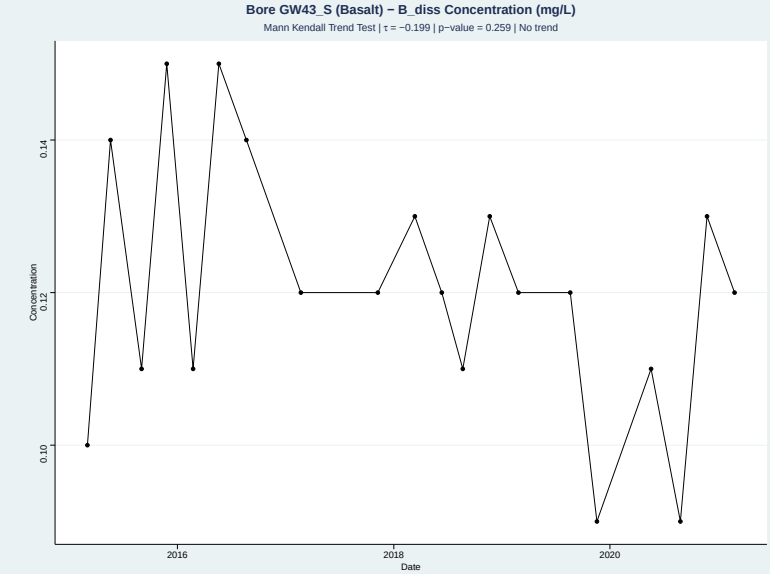
Appendix C Groundwater Quality Time Series

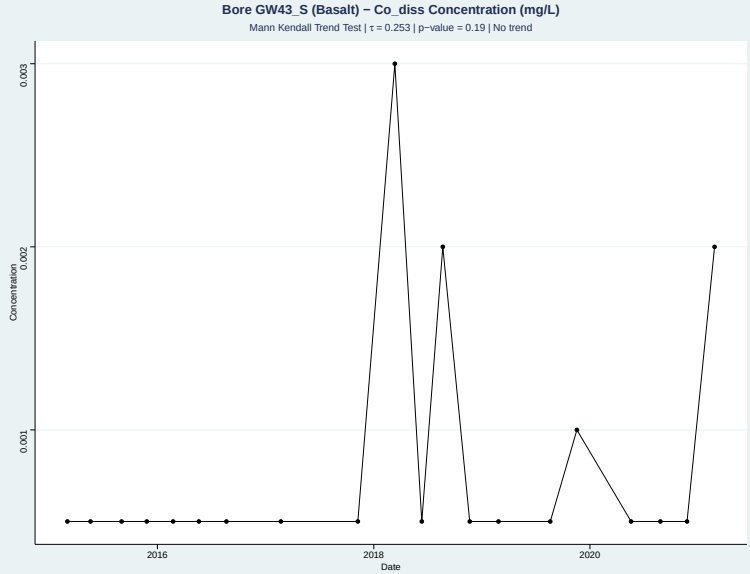




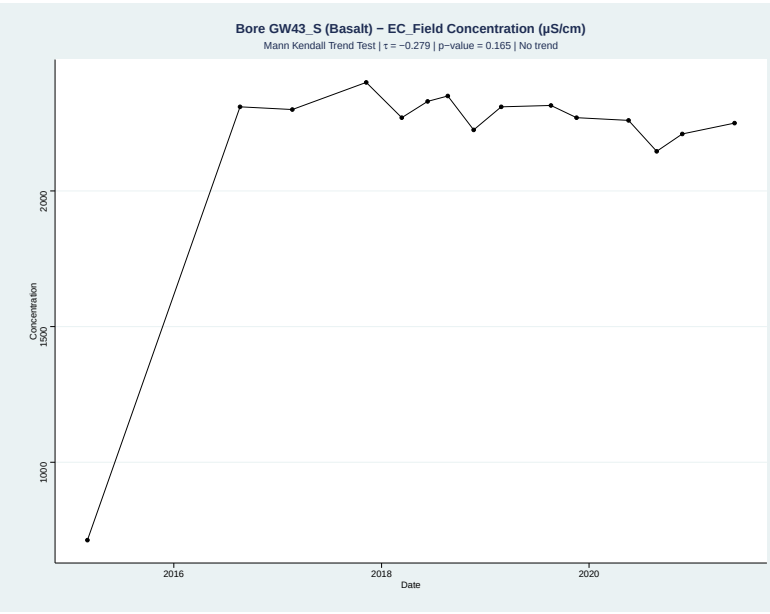


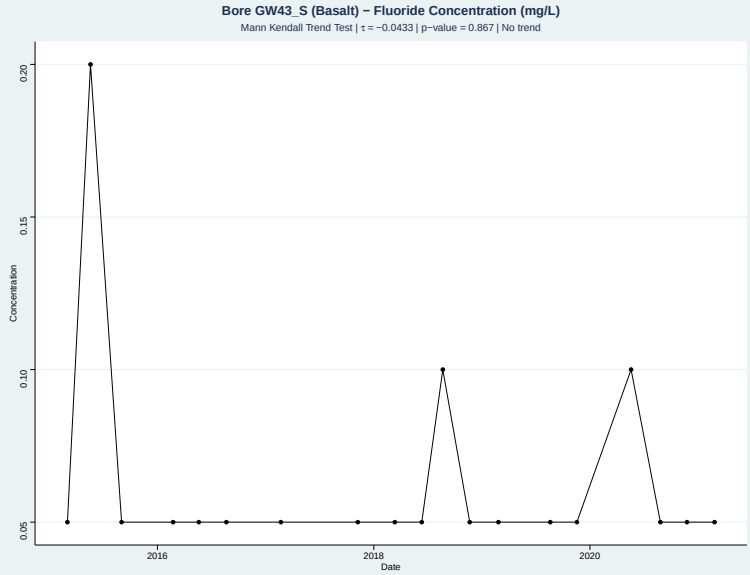


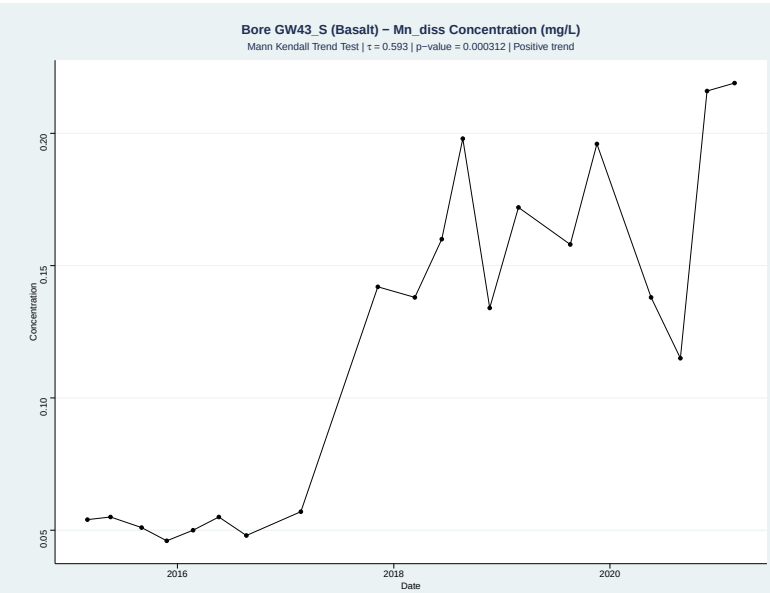


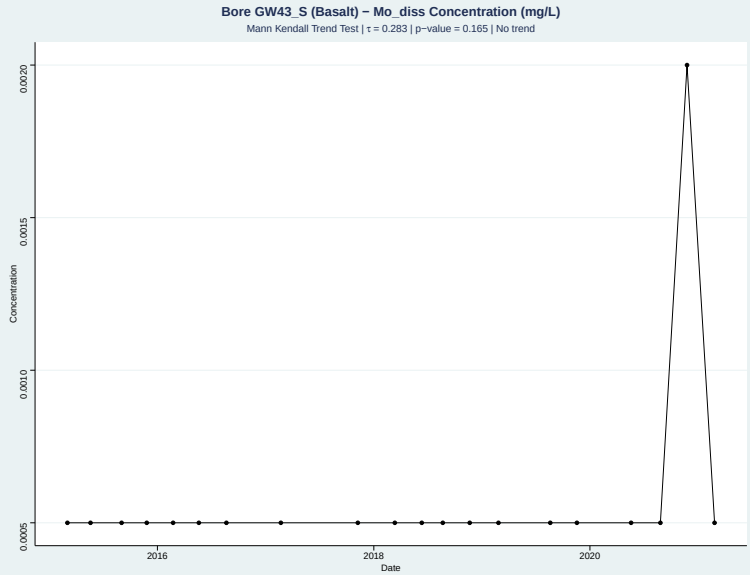


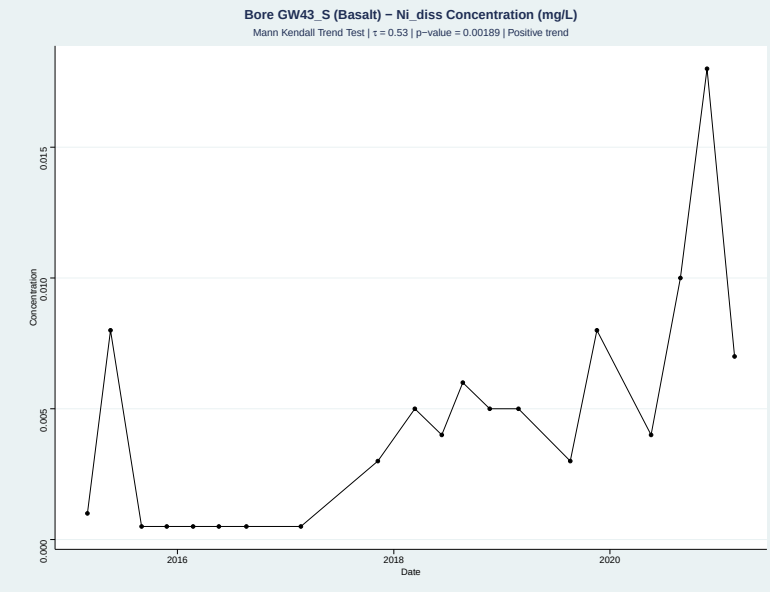
Appendix C Groundwater Quality Time Series

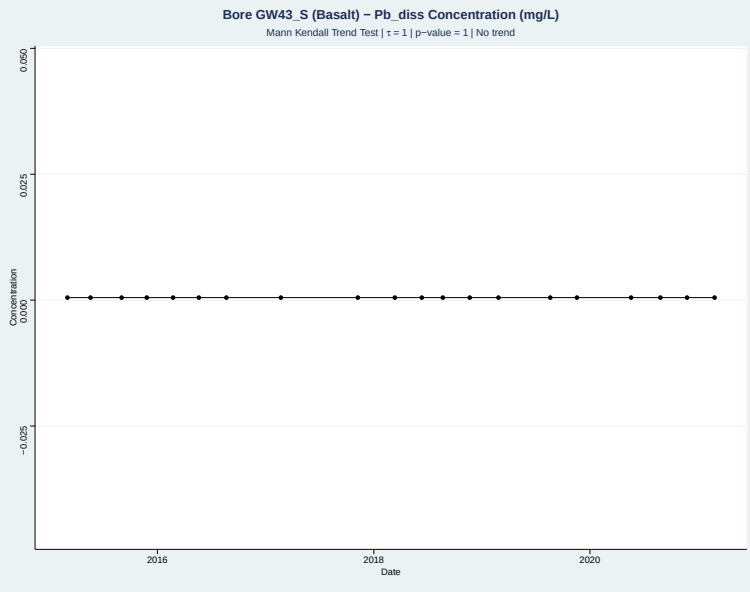




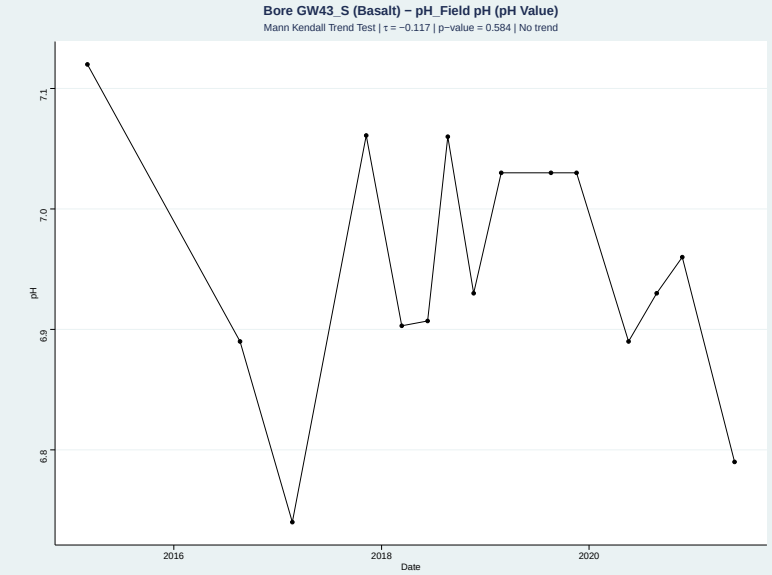


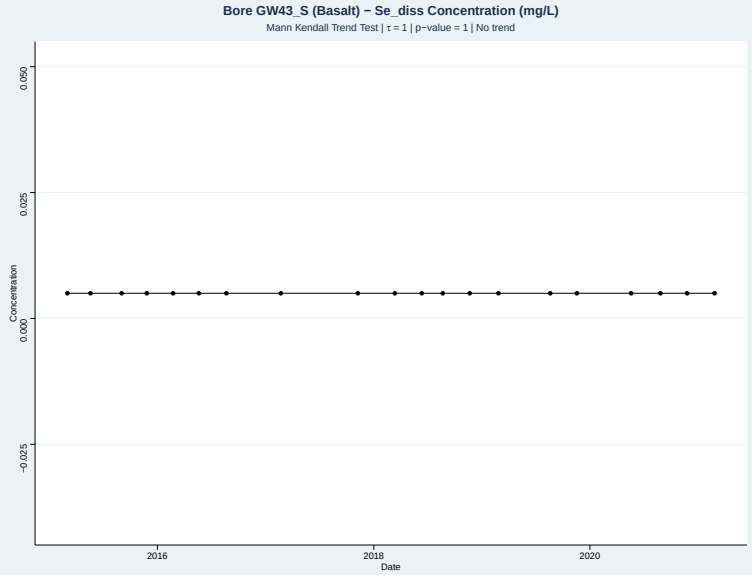


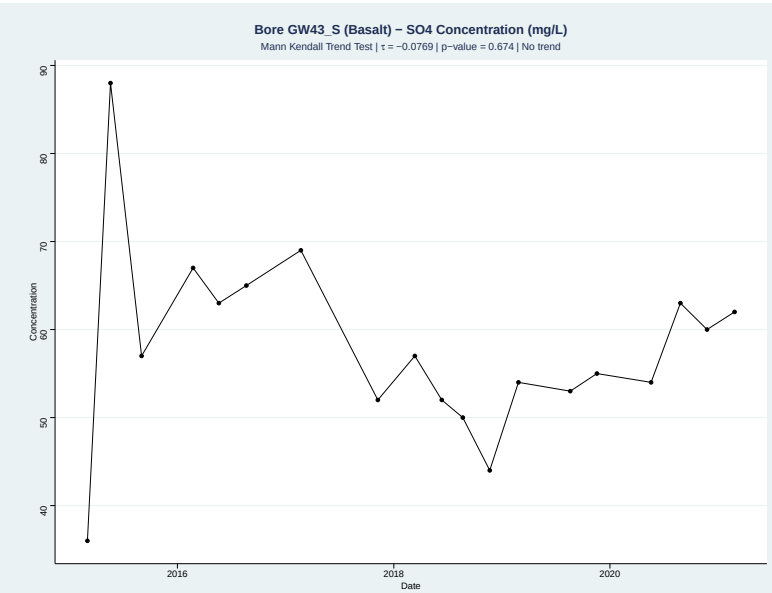


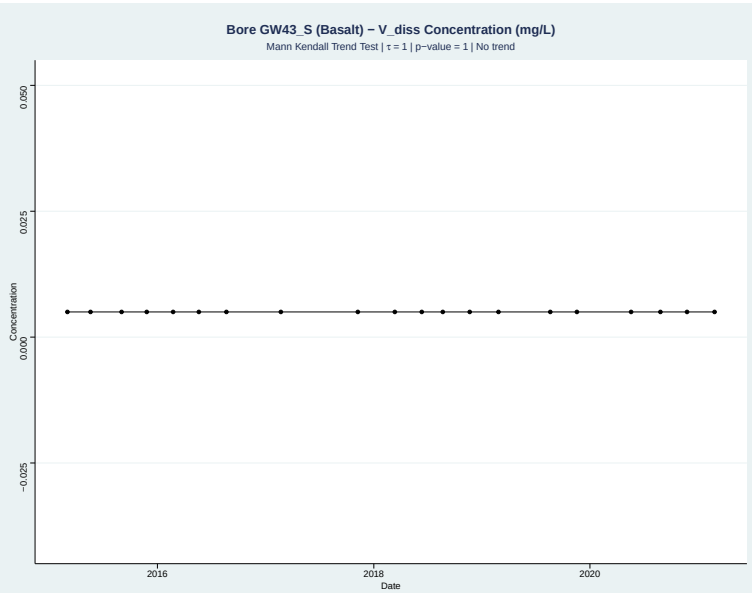


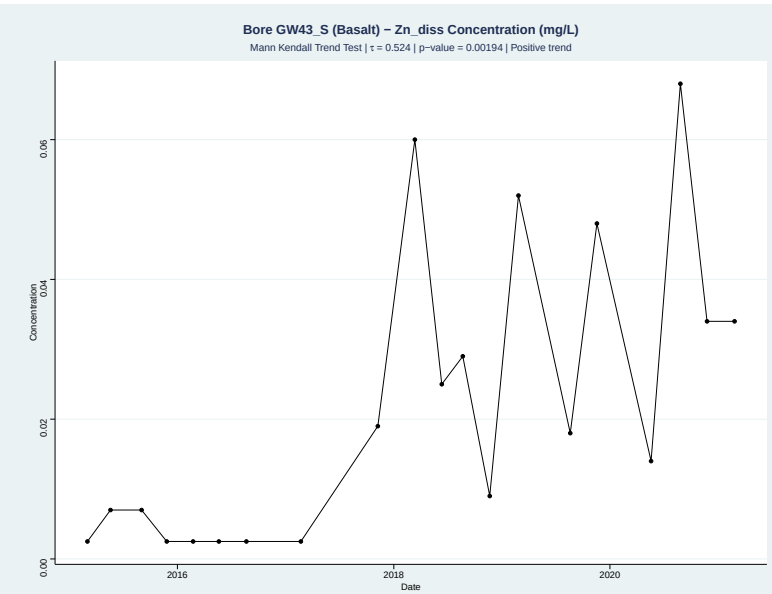
Appendix C Groundwater Quality Time Series

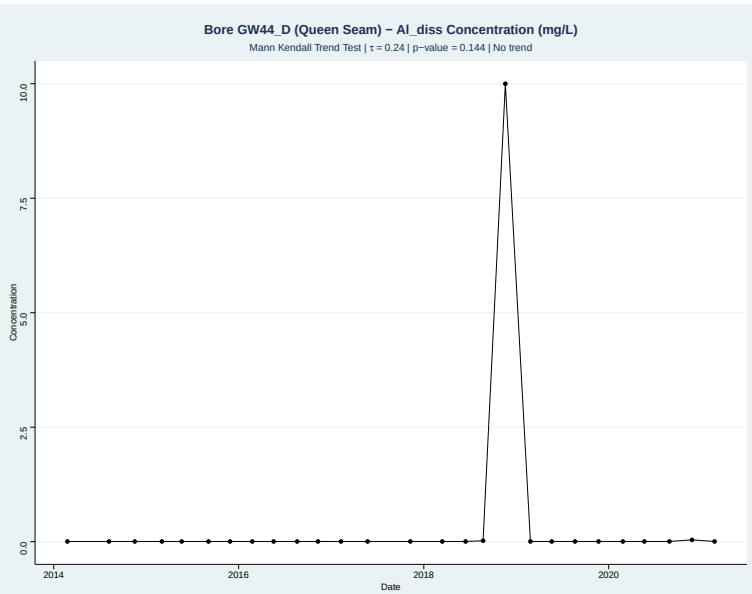




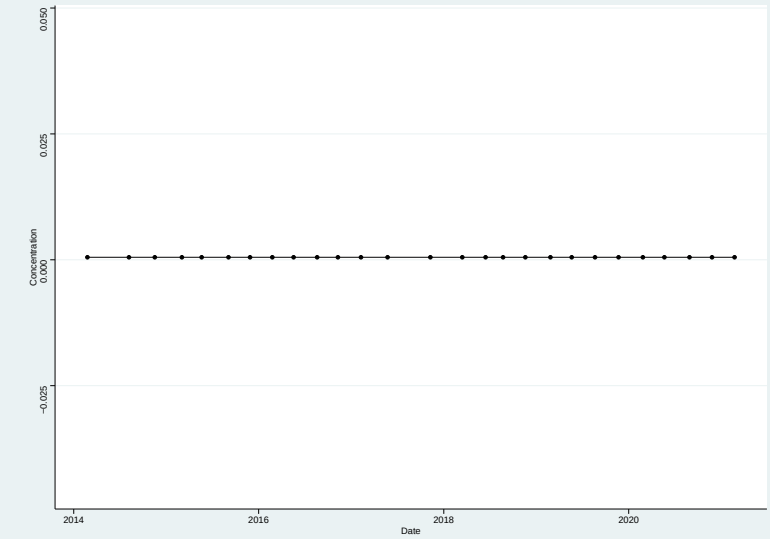


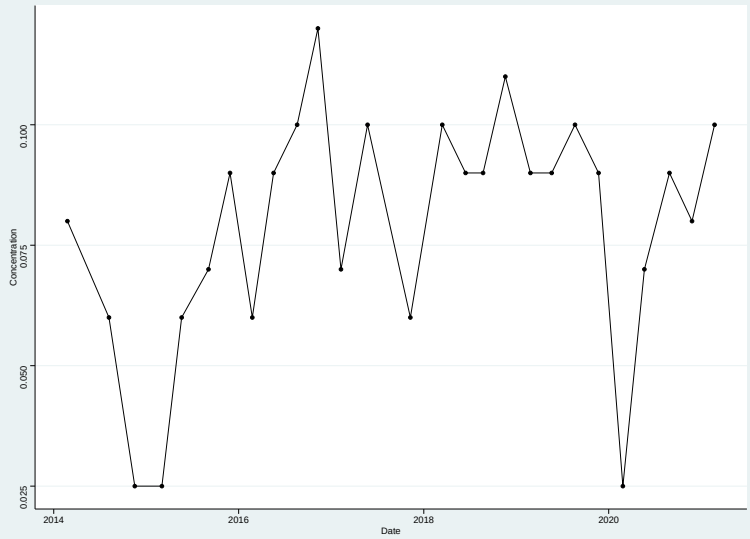


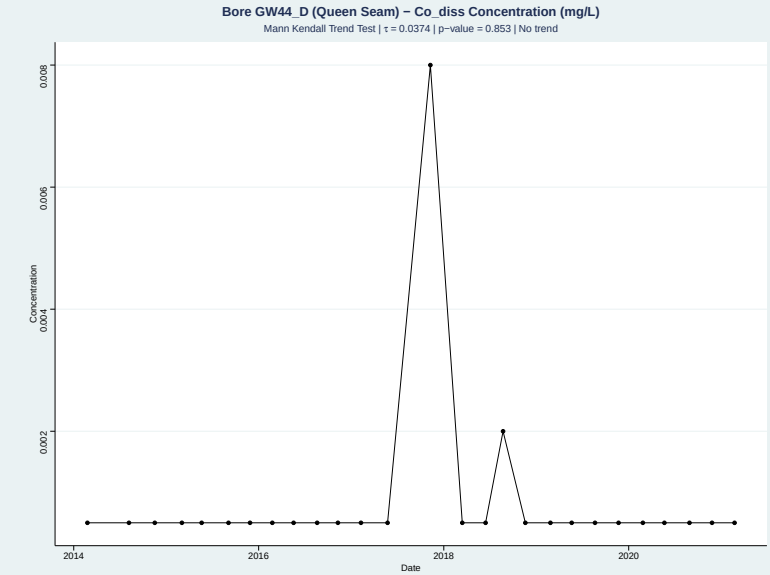


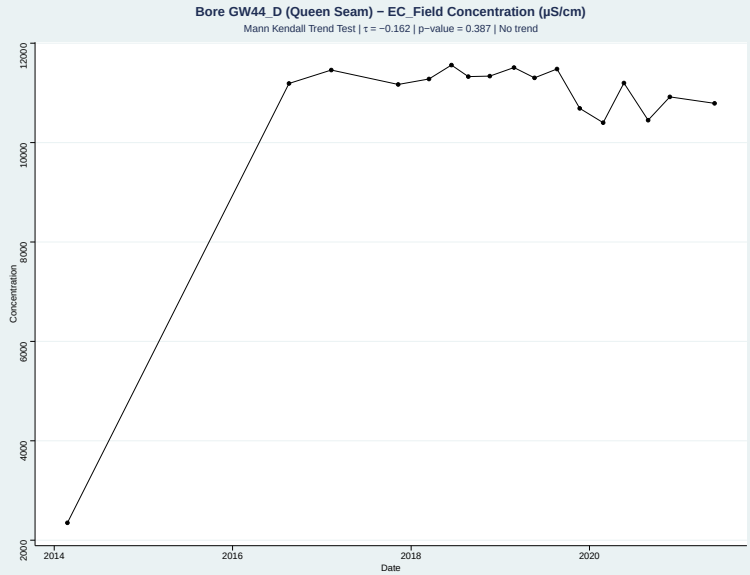


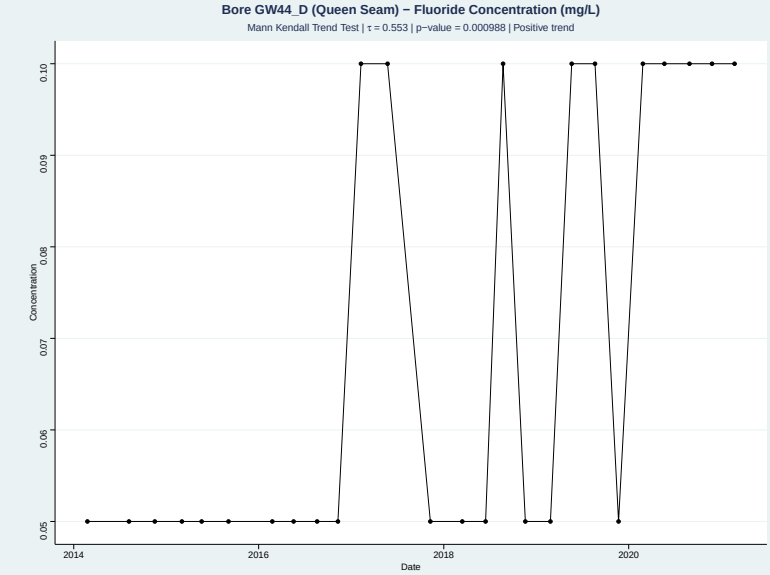
Appendix C Groundwater Quality Time Series

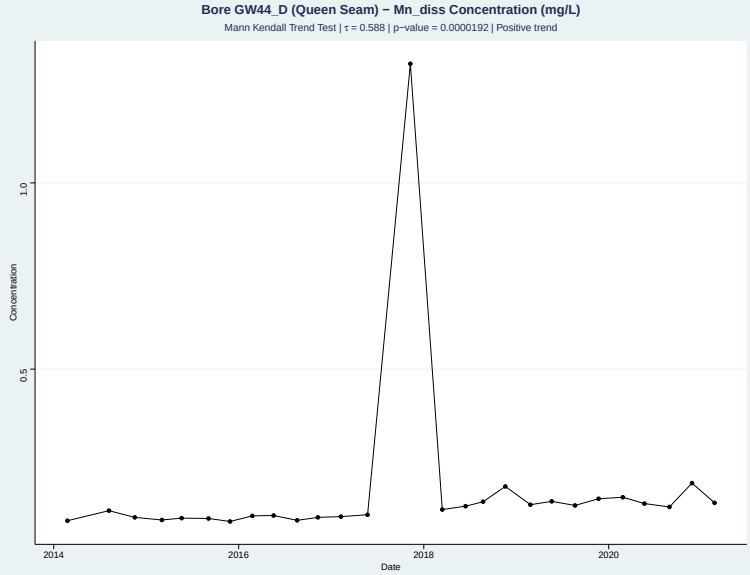




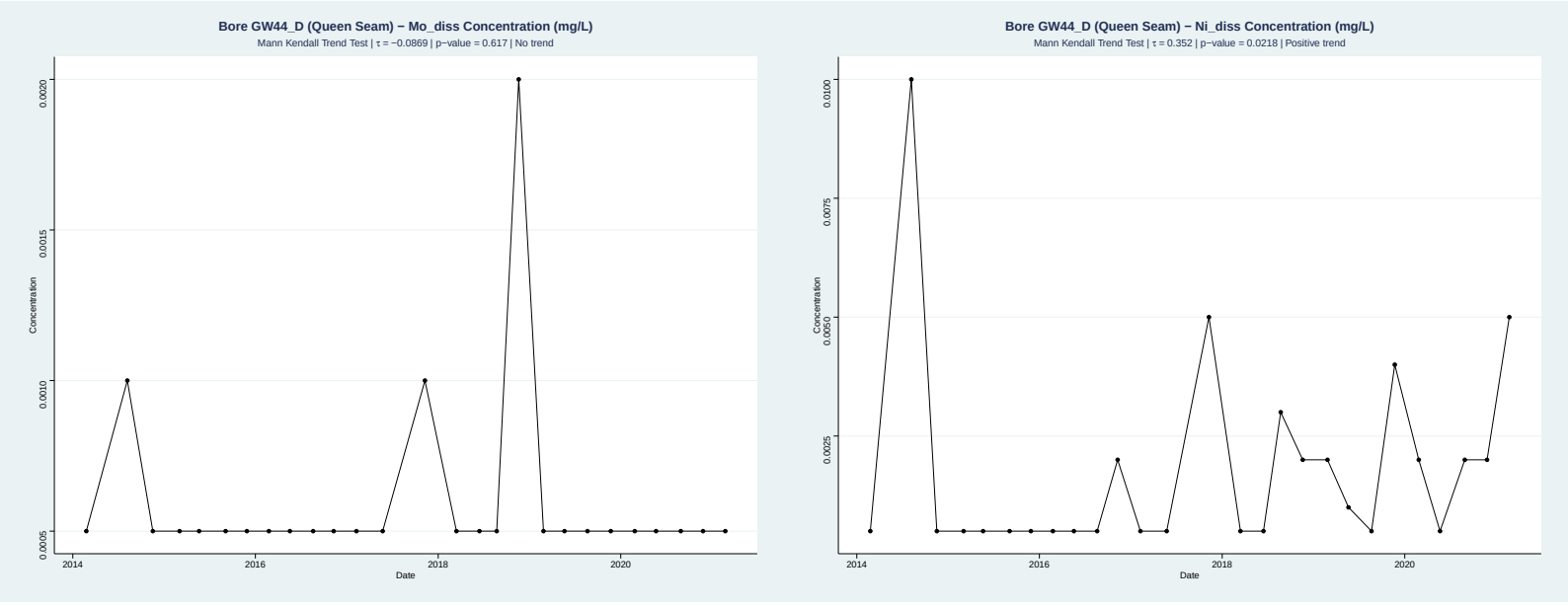


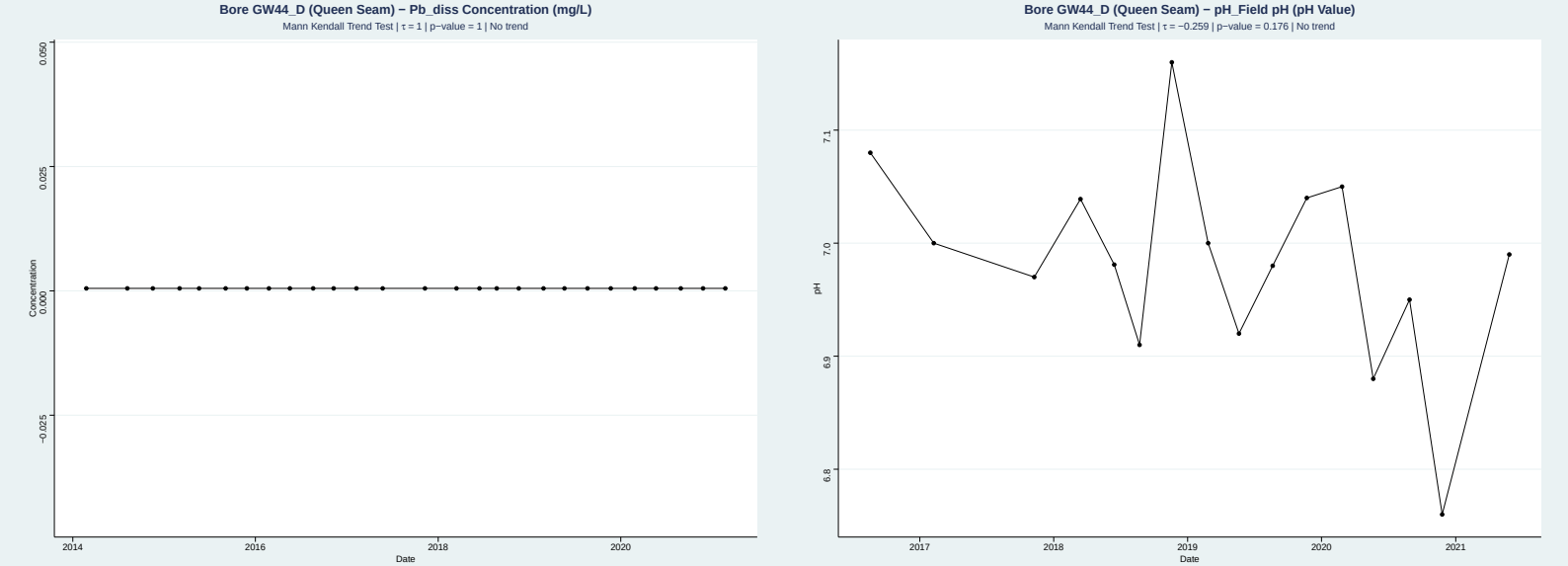


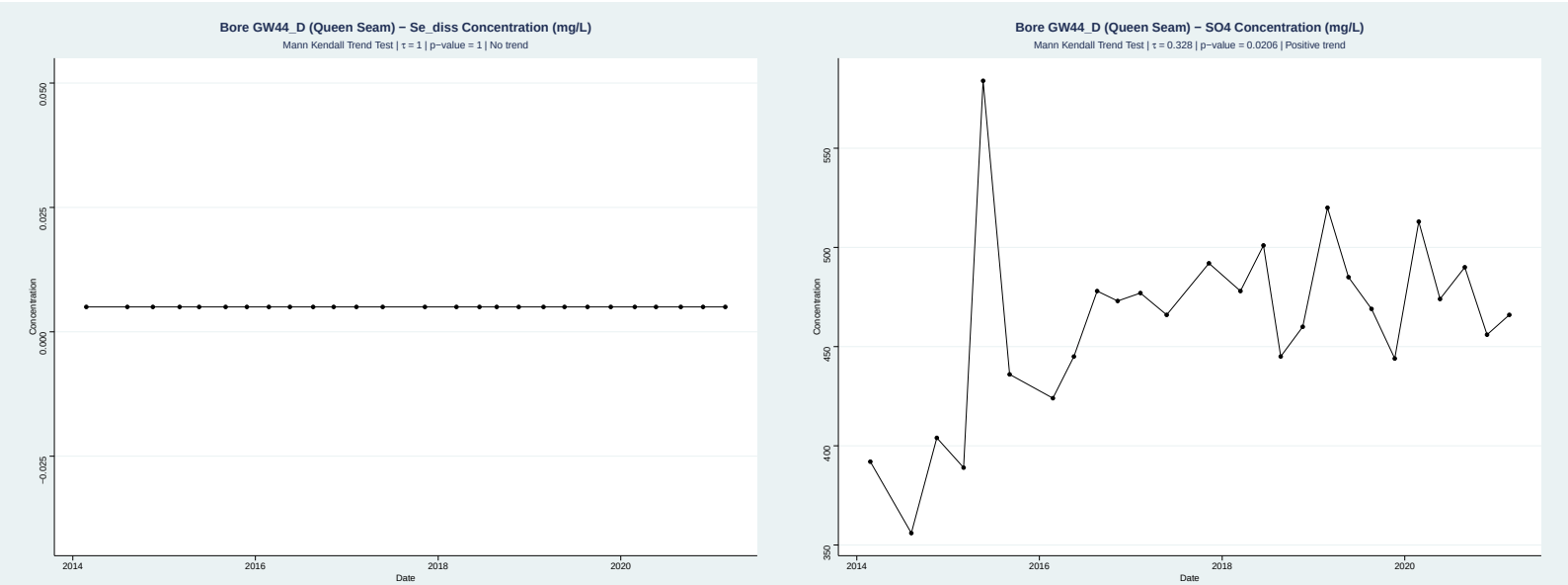




Appendix C Groundwater Quality Time Series







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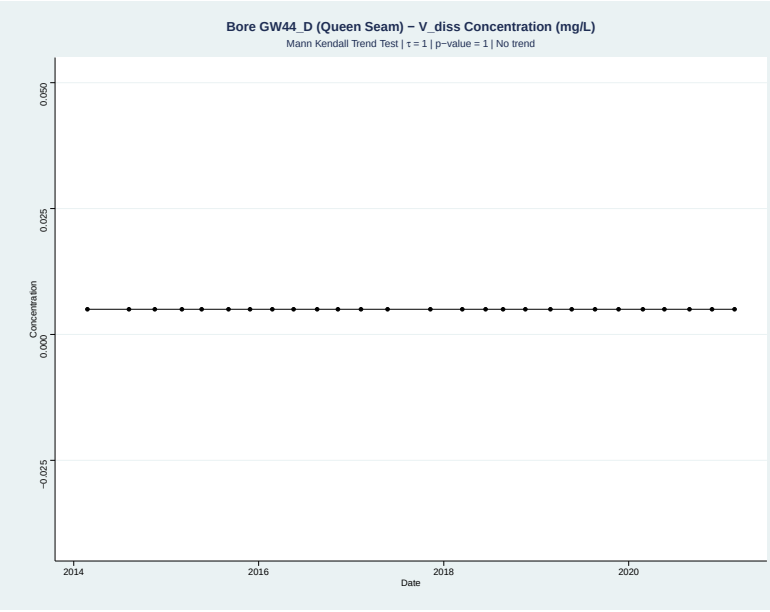

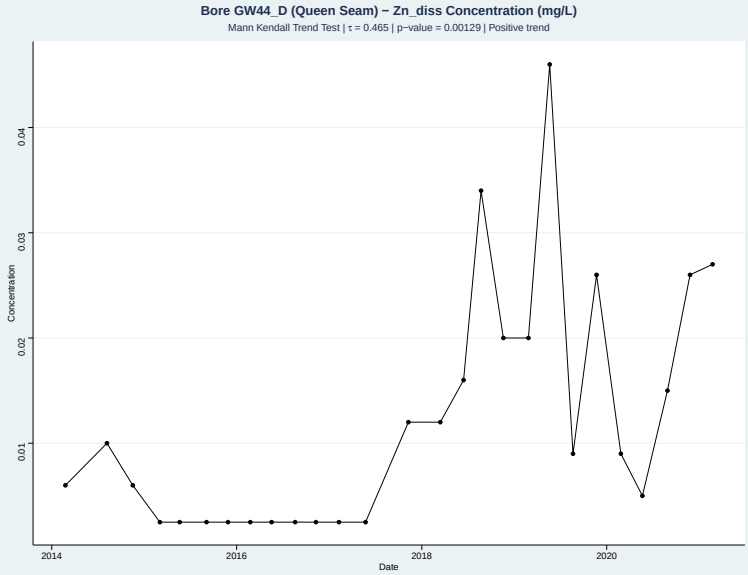

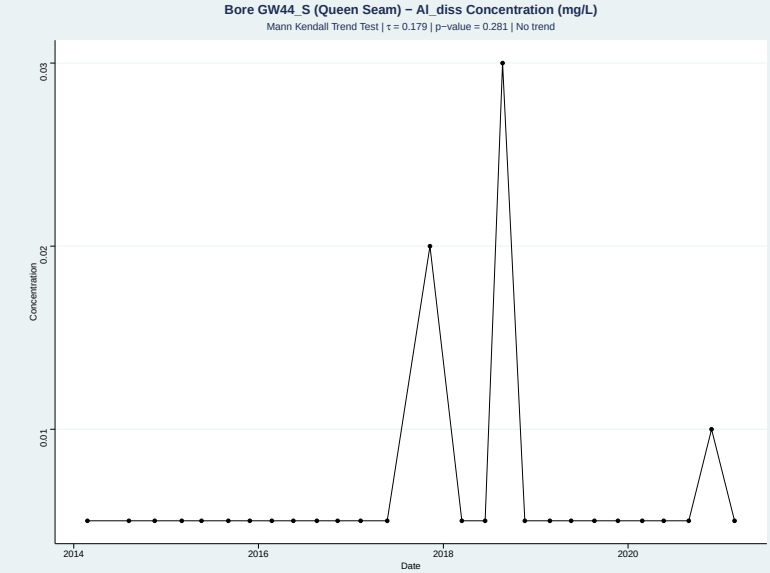

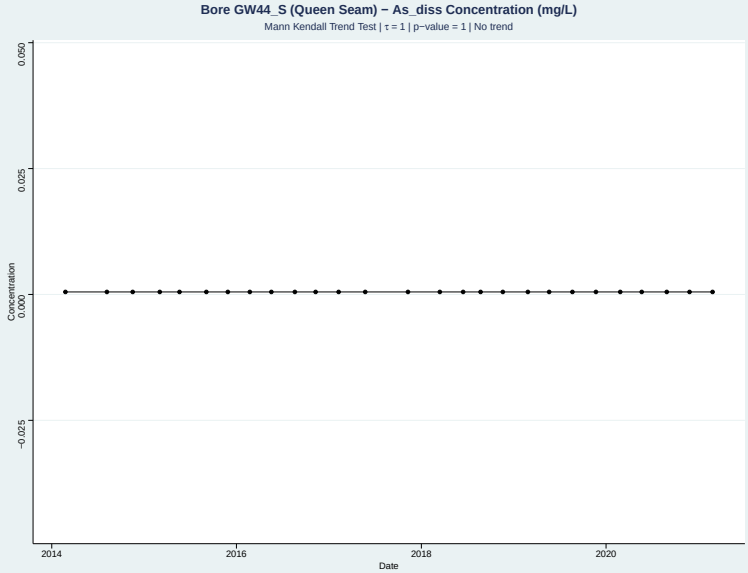

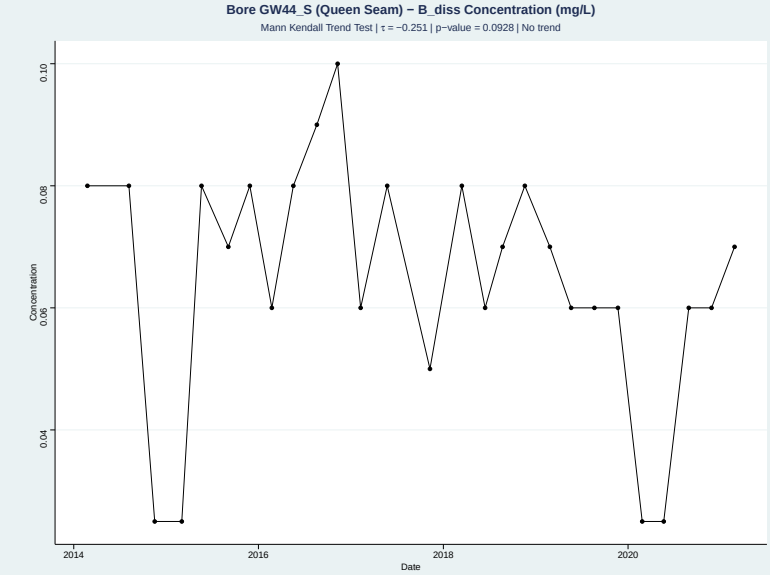

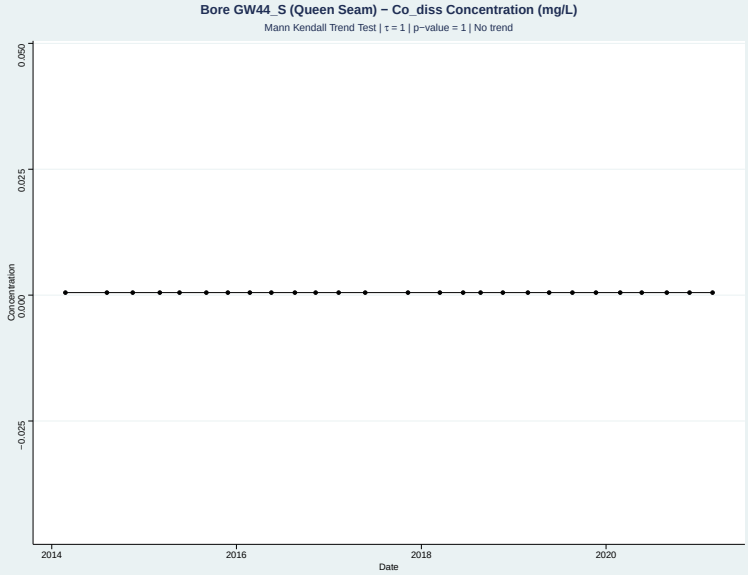

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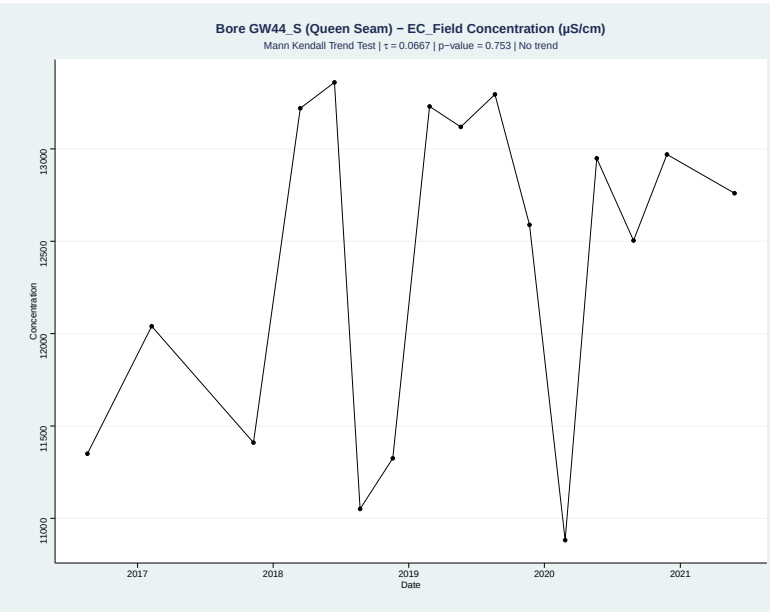

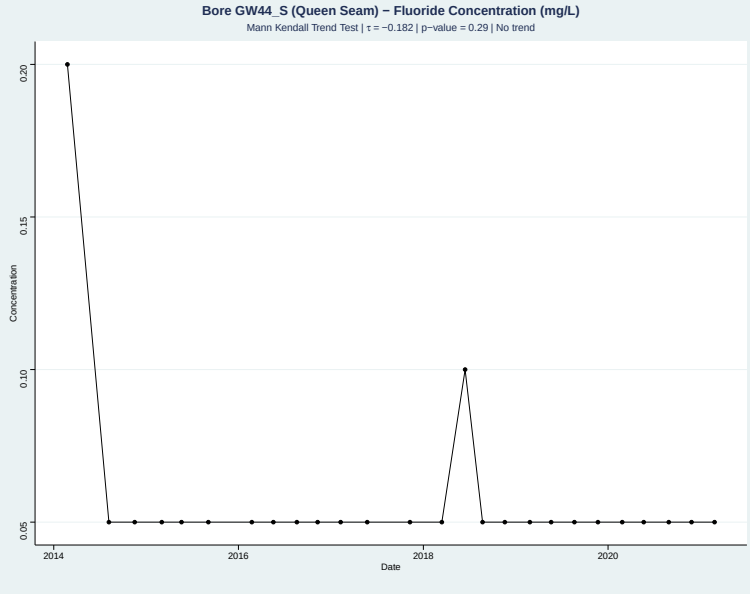

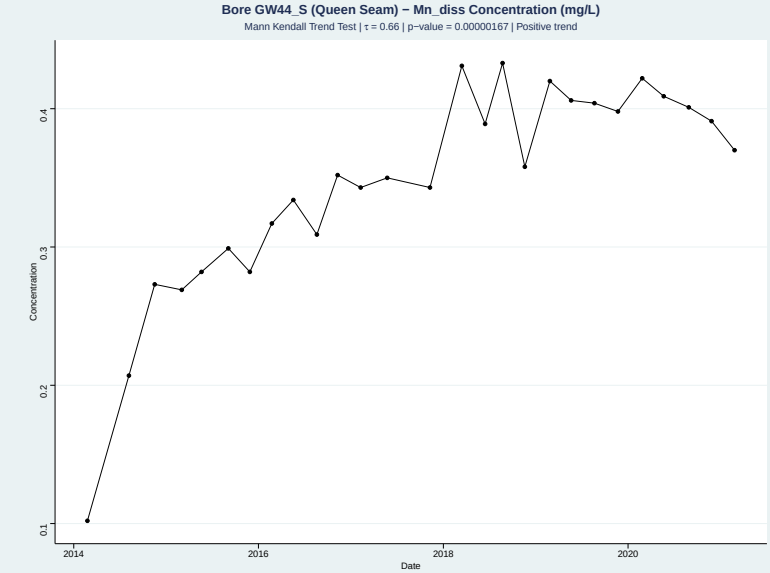

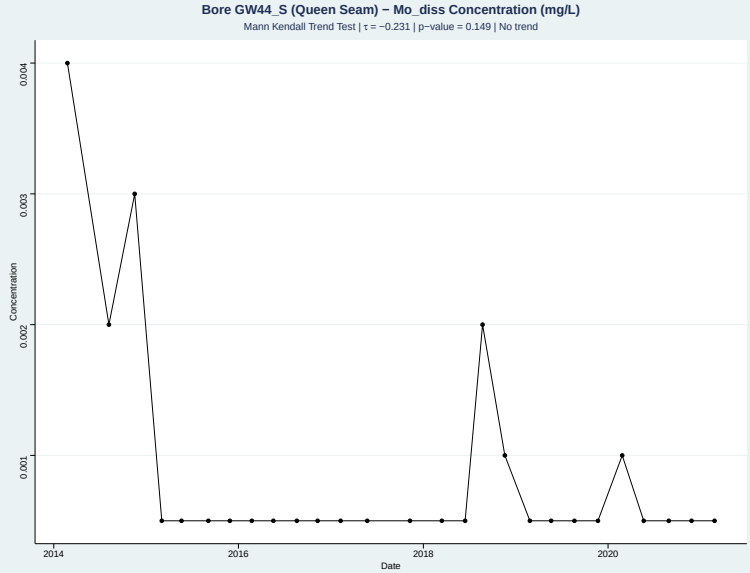

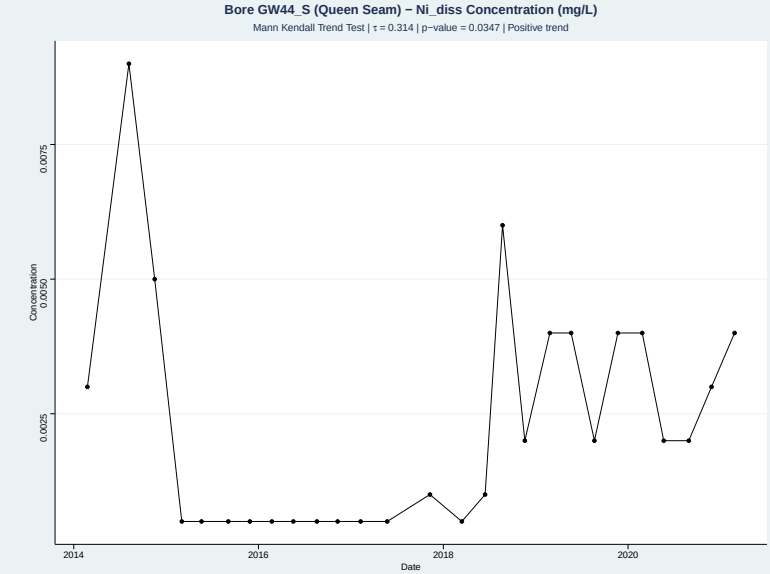

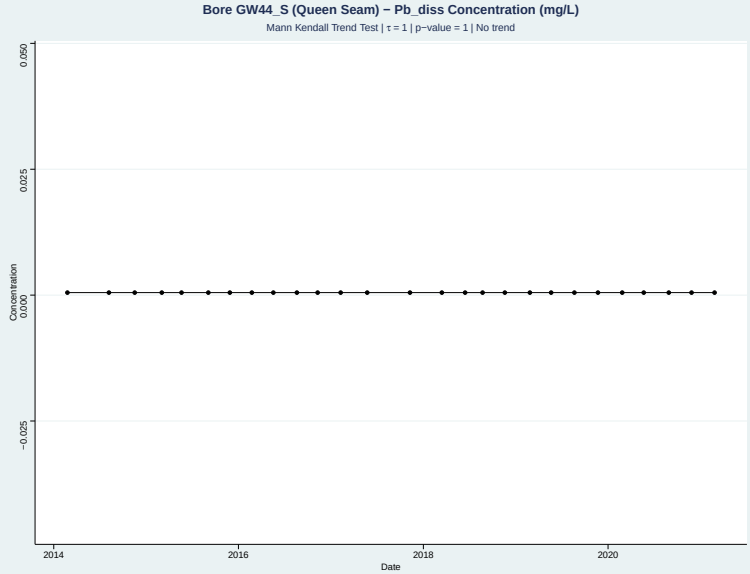

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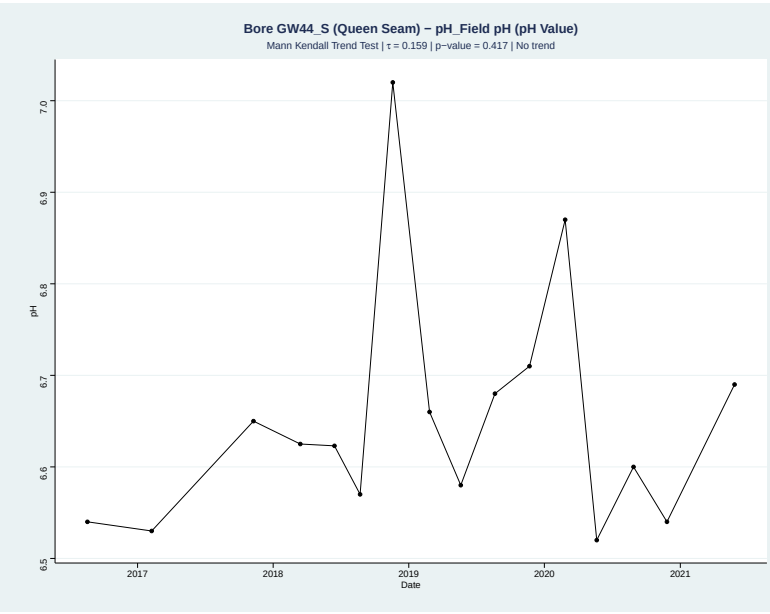

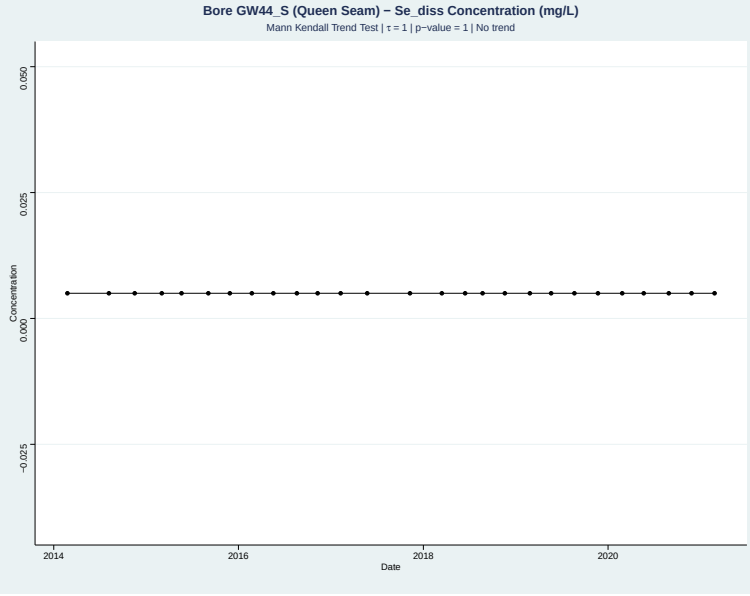

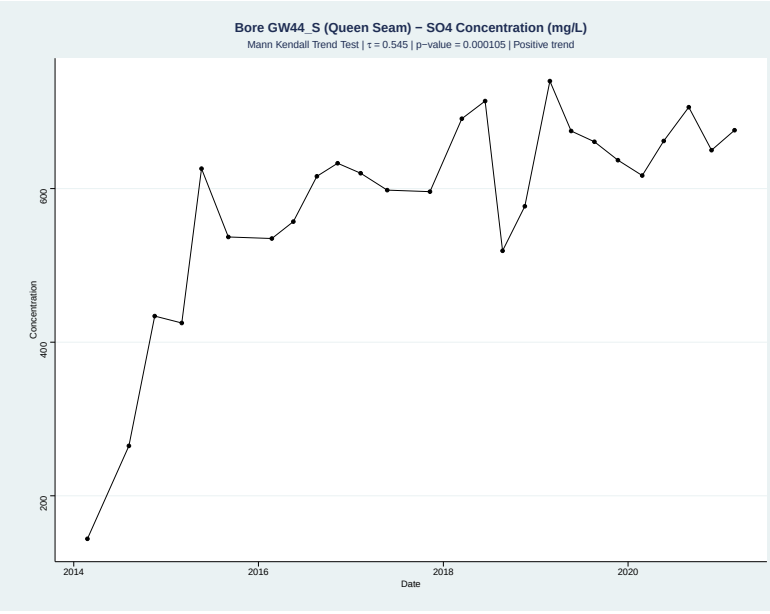

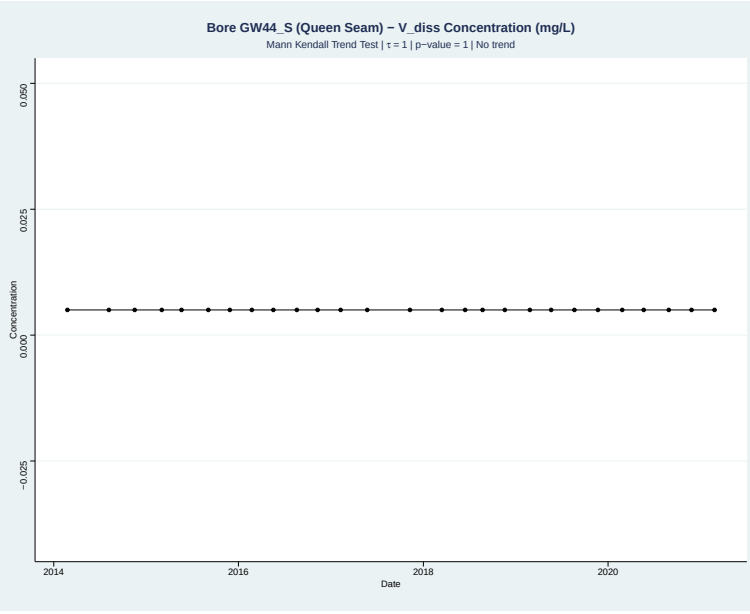

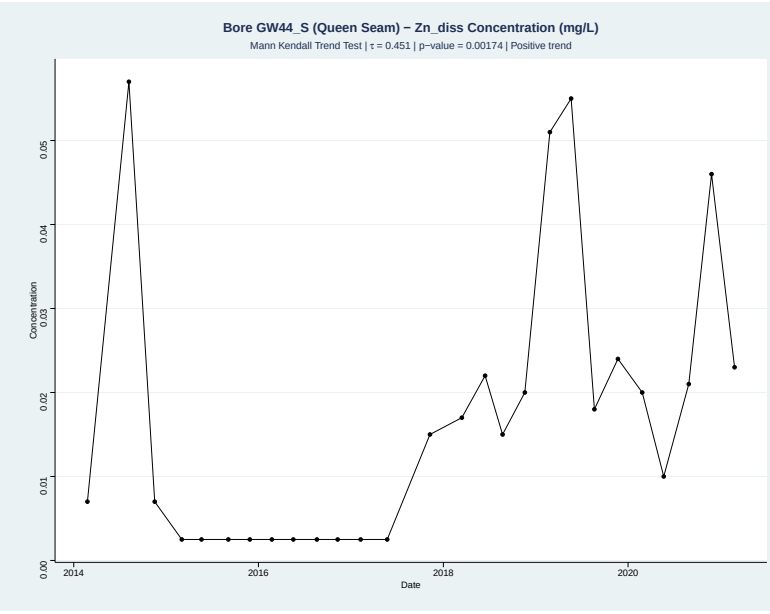

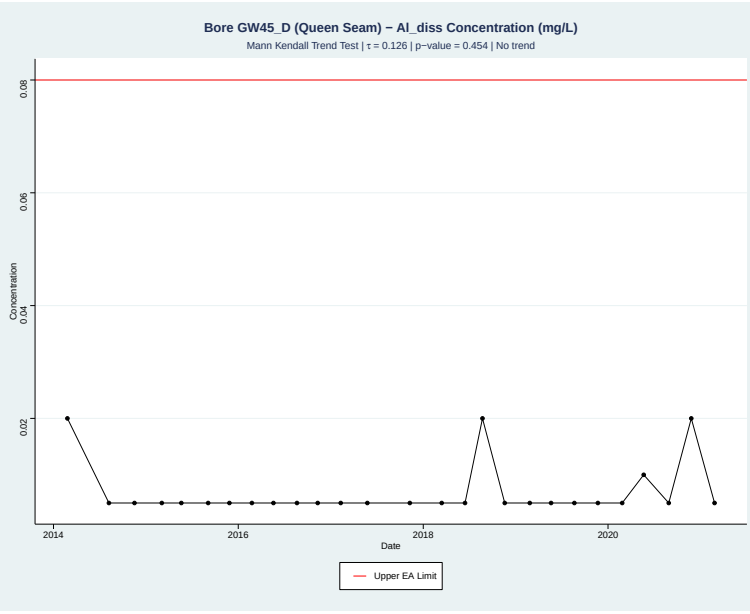

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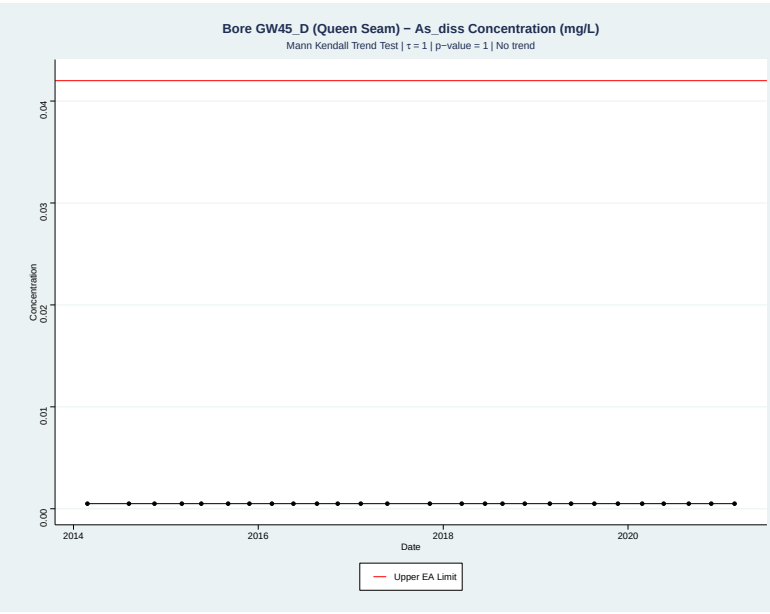

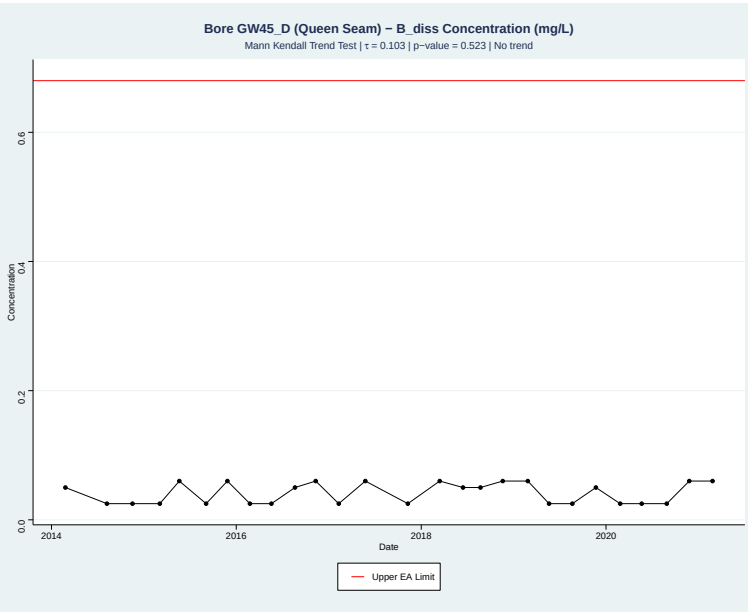

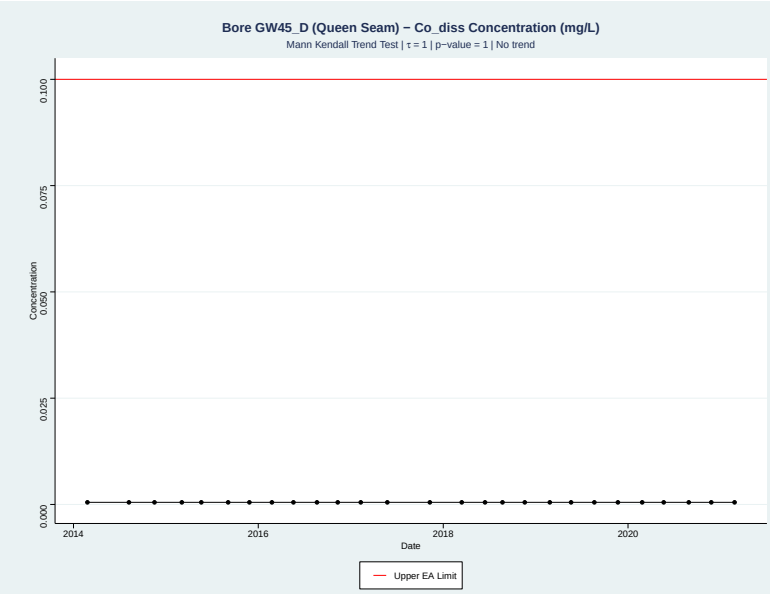

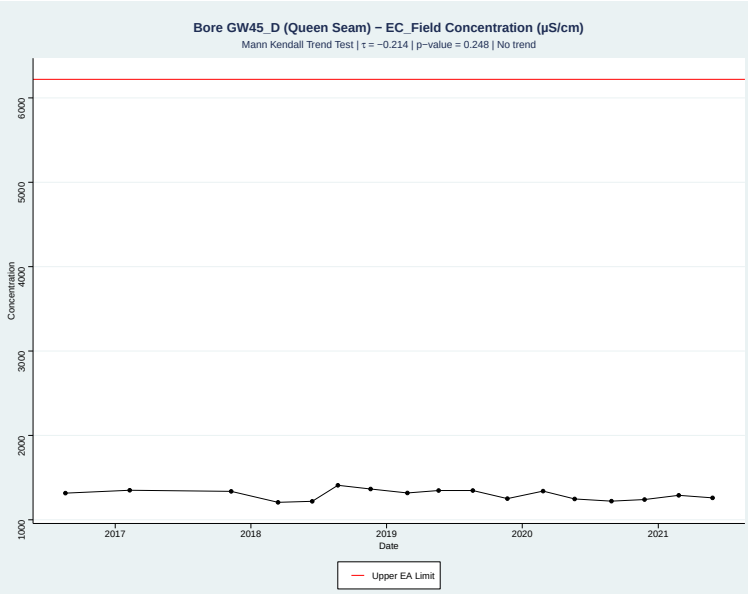

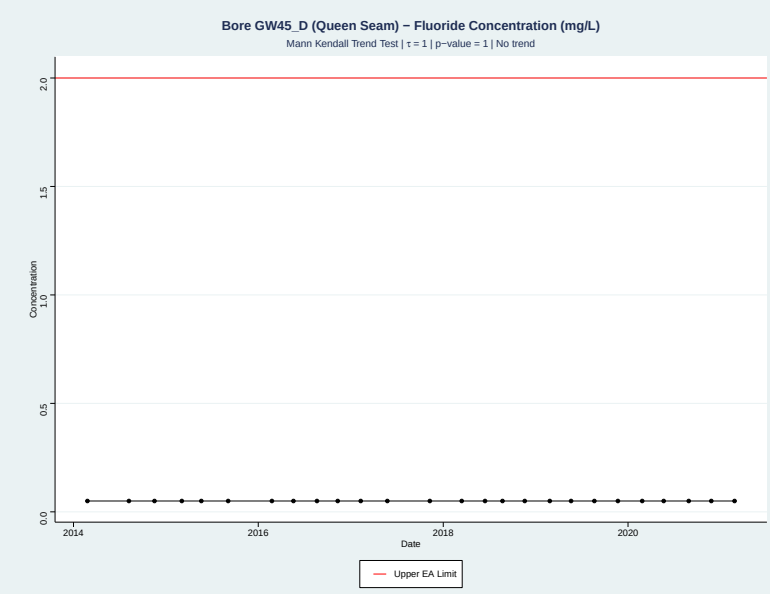

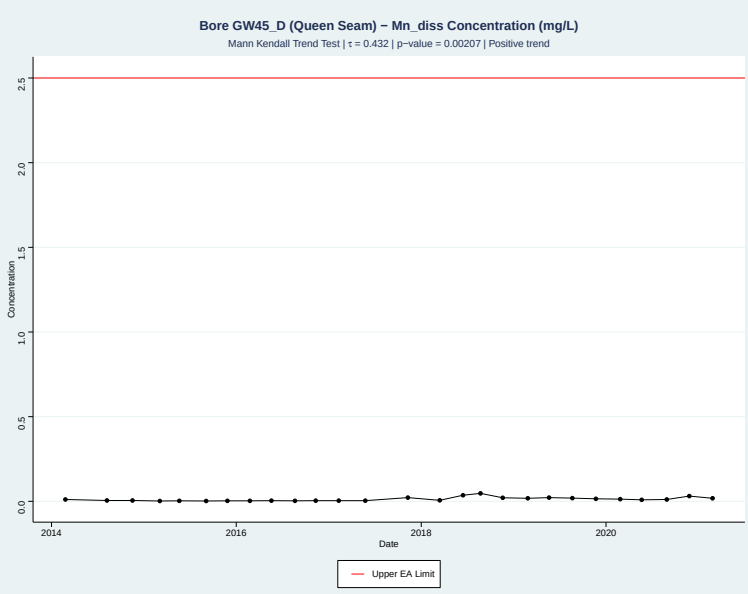

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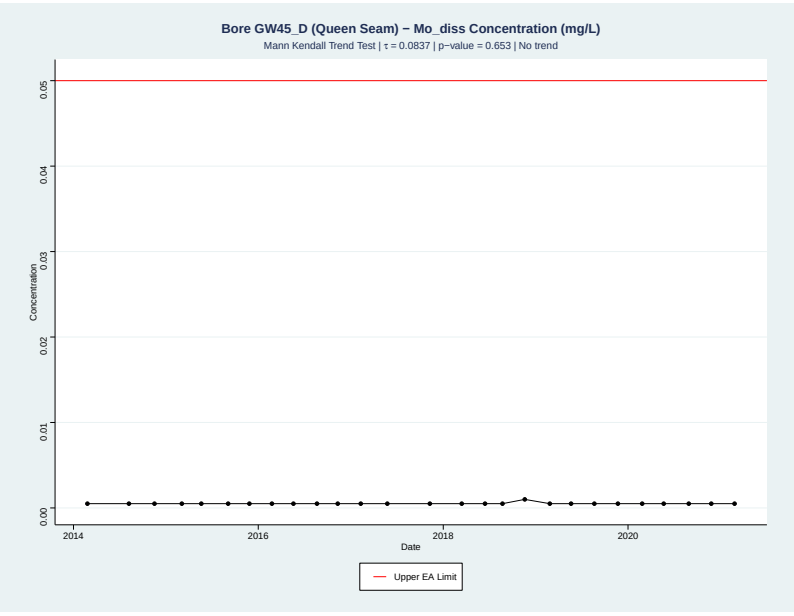
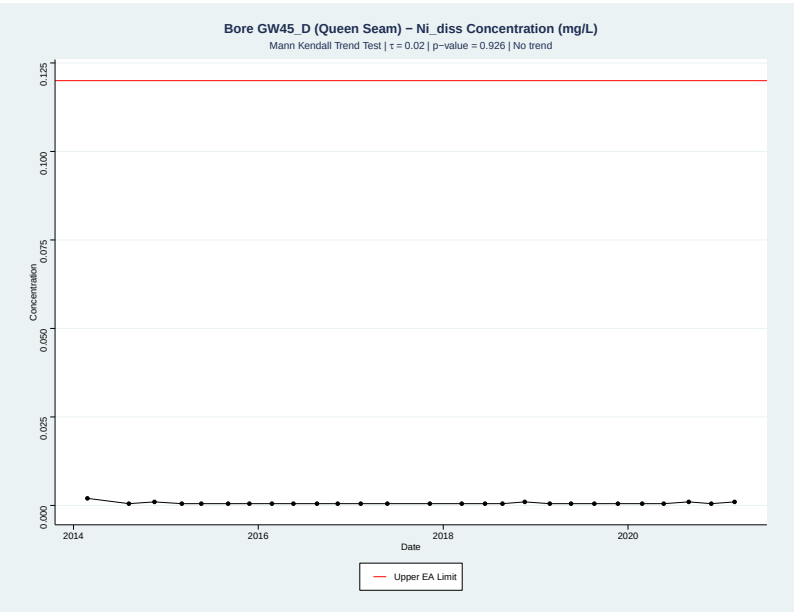
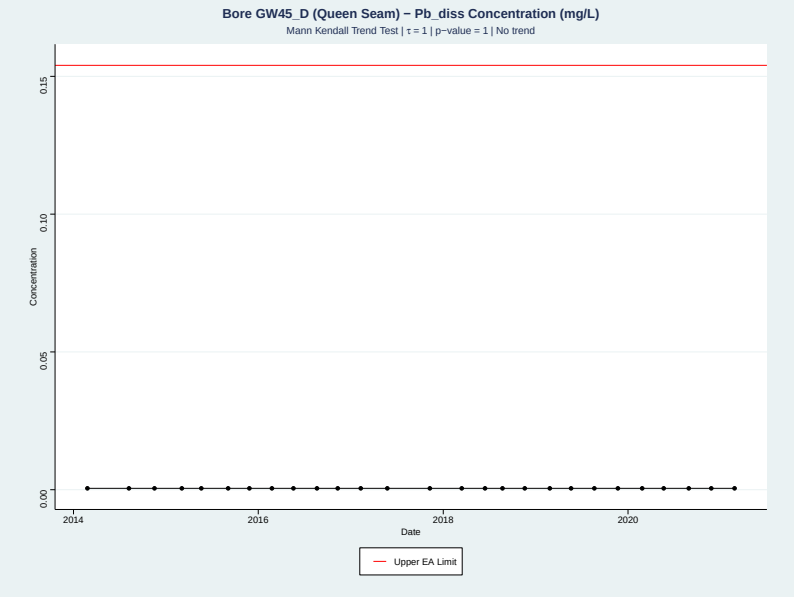
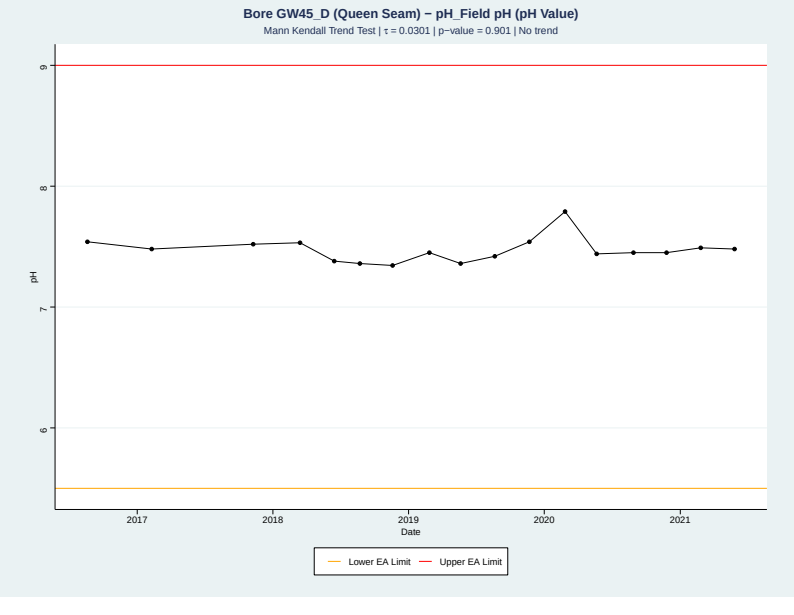
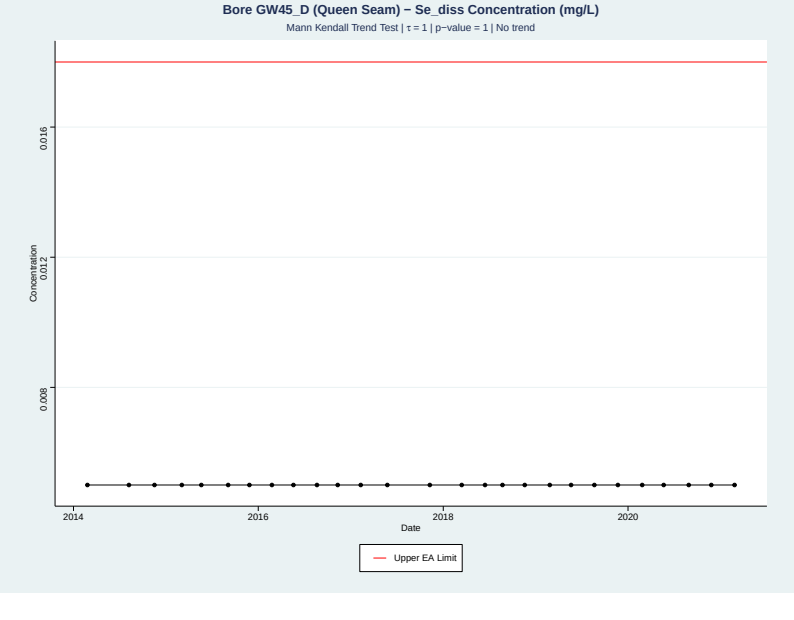
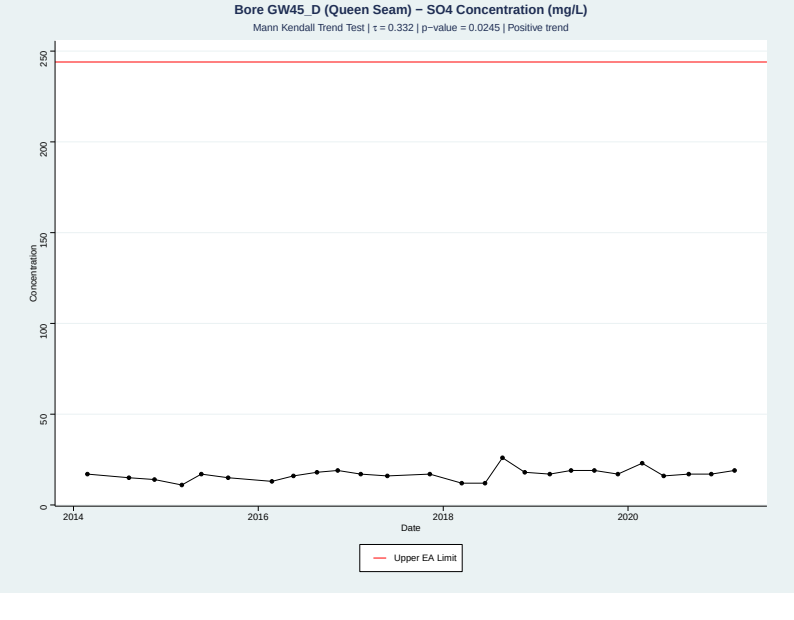




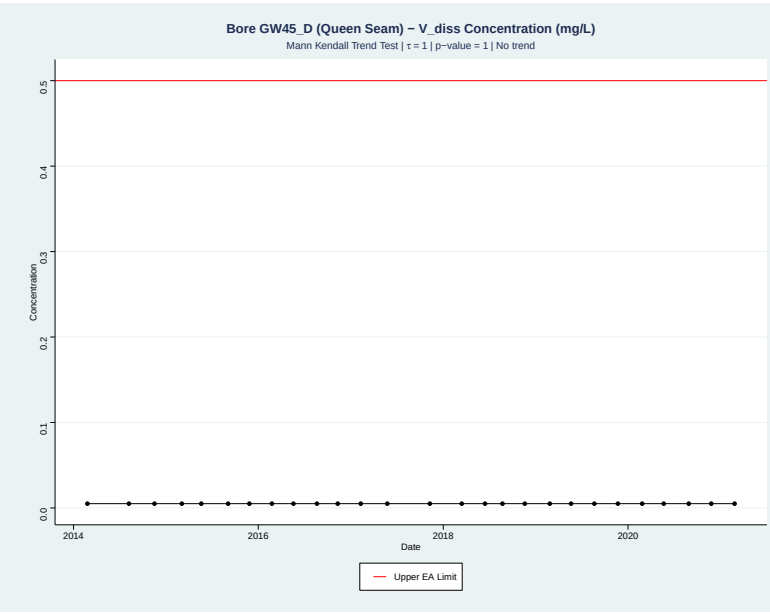


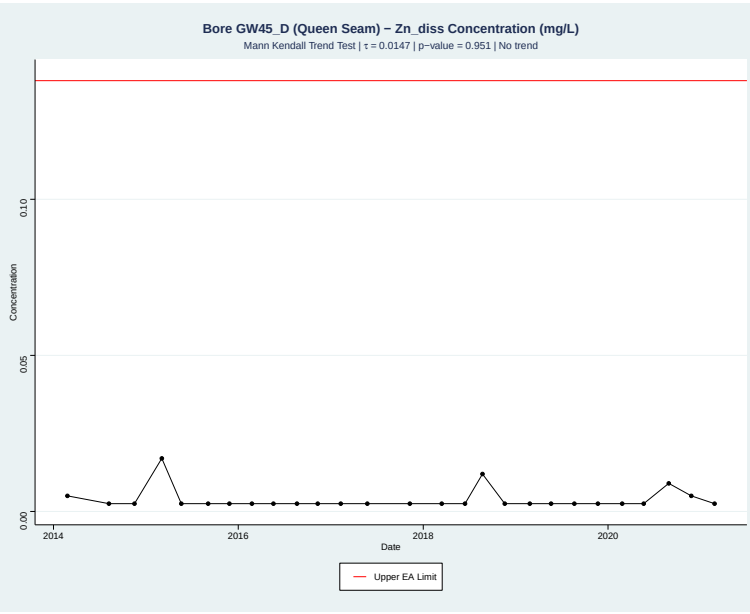


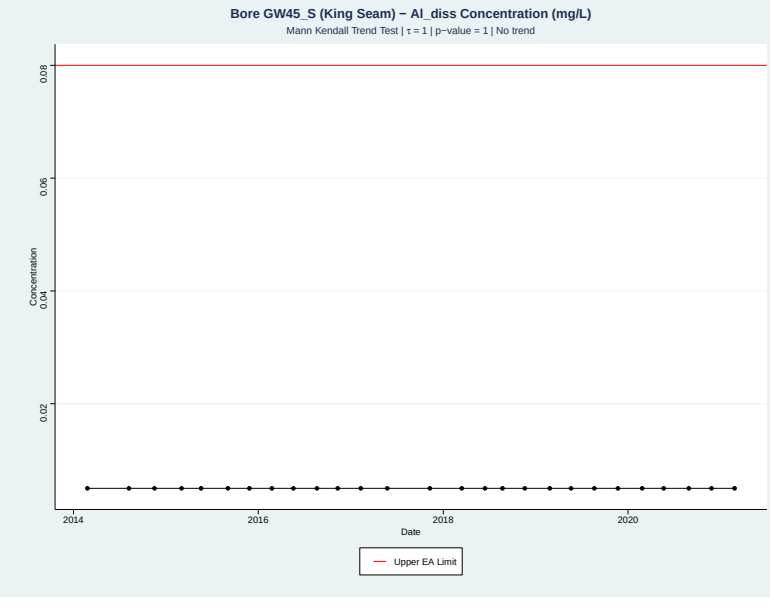


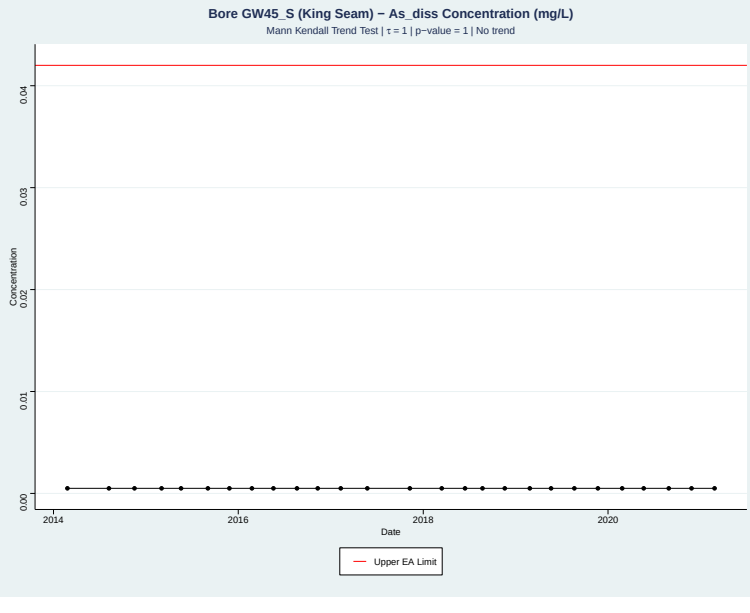


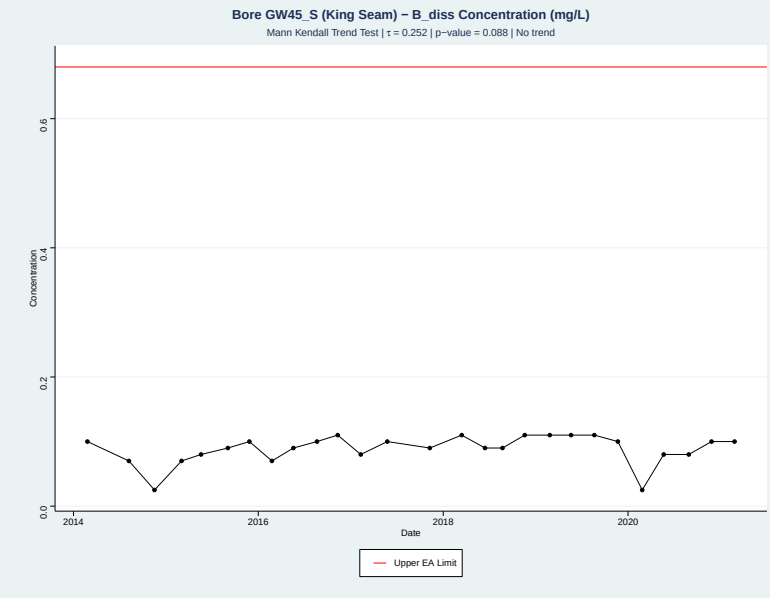
Appendix C Groundwater Quality Time Series

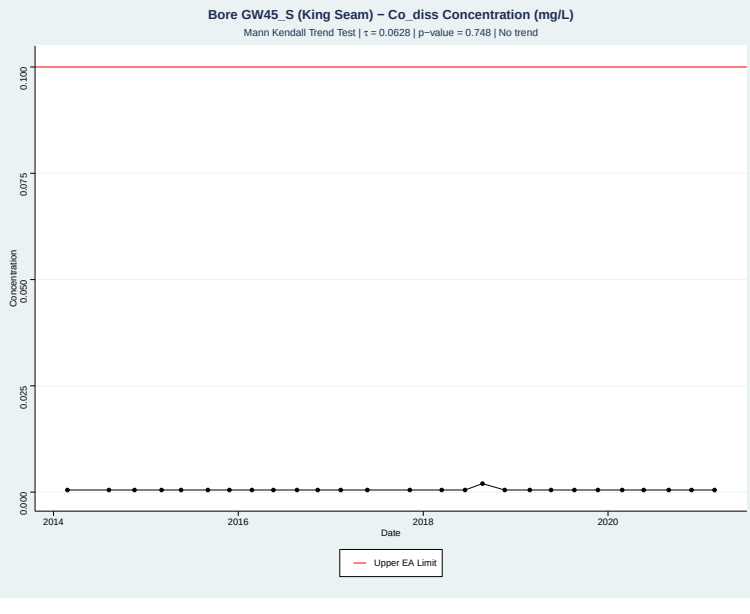




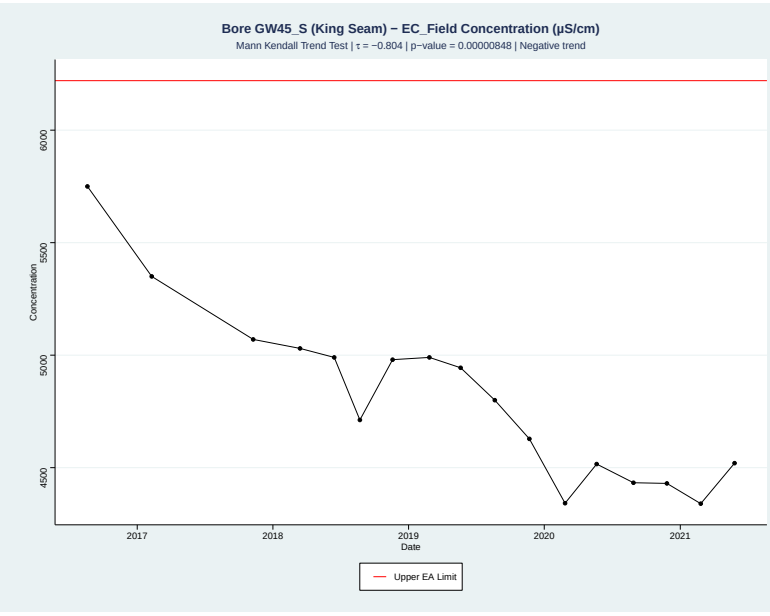


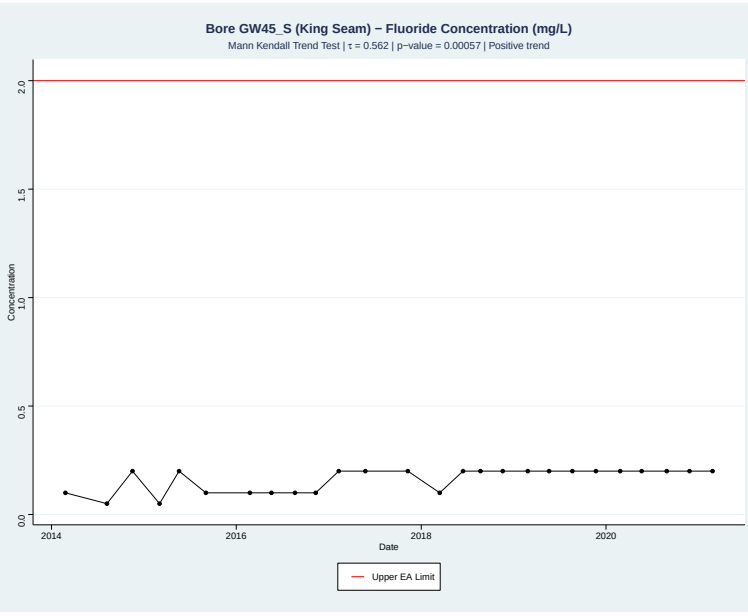


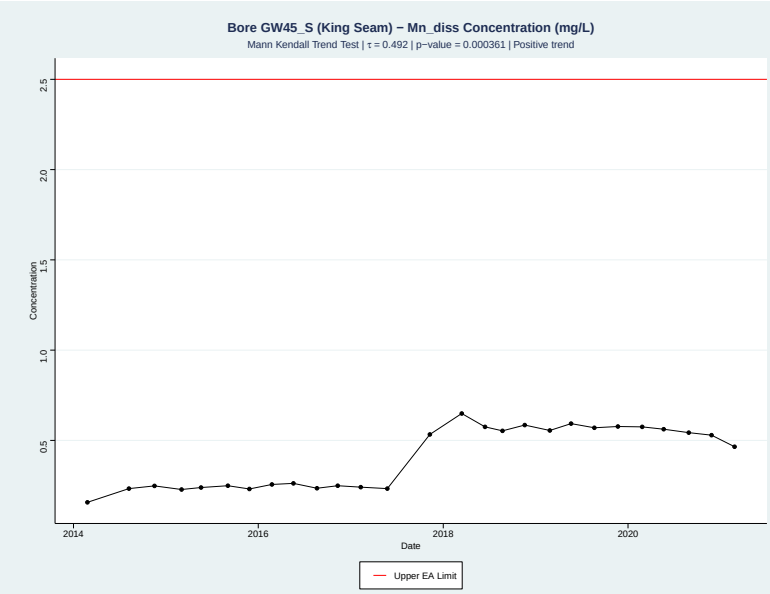


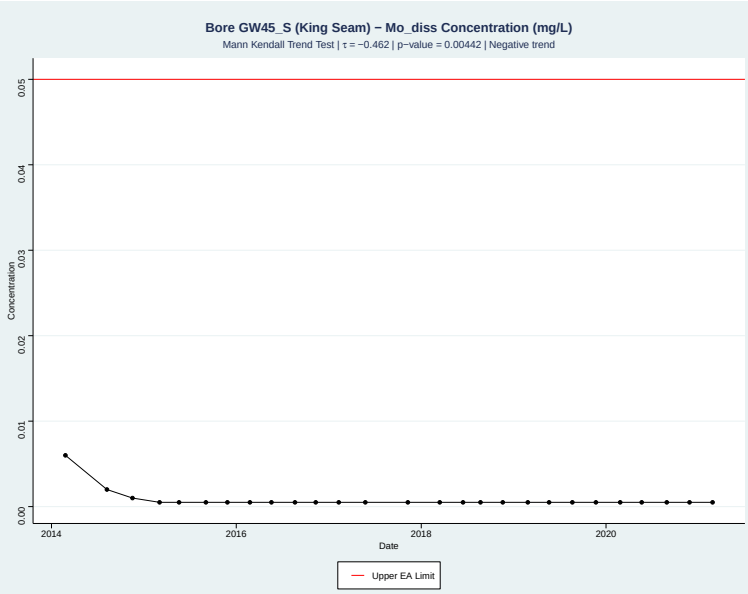


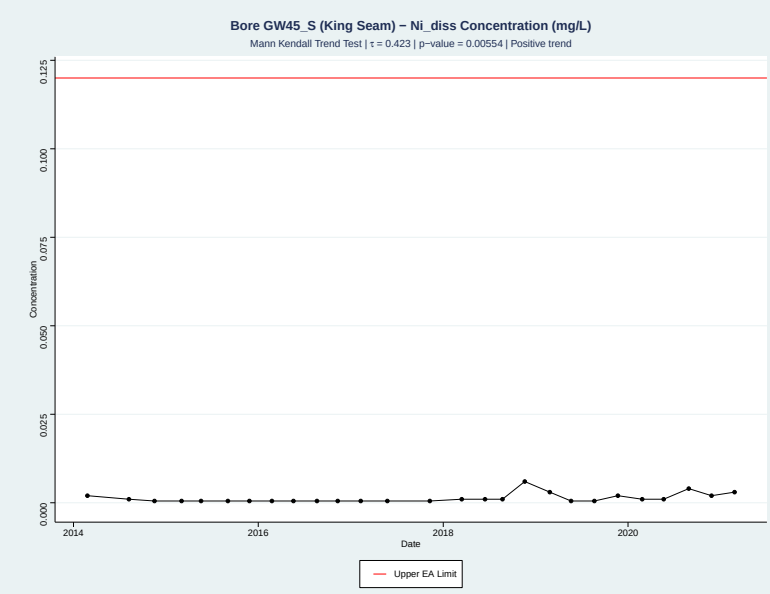
Appendix C Groundwater Quality Time Series

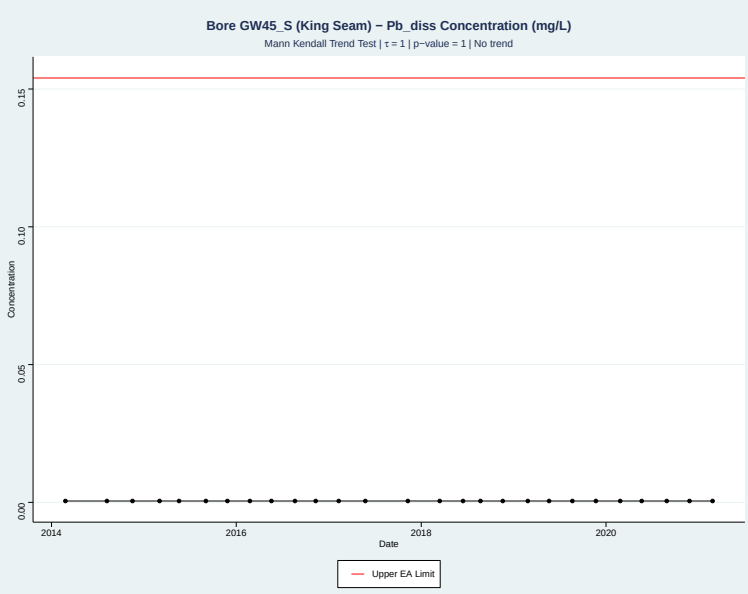




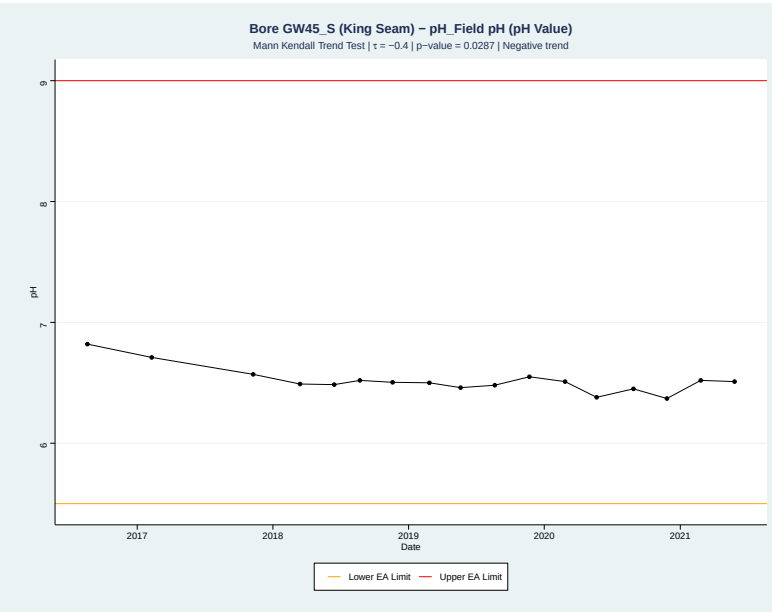


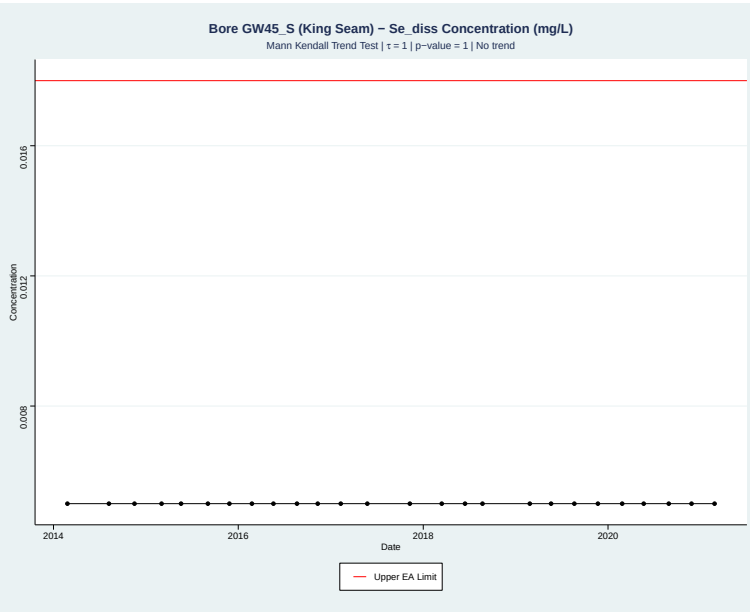


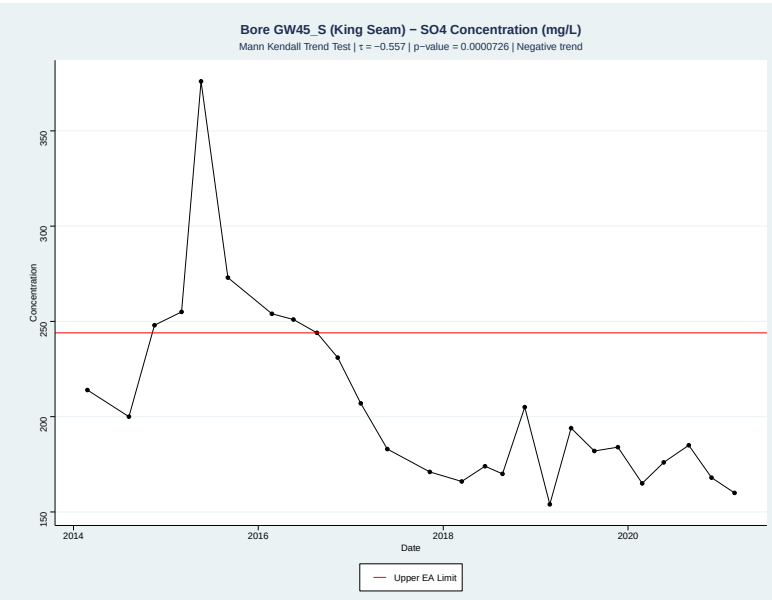


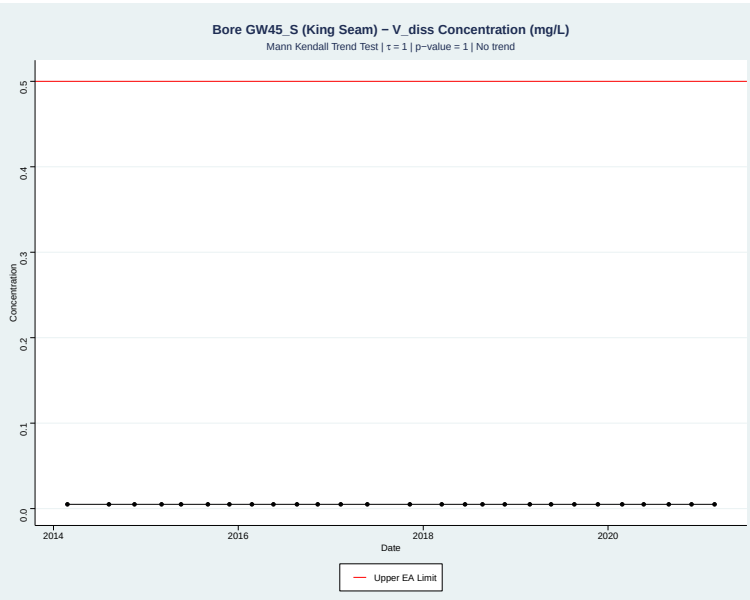


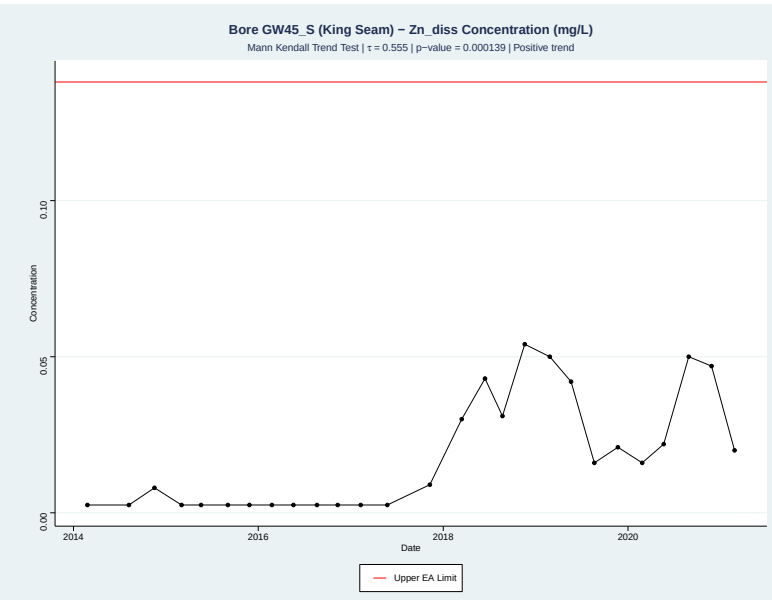
Appendix C Groundwater Quality Time Series

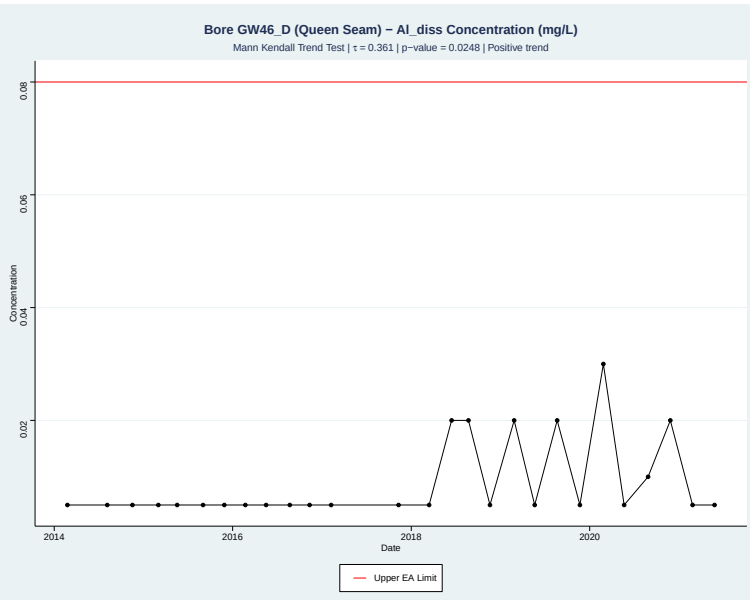




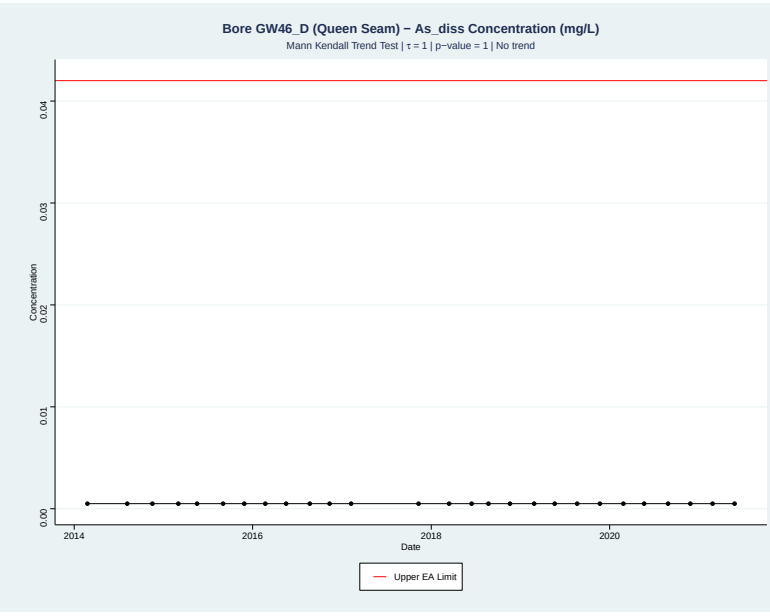


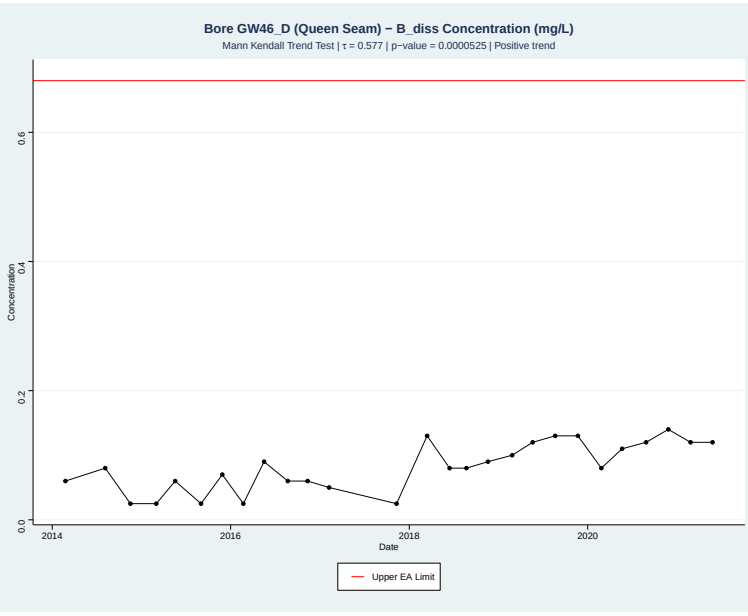


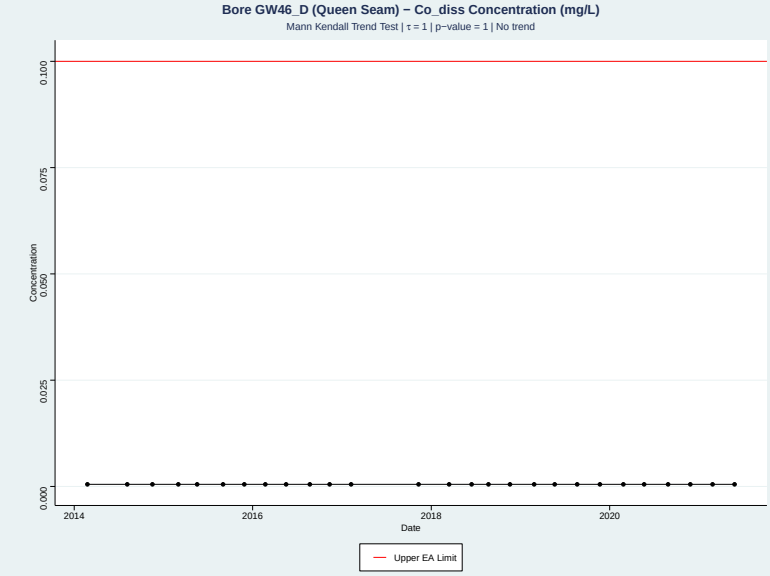


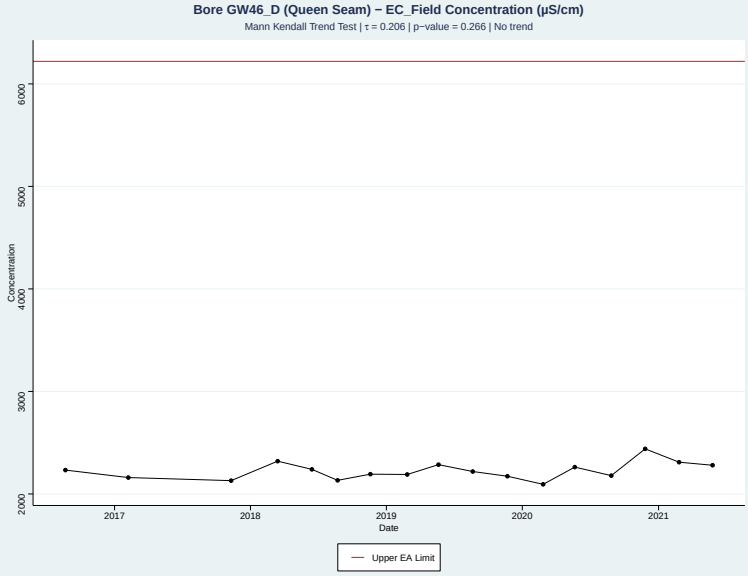


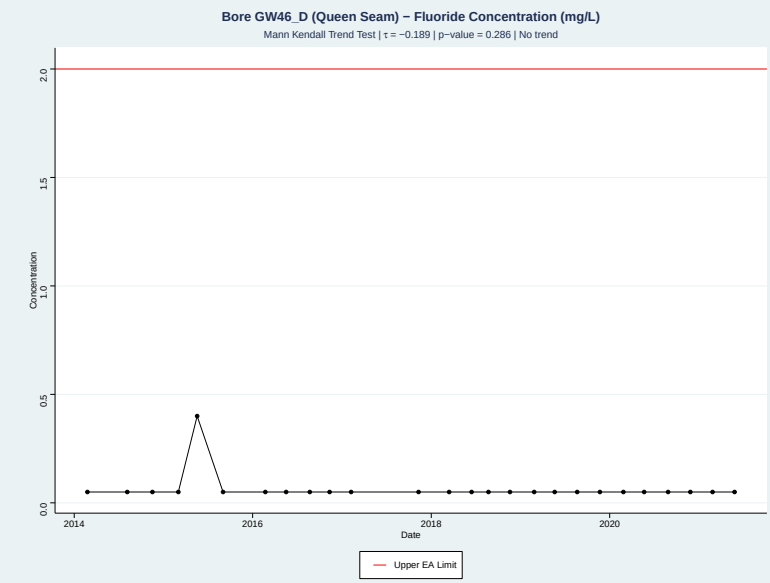
Appendix C Groundwater Quality Time Series

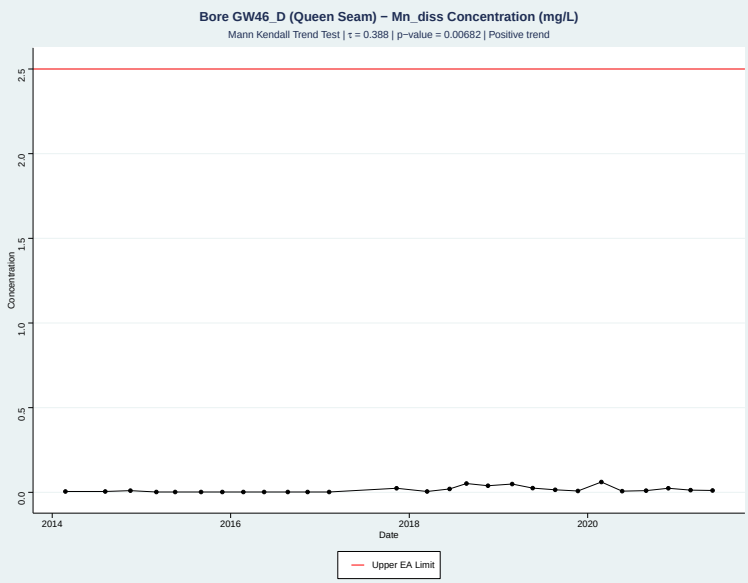




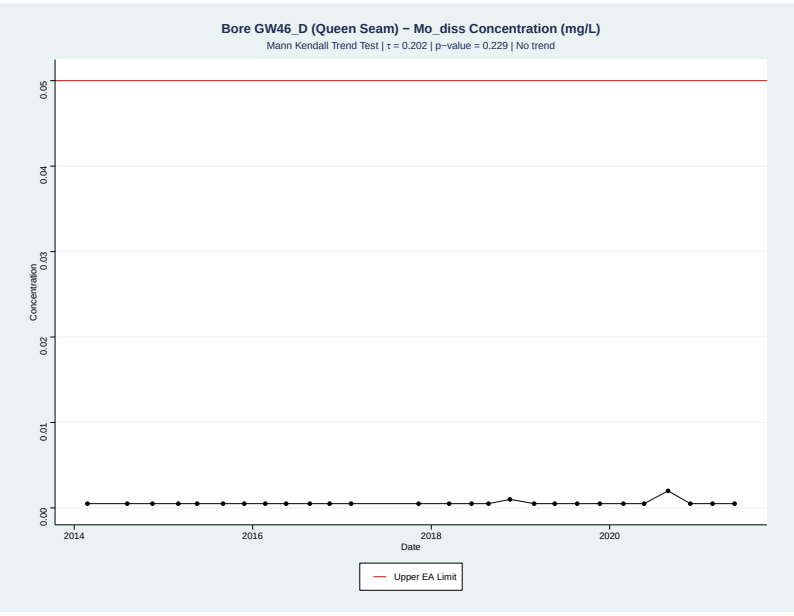


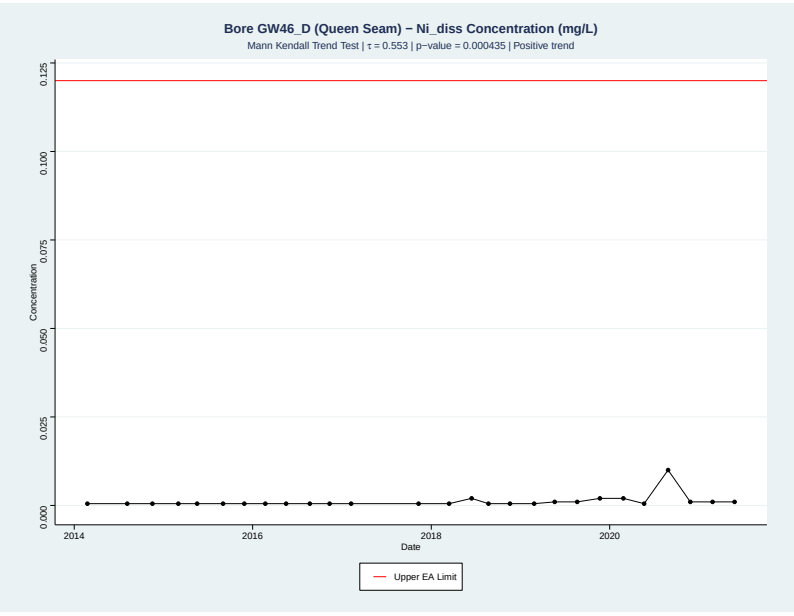


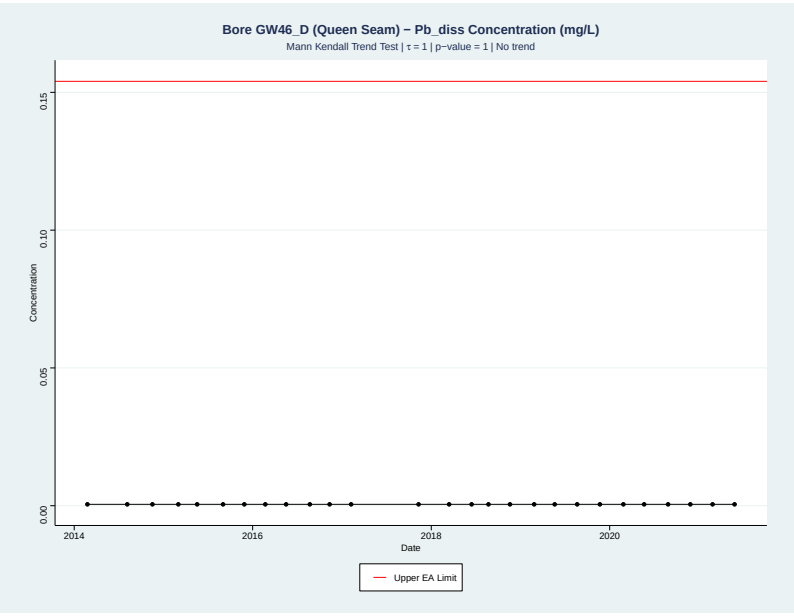


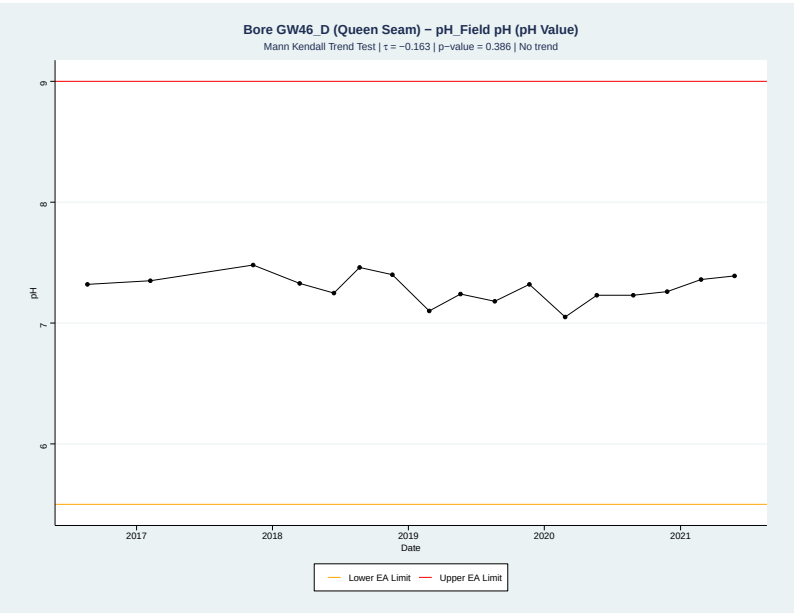


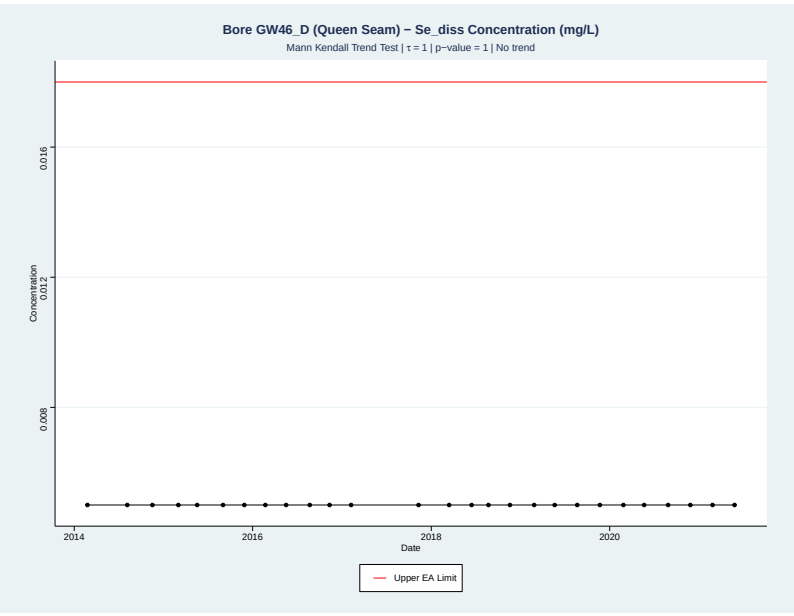
Appendix C Groundwater Quality Time Series

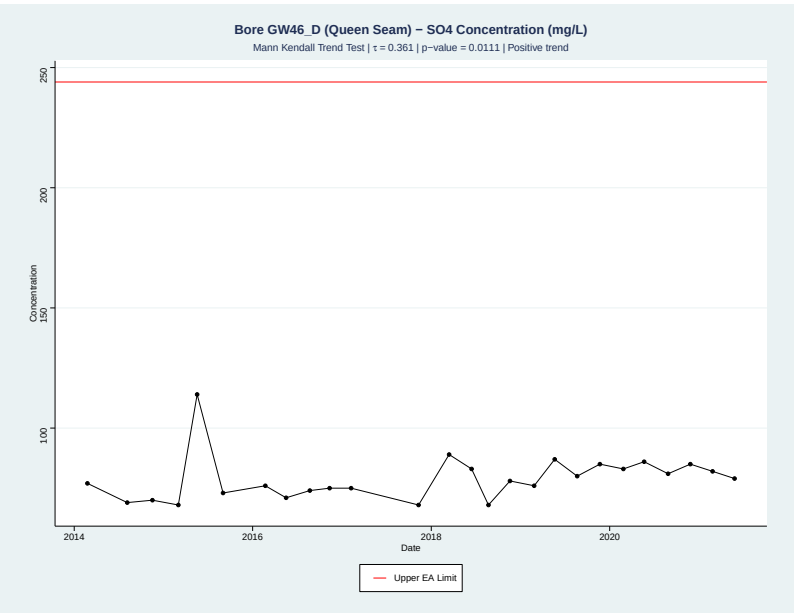


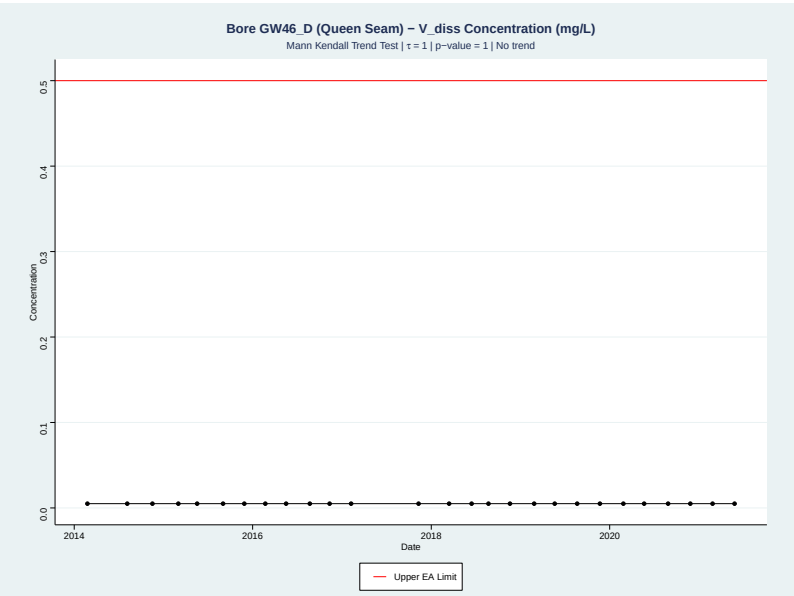


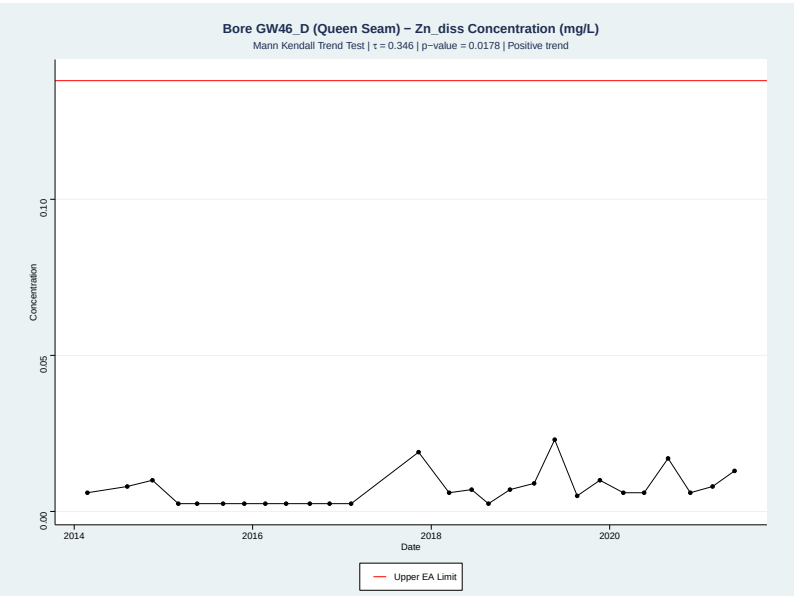


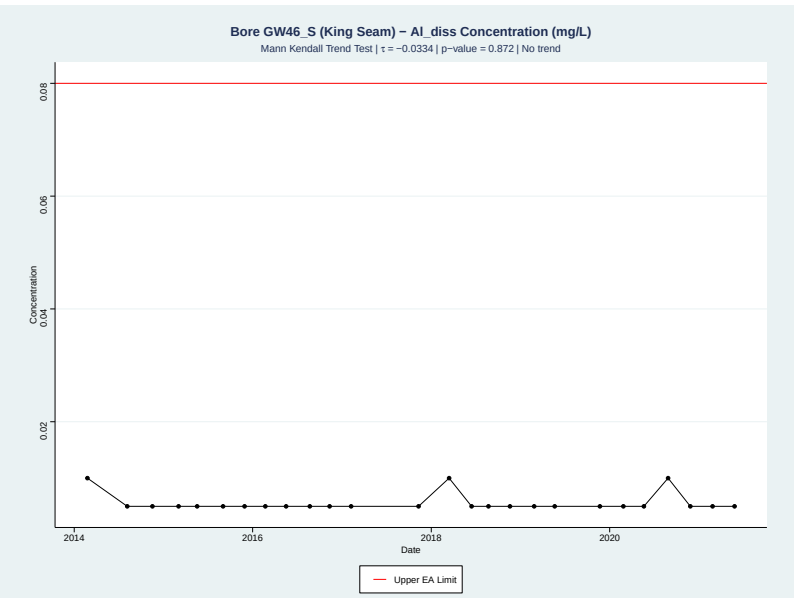


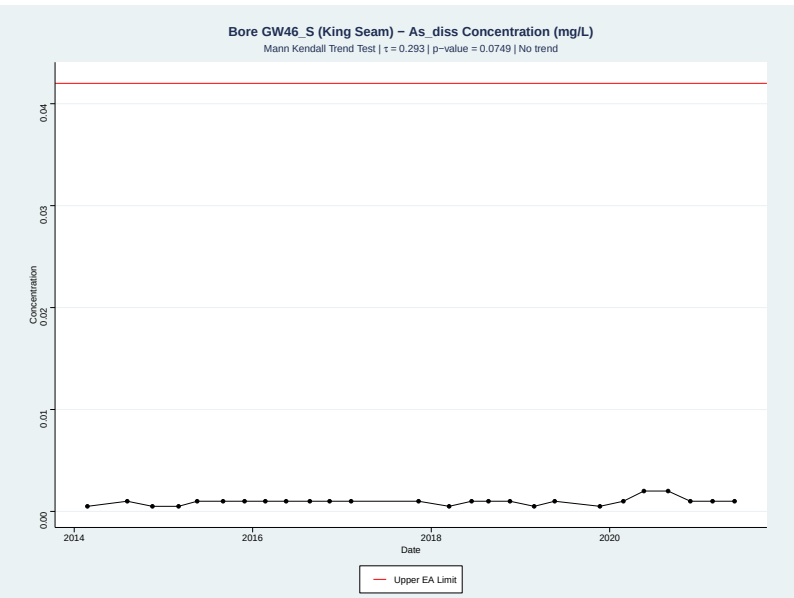


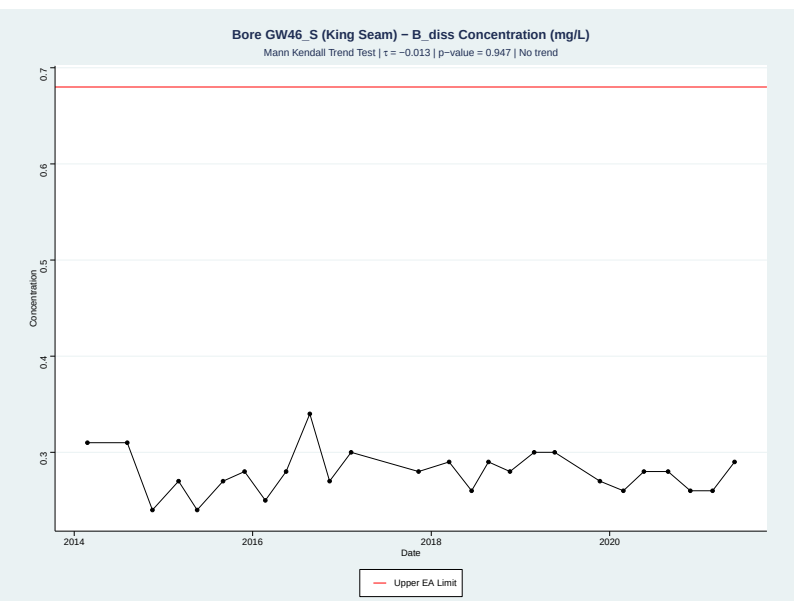


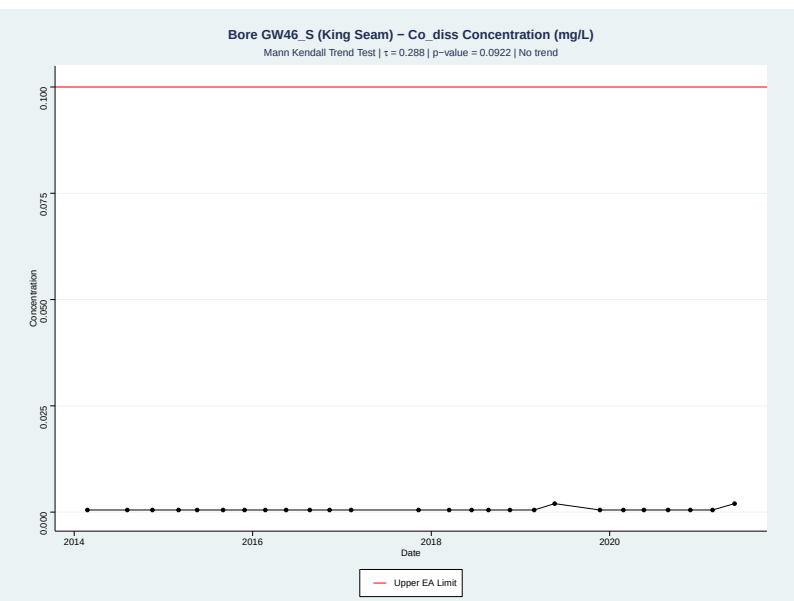

Bore GW46_D (Queen Seam) − V_diss Concentration (mg/L)
Mann Kendall Trend Test | τ = 1 | p−value = 1 | No trend
Concentration
0.0
0.1
0.2
0.3
0.4
0.5
2014
2016
2018
2020
Date
Upper EA Limit


Bore GW46_D (Queen Seam) − Zn_diss Concentration (mg/L)
Mann Kendall Trend Test | τ = 0.346 | p−value = 0.0178 | Positive trend
Concentration
0.00
0.05
0.10
2014
2016
2018
2020
Date
Upper EA Limit

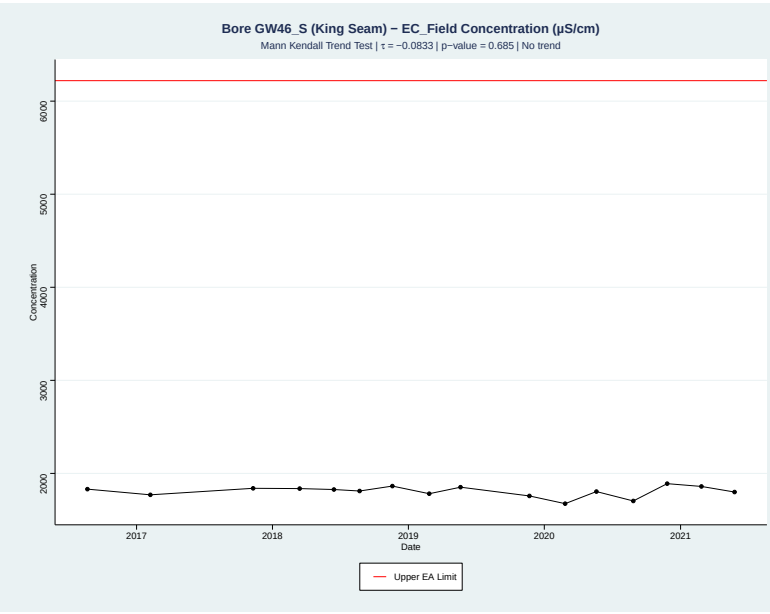

Bore GW46_S (King Seam) − Al_diss Concentration (mg/L)
Mann Kendall Trend Test | τ = −0.0334 | p−value = 0.872 | No trend
Concentration
0.02
0.04
0.06
0.08
2014
2016
2018
2020
Date
Upper EA Limit

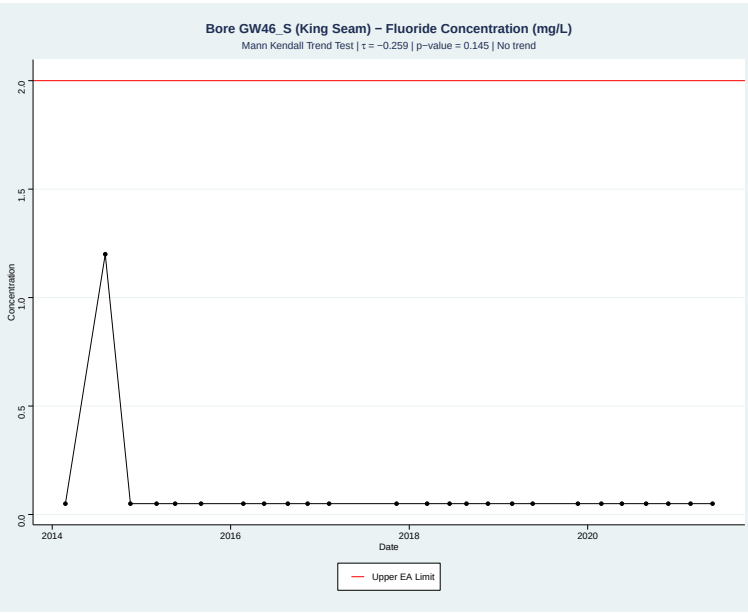

Bore GW46_S (King Seam) − As_diss Concentration (mg/L)
Mann Kendall Trend Test | τ = 0.293 | p−value = 0.0749 | No trend
Concentration
0.00
0.01
0.02
0.03
0.04
2014
2016
2018
2020
Date
Upper EA Limit

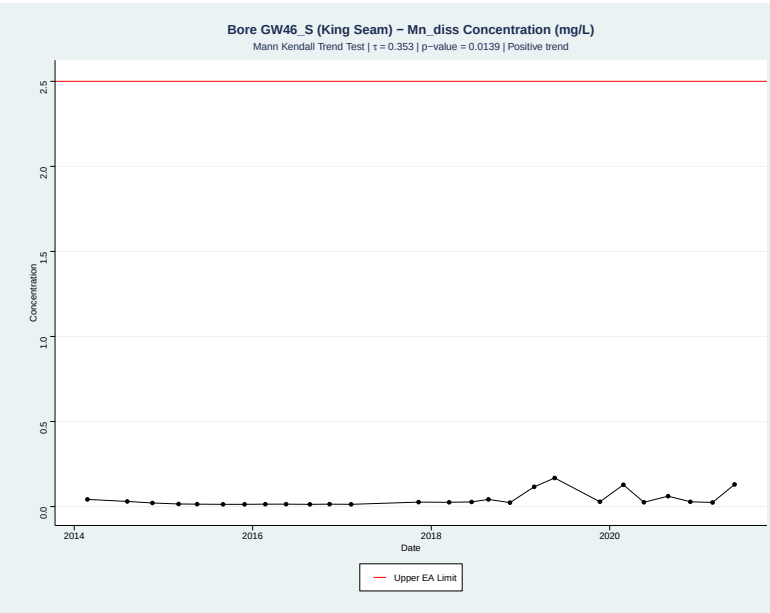

Bore GW46_S (King Seam) − B_diss Concentration (mg/L)
Mann Kendall Trend Test | τ = −0.013 | p−value = 0.947 | No trend
Concentration
0.3
0.4
0.5
0.6
0.7
2014
2016
2018
2020
Date
Upper EA Limit

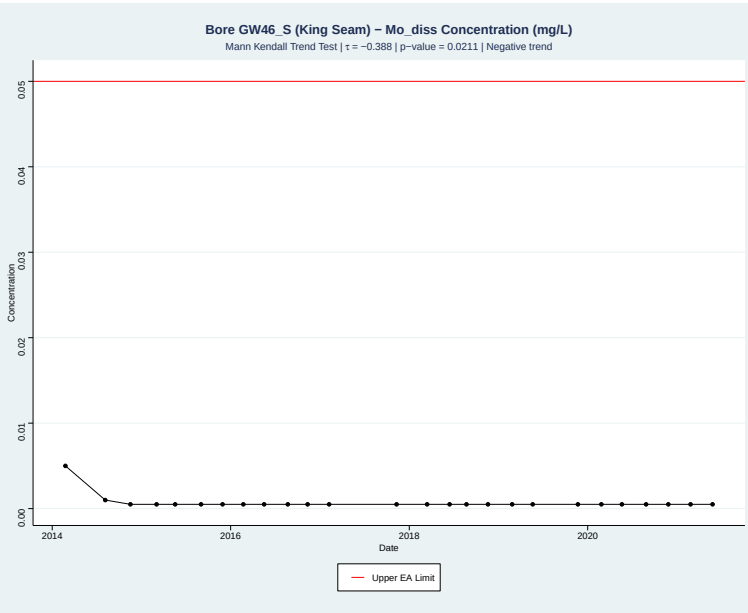

Bore GW46_S (King Seam) − Co_diss Concentration (mg/L)
Mann Kendall Trend Test | τ = 0.288 | p−value = 0.0922 | No trend
Concentration
0.000
0.025
0.050
0.075
0.100
2014
2016
2018
2020
Date
Upper EA Limit

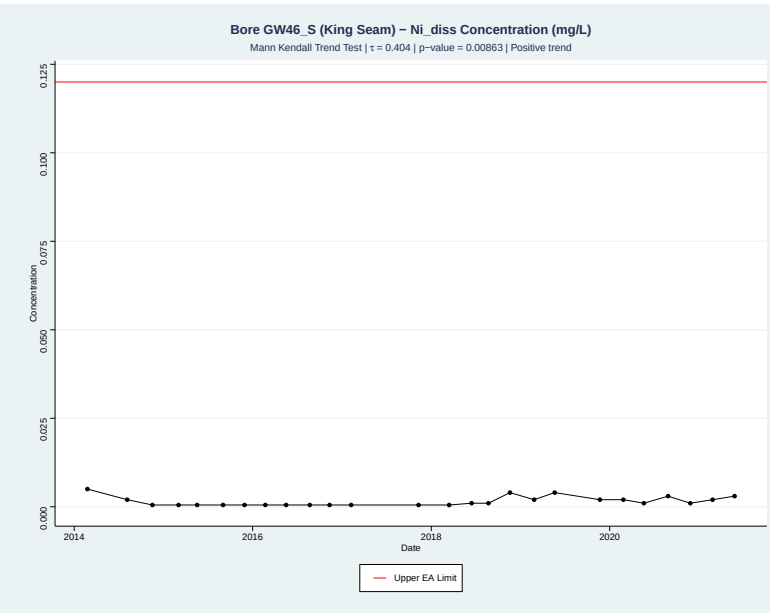
Appendix C Groundwater Quality Time Series

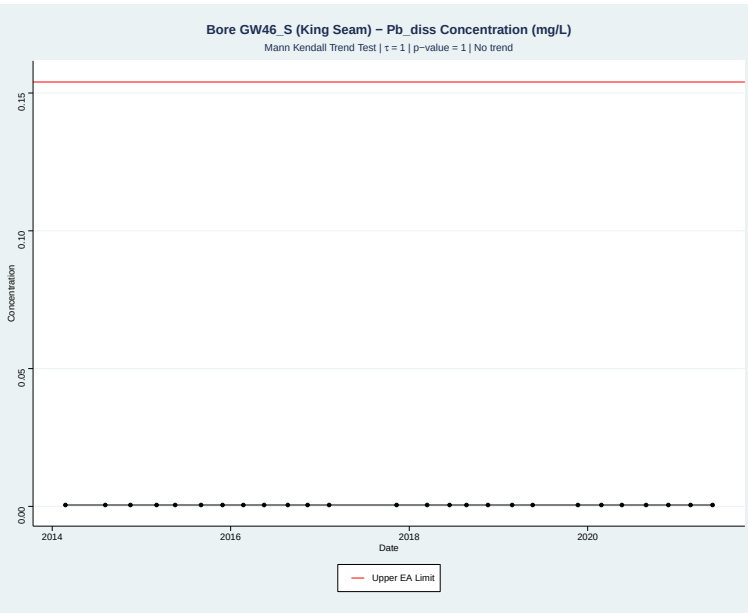




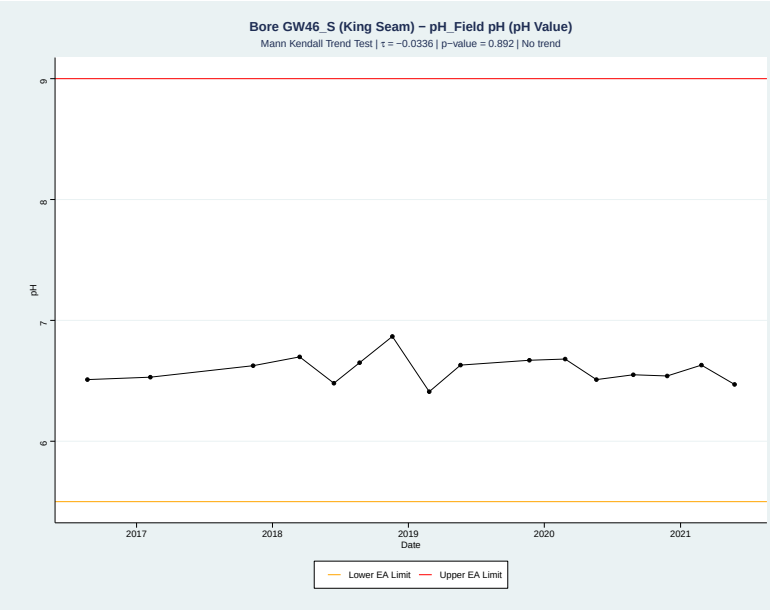


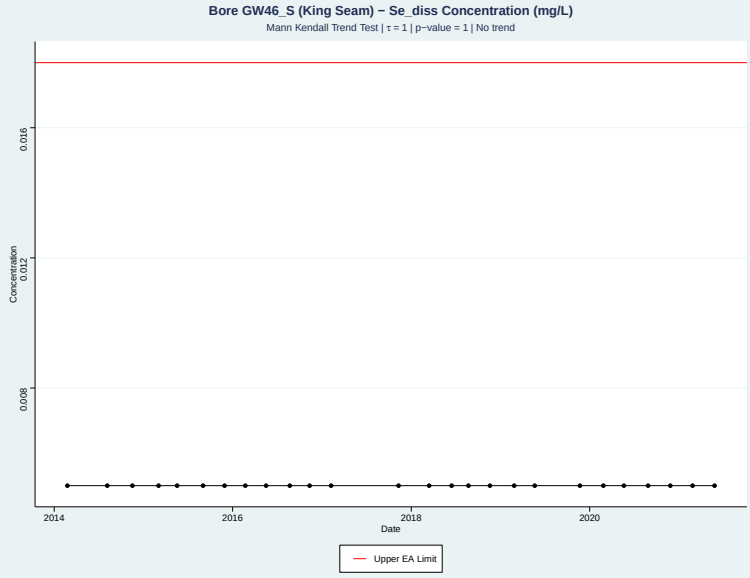


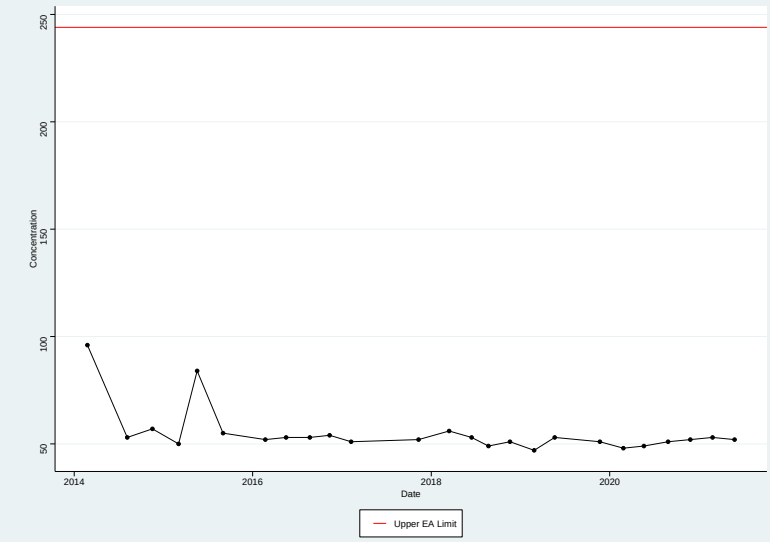


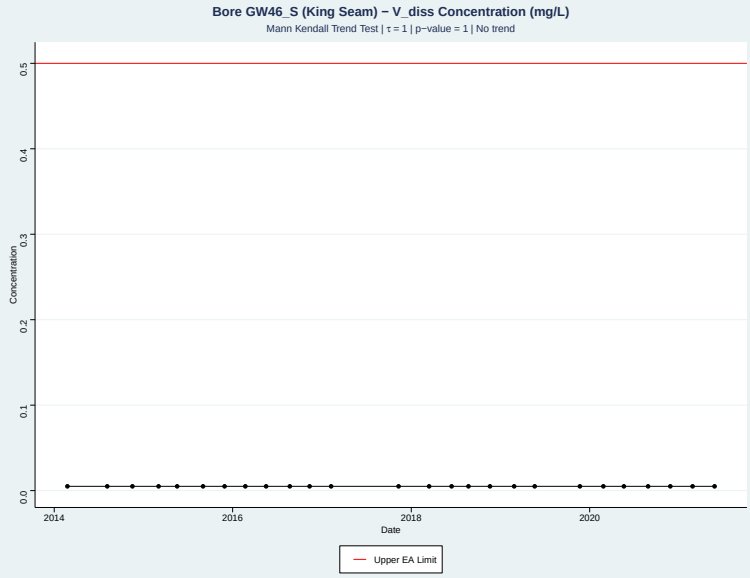


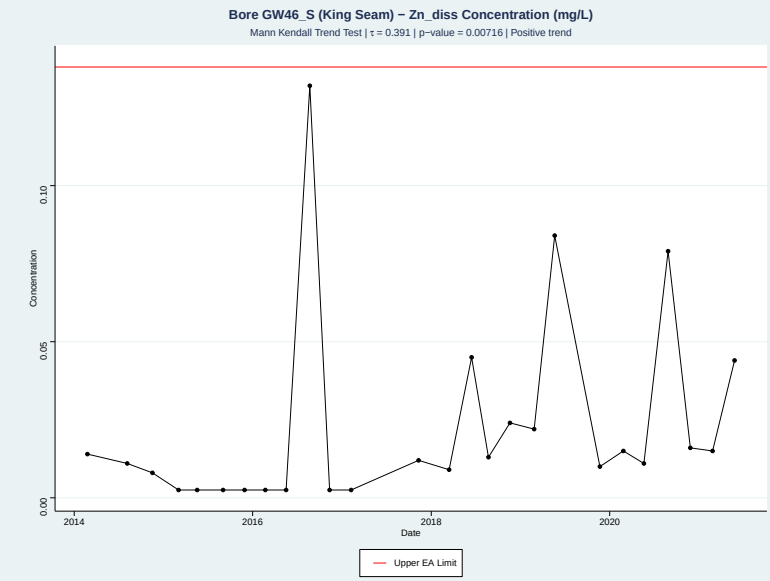
Appendix C Groundwater Quality Time Series

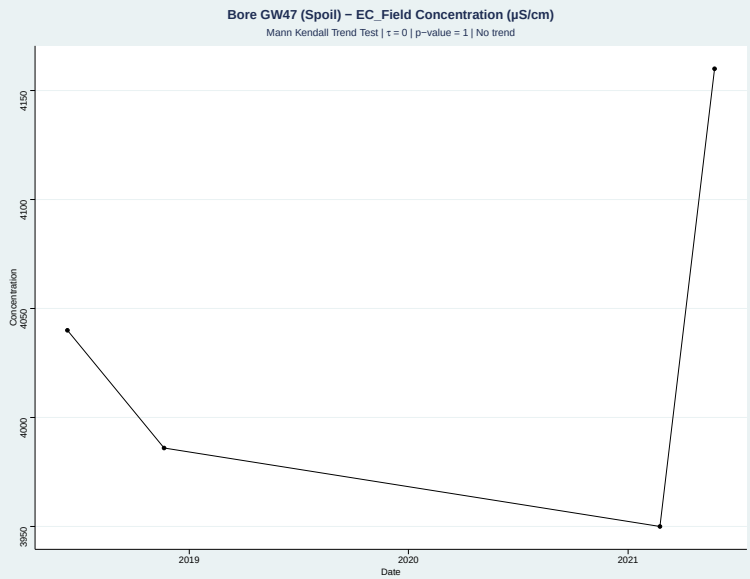




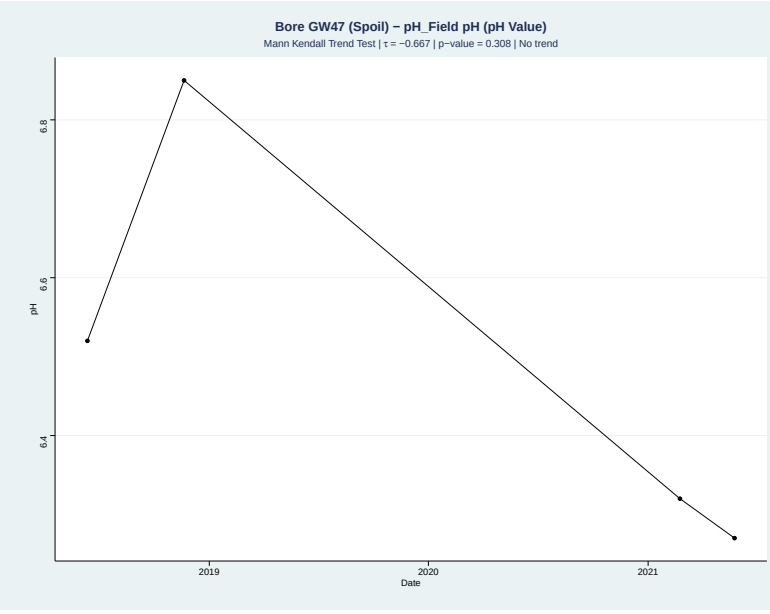


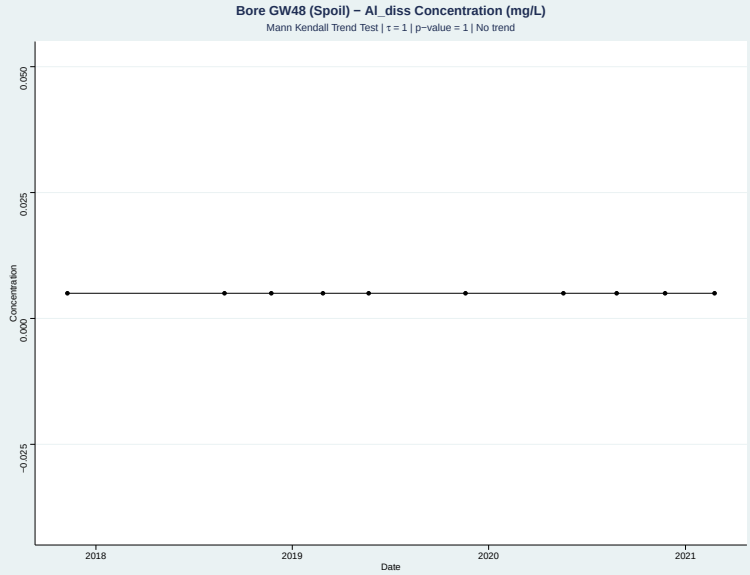


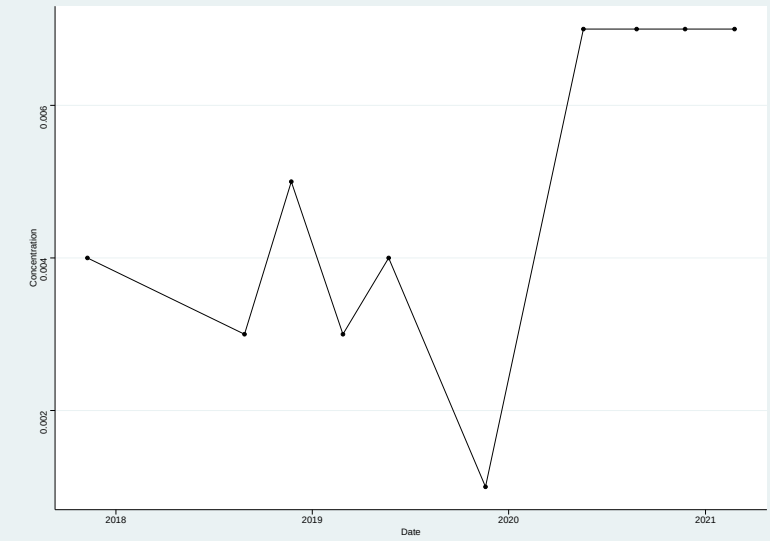


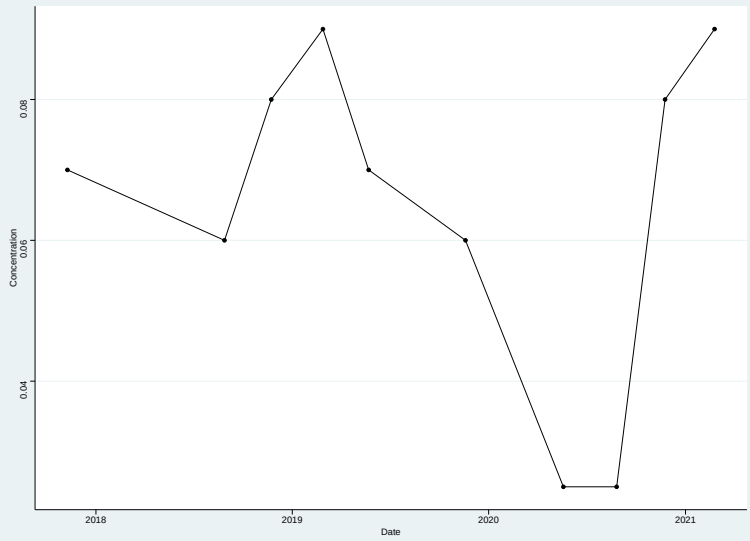


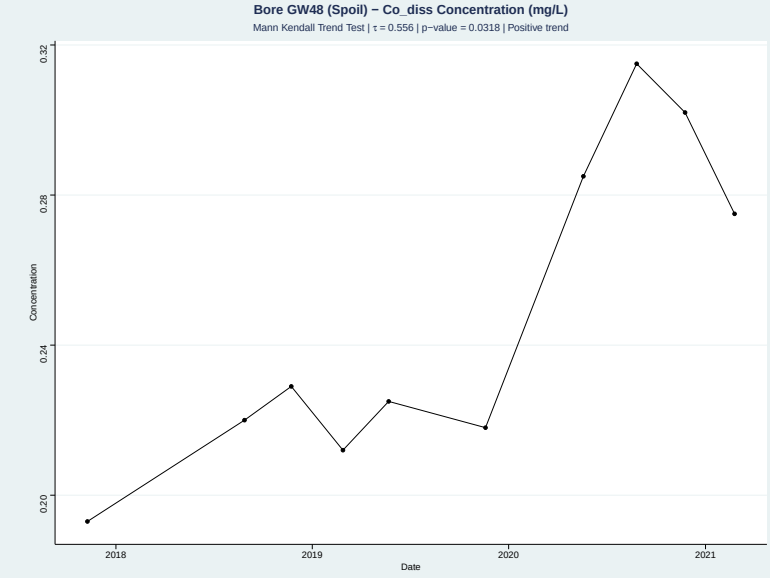
Appendix C Groundwater Quality Time Series

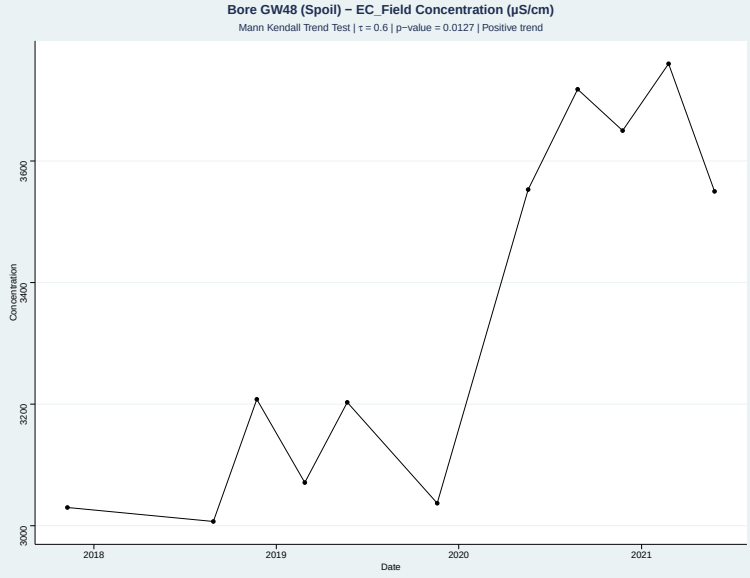




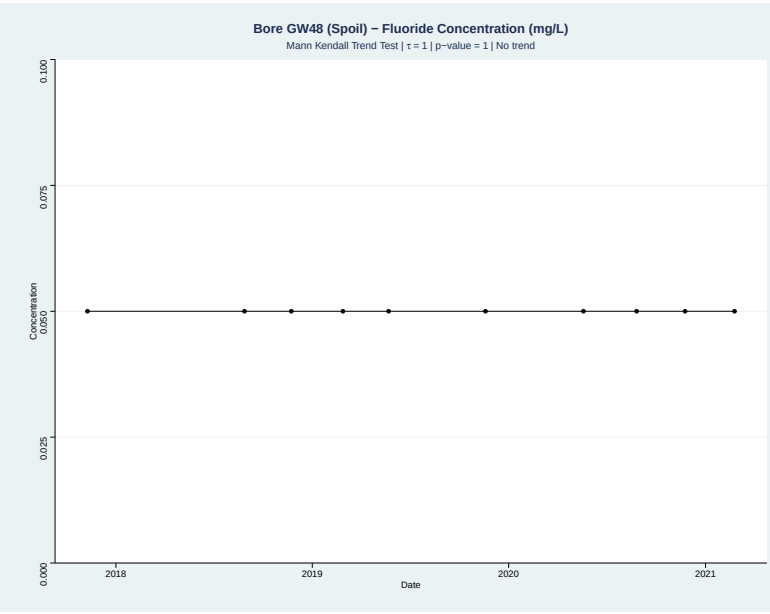


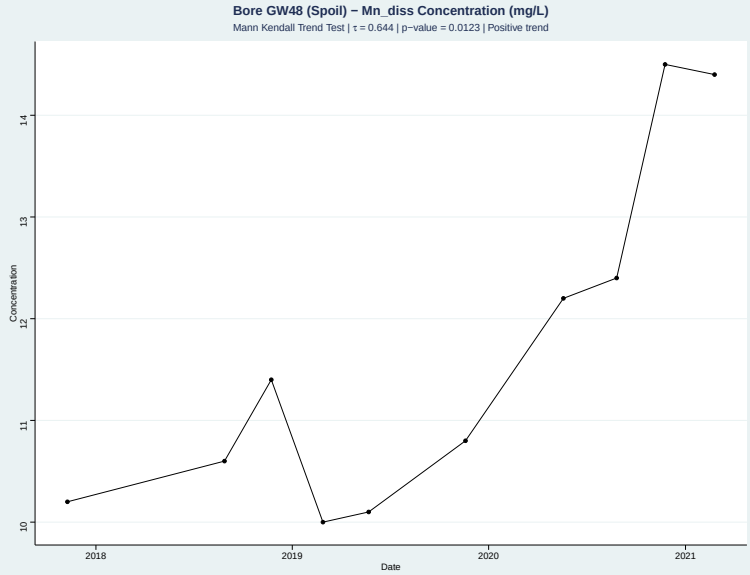


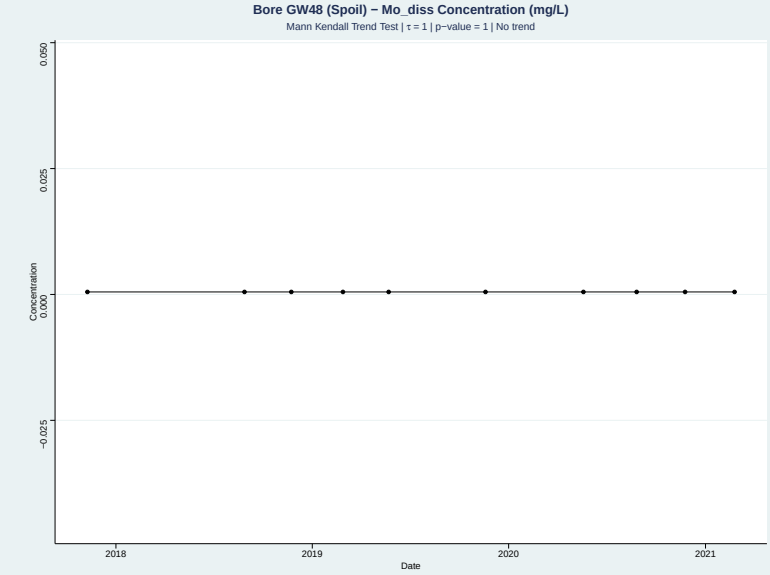


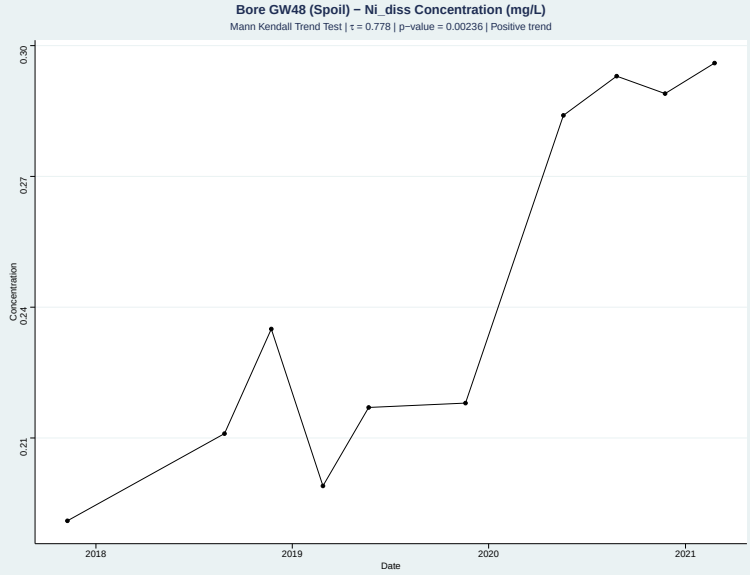


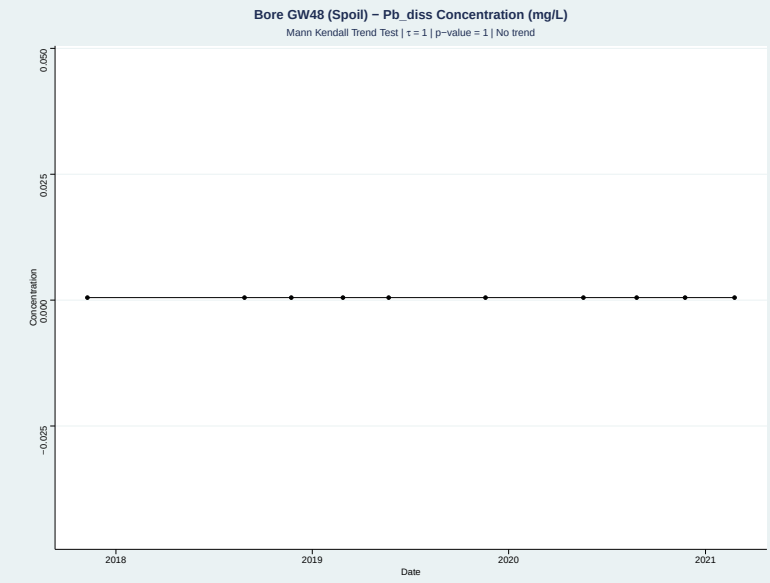
Appendix C Groundwater Quality Time Series

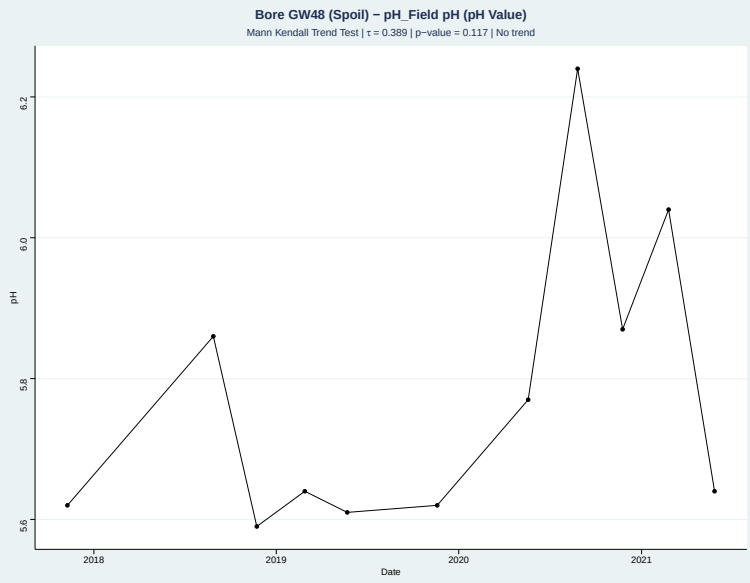




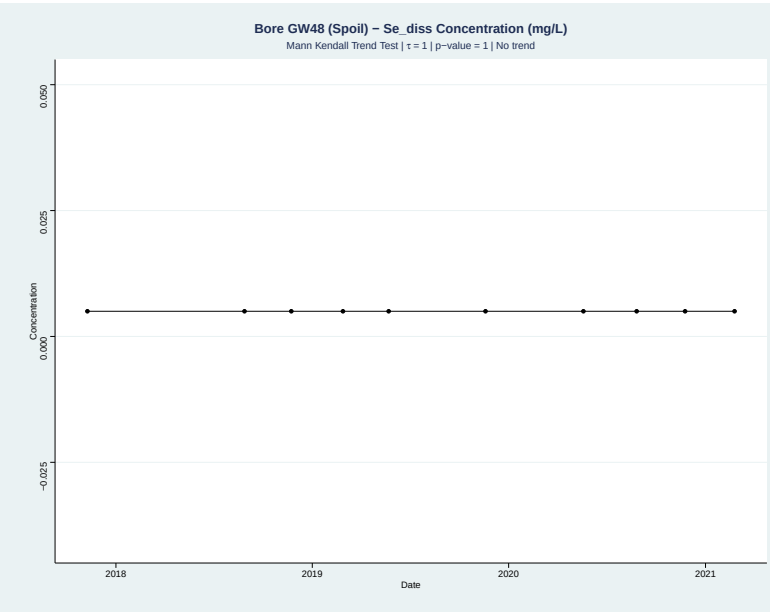


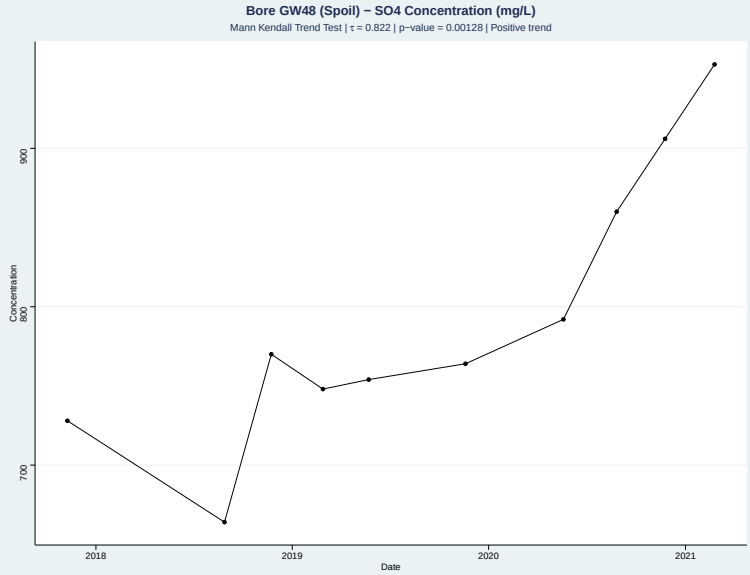


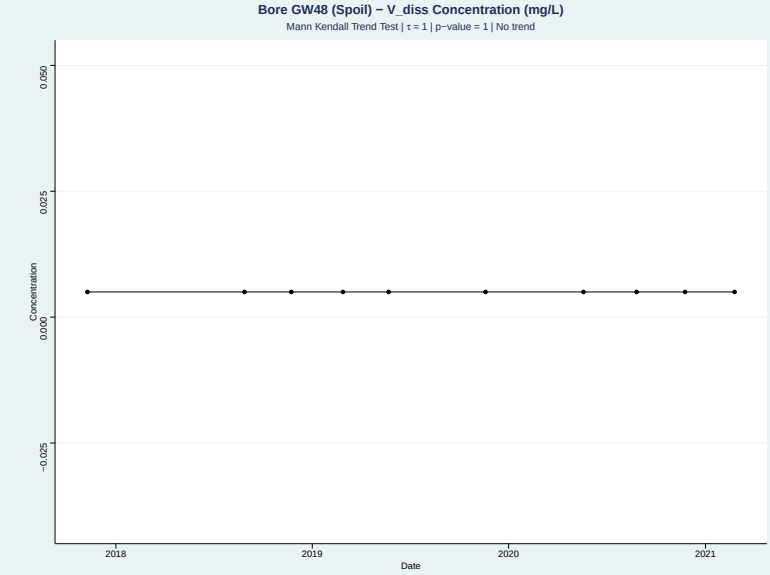


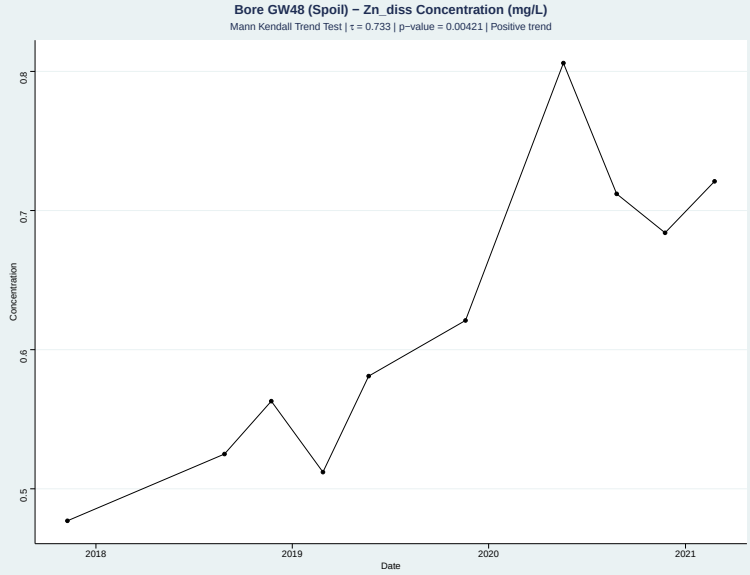


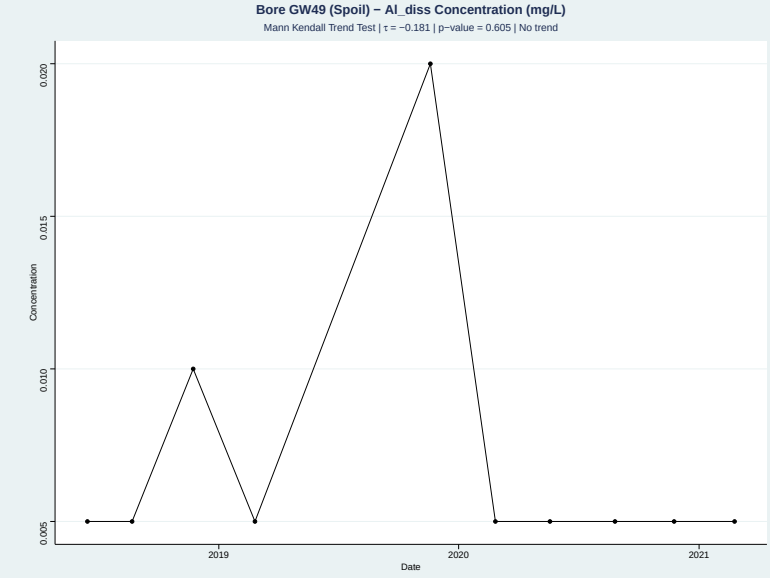
Appendix C Groundwater Quality Time Series

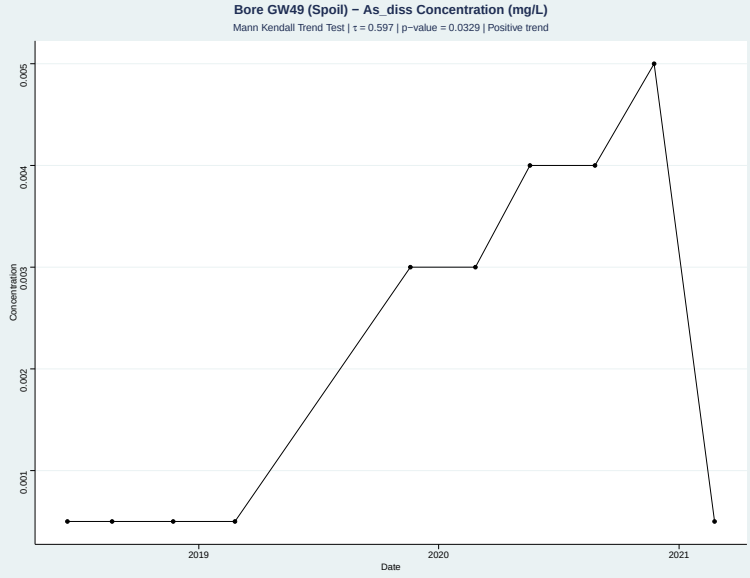




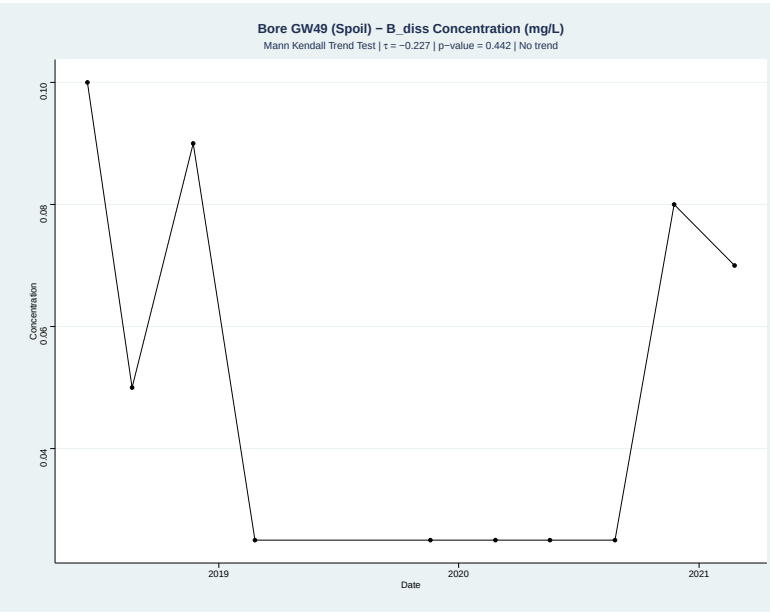


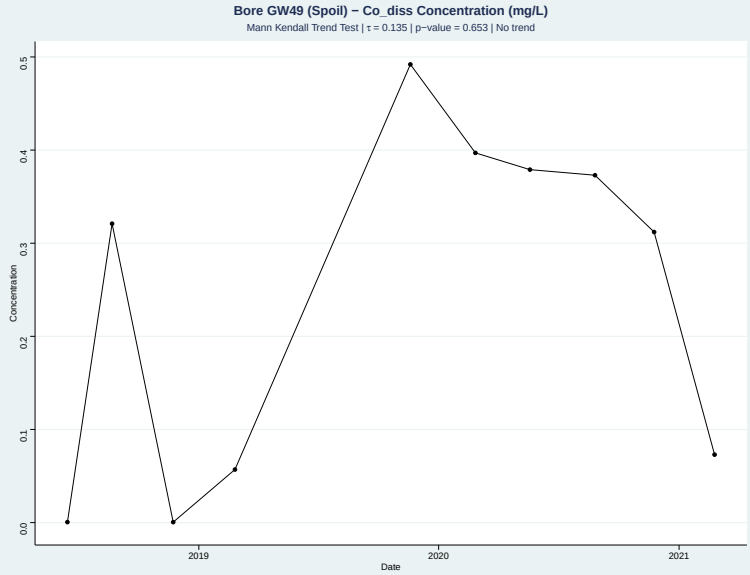


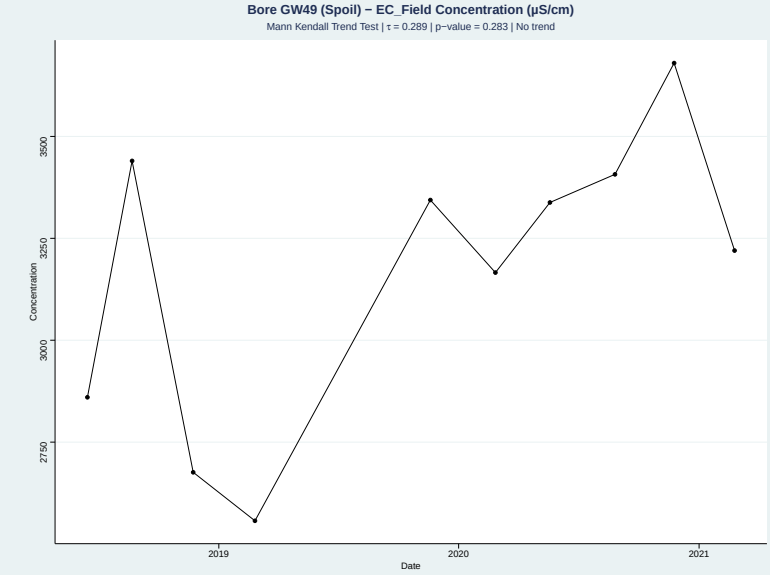


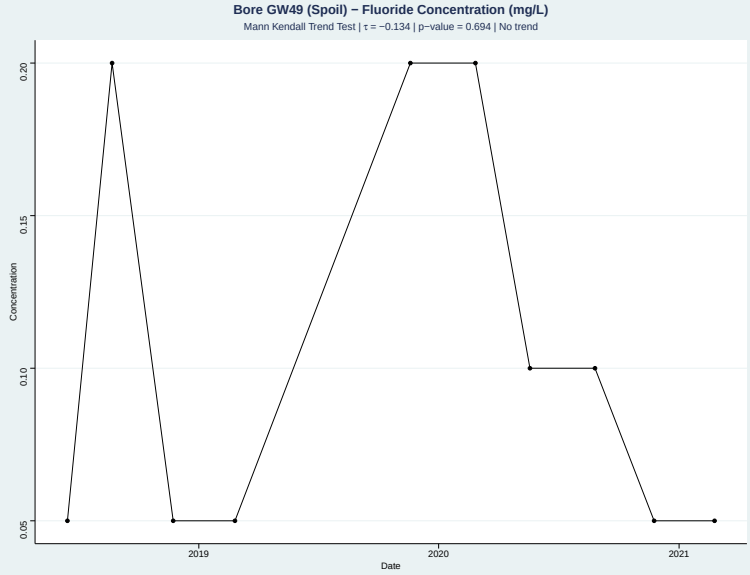


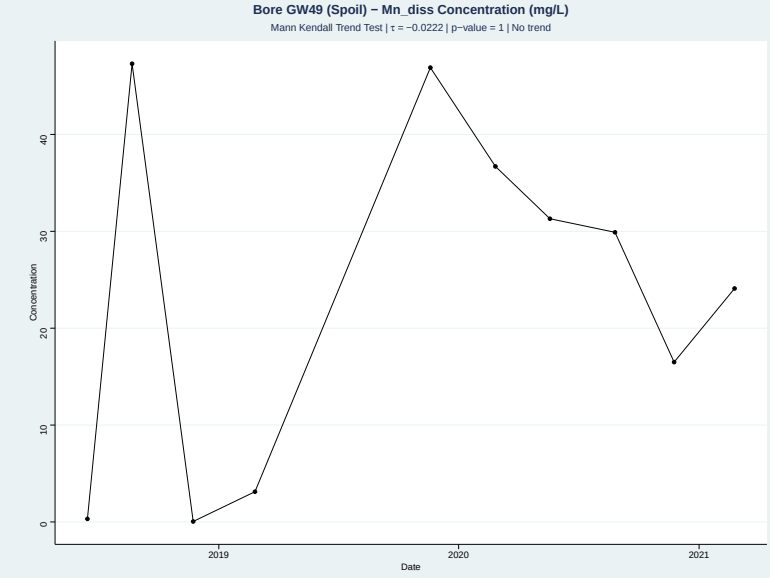
Appendix C Groundwater Quality Time Series

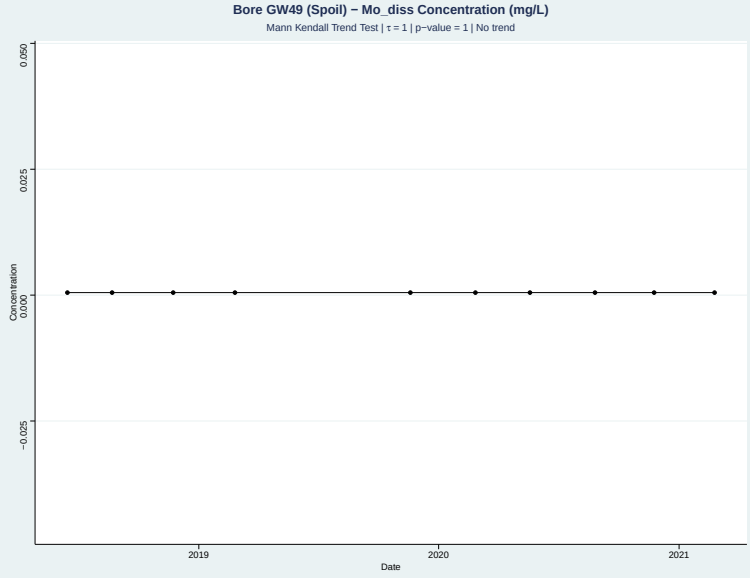




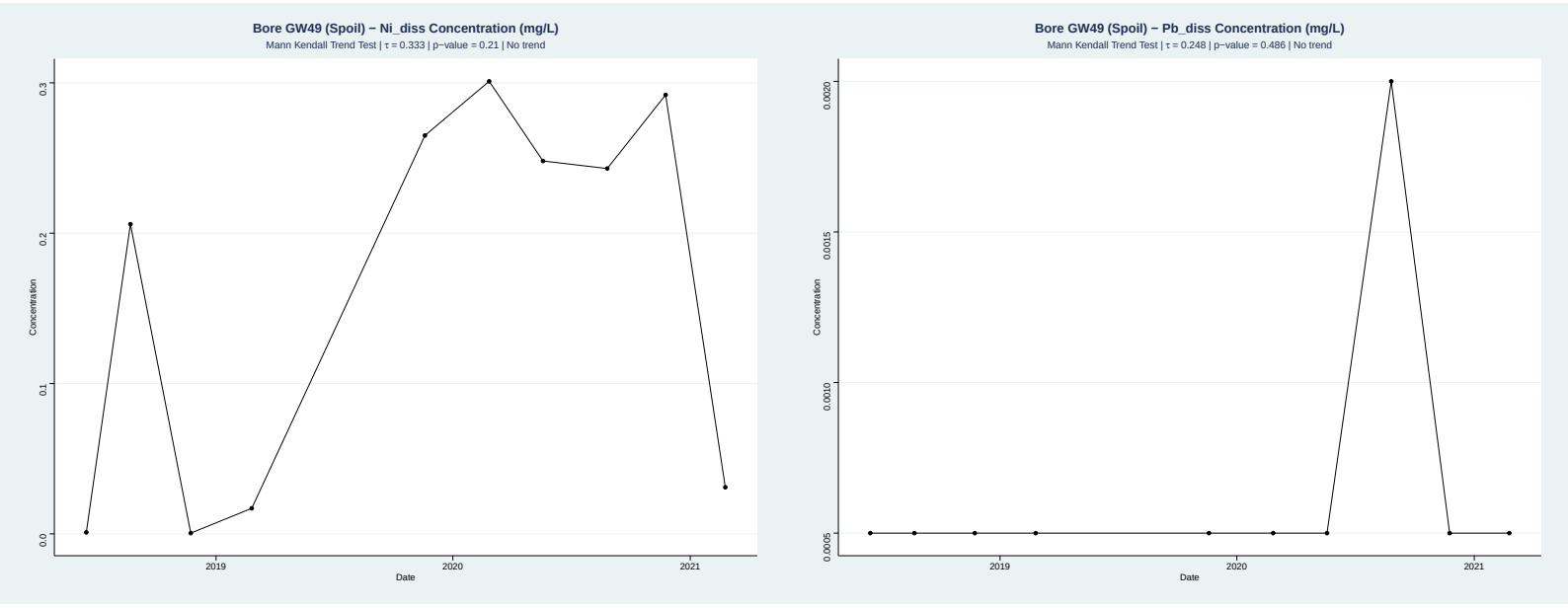


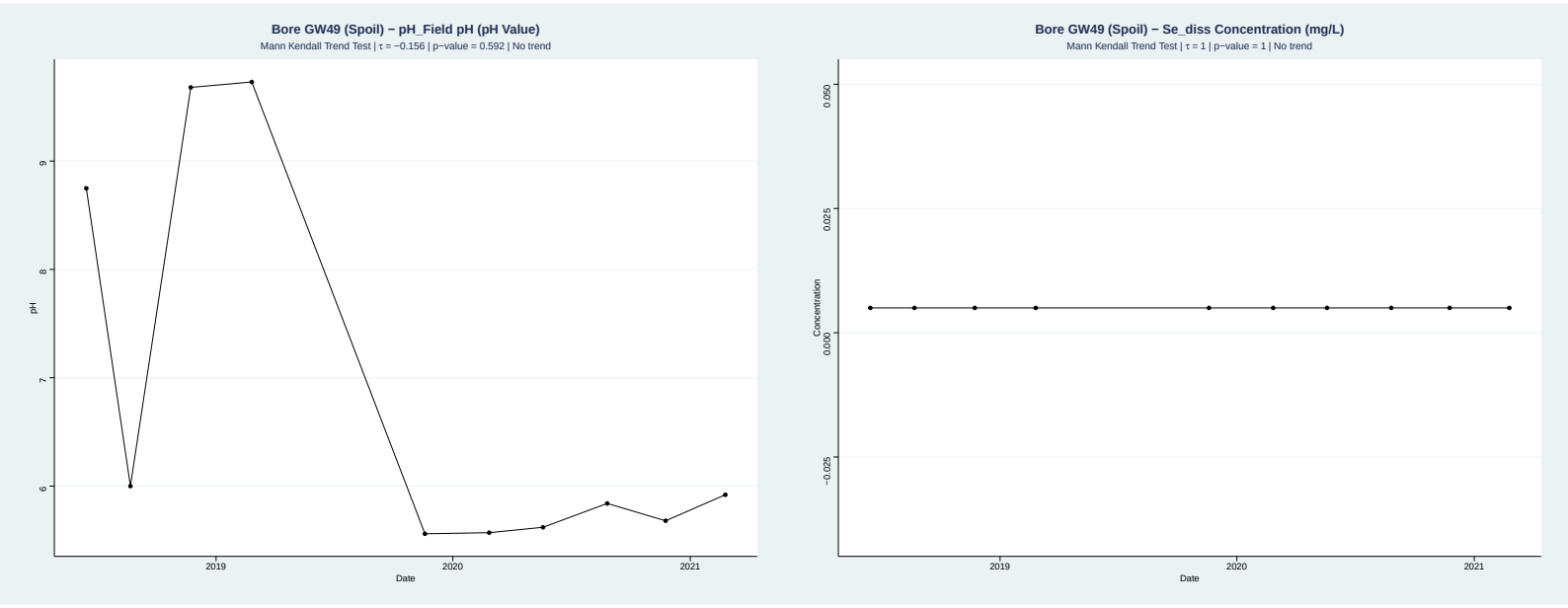


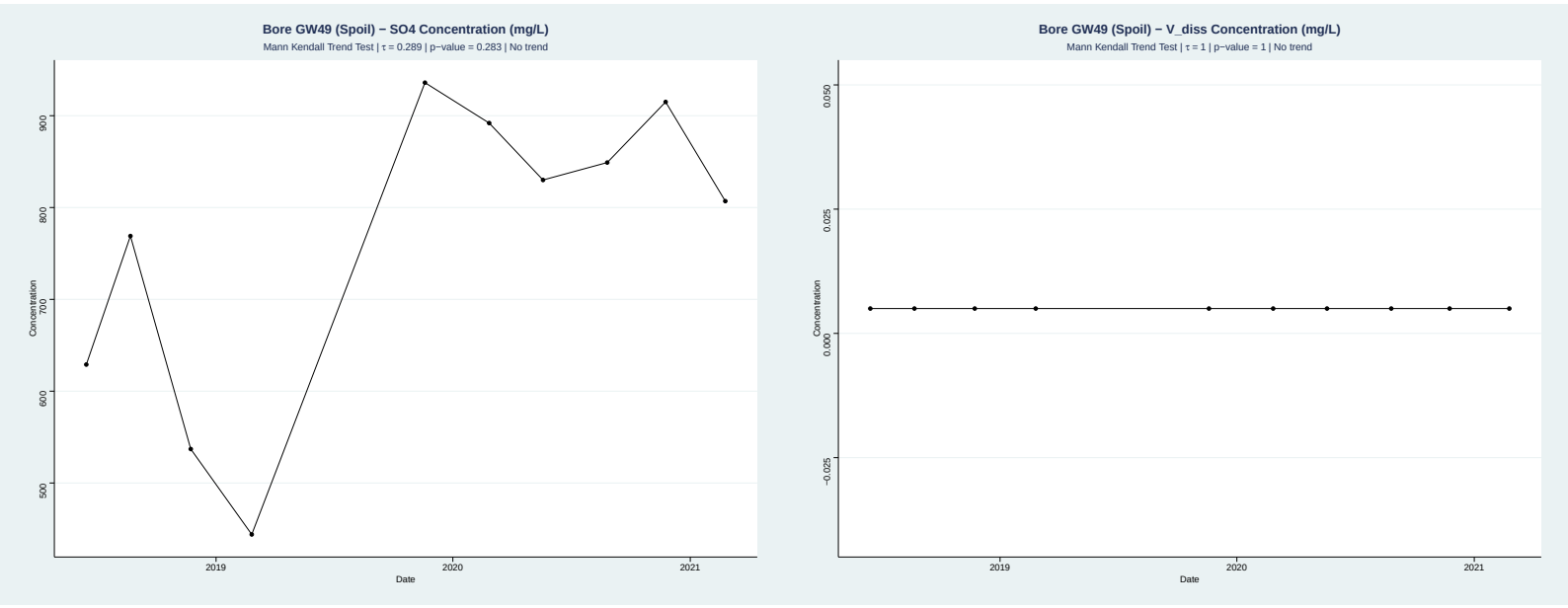




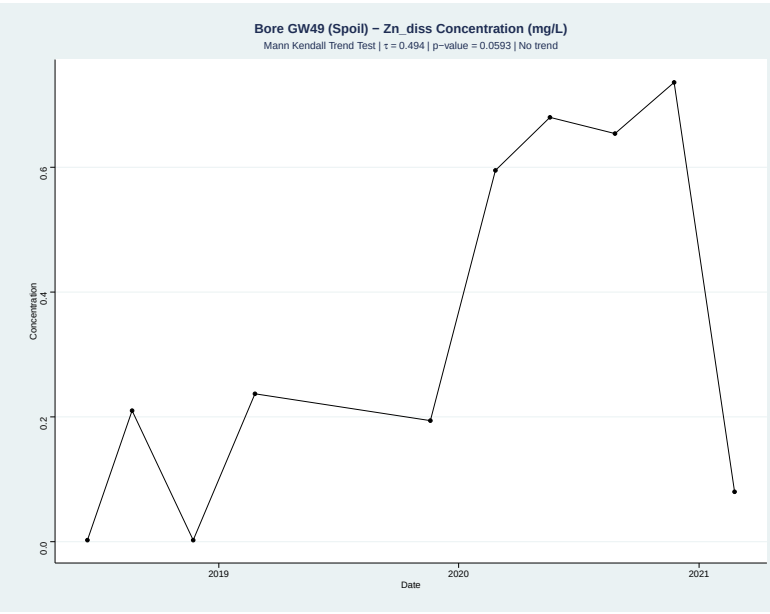
Appendix C Groundwater Quality Time Series

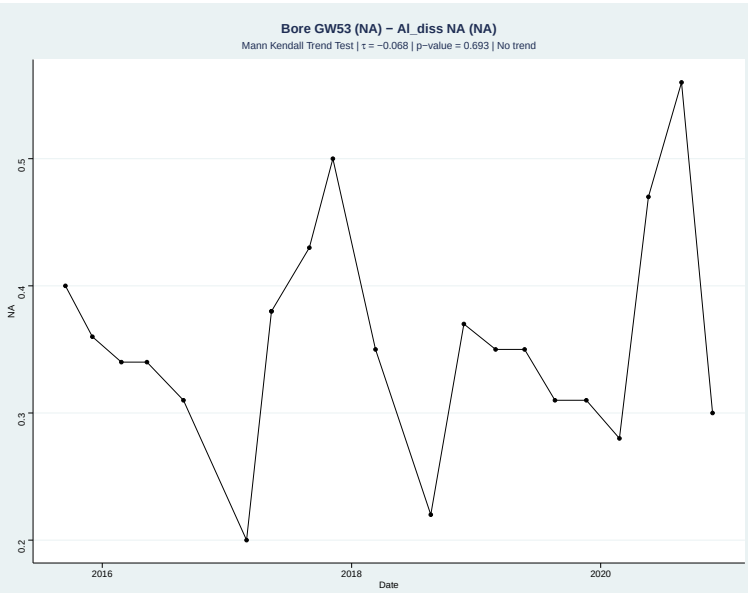


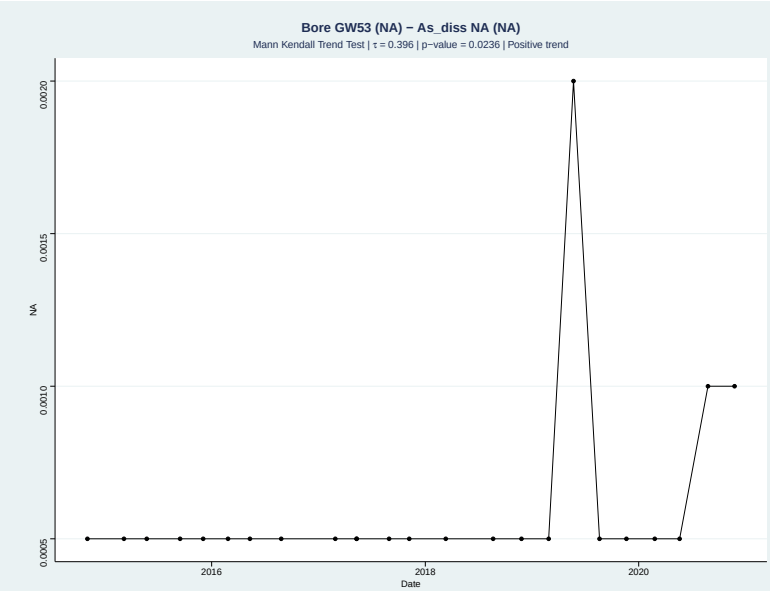


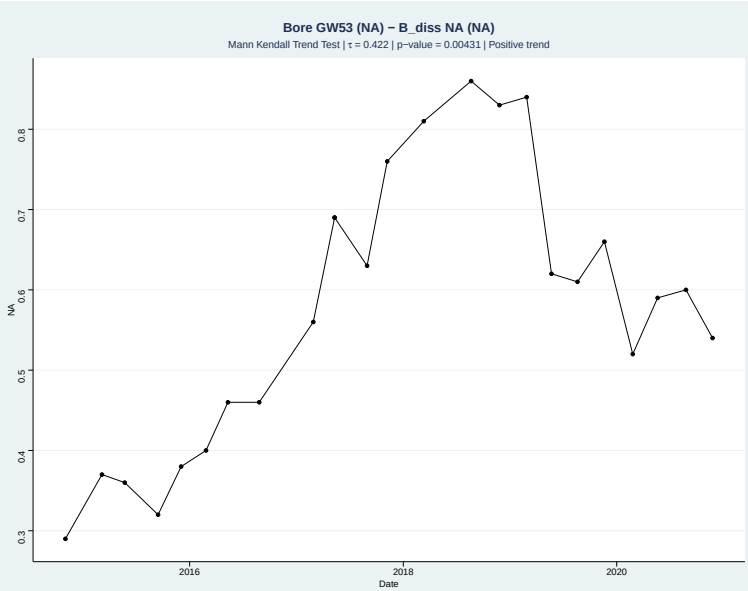


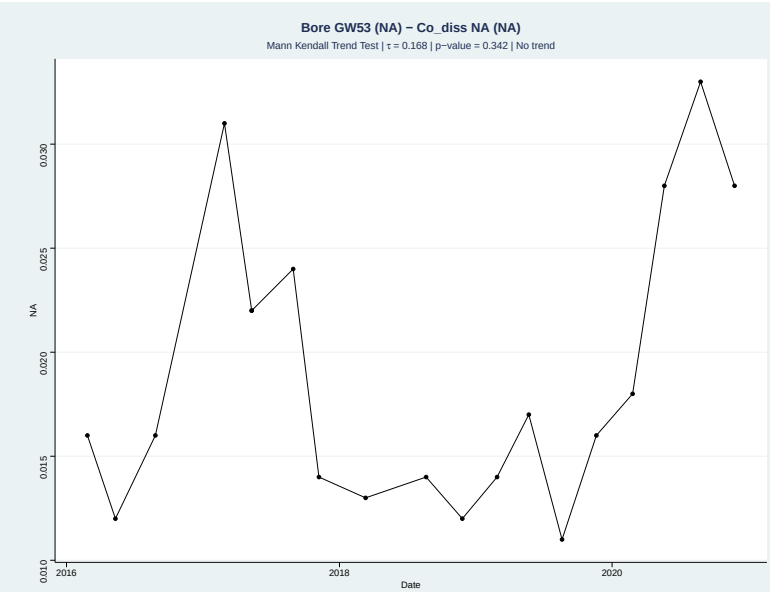
Appendix C Groundwater Quality Time Series

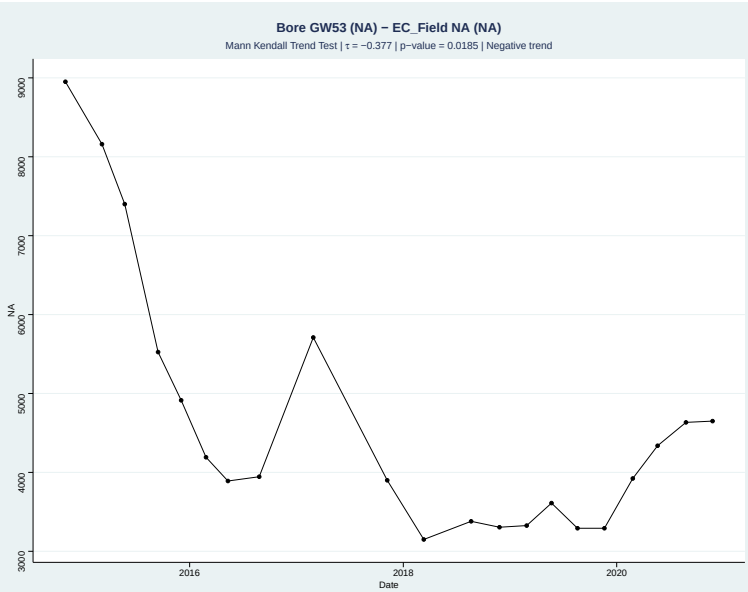




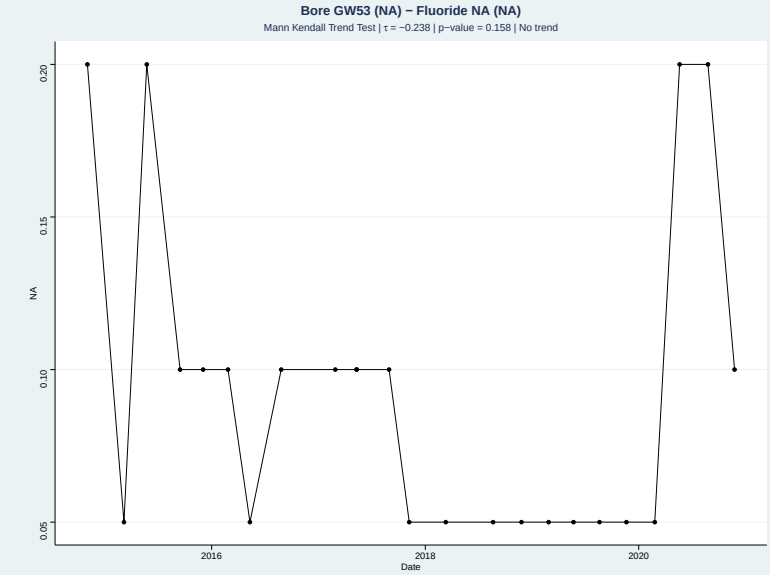


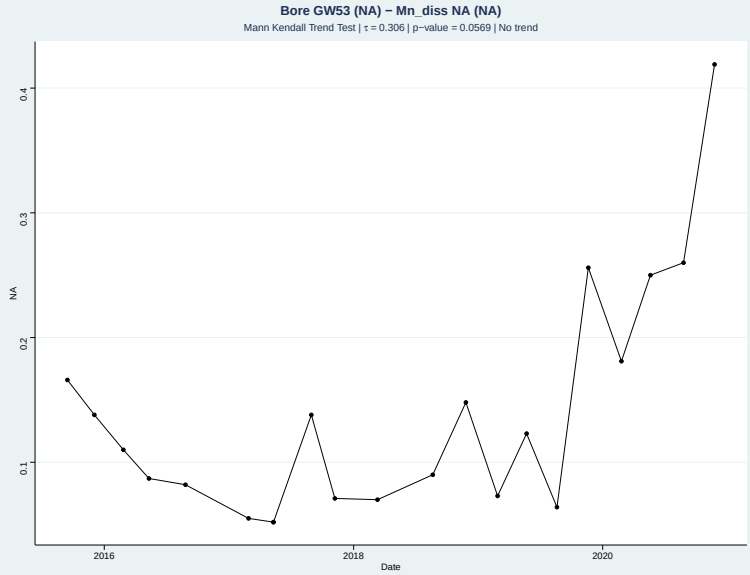


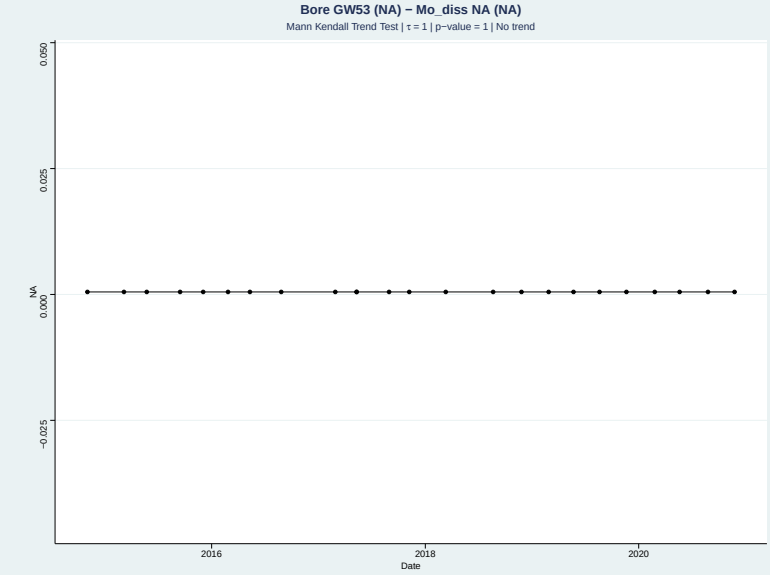


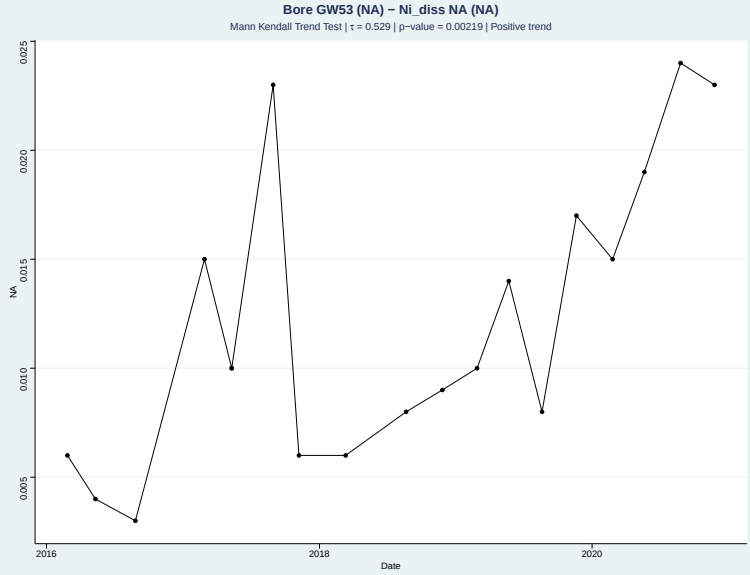


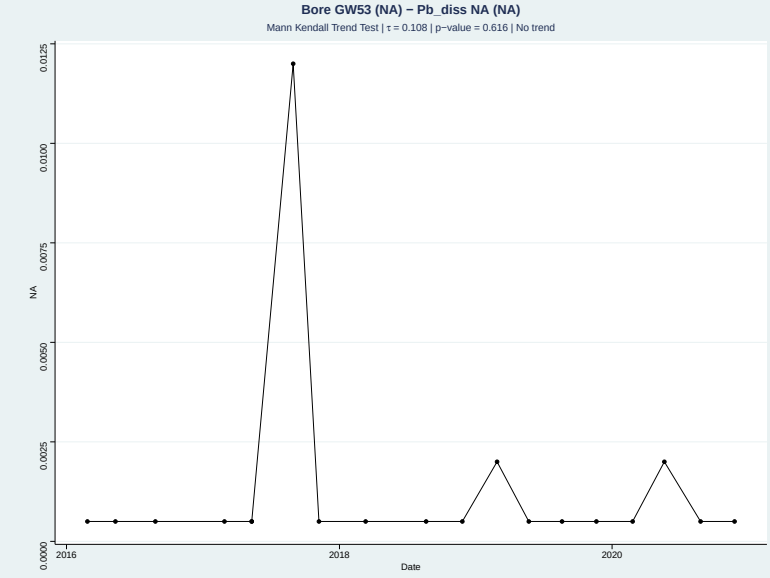
Appendix C Groundwater Quality Time Series

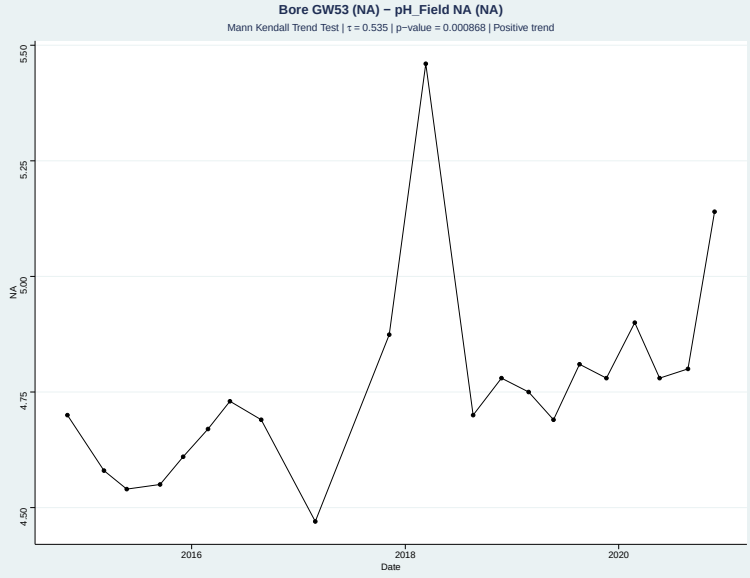




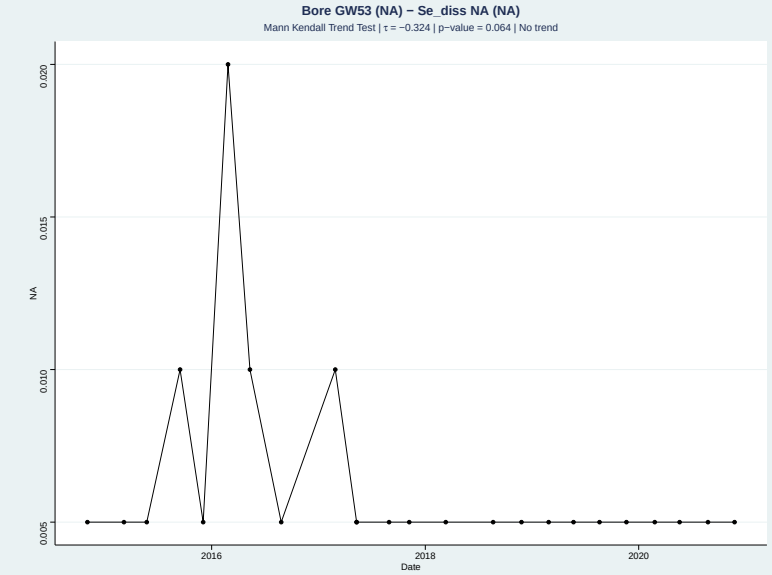


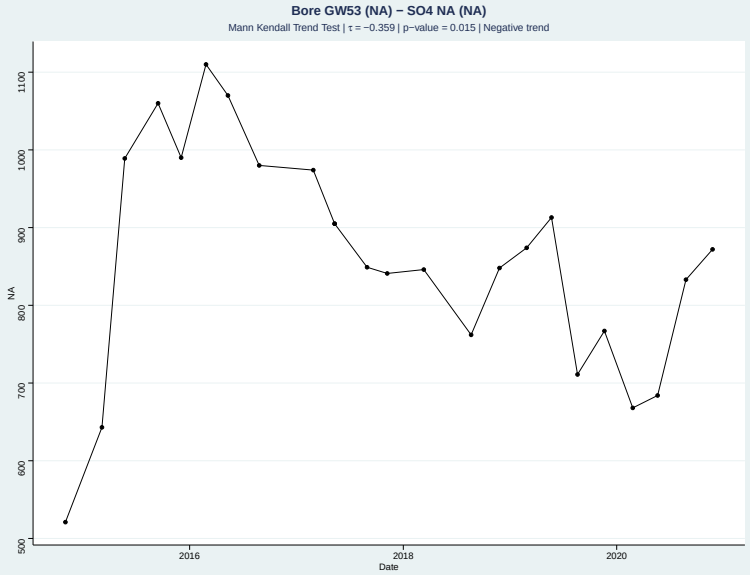


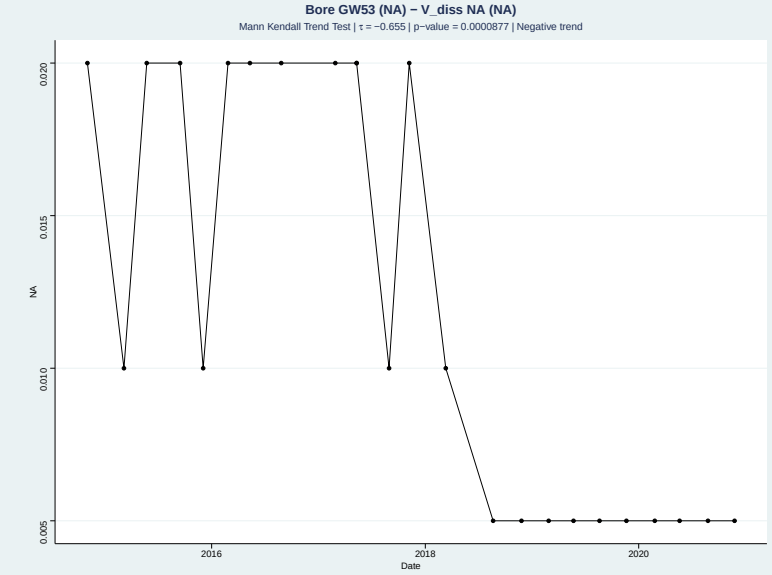


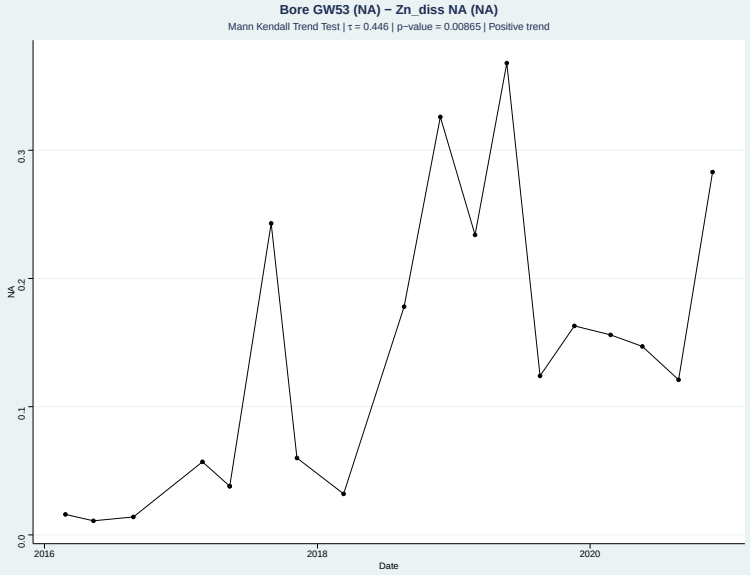


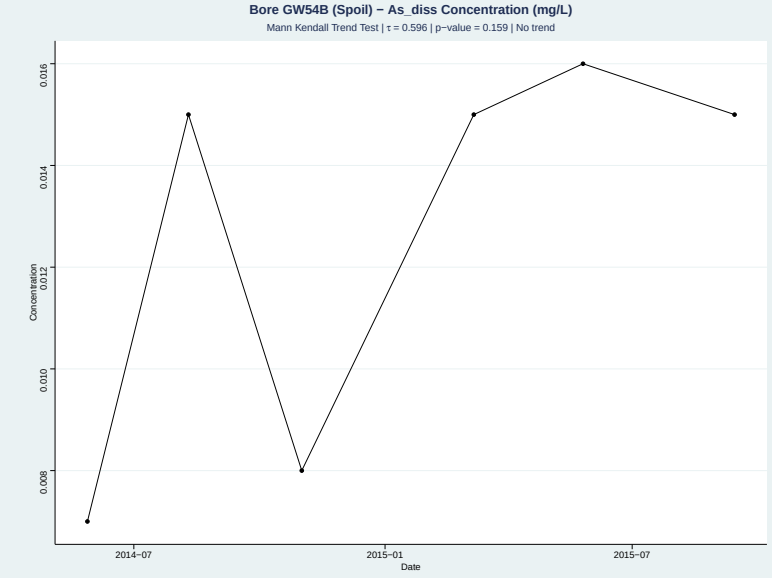
Appendix C Groundwater Quality Time Series

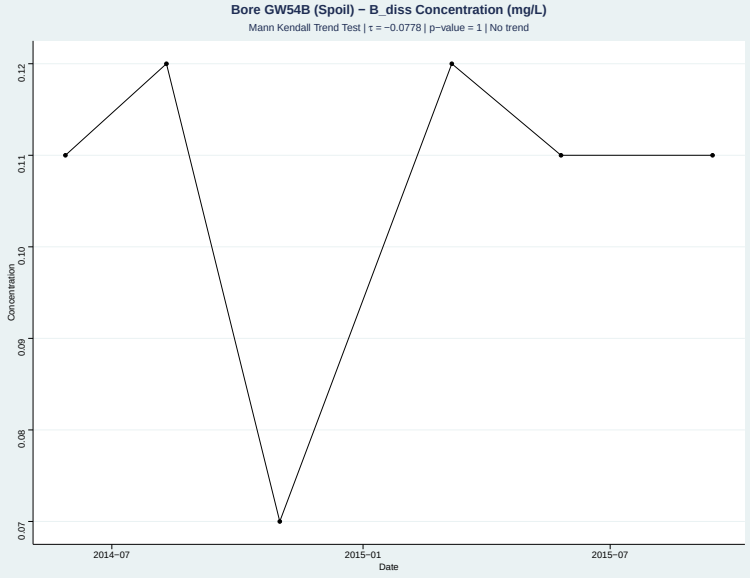












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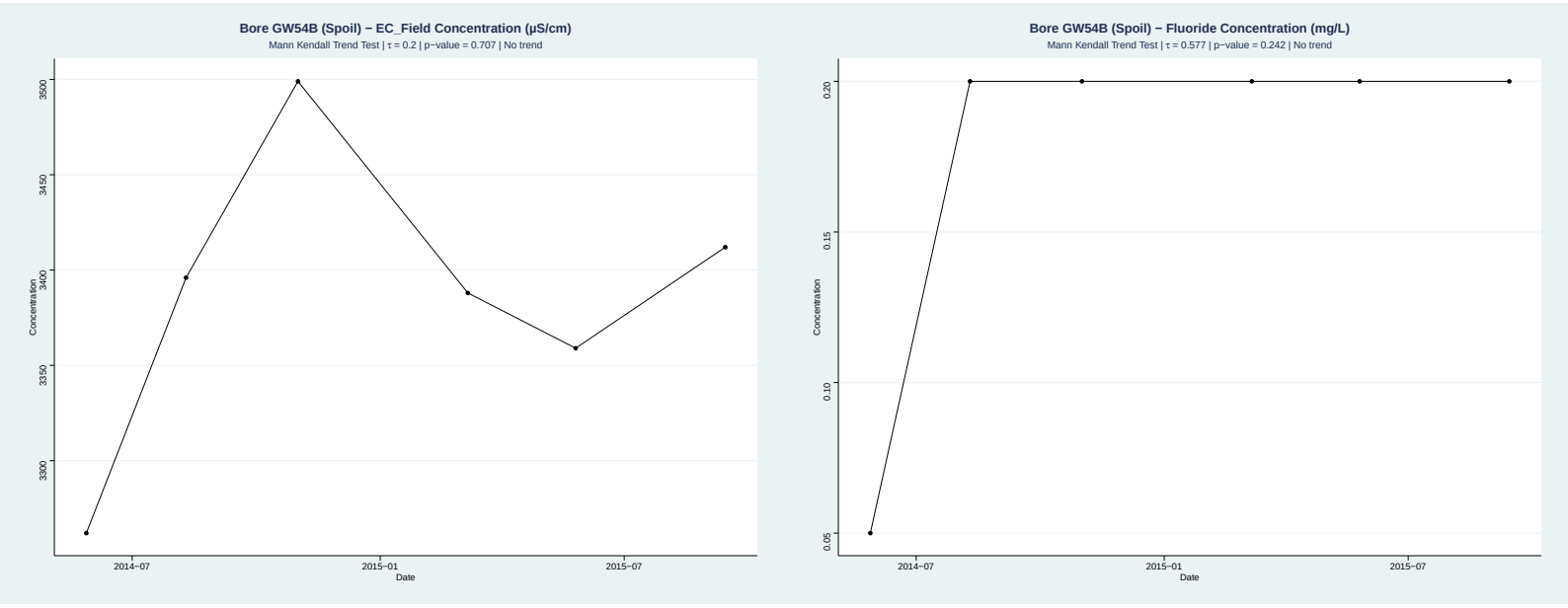

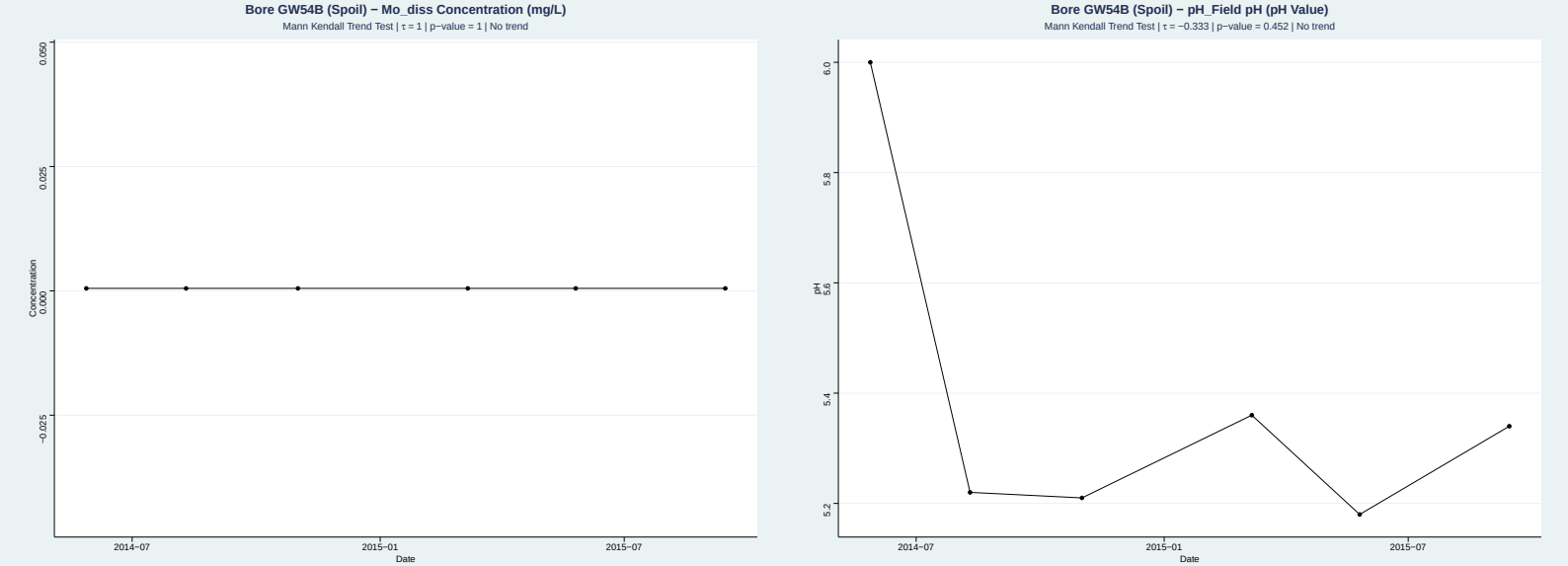

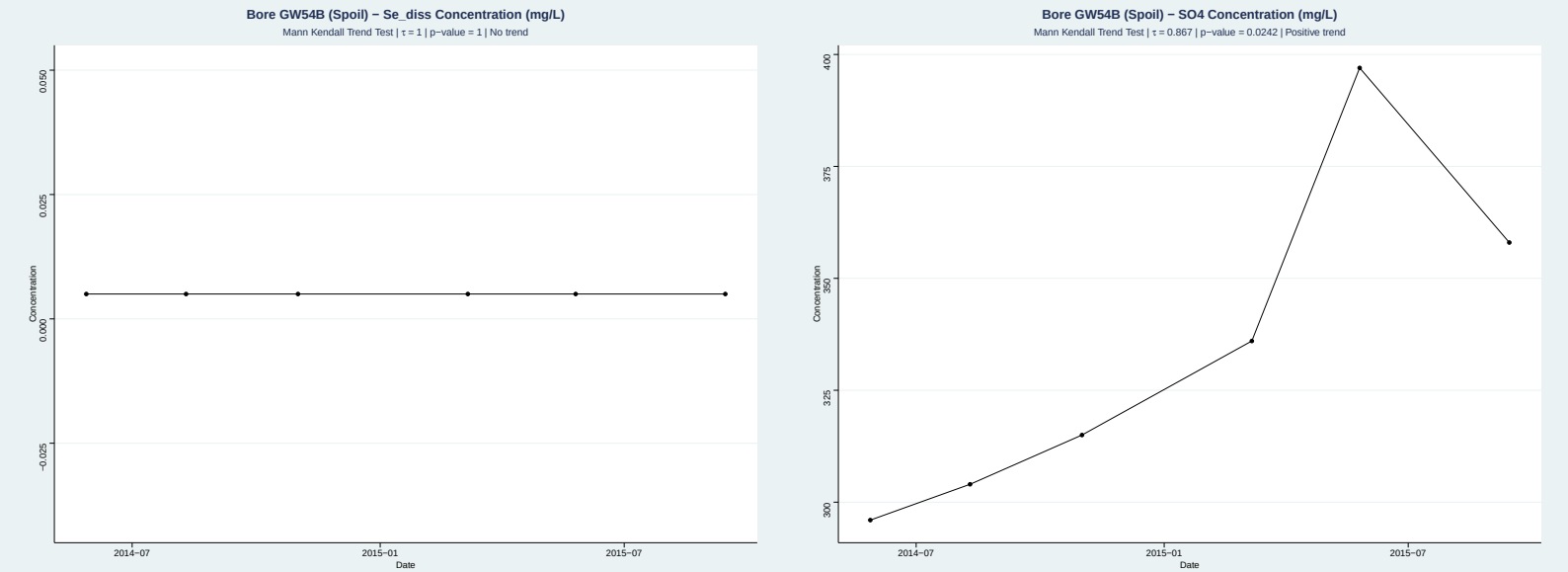

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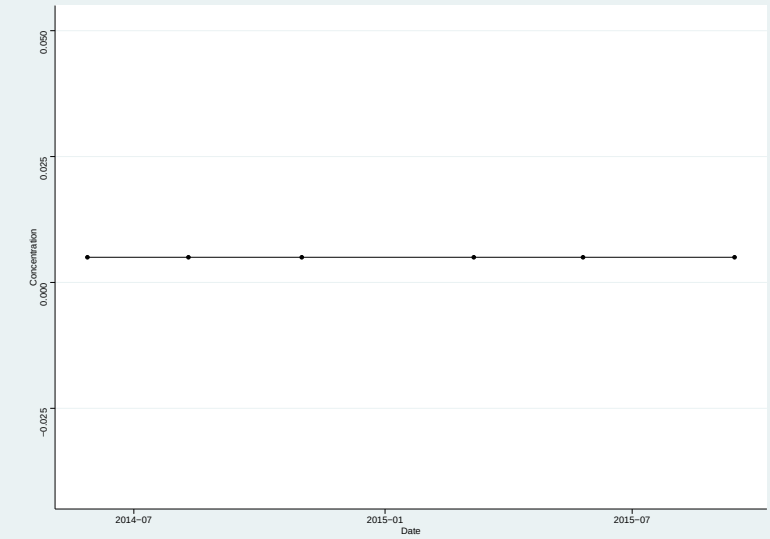

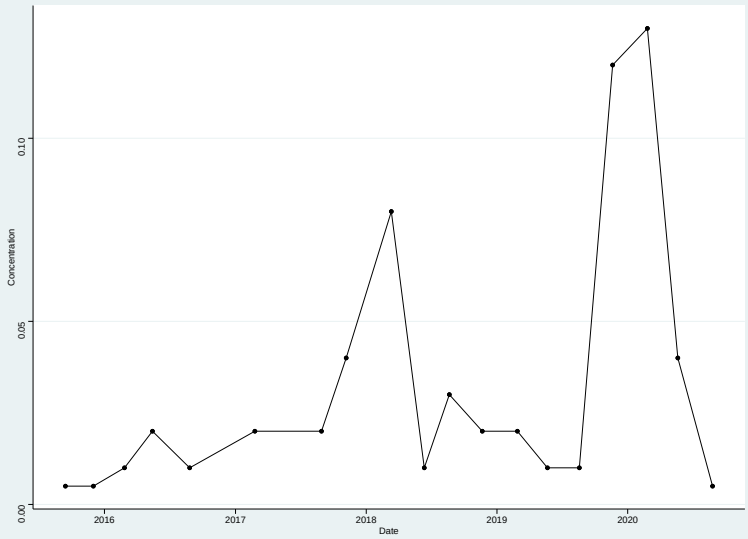

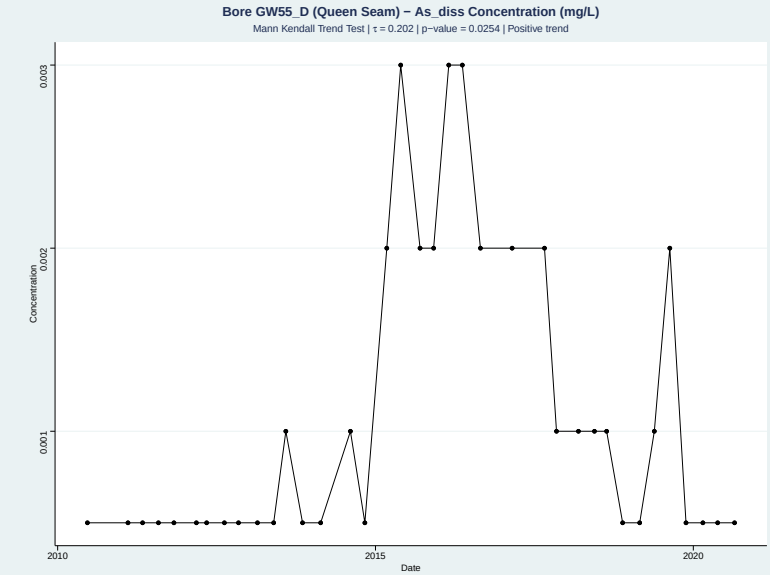

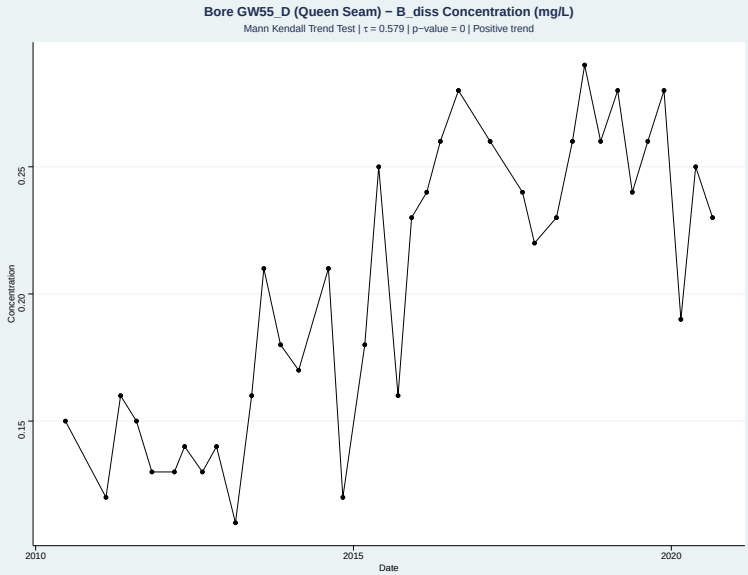

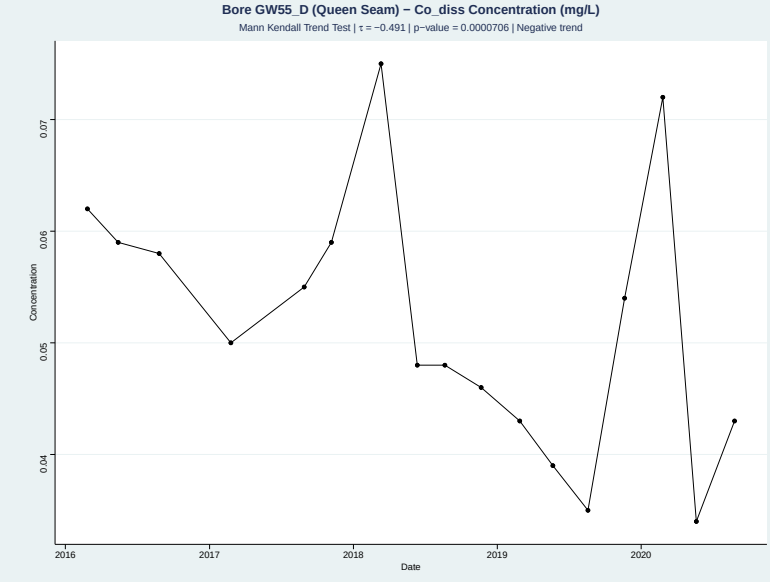

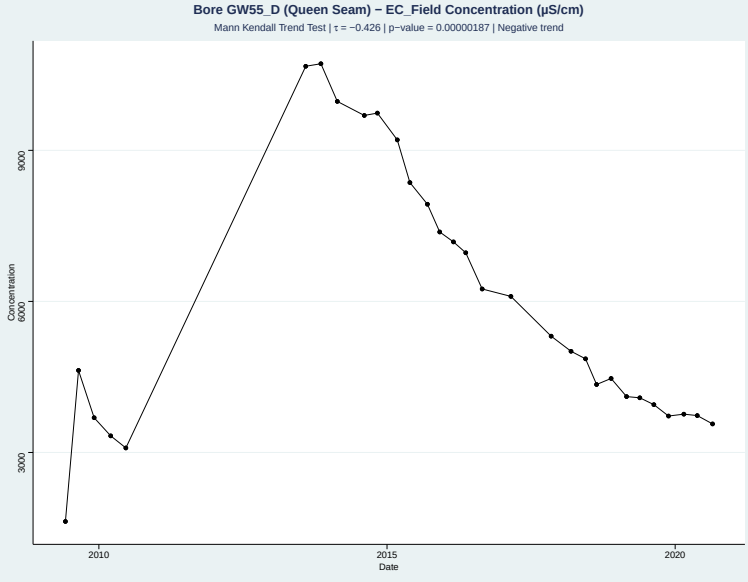

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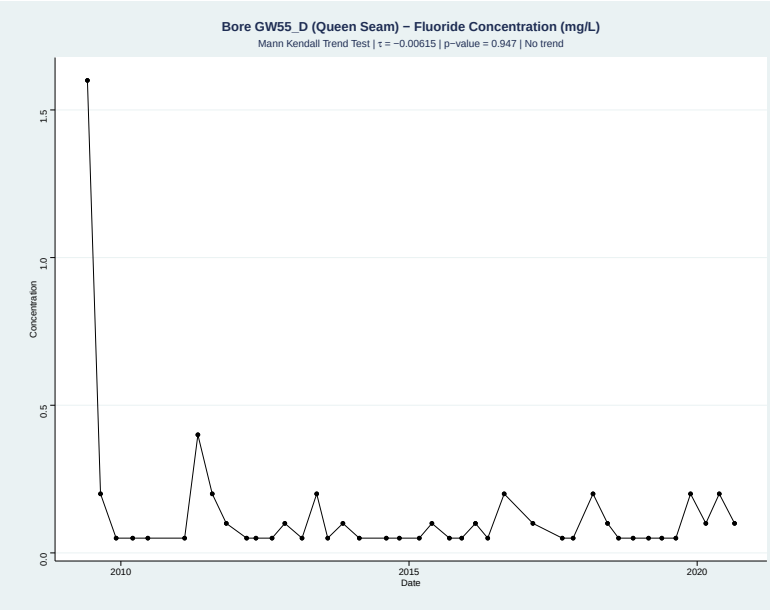

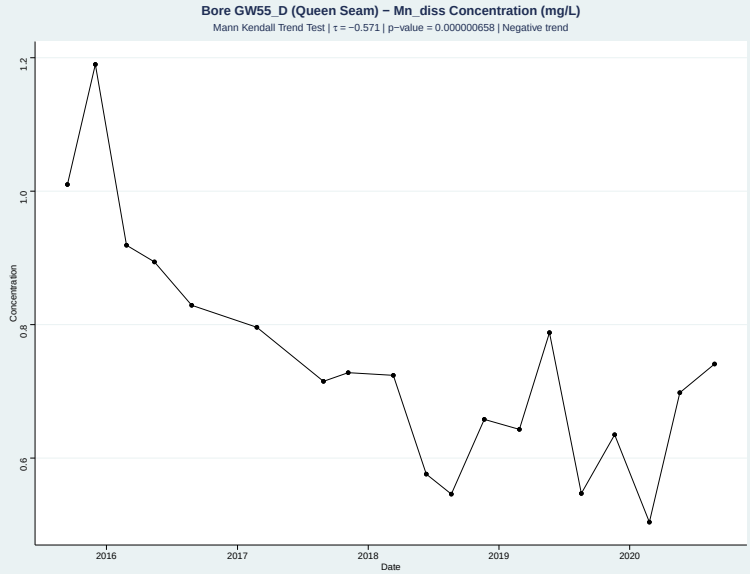

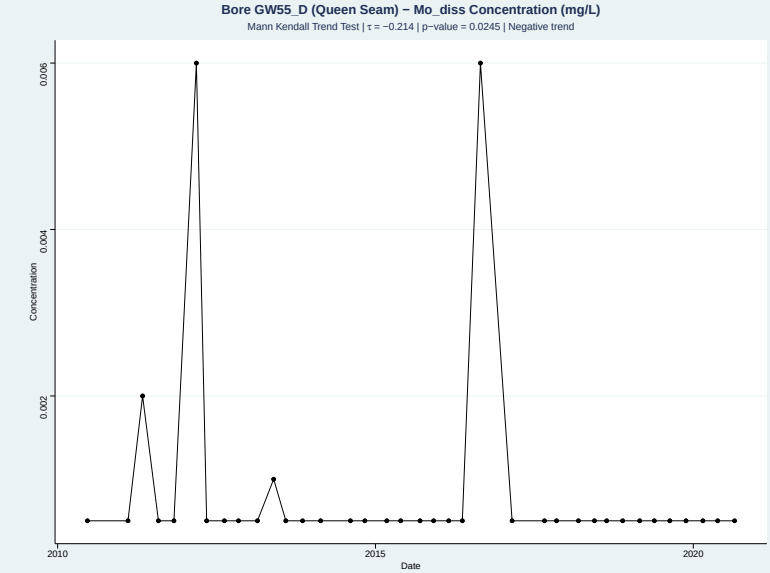

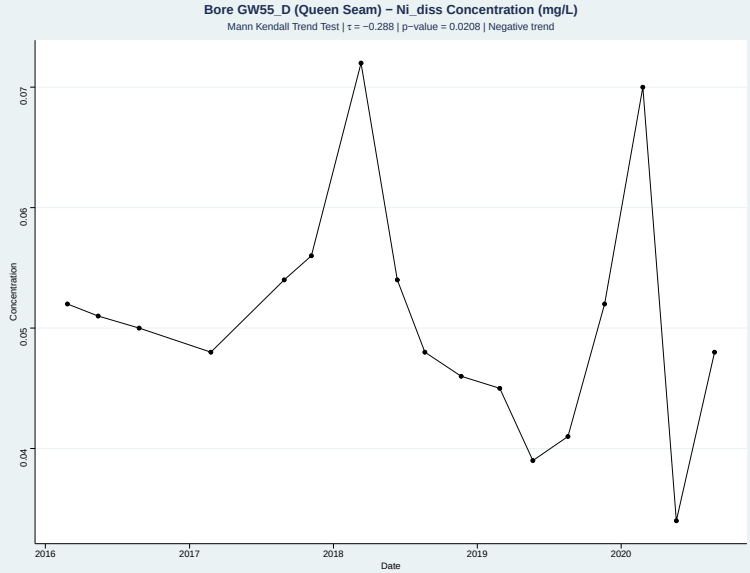

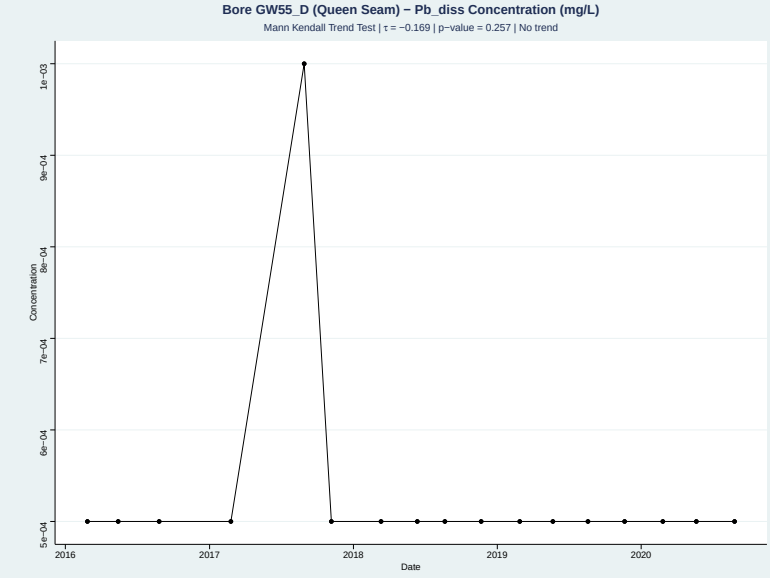

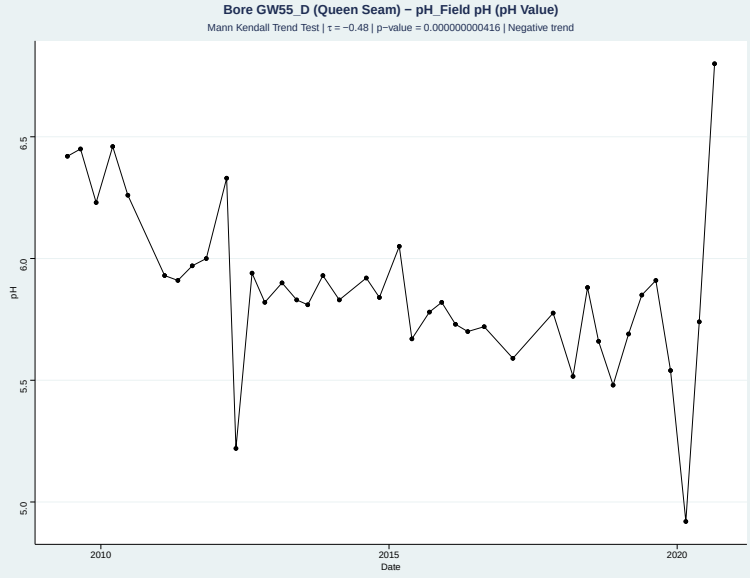

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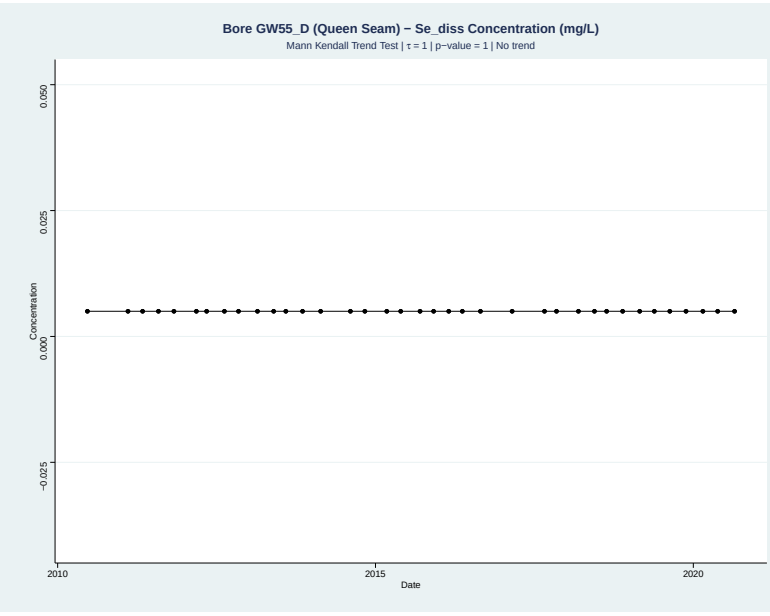
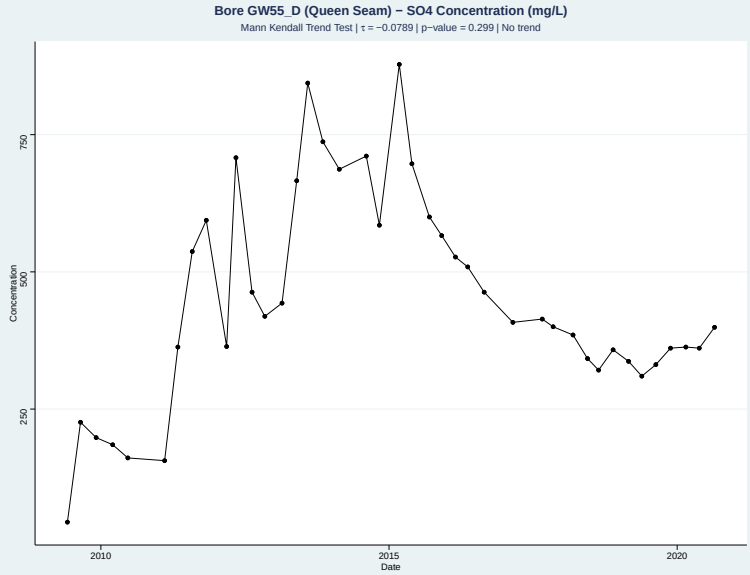
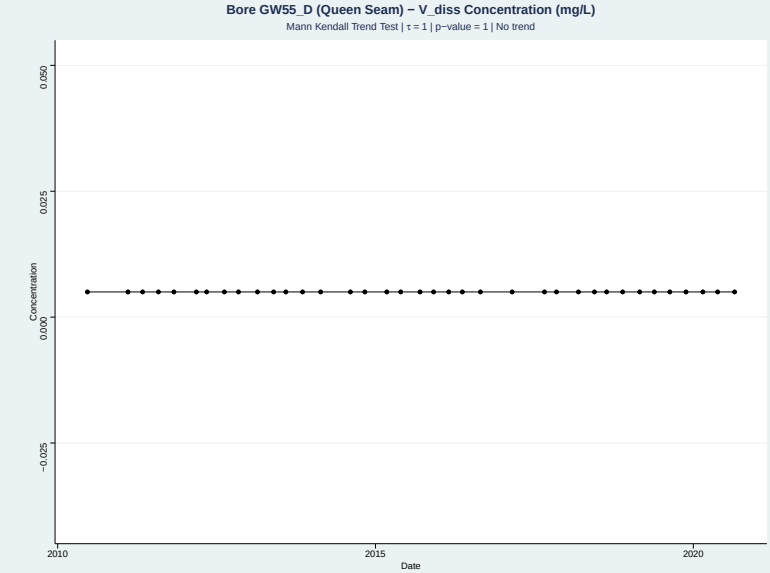
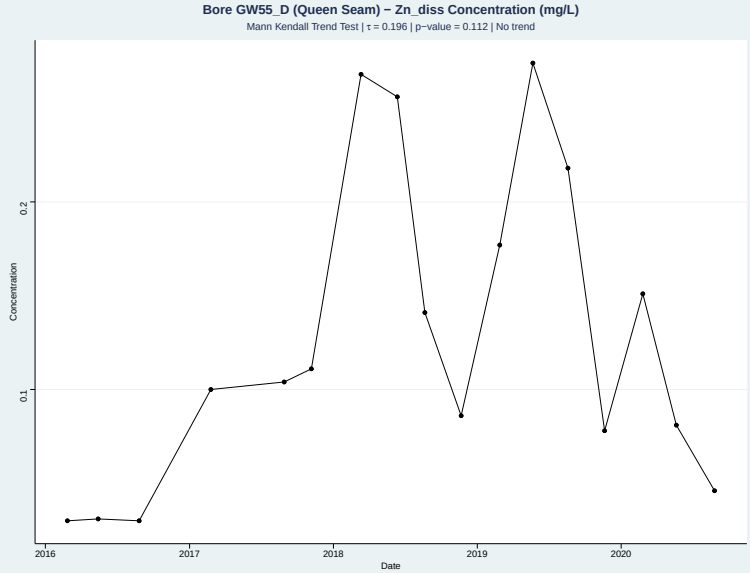
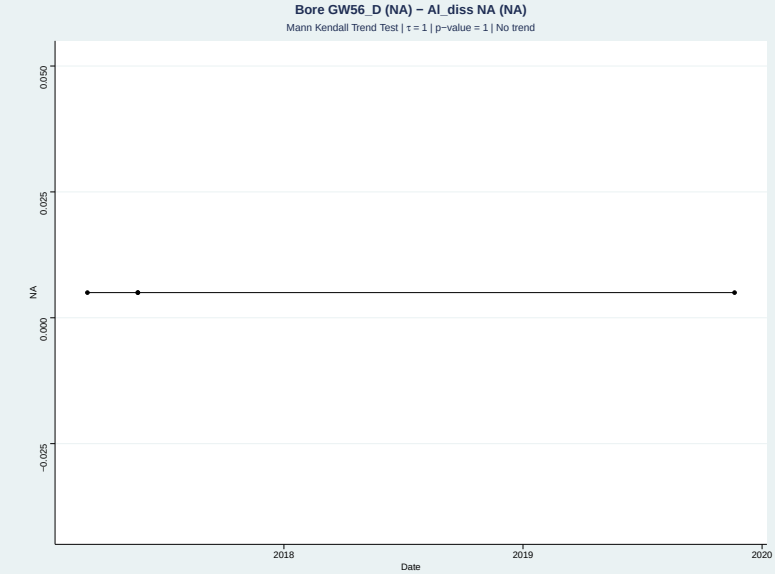
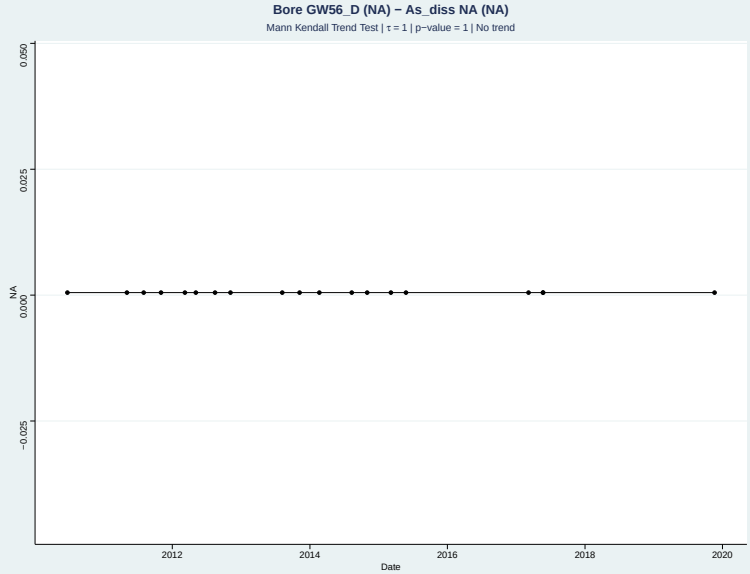




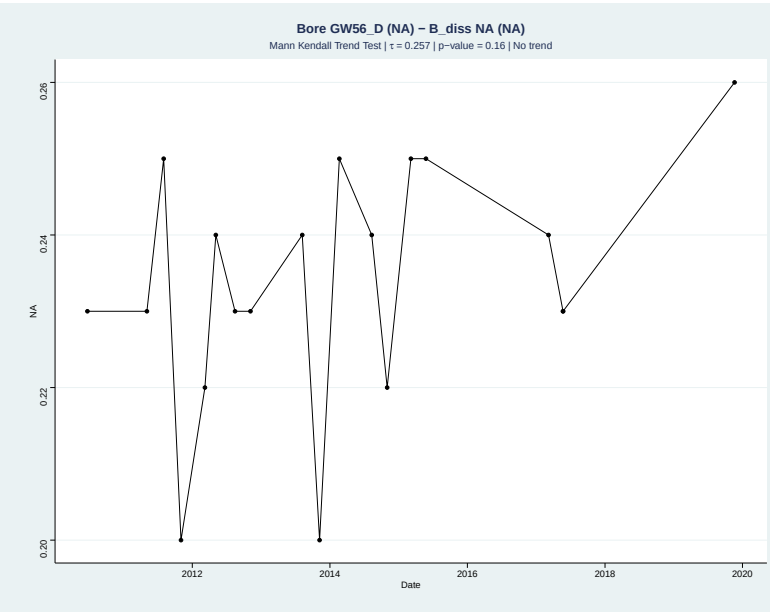


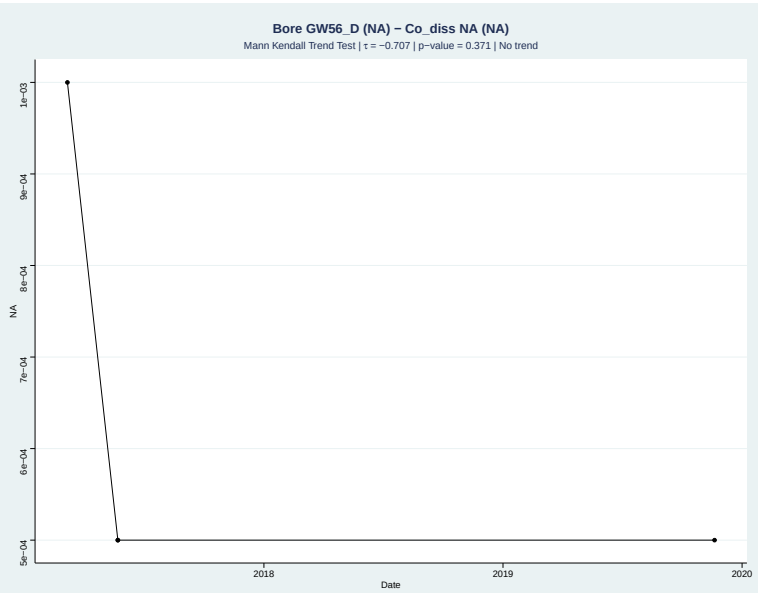


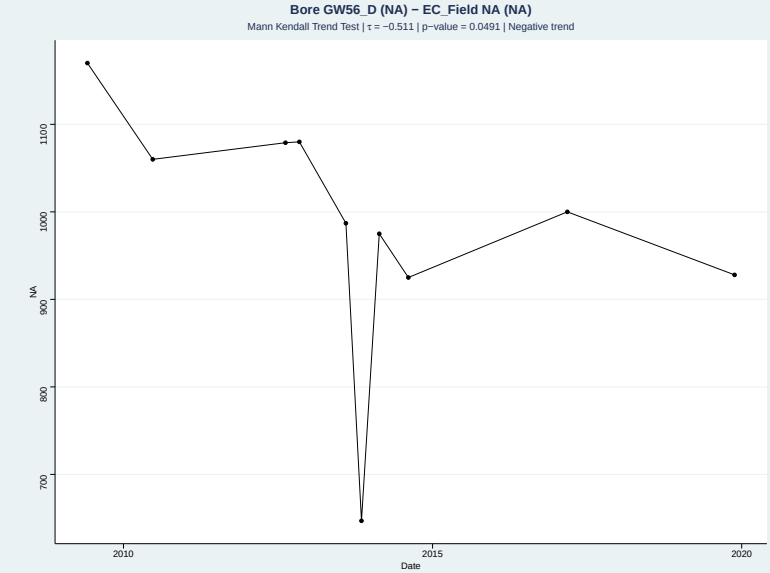


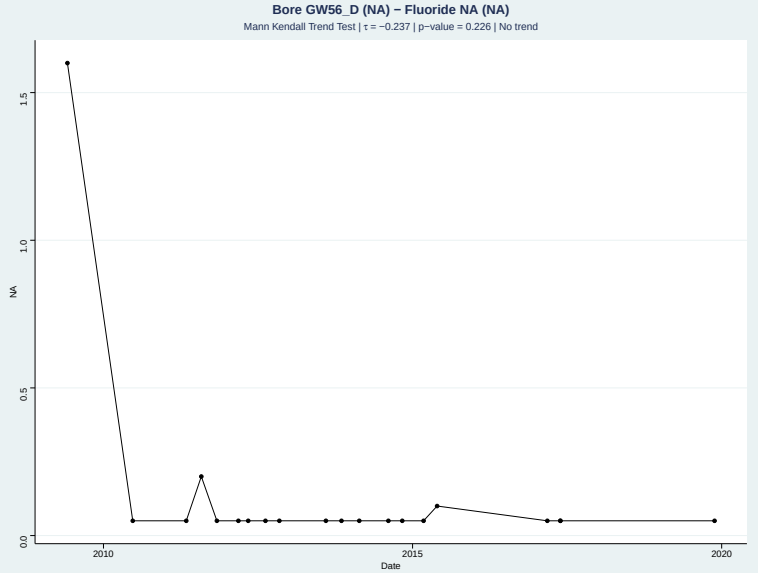


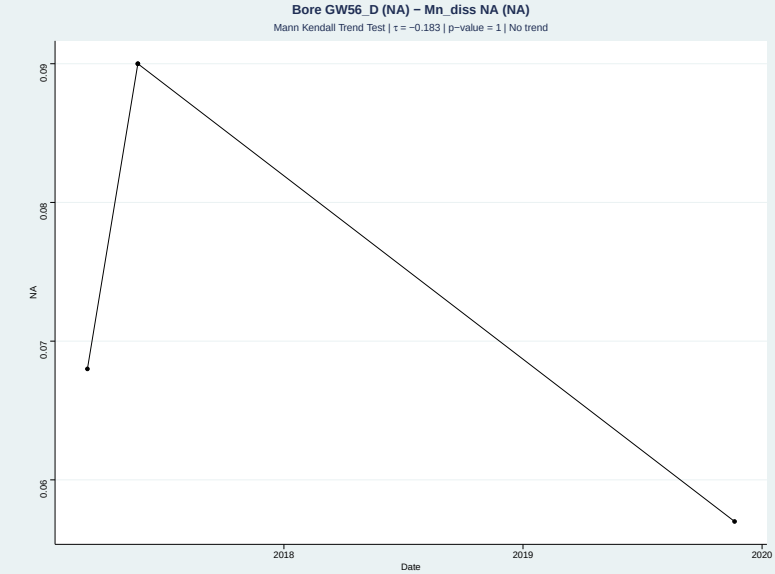
Appendix C Groundwater Quality Time Series

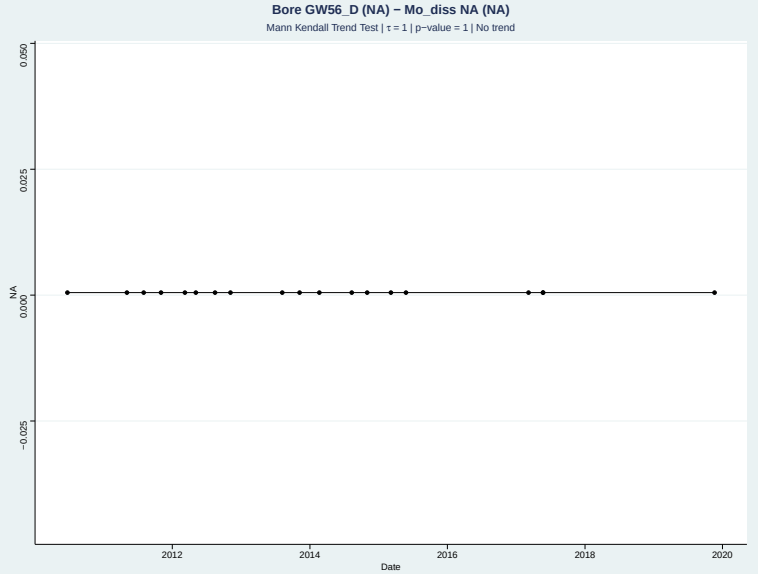




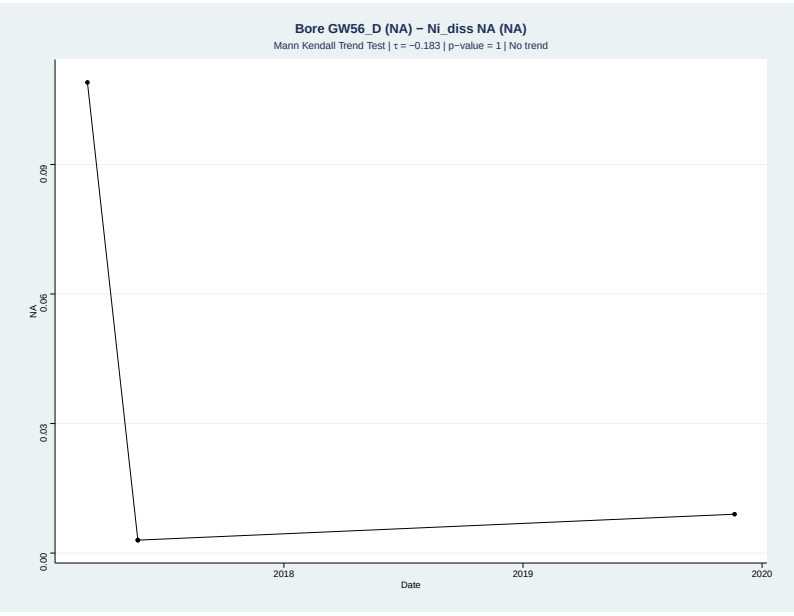


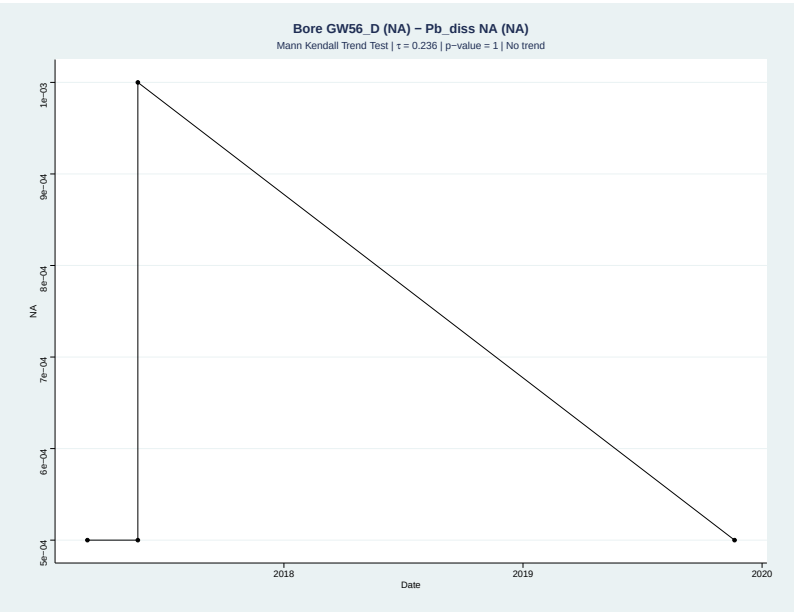


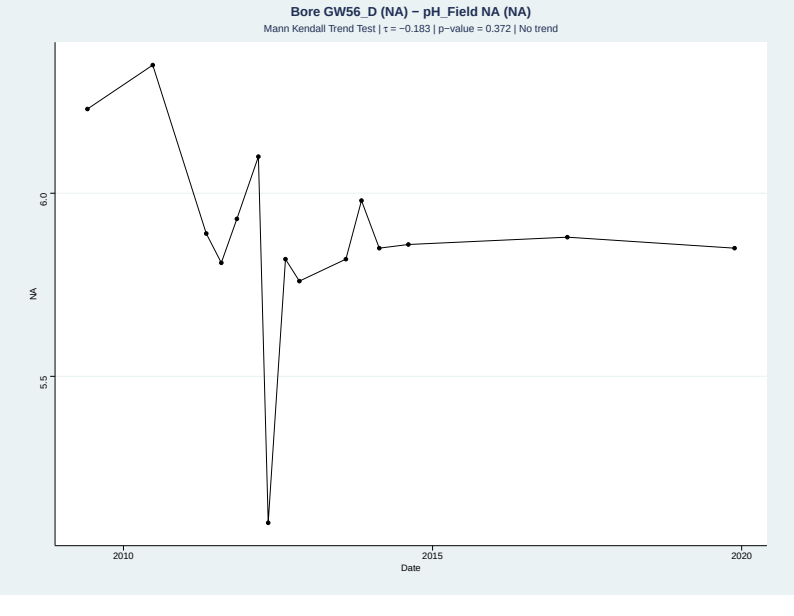


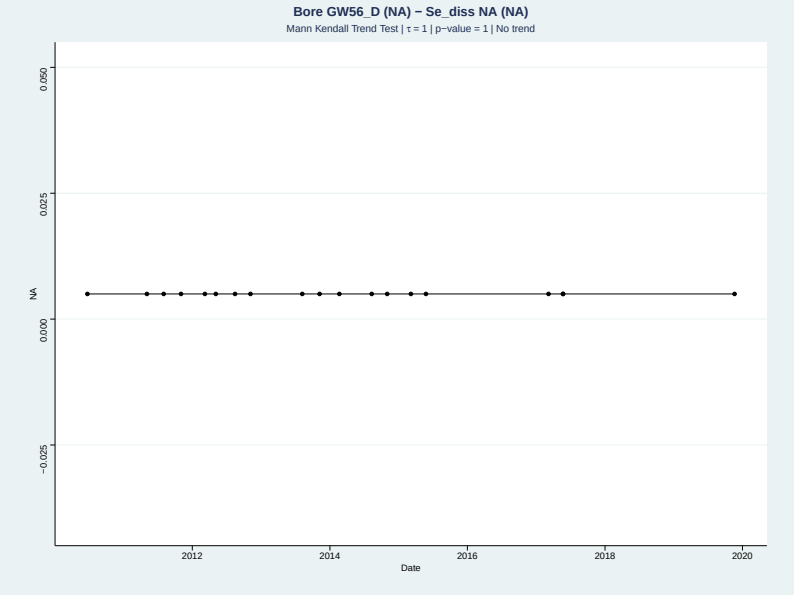


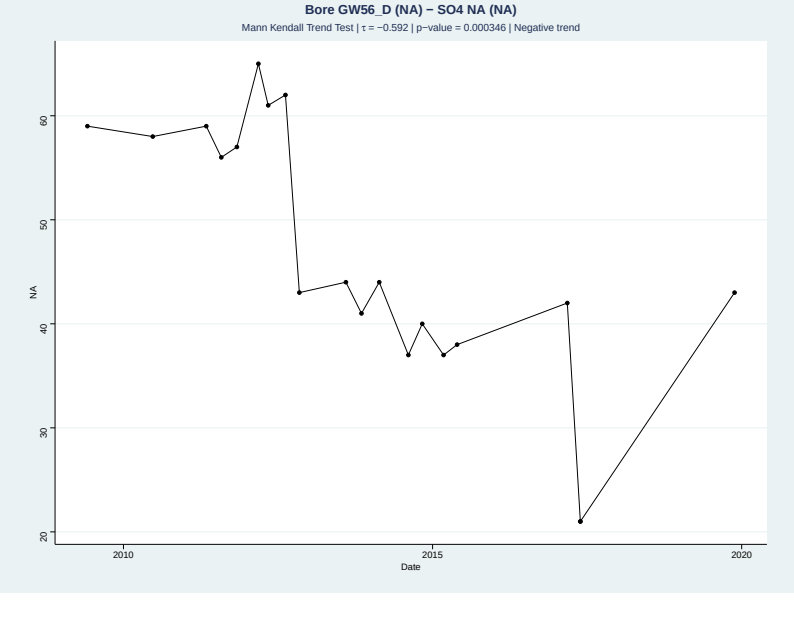
Appendix C Groundwater Quality Time Series

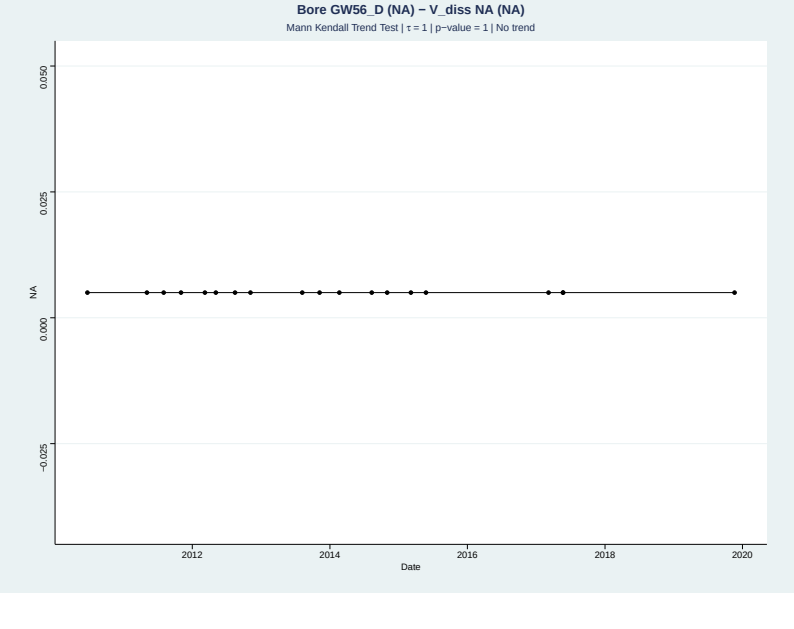




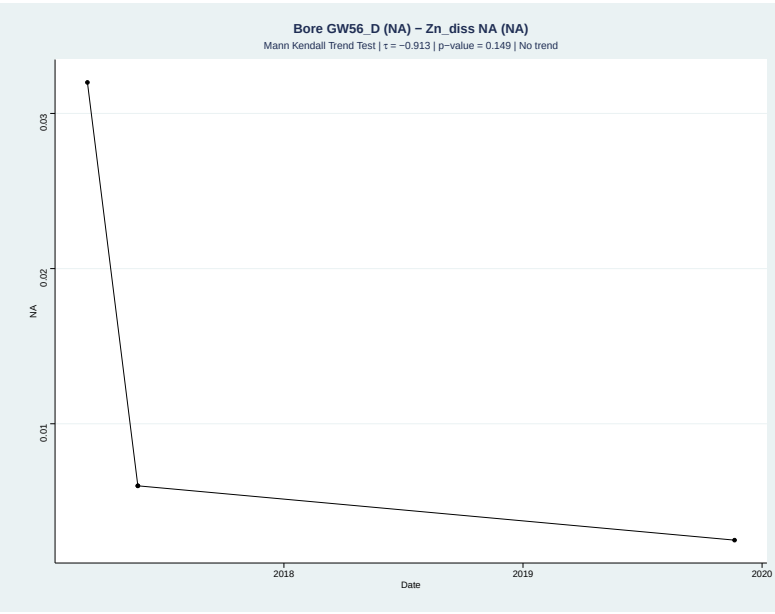


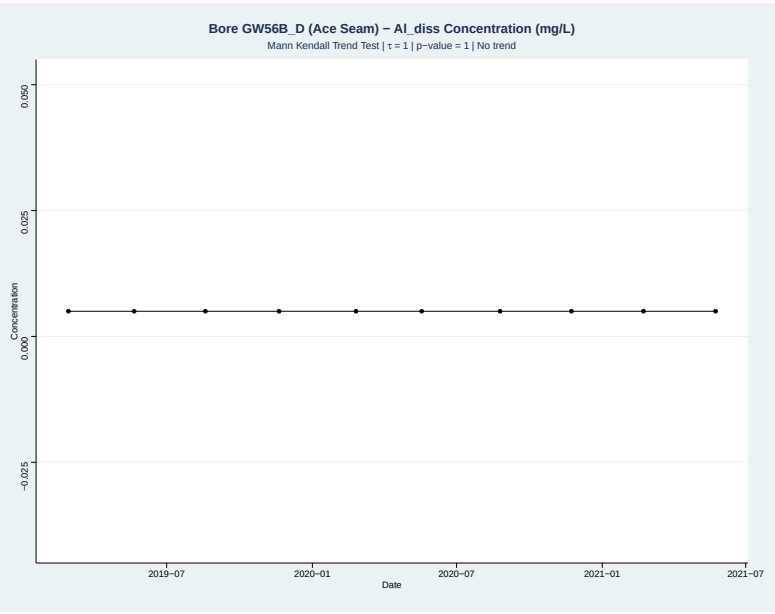


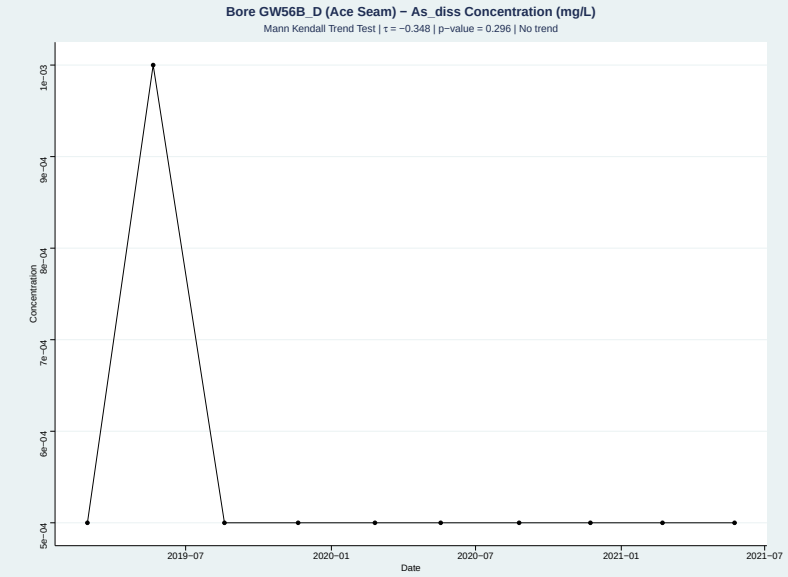


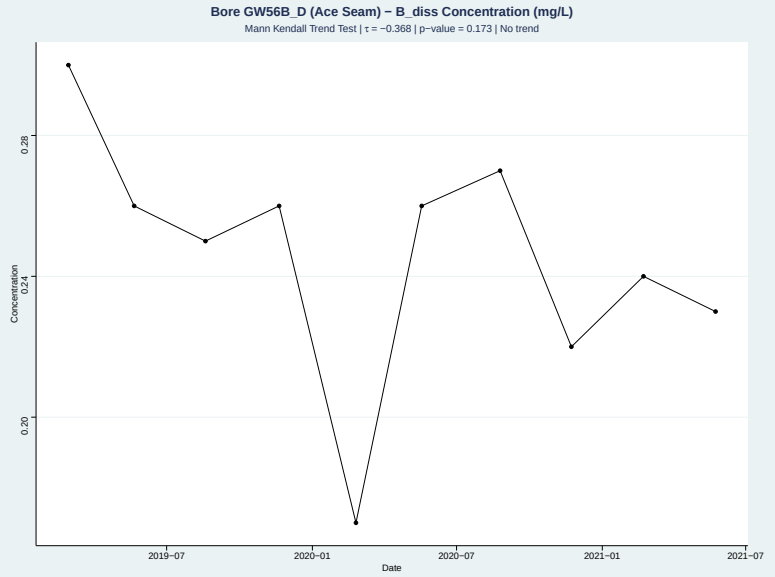


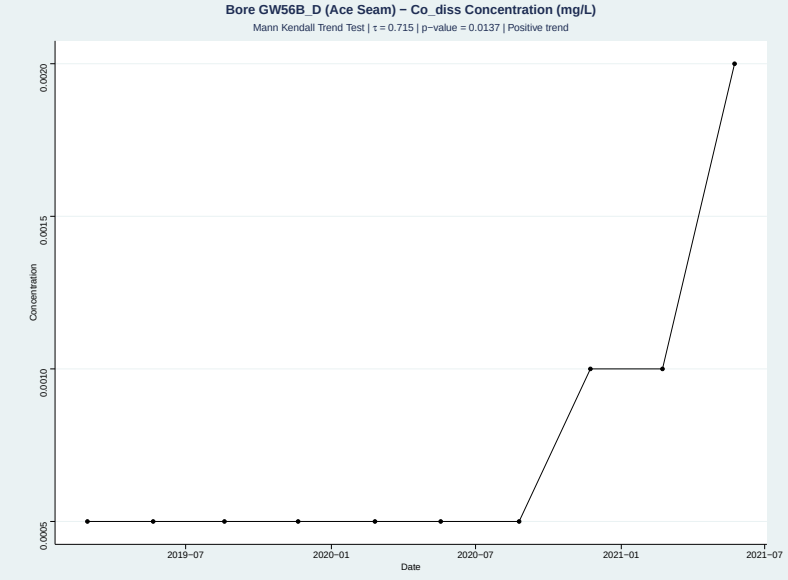
Appendix C Groundwater Quality Time Series

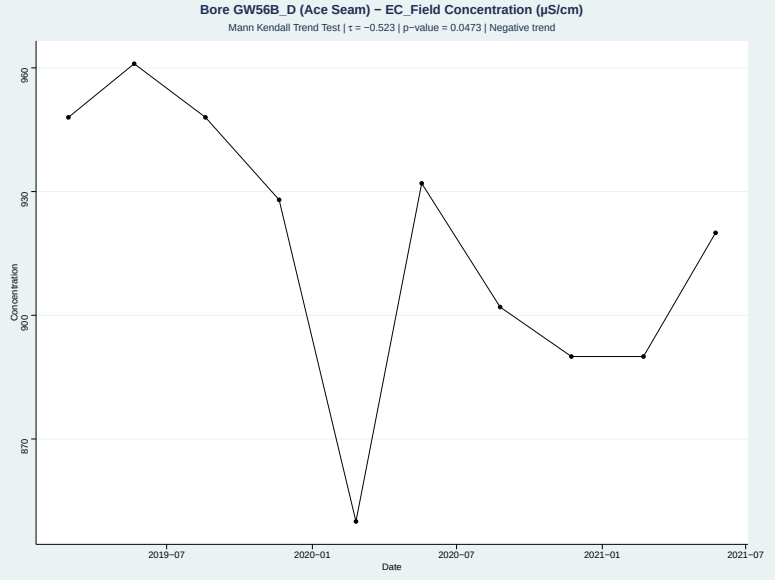




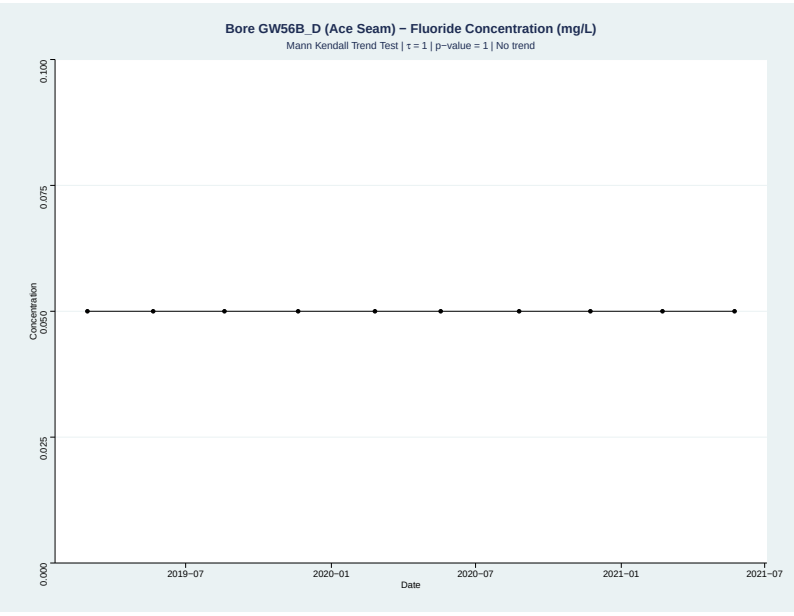


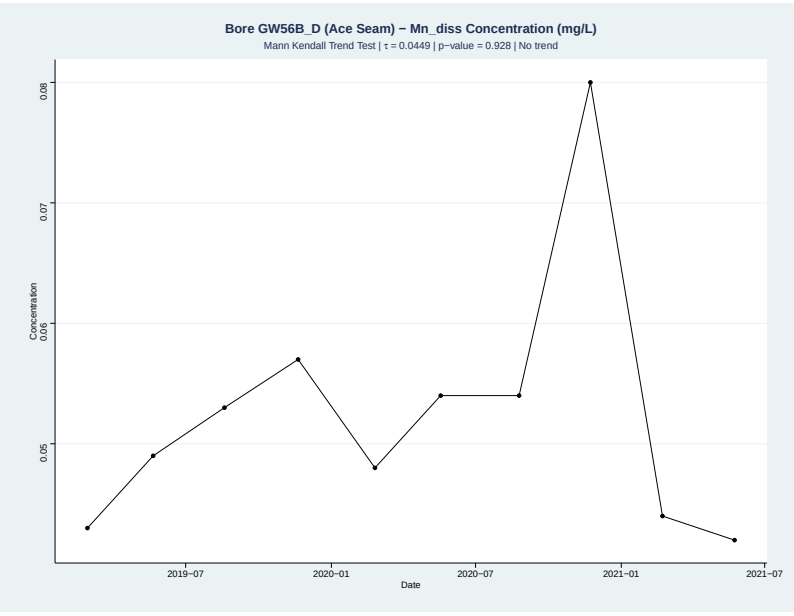


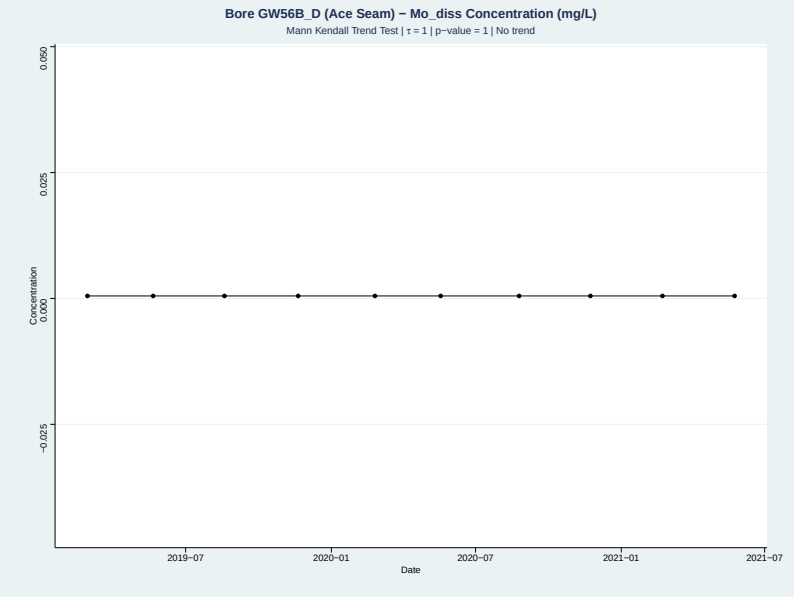


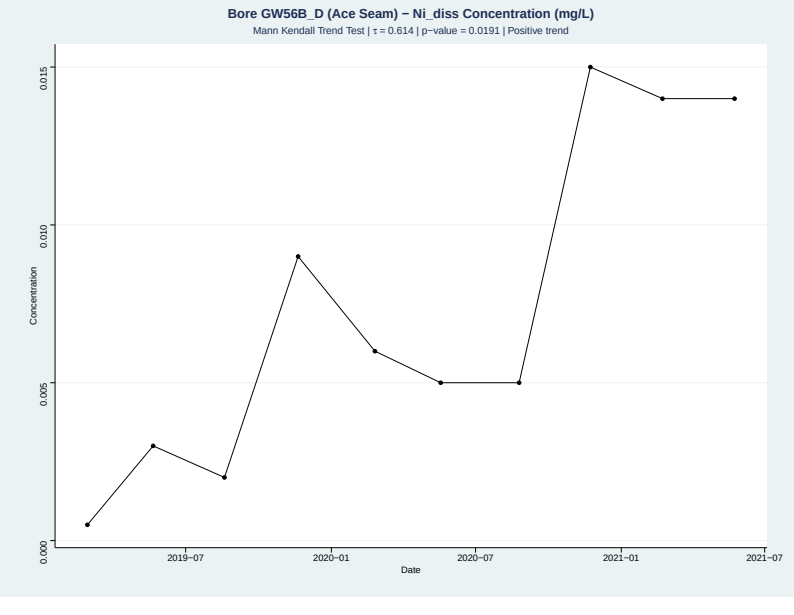


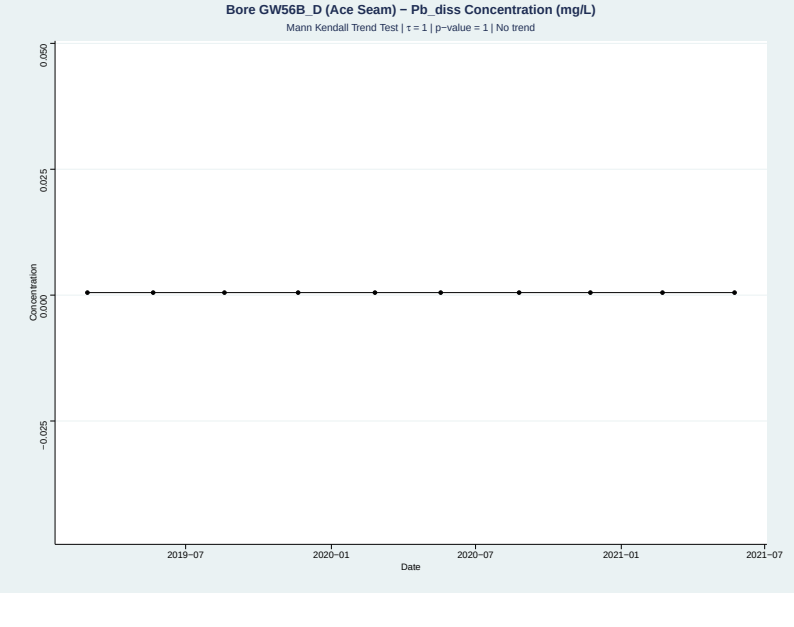
Appendix C Groundwater Quality Time Series

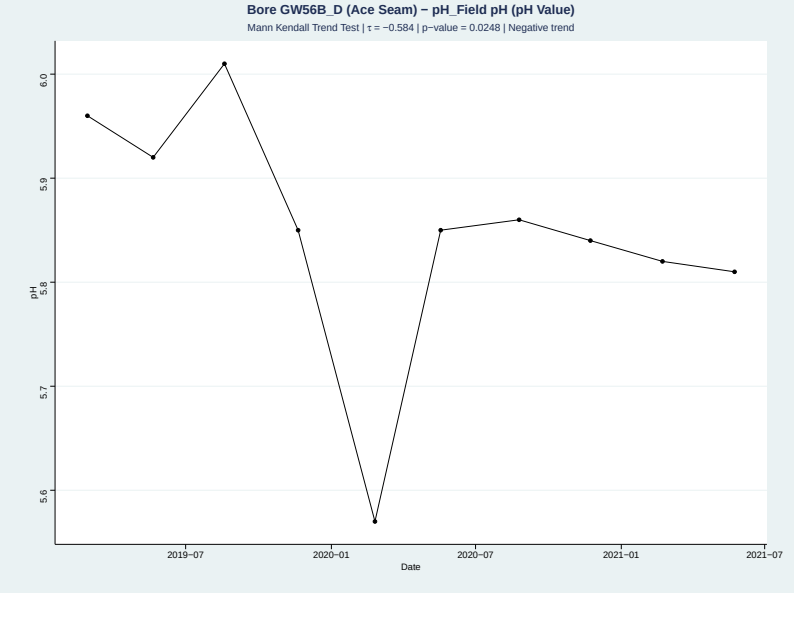




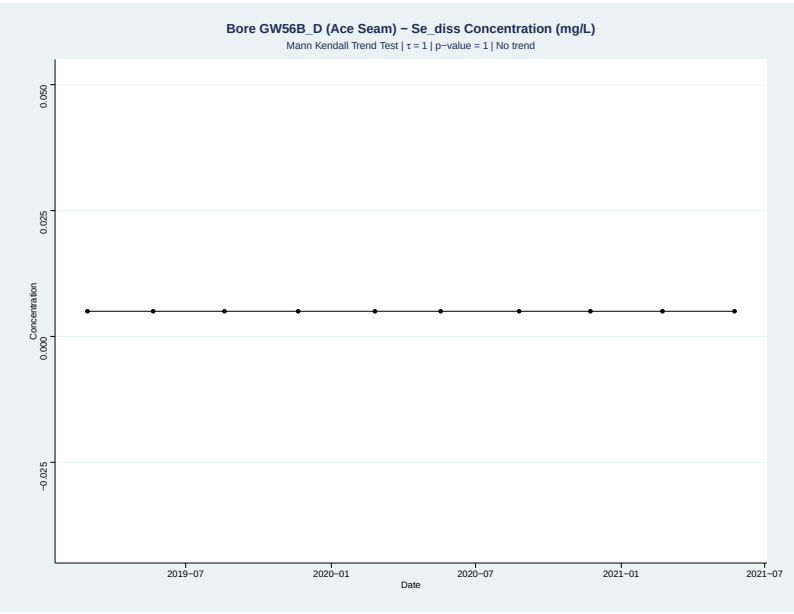


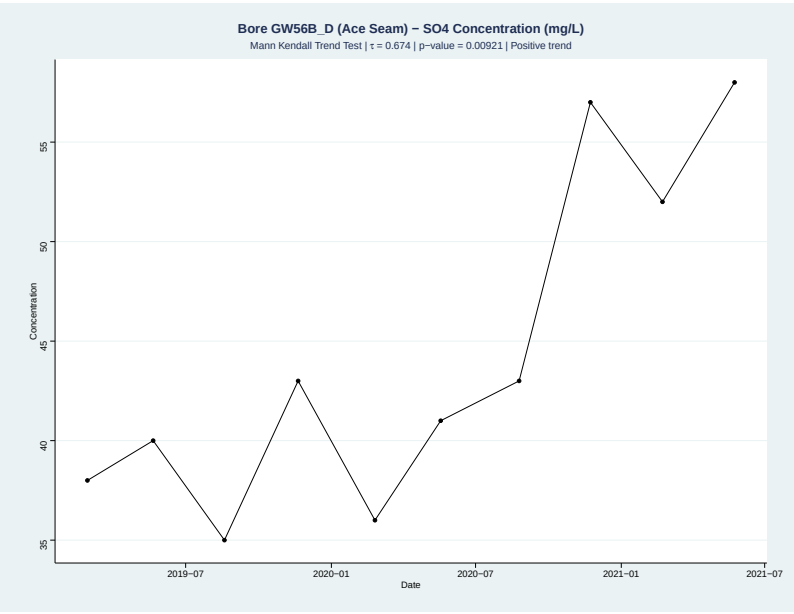


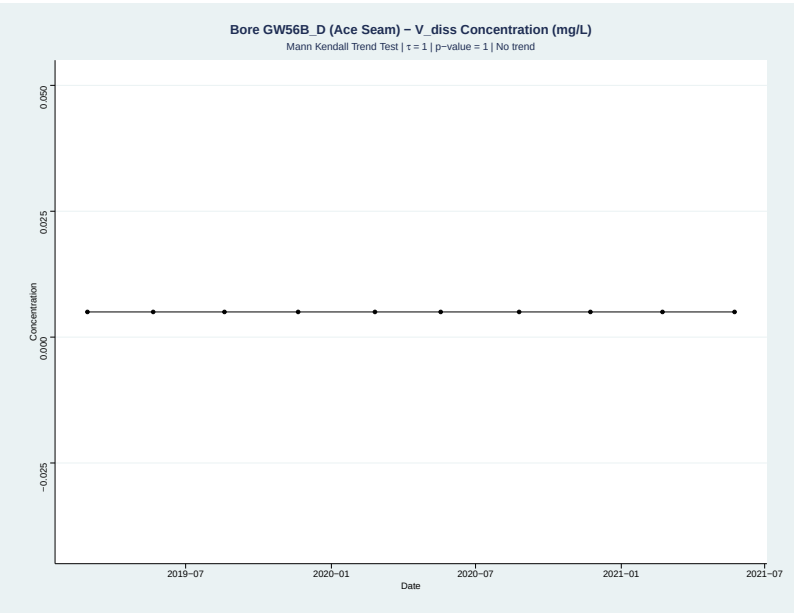


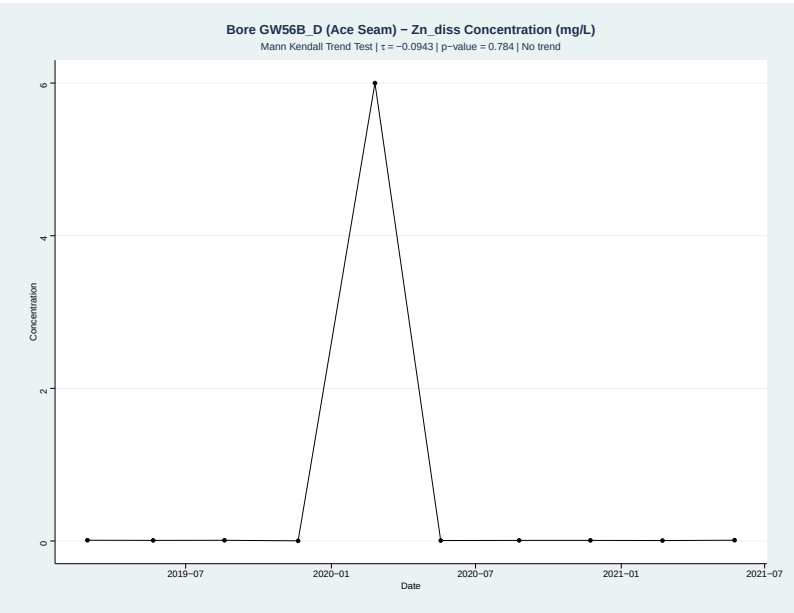


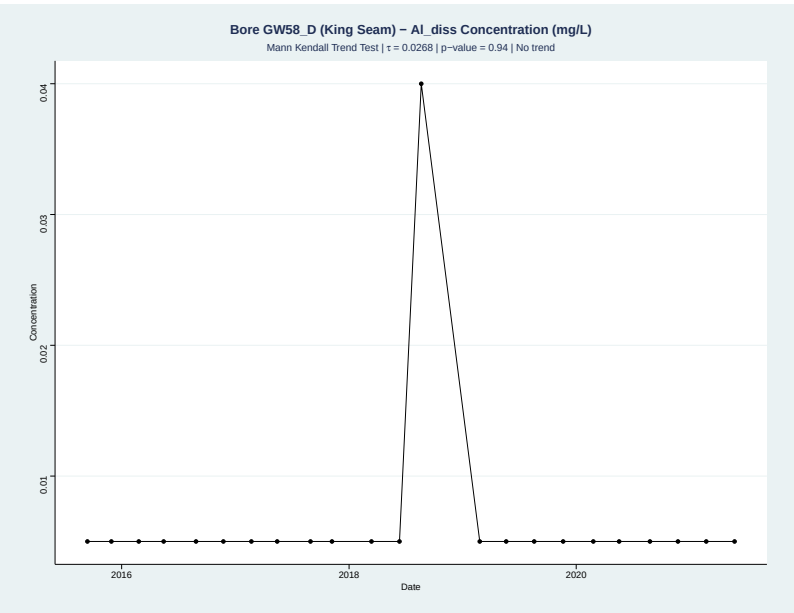
Appendix C Groundwater Quality Time Series

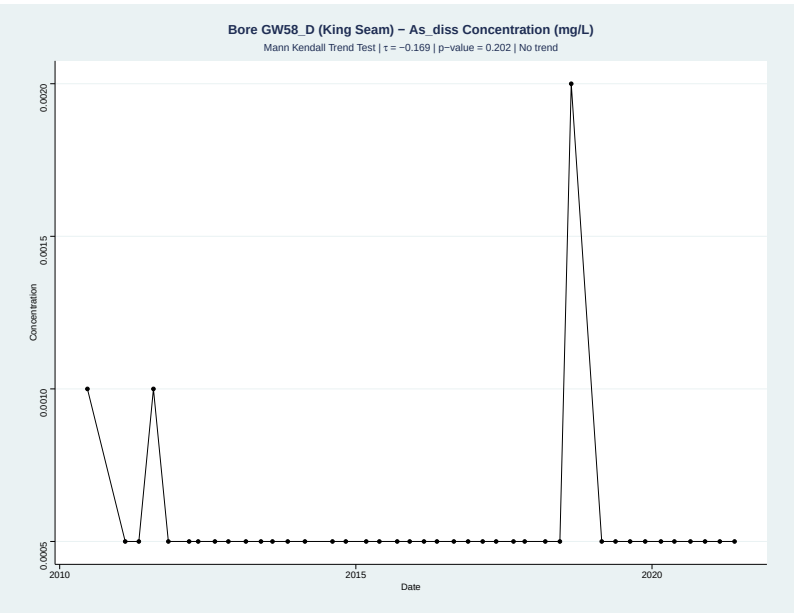




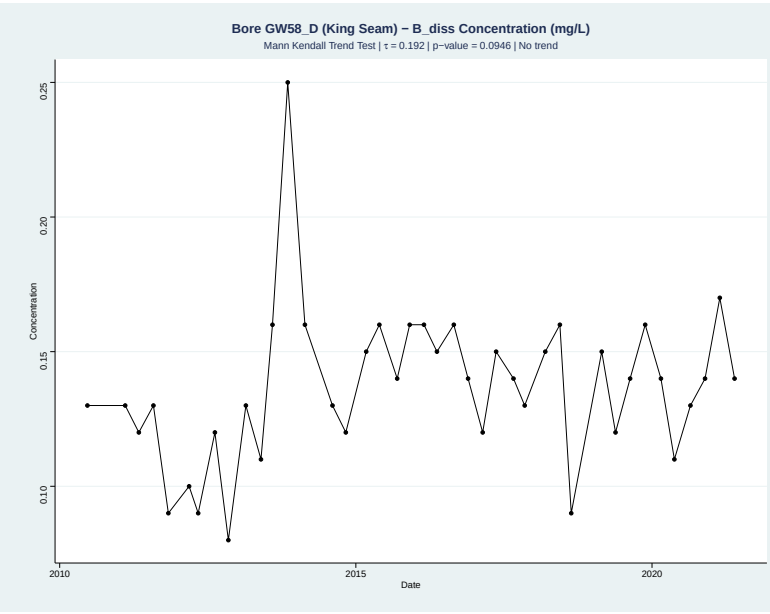


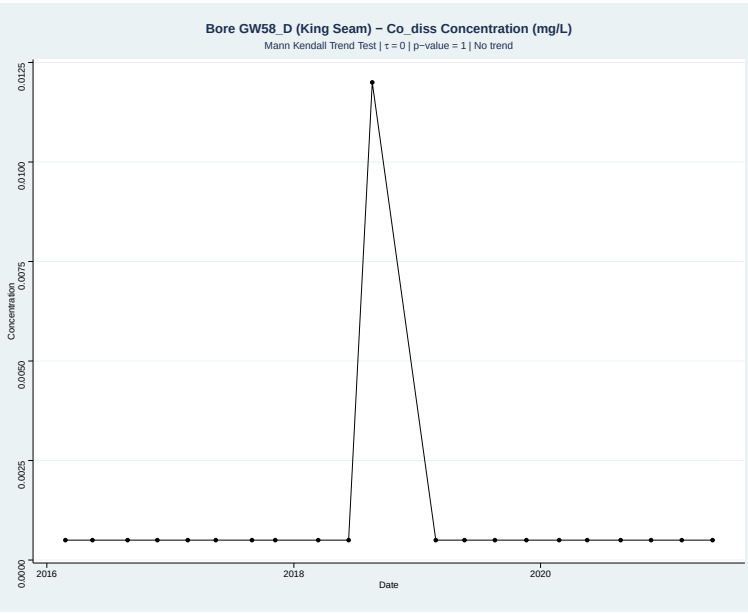


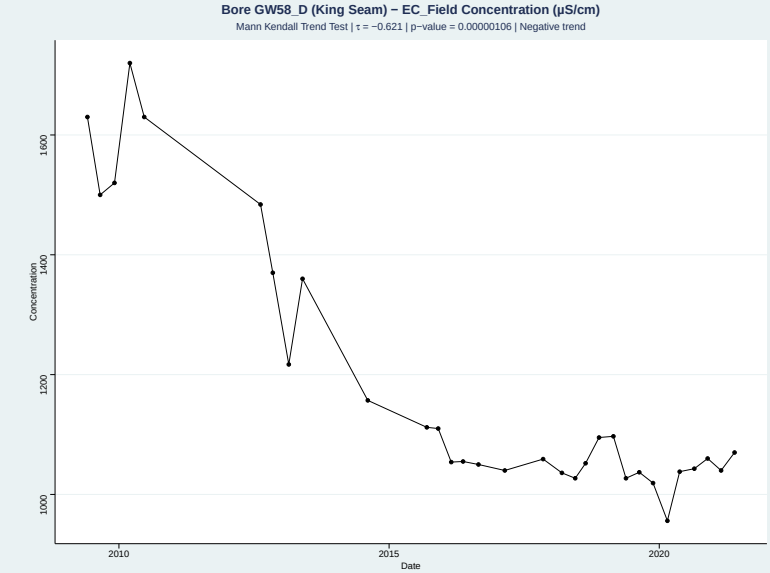


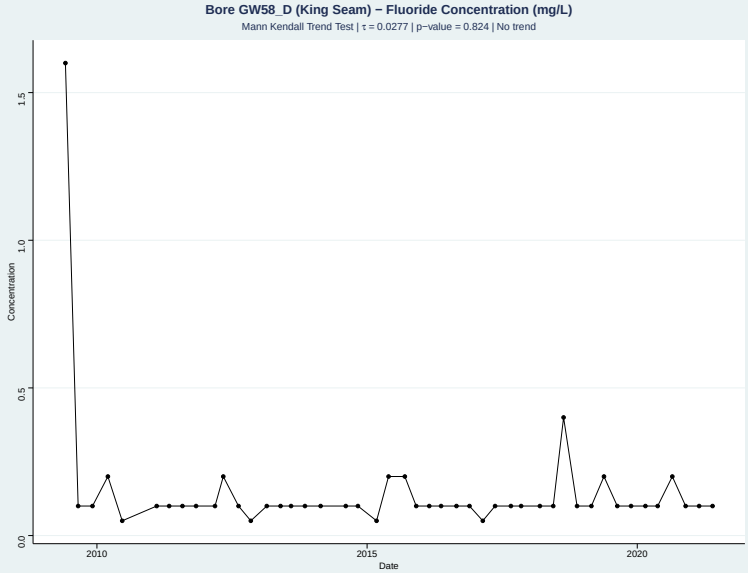


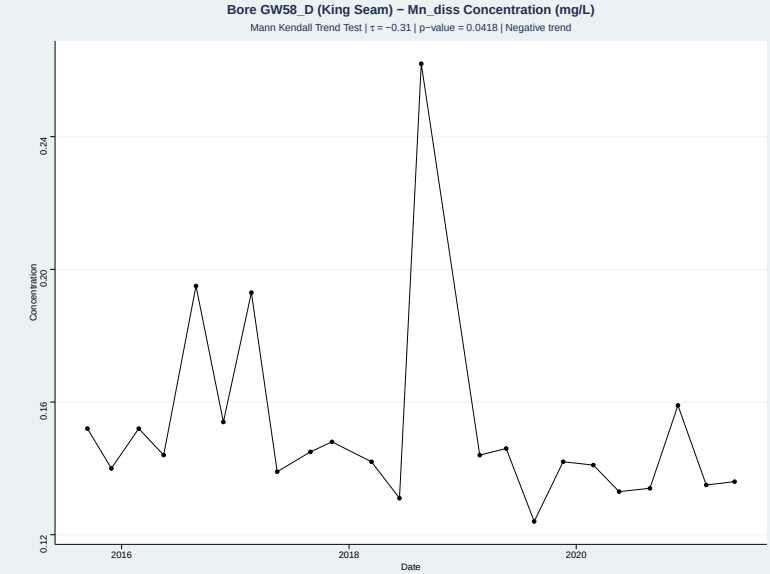
Appendix C Groundwater Quality Time Series

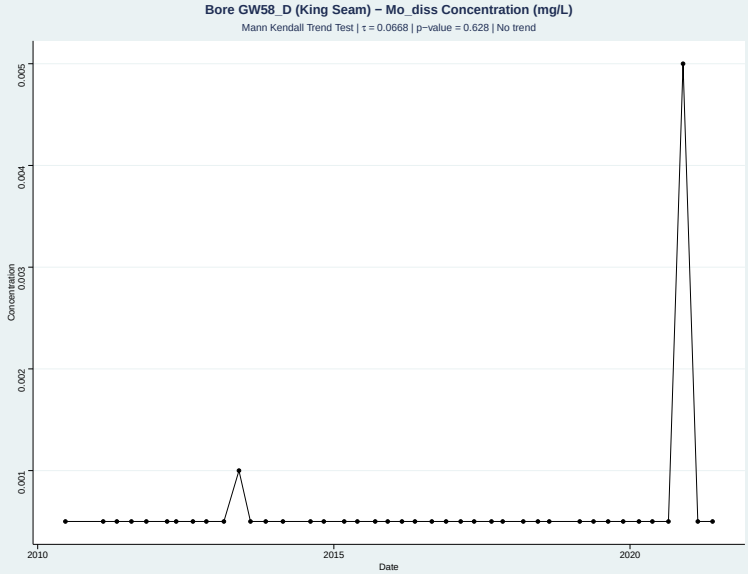




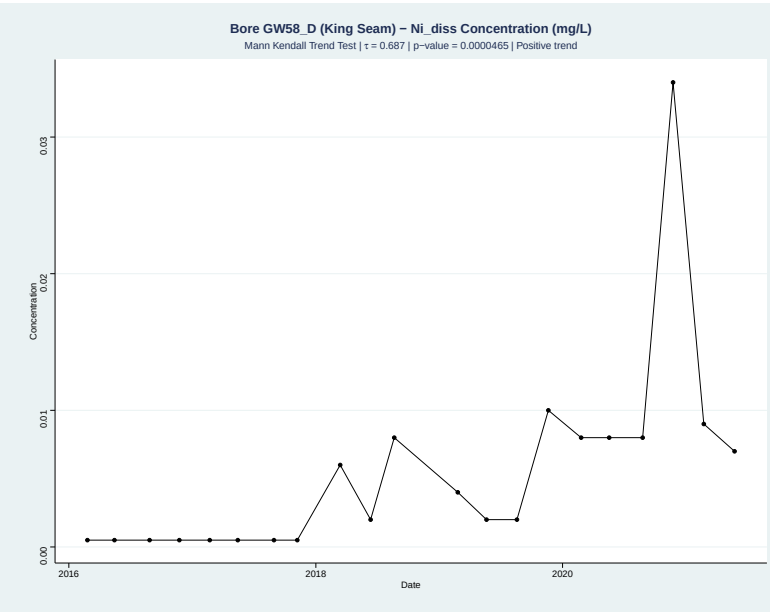


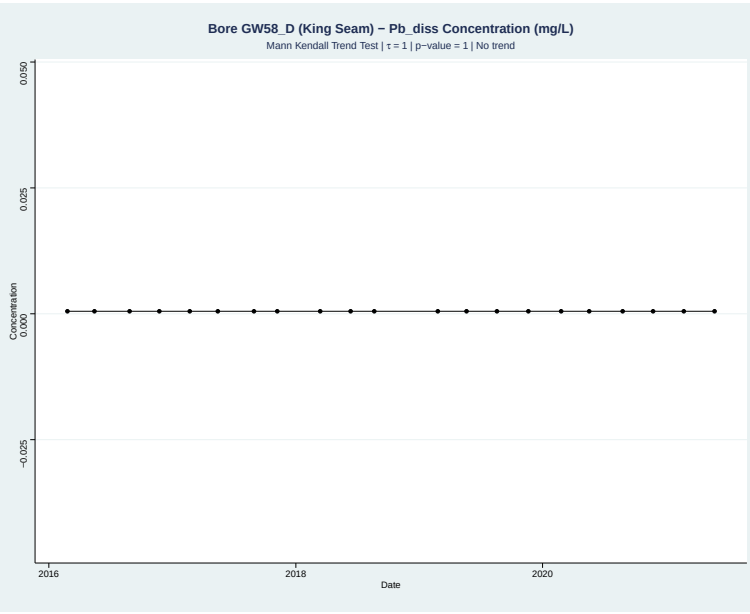


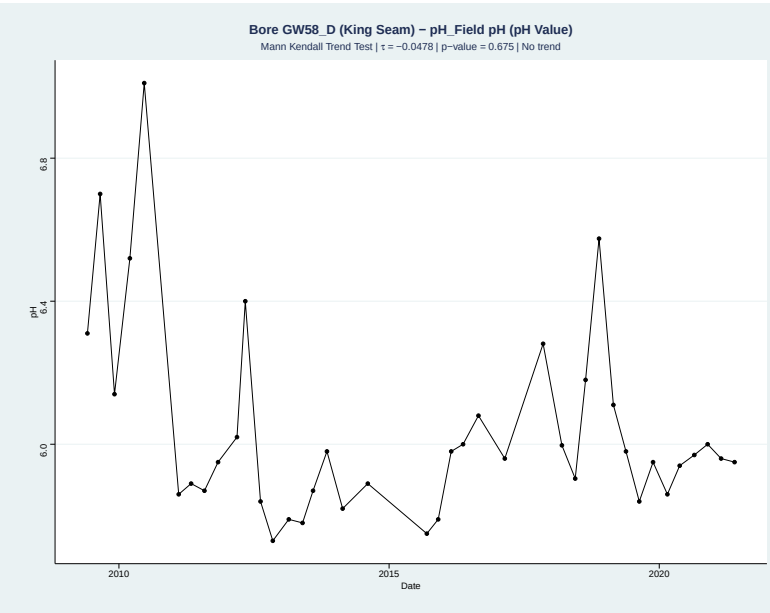


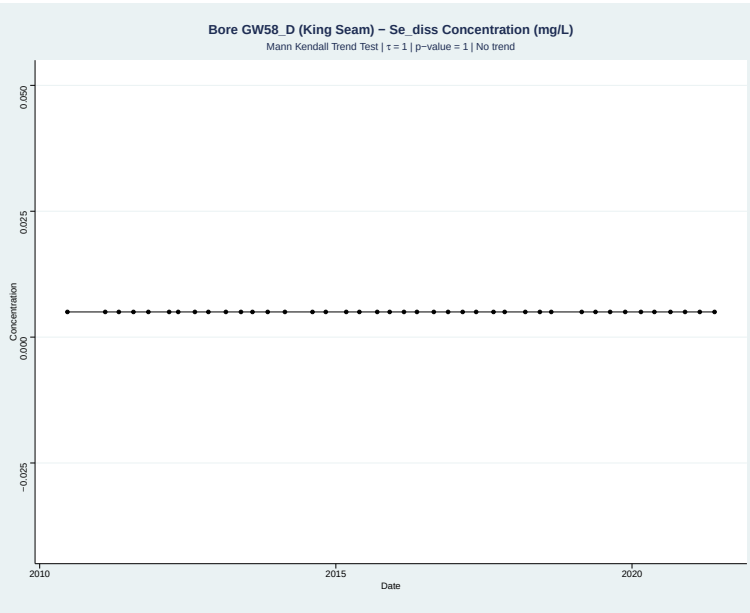


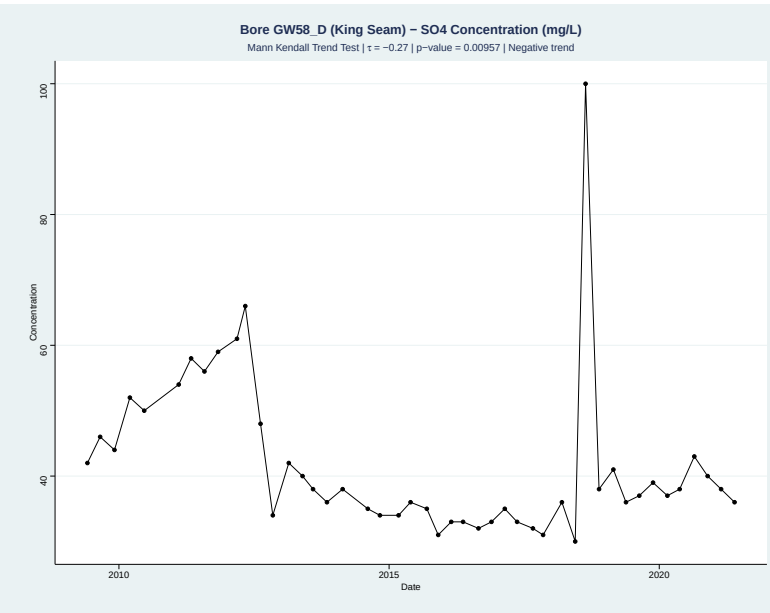
Appendix C Groundwater Quality Time Series

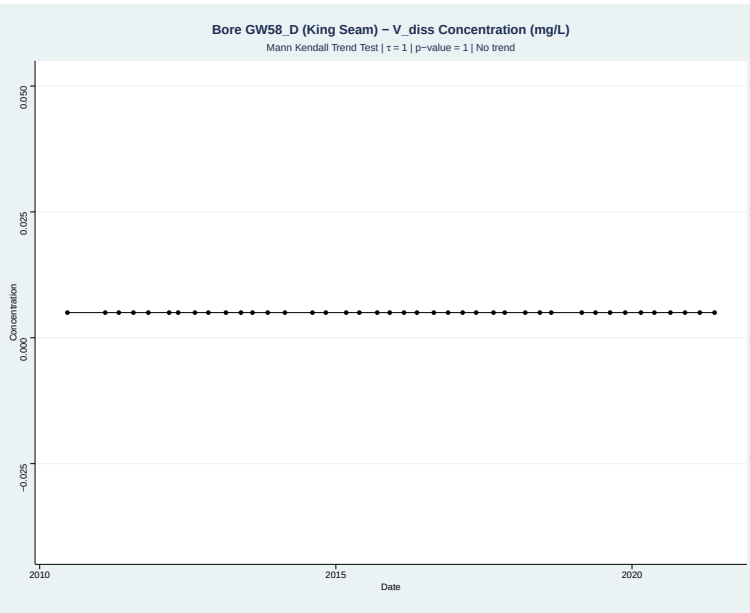




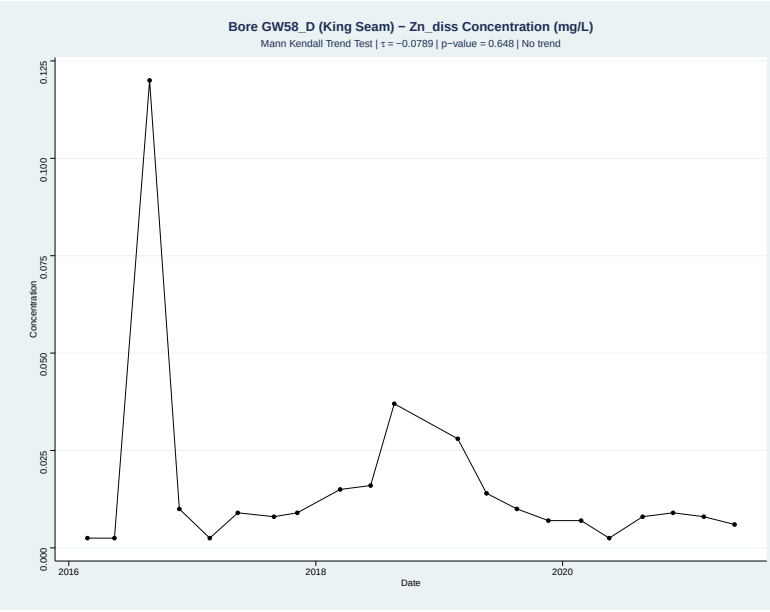


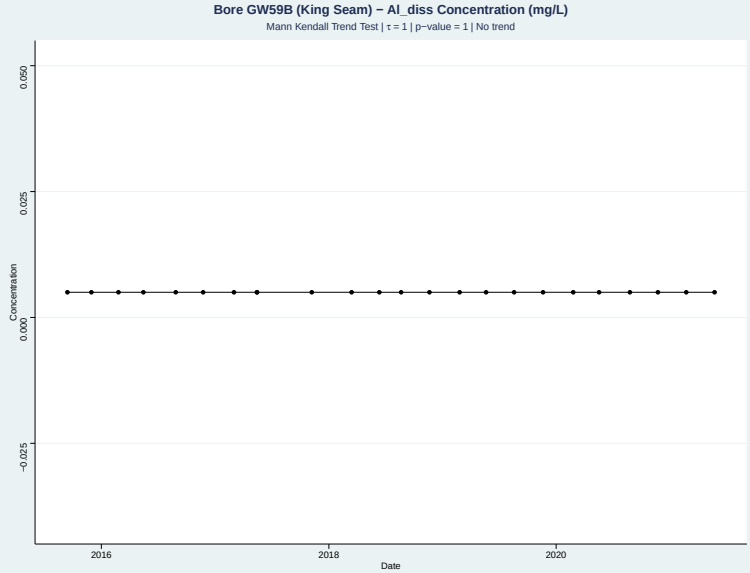


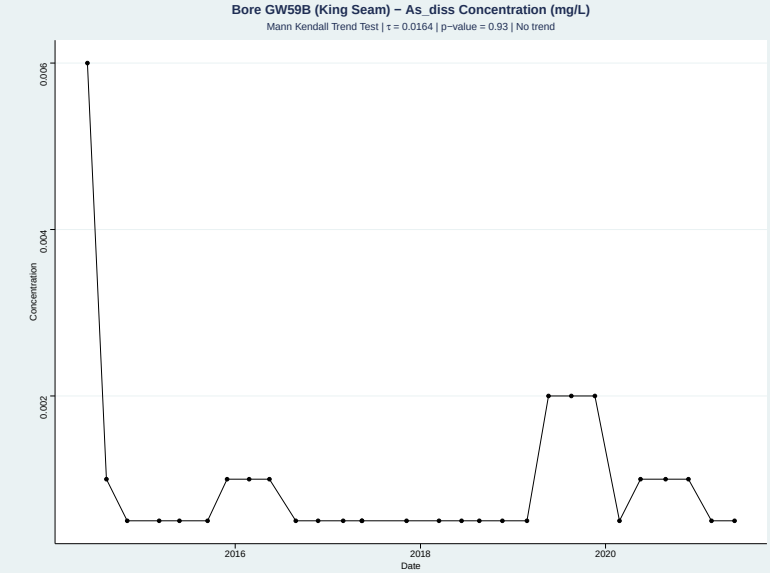


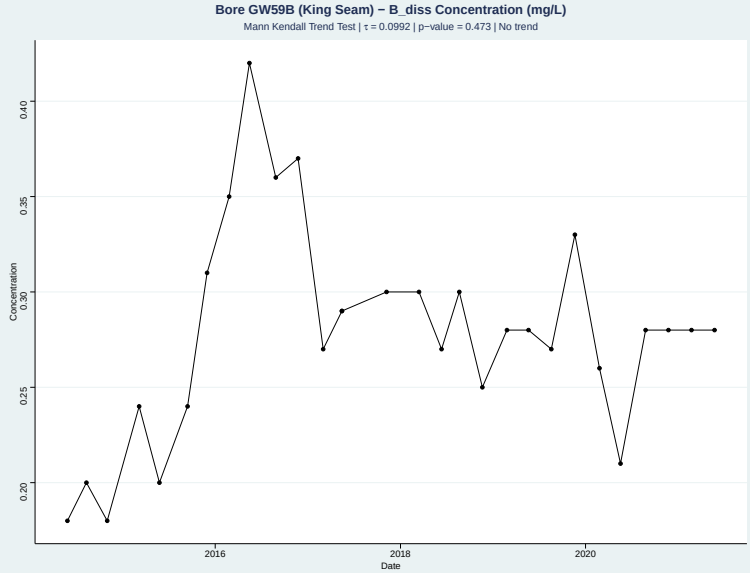


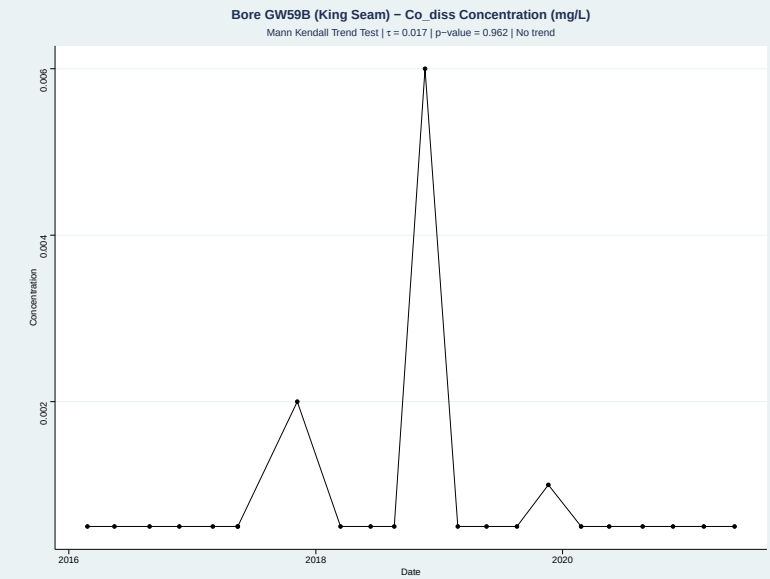
Appendix C Groundwater Quality Time Series

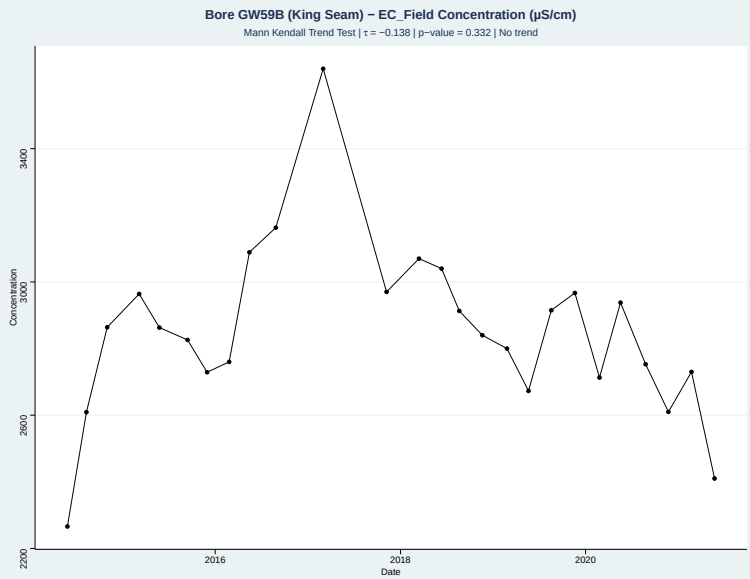








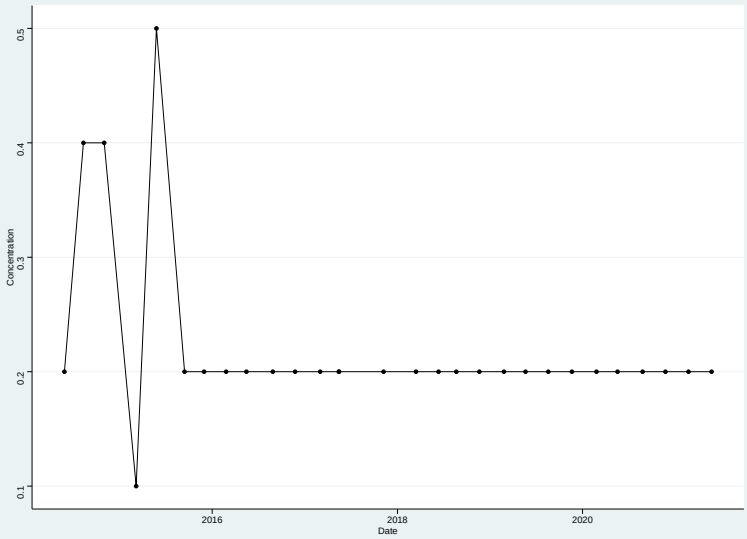




Appendix C Groundwater Quality Time Series

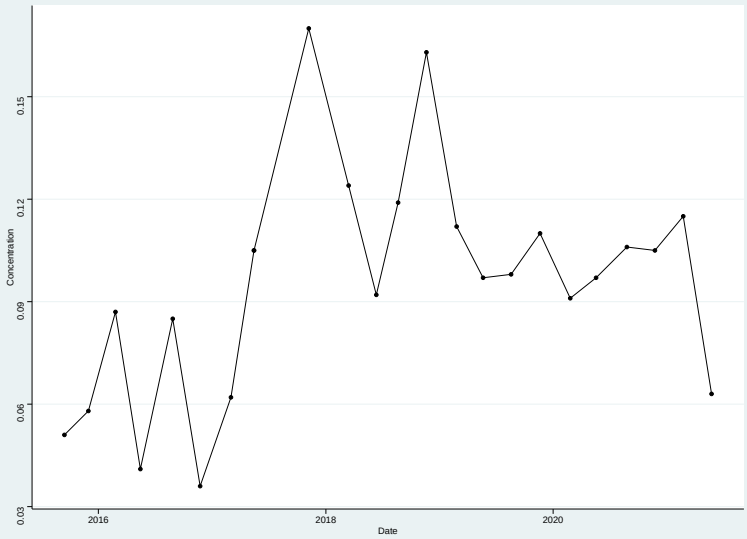
Bore GW59B (King Seam) – Fluoride Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.218 | p−value = 0.166 | No trend



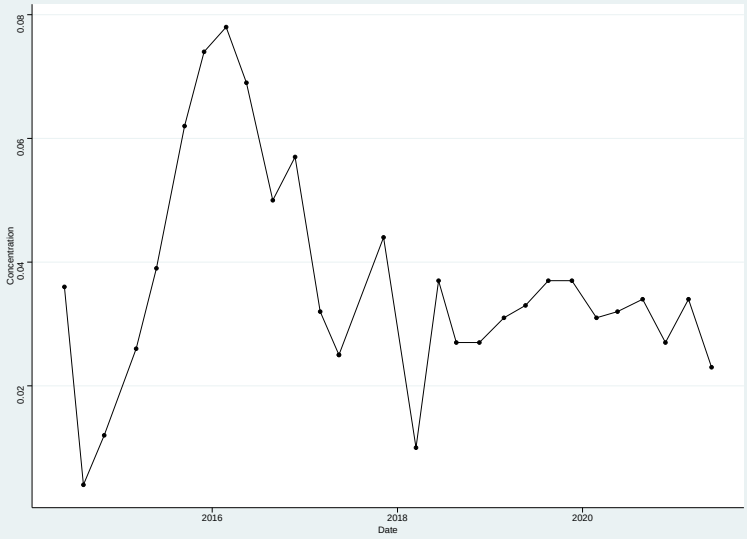
Bore GW59B (King Seam) – Mn_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.285 | p−value = 0.0558 | No trend



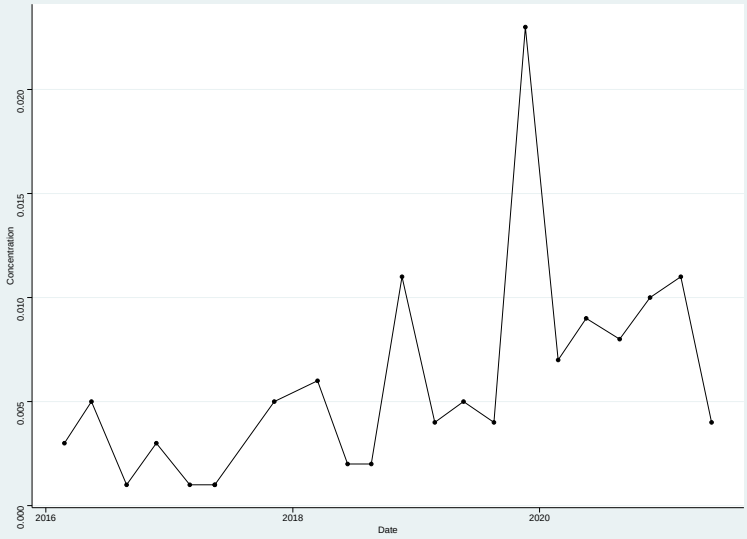
Bore GW59B (King Seam) – Mo_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.12 | p−value = 0.377 | No trend



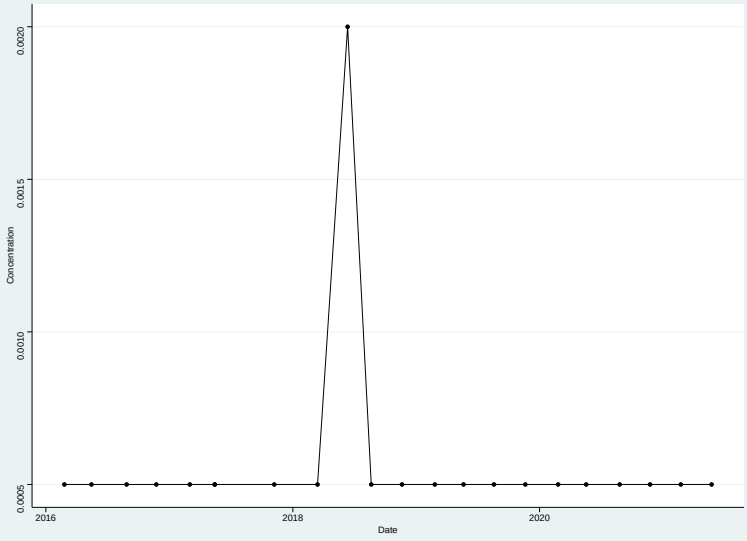
Bore GW59B (King Seam) – Ni_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.483 | p−value = 0.00236 | Positive trend



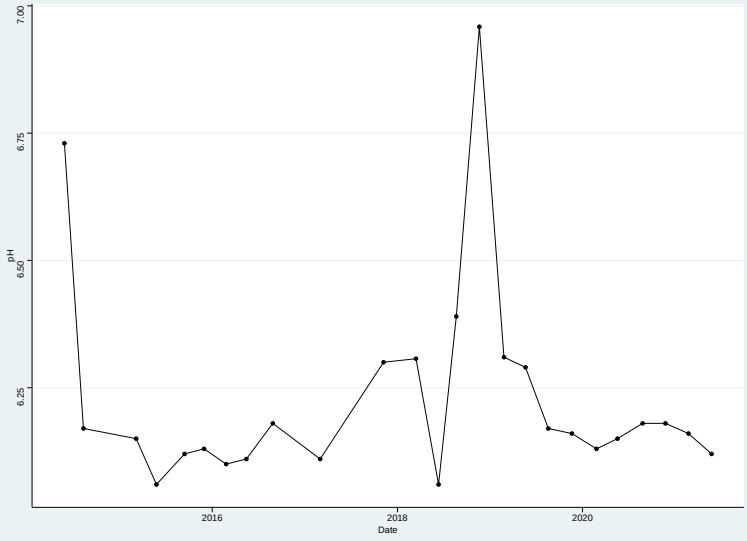
Bore GW59B (King Seam) – Pb_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.0431 | p−value = 0.875 | No trend

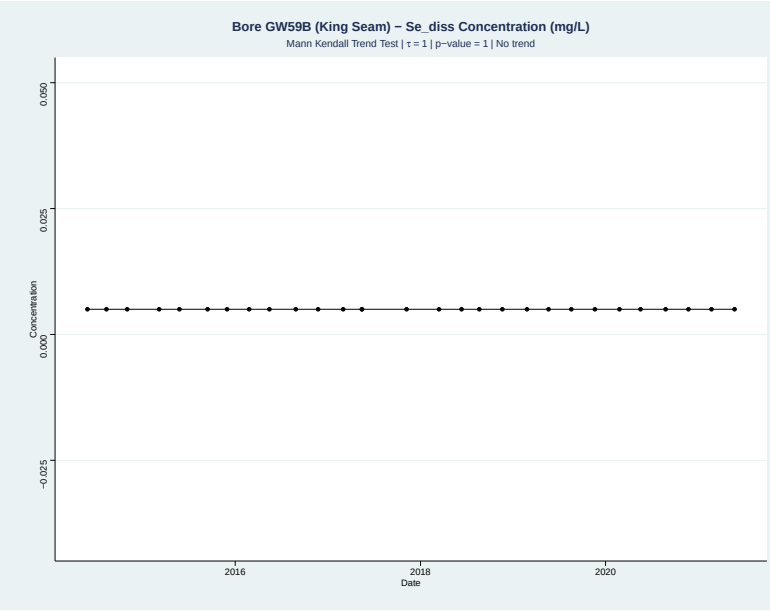


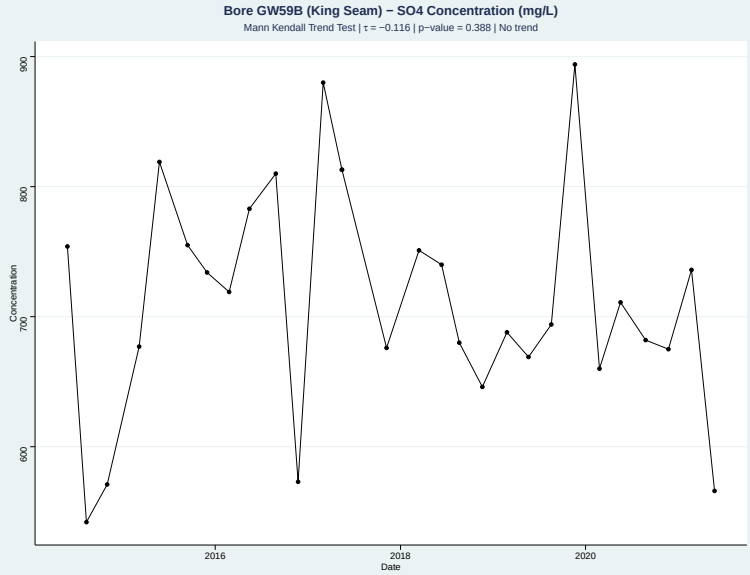
Bore GW59B (King Seam) – pH_Field pH (pH Value)

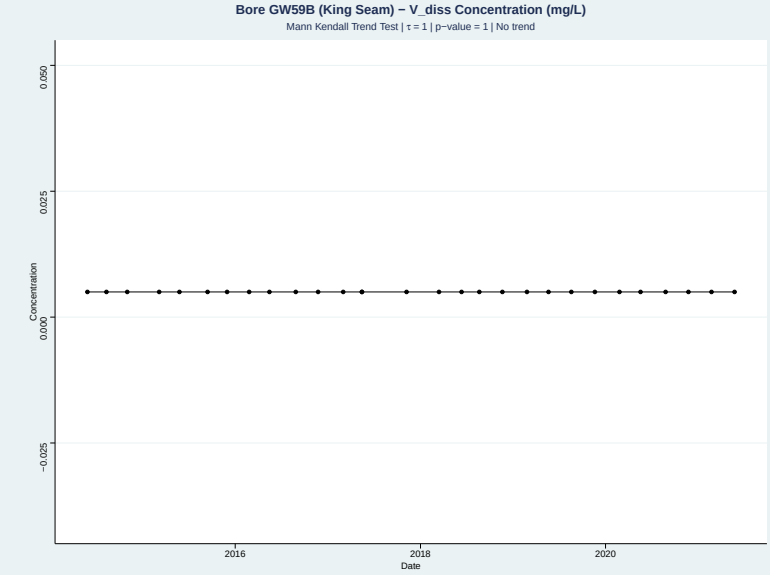
Mann Kendall Trend Test | τ = 0.0542 | p−value = 0.725 | No trend

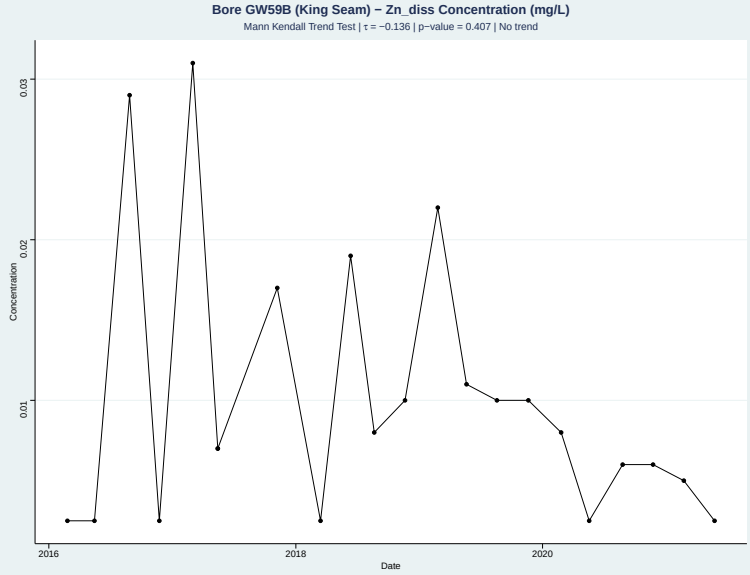


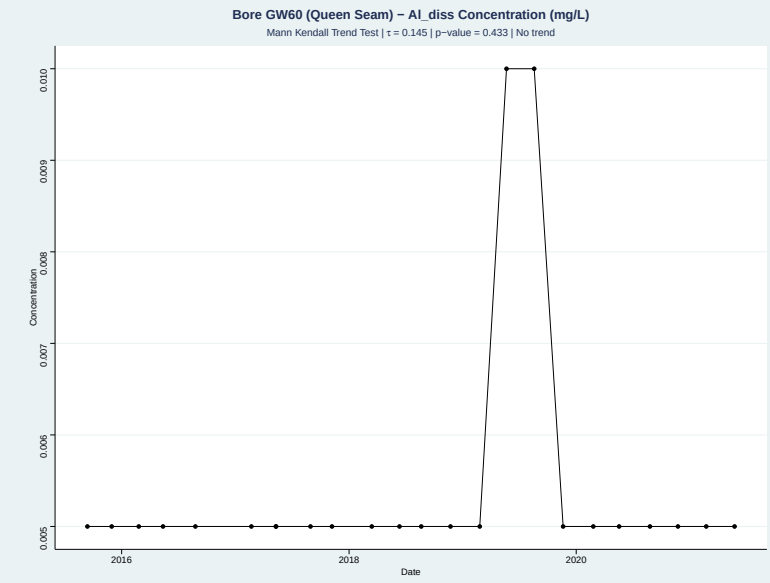
Appendix C Groundwater Quality Time Series

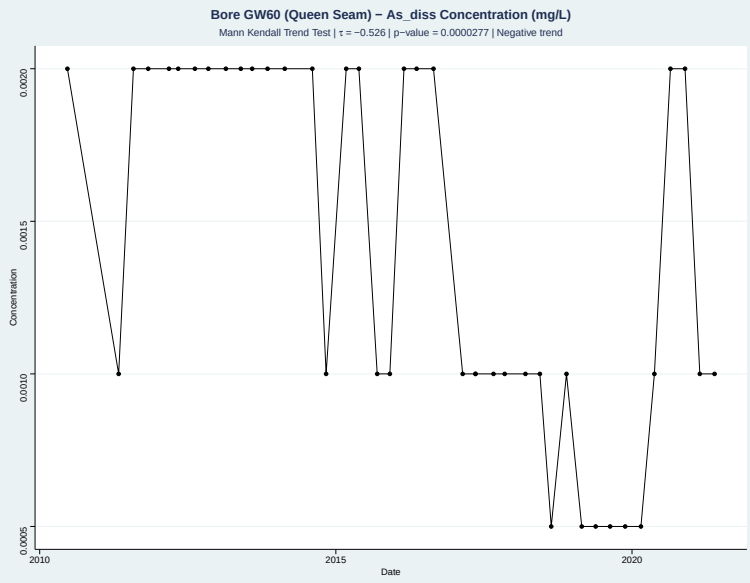




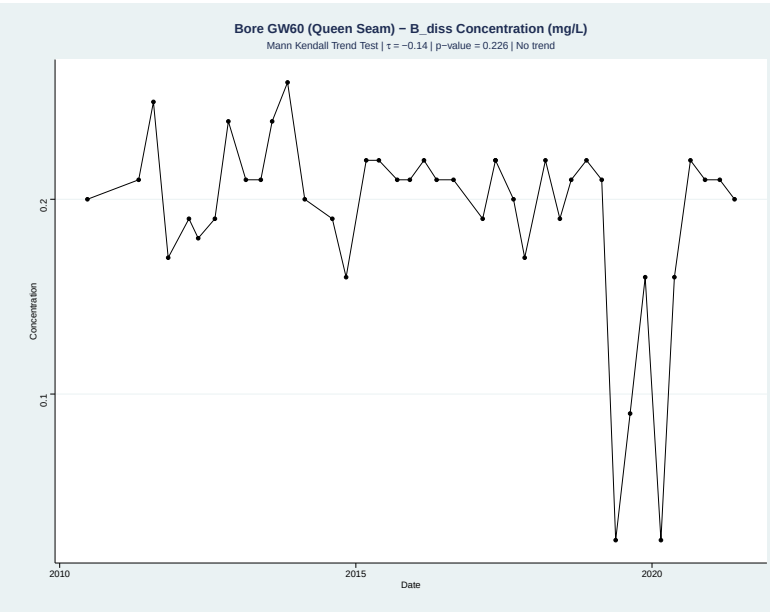


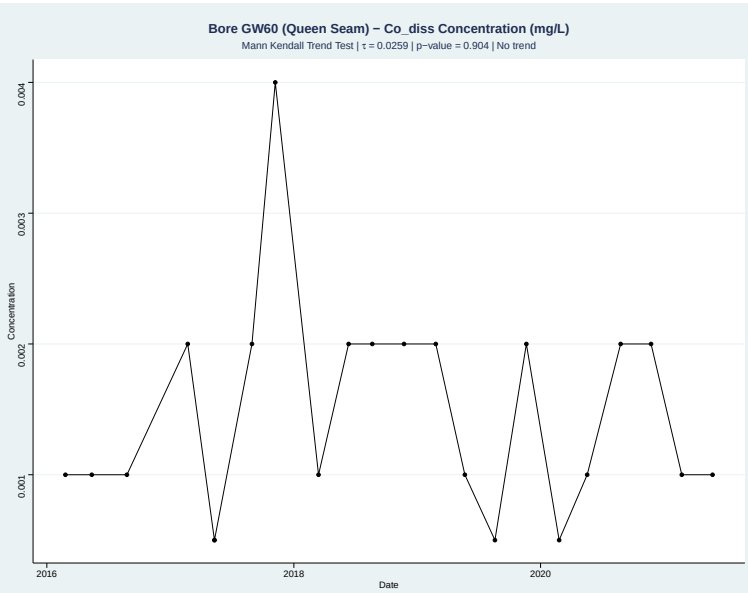


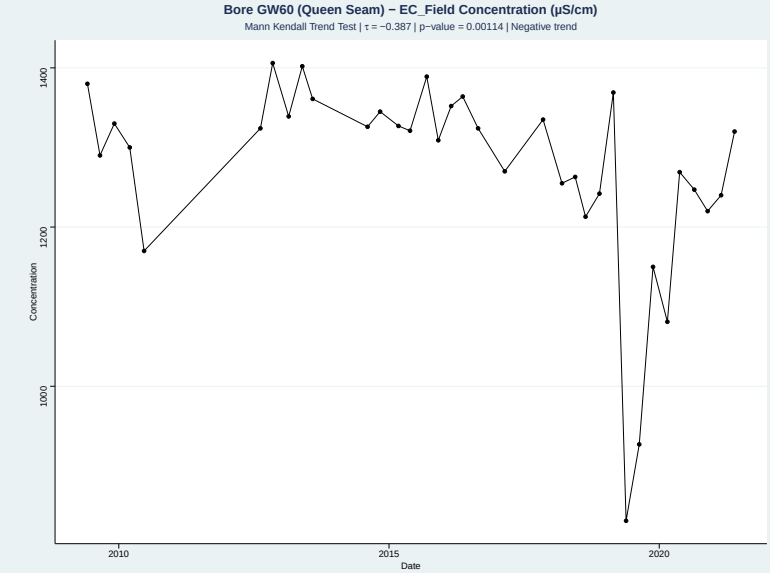


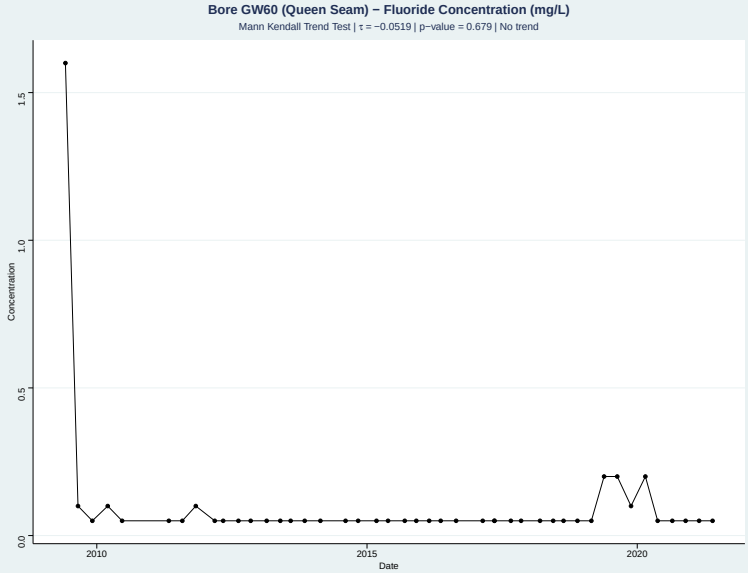


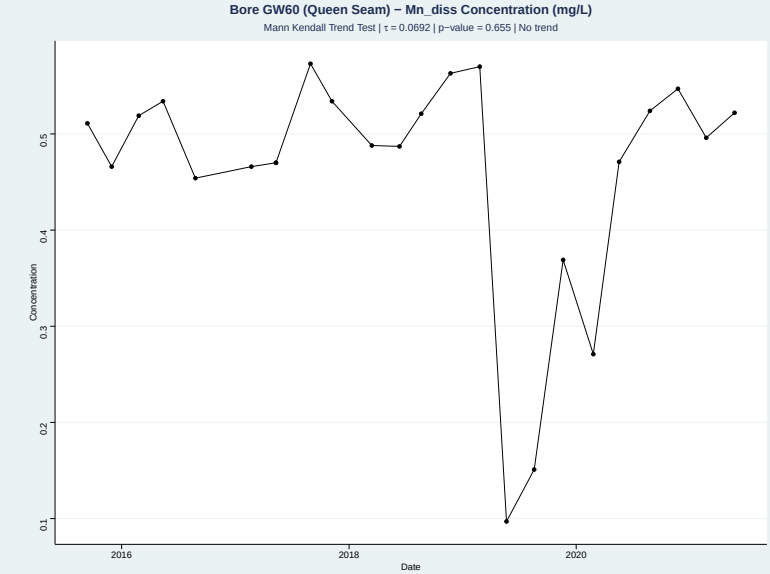
Appendix C Groundwater Quality Time Series

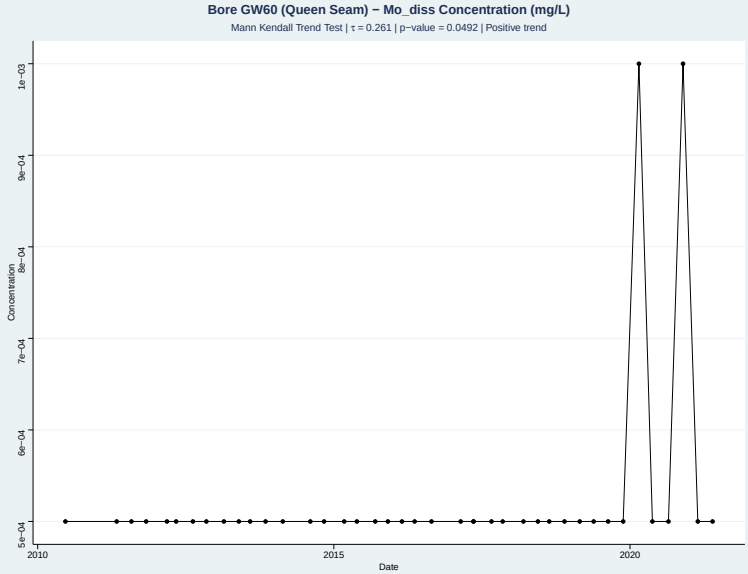




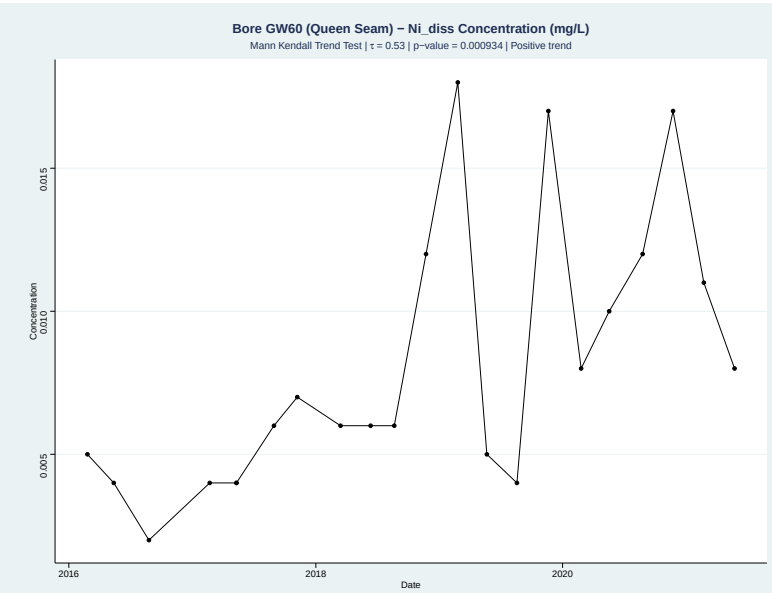


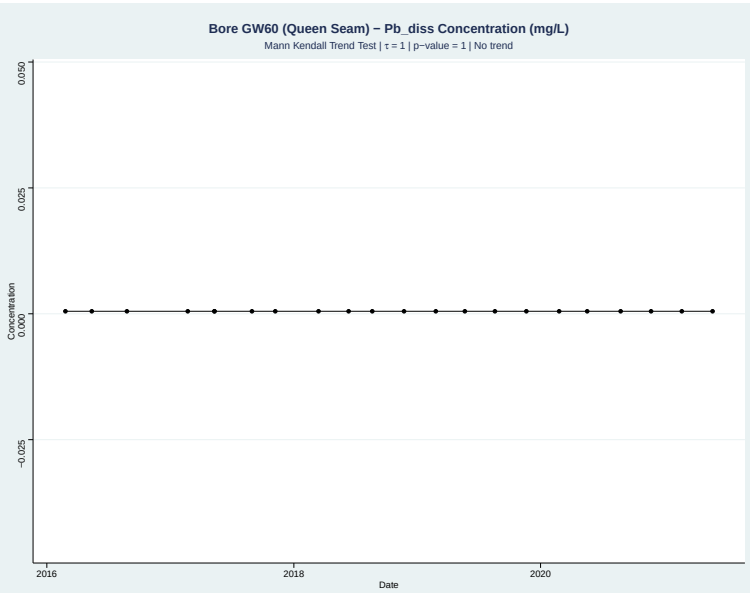


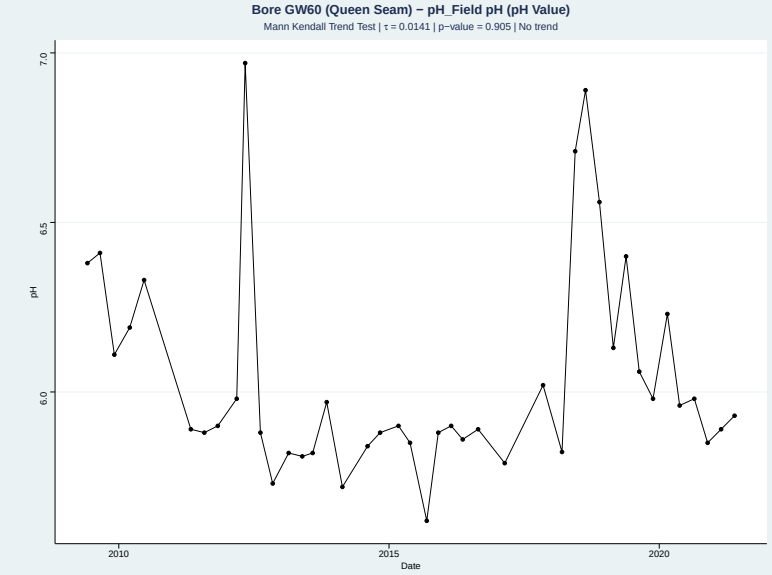


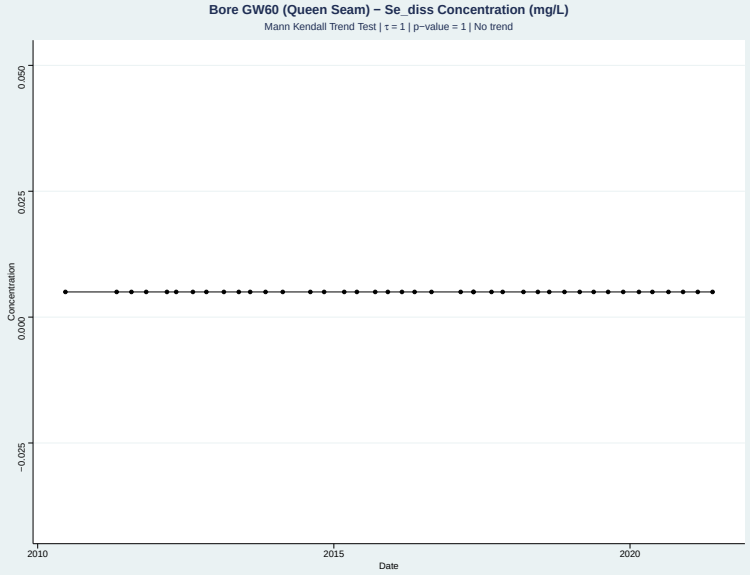


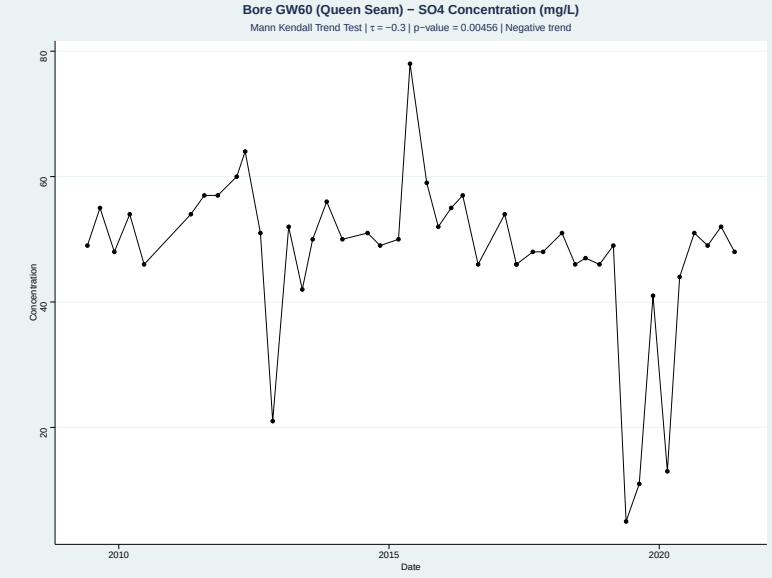
Appendix C Groundwater Quality Time Series

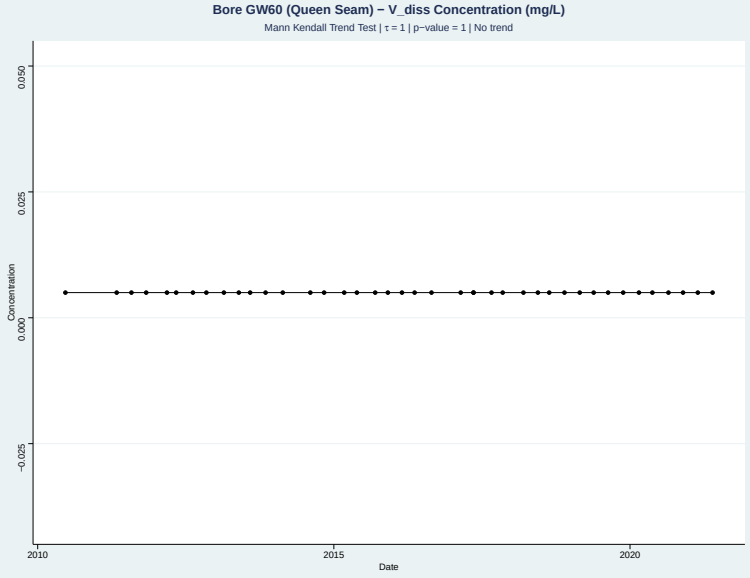








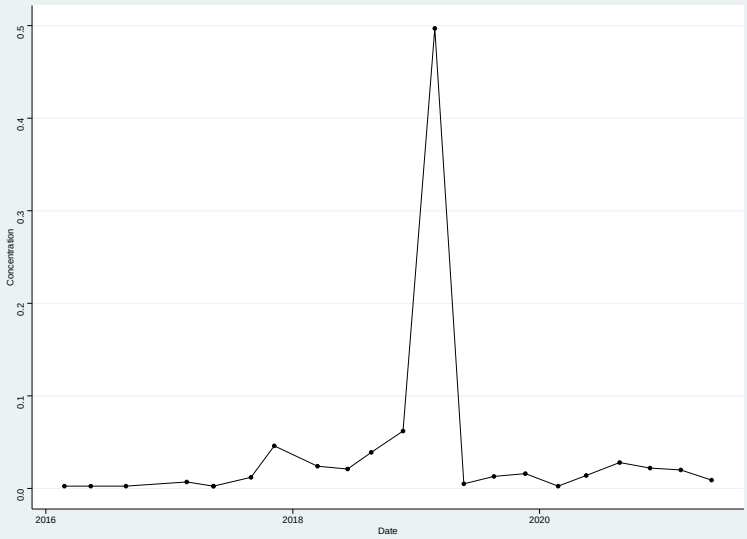




Appendix C Groundwater Quality Time Series

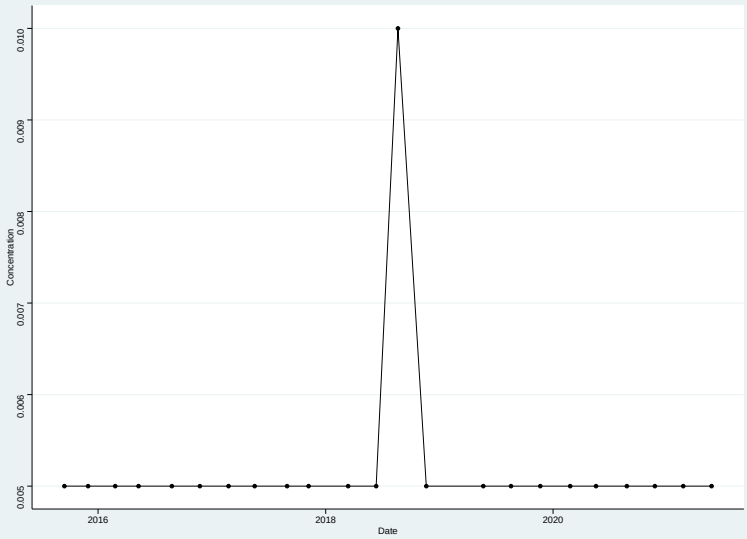
Bore GW60 (Queen Seam) – Zn_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.295 | p−value = 0.0638 | No trend



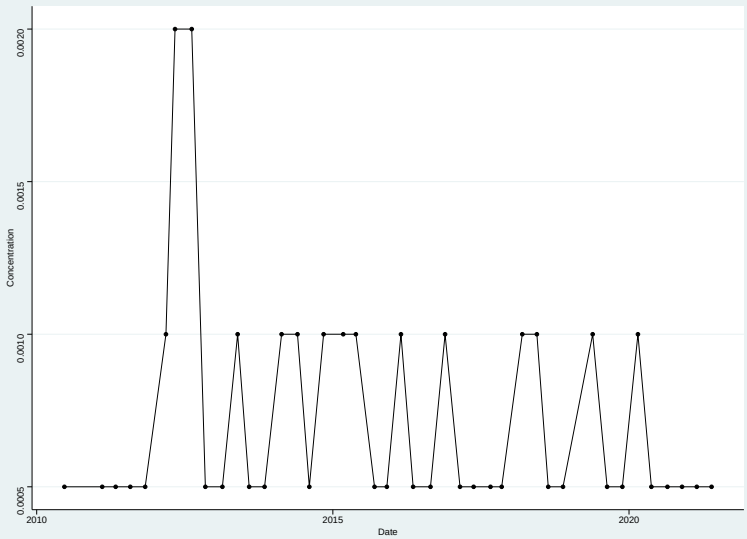
Bore GW61_D (Regolith) – Al_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.0268 | p−value = 0.94 | No trend



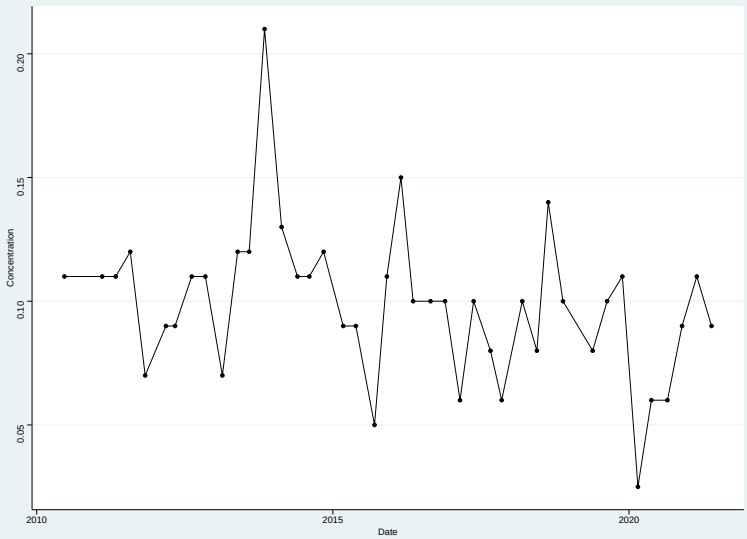
Bore GW61_D (Regolith) – As_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.13 | p−value = 0.312 | No trend



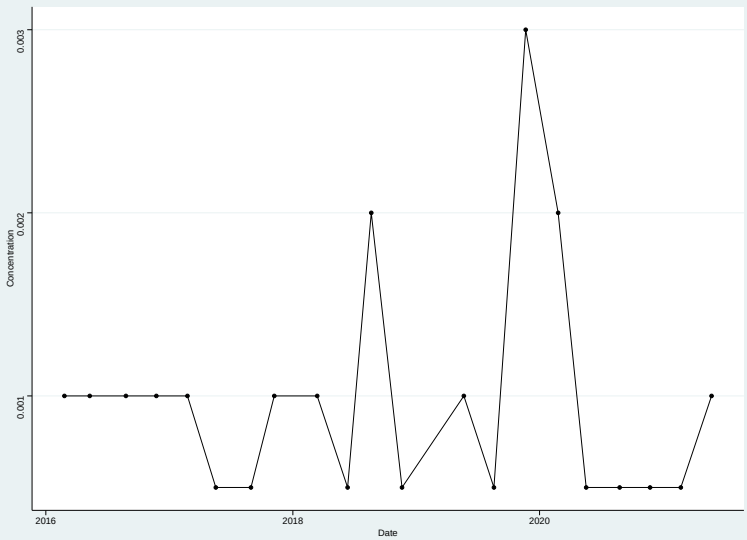
Bore GW61_D (Regolith) – B_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.256 | p−value = 0.023 | Negative trend



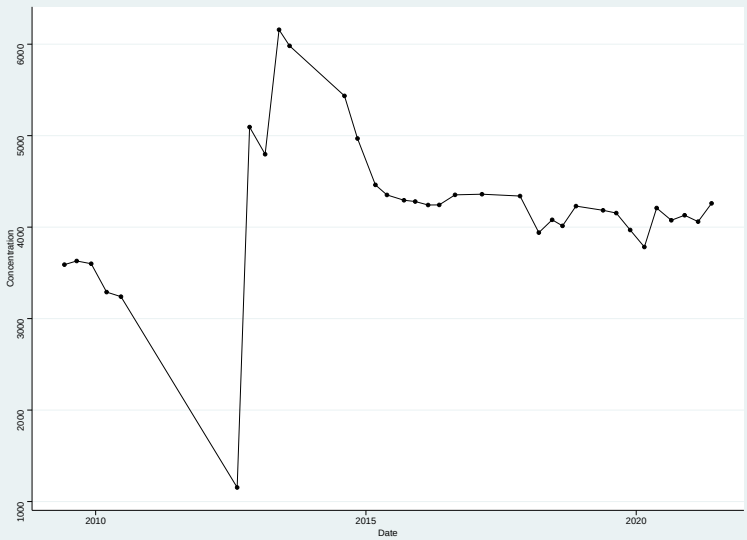
Bore GW61_D (Regolith) – Co_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.171 | p−value = 0.354 | No trend



Bore GW61_D (Regolith) – EC_Field Concentration (µS/cm)

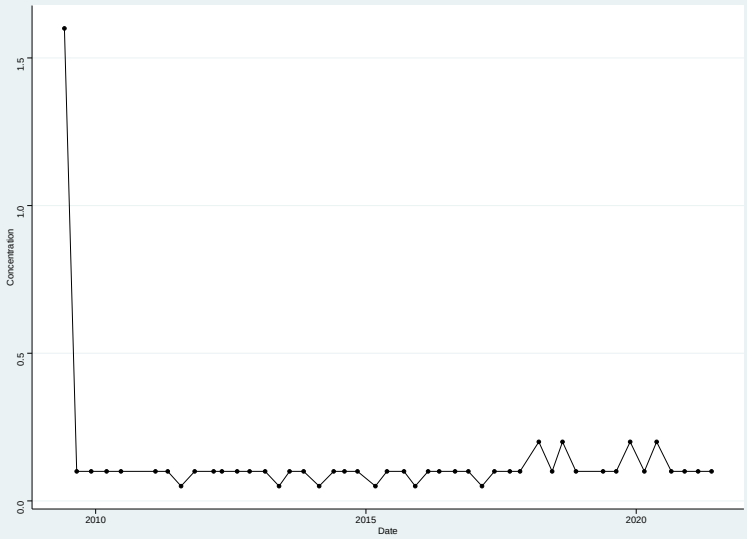
Mann Kendall Trend Test | τ = −0.144 | p−value = 0.236 | No trend



Appendix C Groundwater Quality Time Series

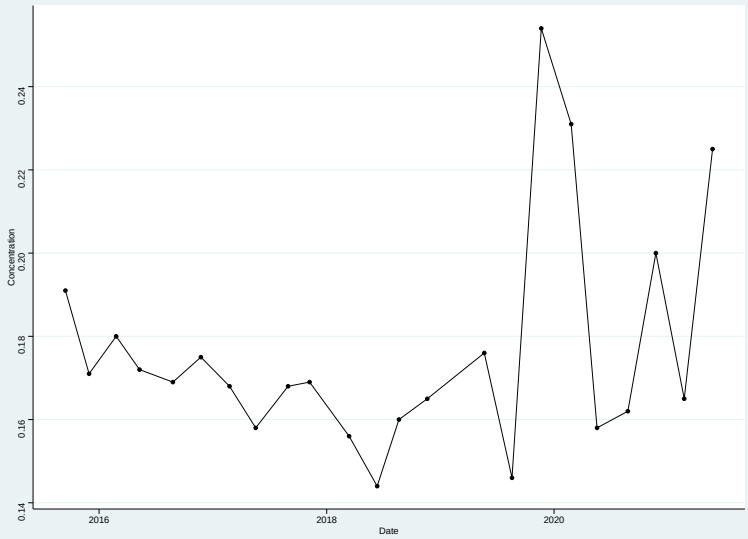
Bore GW61_D (Regolith) – Fluoride Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.144 | p−value = 0.231 | No trend



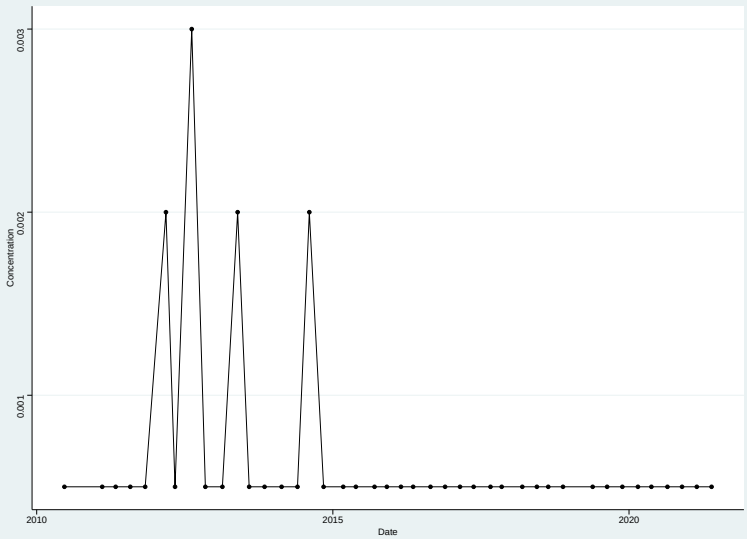
Bore GW61_D (Regolith) – Mn_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.0757 | p−value = 0.634 | No trend



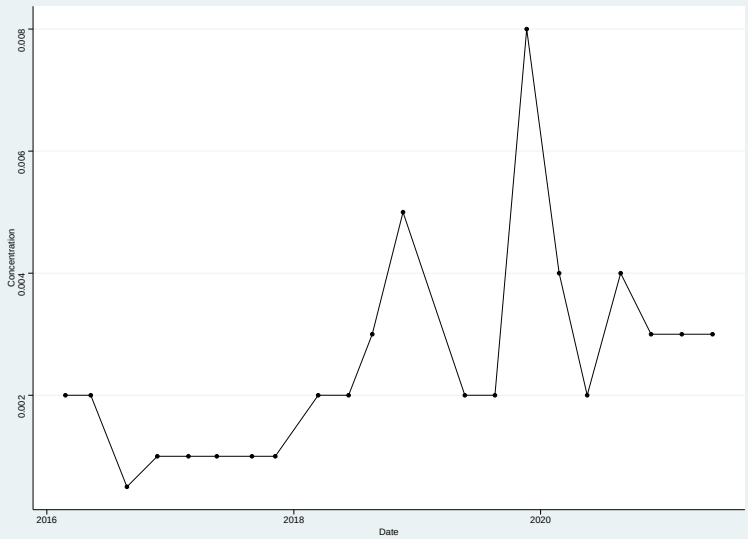
Bore GW61_D (Regolith) – Mo_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.249 | p−value = 0.0541 | No trend



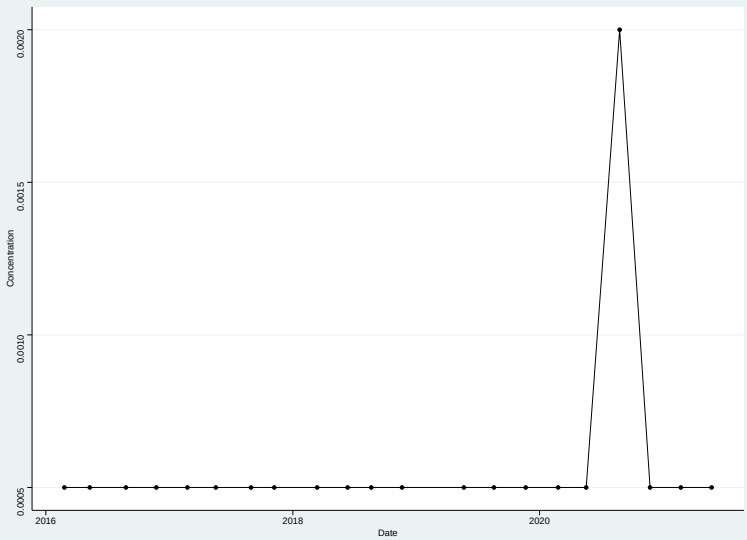
Bore GW61_D (Regolith) – Ni_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.526 | p−value = 0.002 | Positive trend



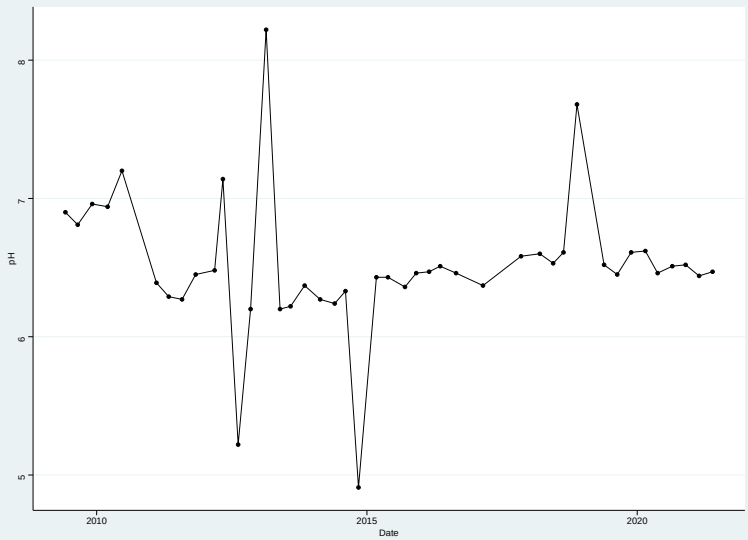
Bore GW61_D (Regolith) – Pb_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.216 | p−value = 0.283 | No trend

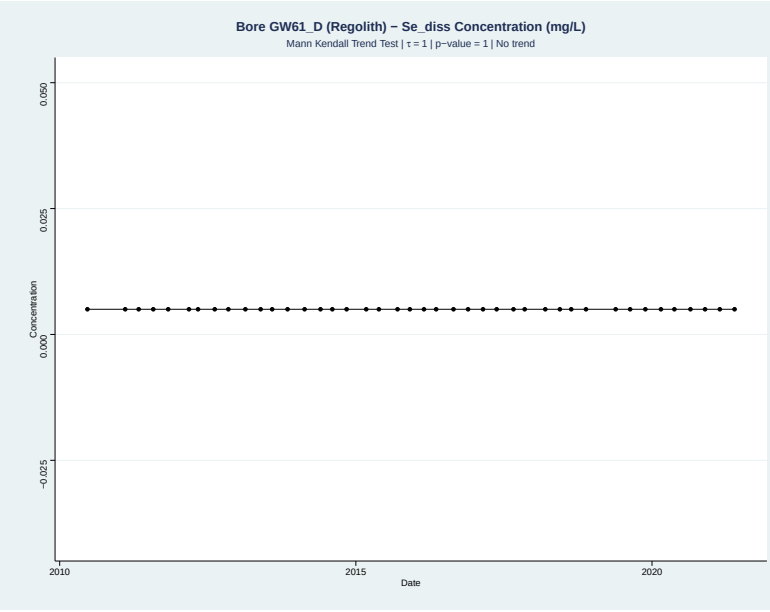


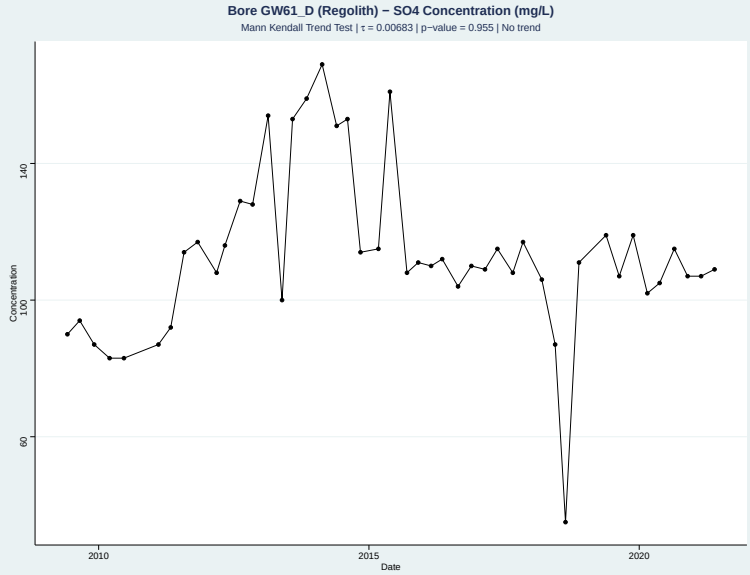
Bore GW61_D (Regolith) – pH_Field pH (pH Value)

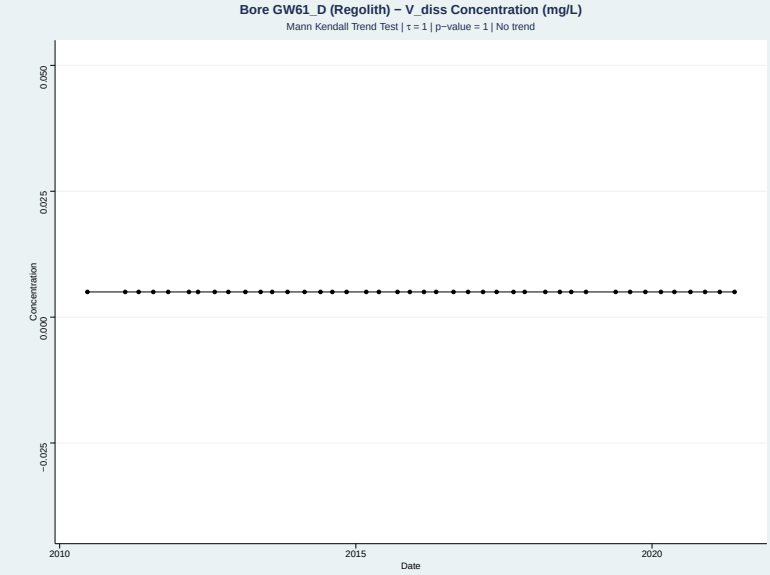
Mann Kendall Trend Test | τ = 0.119 | p−value = 0.267 | No trend

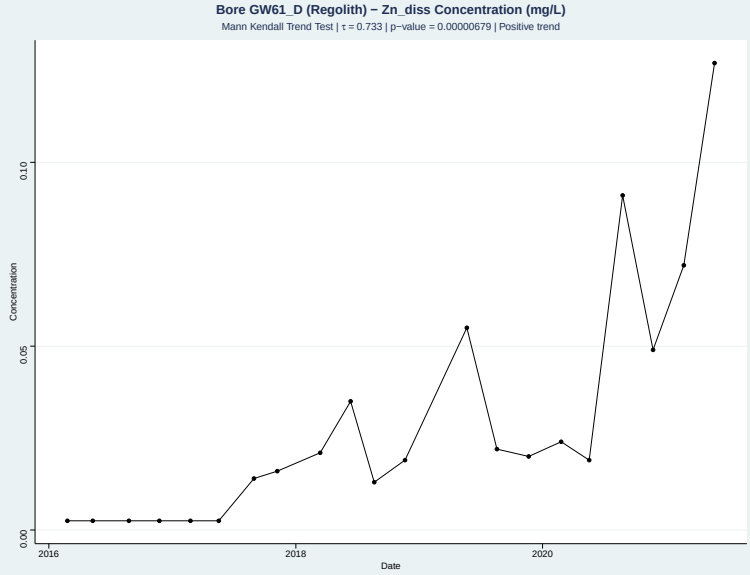


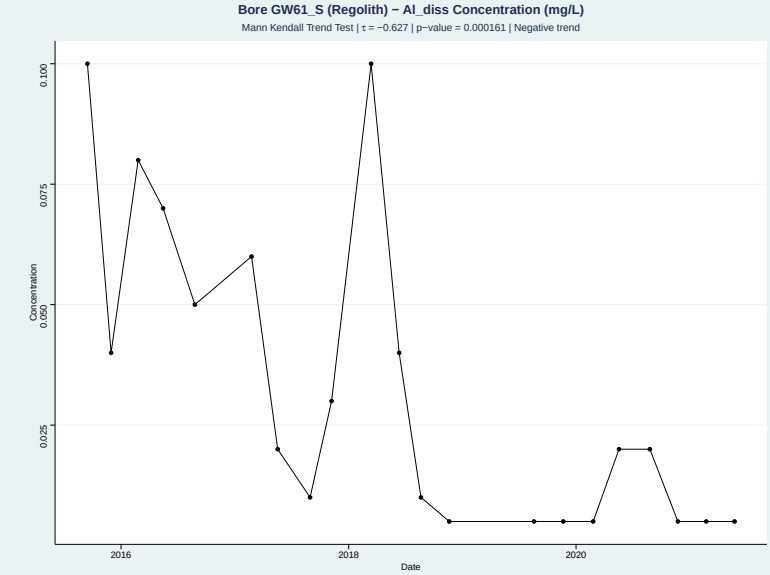
Appendix C Groundwater Quality Time Series

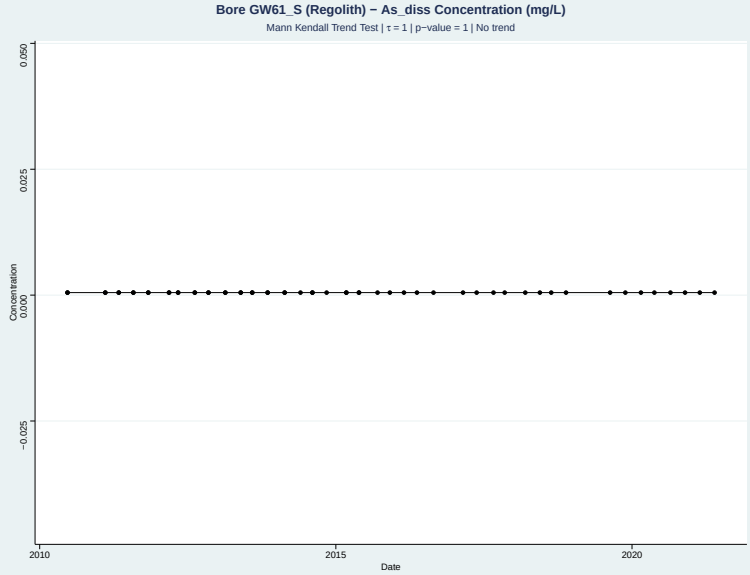




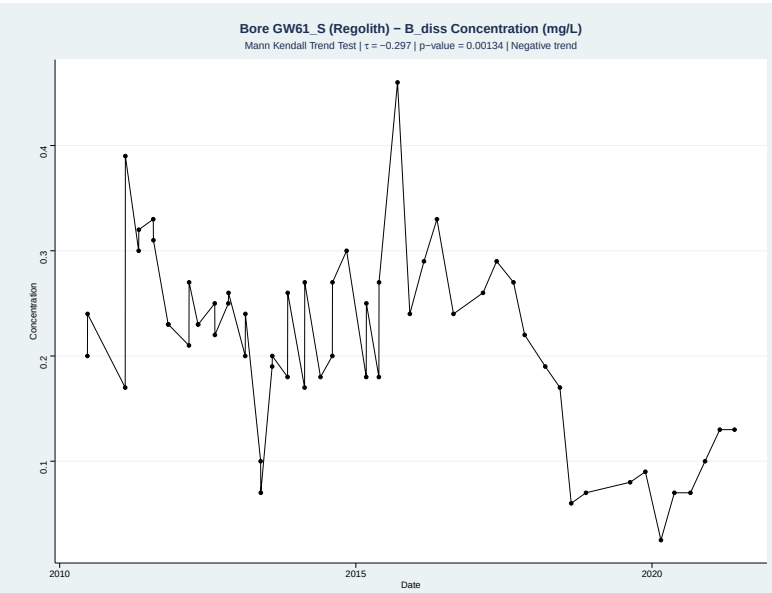


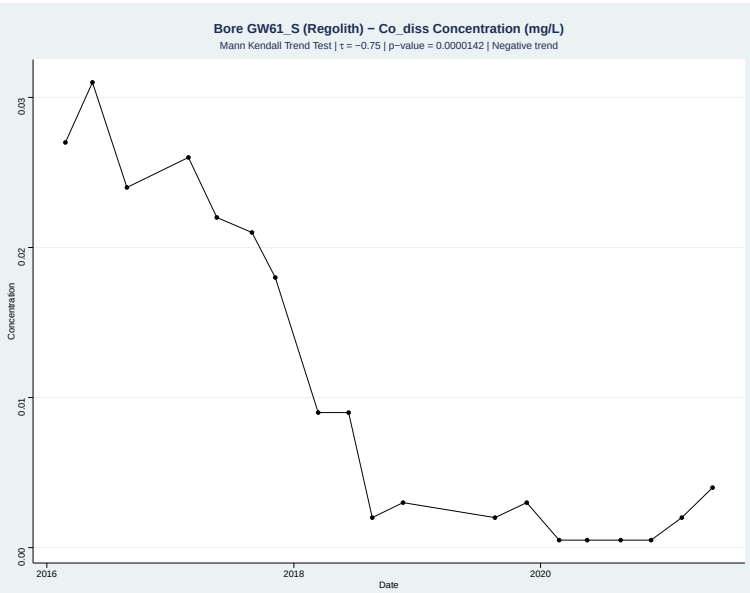


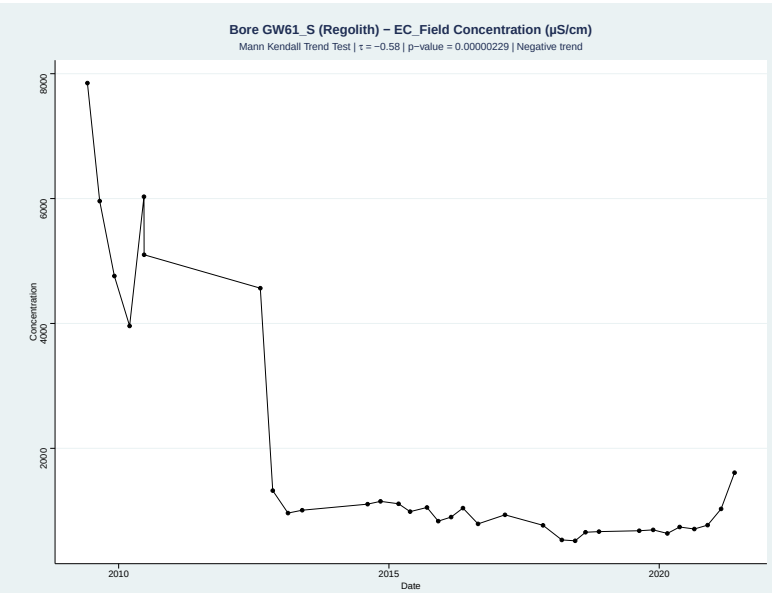


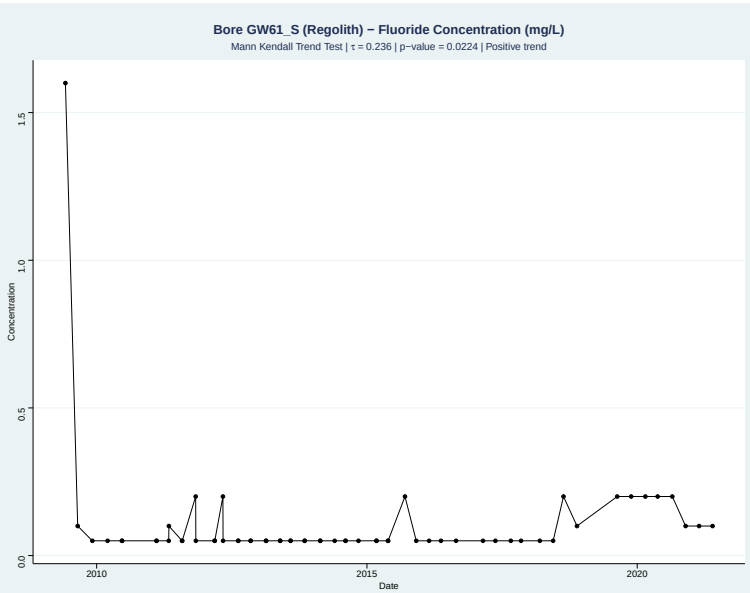


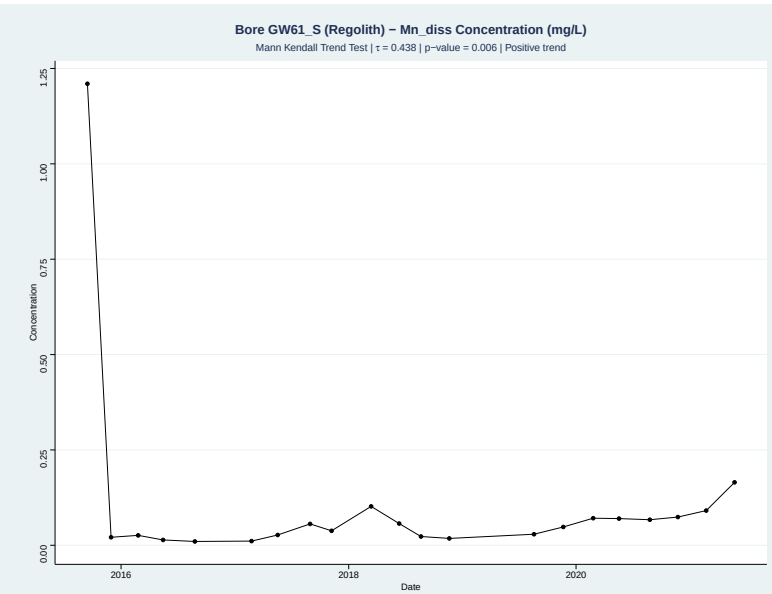
Appendix C Groundwater Quality Time Series

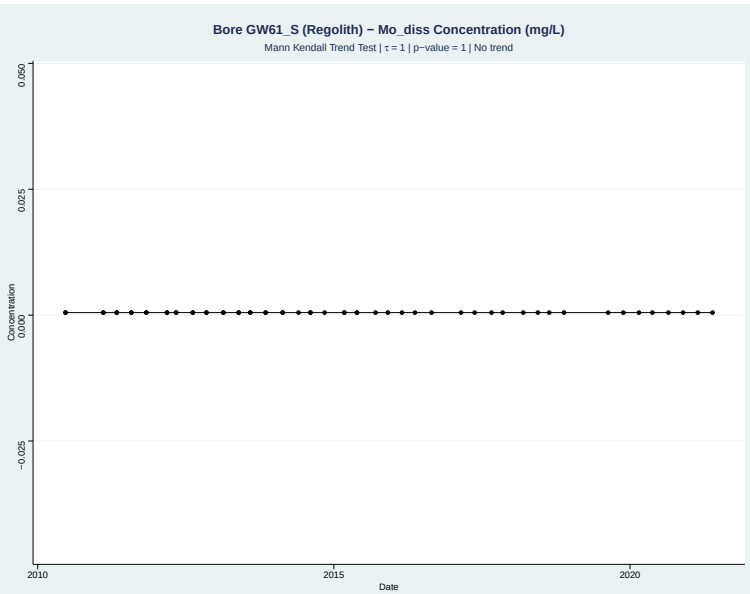




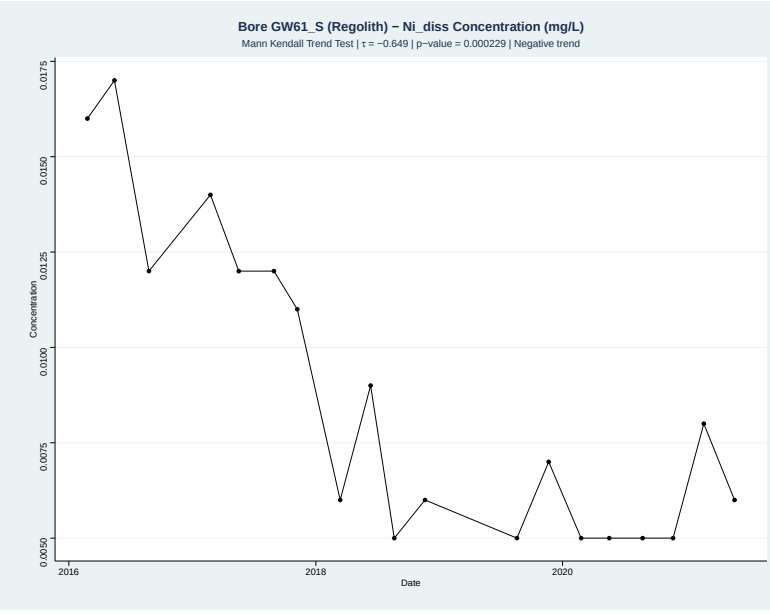


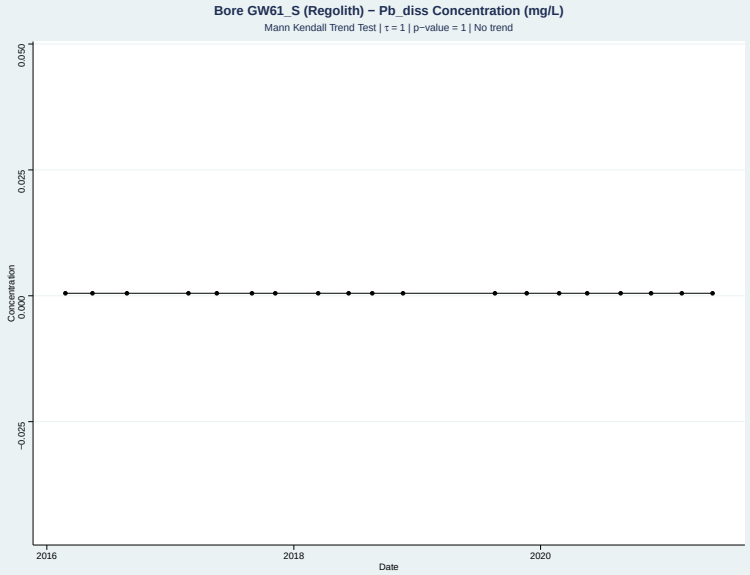


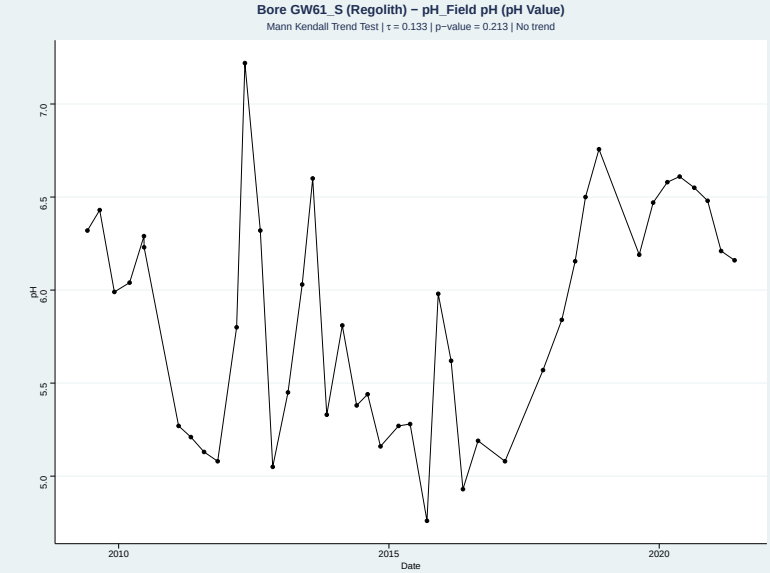


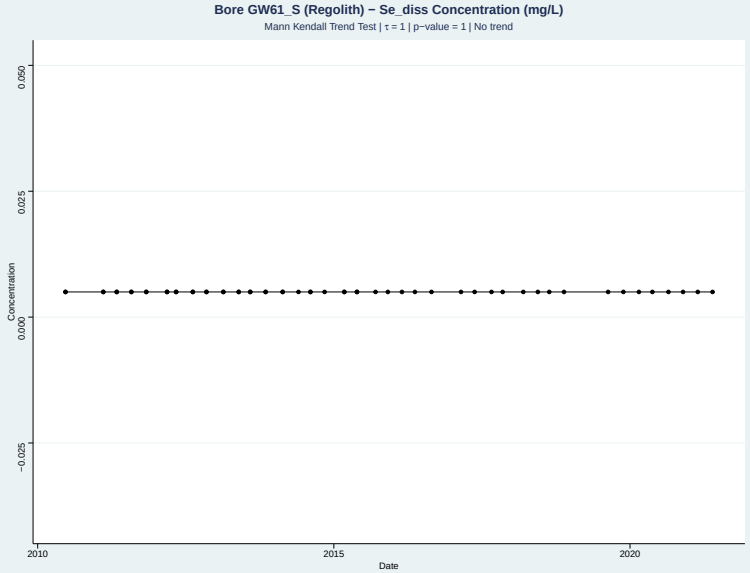


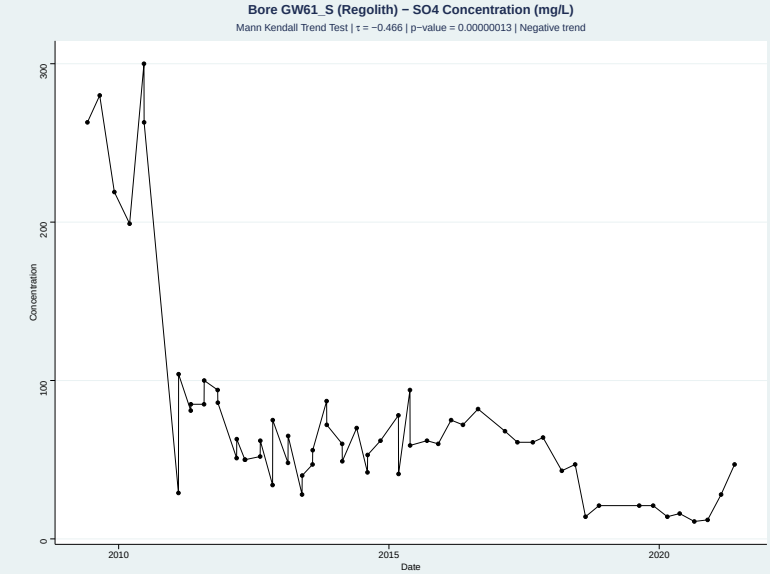
Appendix C Groundwater Quality Time Series

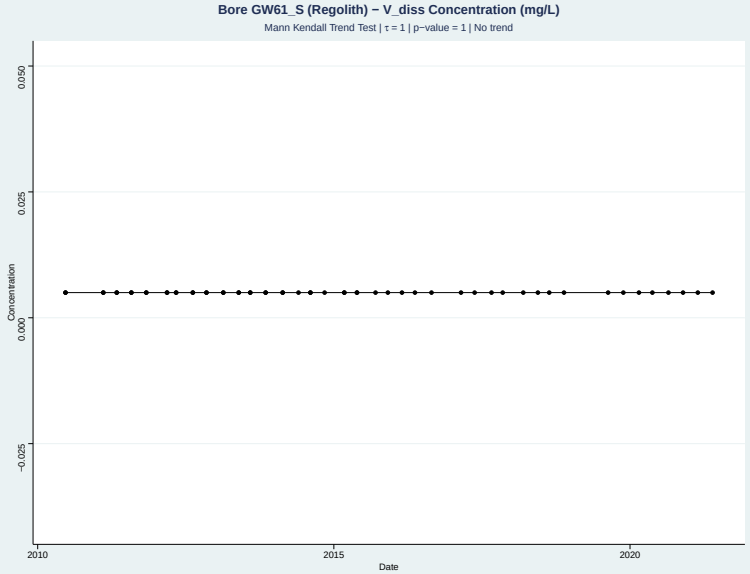




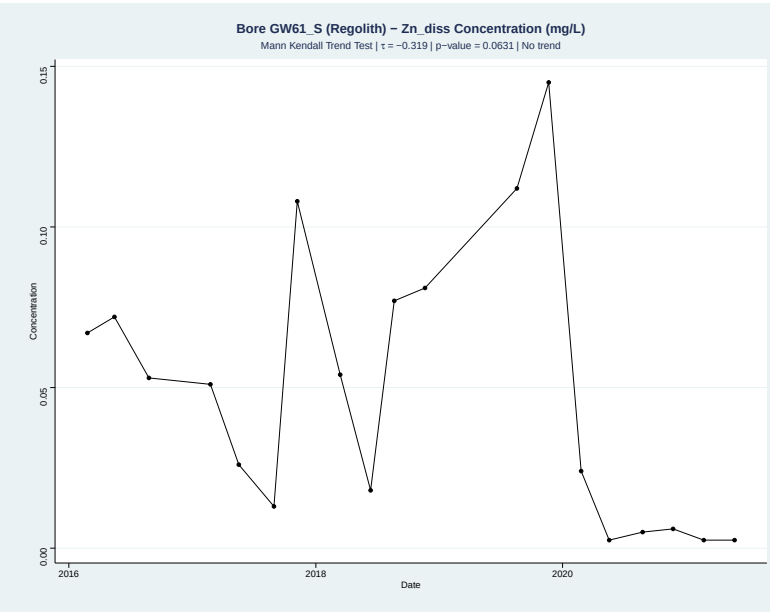


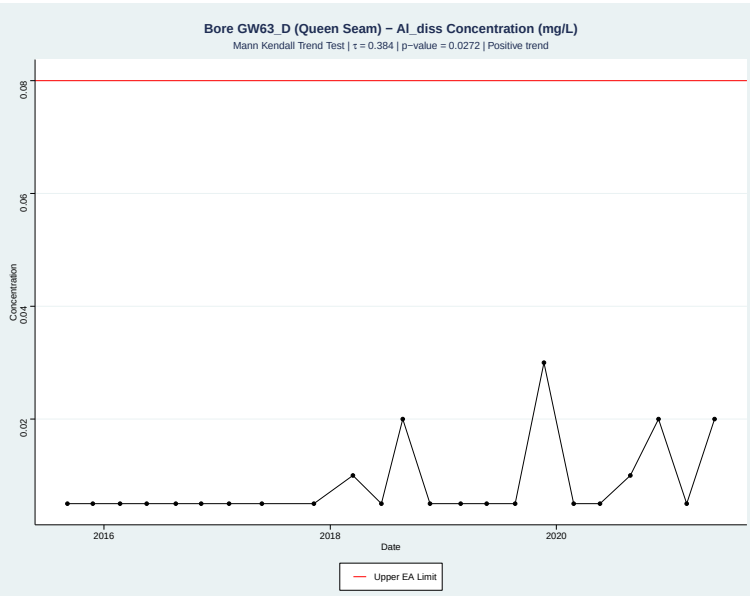


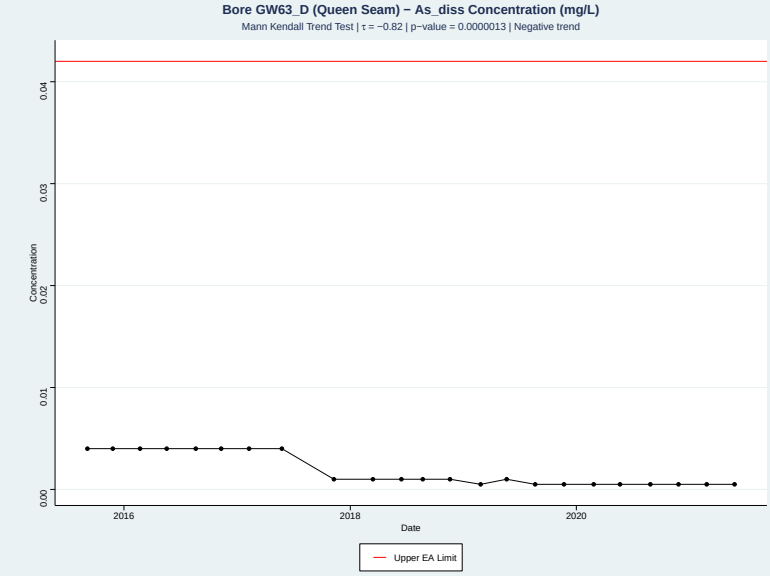


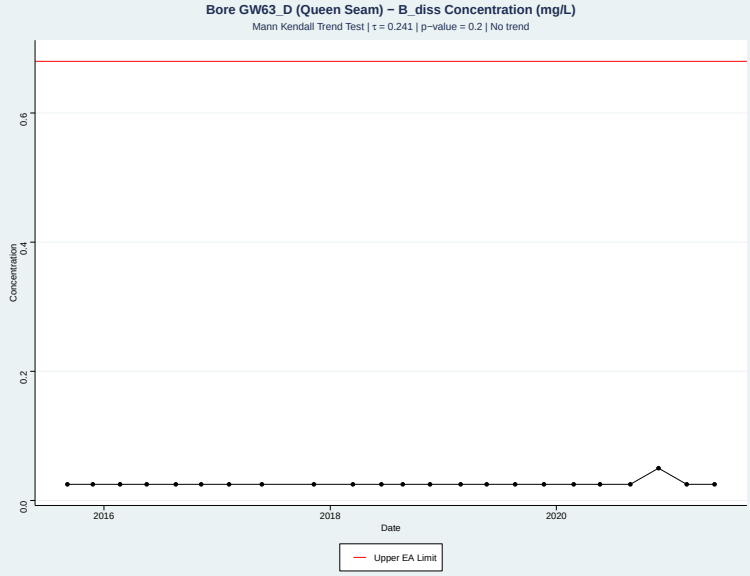


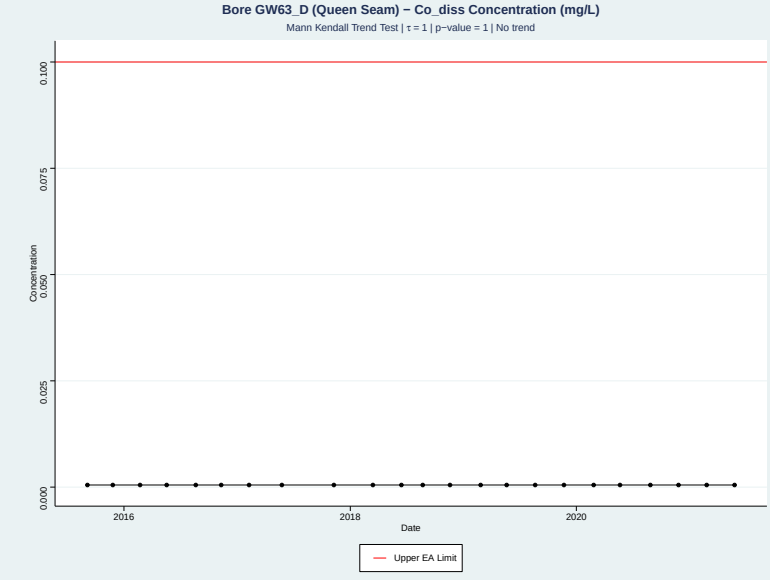
Appendix C Groundwater Quality Time Series

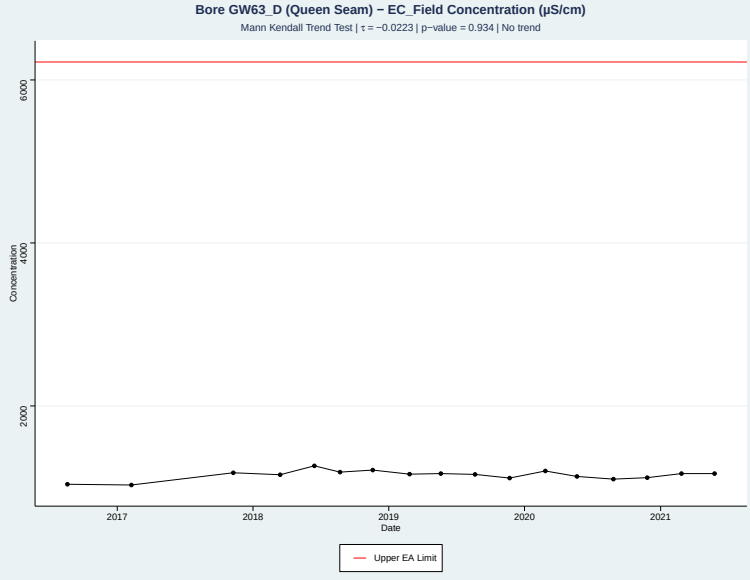




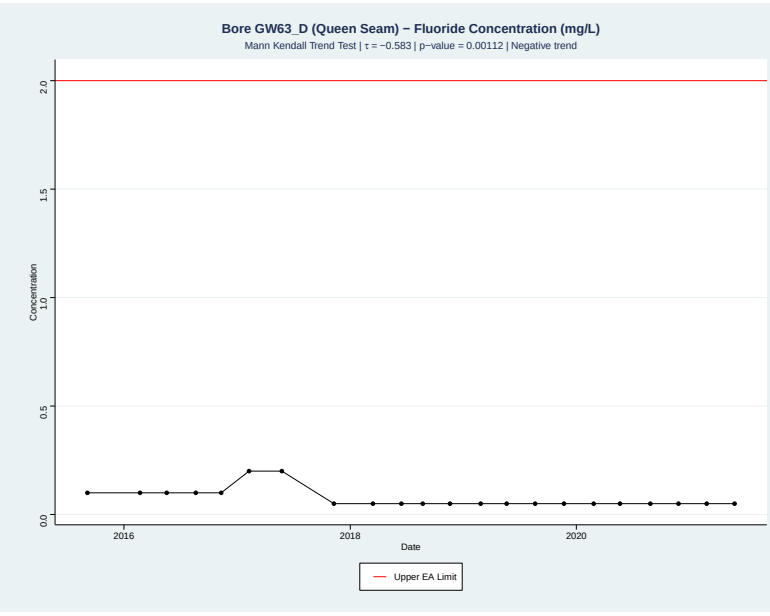


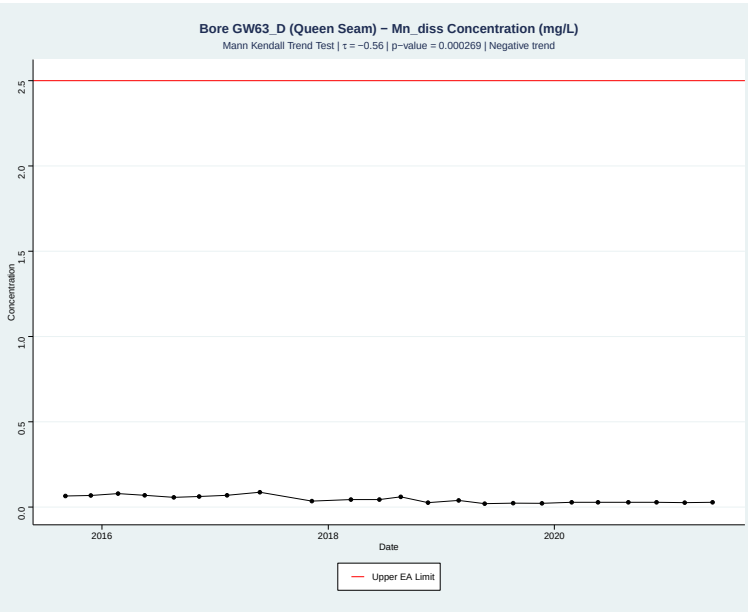


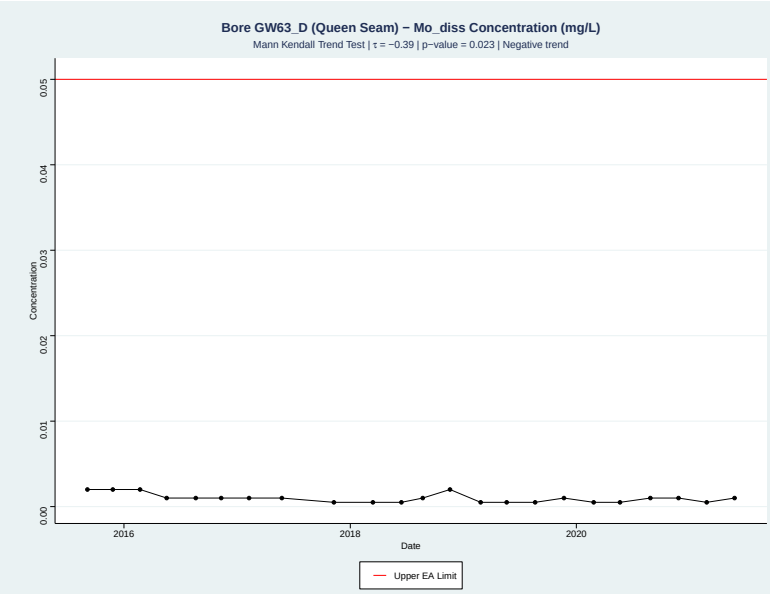


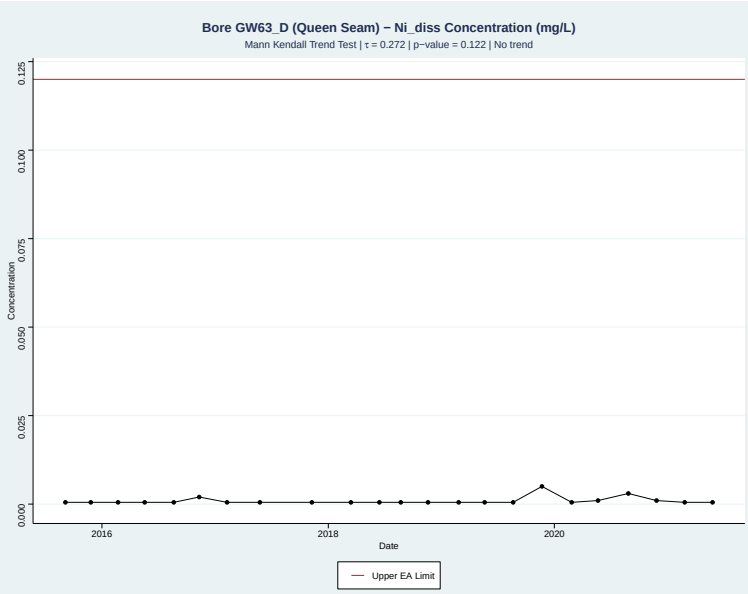


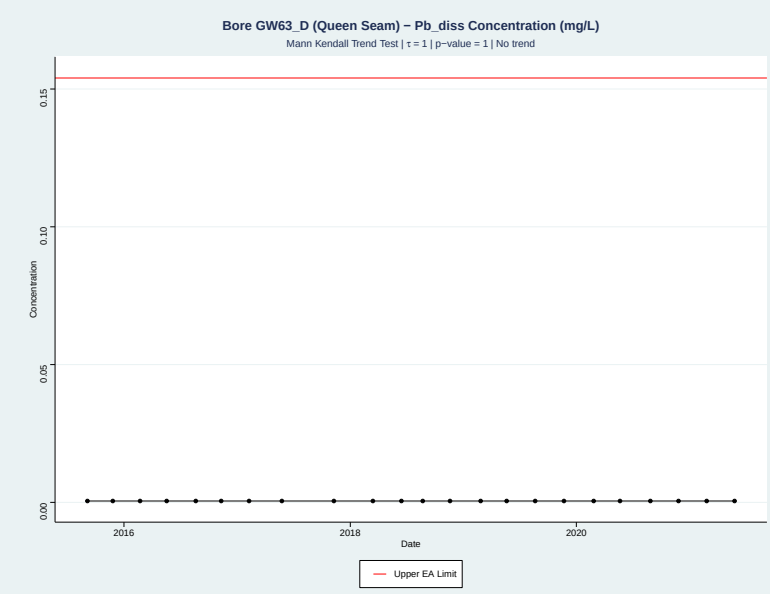
Appendix C Groundwater Quality Time Series

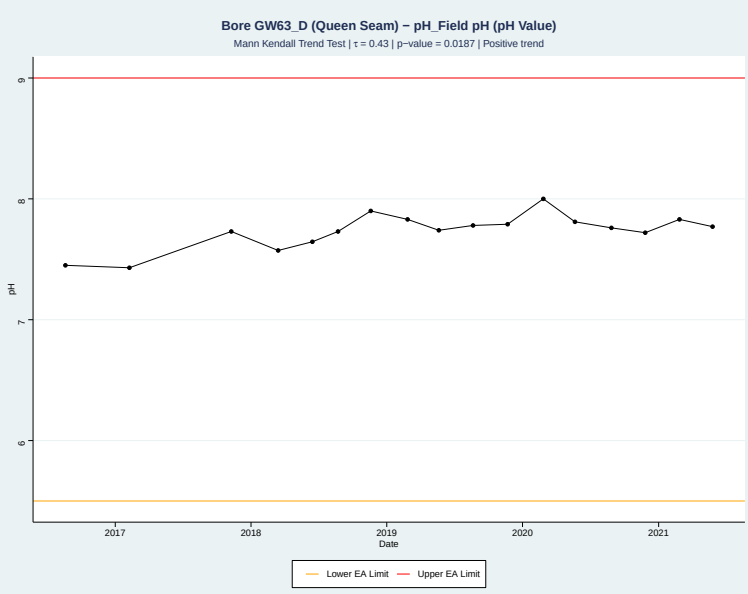




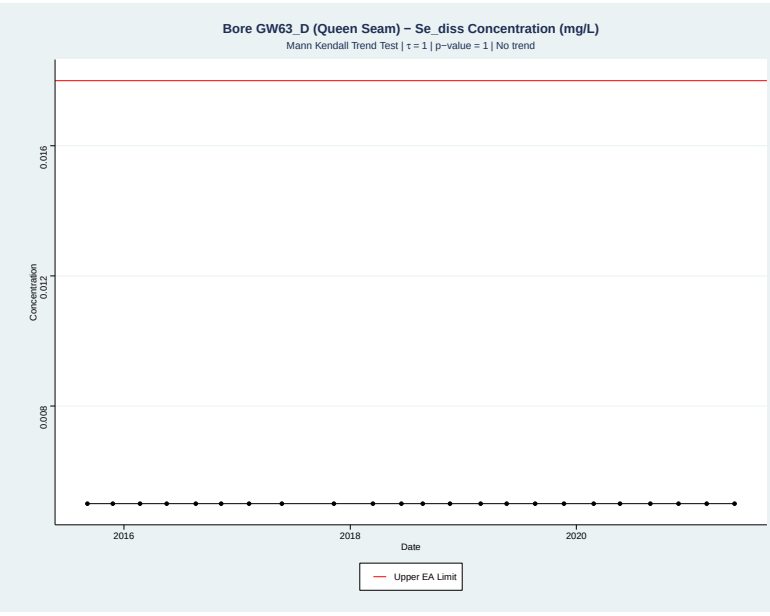


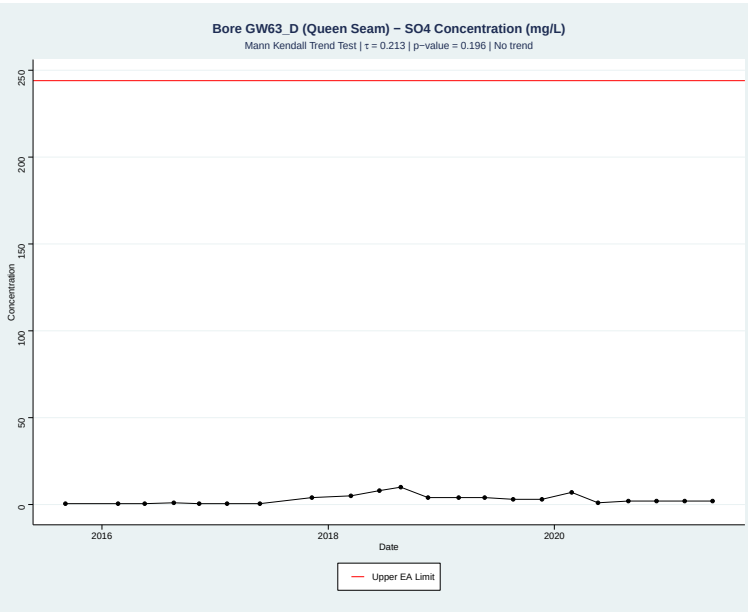


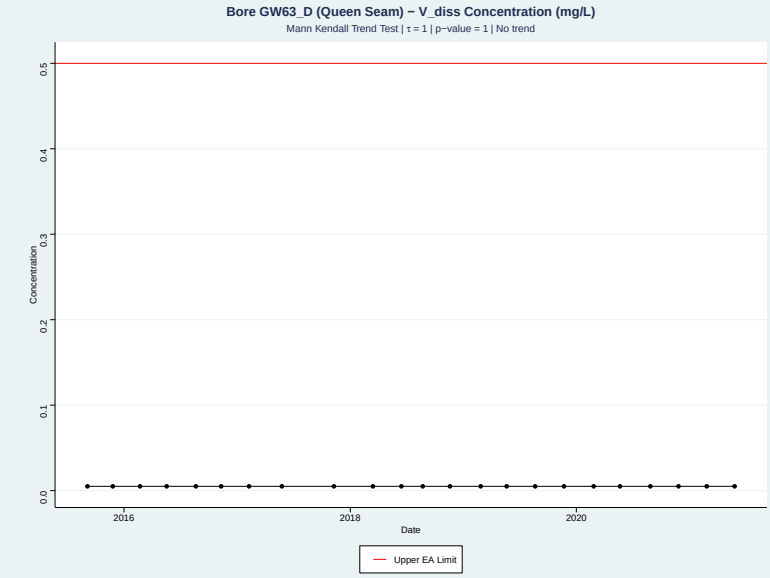


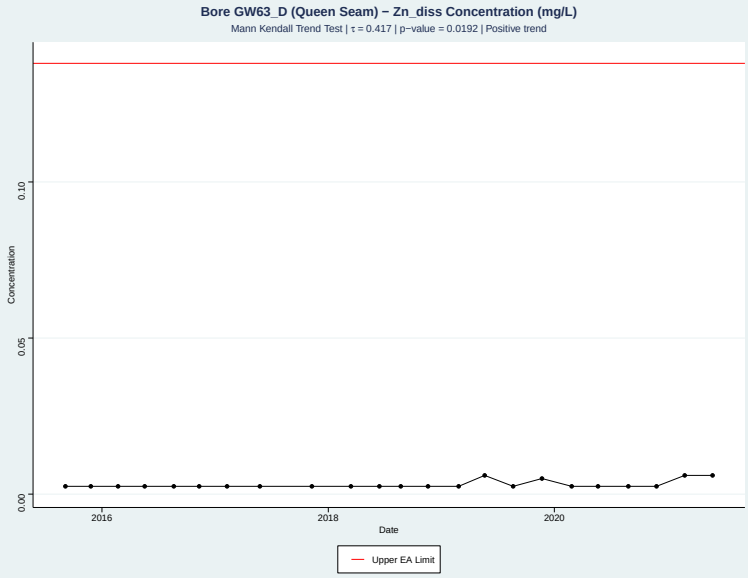


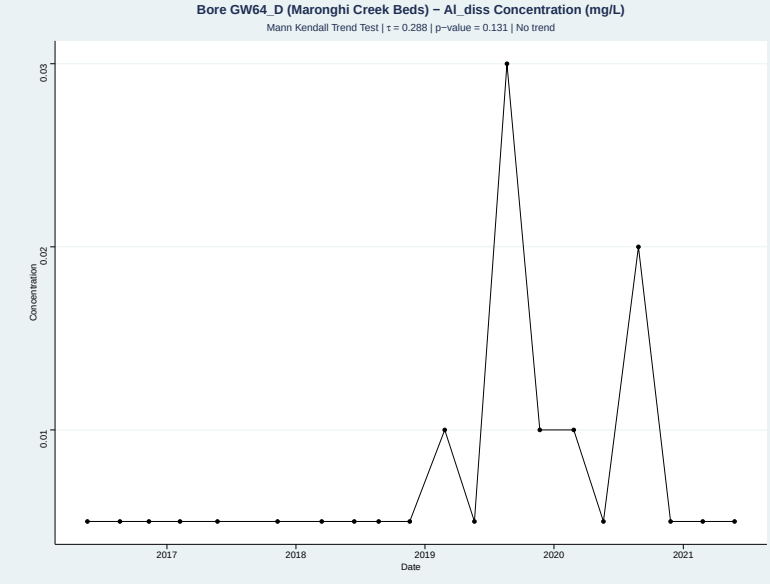
Appendix C Groundwater Quality Time Series

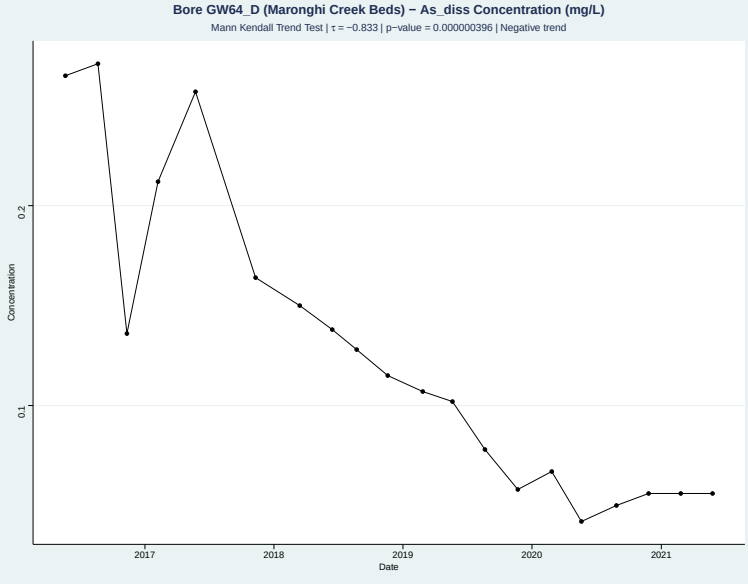




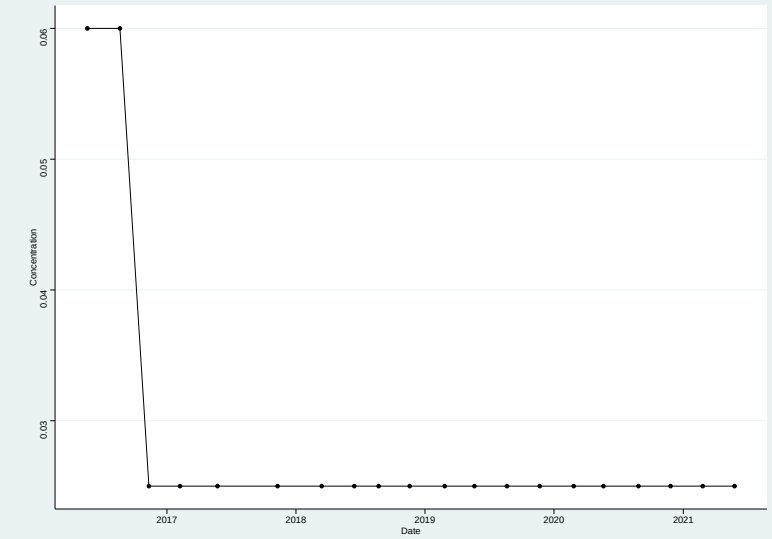


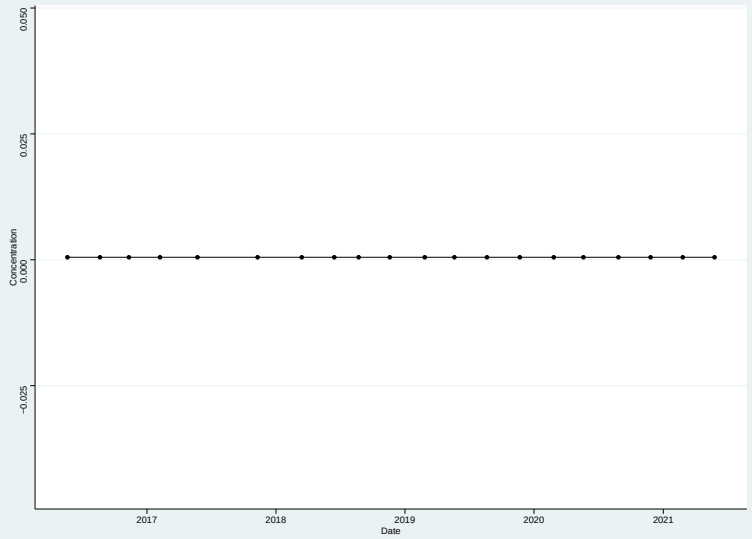


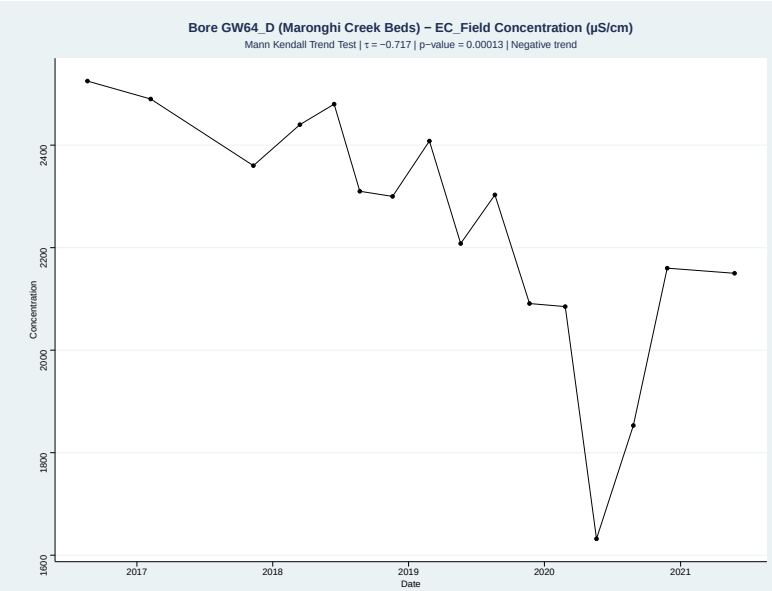


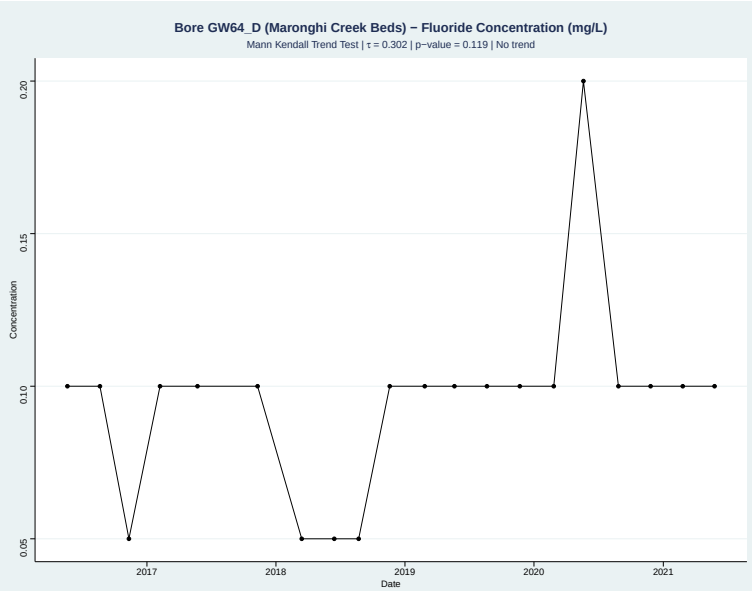


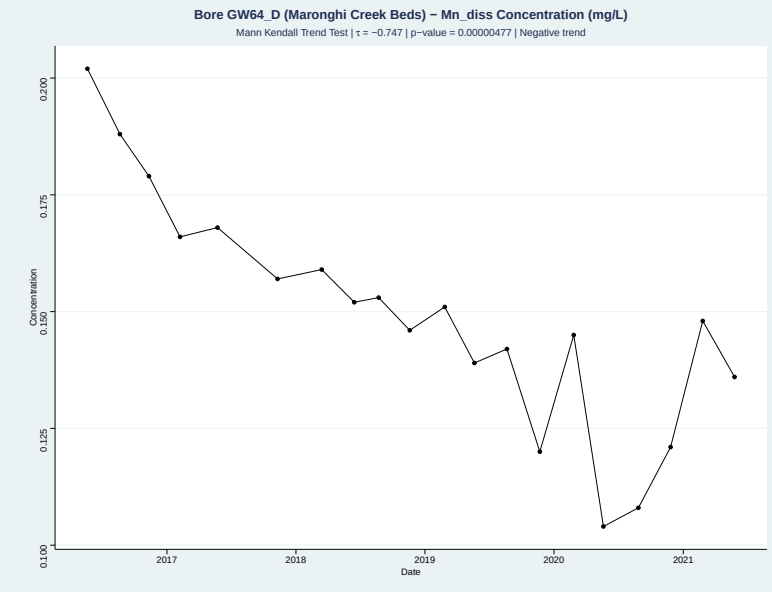
Appendix C Groundwater Quality Time Series

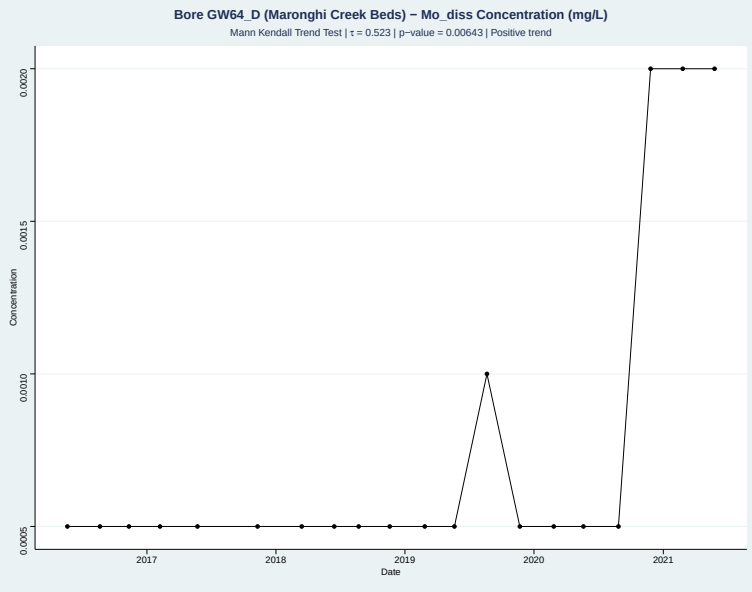




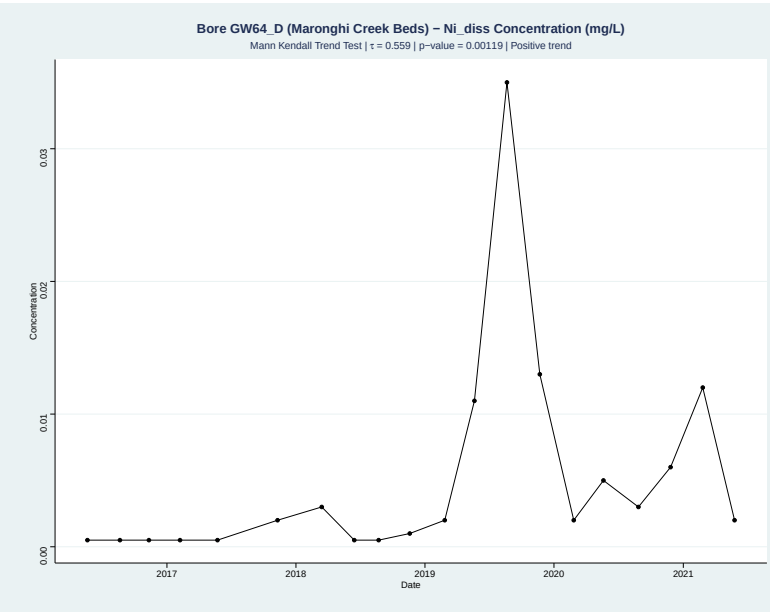


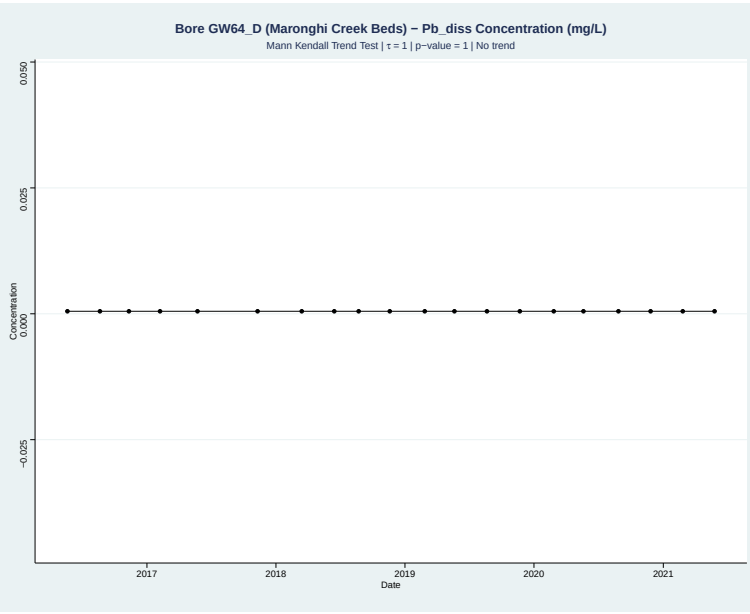


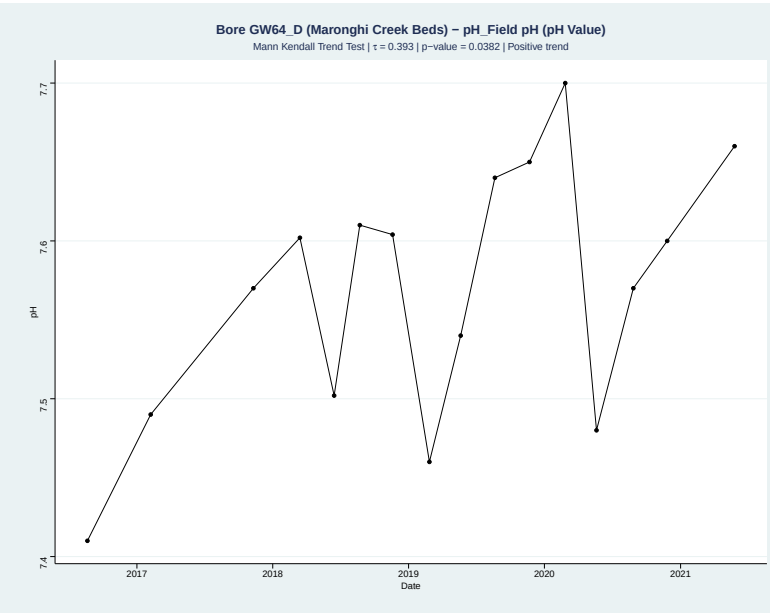


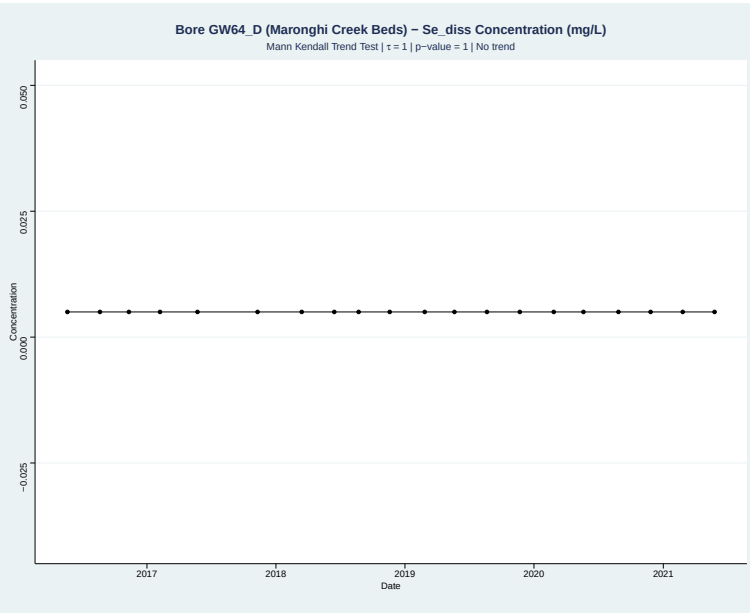


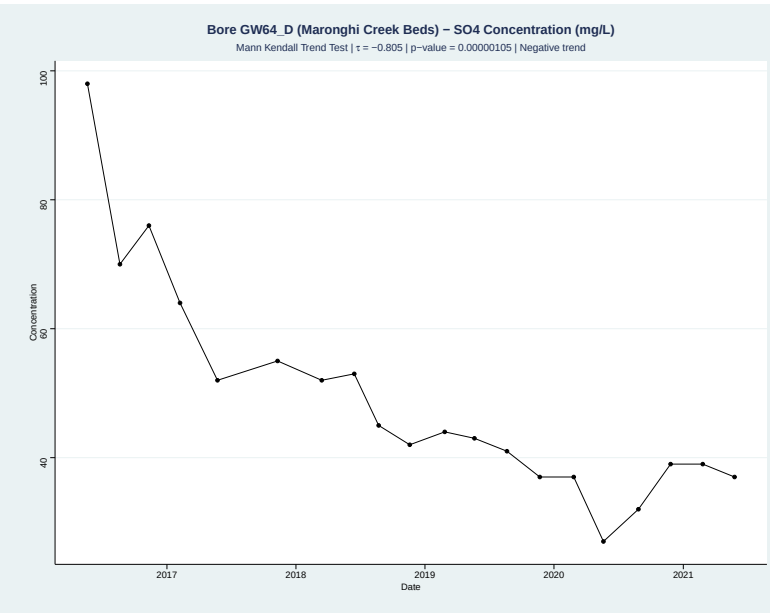
Appendix D Groundwater Quality Time Series

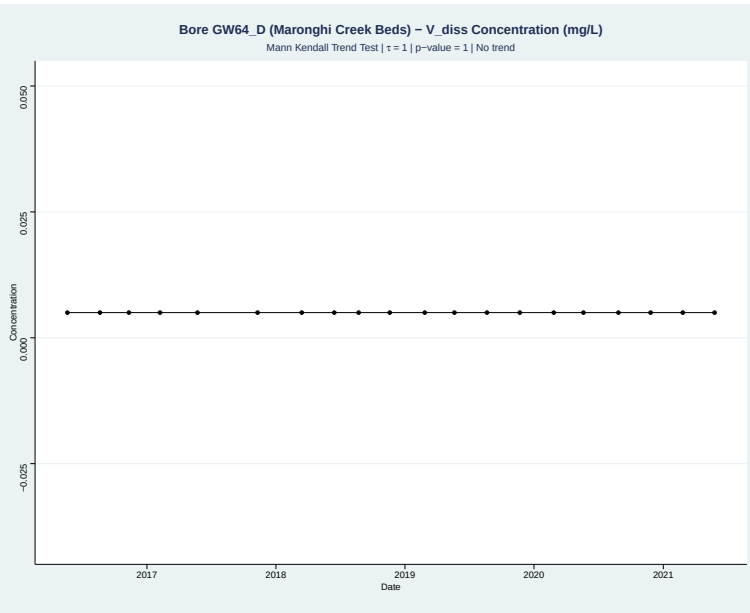




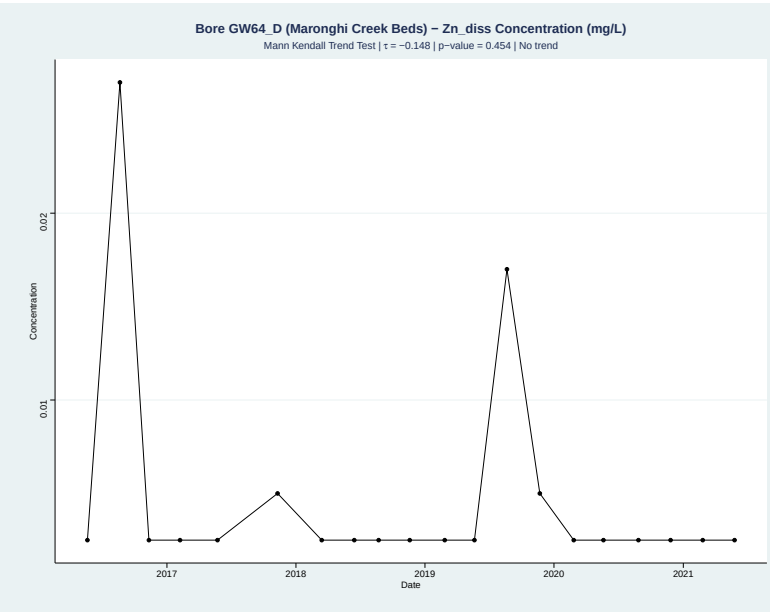


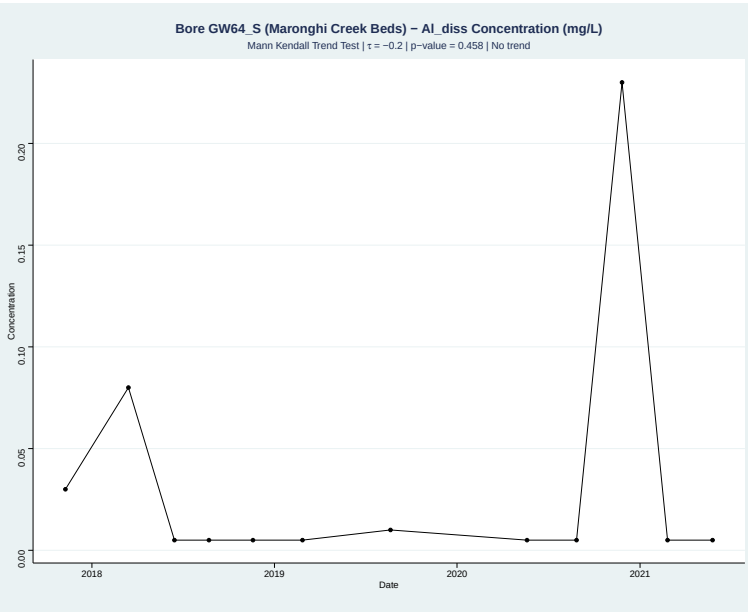


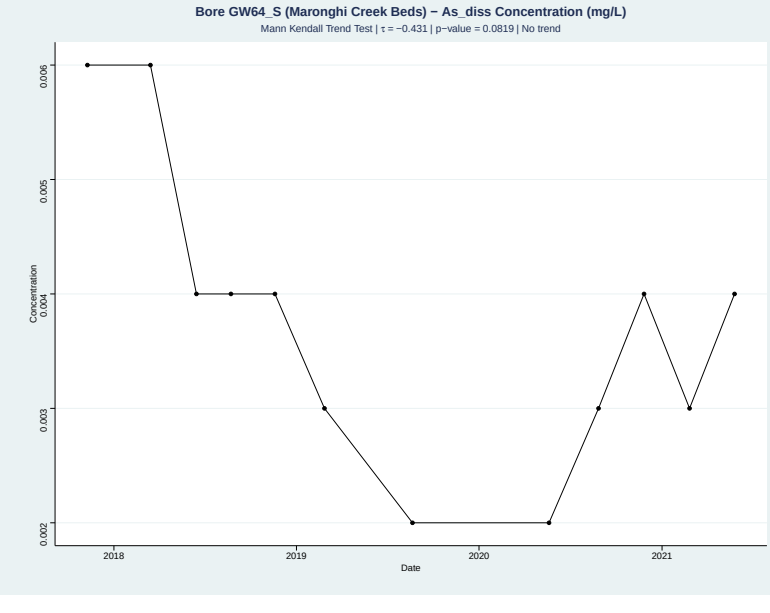


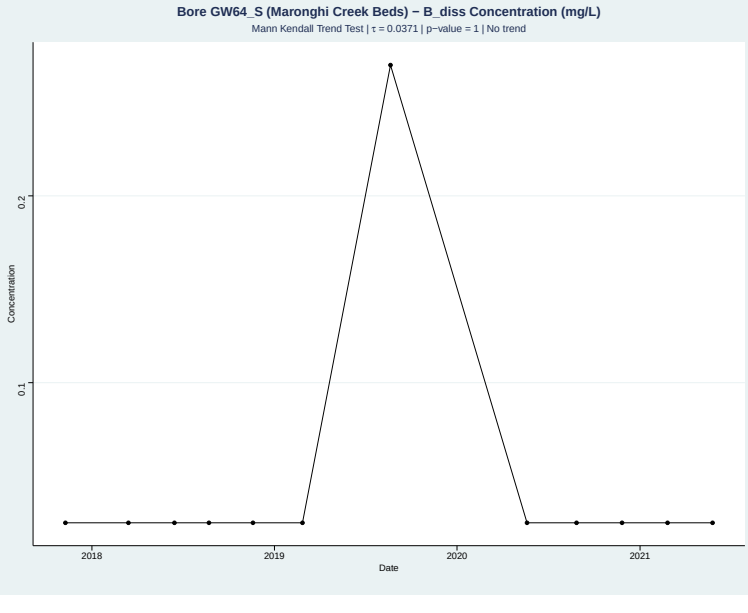


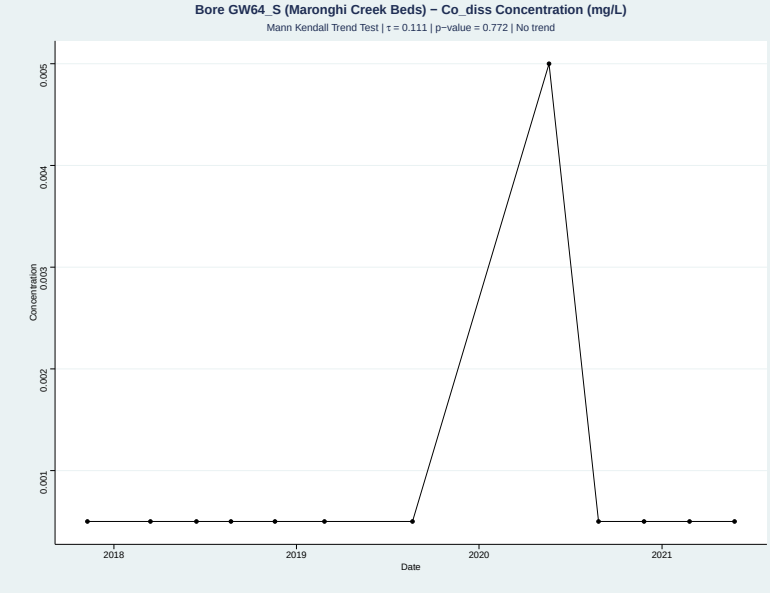
Appendix C Groundwater Quality Time Series

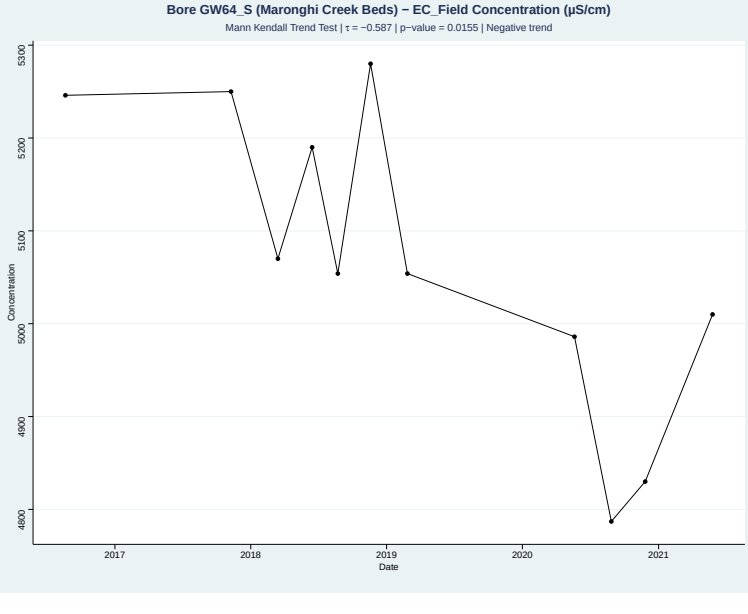




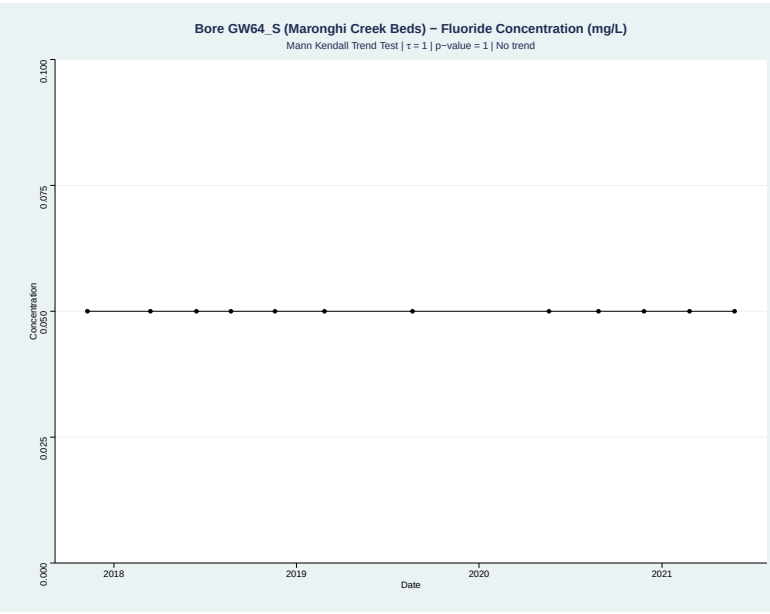


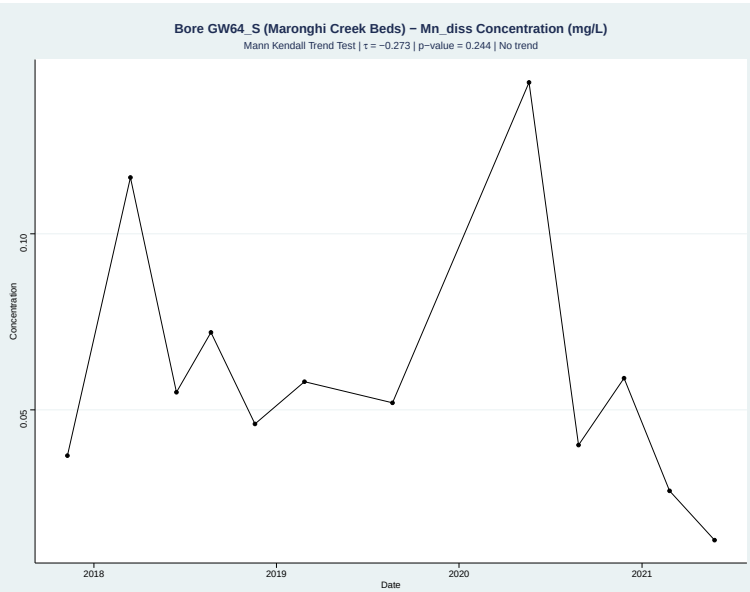


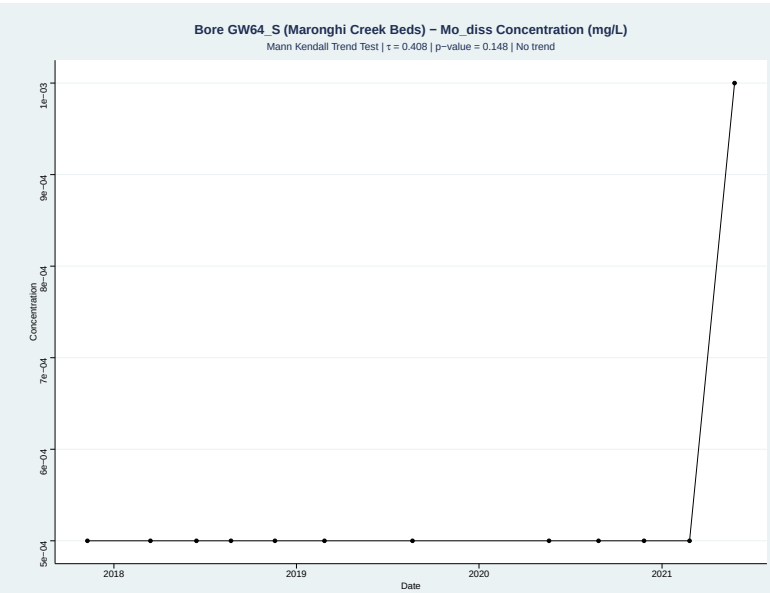


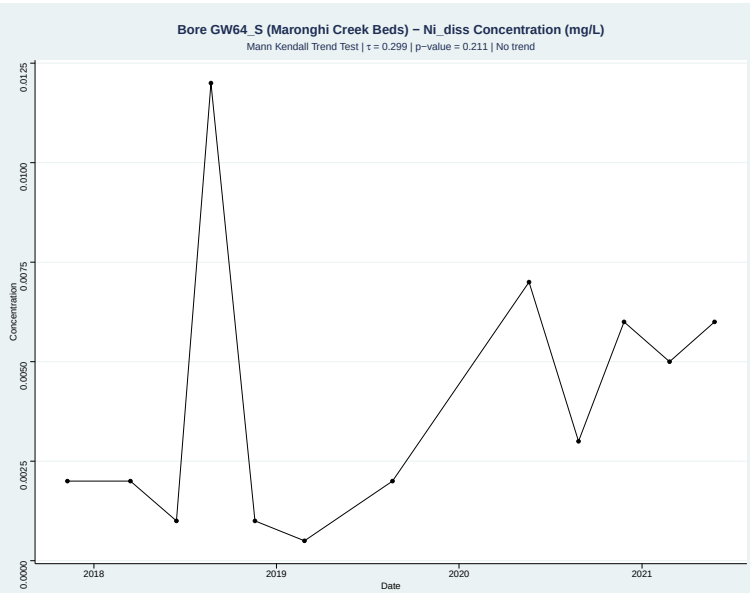


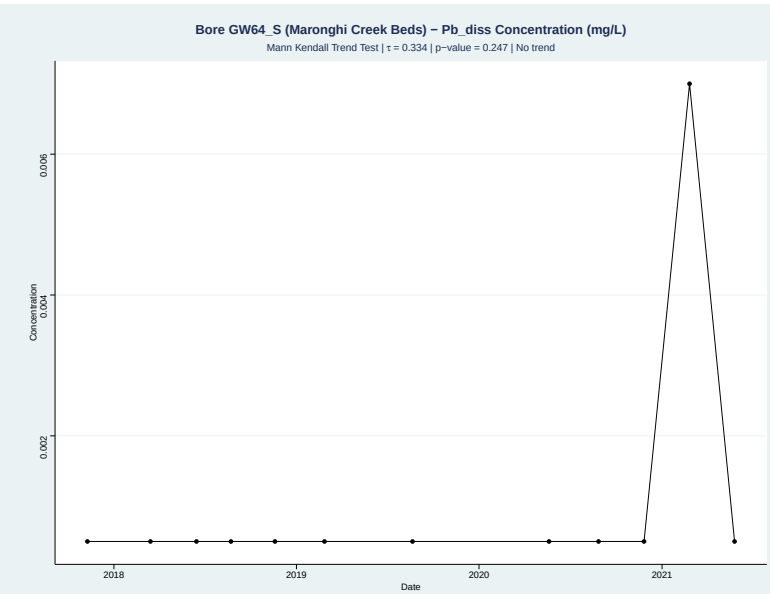
Appendix C Groundwater Quality Time Series

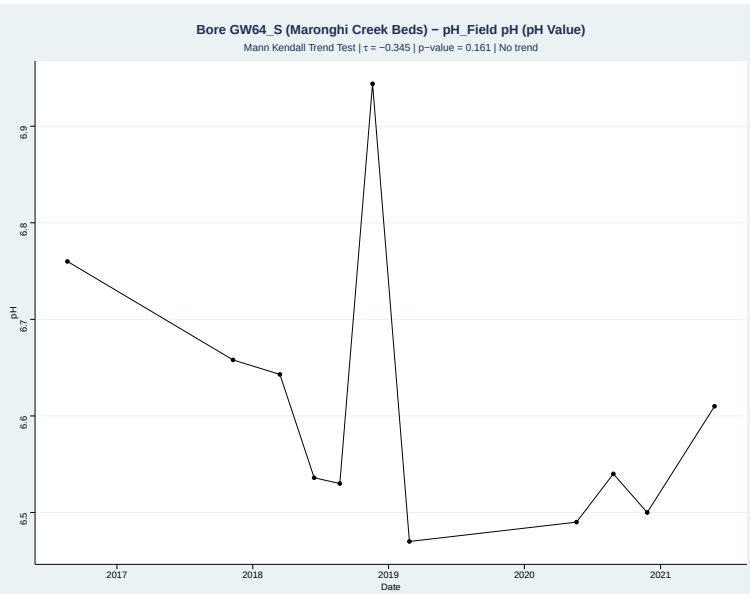




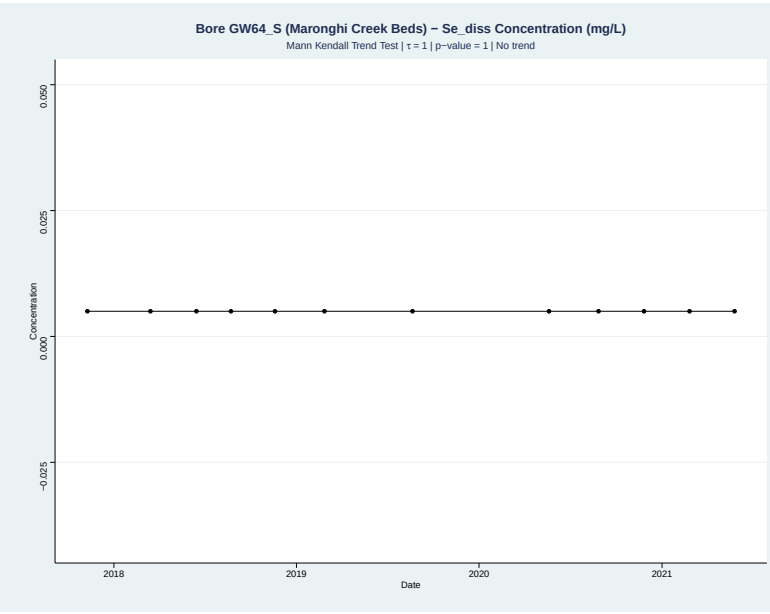


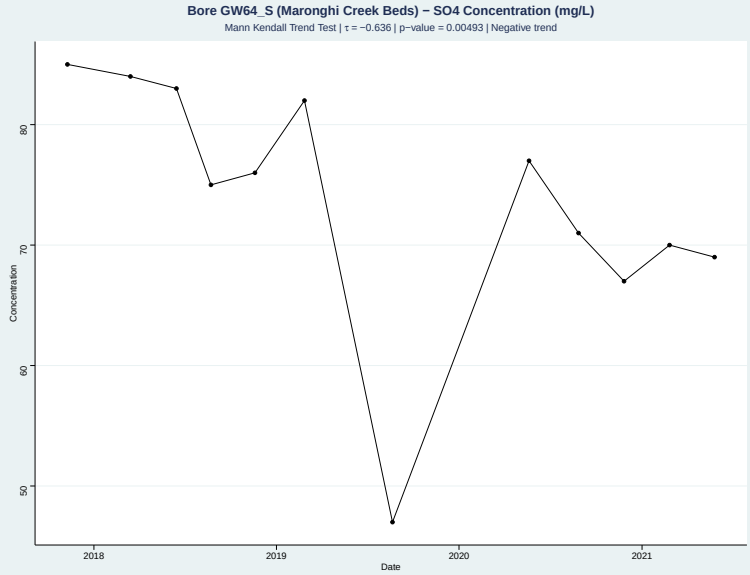


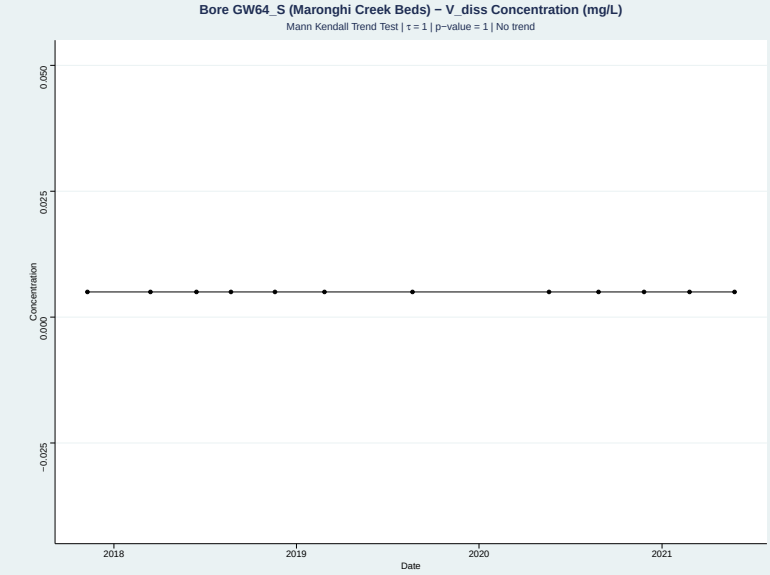


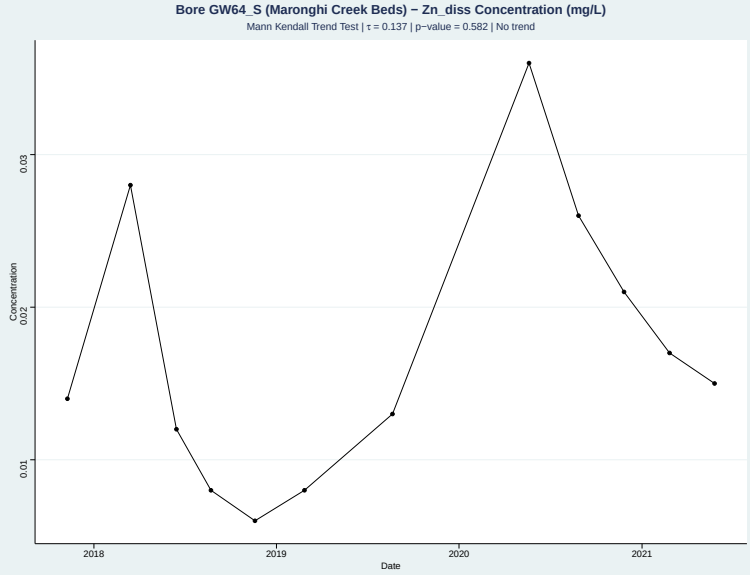


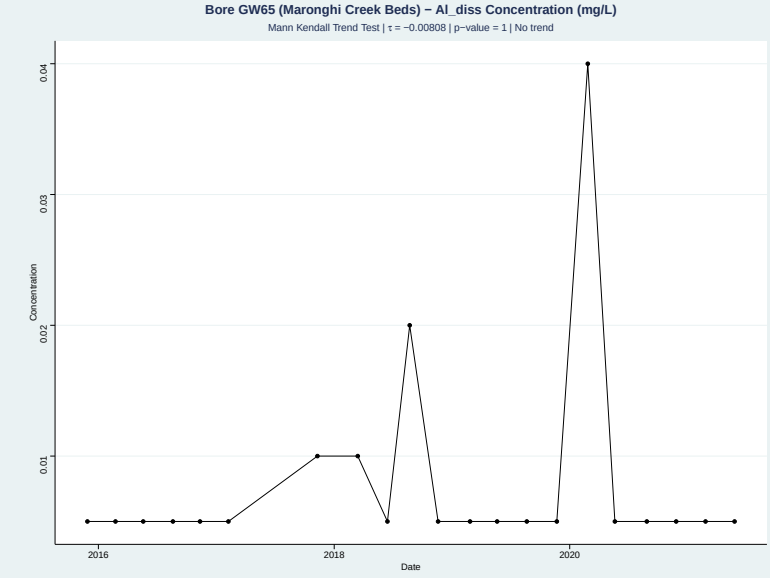
Appendix C Groundwater Quality Time Series

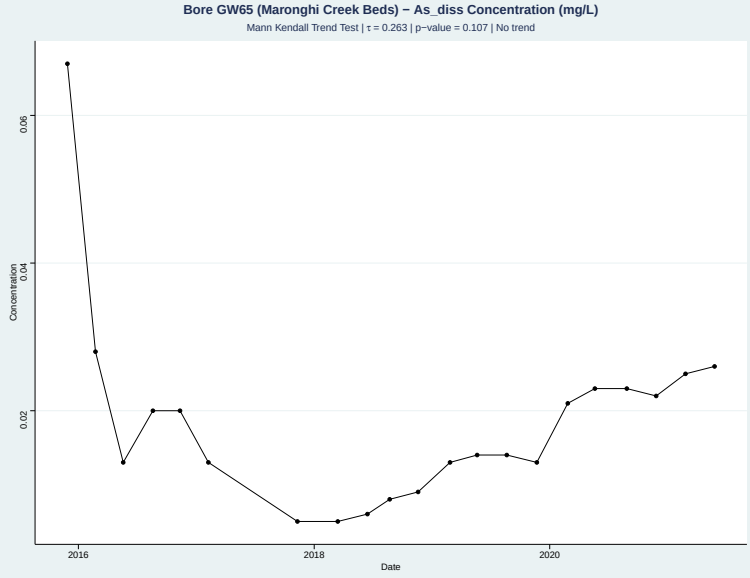




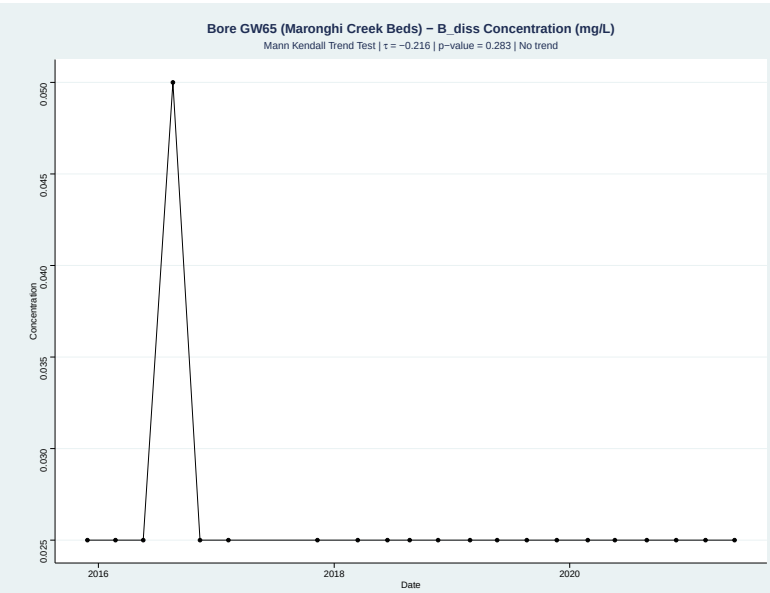


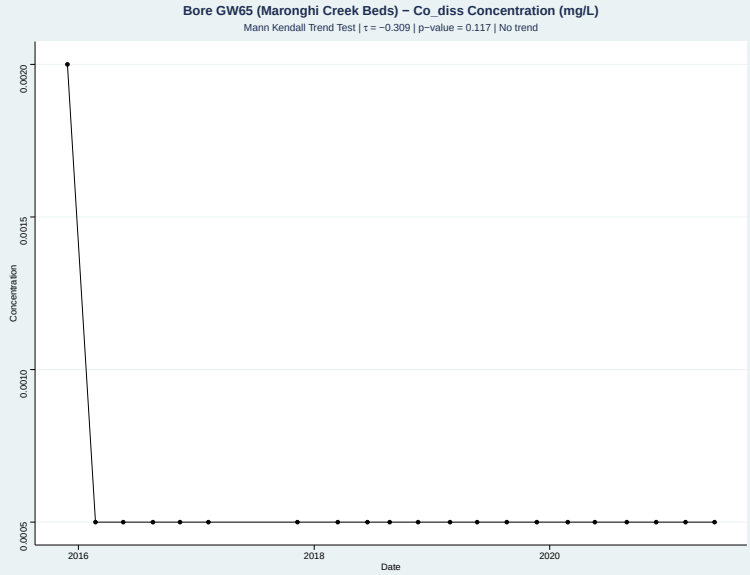


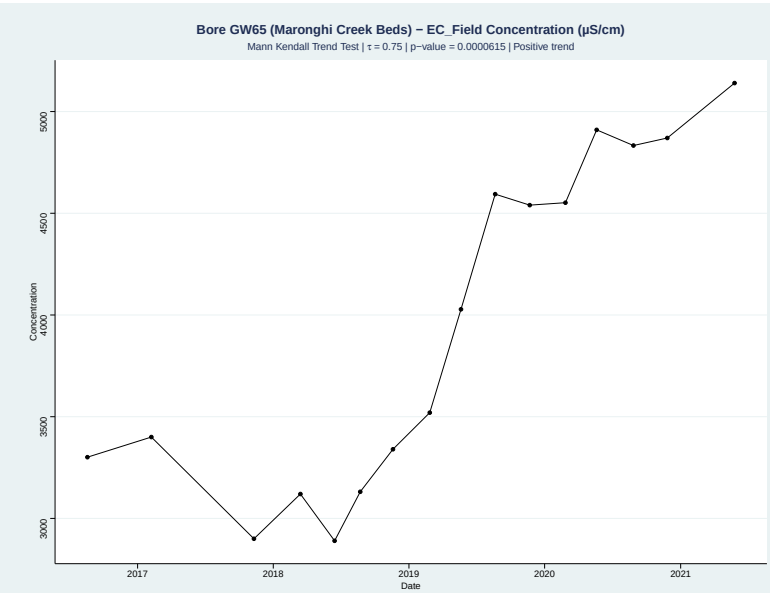


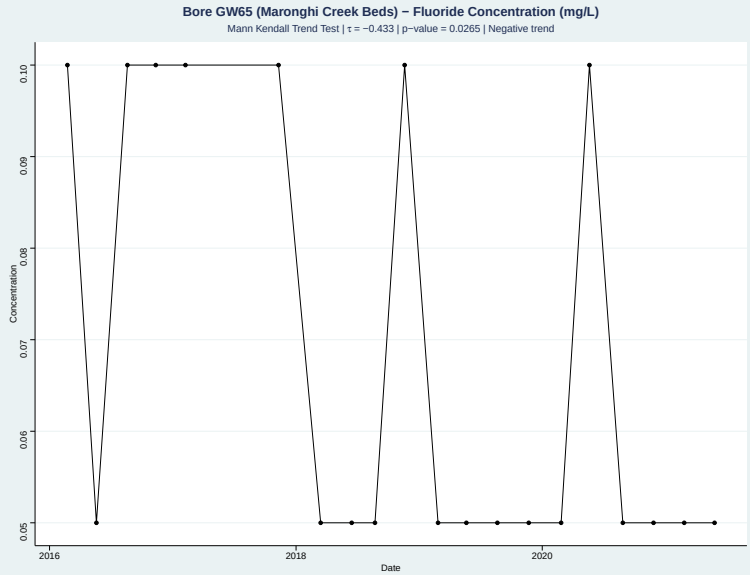


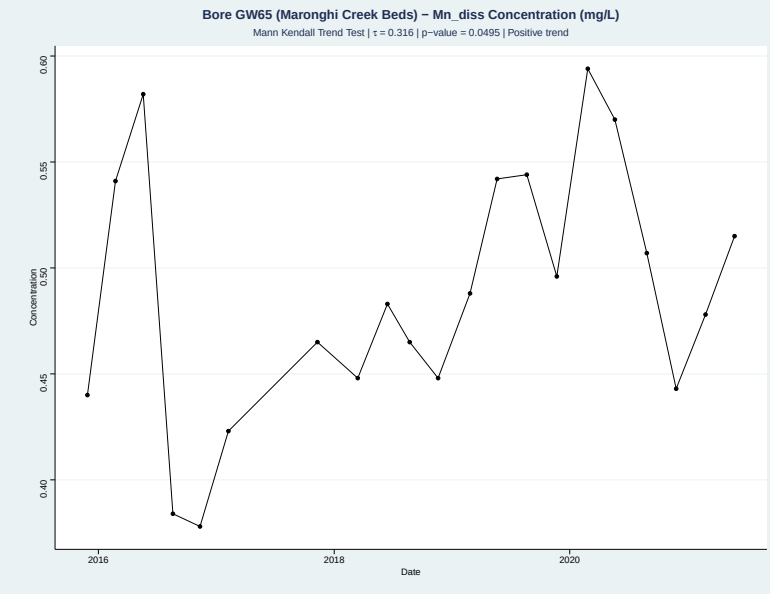
Appendix C Groundwater Quality Time Series

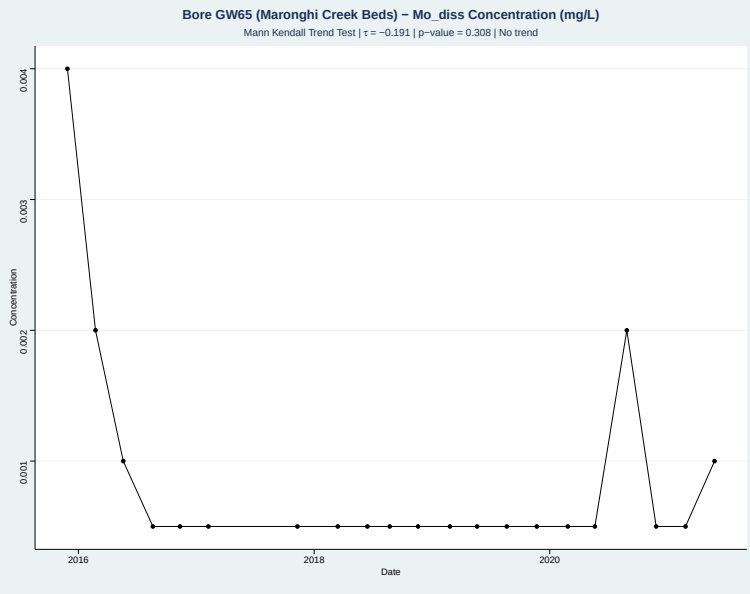




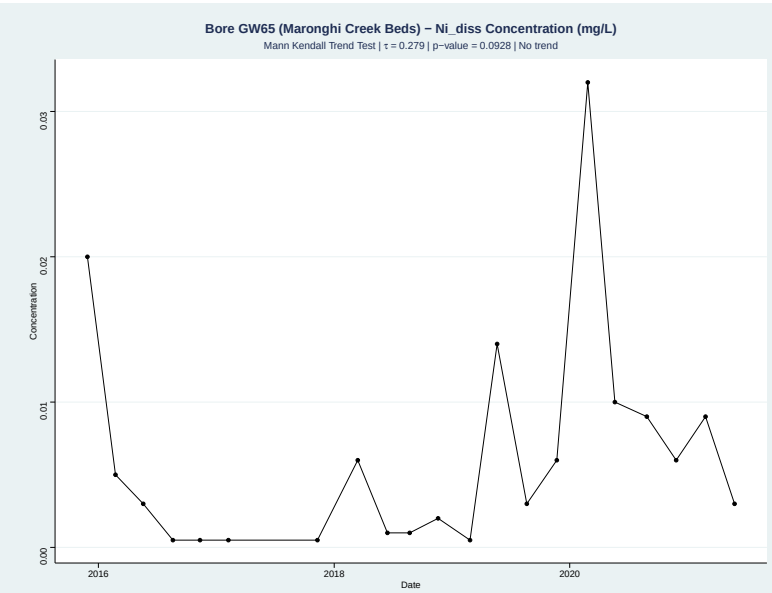


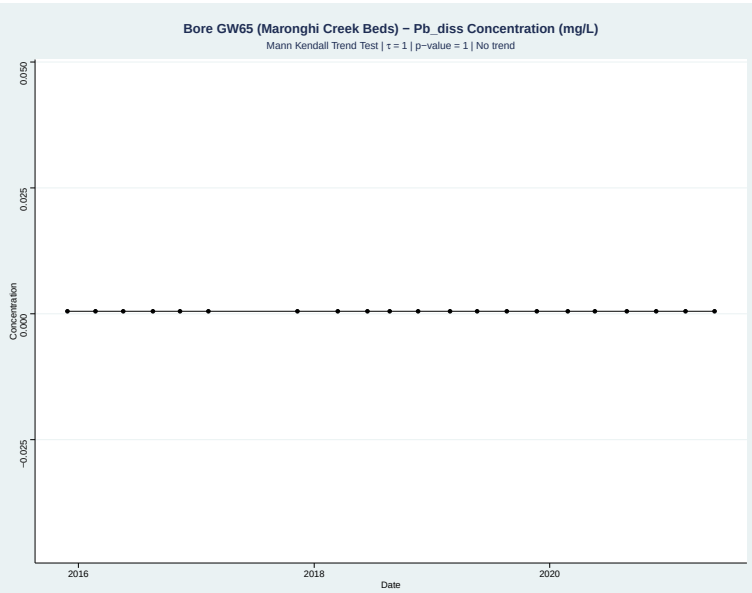


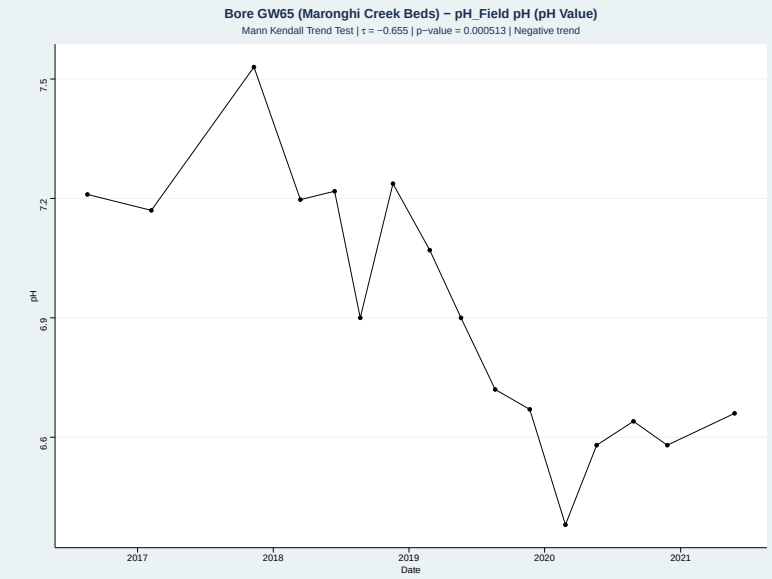


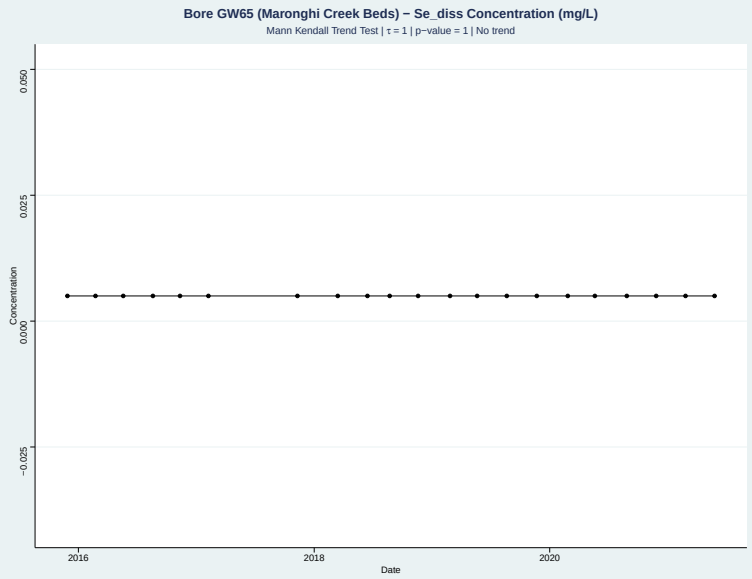


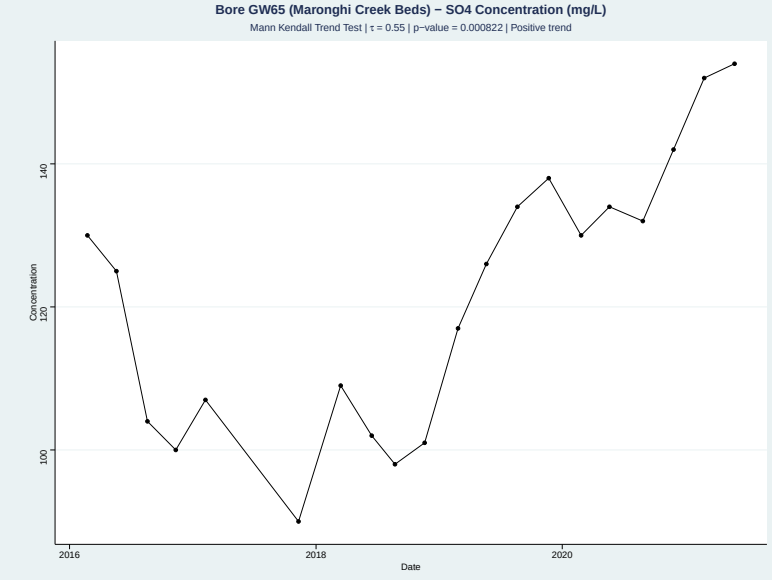
Appendix C Groundwater Quality Time Series

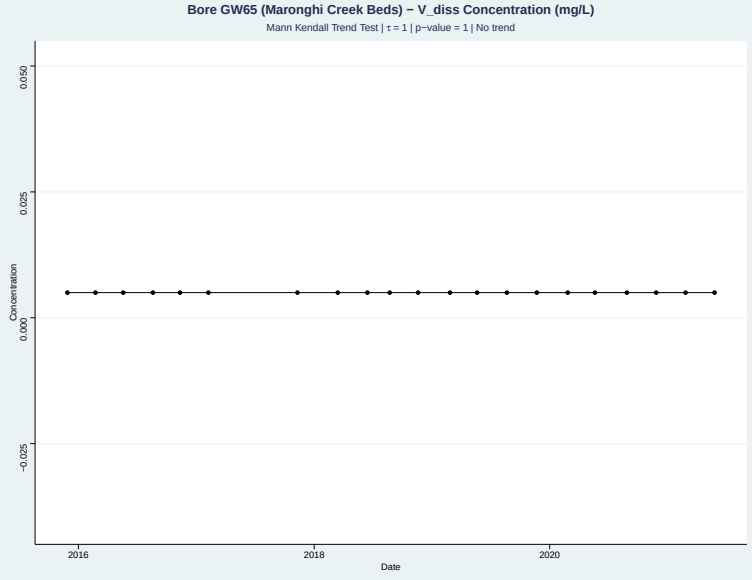




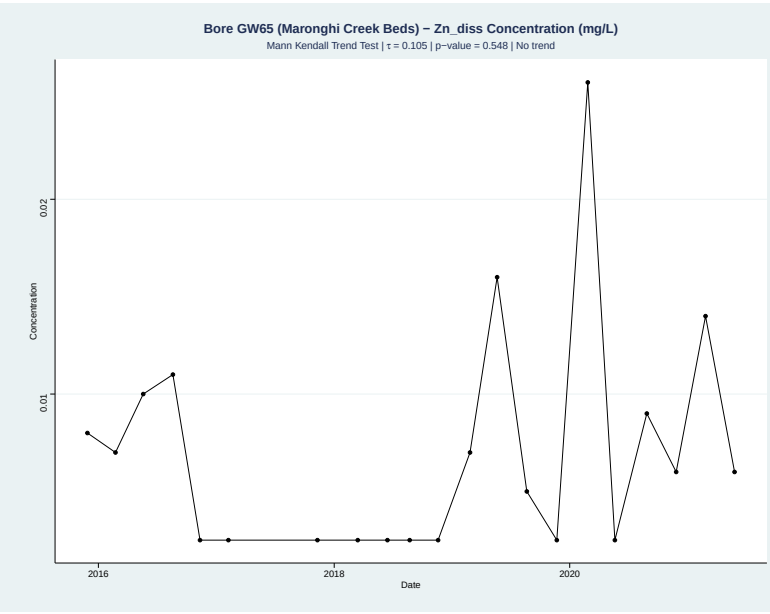


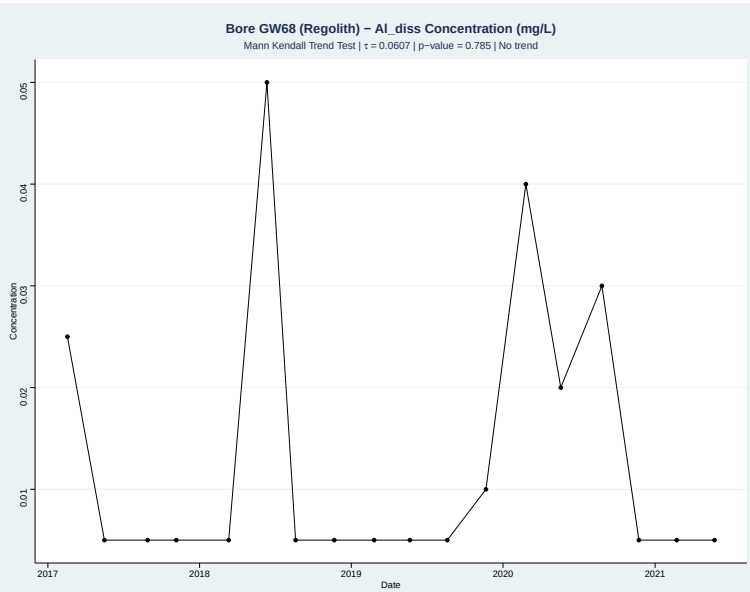


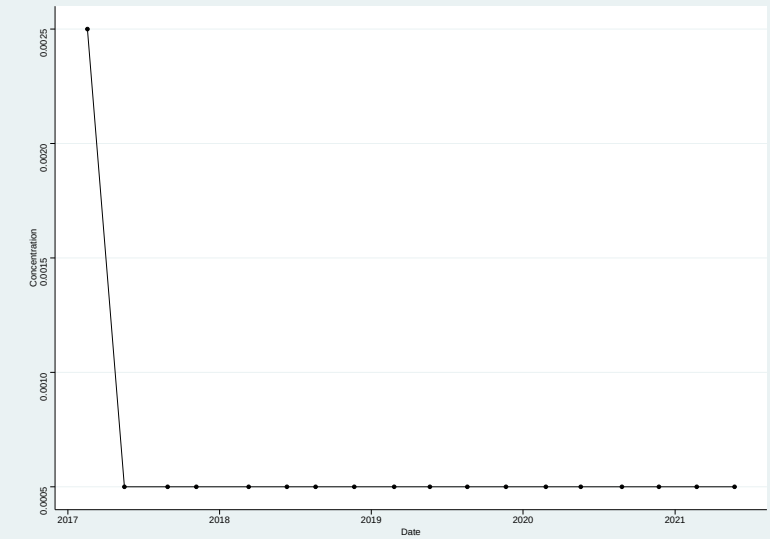


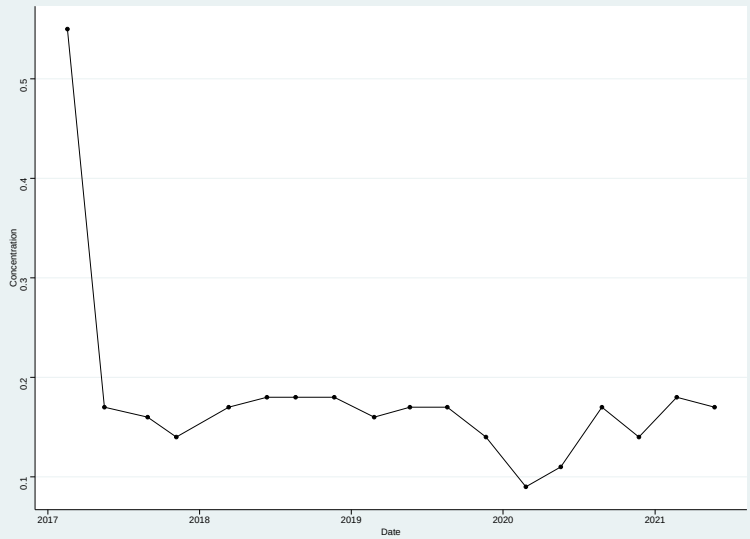


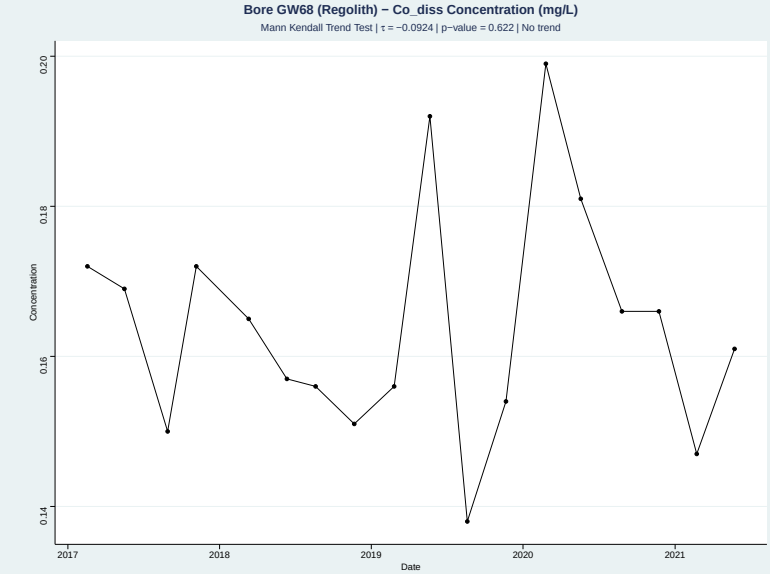
Appendix C Groundwater Quality Time Series

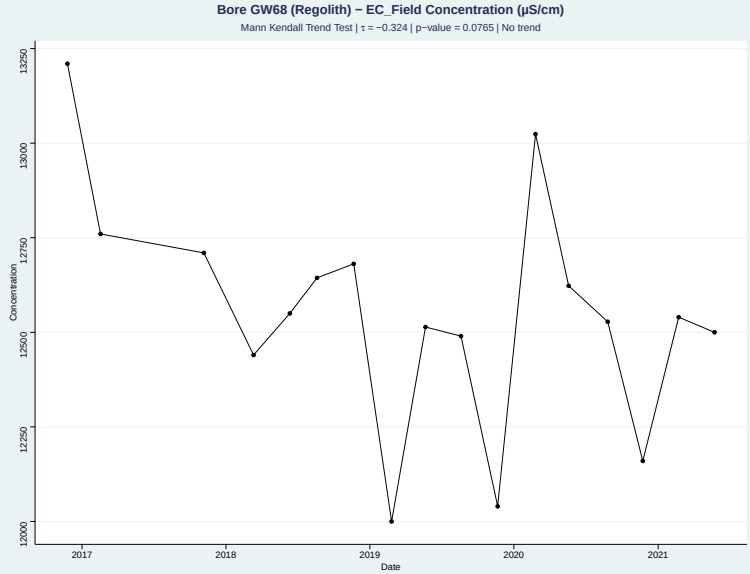




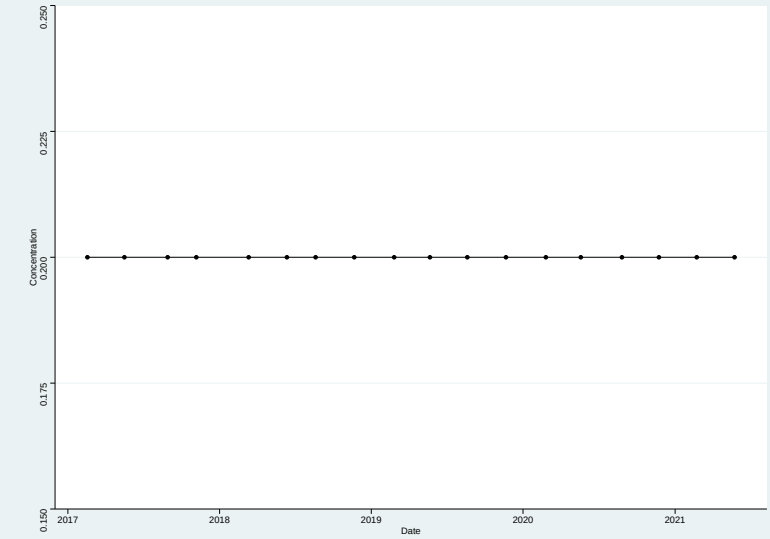


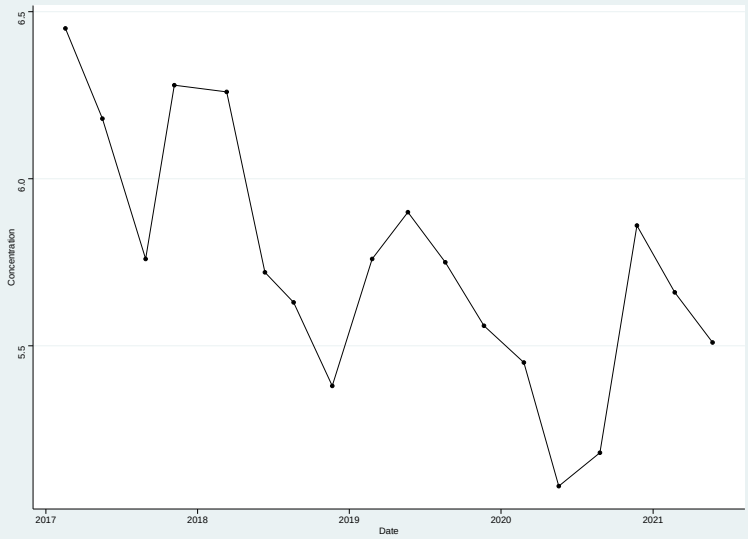


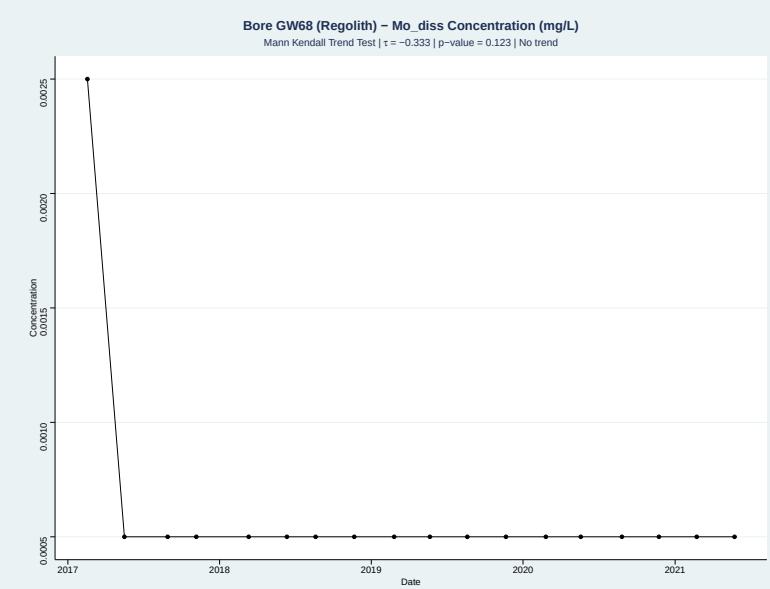


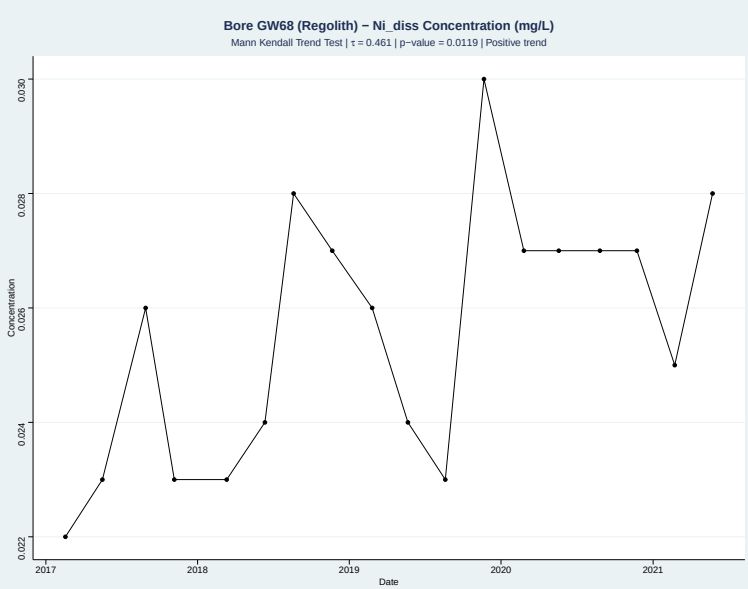


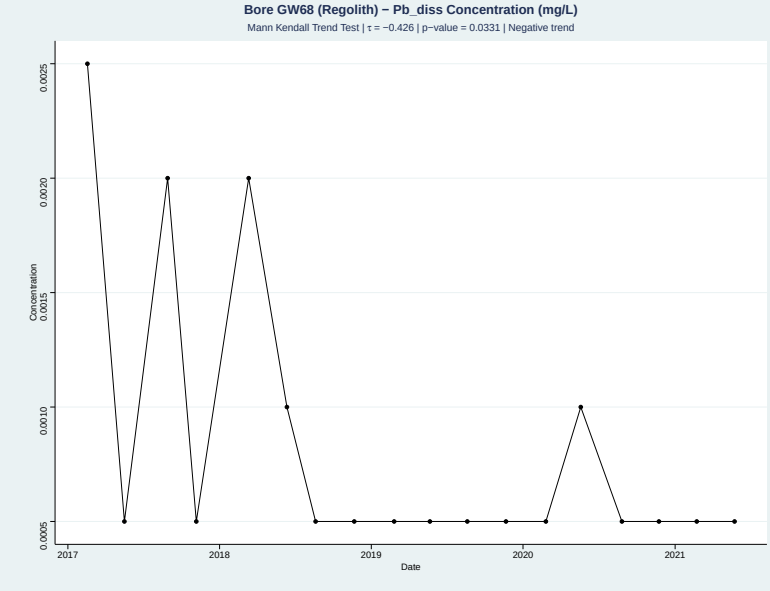
Appendix C Groundwater Quality Time Series

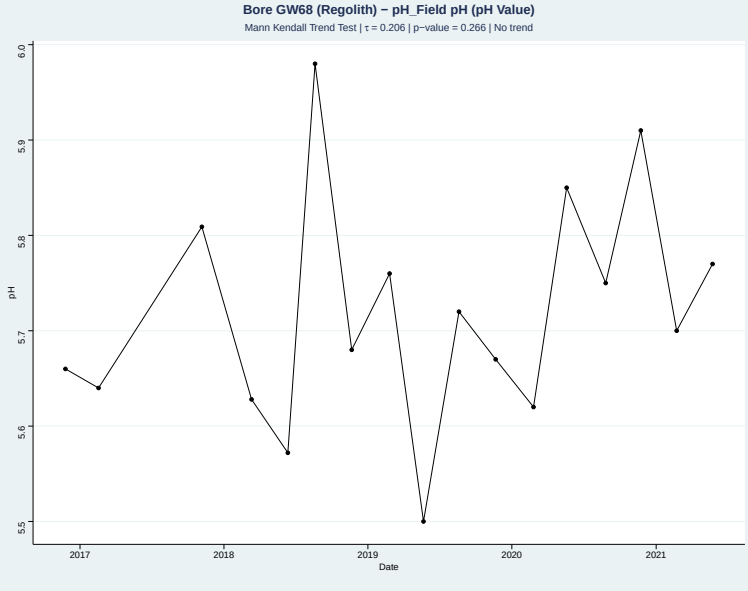




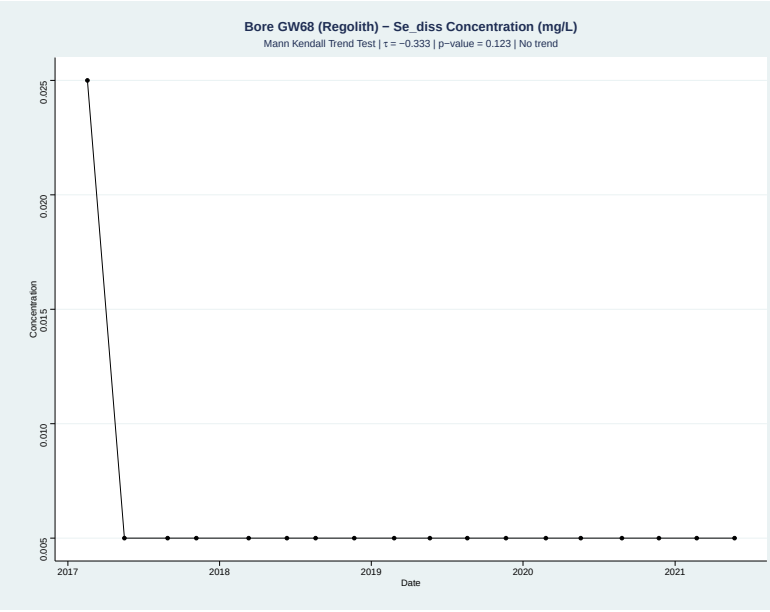


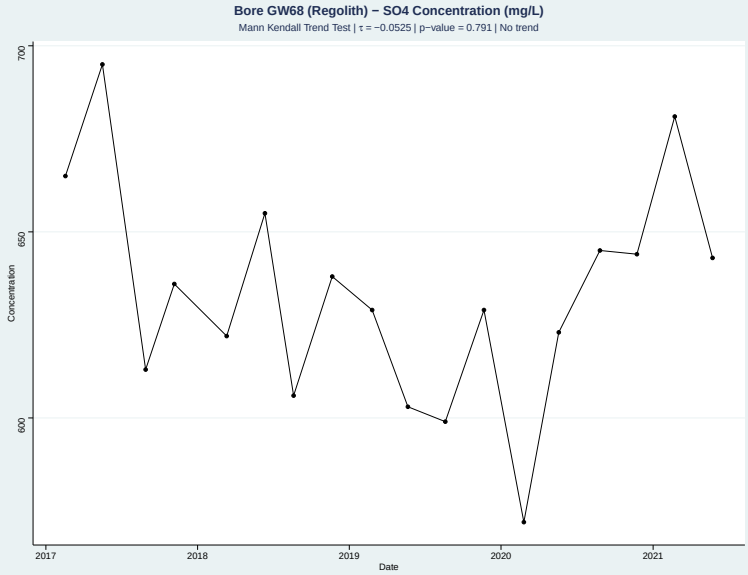


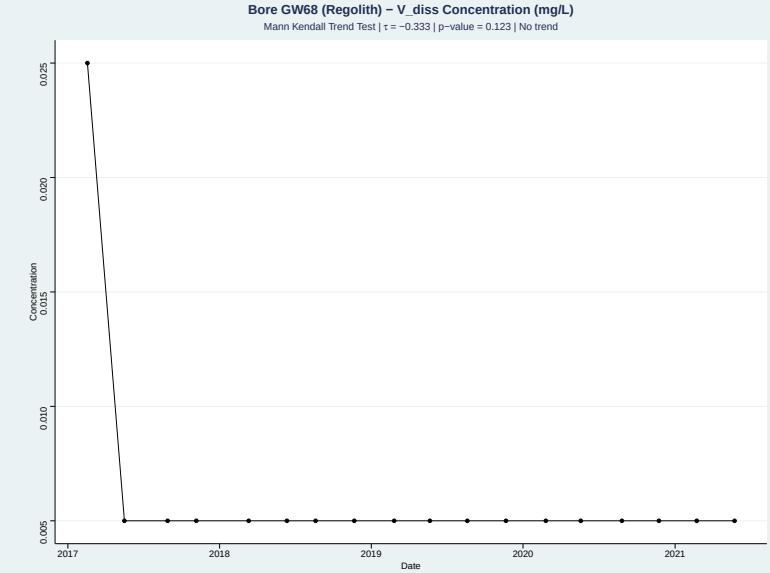


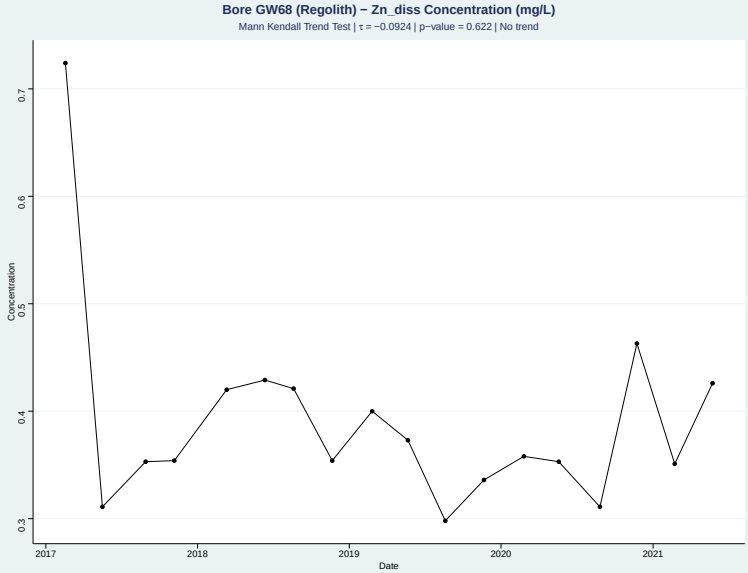


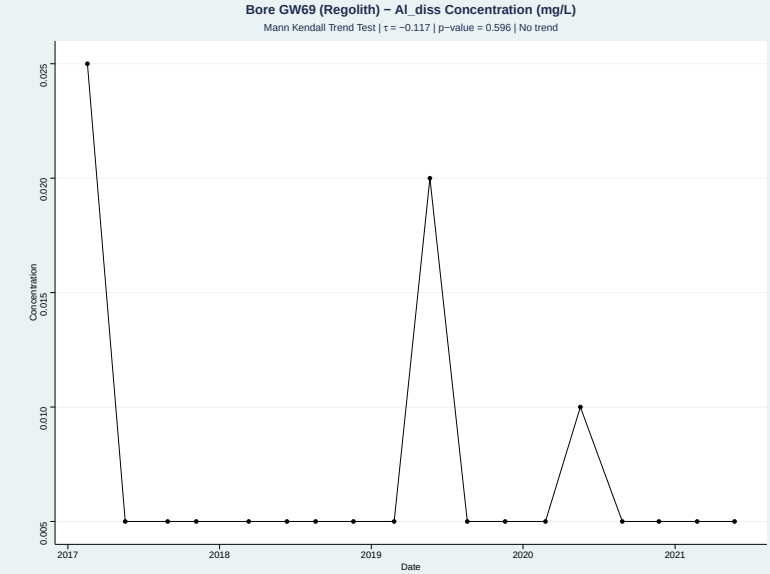
Appendix C Groundwater Quality Time Series

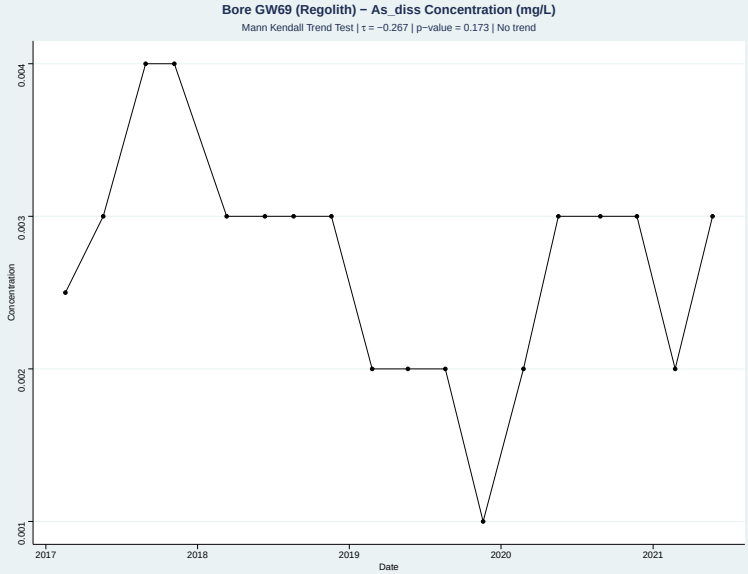




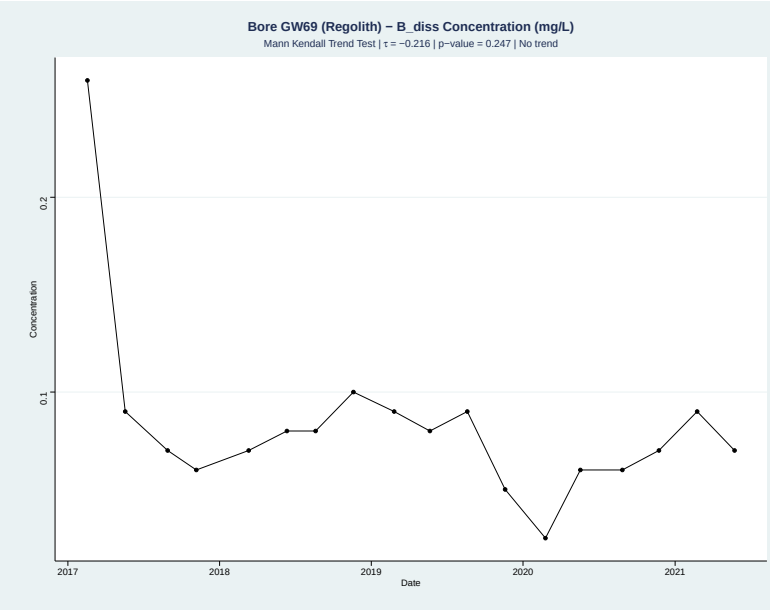


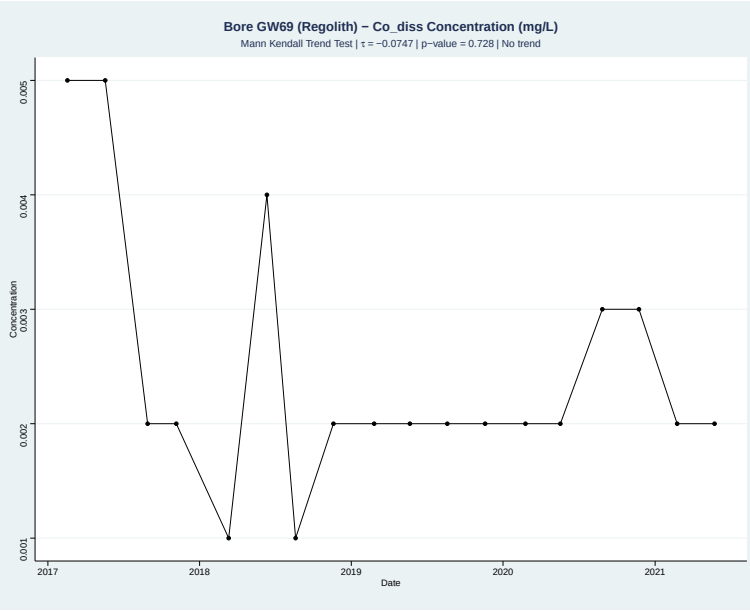


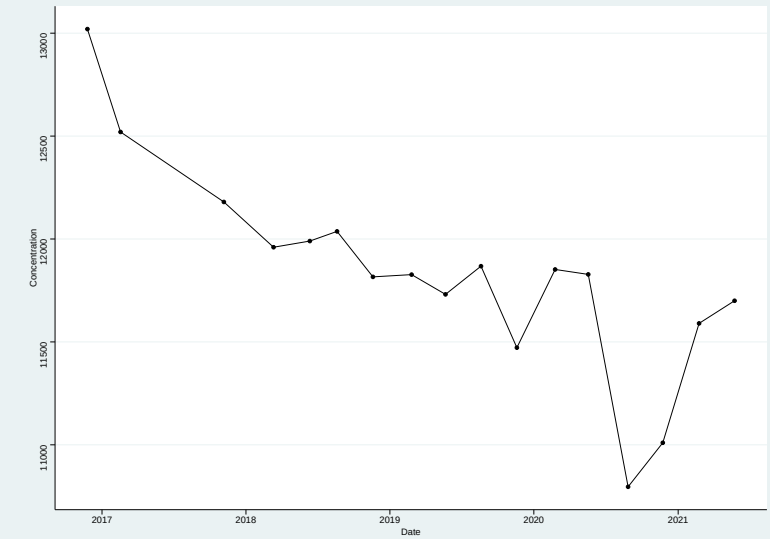


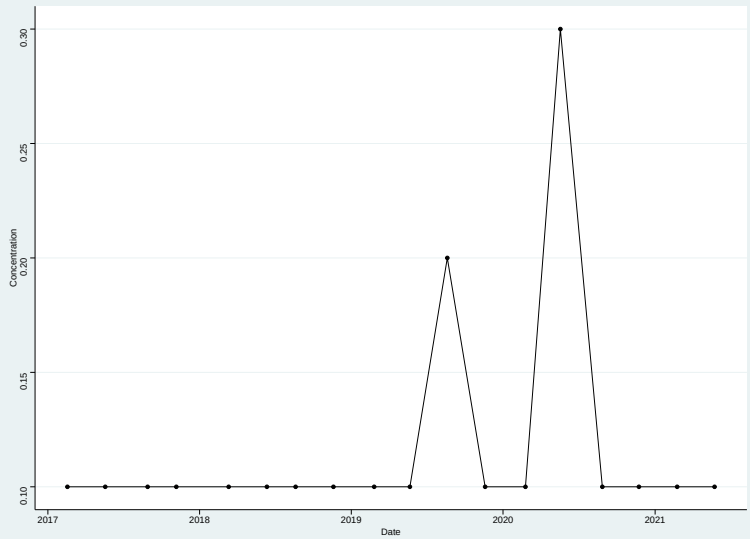


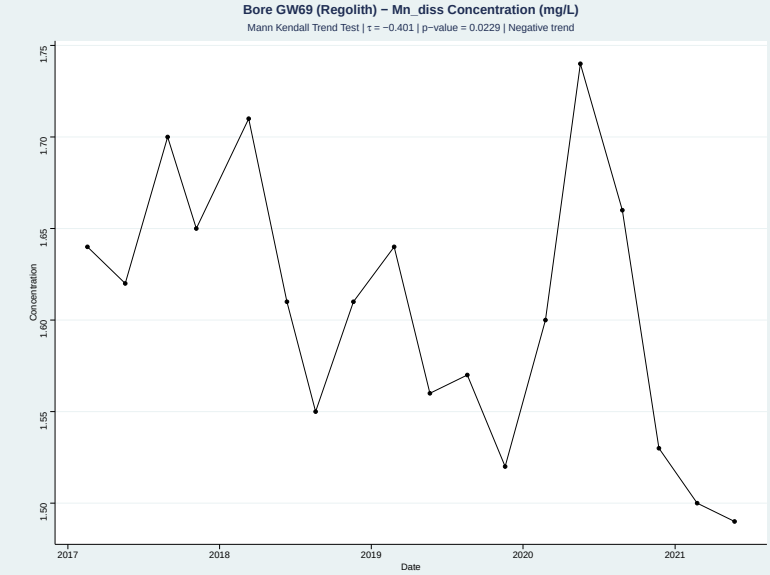
Appendix C Groundwater Quality Time Series

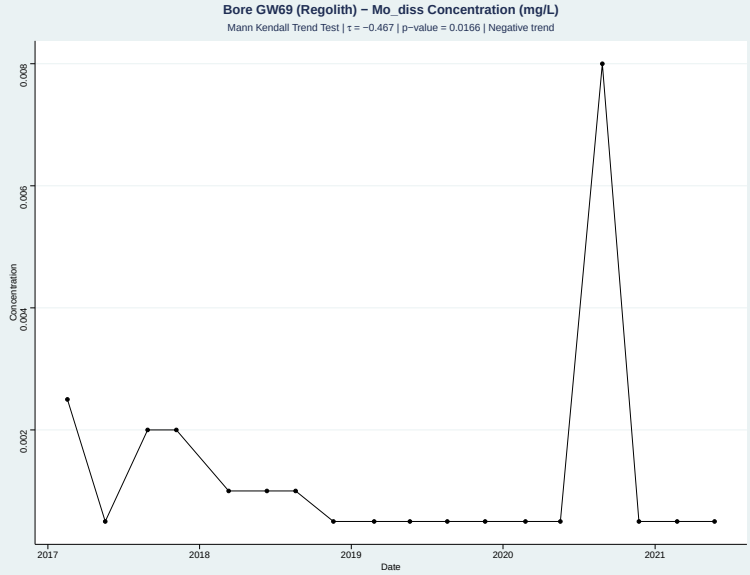








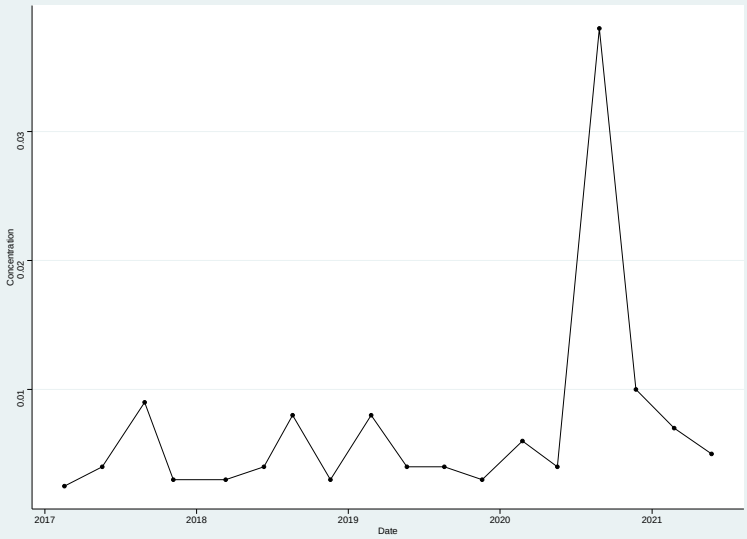




Appendix C Groundwater Quality Time Series

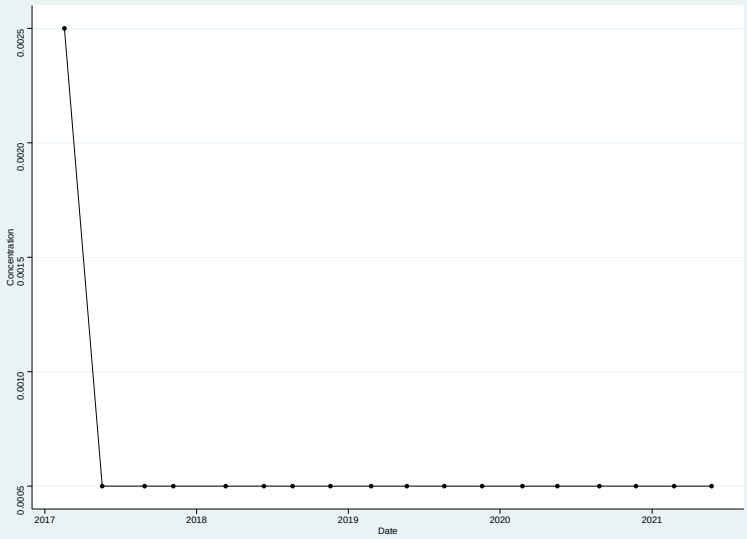
Bore GW69 (Regolith) – Ni_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.333 | p−value = 0.0695 | No trend



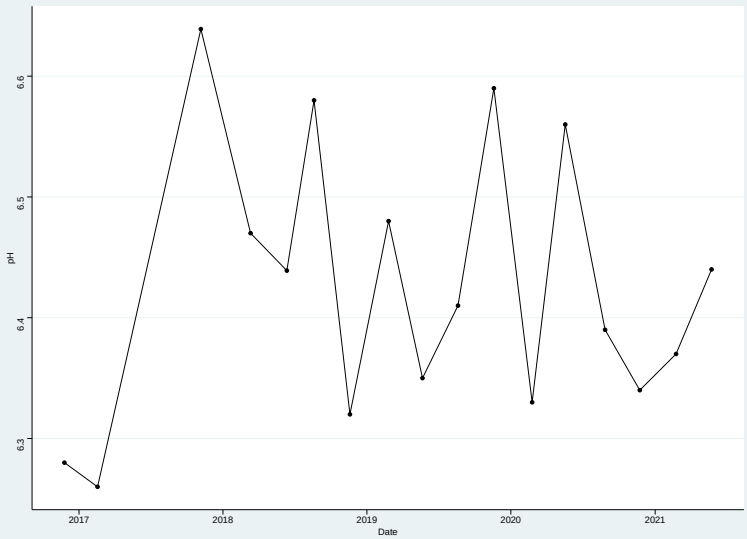
Bore GW69 (Regolith) – Pb_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.333 | p−value = 0.123 | No trend



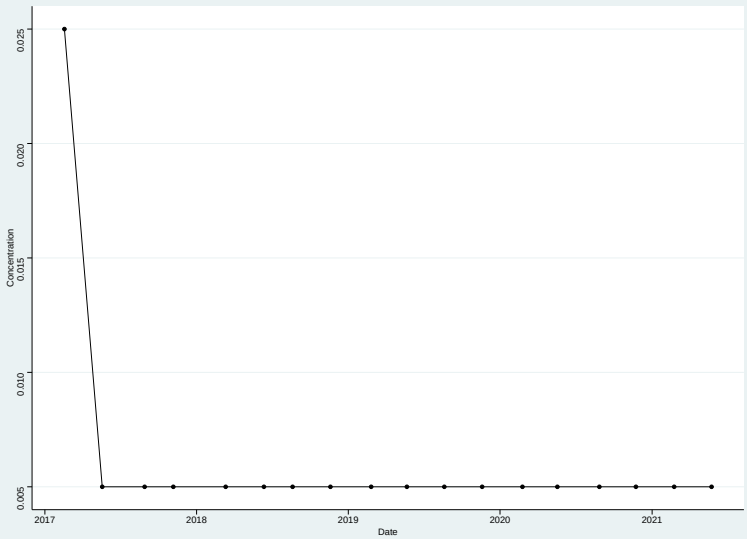
Bore GW69 (Regolith) – pH_Field pH (pH Value)

Mann Kendall Trend Test | τ = 0.0294 | p−value = 0.902 | No trend



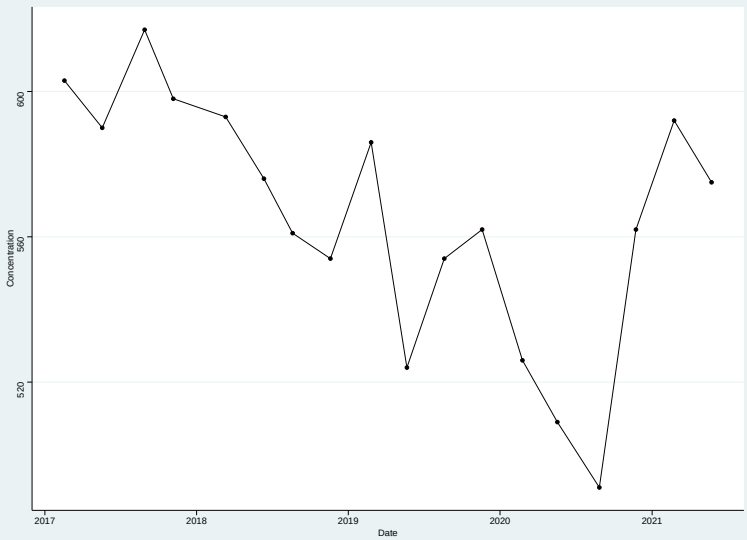
Bore GW69 (Regolith) – Se_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.333 | p−value = 0.123 | No trend



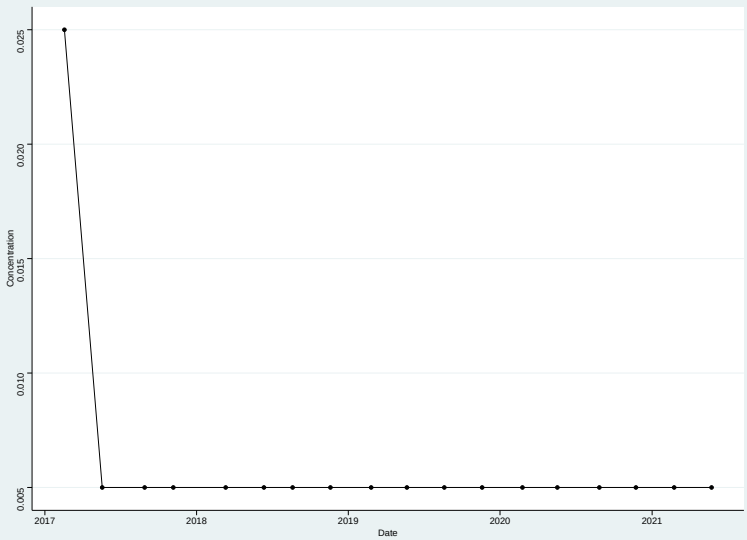
Bore GW69 (Regolith) – SO4 Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.454 | p−value = 0.0099 | Negative trend

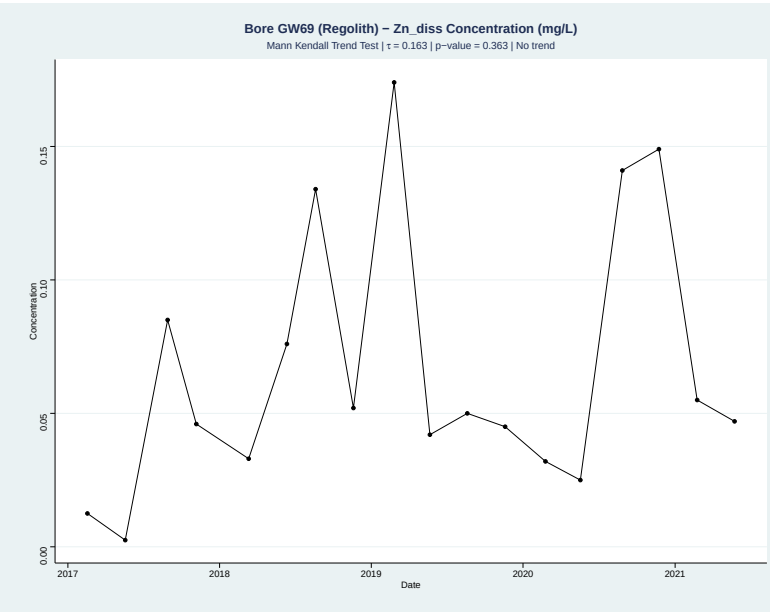


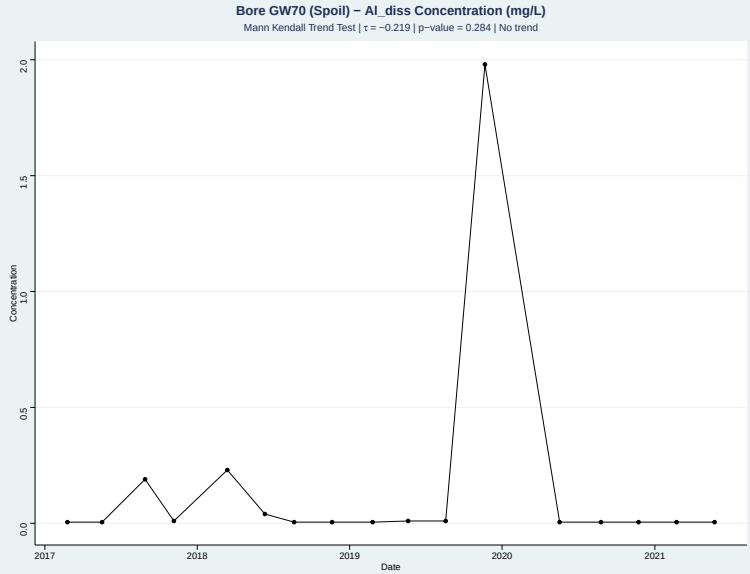
Bore GW69 (Regolith) – V_diss Concentration (mg/L)

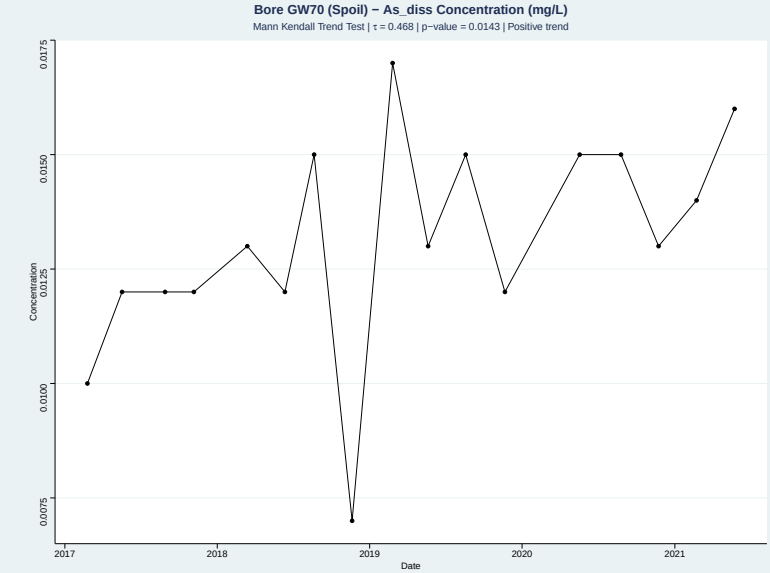
Mann Kendall Trend Test | τ = −0.333 | p−value = 0.123 | No trend

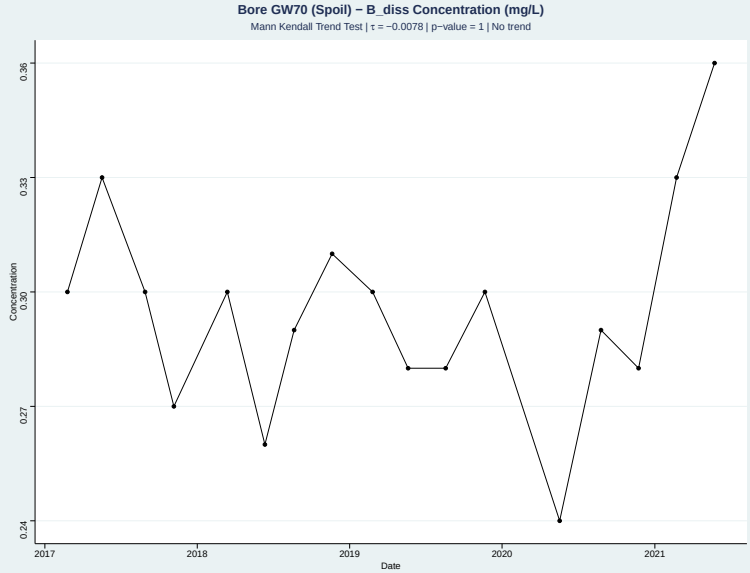


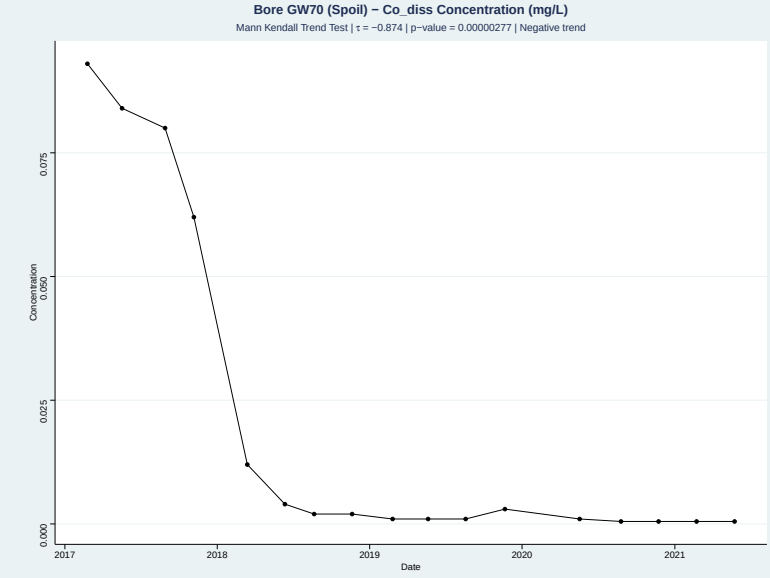
Appendix C Groundwater Quality Time Series

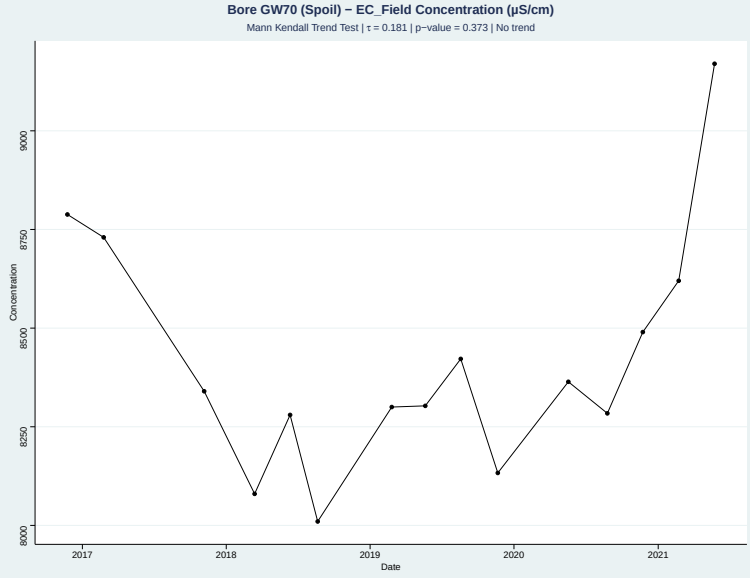








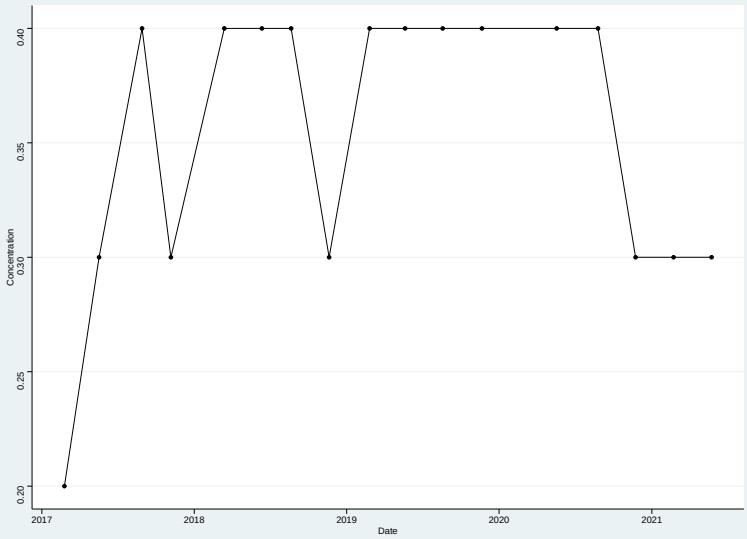




Appendix C Groundwater Quality Time Series

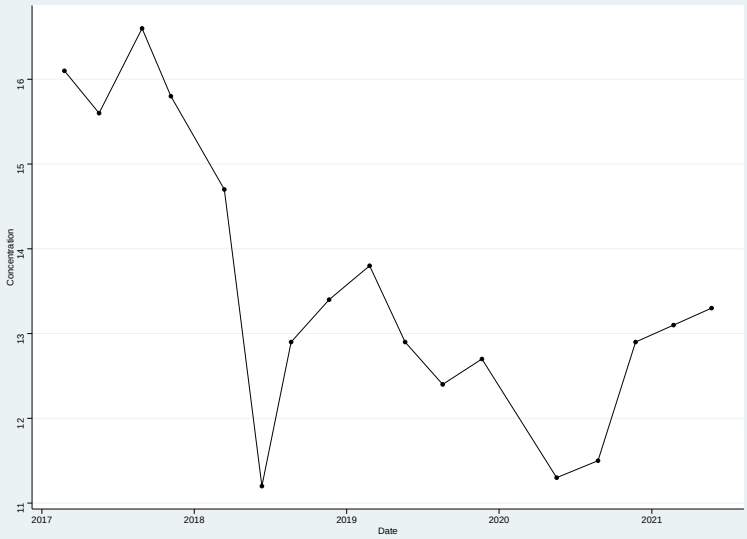
Bore GW70 (Spoil) – Fluoride Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.059 | p−value = 0.811 | No trend



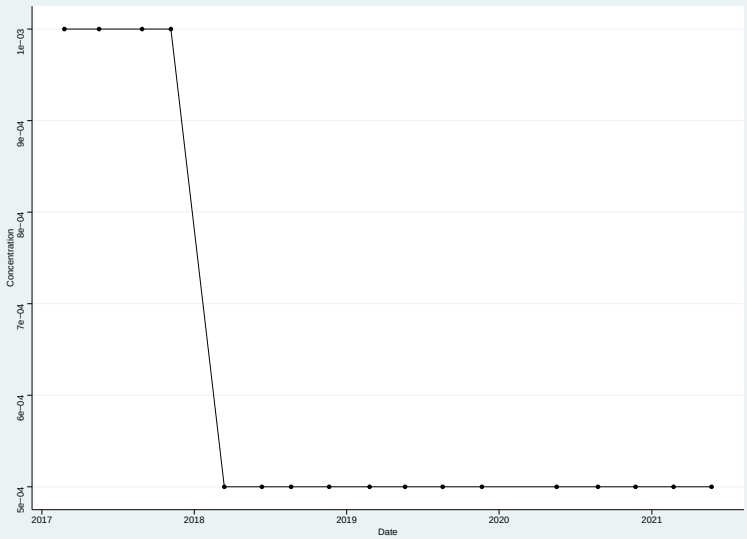
Bore GW70 (Spoil) – Mn_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.424 | p−value = 0.0207 | Negative trend



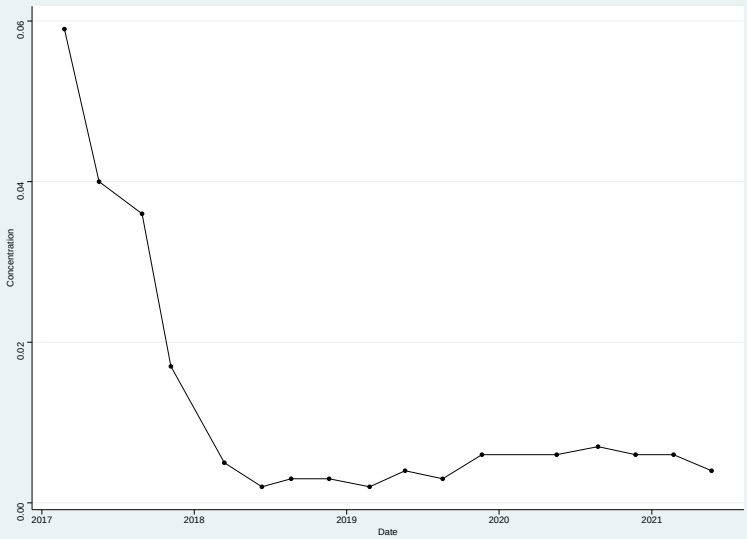
Bore GW70 (Spoil) – Mo_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.618 | p−value = 0.00389 | Negative trend



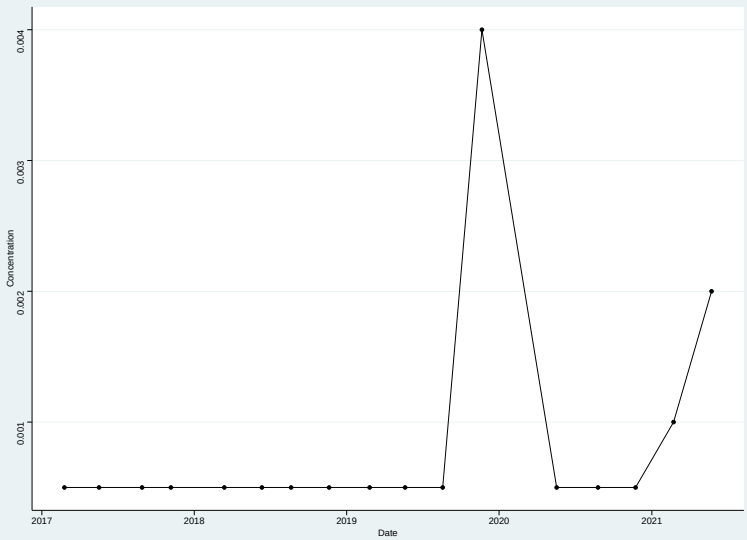
Bore GW70 (Spoil) – Ni_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.192 | p−value = 0.317 | No trend



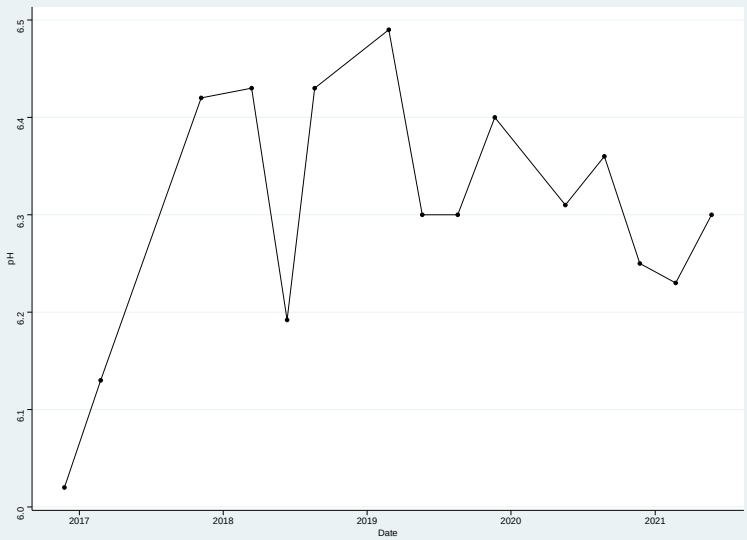
Bore GW70 (Spoil) – Pb_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.447 | p−value = 0.0335 | Positive trend



Bore GW70 (Spoil) – pH_Field pH (pH Value)

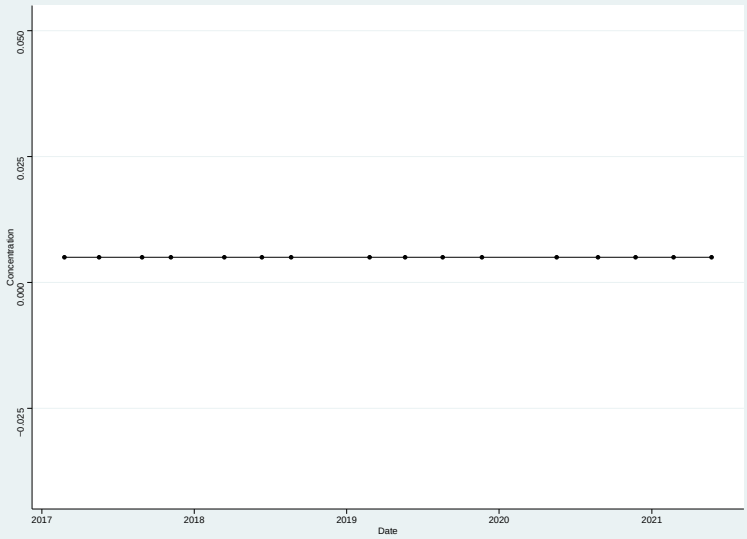
Mann Kendall Trend Test | τ = 0.00971 | p−value = 1 | No trend



Appendix C Groundwater Quality Time Series

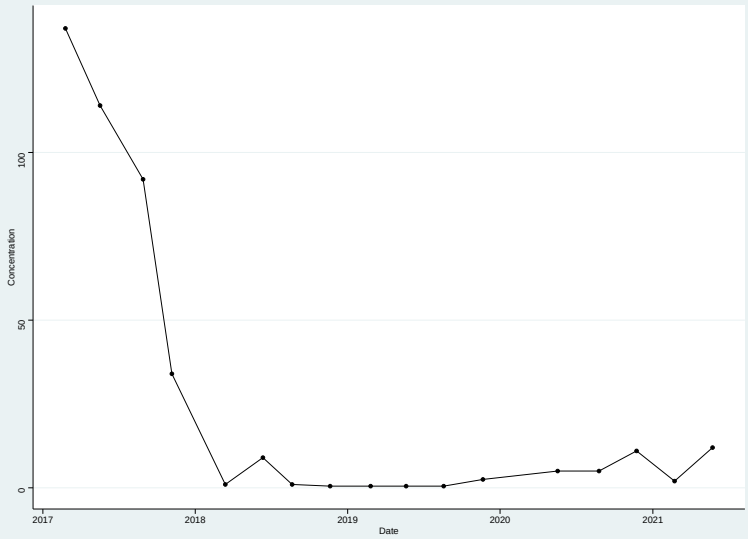
Bore GW70 (Spoil) − Se_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 1 | p−value = 1 | No trend



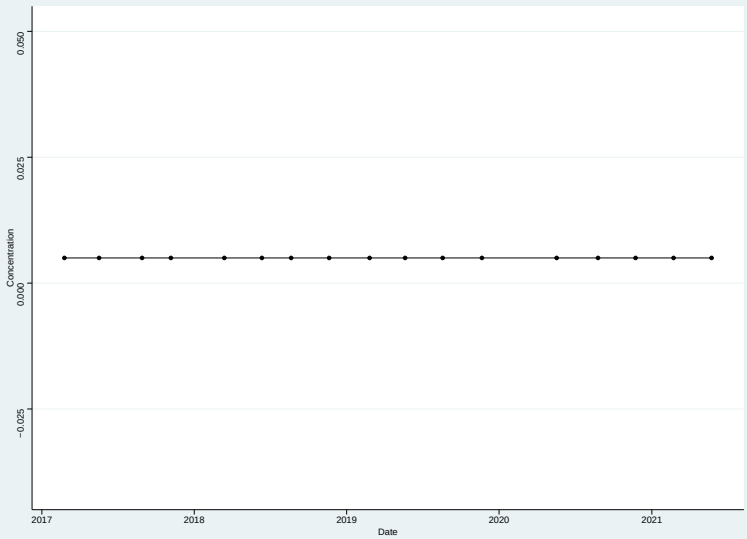
Bore GW70 (Spoil) − SO4 Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.227 | p−value = 0.228 | No trend



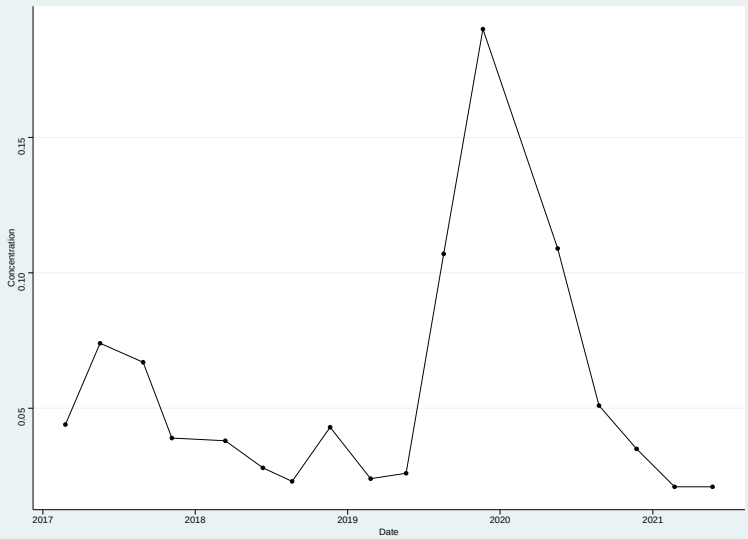
Bore GW70 (Spoil) − V_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 1 | p−value = 1 | No trend



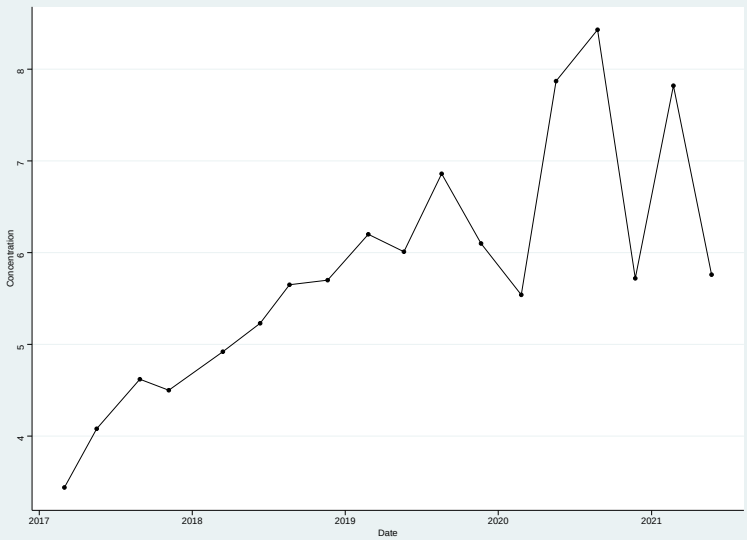
Bore GW70 (Spoil) − Zn_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.214 | p−value = 0.248 | No trend



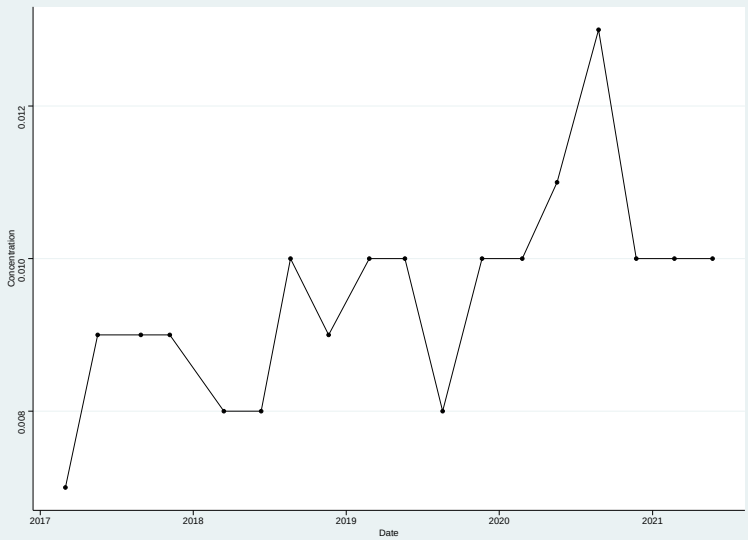
Bore GW71 (Spoil) − Al_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.673 | p−value = 0.000112 | Positive trend

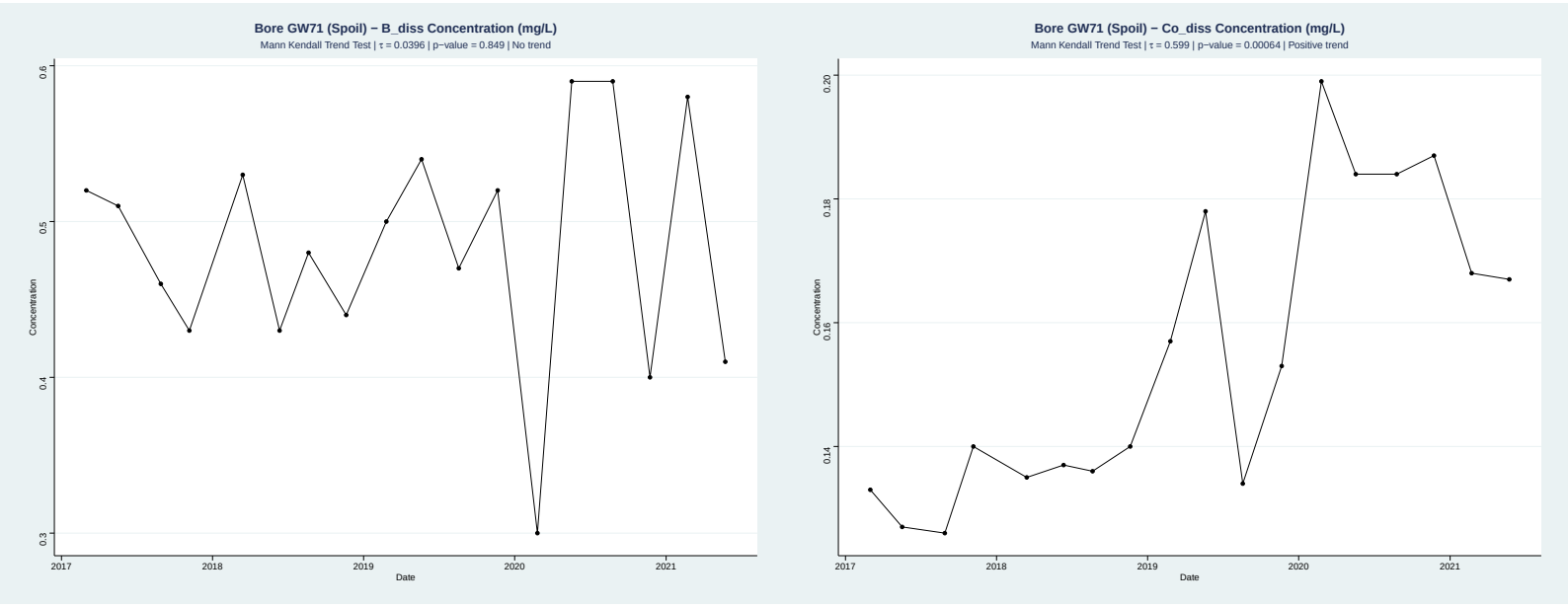


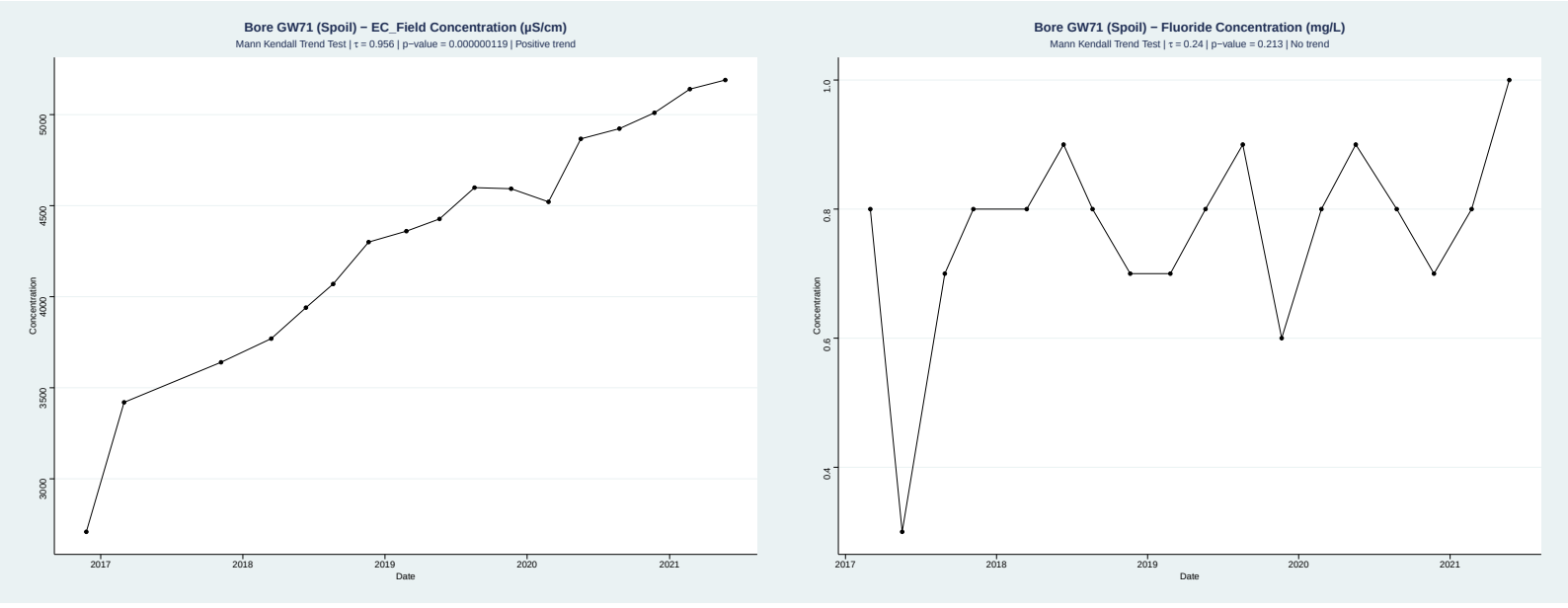
Bore GW71 (Spoil) − As_diss Concentration (mg/L)

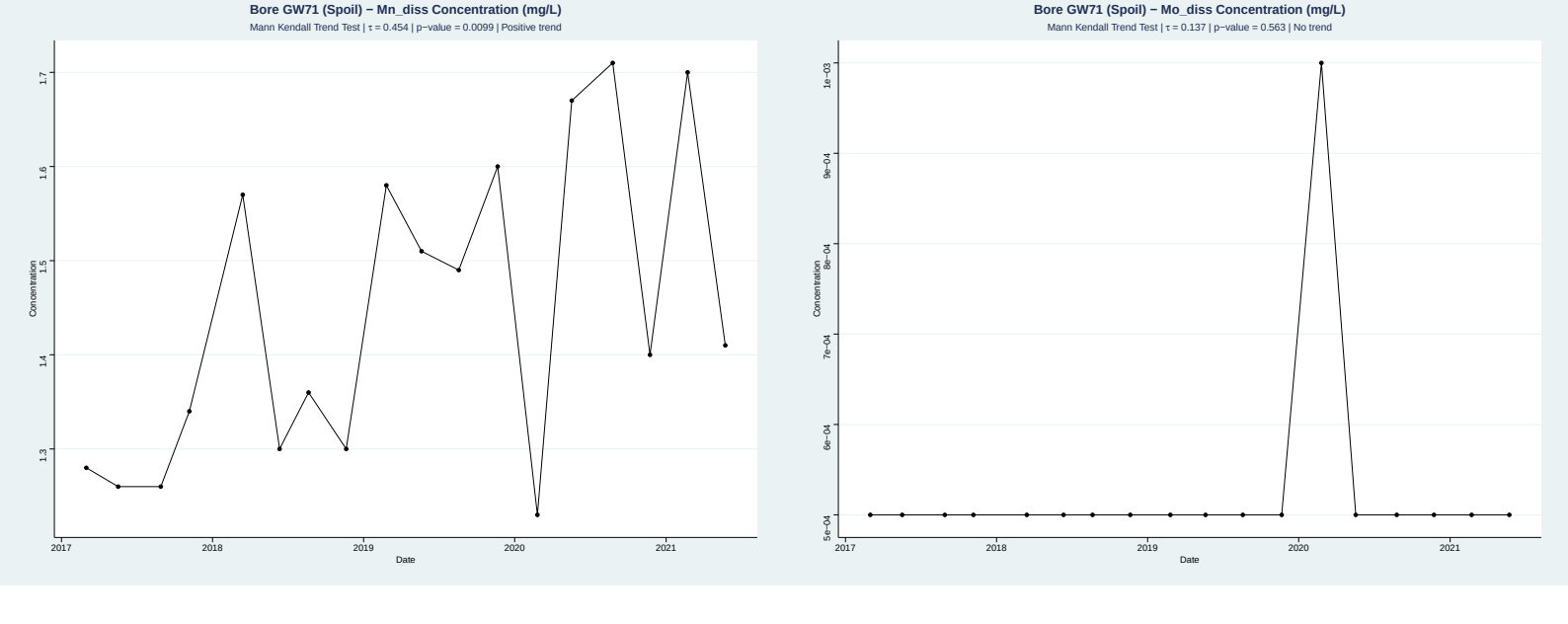
Mann Kendall Trend Test | τ = 0.57 | p−value = 0.00258 | Positive trend



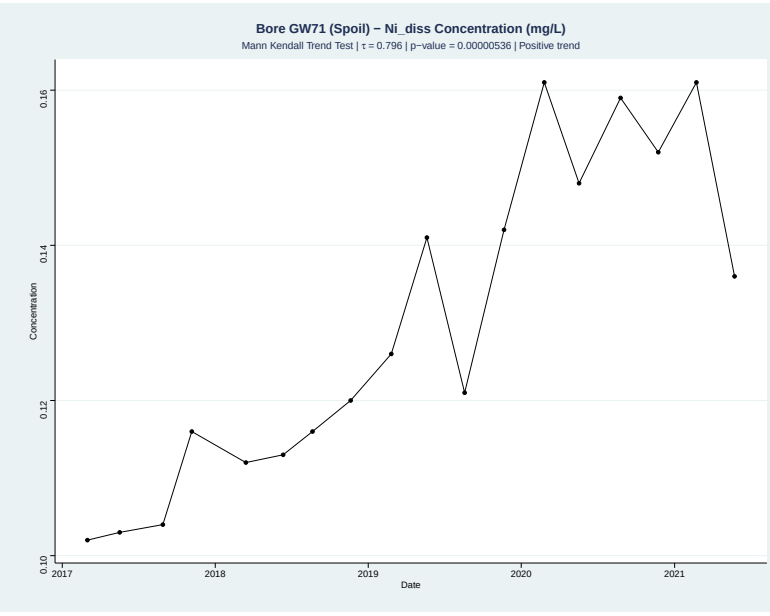
Appendix C Groundwater Quality Time Series

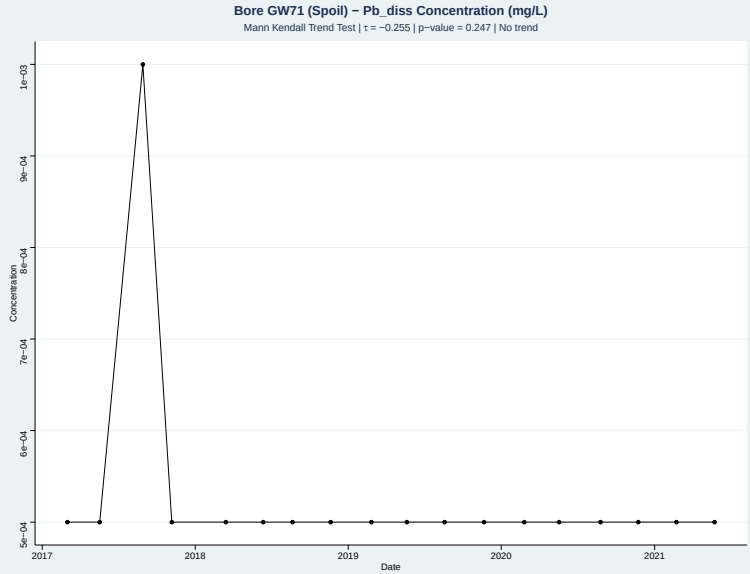


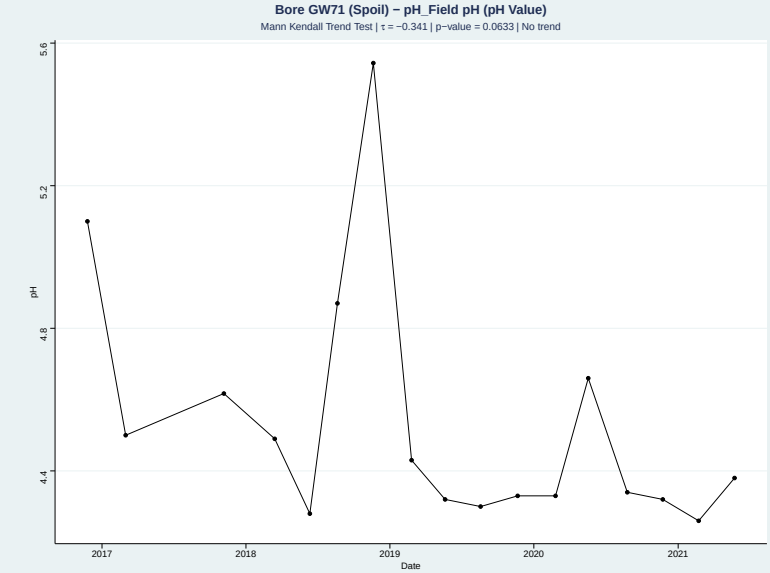


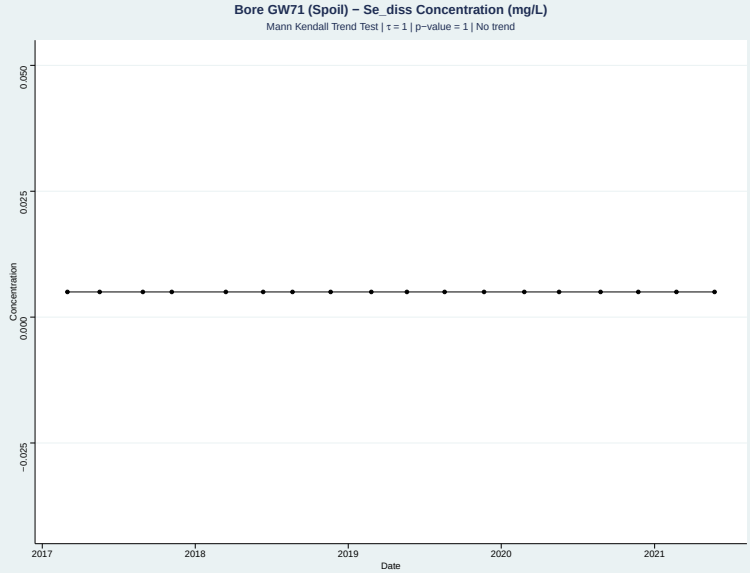


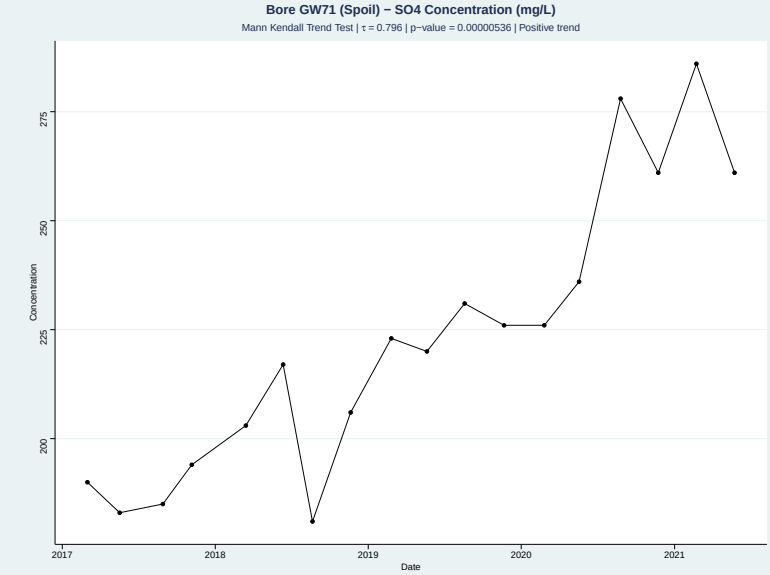
Appendix C Groundwater Quality Time Series

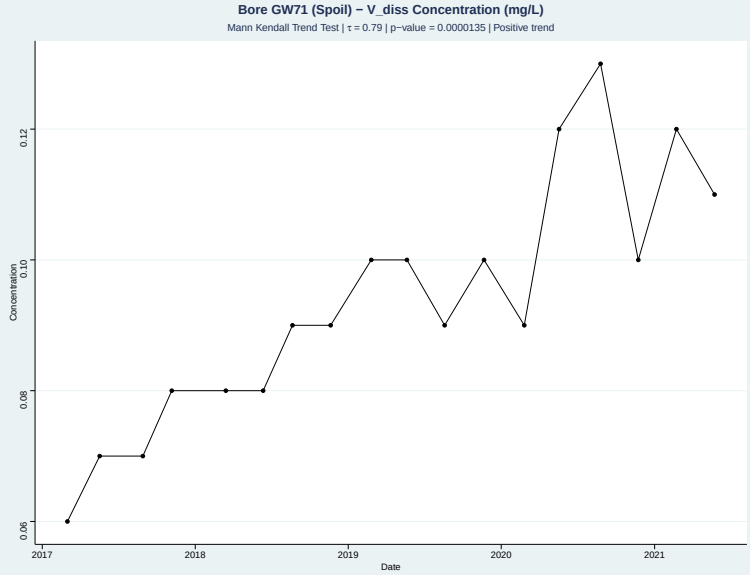




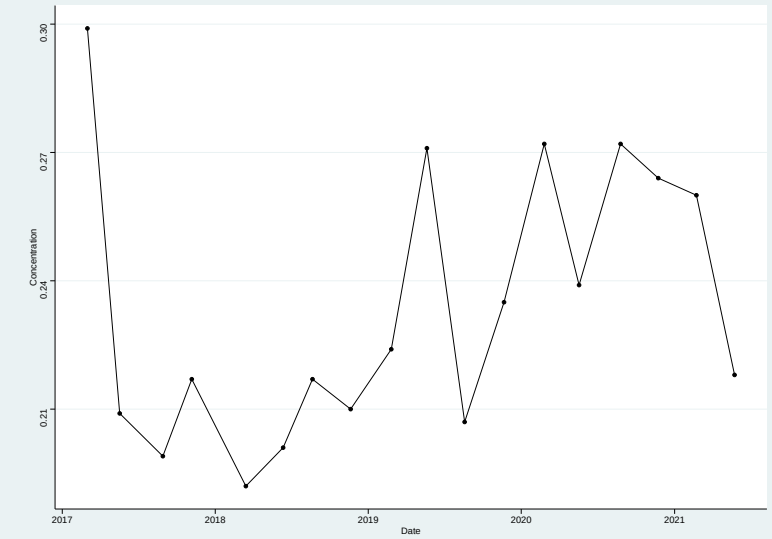


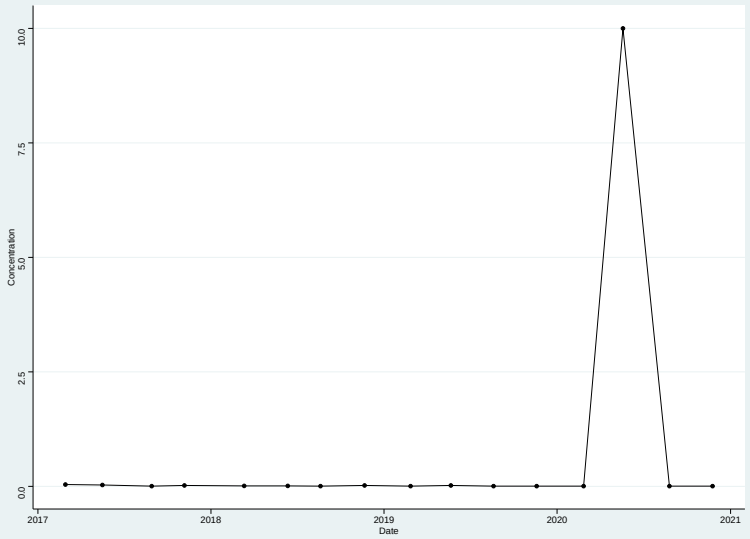


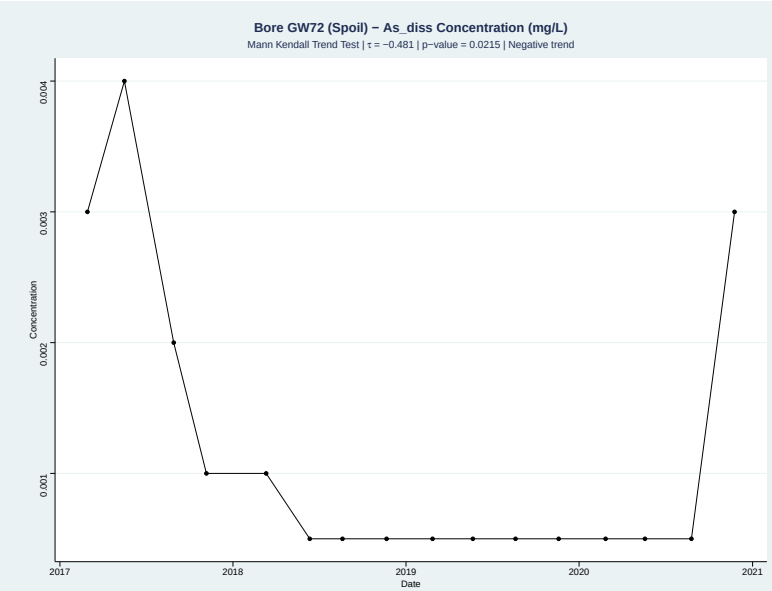


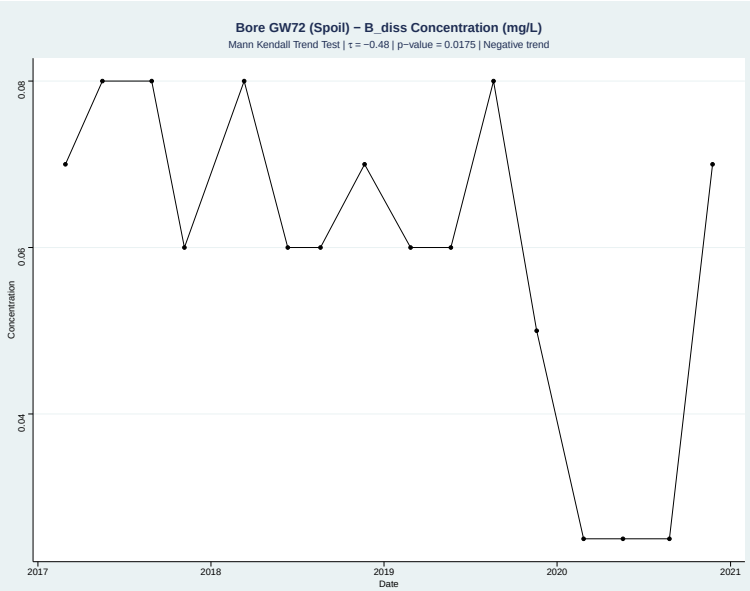


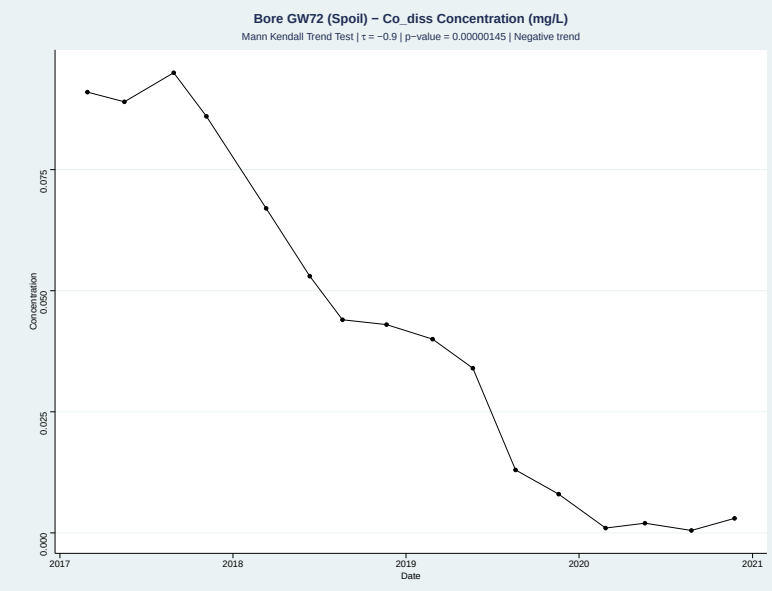
Appendix C Groundwater Quality Time Series

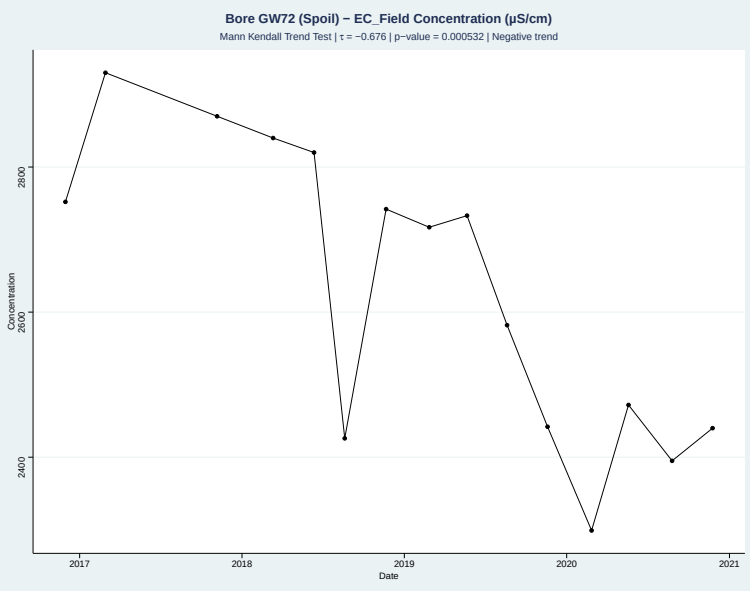








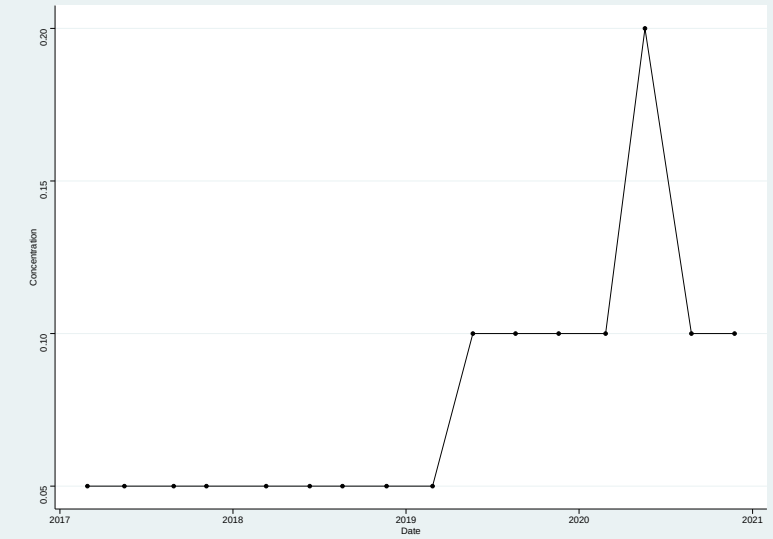




Appendix C Groundwater Quality Time Series

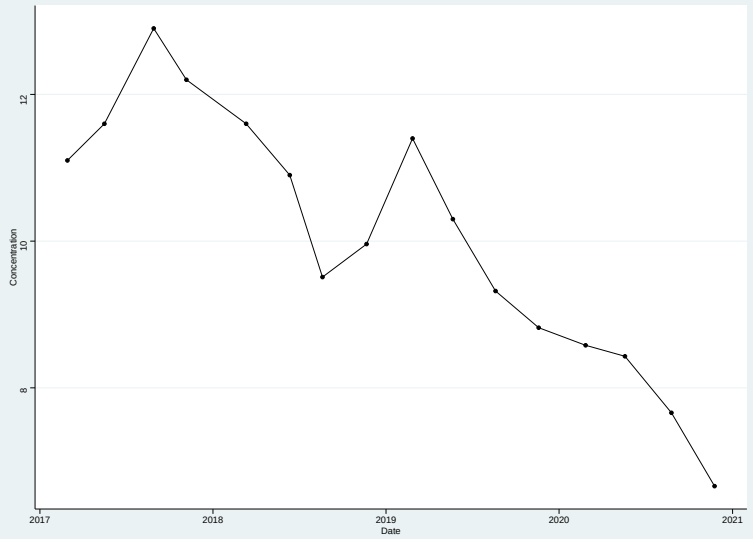
Bore GW72 (Spoil) – Fluoride Concentration (mg/L)

Mann Kendall Trend Test | τ = 0.714 | p−value = 0.00092 | Positive trend



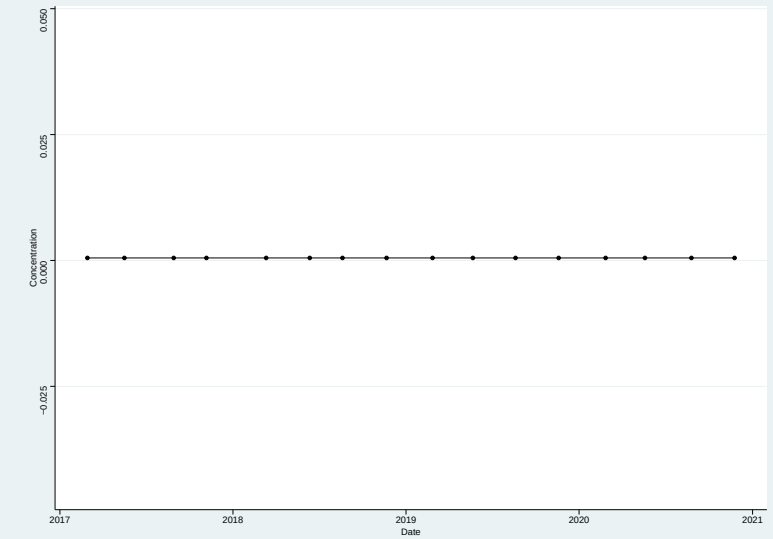
Bore GW72 (Spoil) – Mn_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.778 | p−value = 0.0000338 | Negative trend



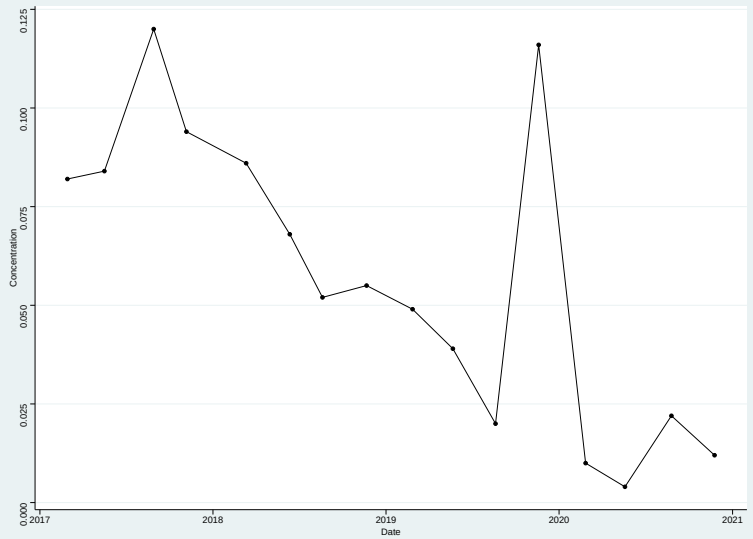
Bore GW72 (Spoil) – Mo_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 1 | p−value = 1 | No trend



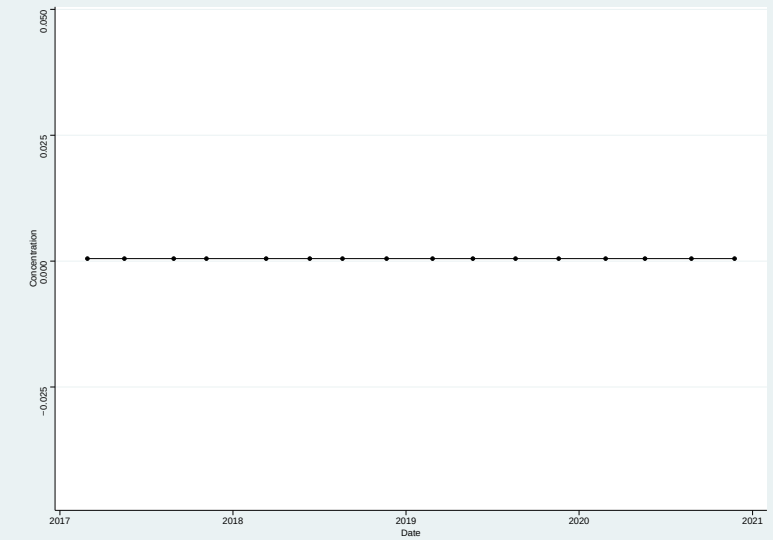
Bore GW72 (Spoil) – Ni_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = −0.617 | p−value = 0.00101 | Negative trend



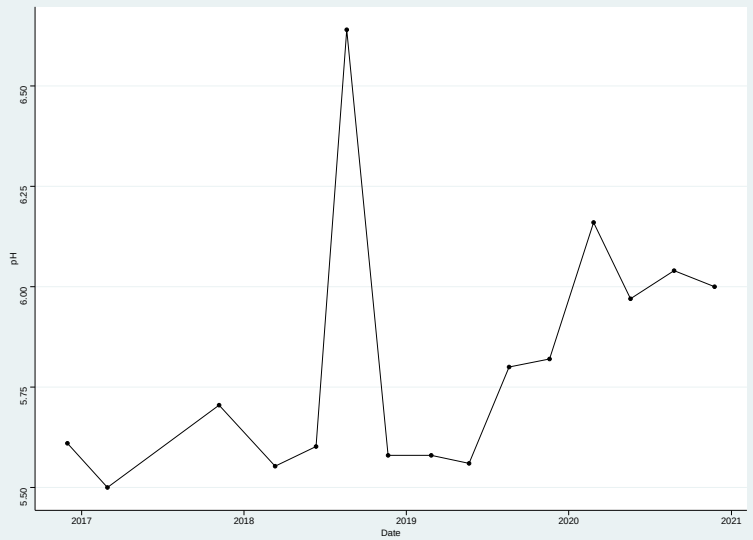
Bore GW72 (Spoil) – Pb_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = 1 | p−value = 1 | No trend

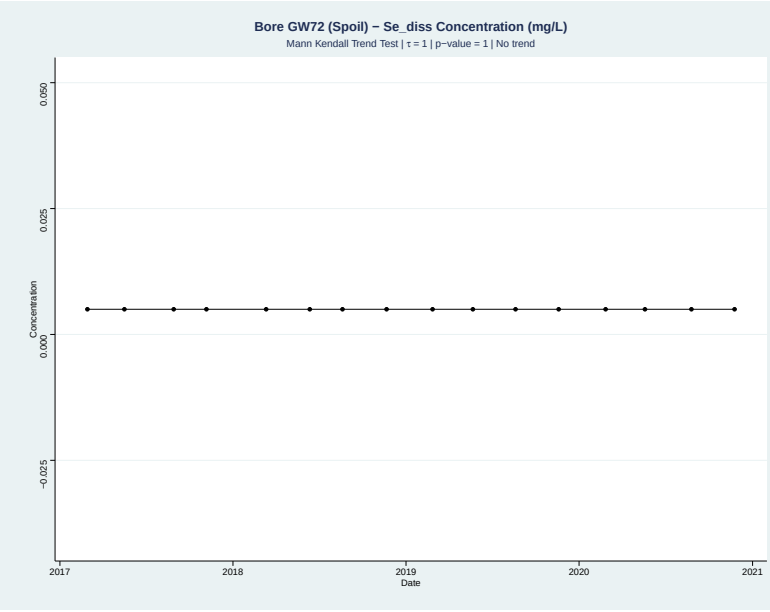


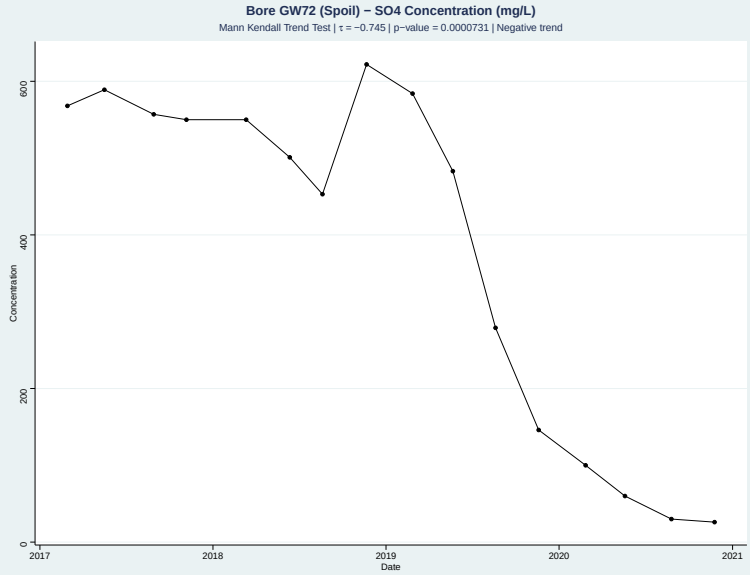
Bore GW72 (Spoil) – pH_Field pH (pH Value)

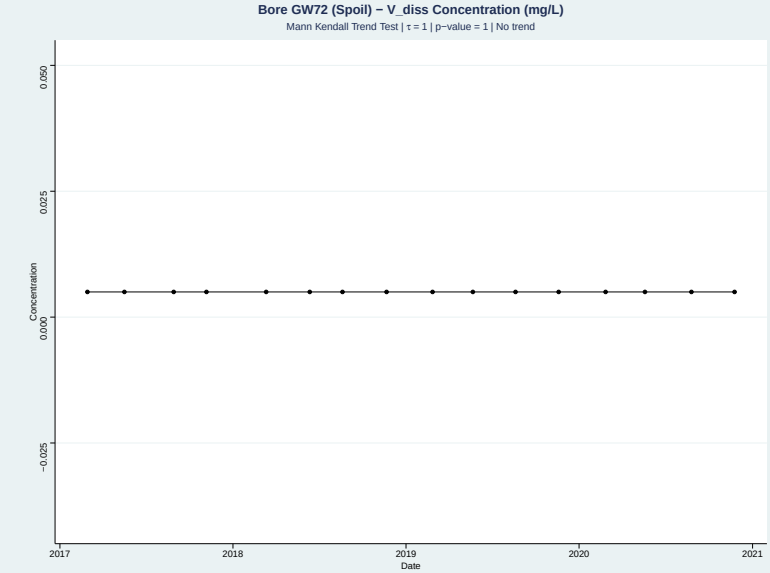
Mann Kendall Trend Test | τ = 0.44 | p−value = 0.0258 | Positive trend

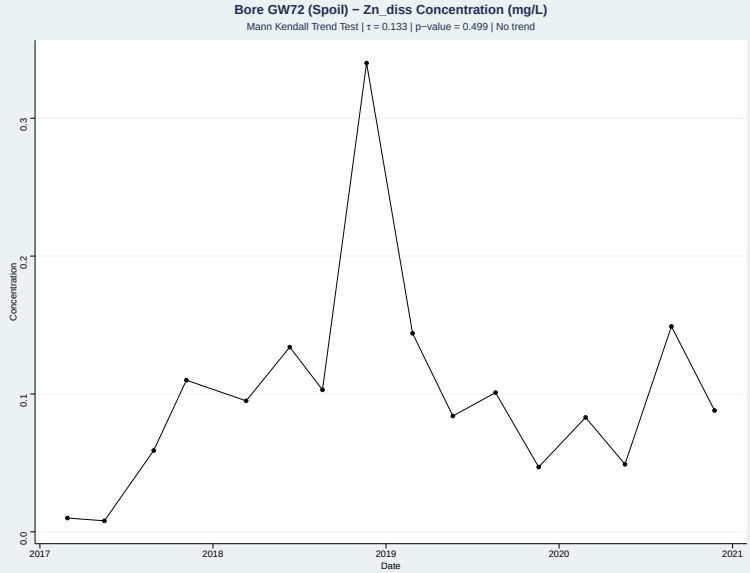


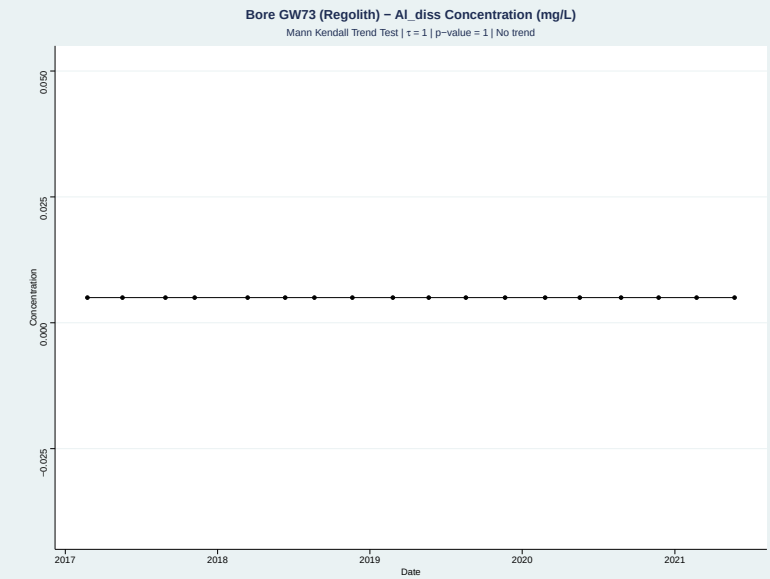
Appendix C Groundwater Quality Time Series

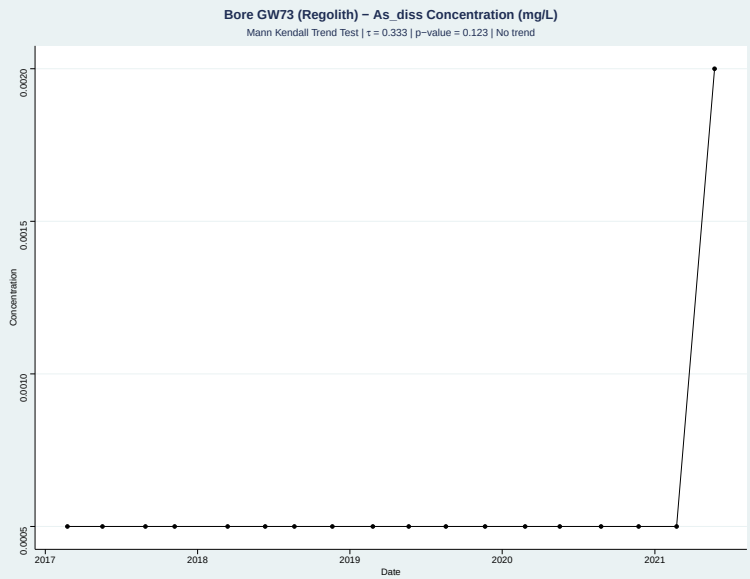




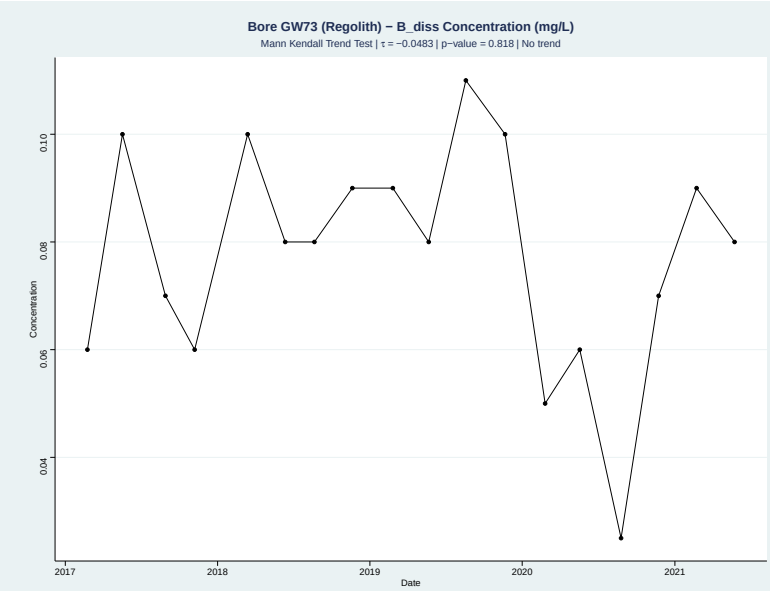


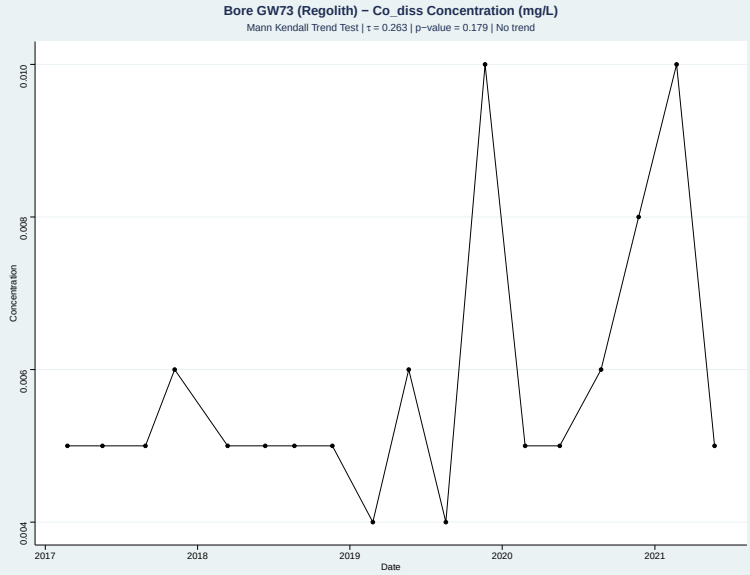


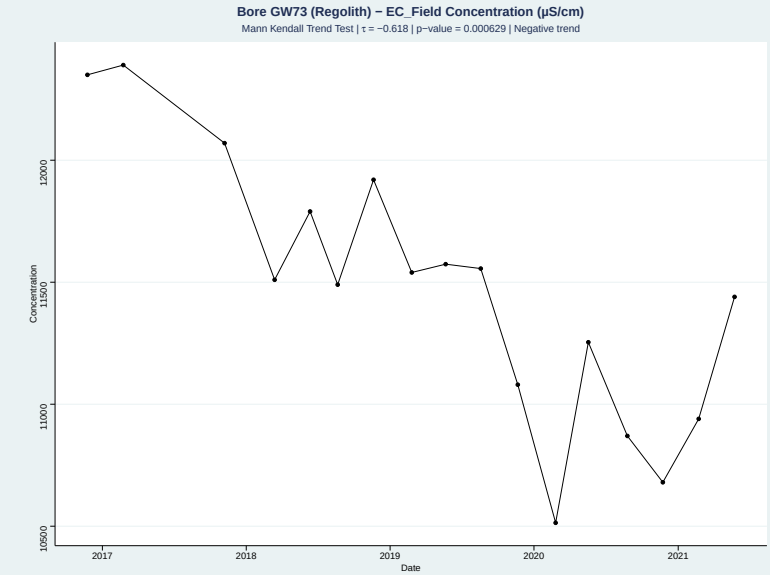


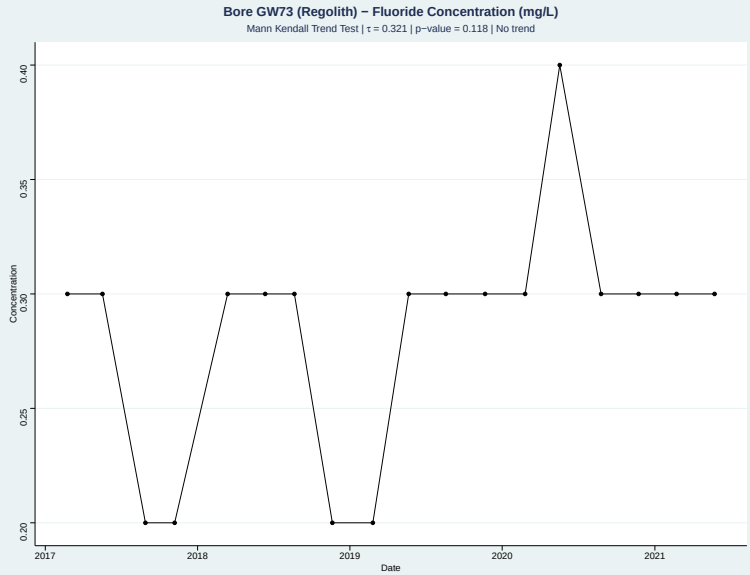


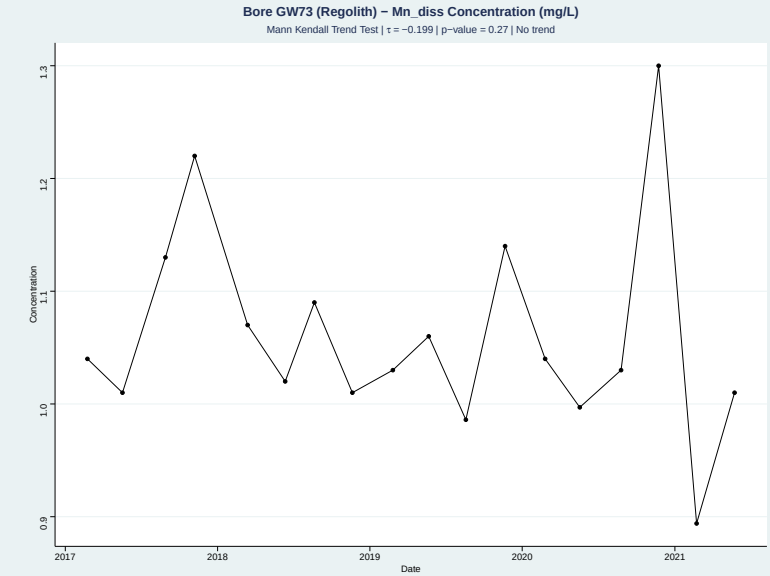
Appendix C Groundwater Quality Time Series

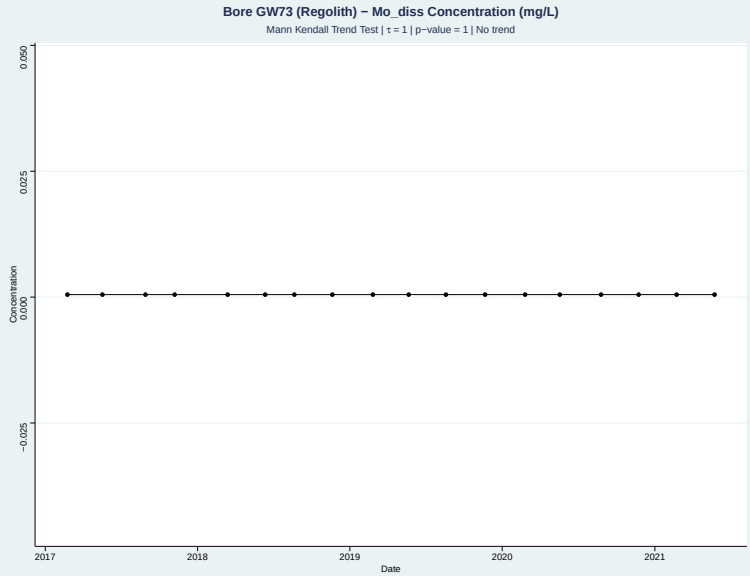




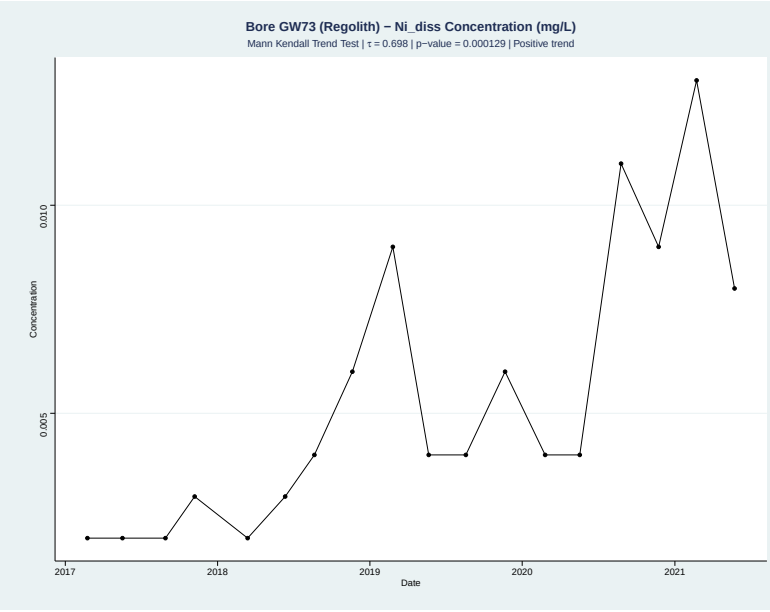


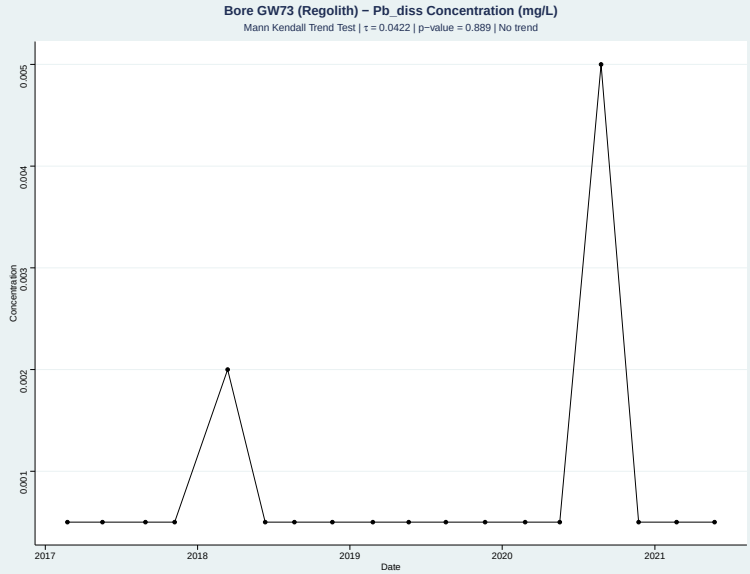


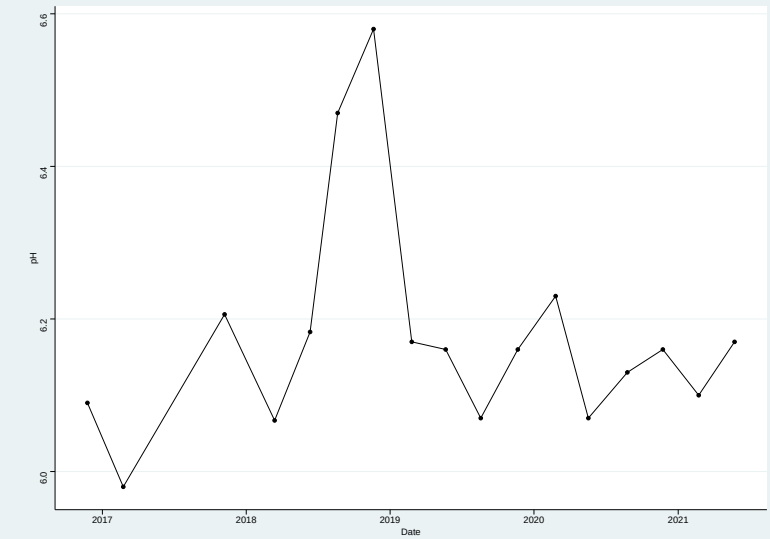


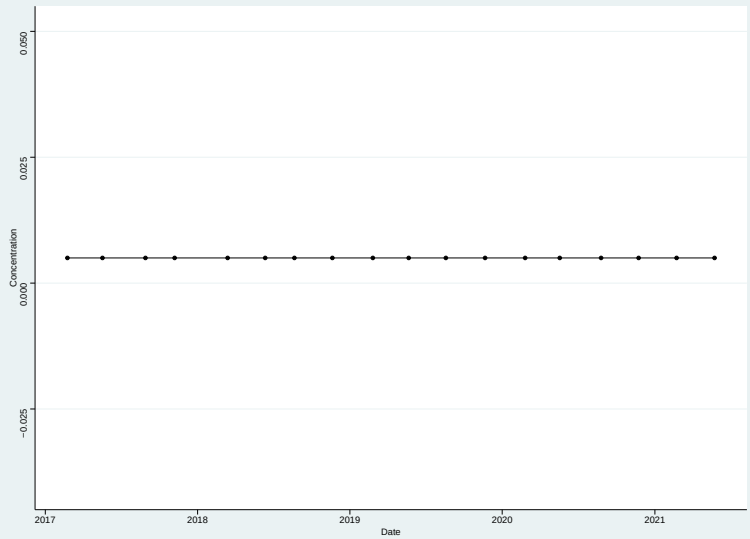


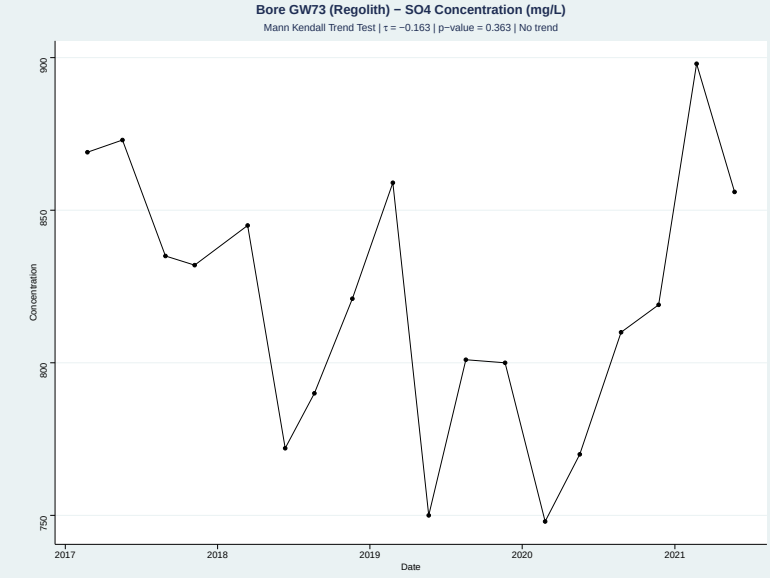
Appendix C Groundwater Quality Time Series

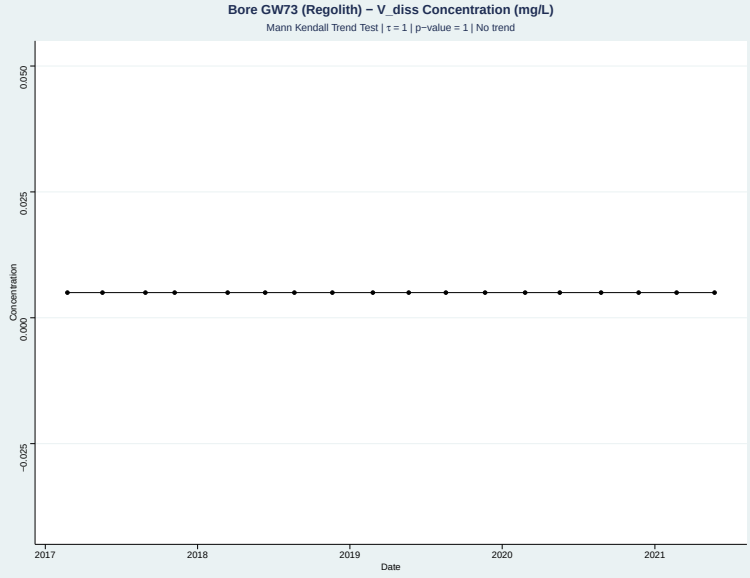




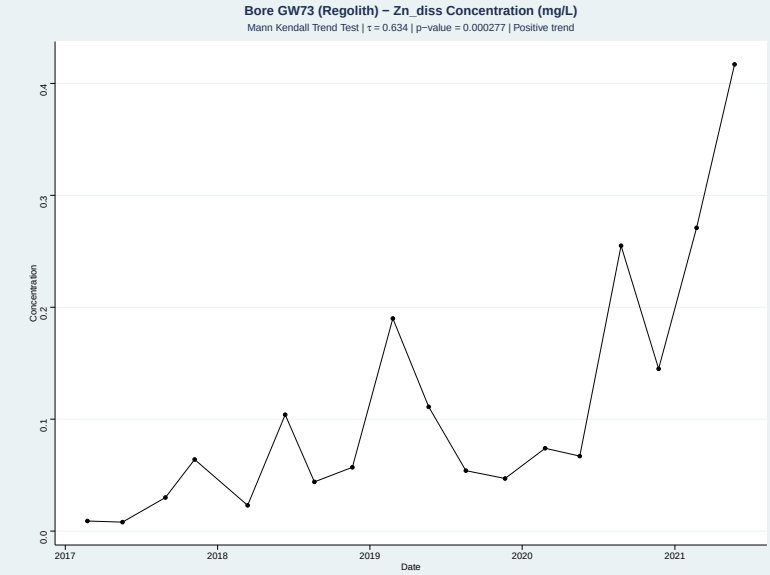


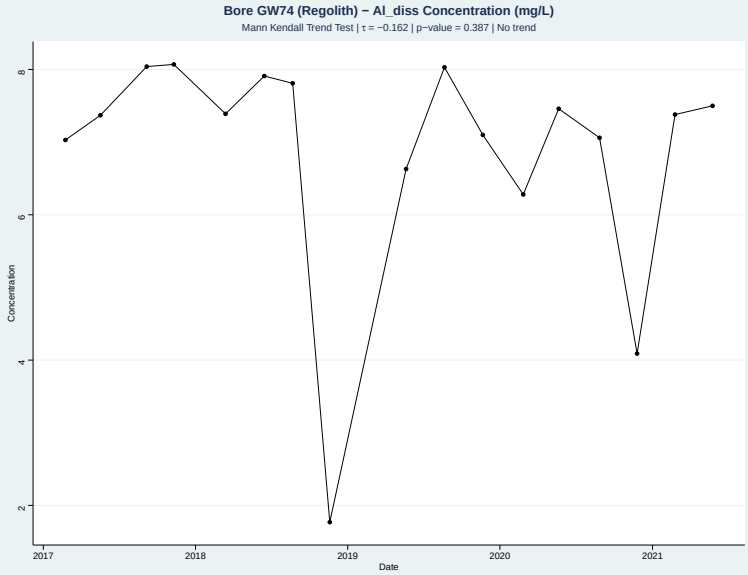


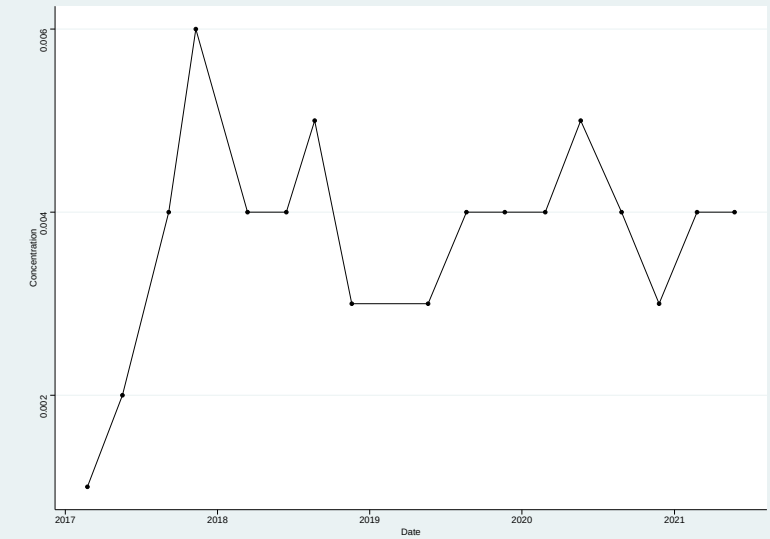


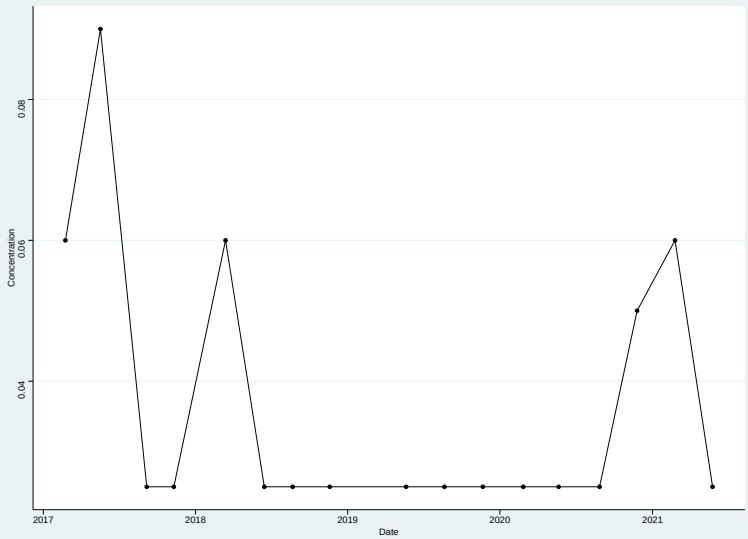


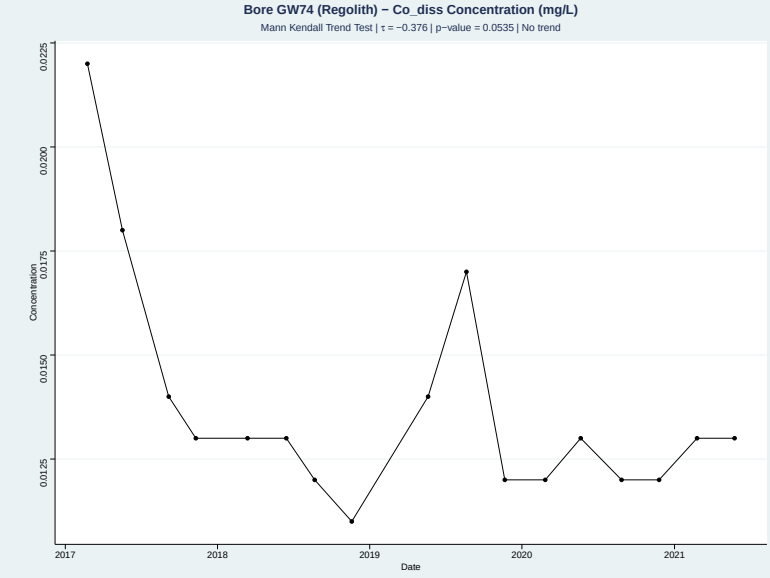
Appendix C Groundwater Quality Time Series

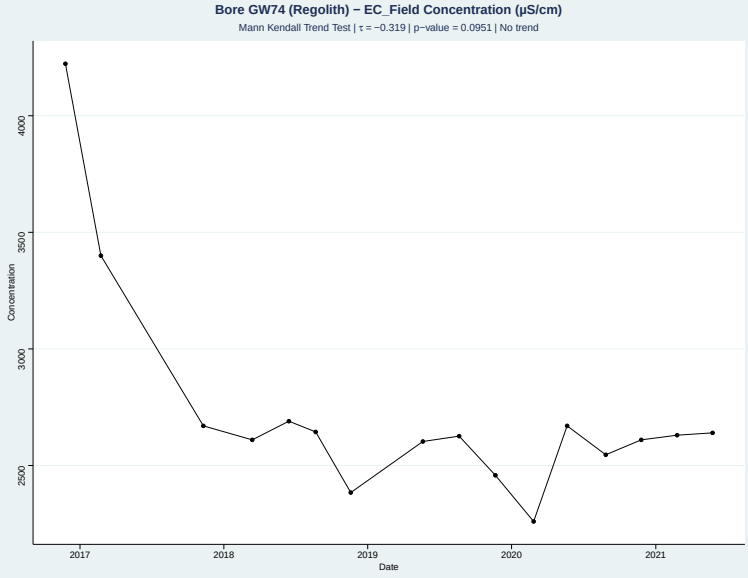




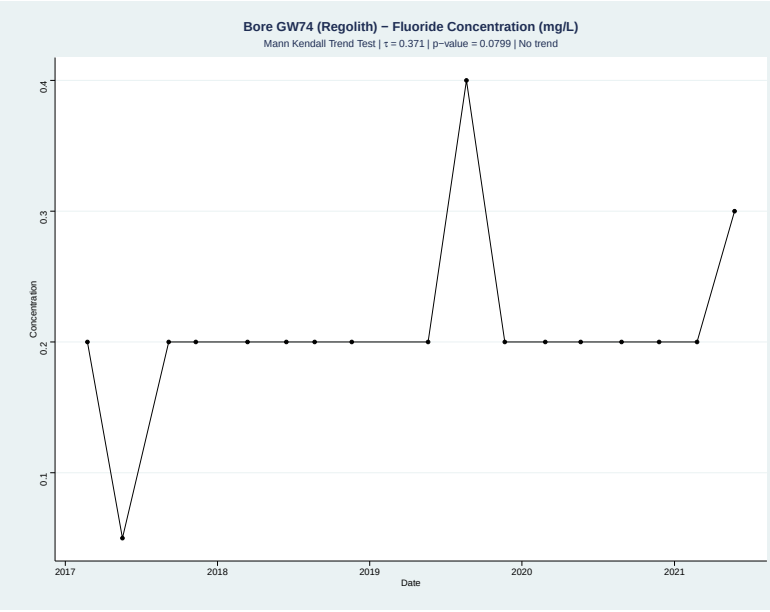


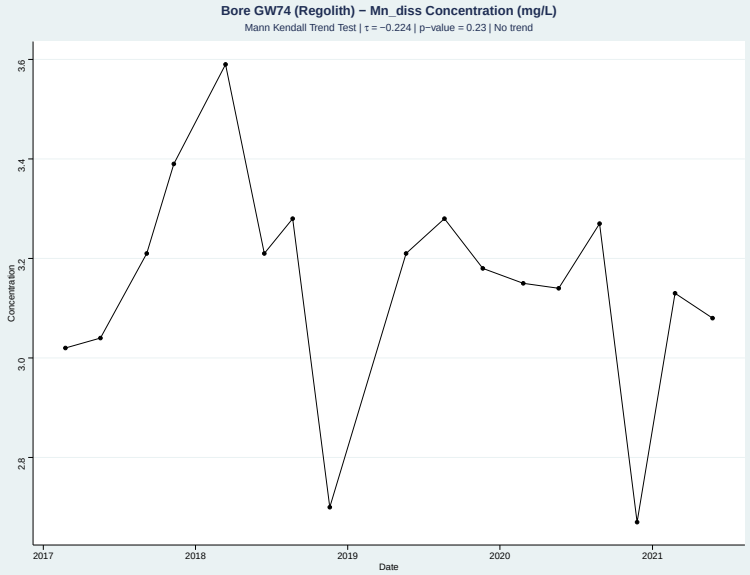


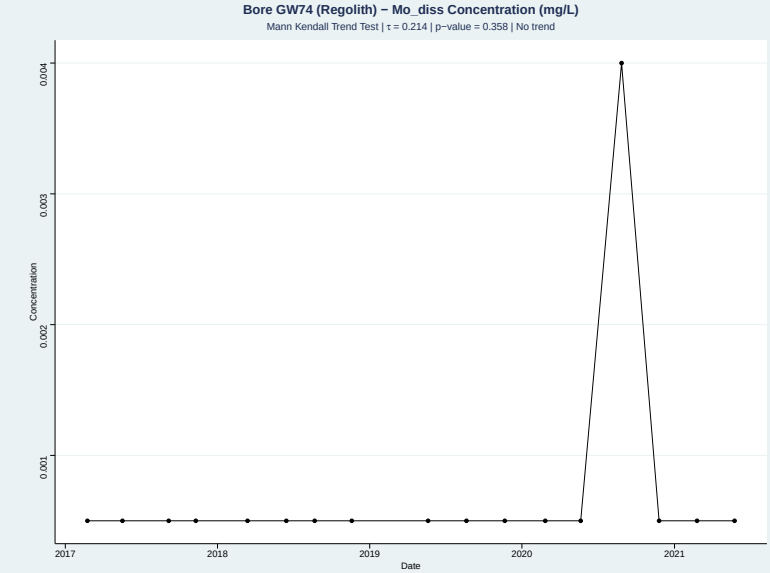


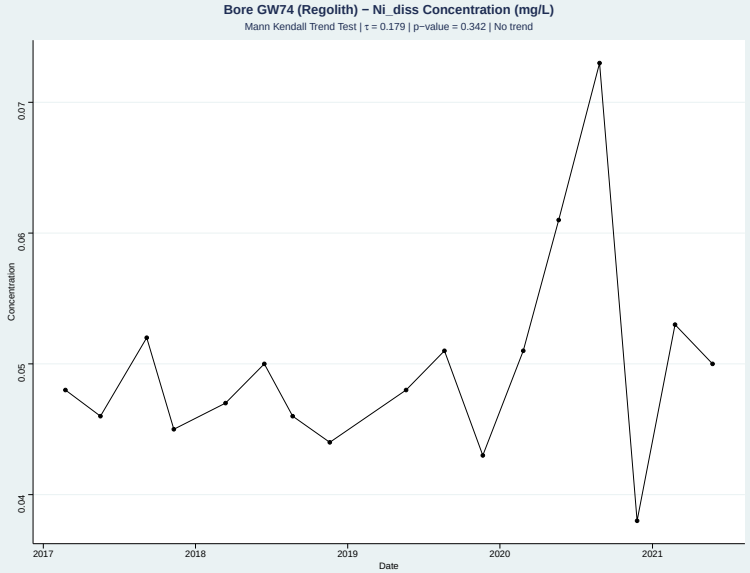


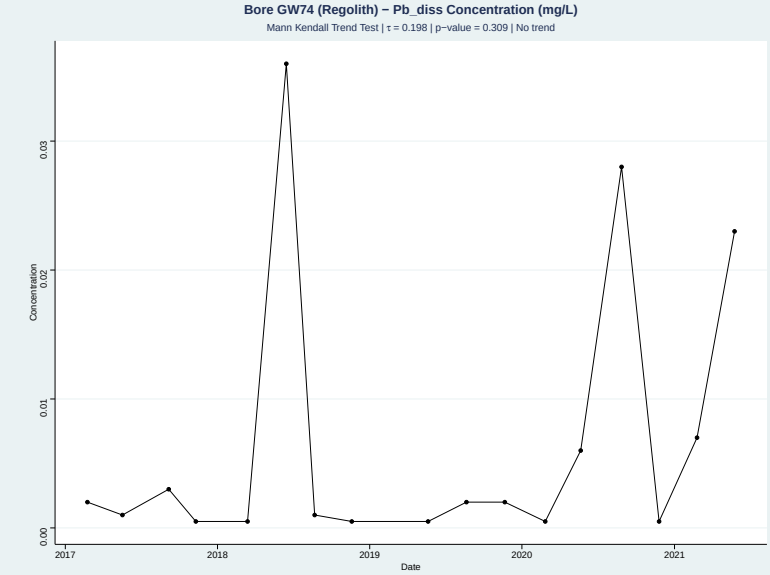
Appendix C Groundwater Quality Time Series

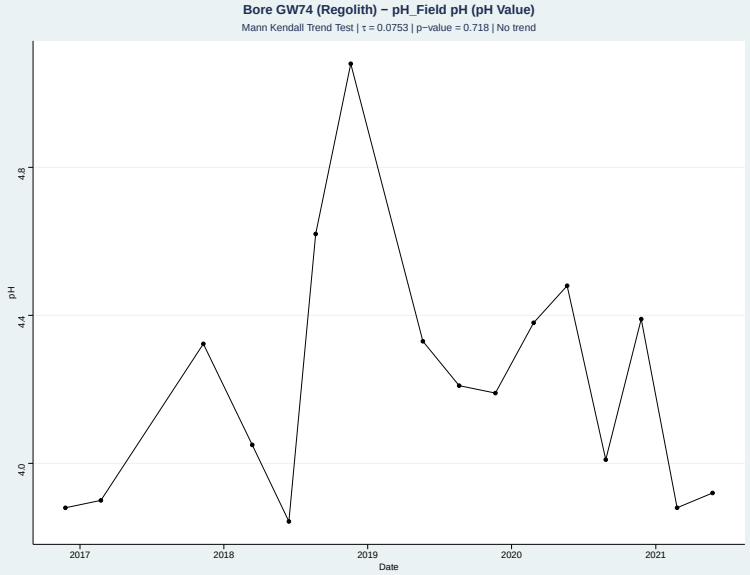




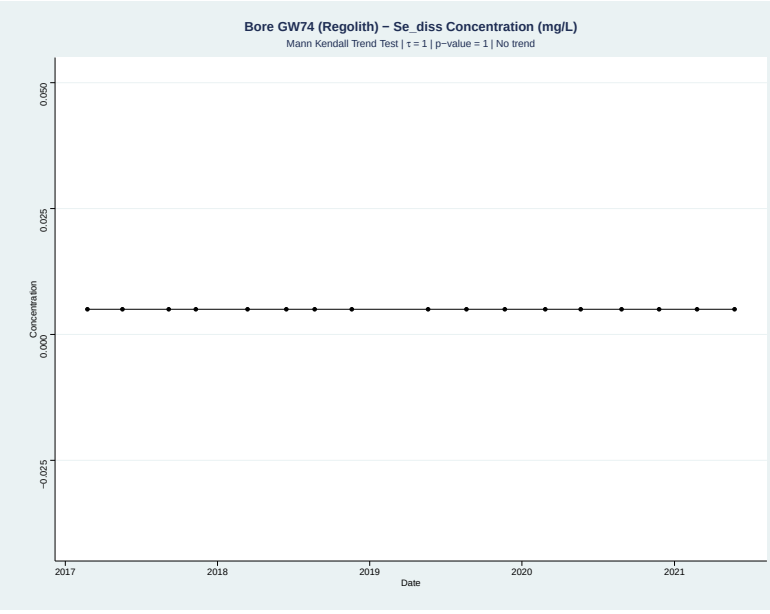


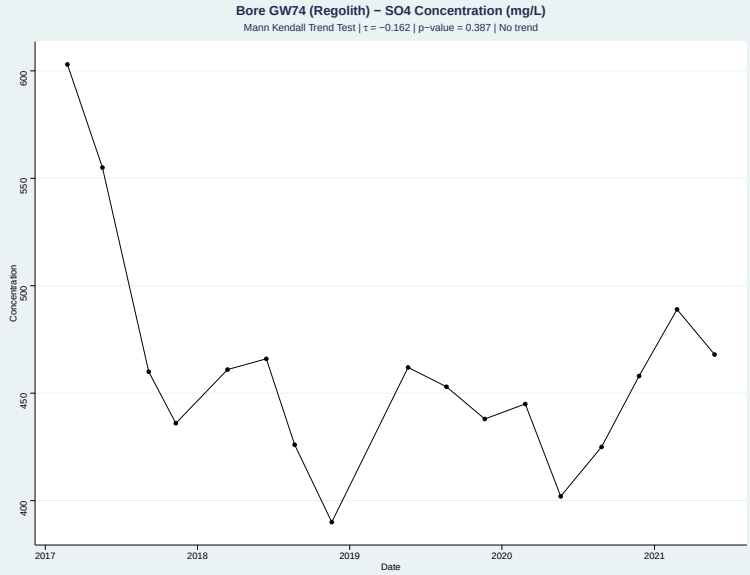


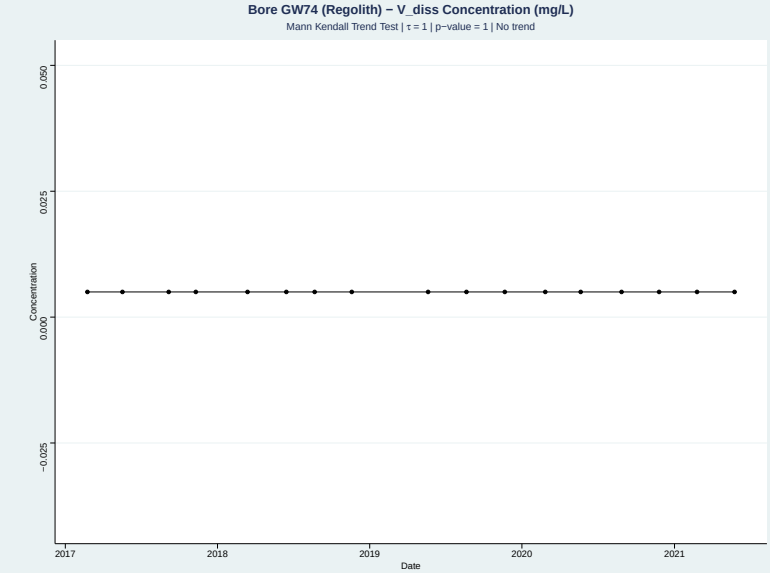


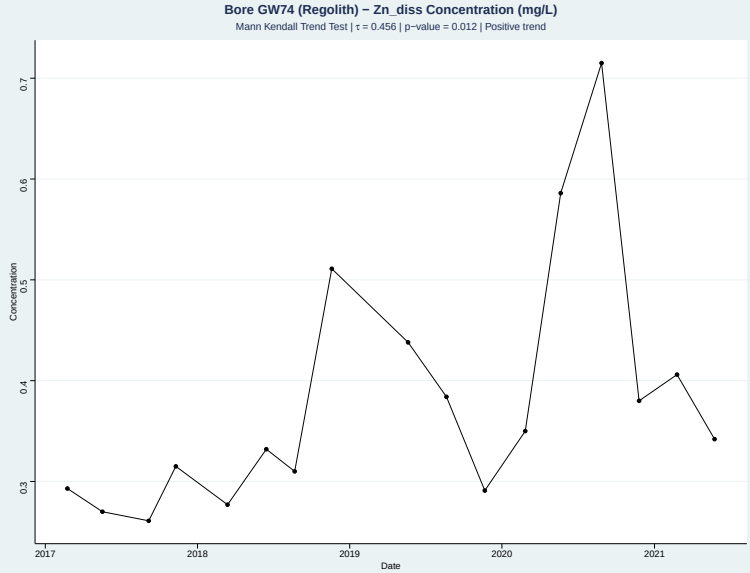


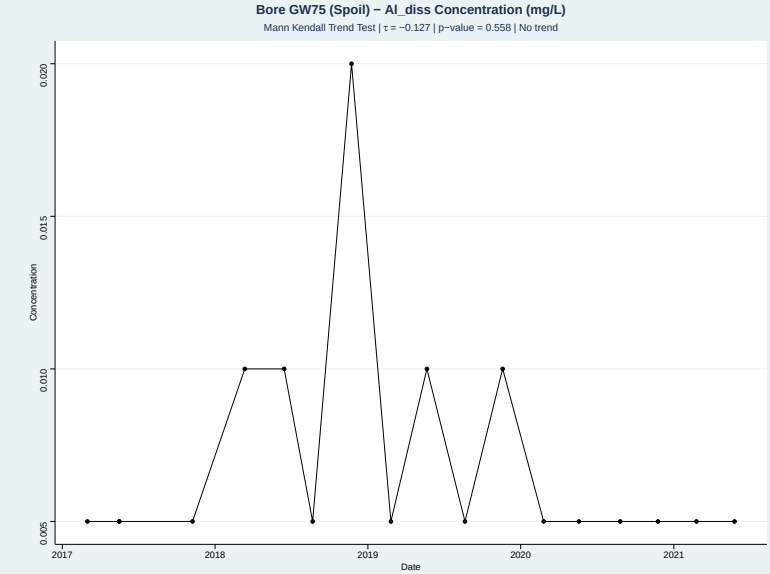
Appendix C Groundwater Quality Time Series

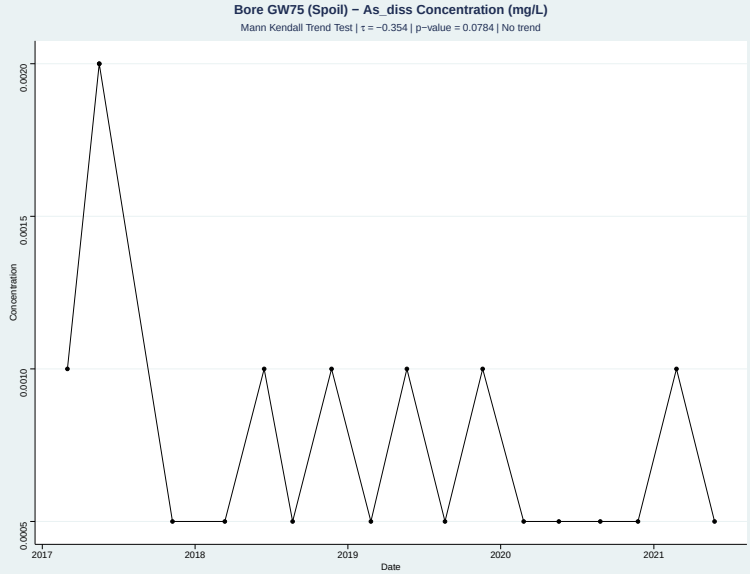




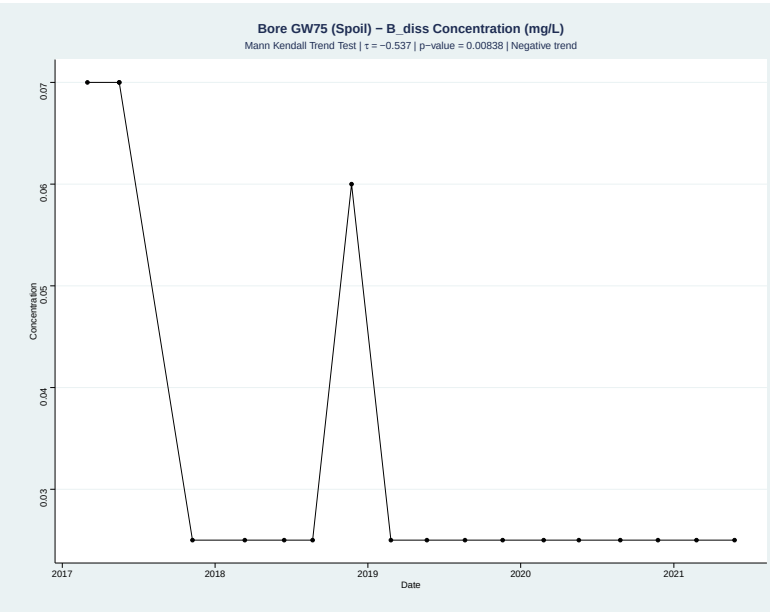


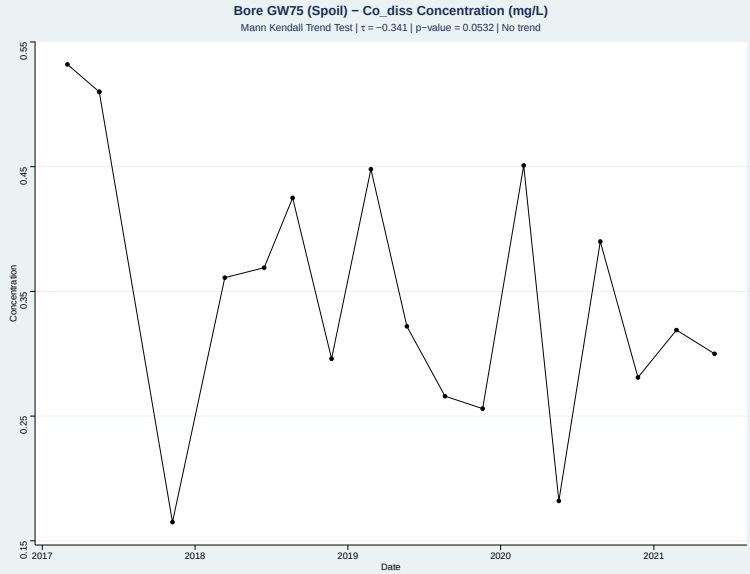


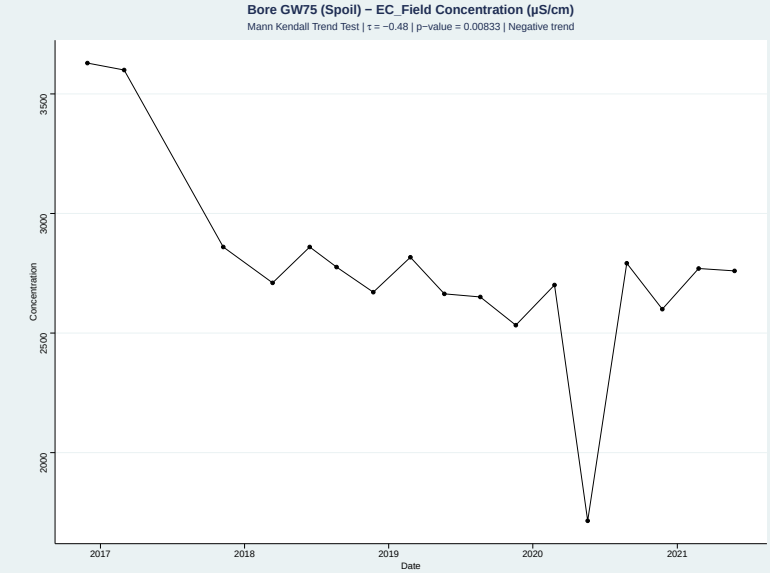


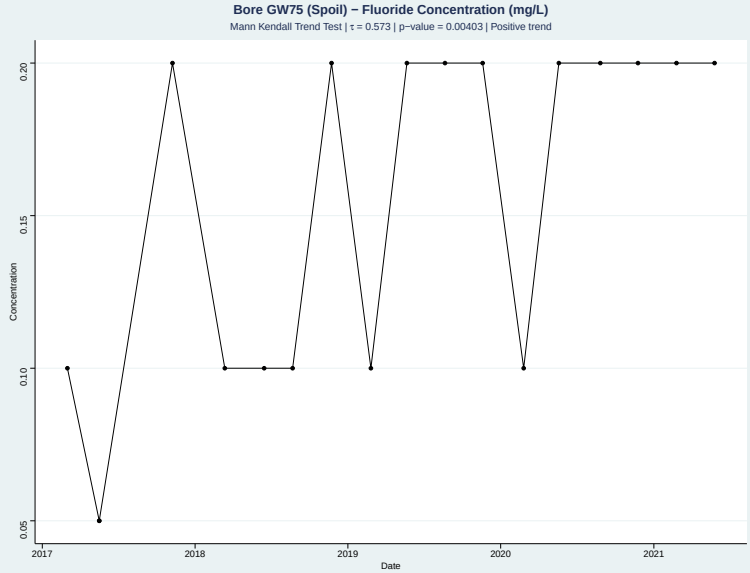


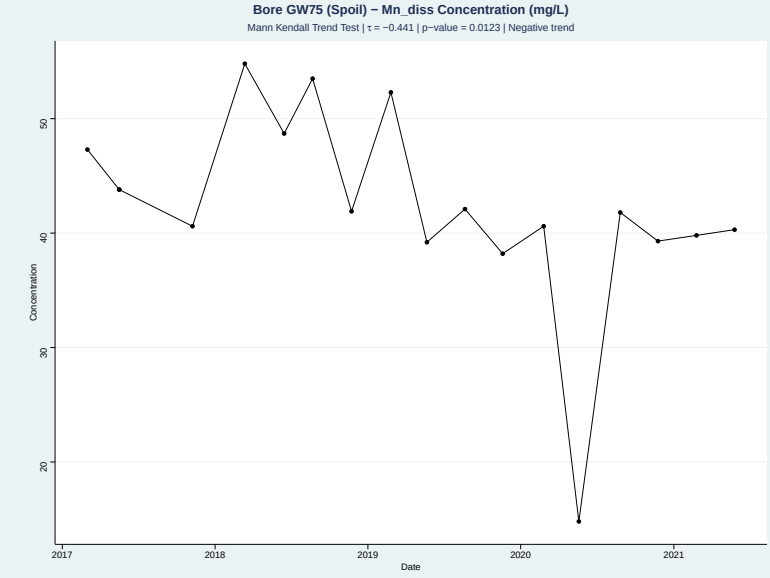
Appendix C Groundwater Quality Time Series

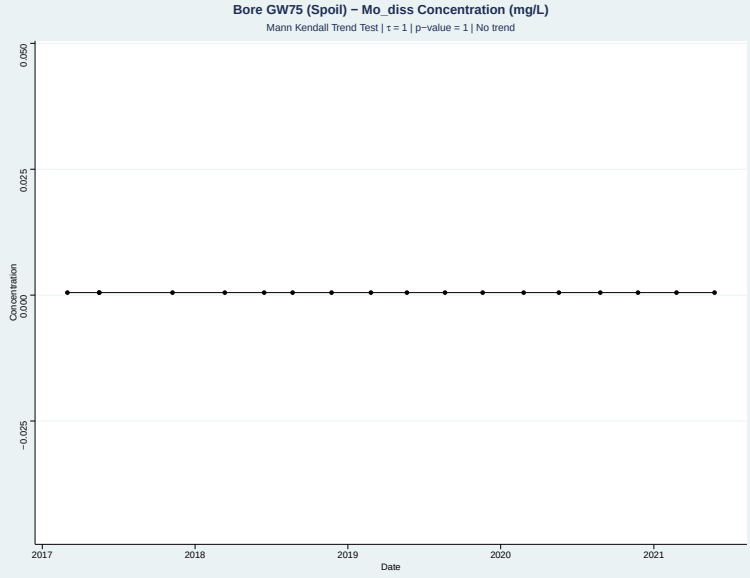




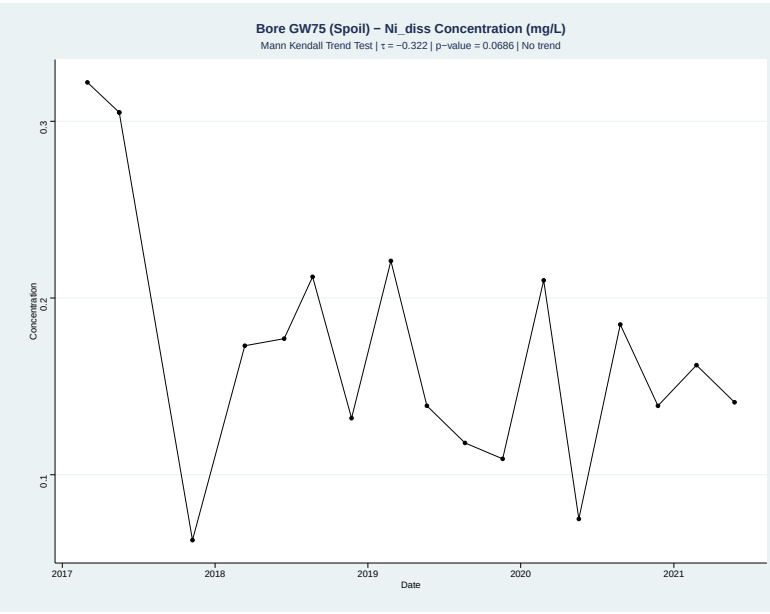


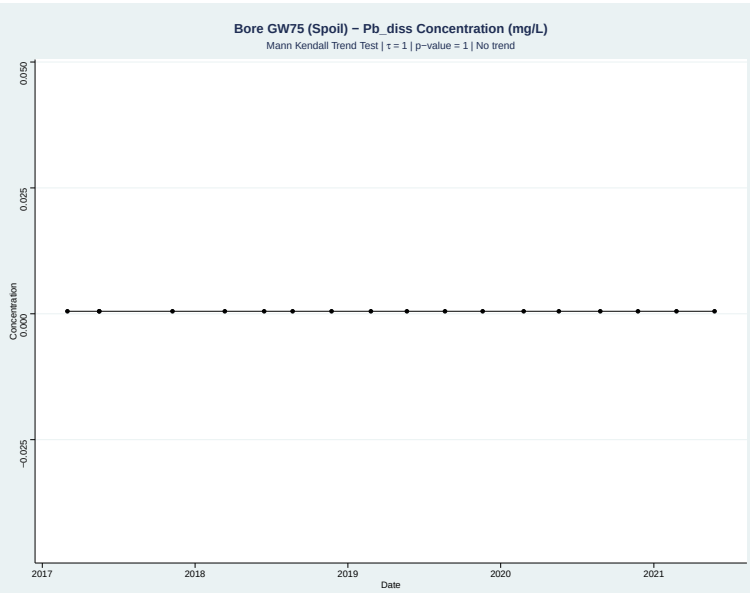


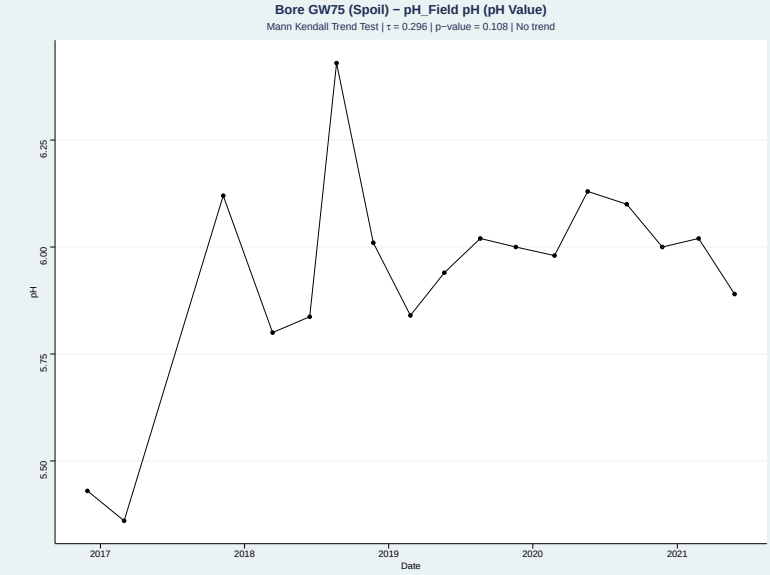


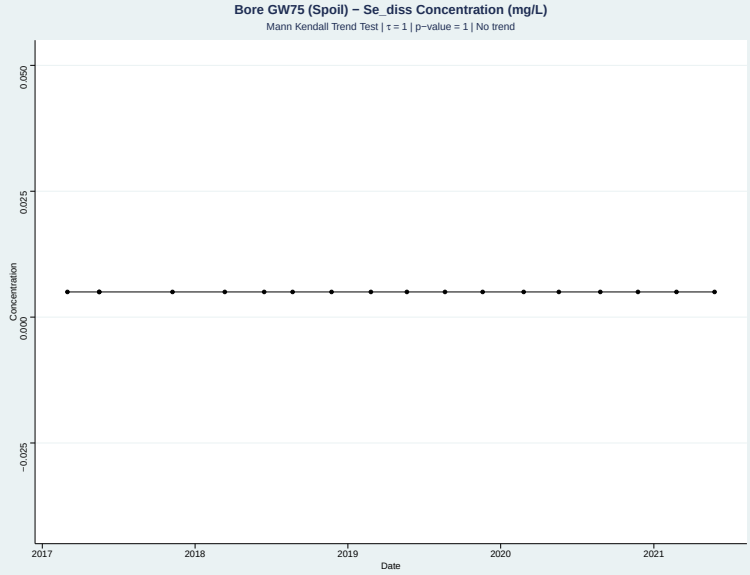


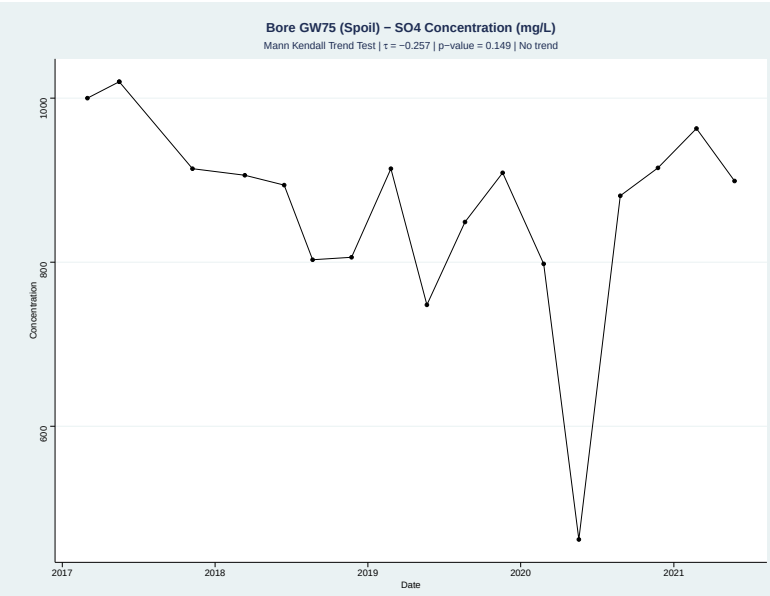
Appendix C Groundwater Quality Time Series

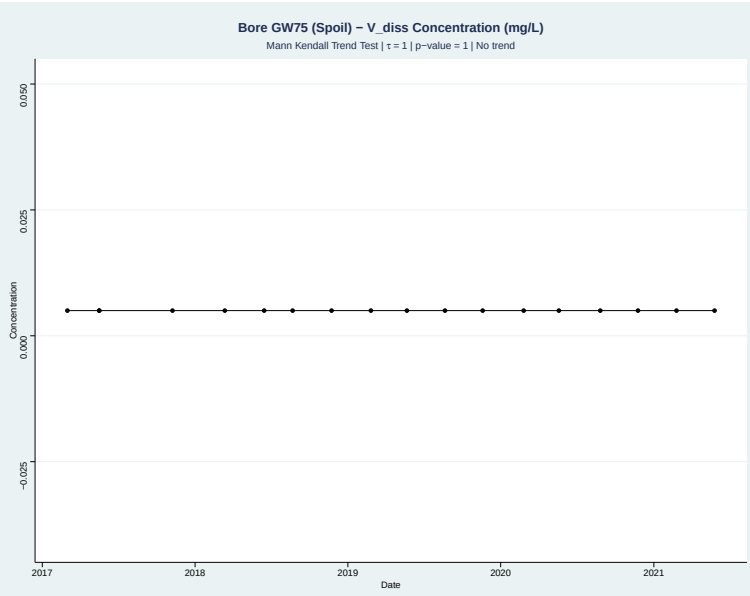




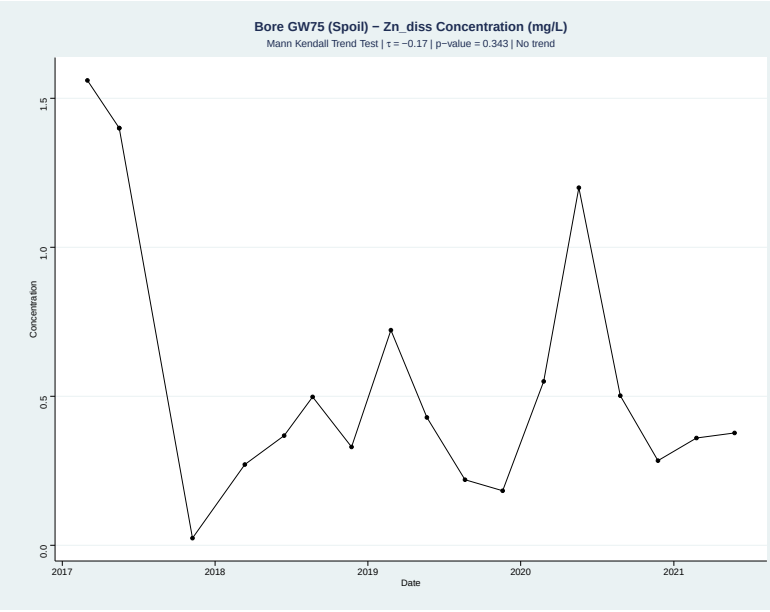


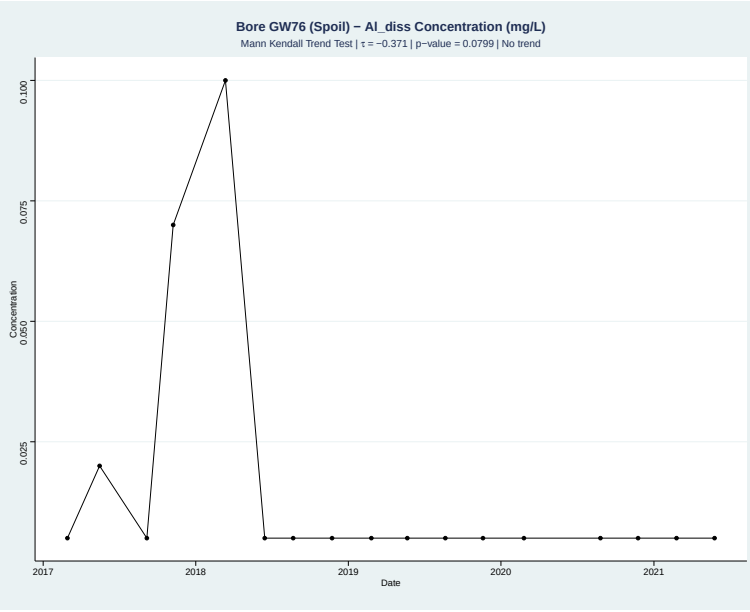


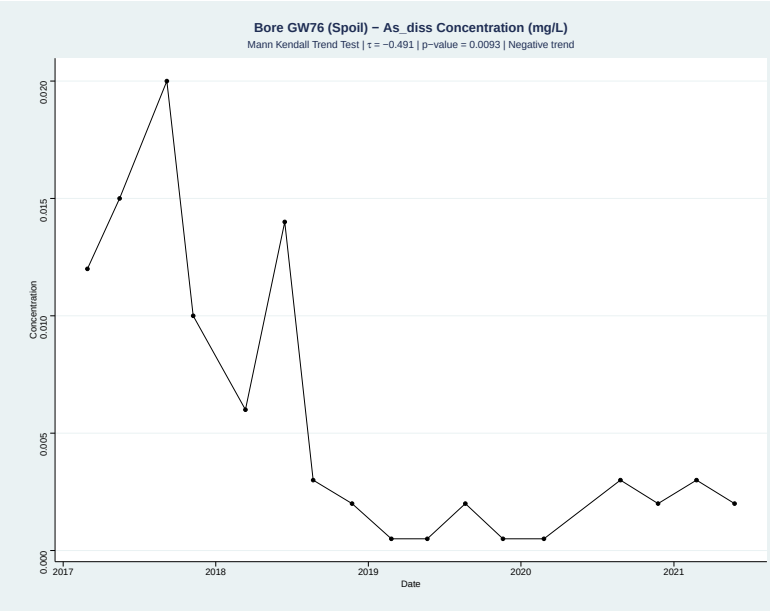


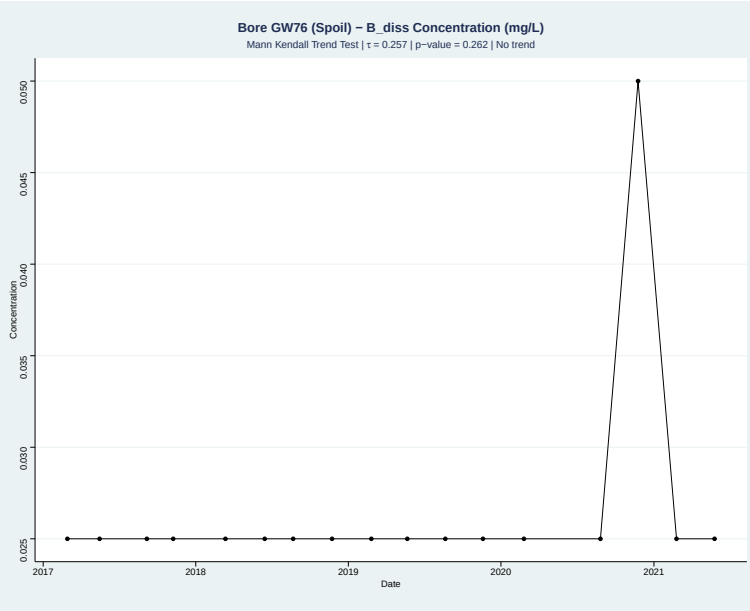


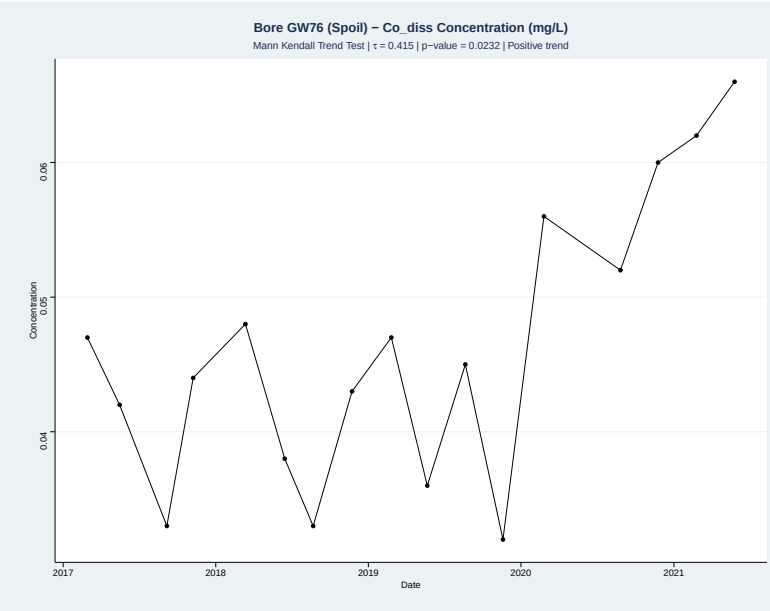
Appendix C Groundwater Quality Time Series

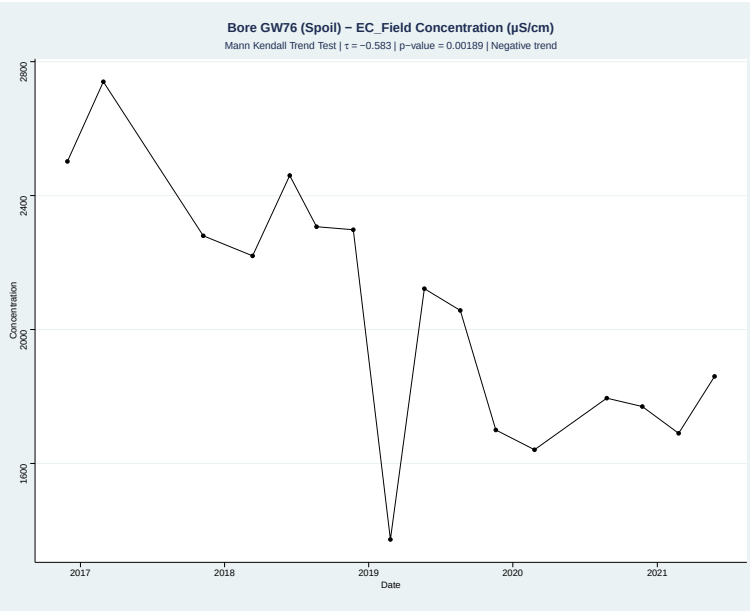




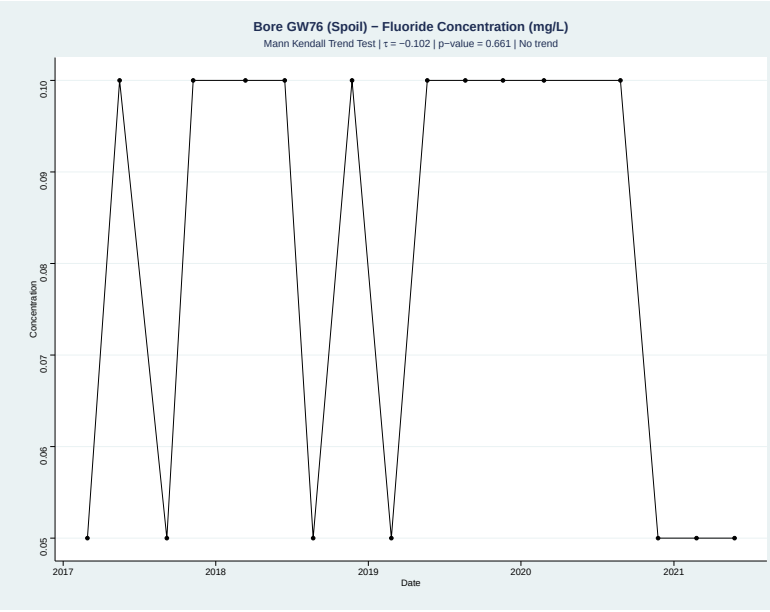


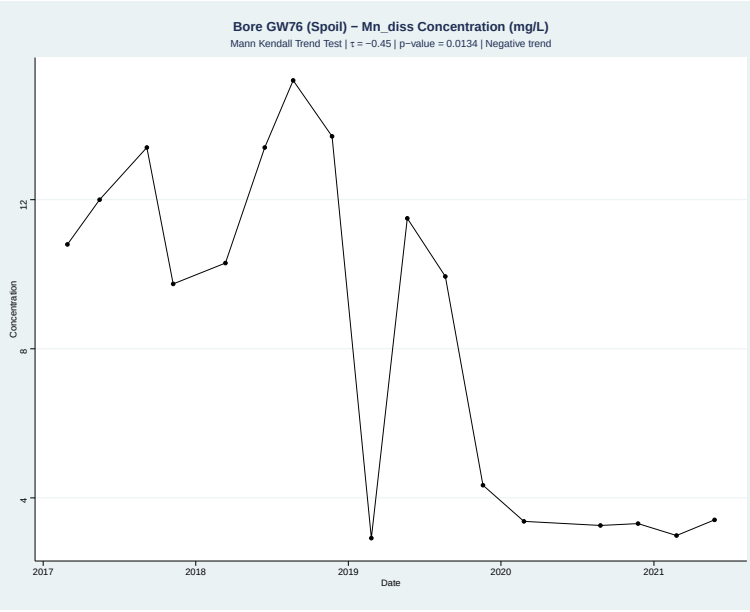


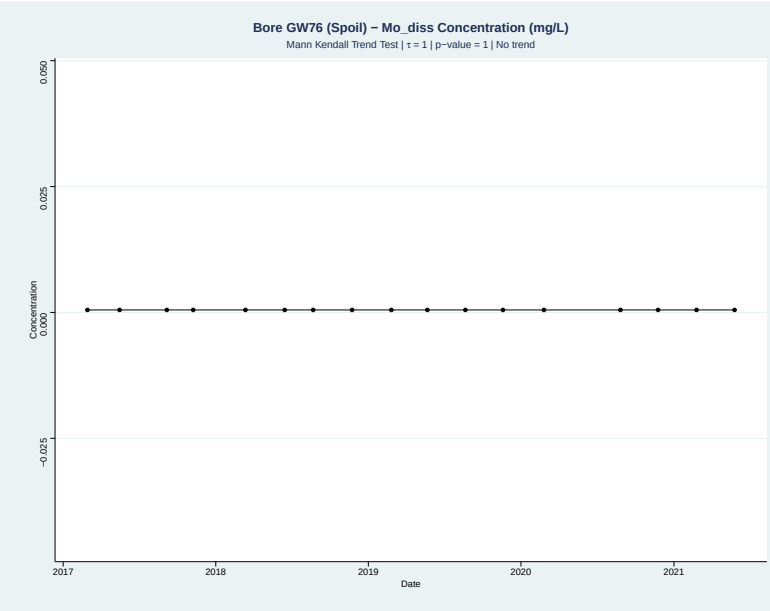


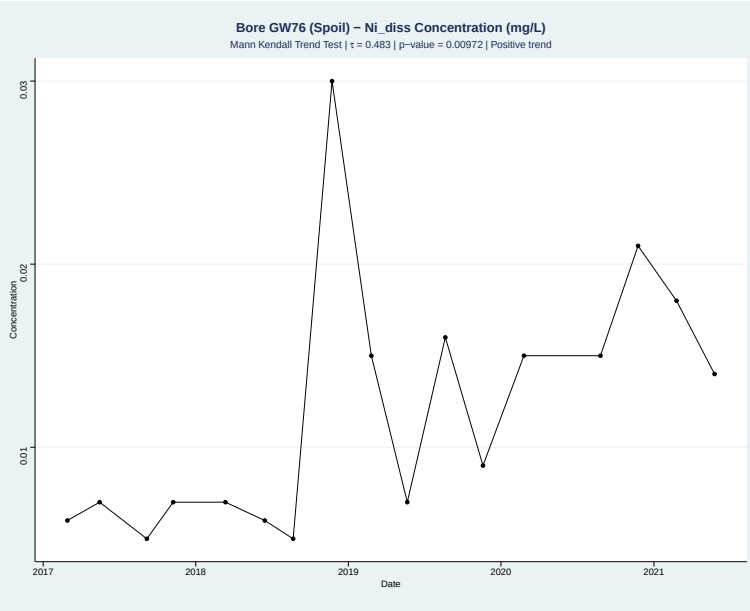


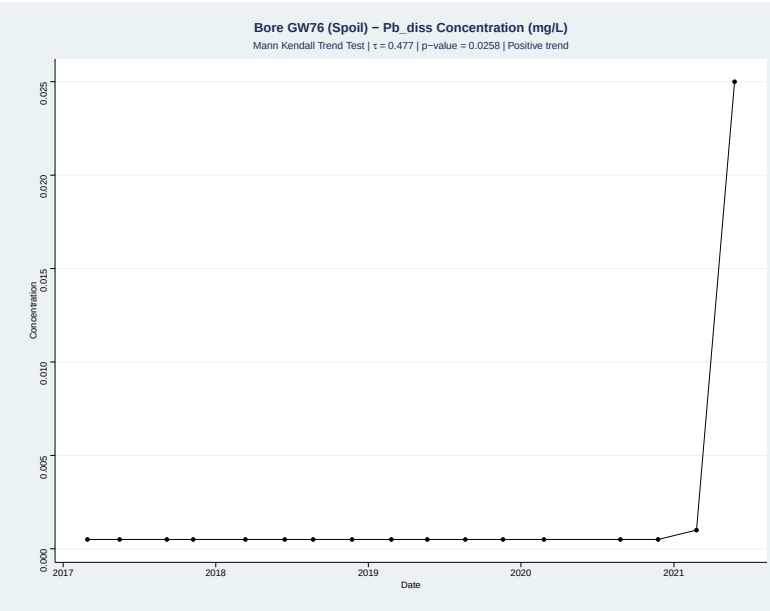
Appendix C Groundwater Quality Time Series

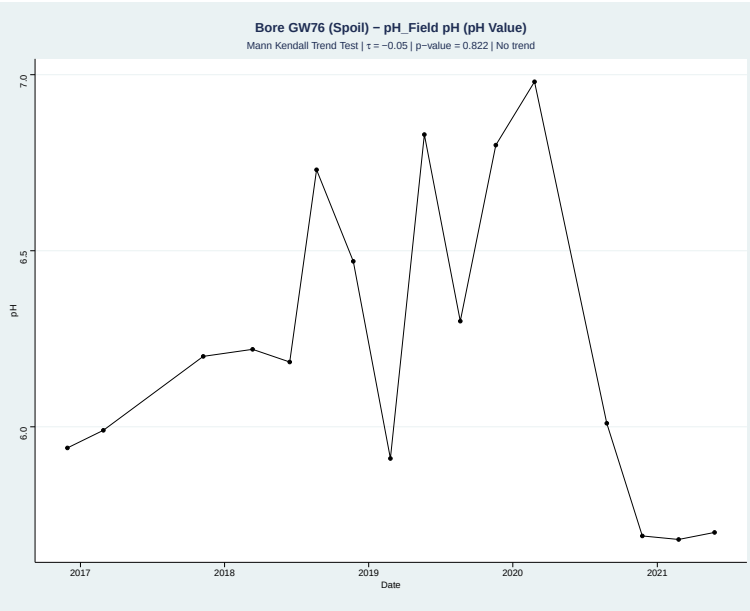




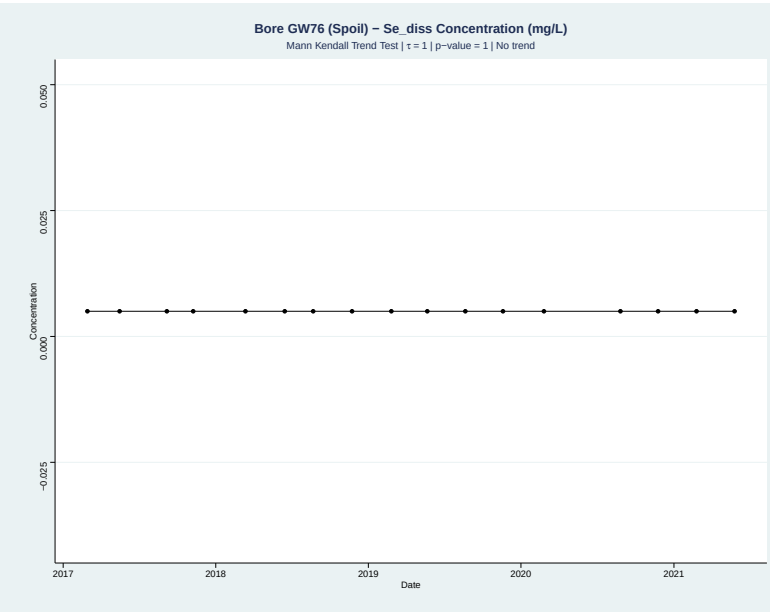


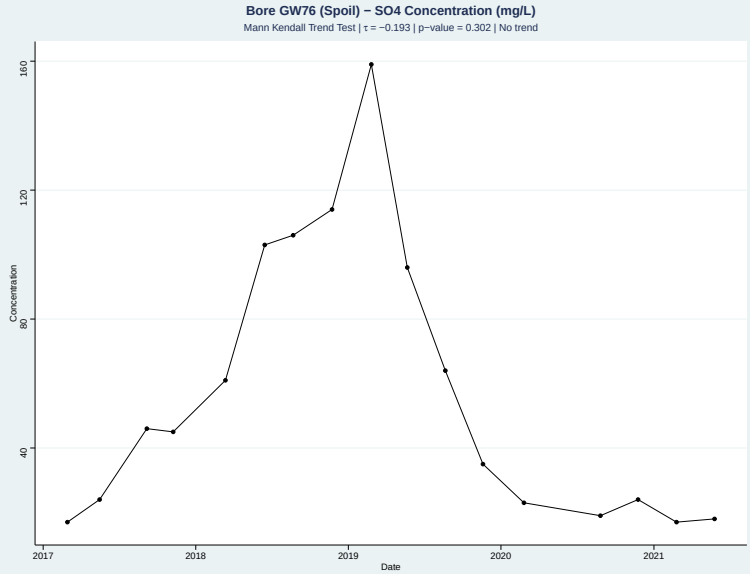


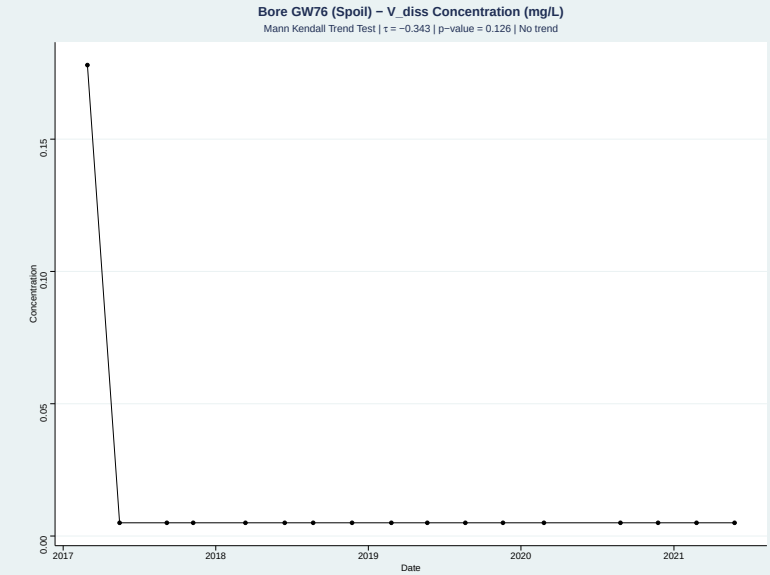


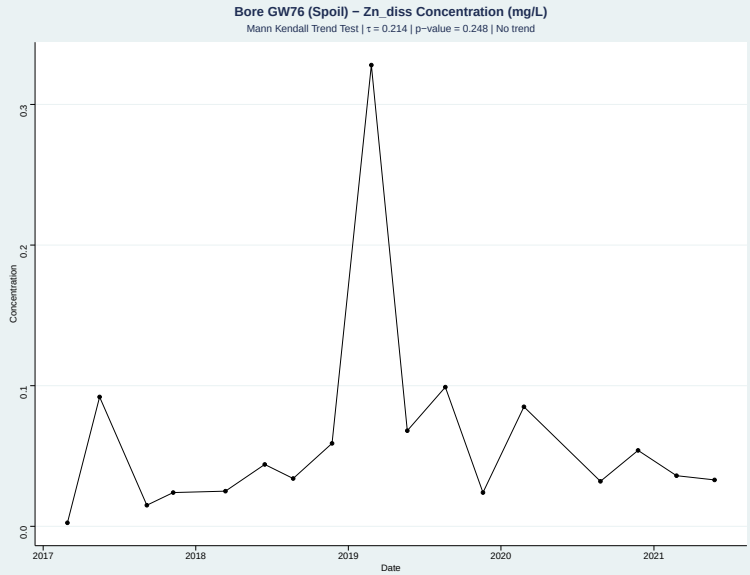


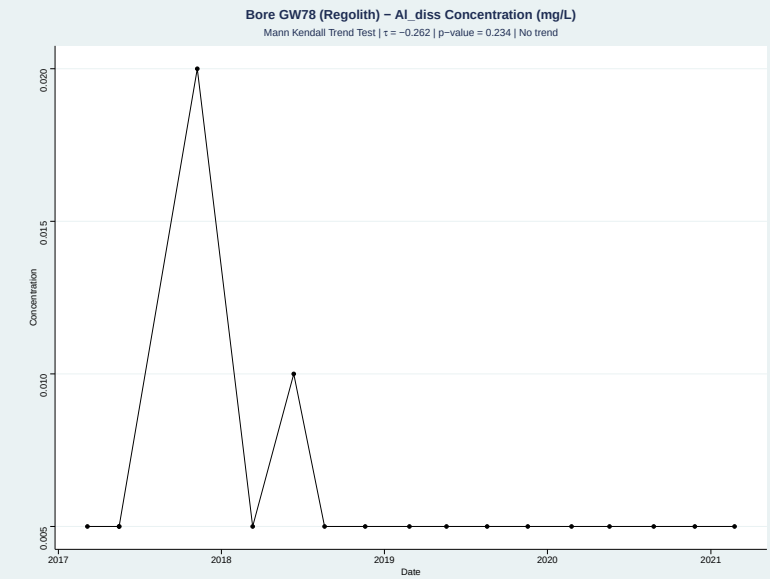
Appendix C Groundwater Quality Time Series

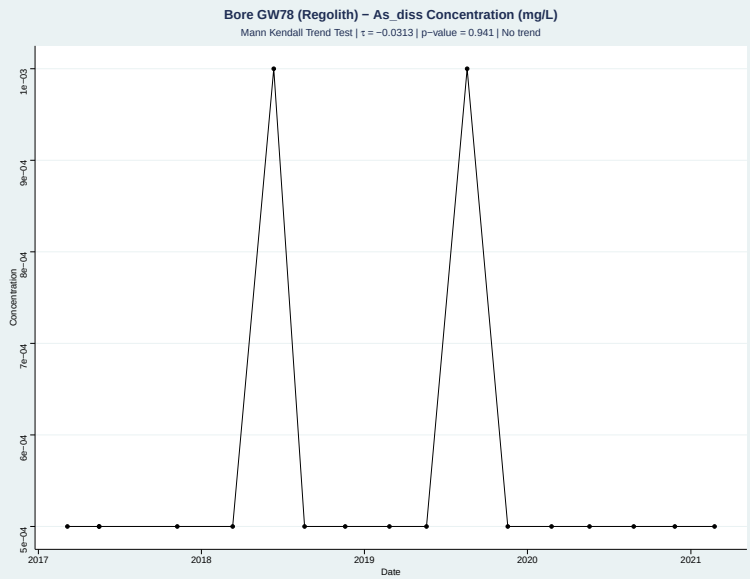




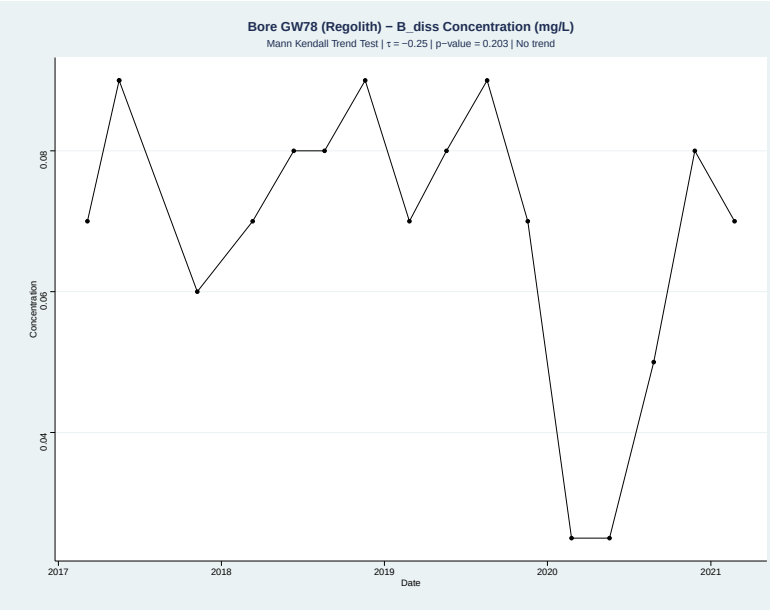


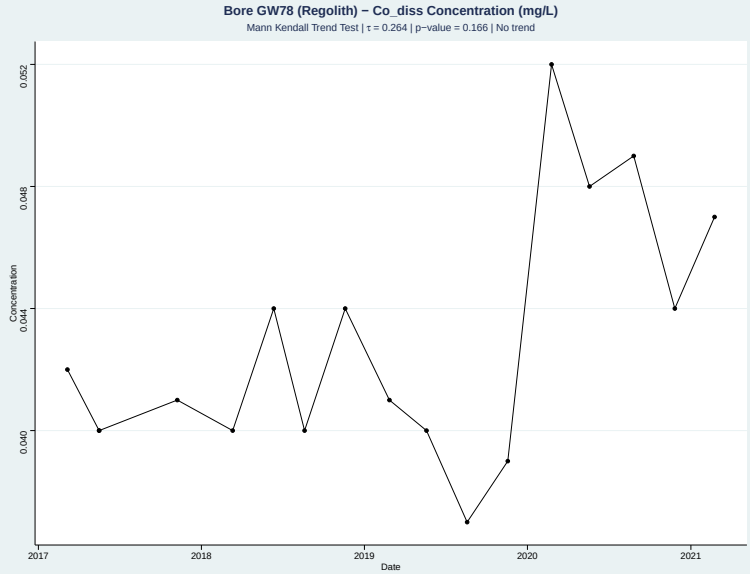


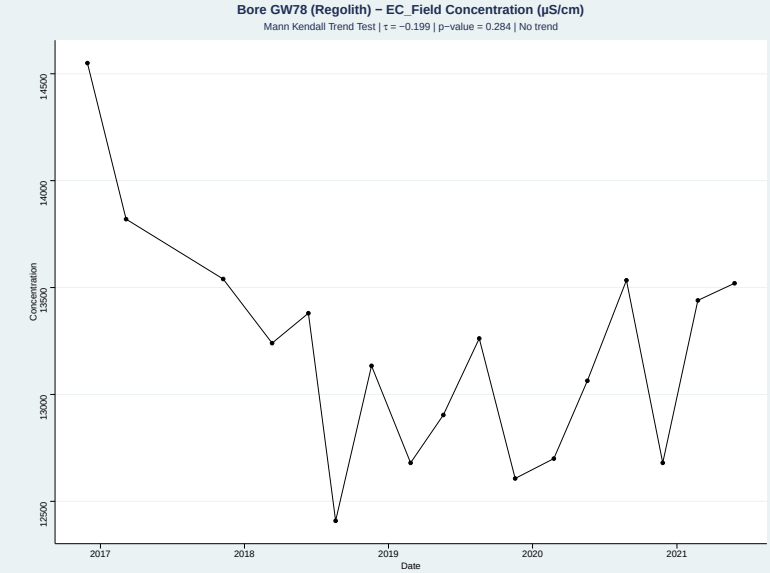


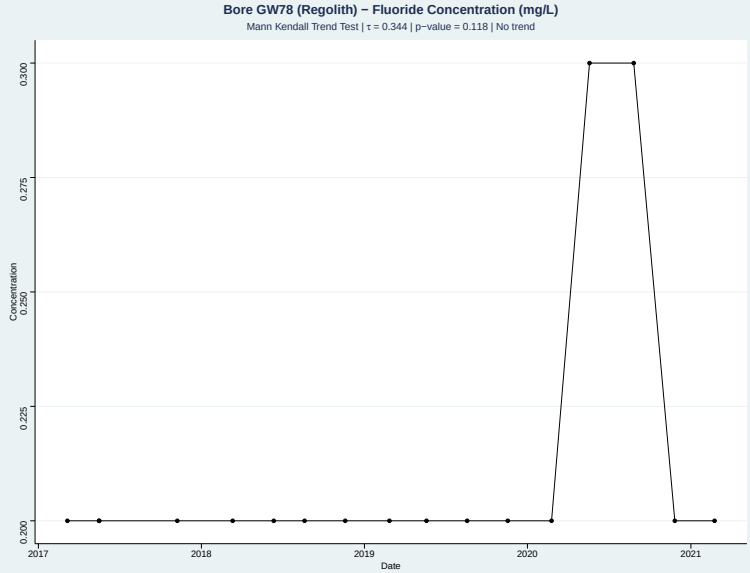


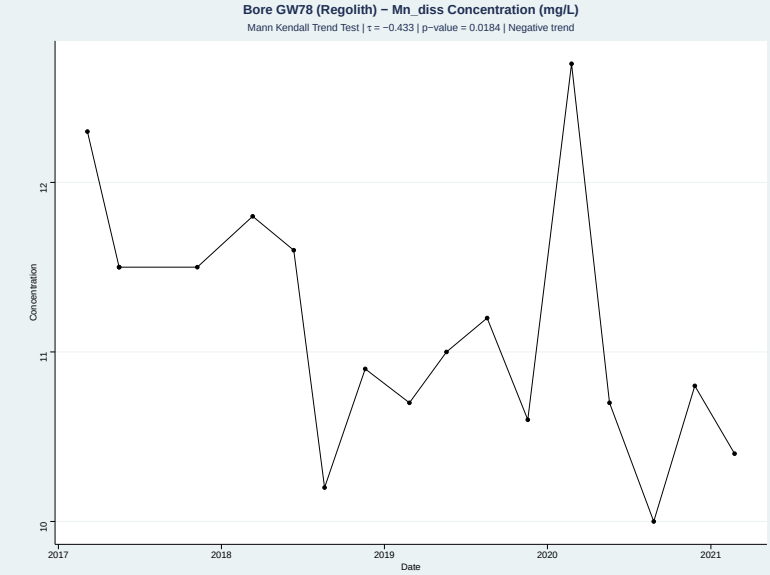
Appendix C Groundwater Quality Time Series

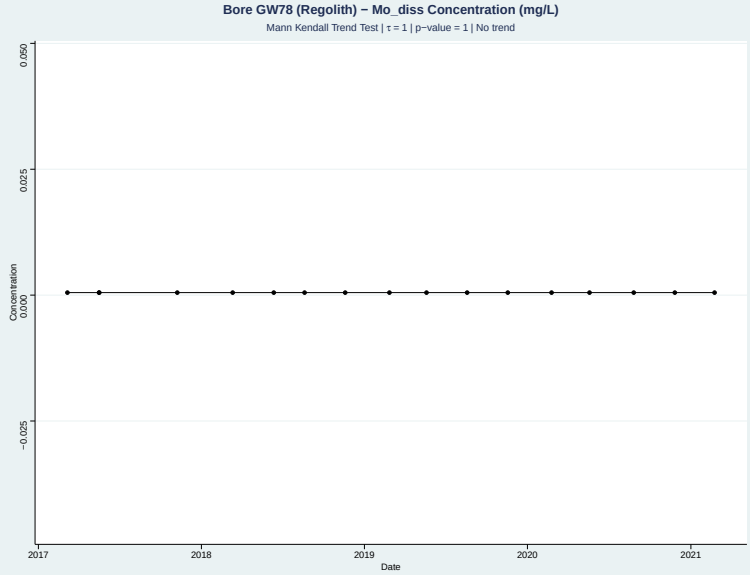












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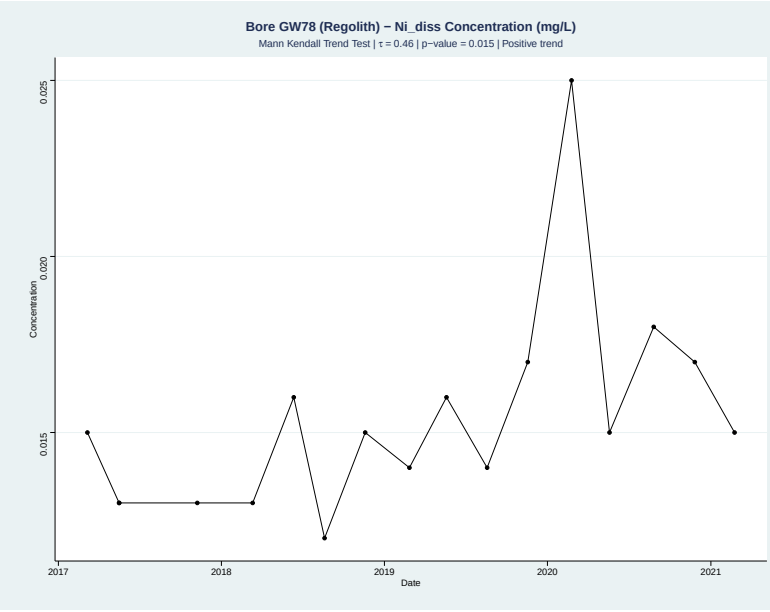
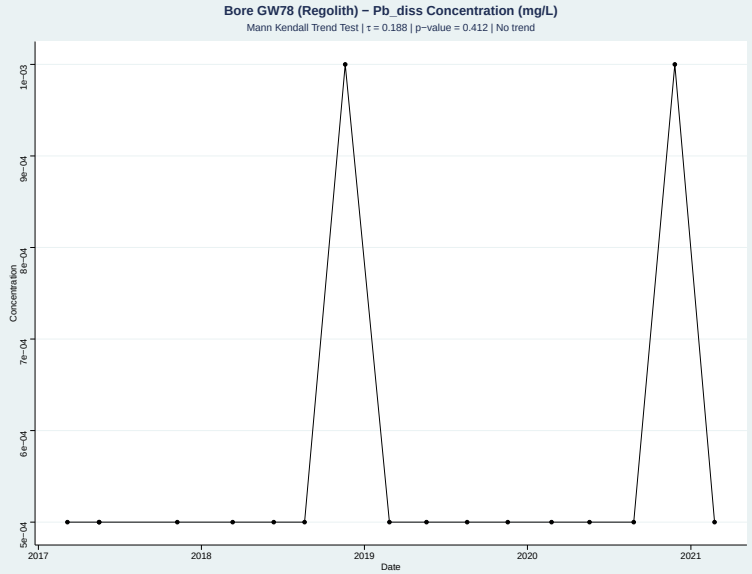
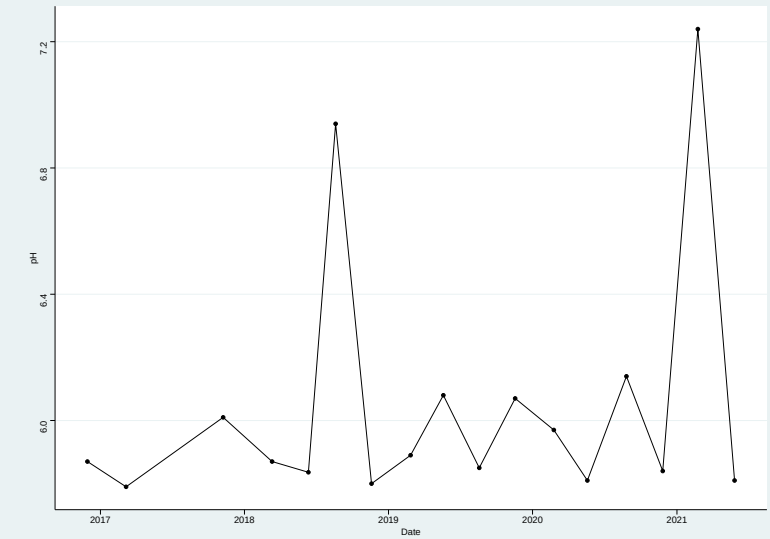
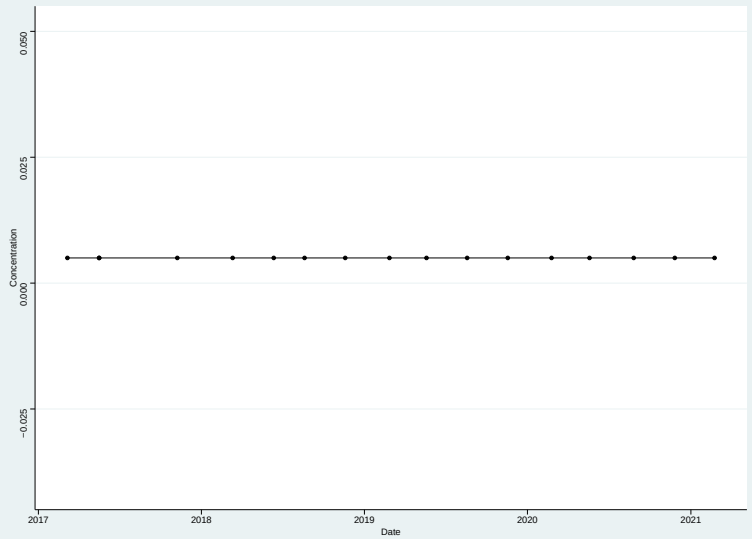
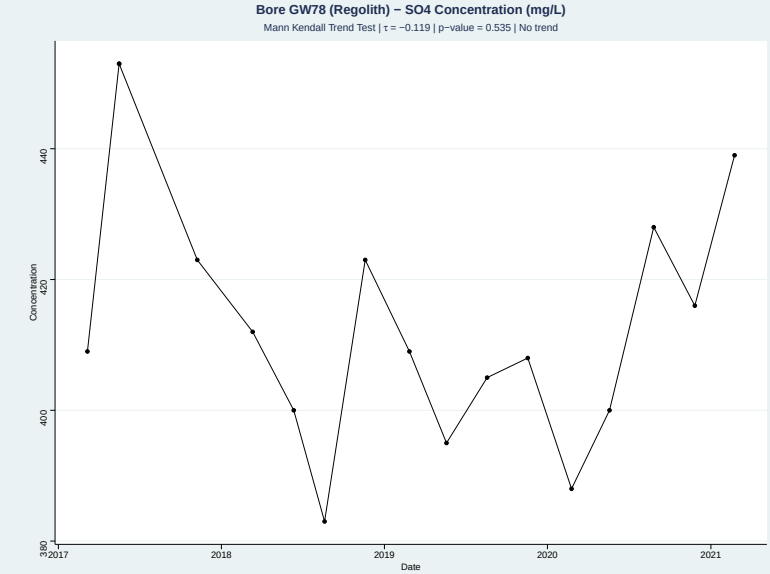
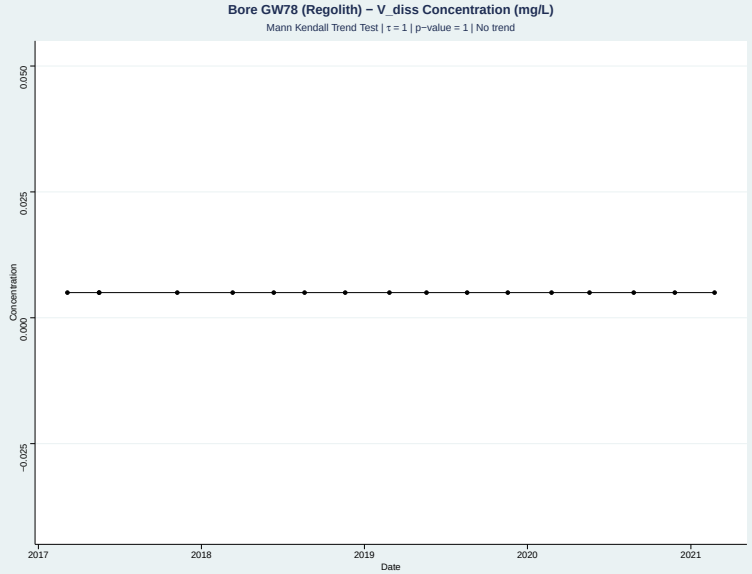




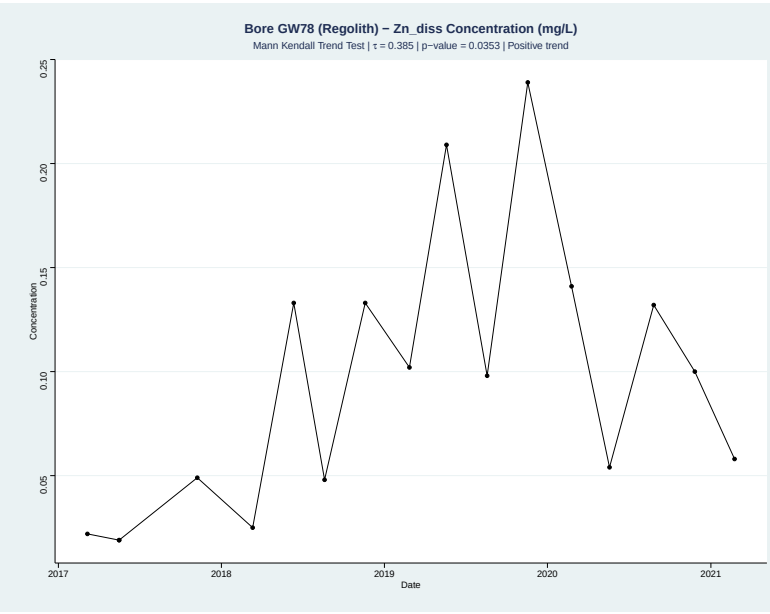


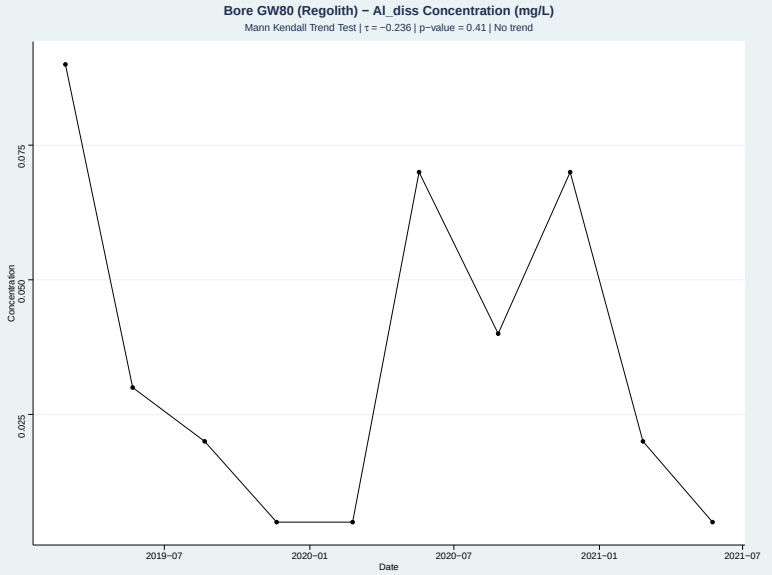


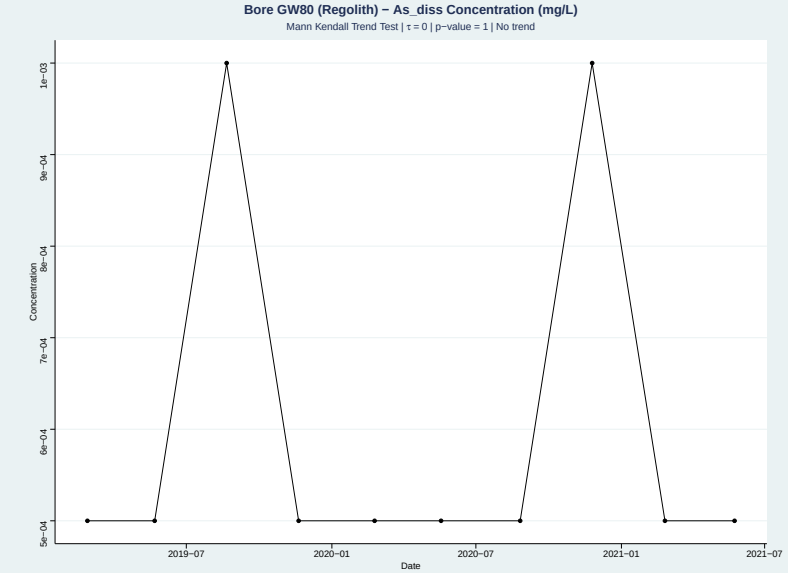


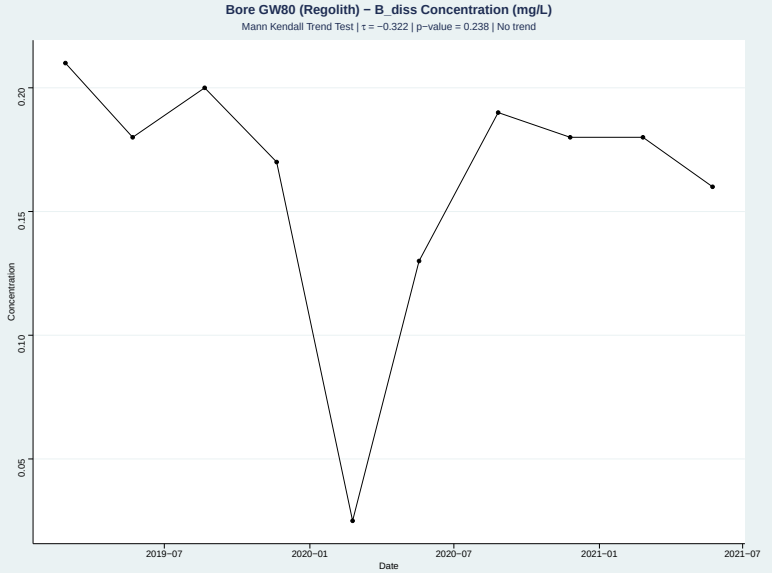


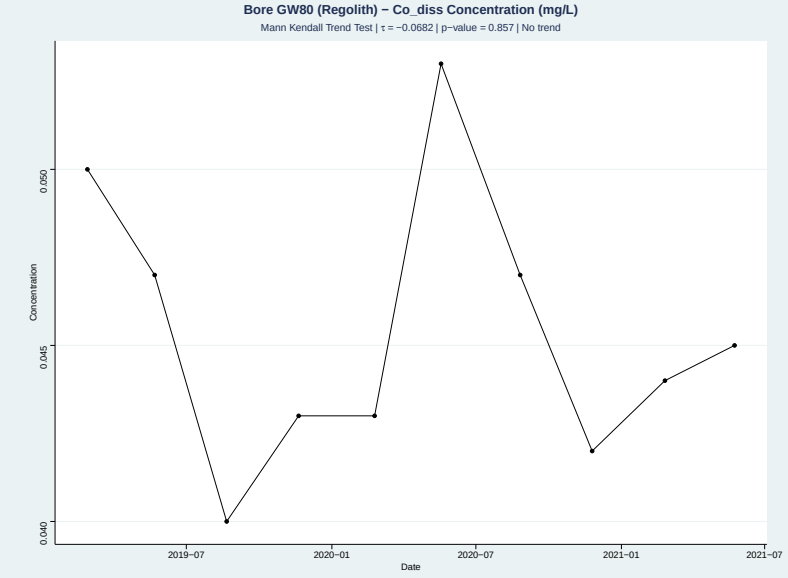
Appendix C Groundwater Quality Time Series

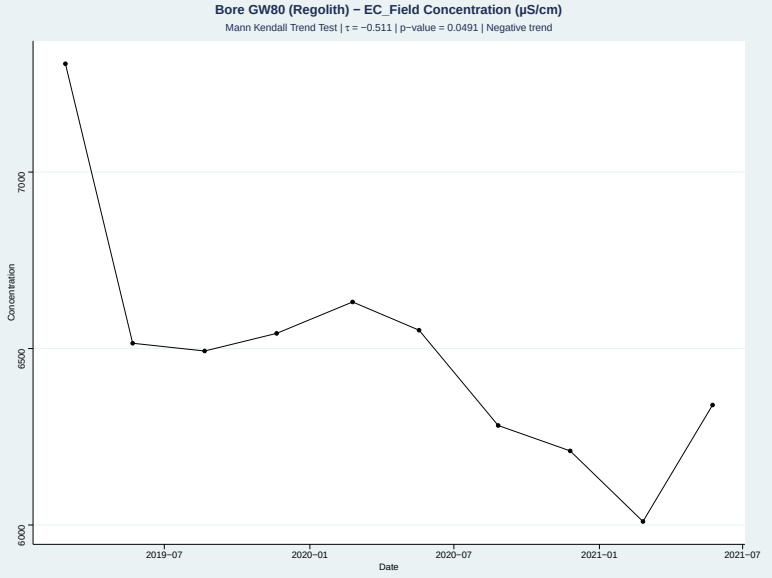




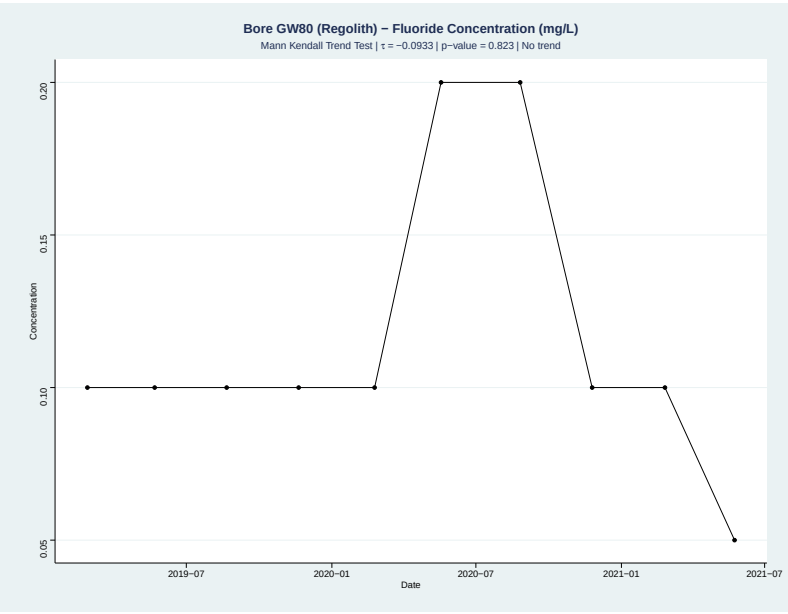


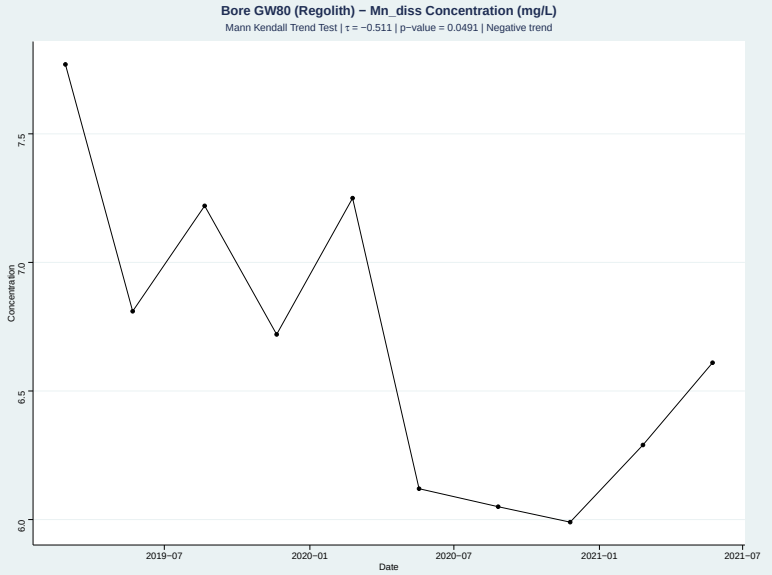


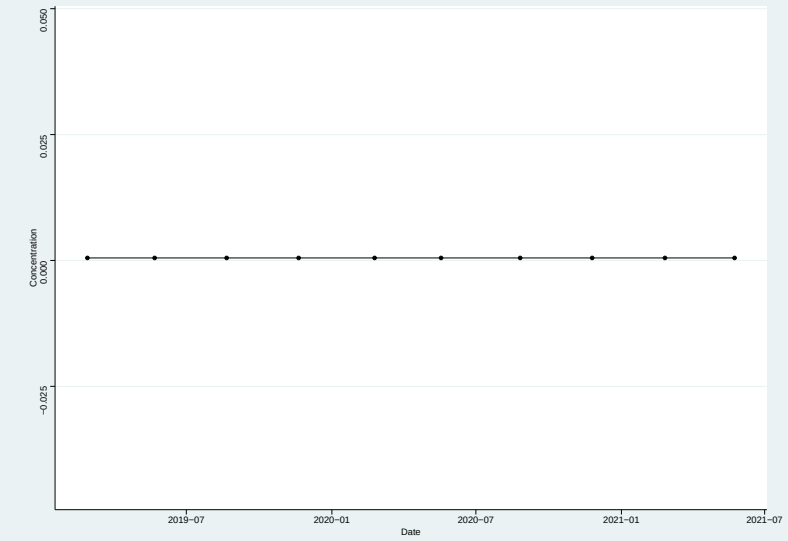


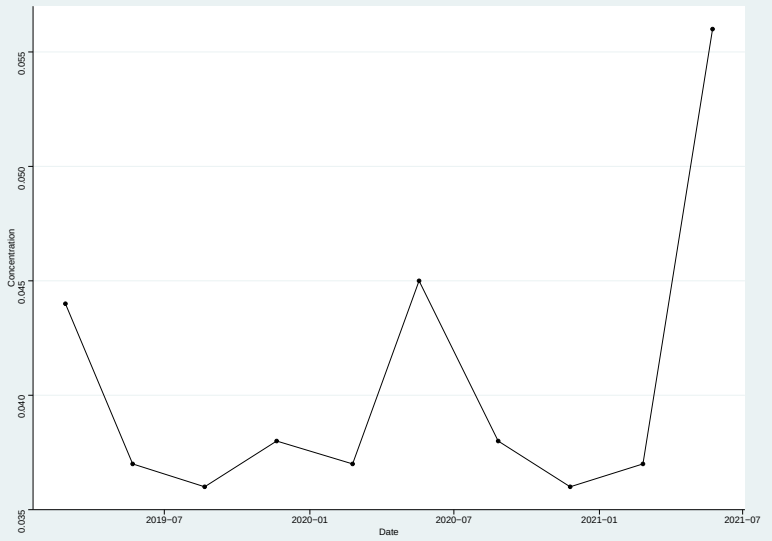


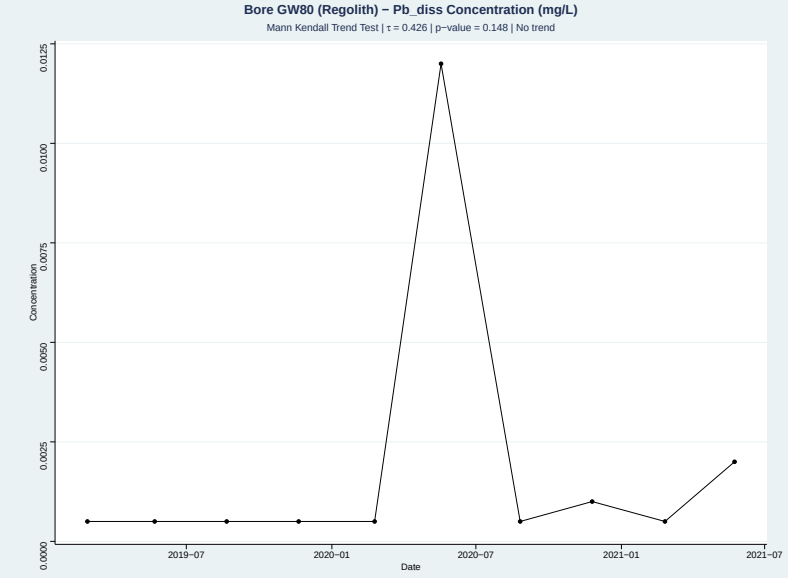
Appendix C Groundwater Quality Time Series

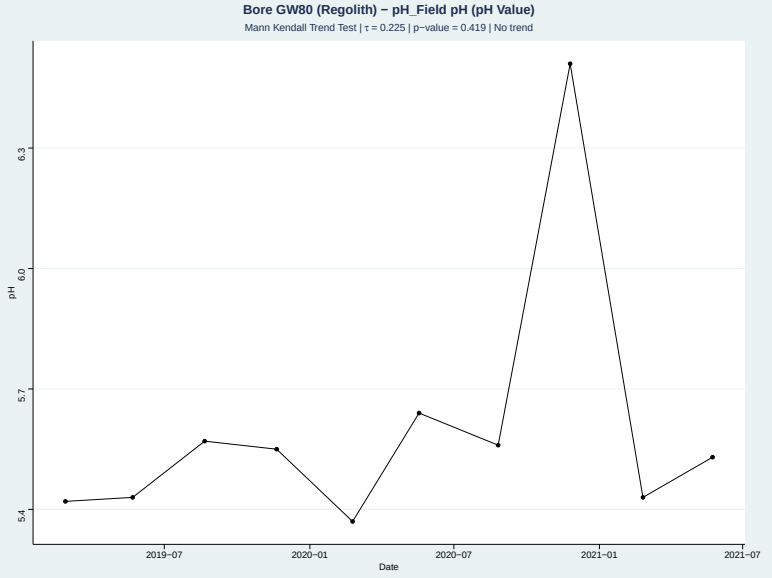




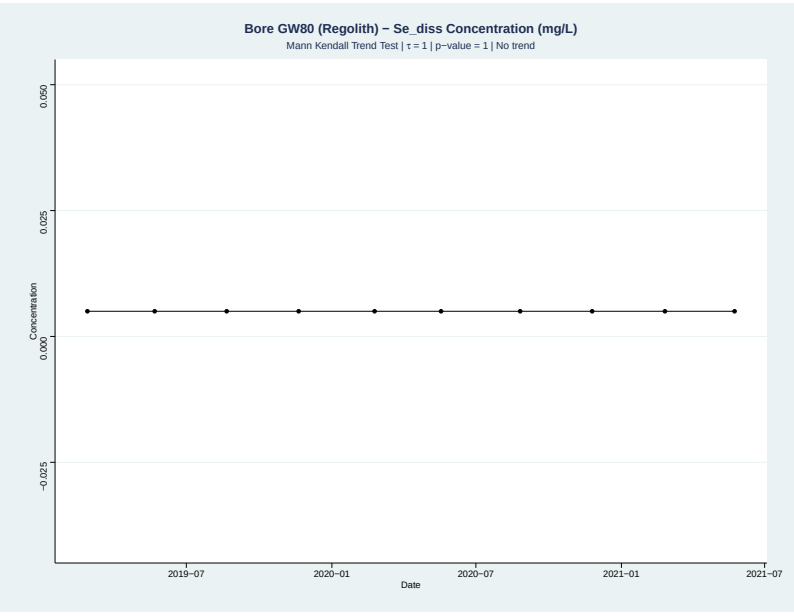


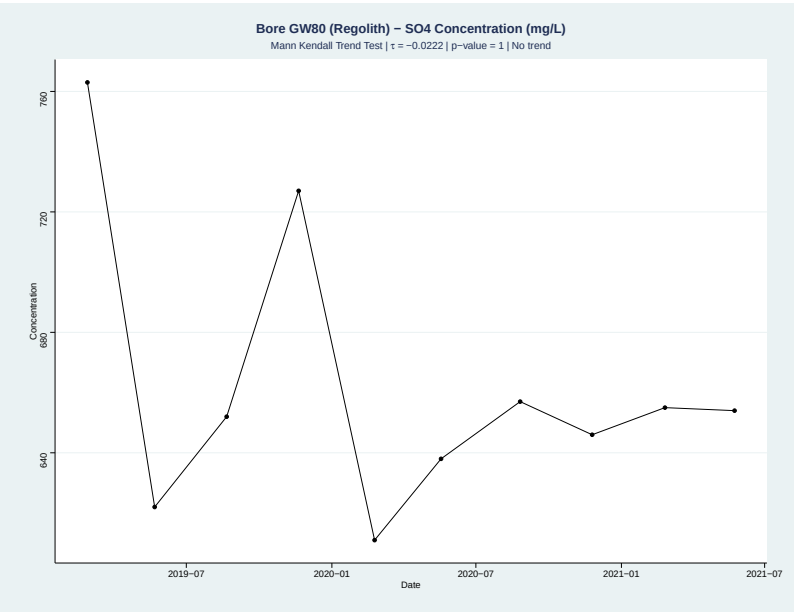


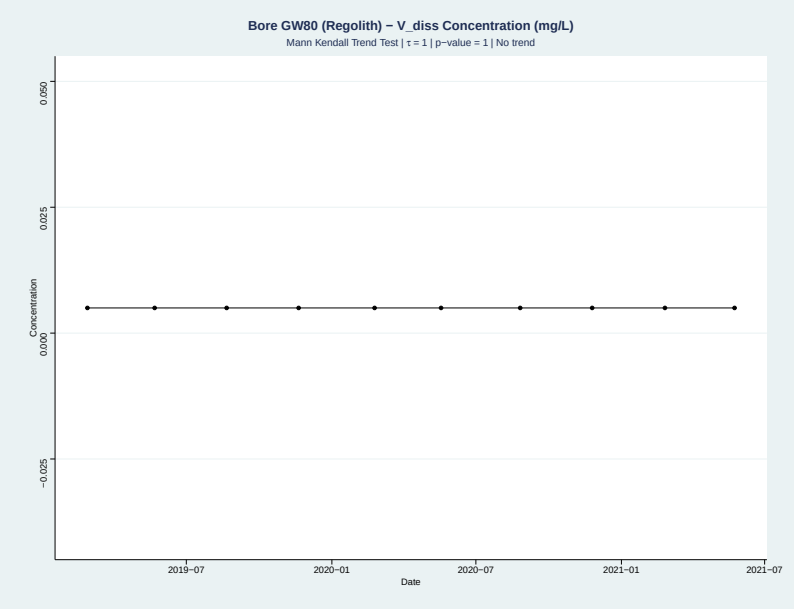


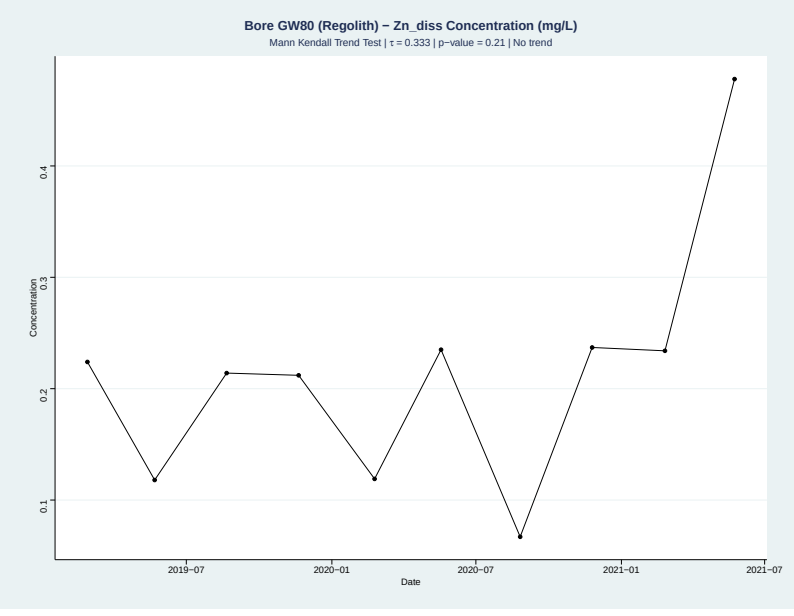


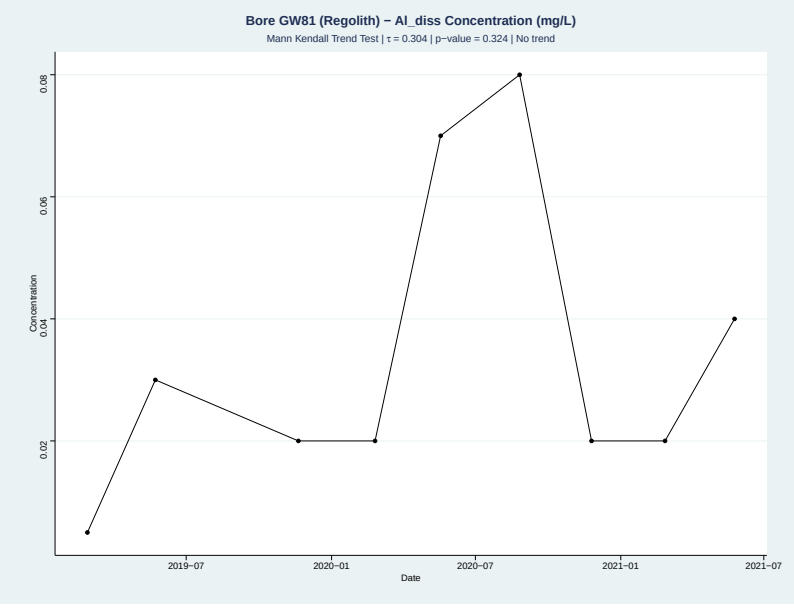
Appendix C Groundwater Quality Time Series

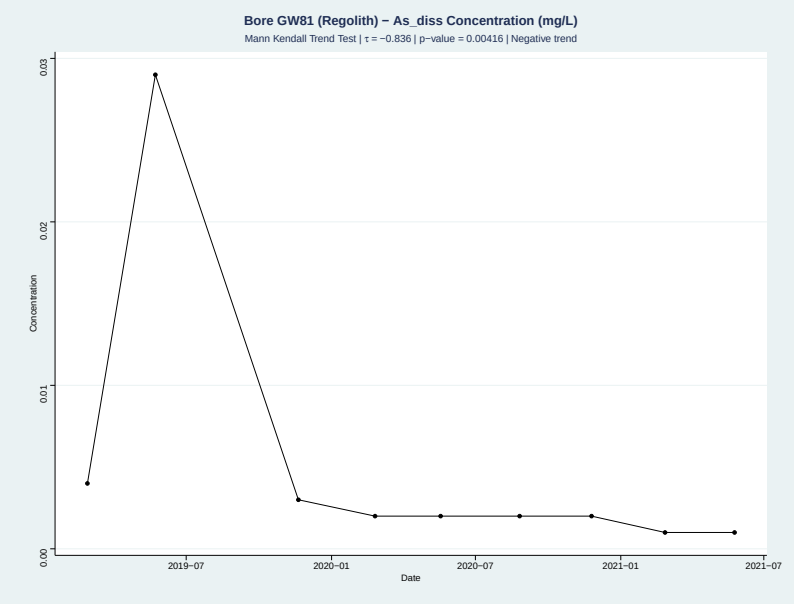




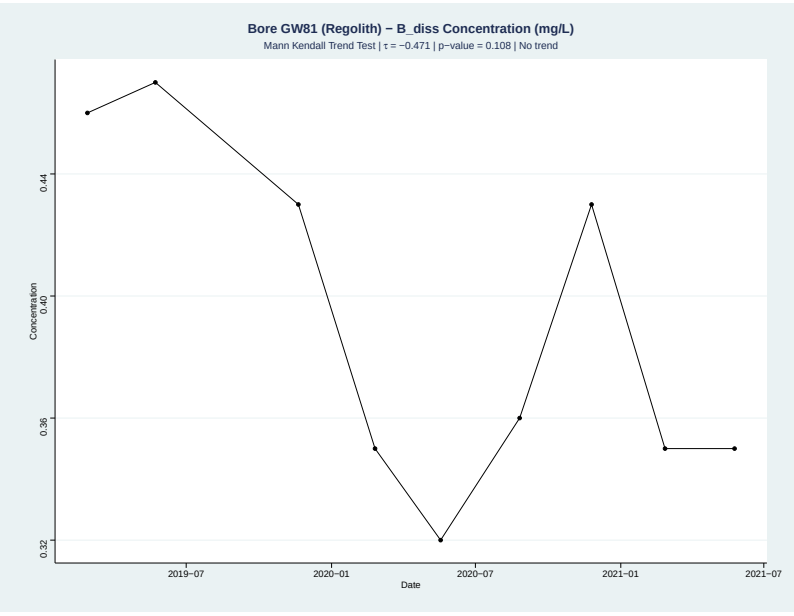


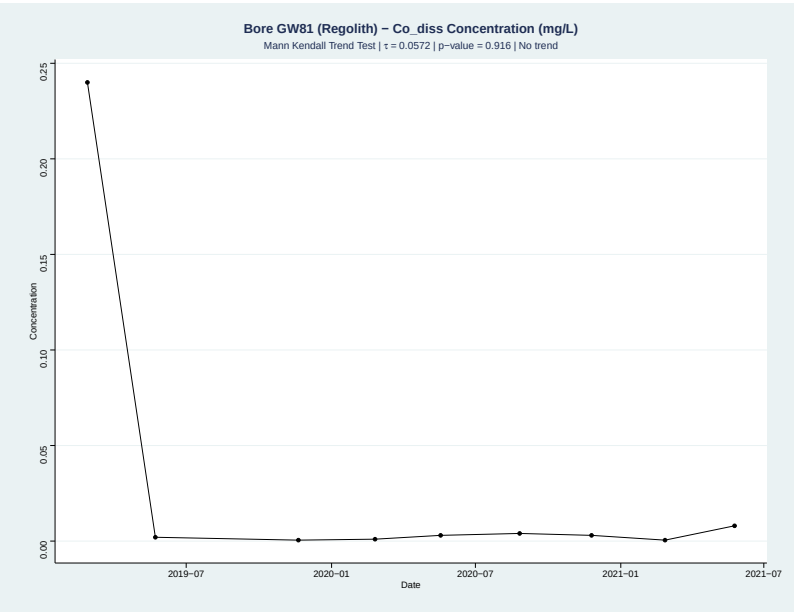


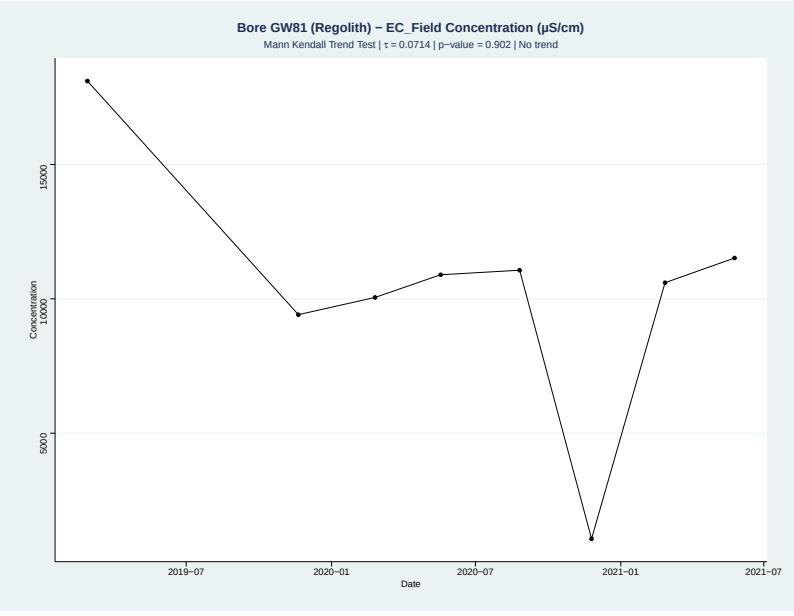


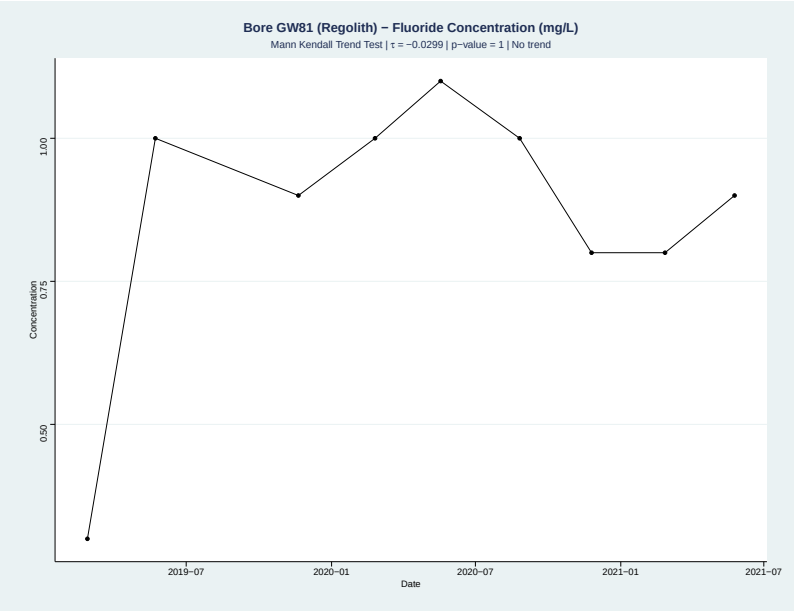


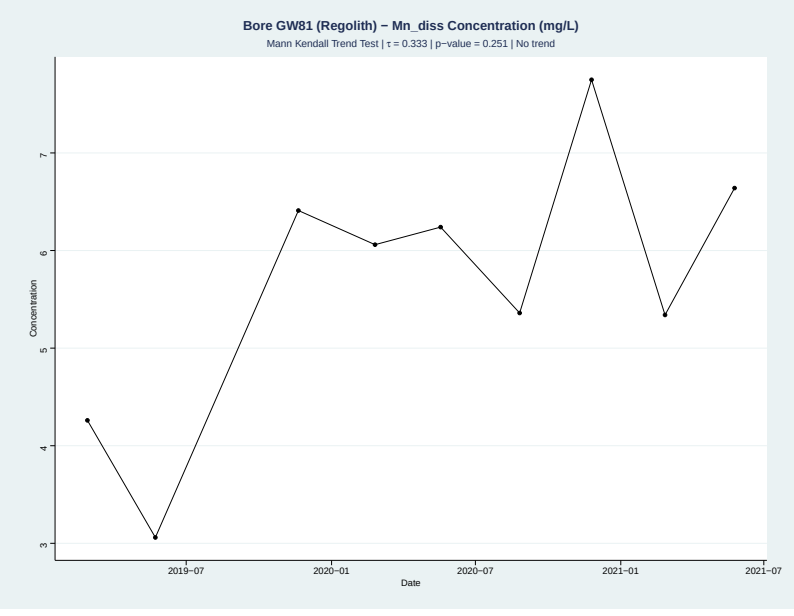
Appendix C Groundwater Quality Time Series

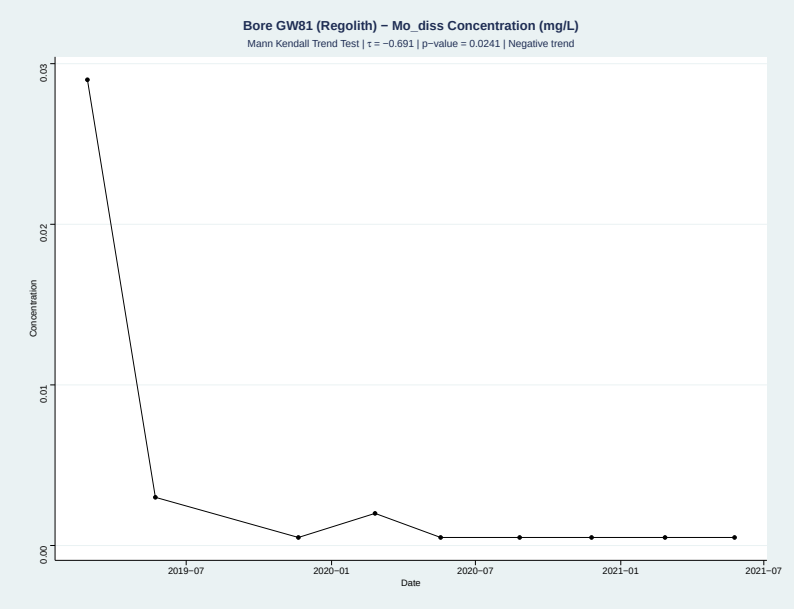




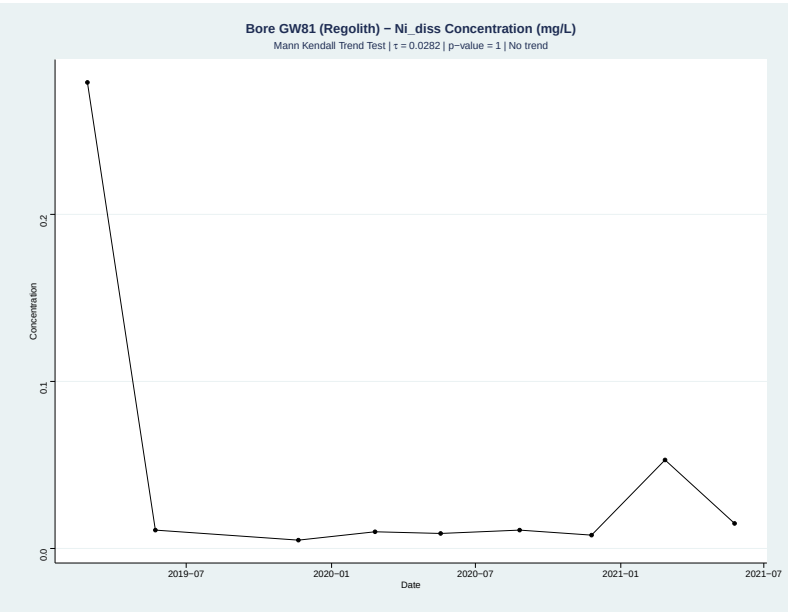


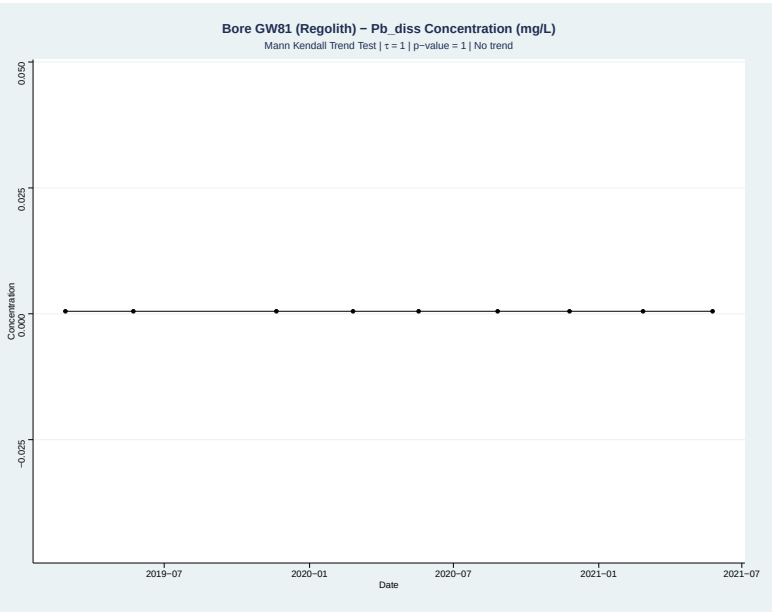


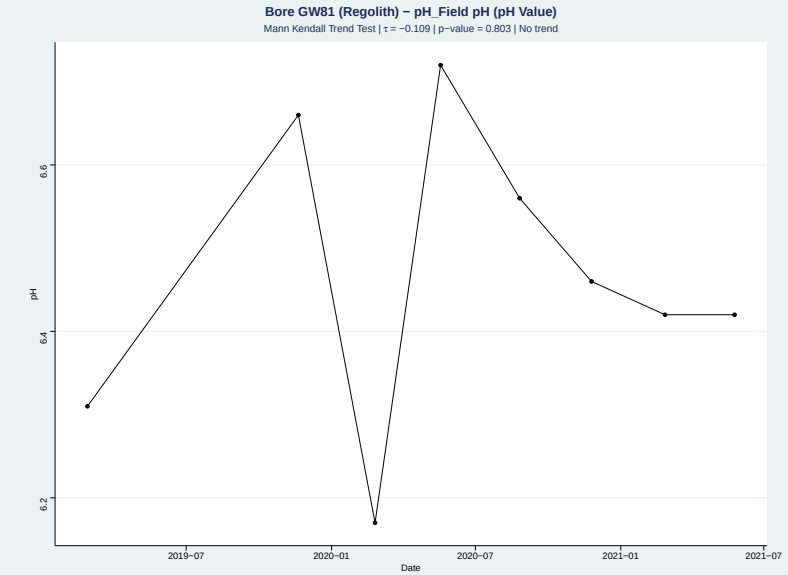


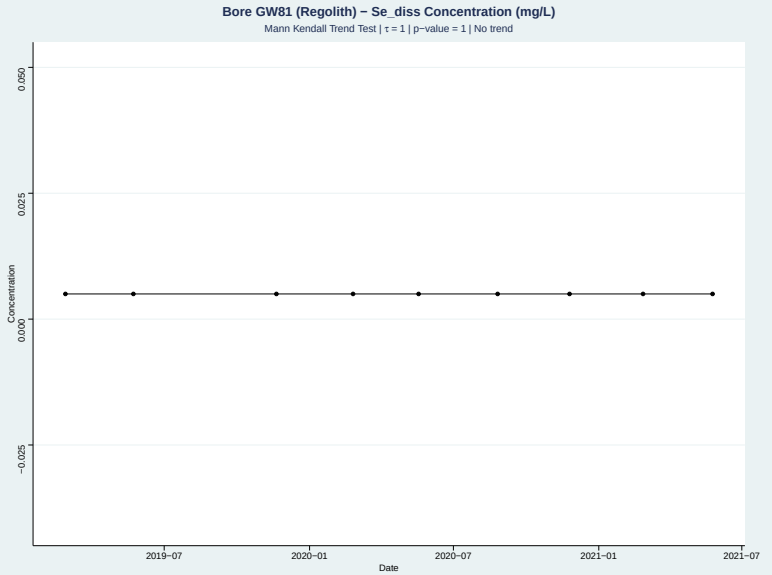


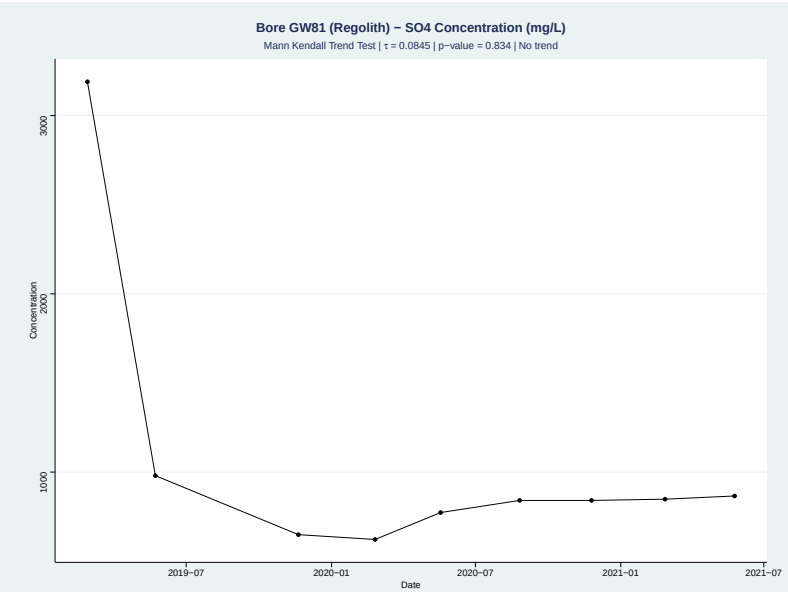
Appendix C Groundwater Quality Time Series

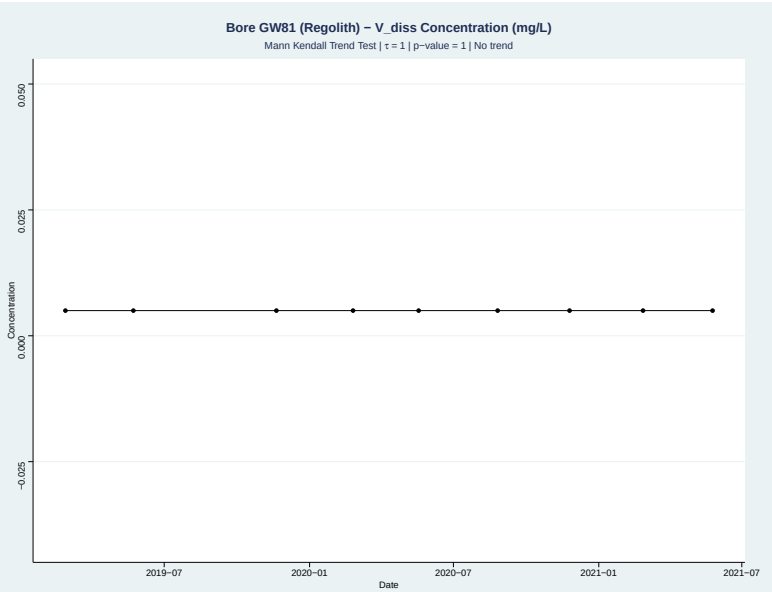




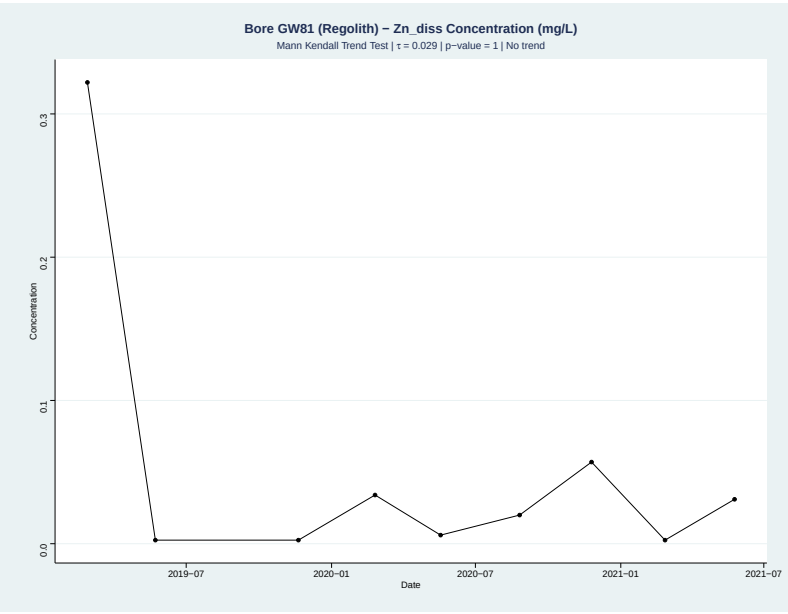


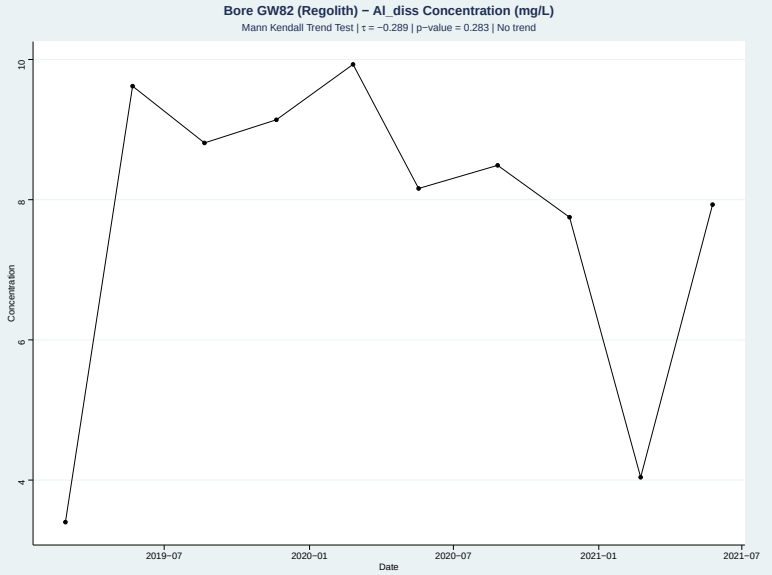


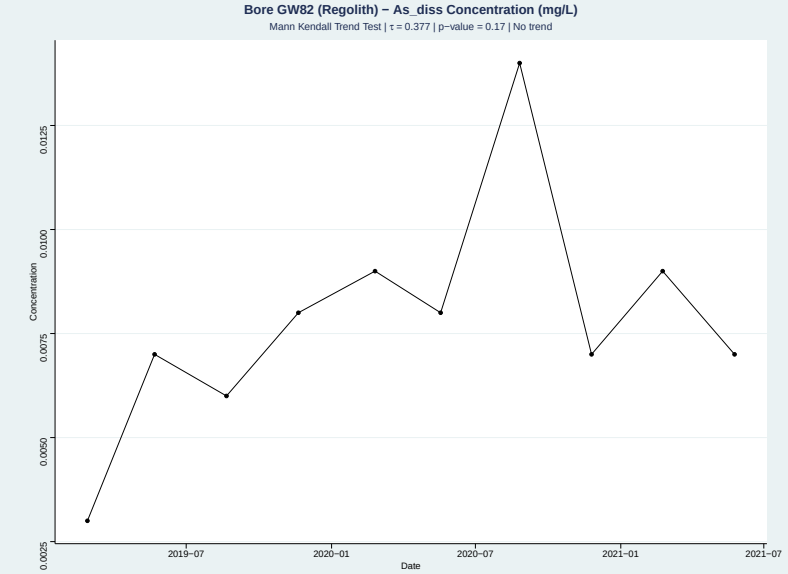


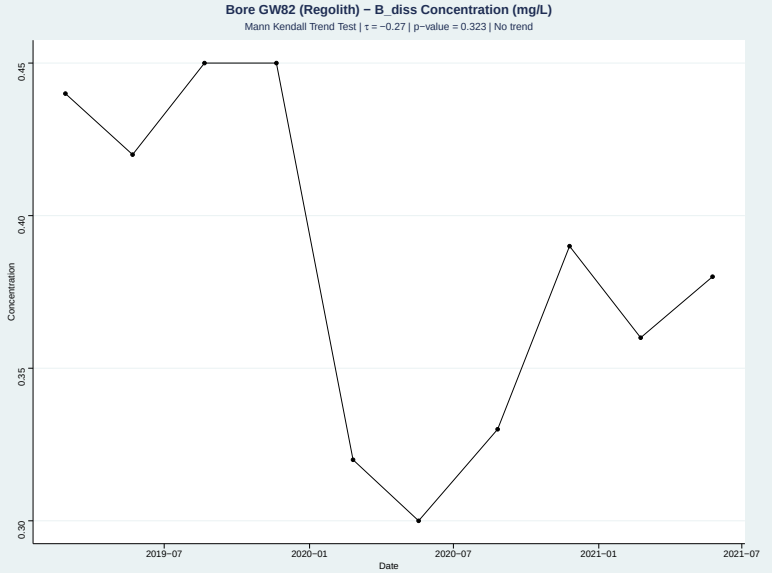


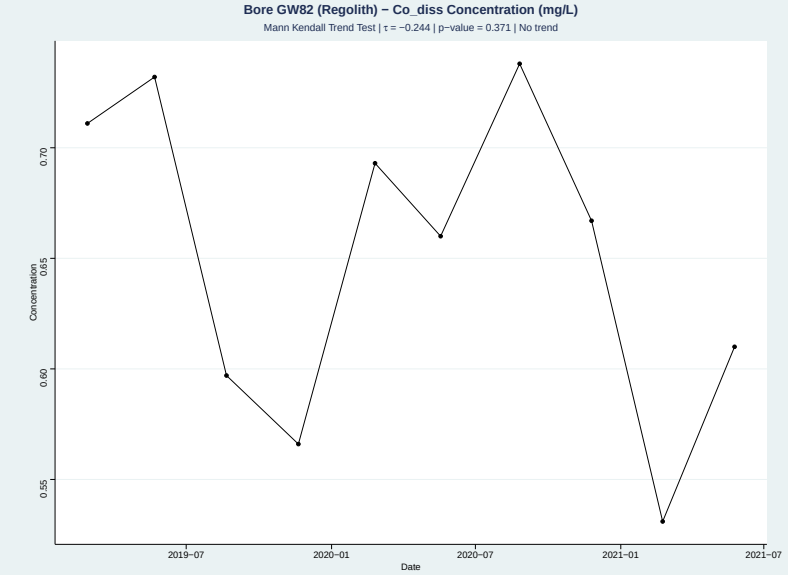
Appendix C Groundwater Quality Time Series

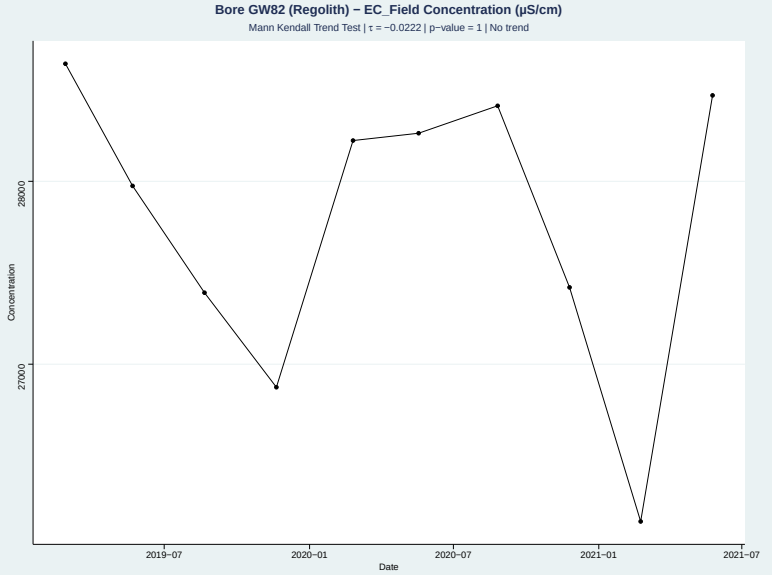




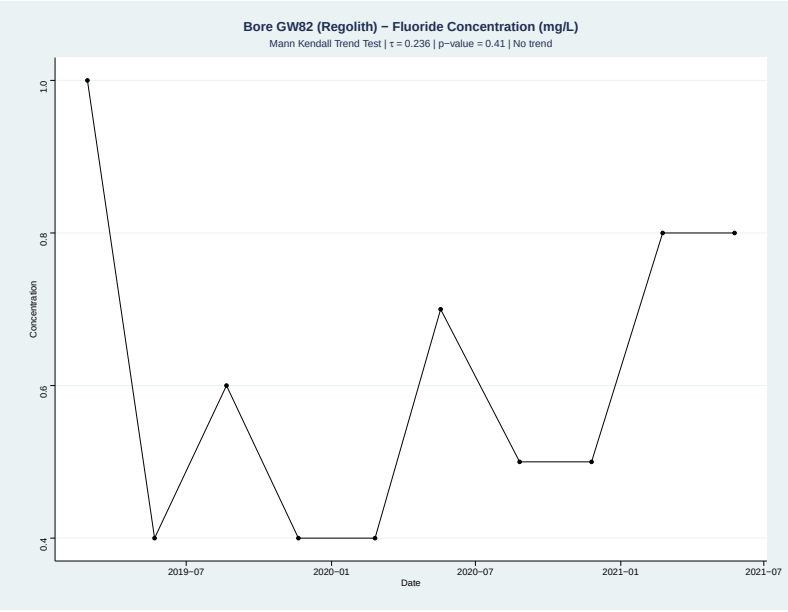


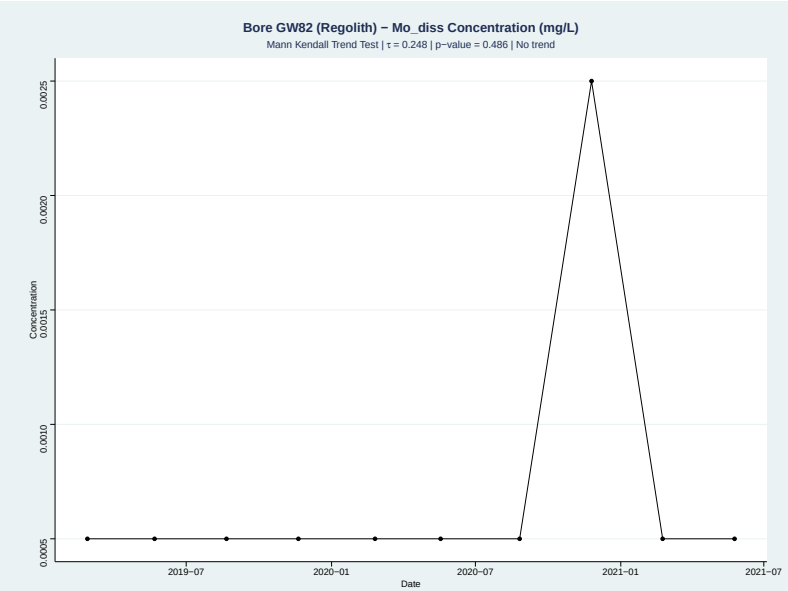


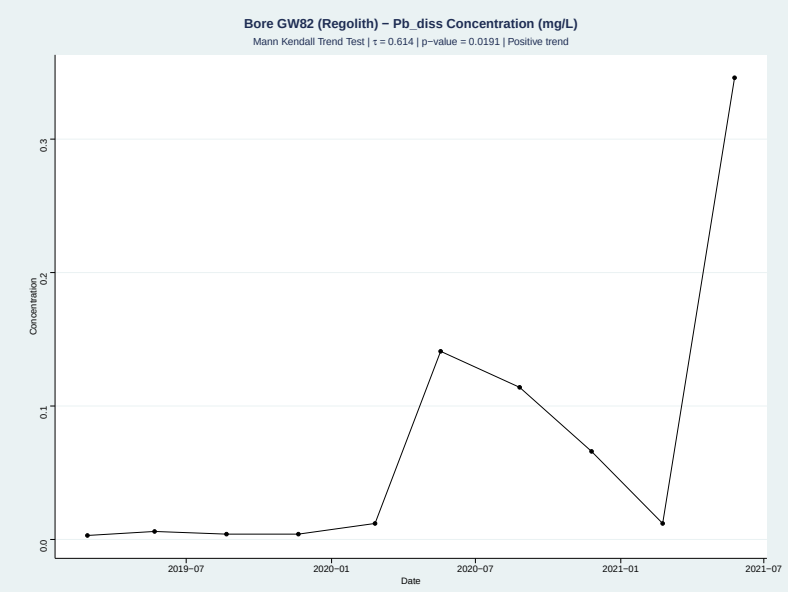


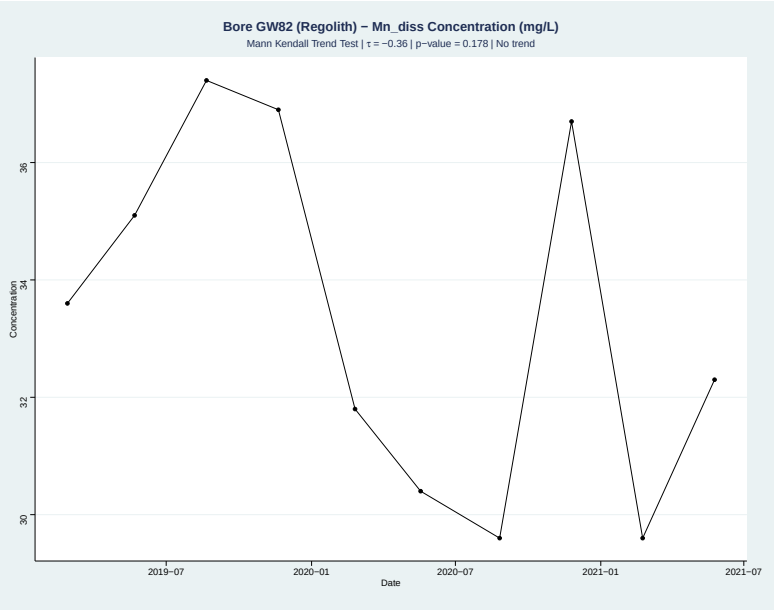


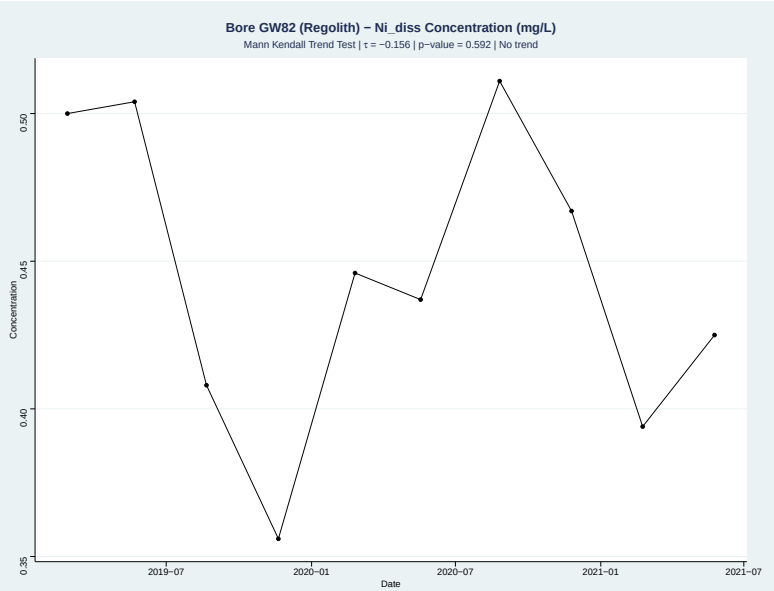
Appendix C Groundwater Quality Time Series

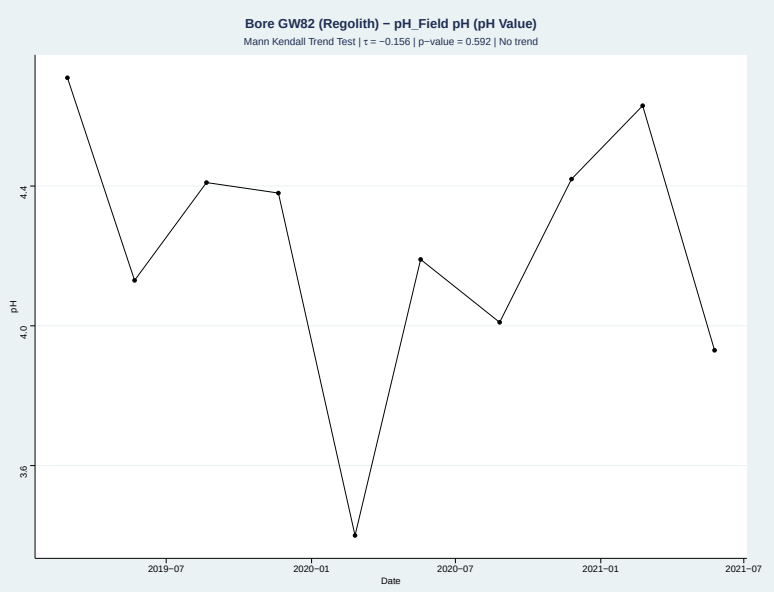




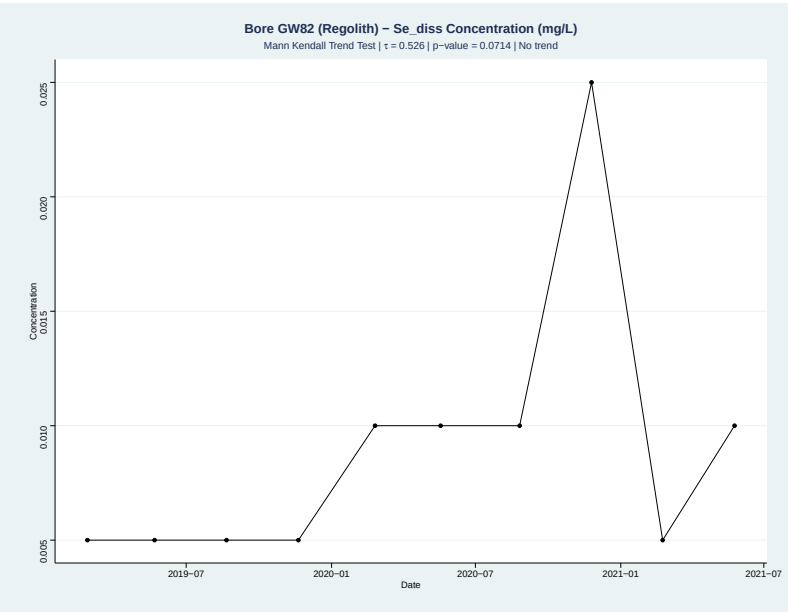


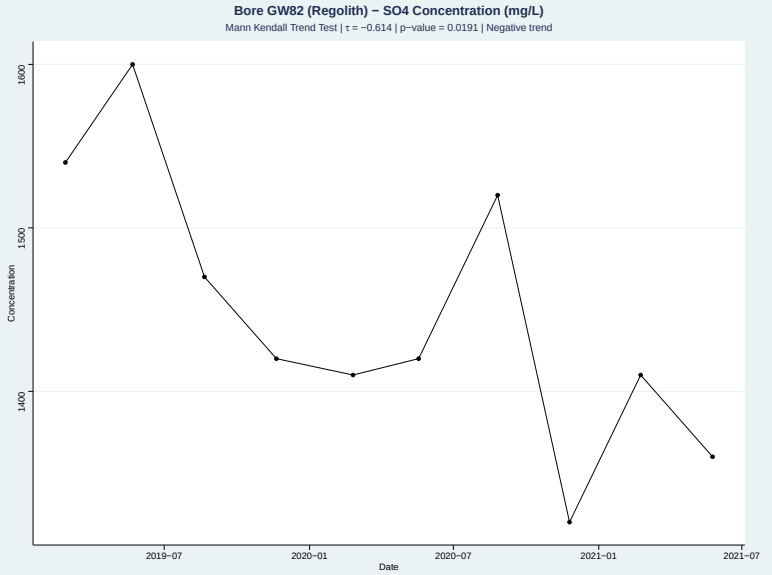


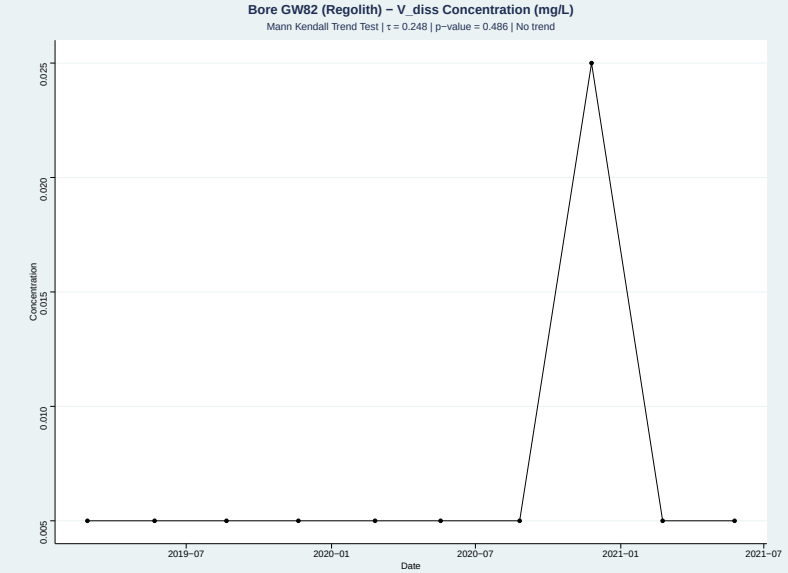


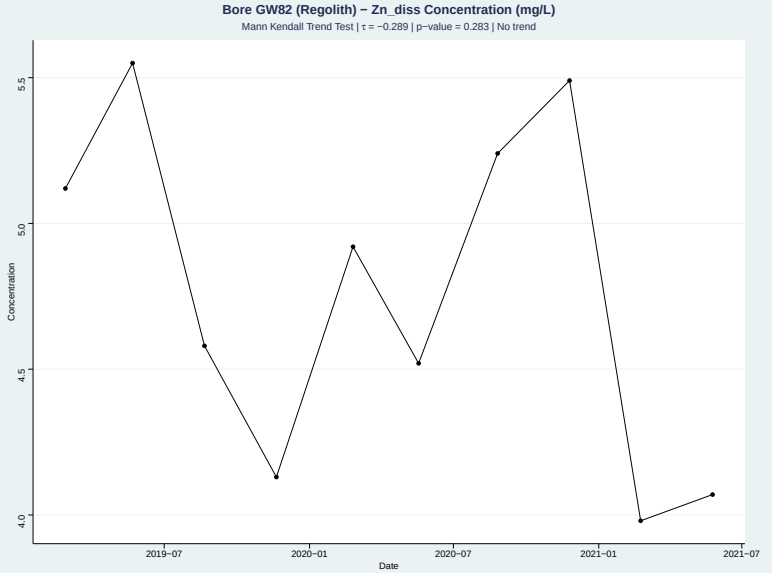


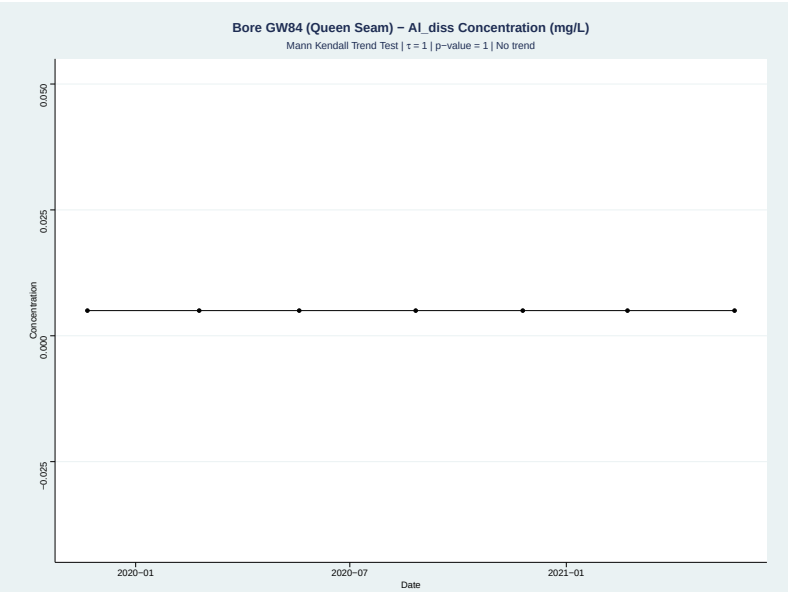
Appendix C Groundwater Quality Time Series

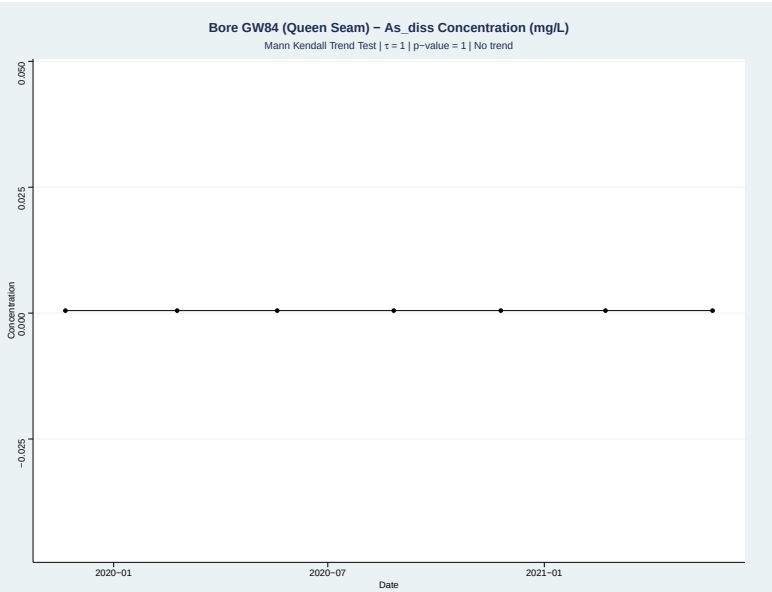




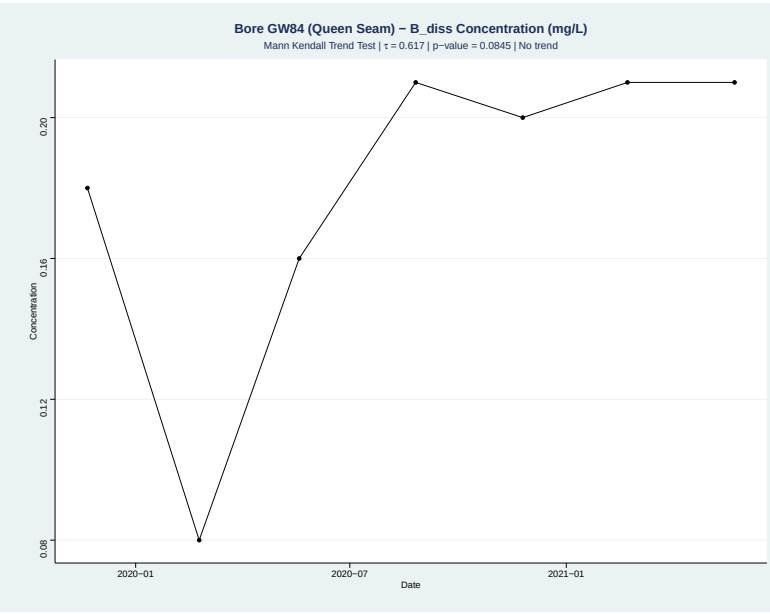


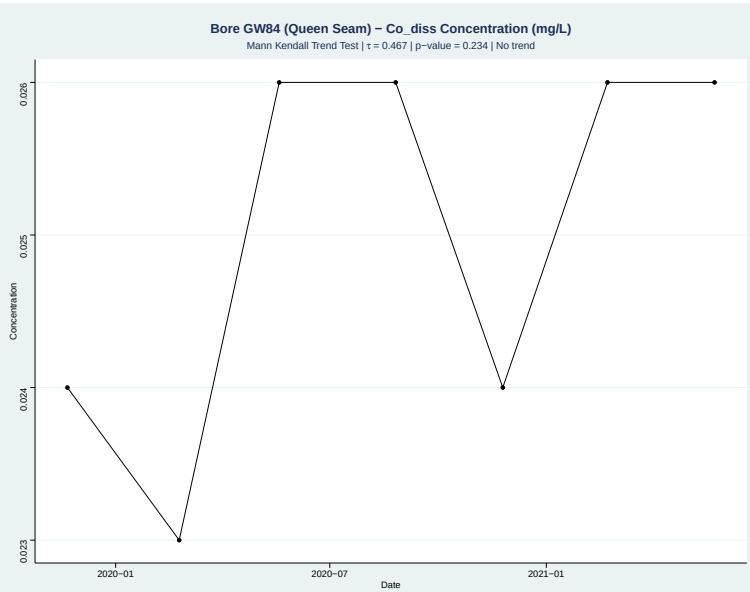


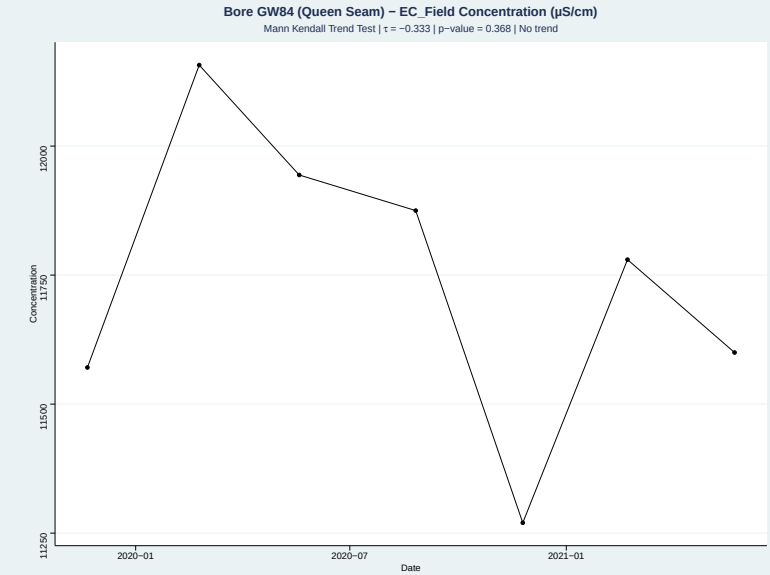


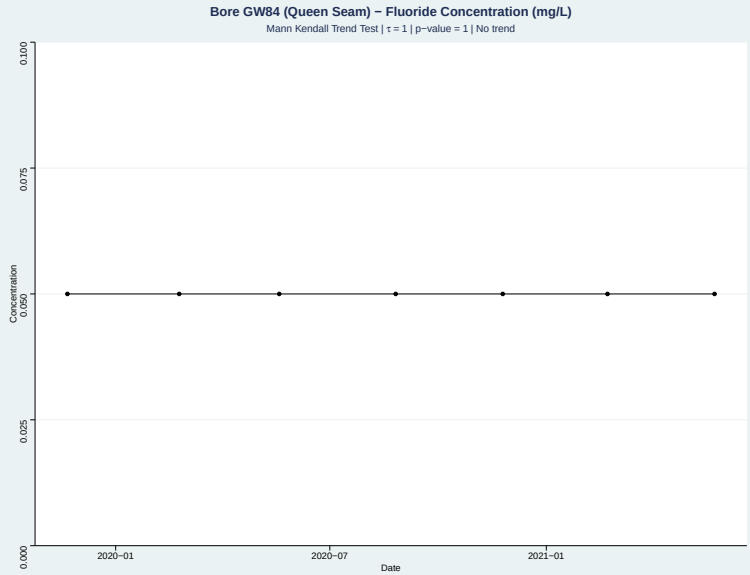


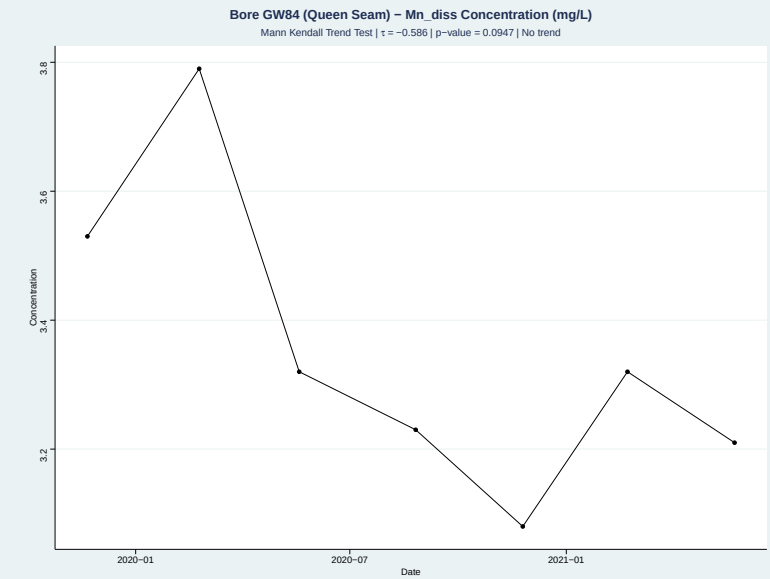
Appendix C Groundwater Quality Time Series

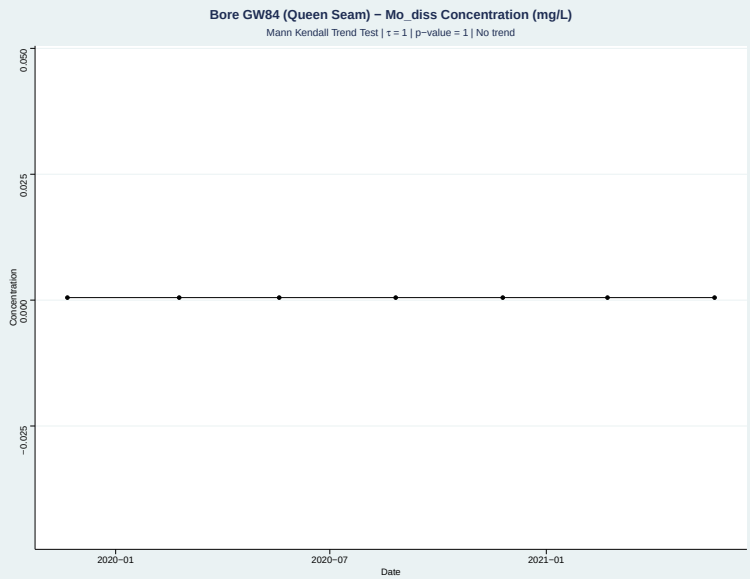












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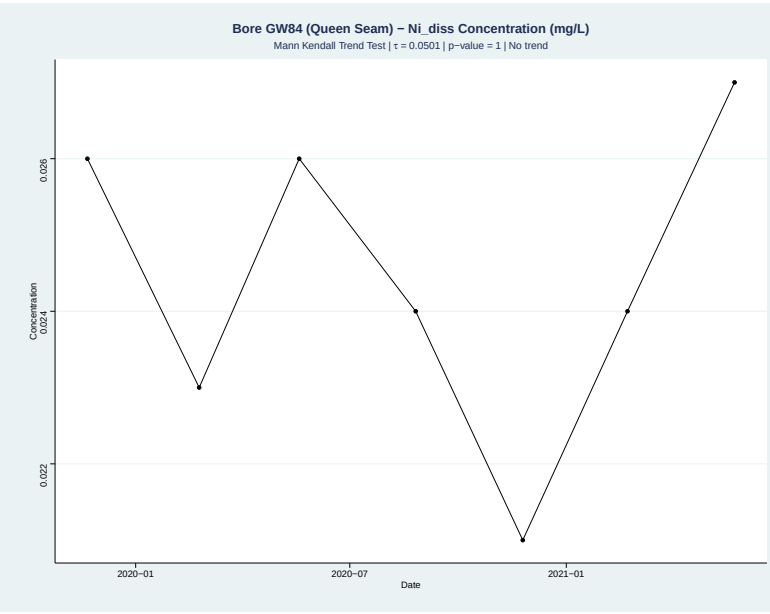

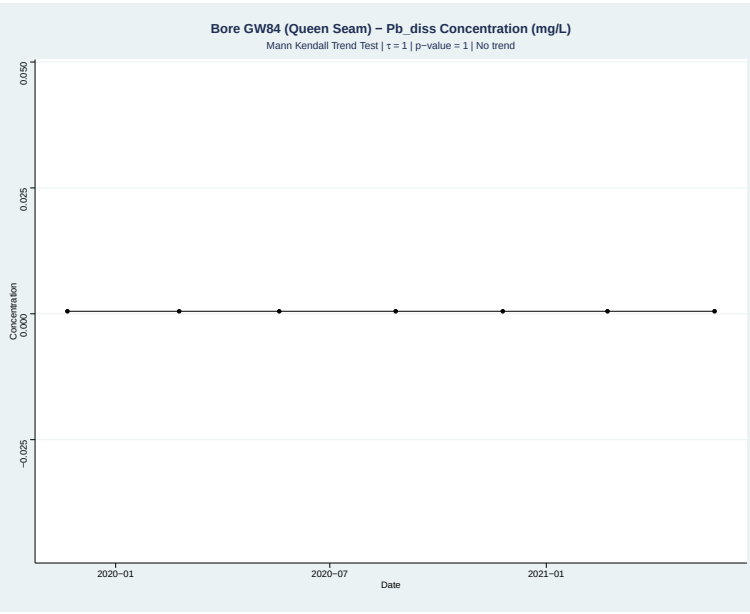

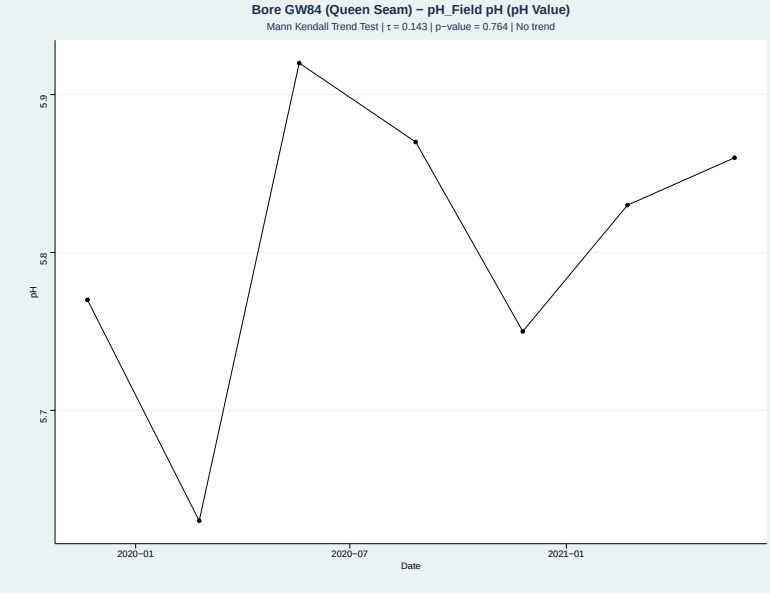

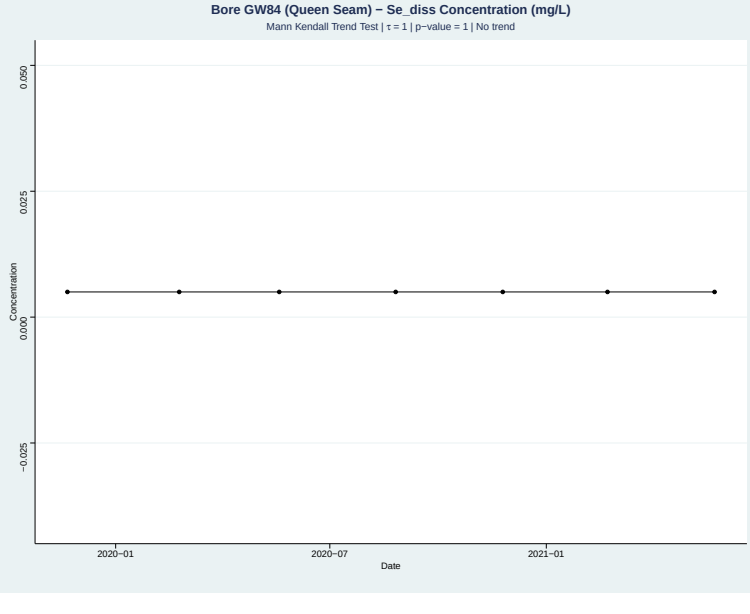

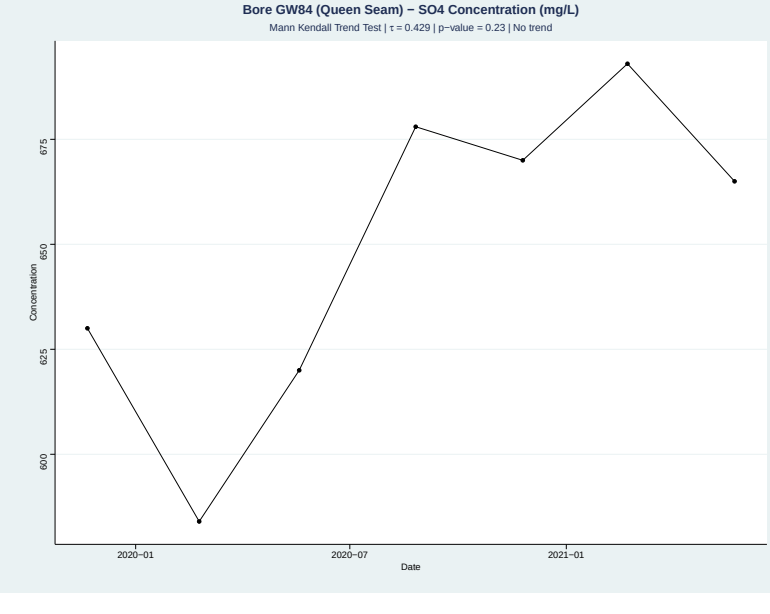

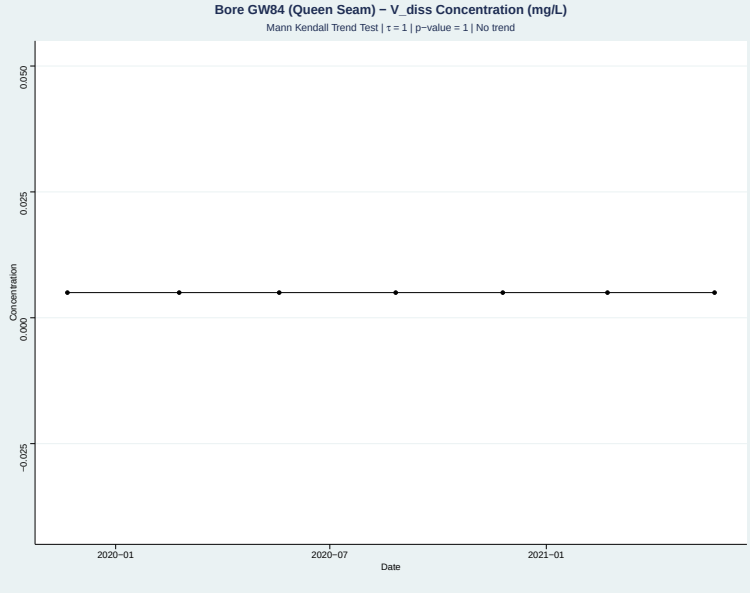

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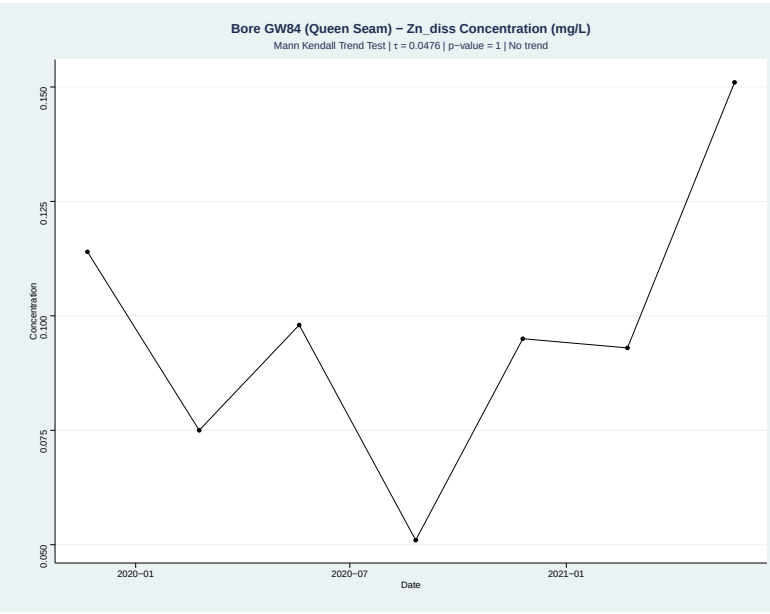

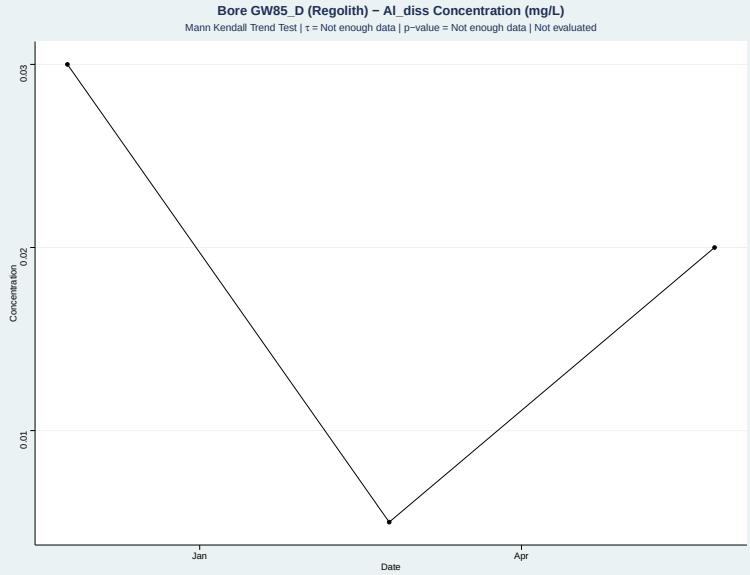

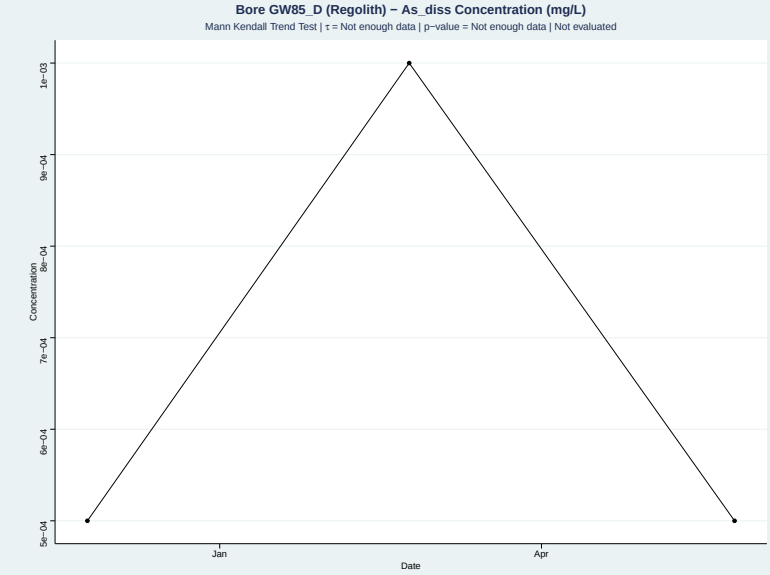

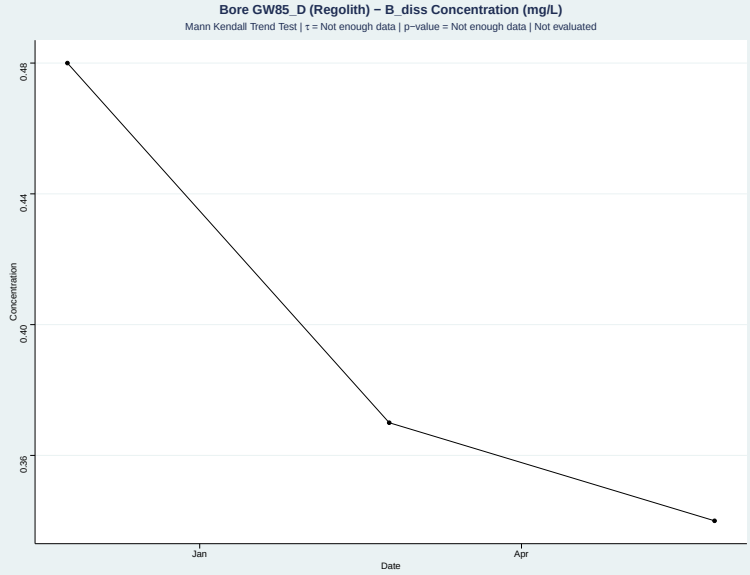

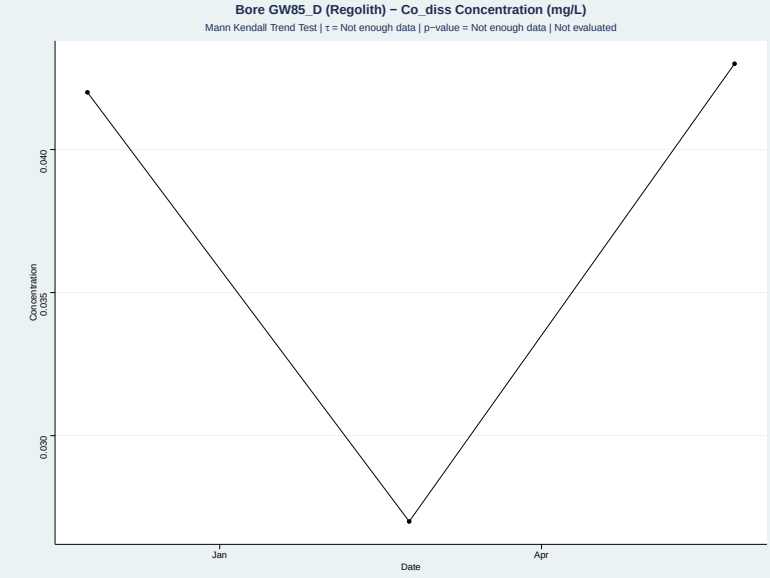

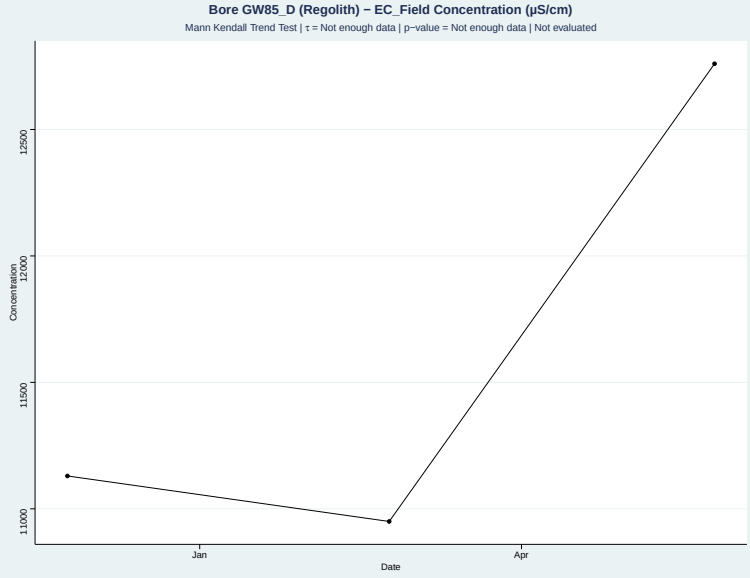

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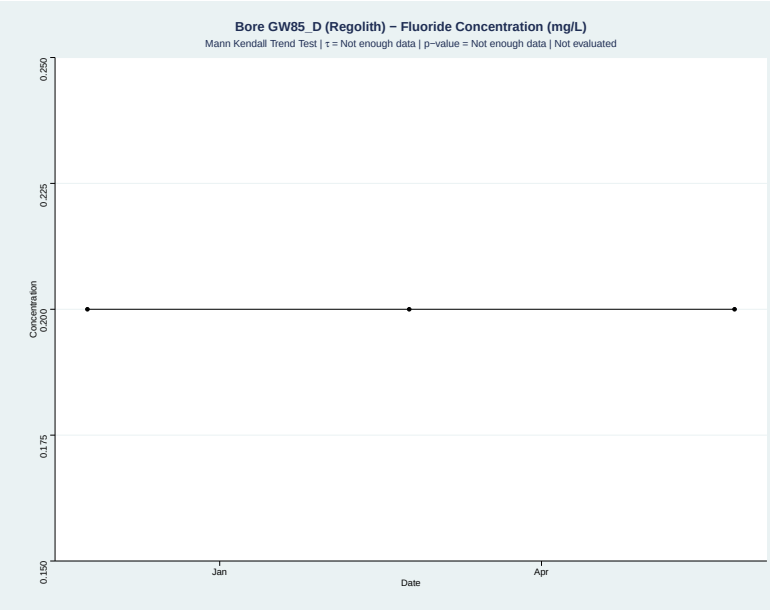
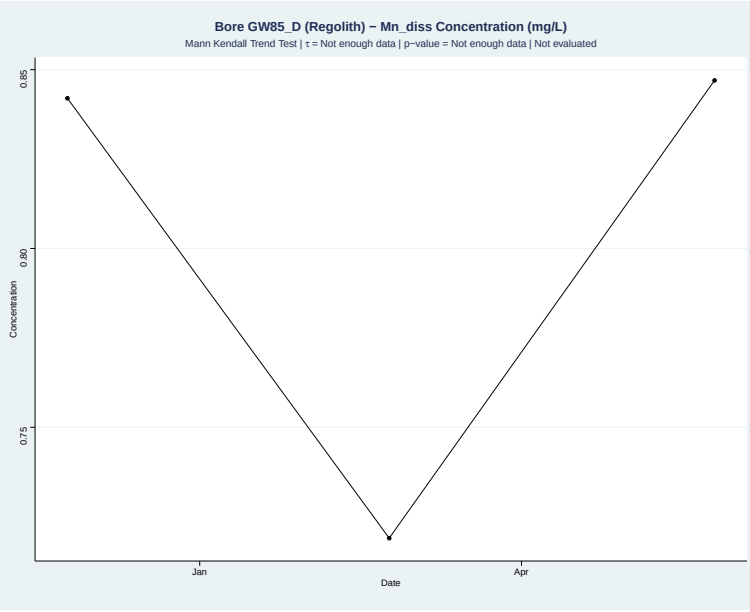
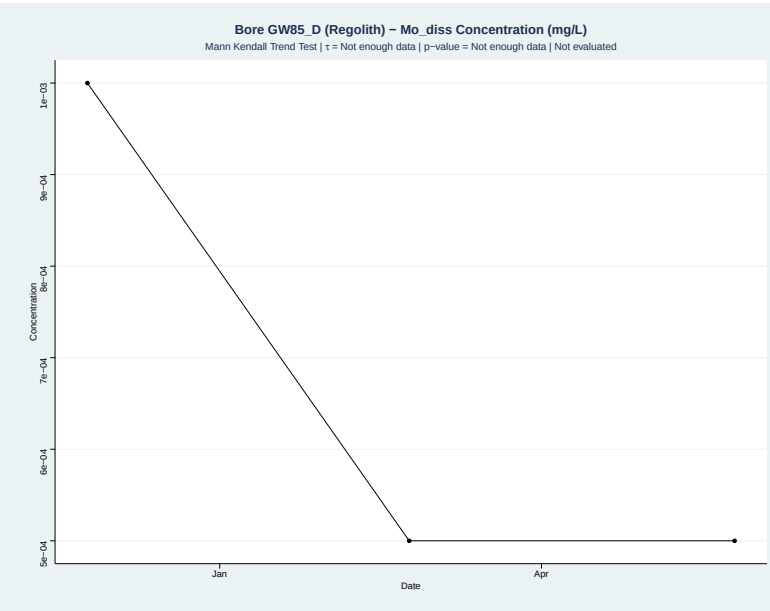
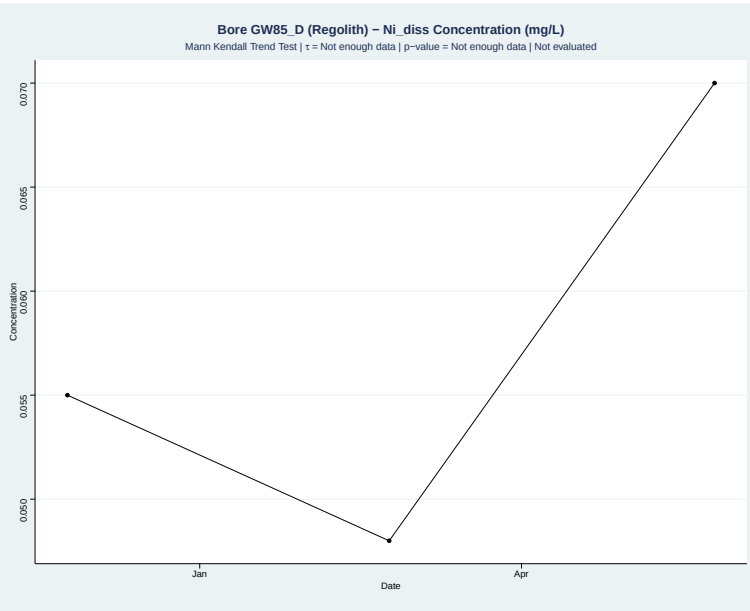
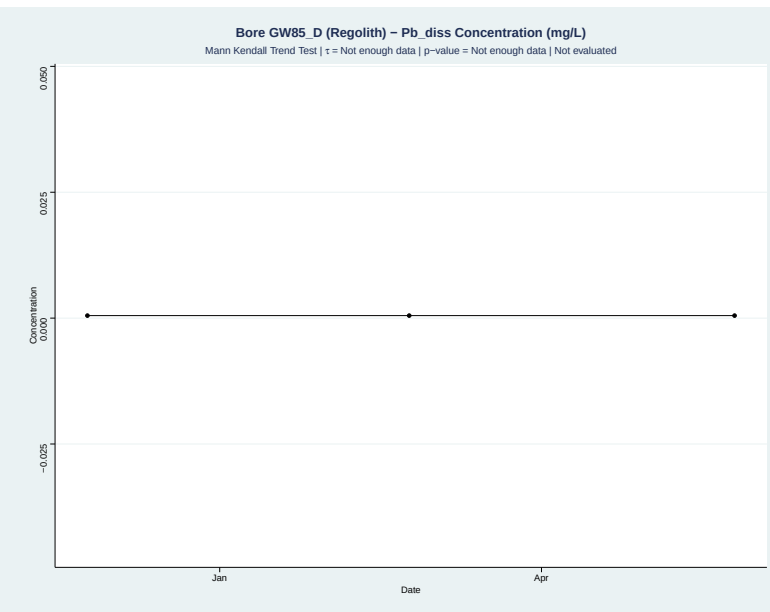
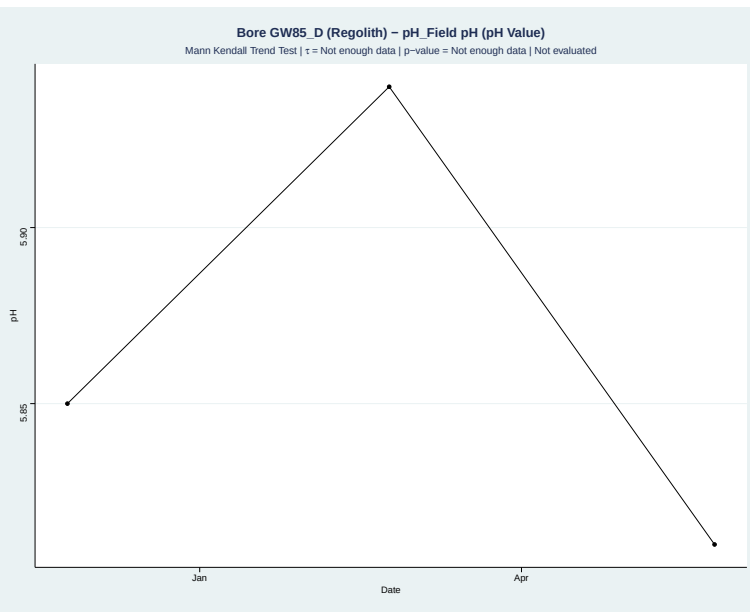




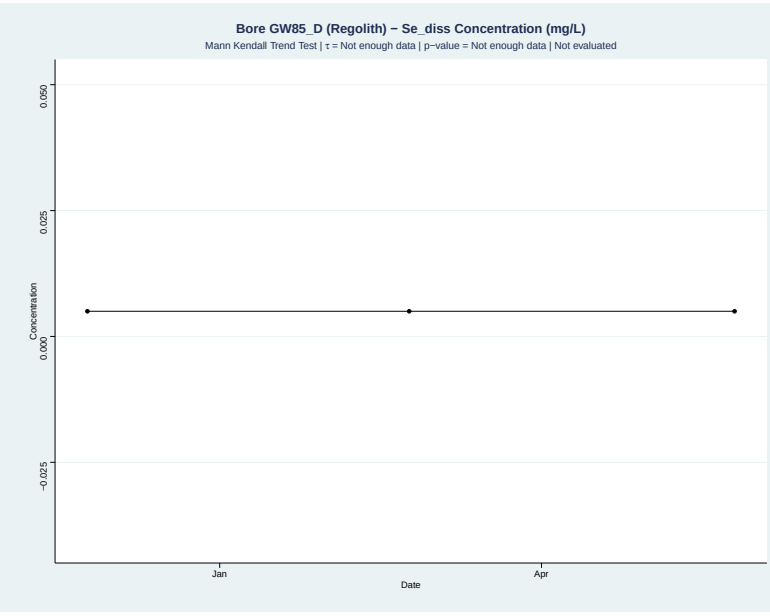


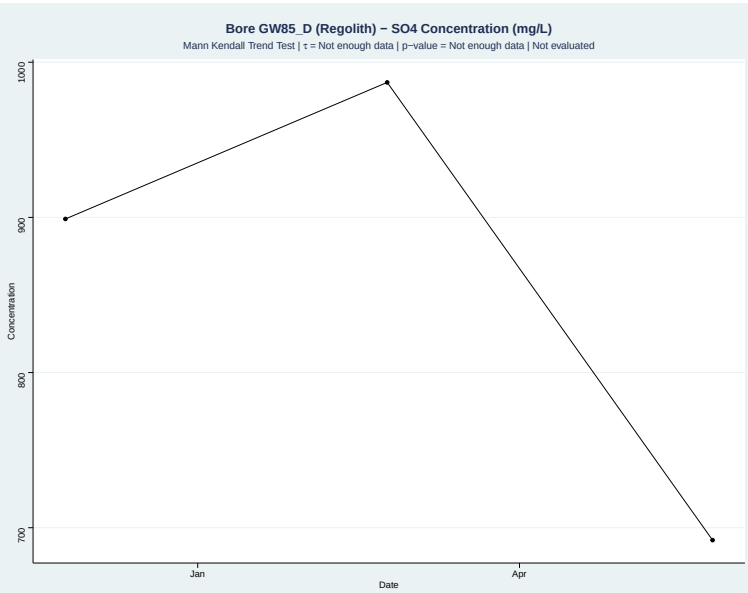


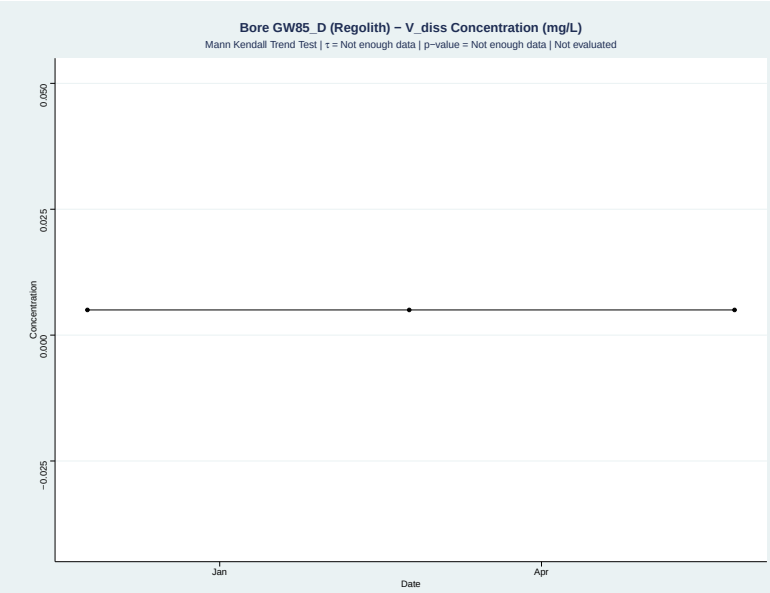


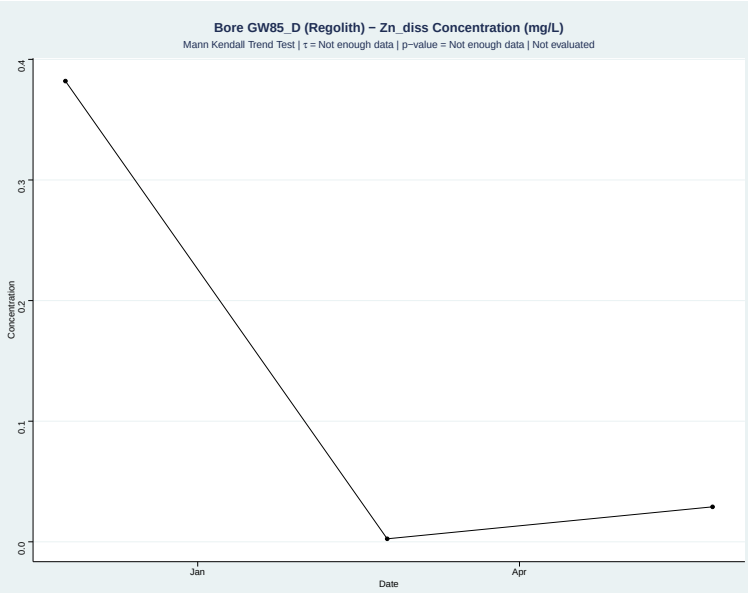


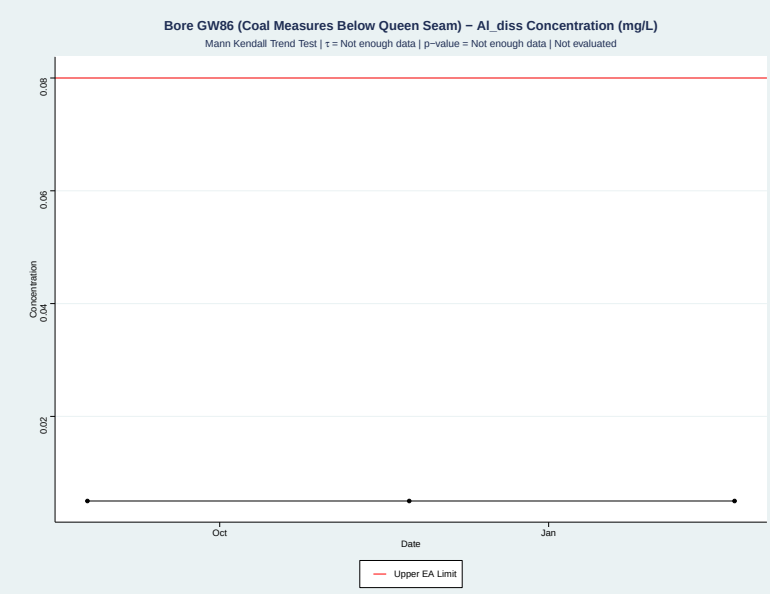
Appendix C Groundwater Quality Time Series

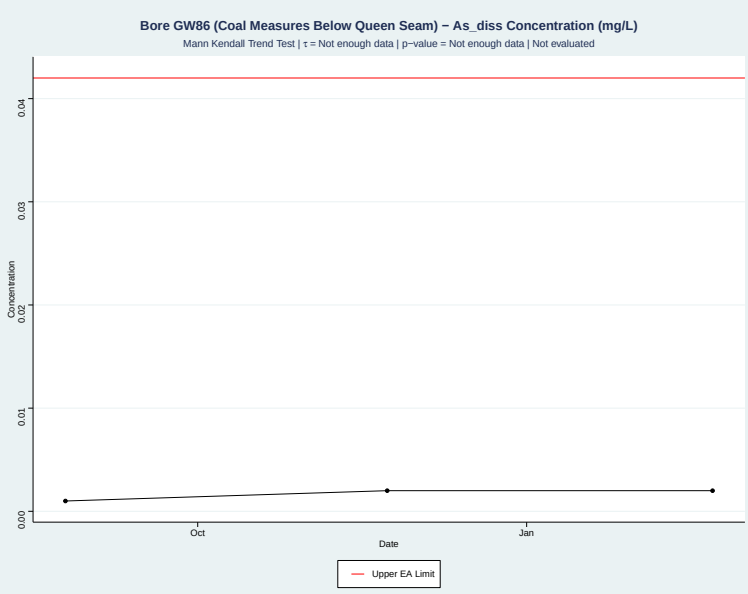




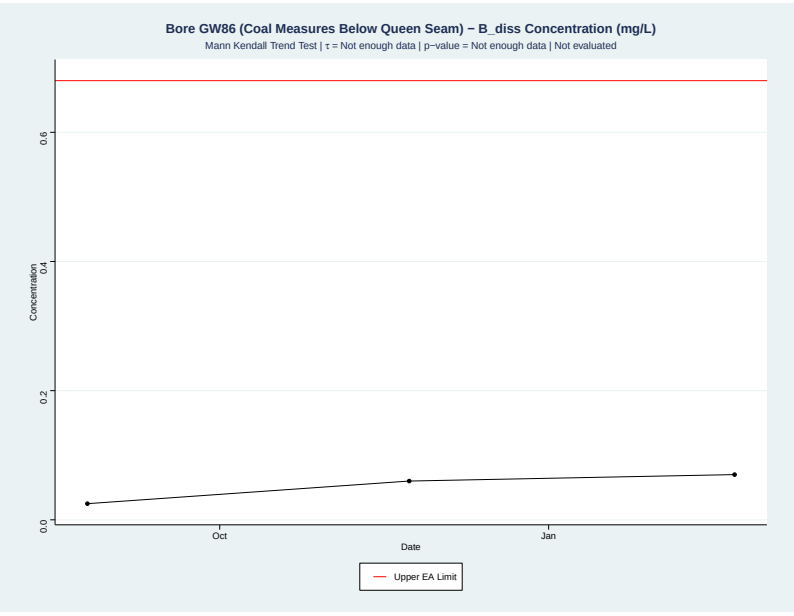


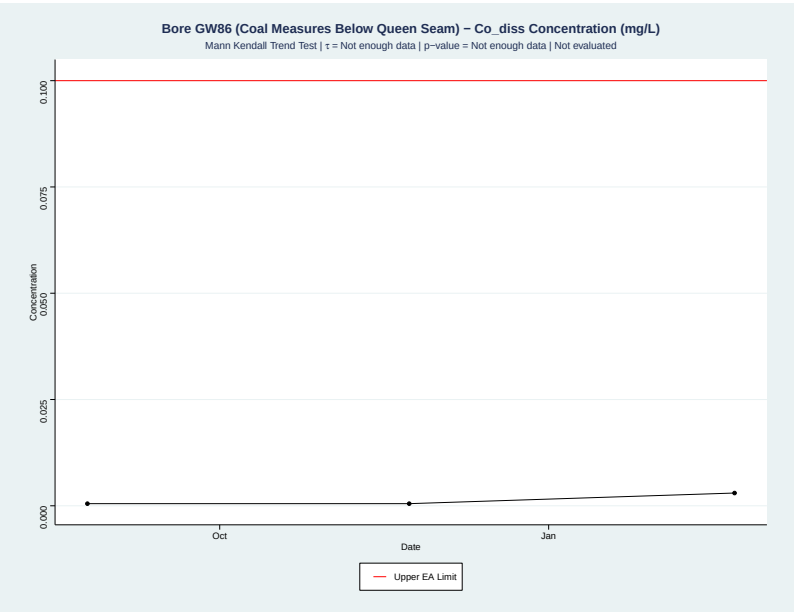


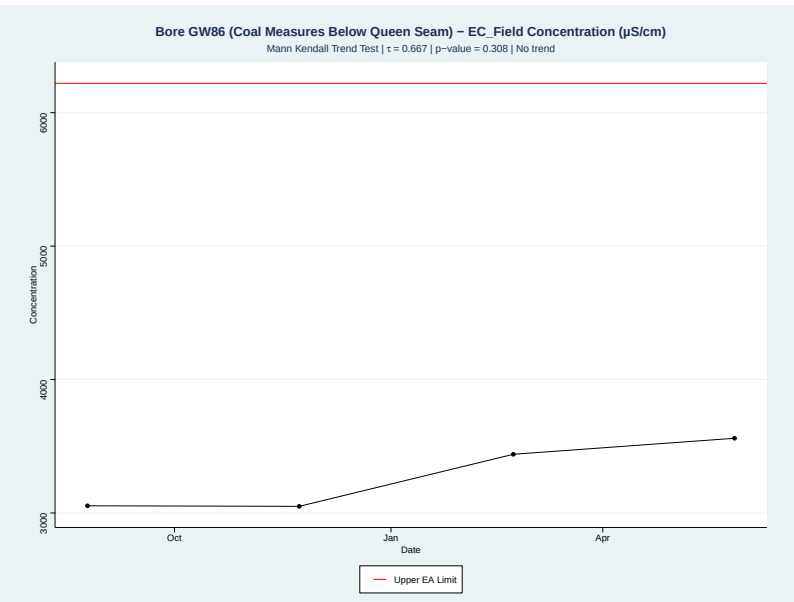


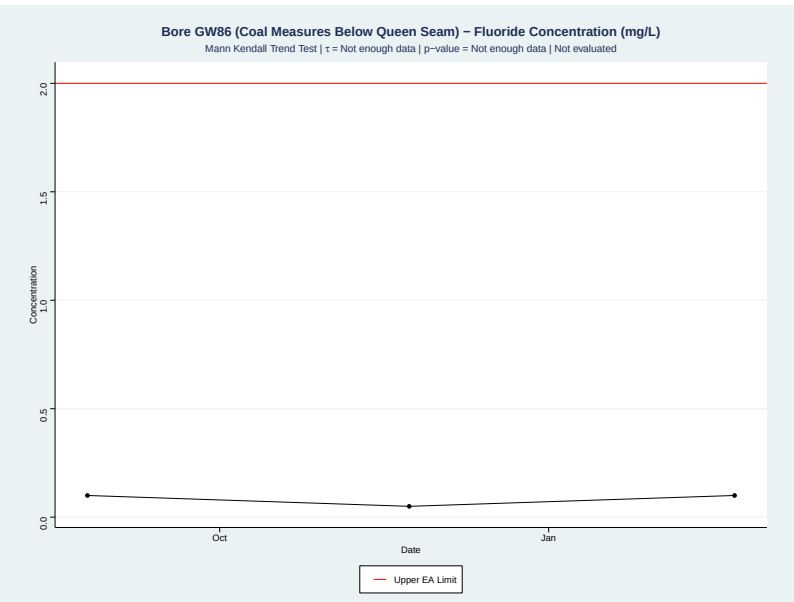


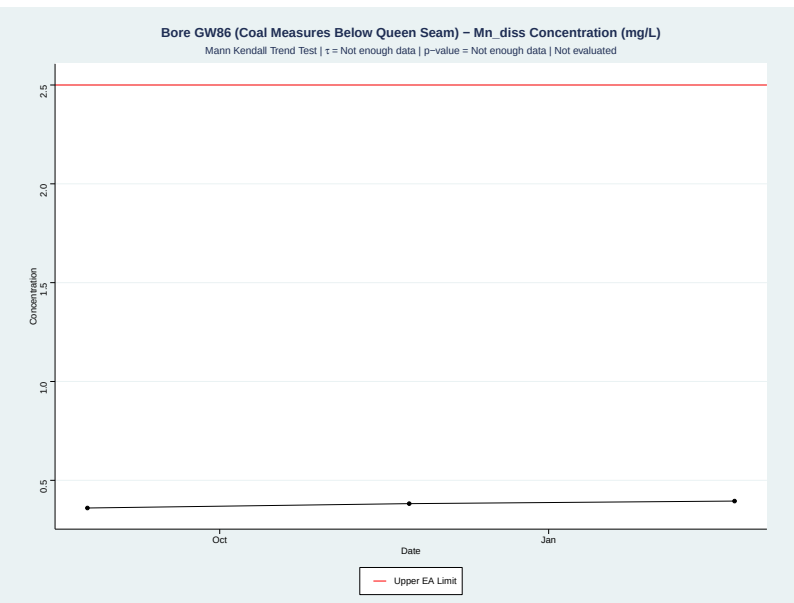
Appendix C Groundwater Quality Time Series

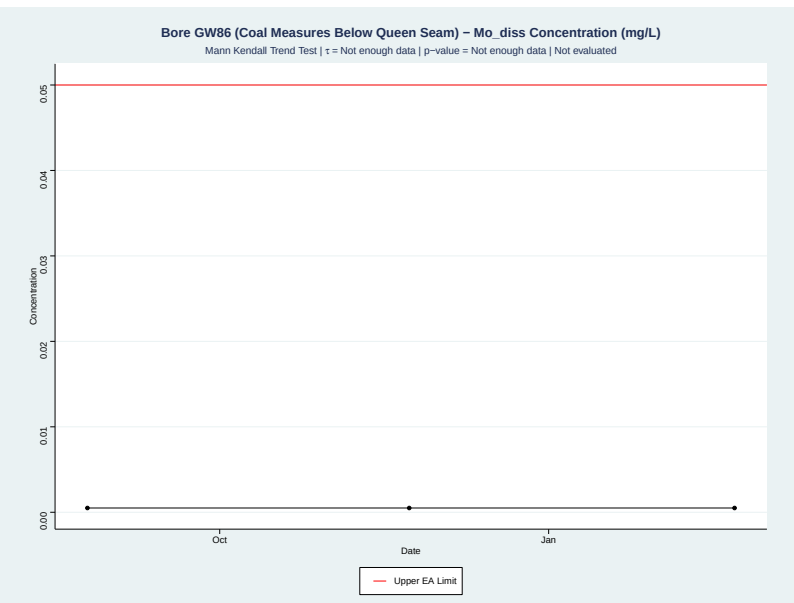




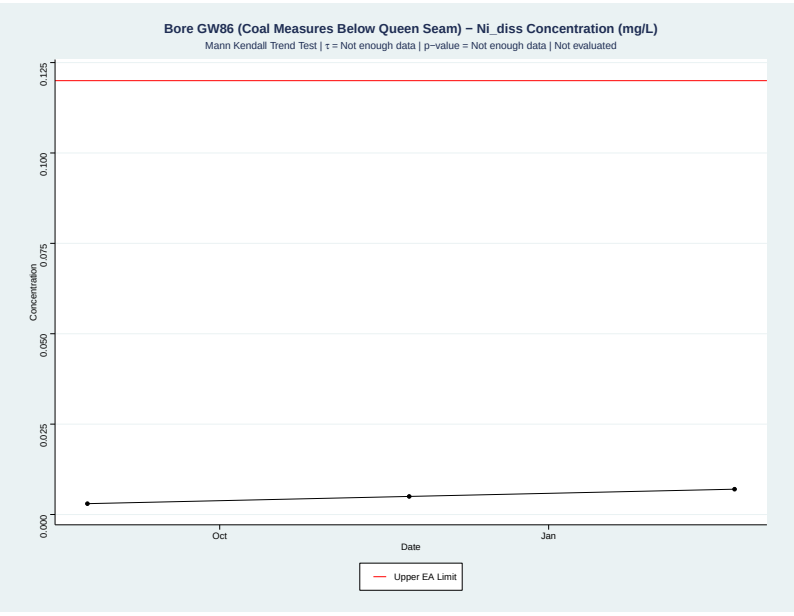


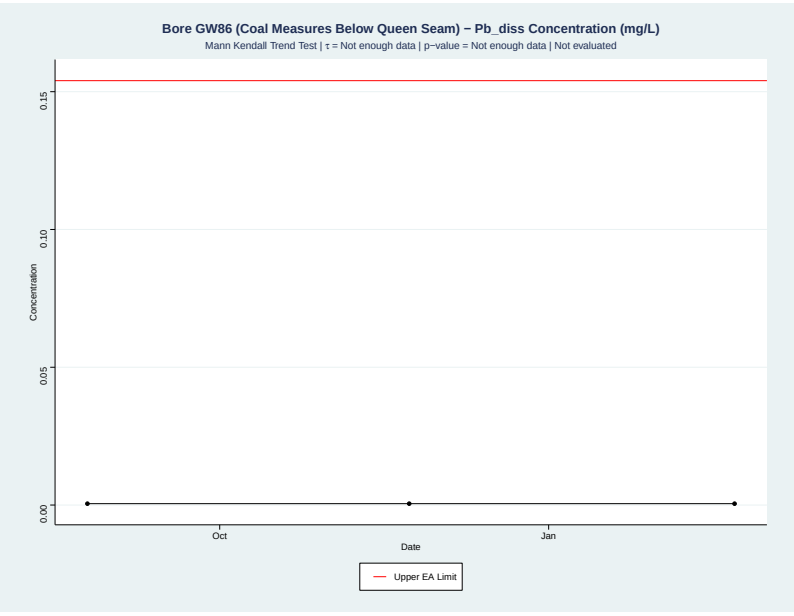


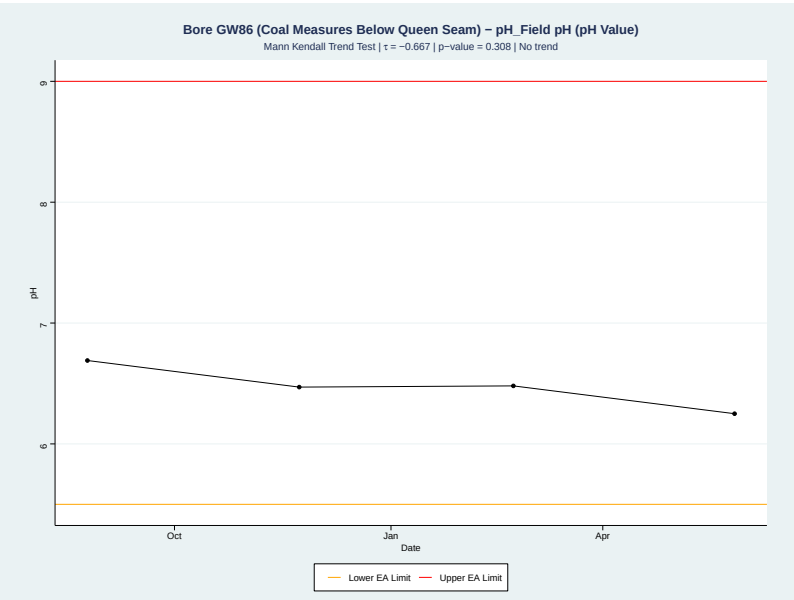


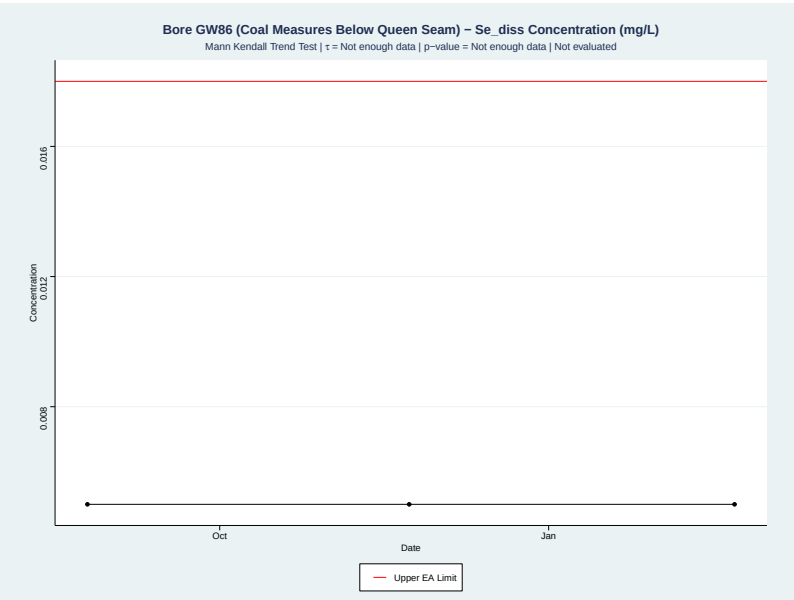


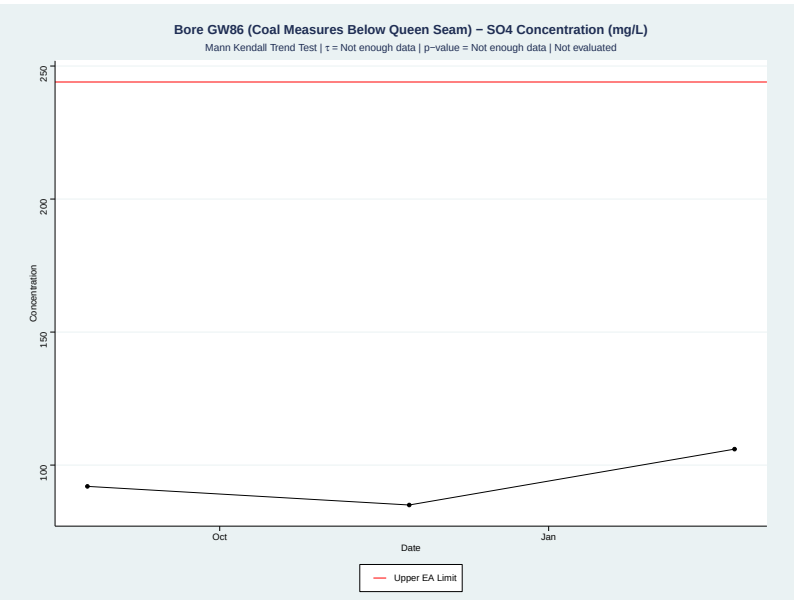
Appendix C Groundwater Quality Time Series

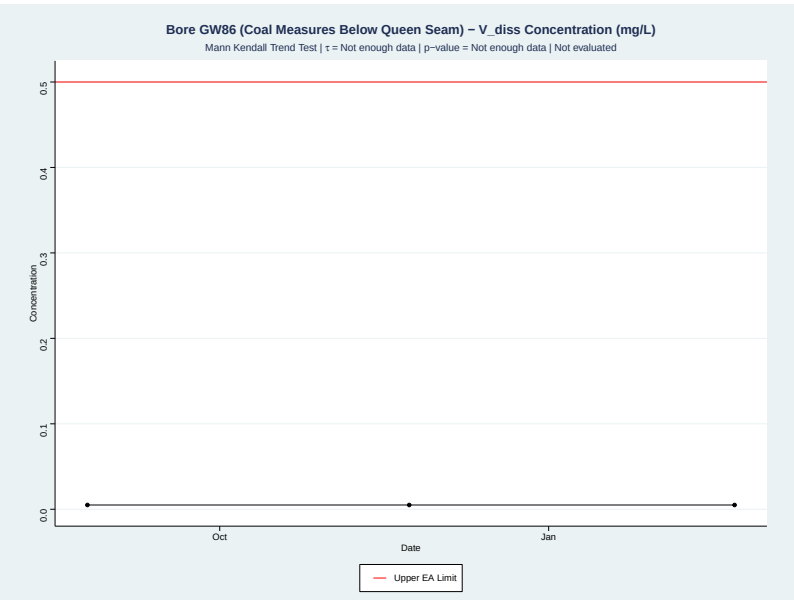




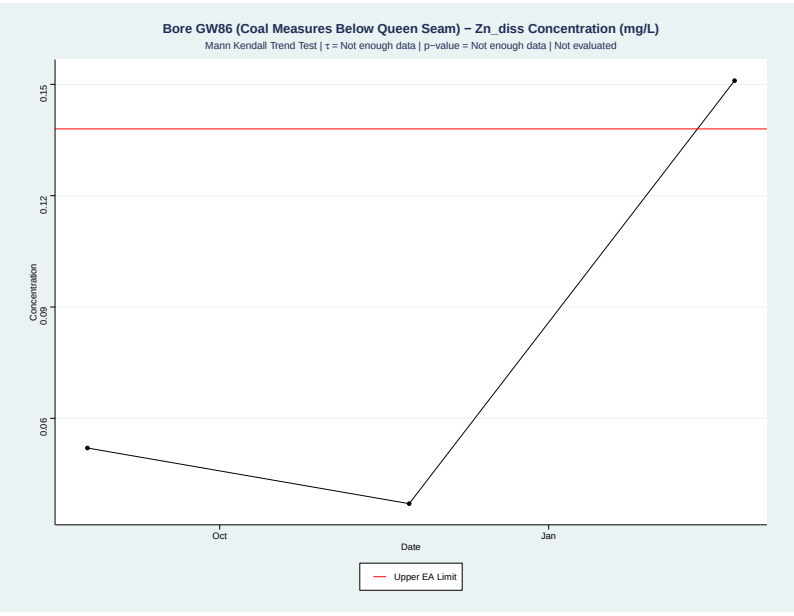


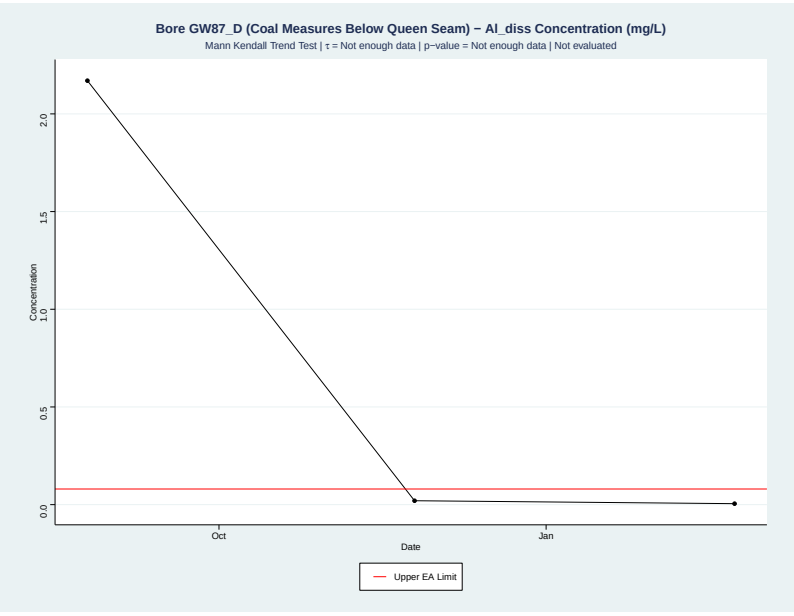


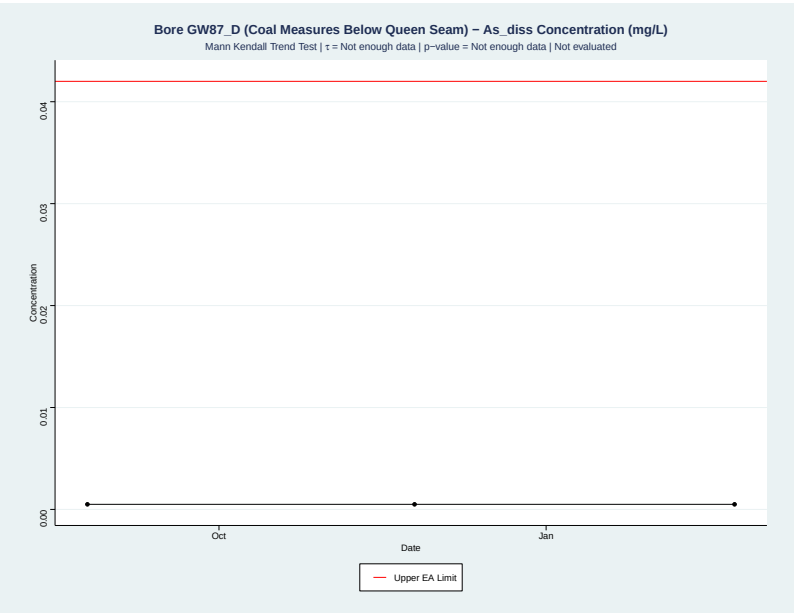


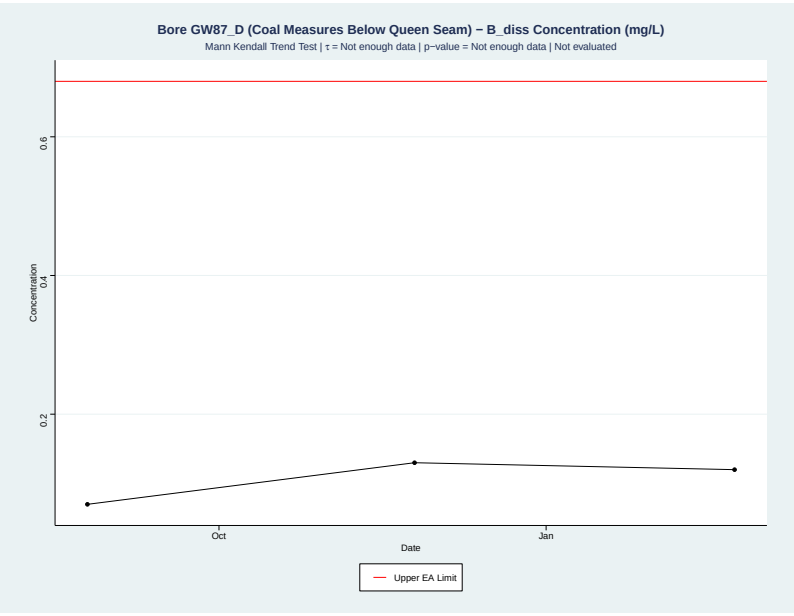


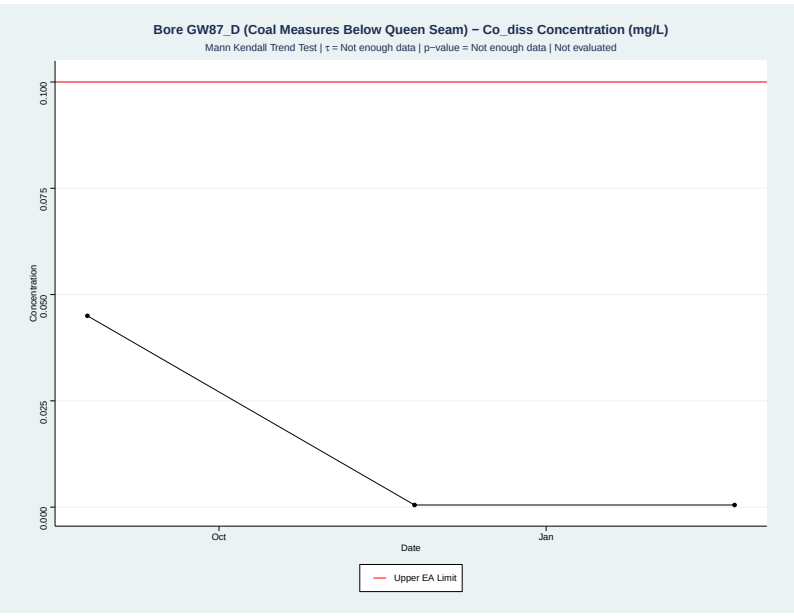
Appendix C Groundwater Quality Time Series

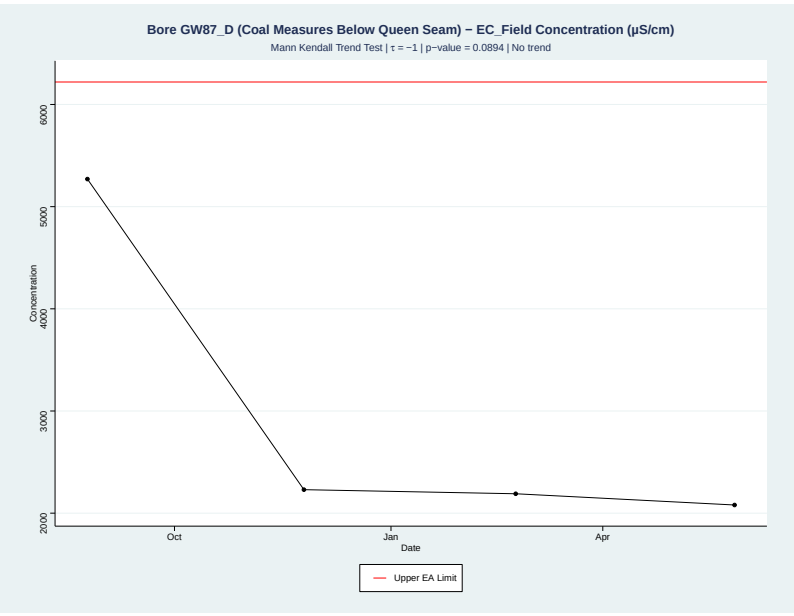




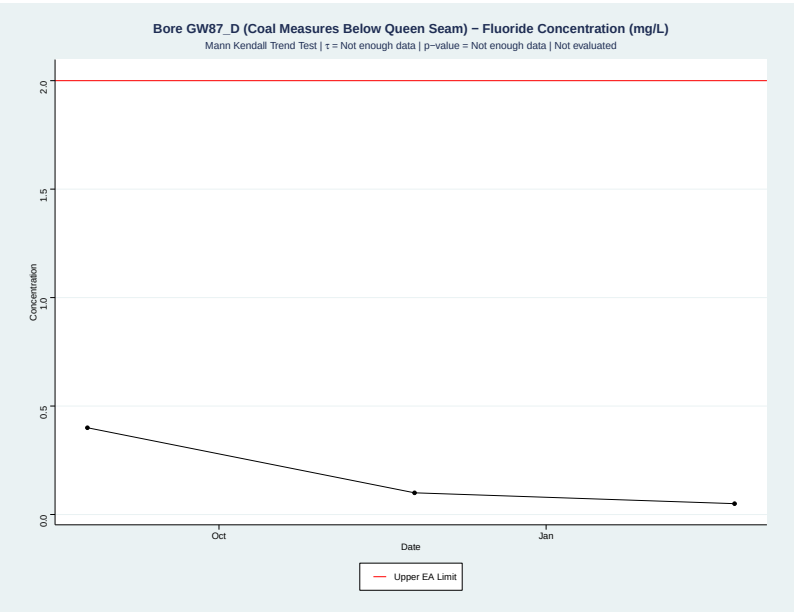


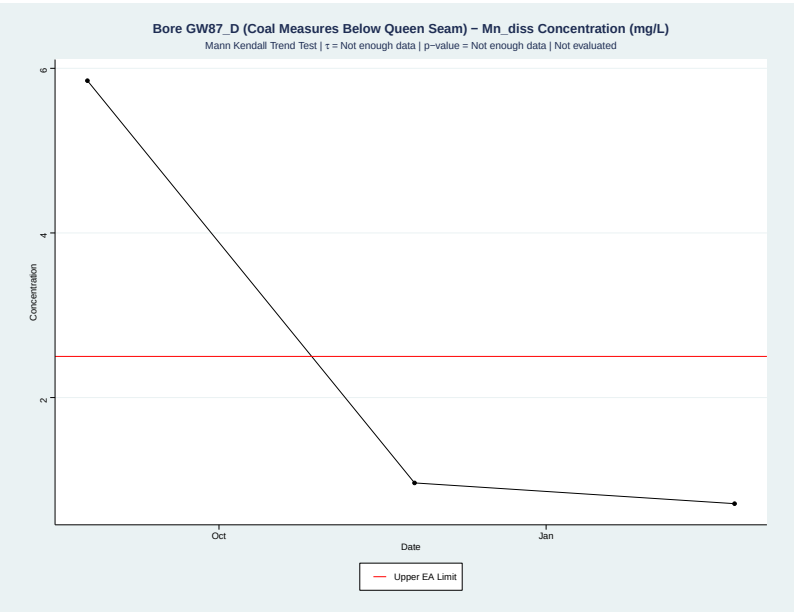


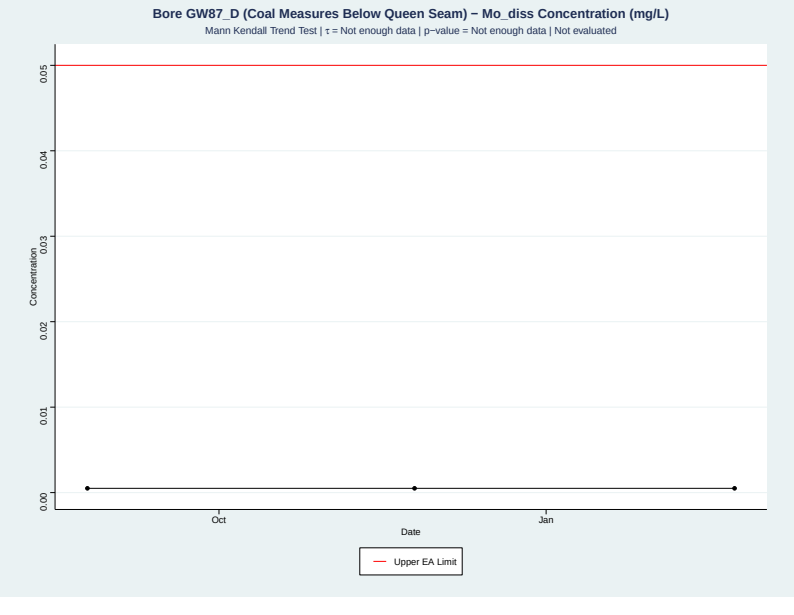


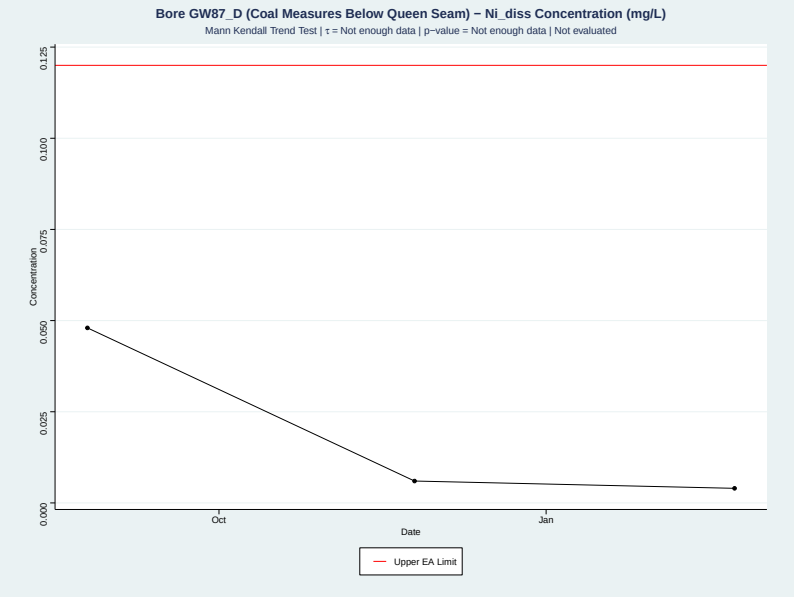


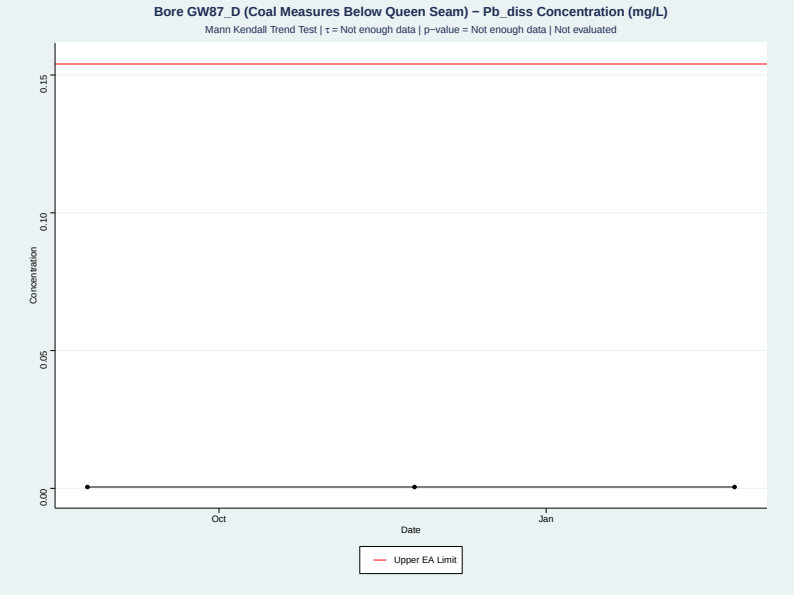
Appendix C Groundwater Quality Time Series

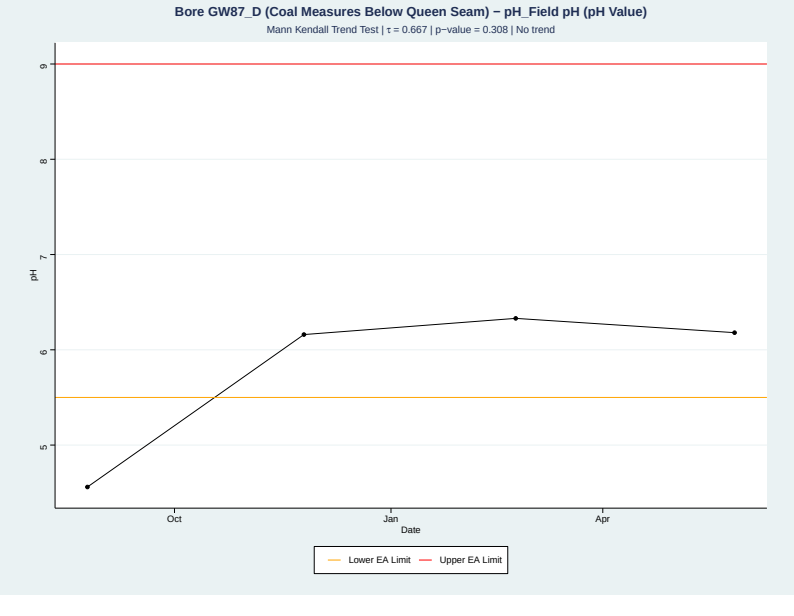




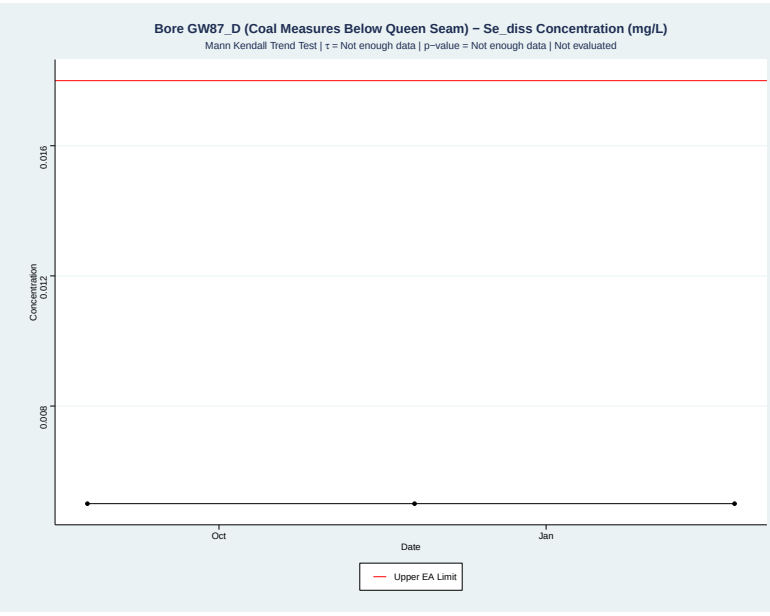


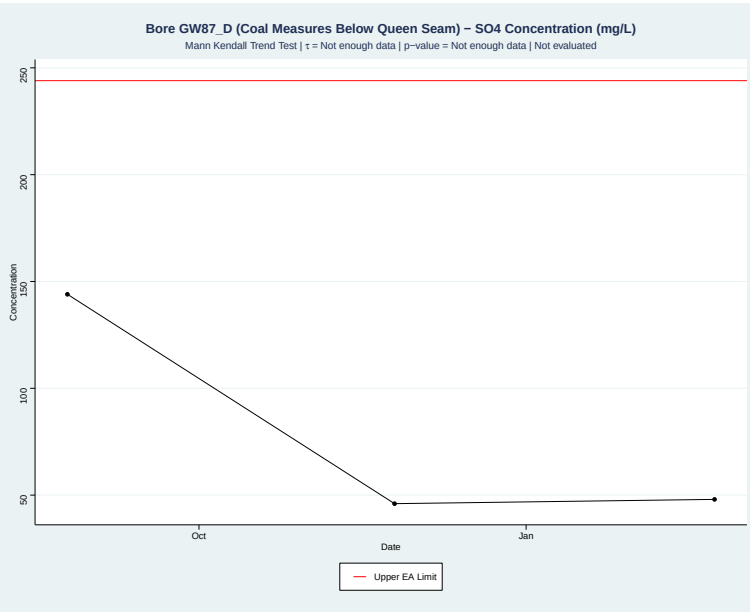




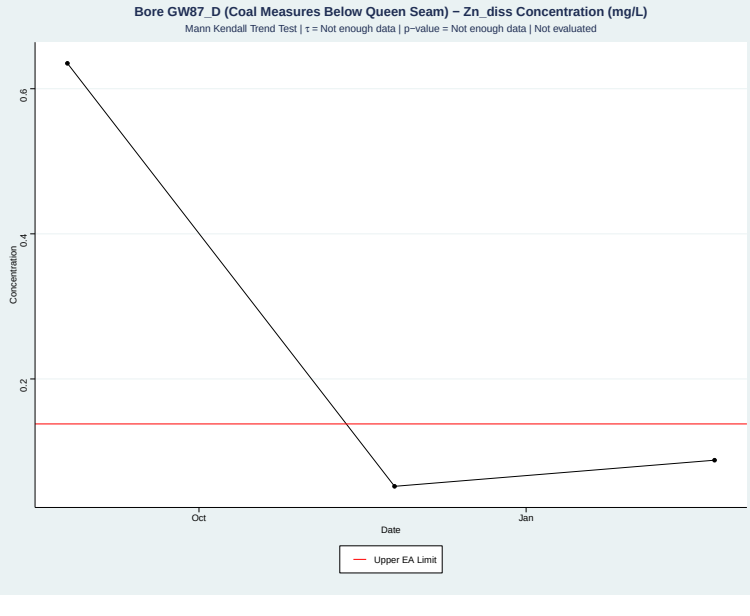


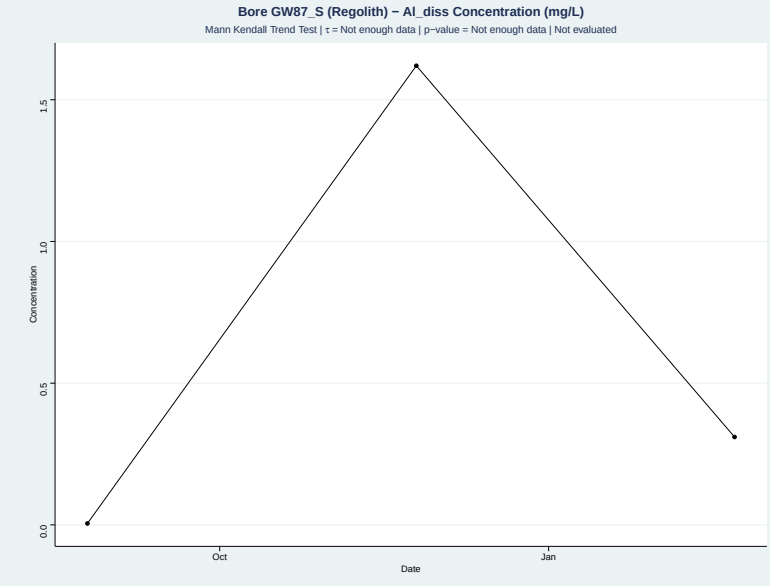
Appendix C Groundwater Quality Time Series

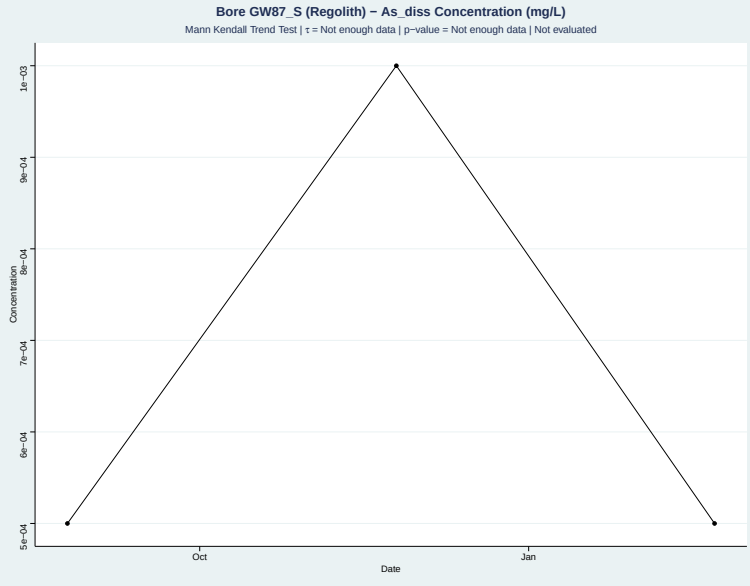




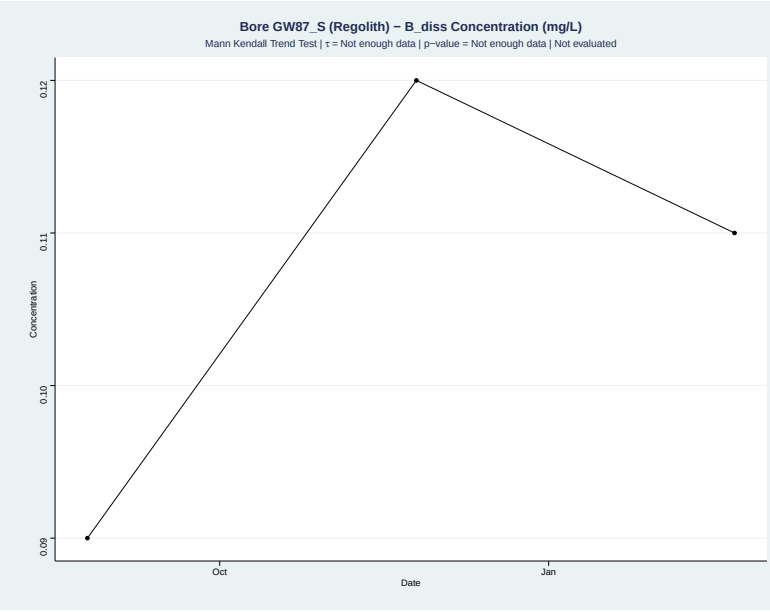


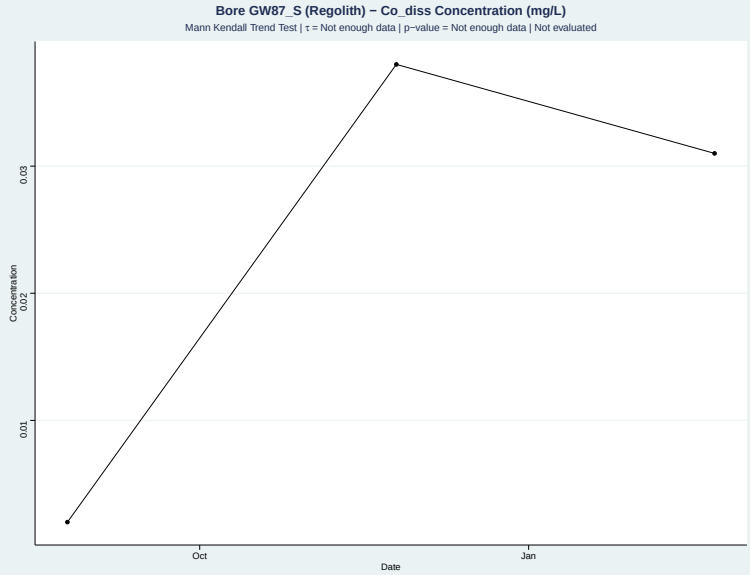


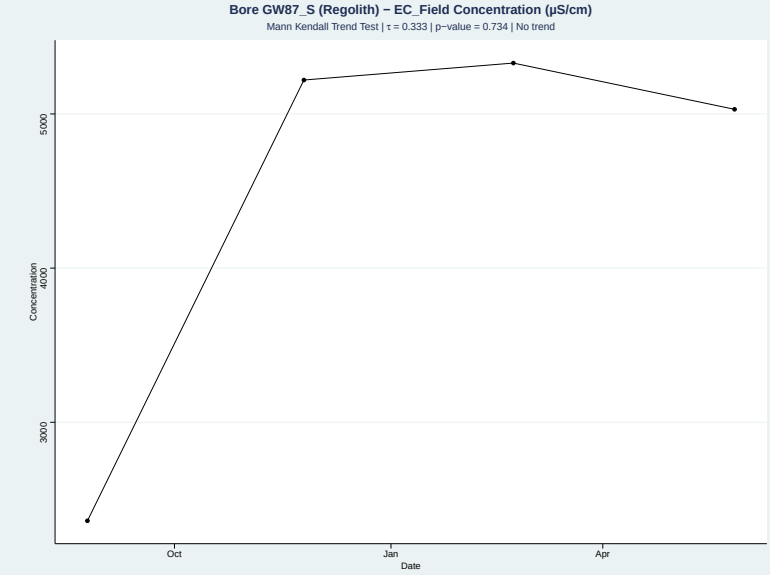


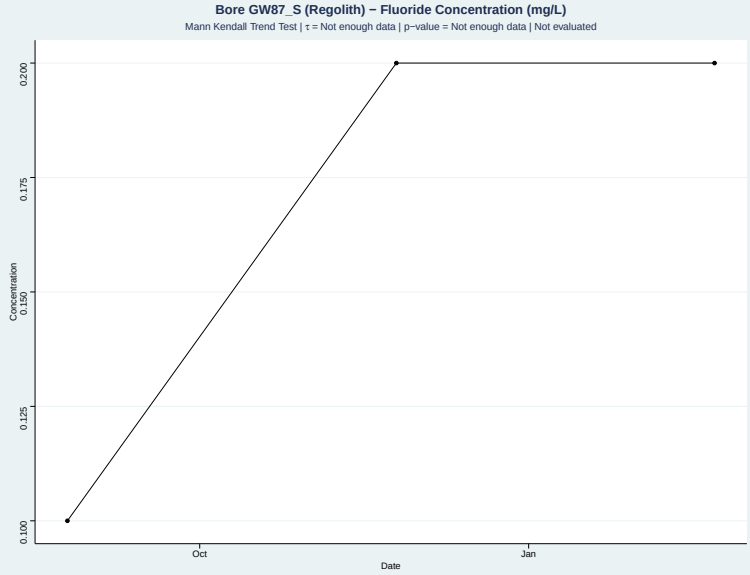


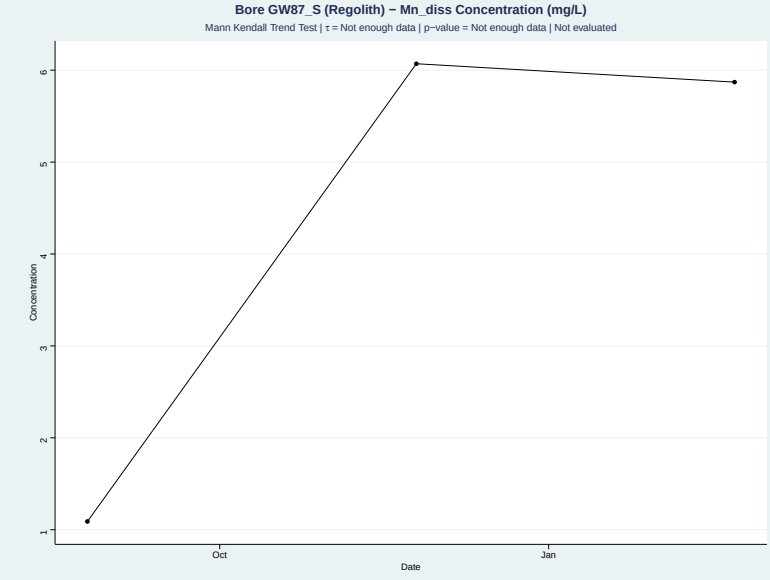
Appendix C Groundwater Quality Time Series

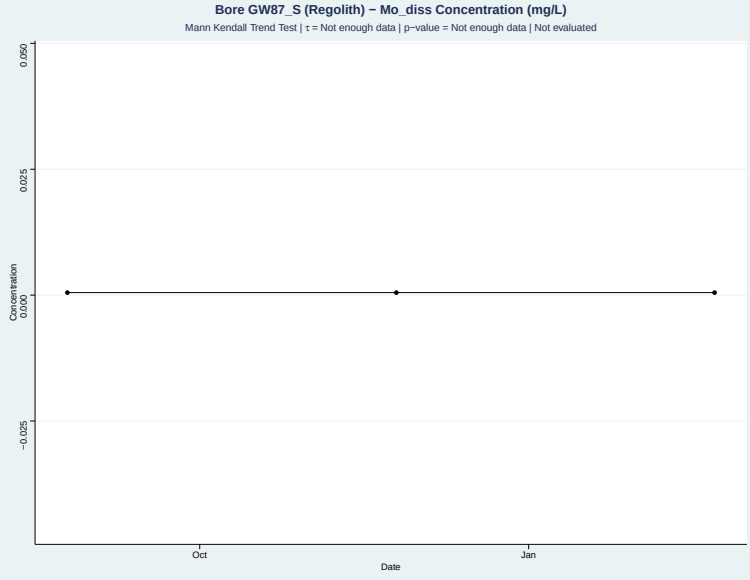








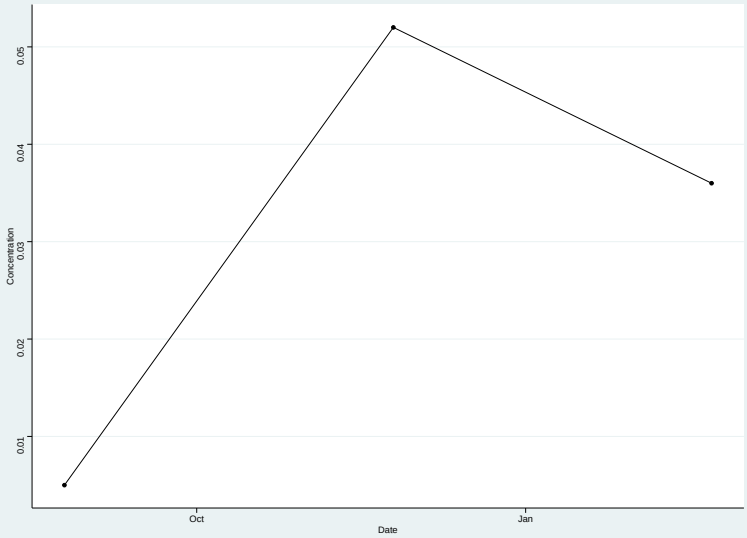




Appendix C Groundwater Quality Time Series

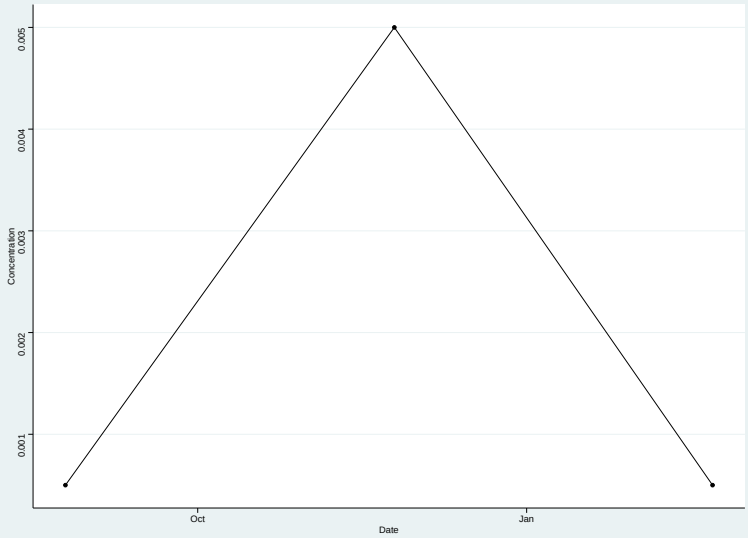
Bore GW87_S (Regolith) − Ni_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p−value = Not enough data | Not evaluated



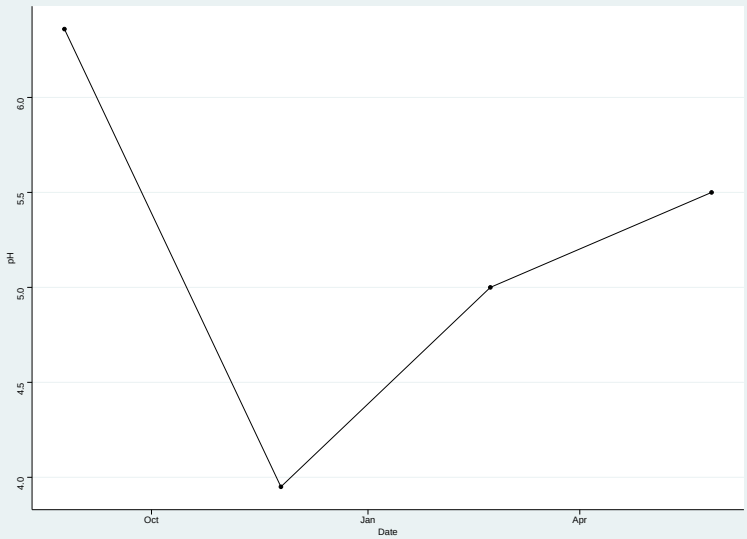
Bore GW87_S (Regolith) − Pb_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p−value = Not enough data | Not evaluated



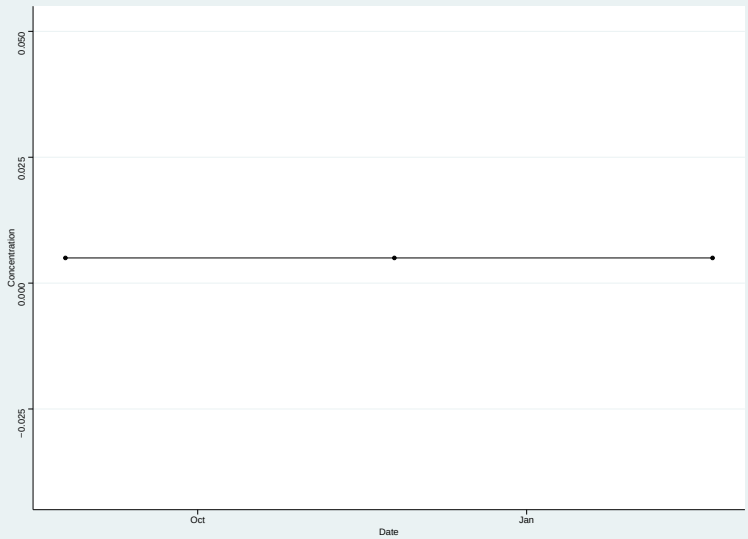
Bore GW87_S (Regolith) − pH_Field pH (pH Value)

Mann Kendall Trend Test | τ = 0 | p−value = 1 | No trend



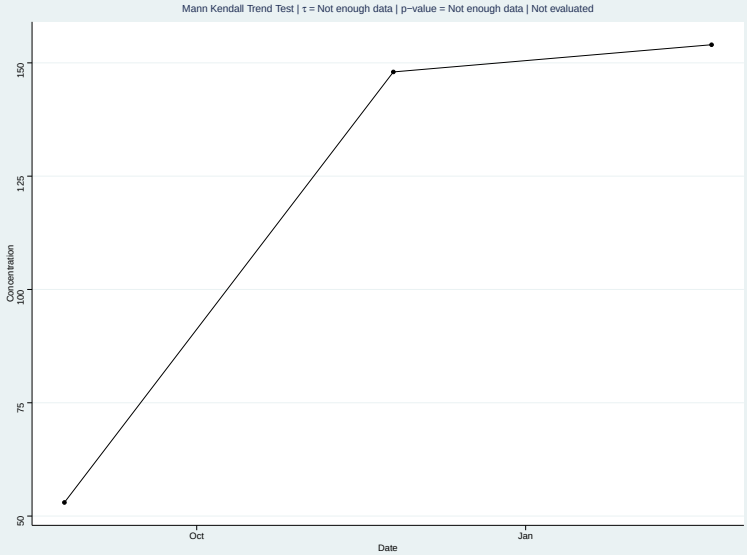
Bore GW87_S (Regolith) − Se_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p−value = Not enough data | Not evaluated



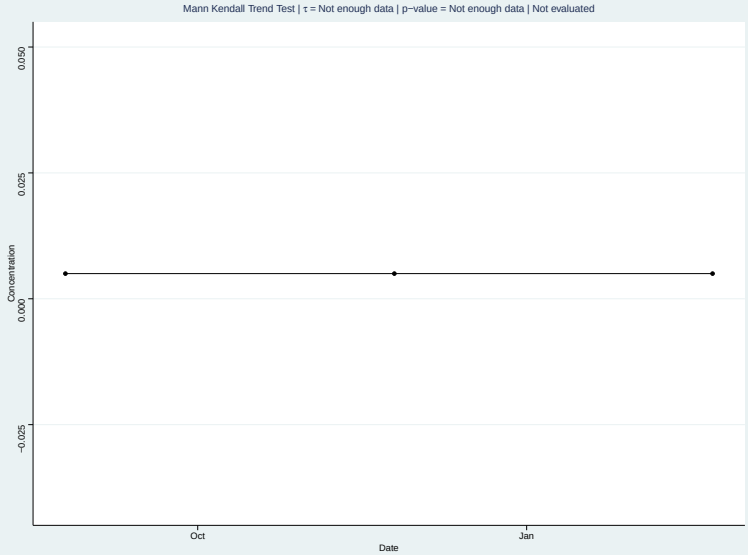
Bore GW87_S (Regolith) − SO4 Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p−value = Not enough data | Not evaluated



Bore GW87_S (Regolith) − V_diss Concentration (mg/L)

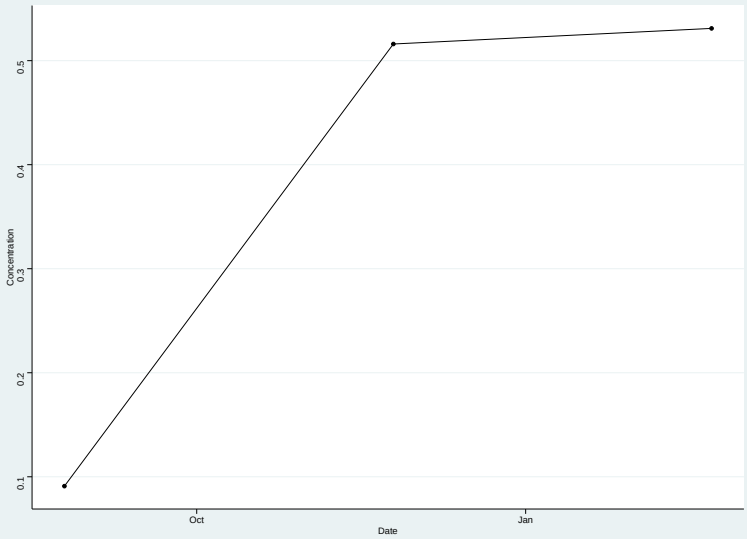
Mann Kendall Trend Test | τ = Not enough data | p−value = Not enough data | Not evaluated



Appendix C Groundwater Quality Time Series

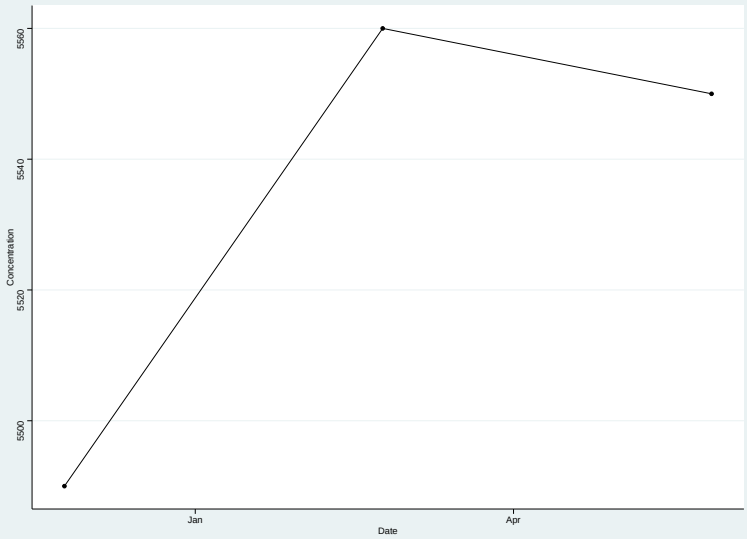
Bore GW87_S (Regolith) – Zn_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



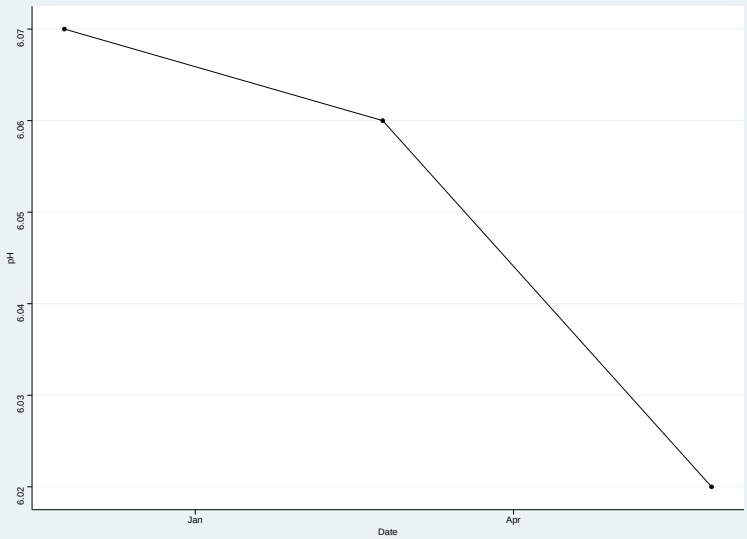
Bore GW88_D (Coal Measures Below Queen Seam) – EC_Field Concentration (µS/cm)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



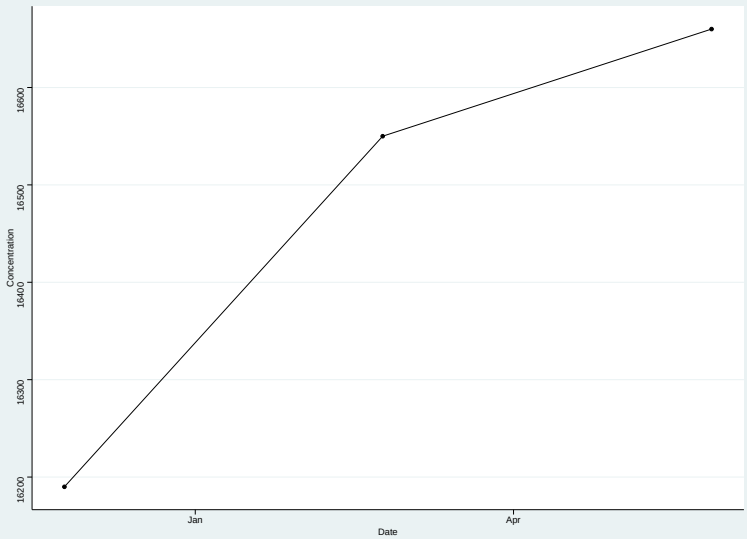
Bore GW88_D (Coal Measures Below Queen Seam) – pH_Field pH (pH Value)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



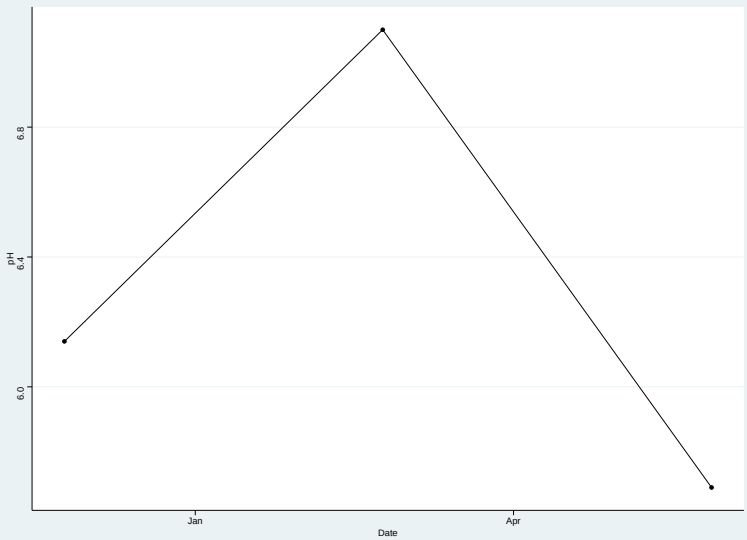
Bore GW88_S (Regolith) – EC_Field Concentration (µS/cm)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



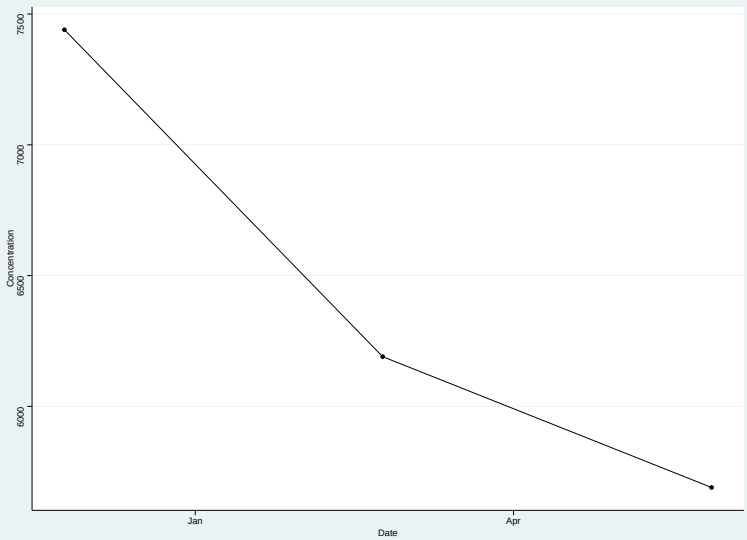
Bore GW88_S (Regolith) – pH_Field pH (pH Value)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



Bore GW89_D (Regolith) – EC_Field Concentration (µS/cm)

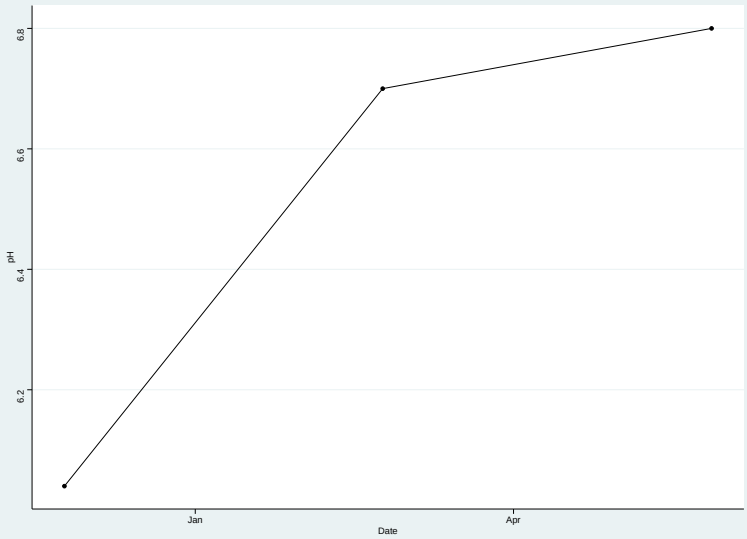
Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



Appendix C Groundwater Quality Time Series

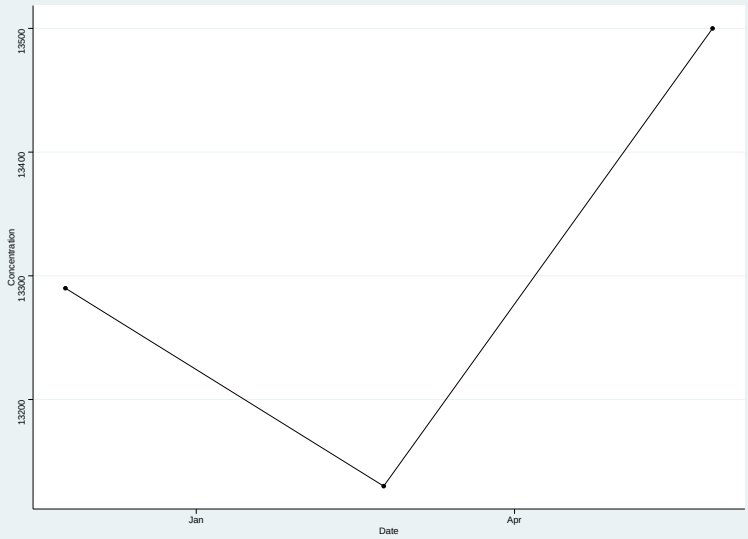
Bore GW89_D (Regolith) – pH_Field pH (pH Value)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



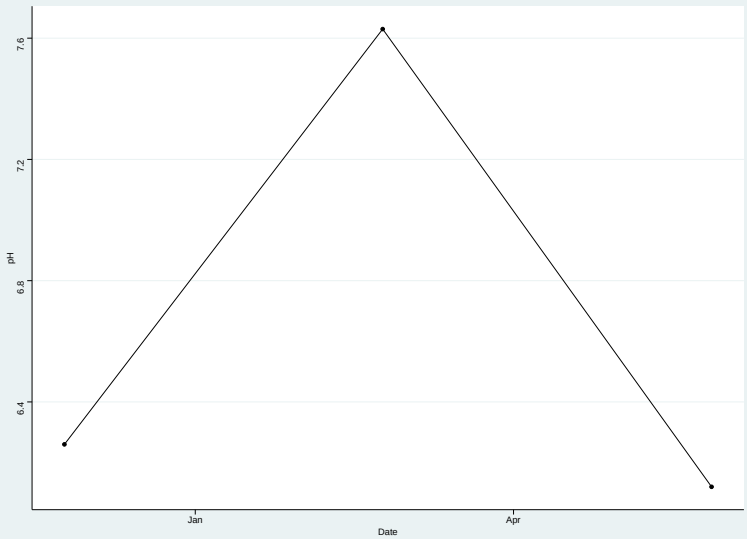
Bore GW89_S (Regolith) – EC_Field Concentration (µS/cm)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



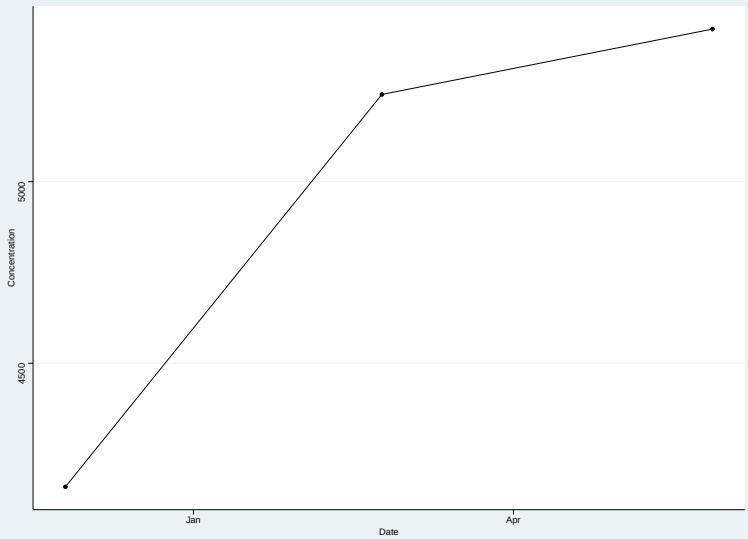
Bore GW89_S (Regolith) – pH_Field pH (pH Value)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



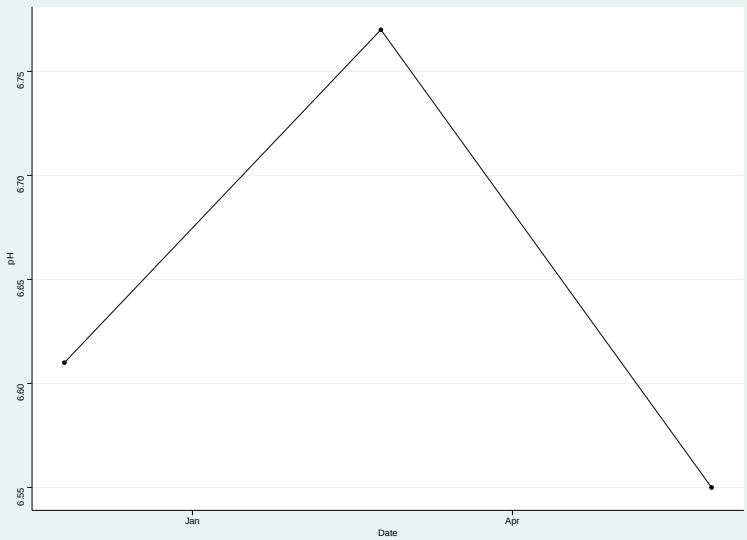
Bore GW90 (Regolith) – EC_Field Concentration (µS/cm)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



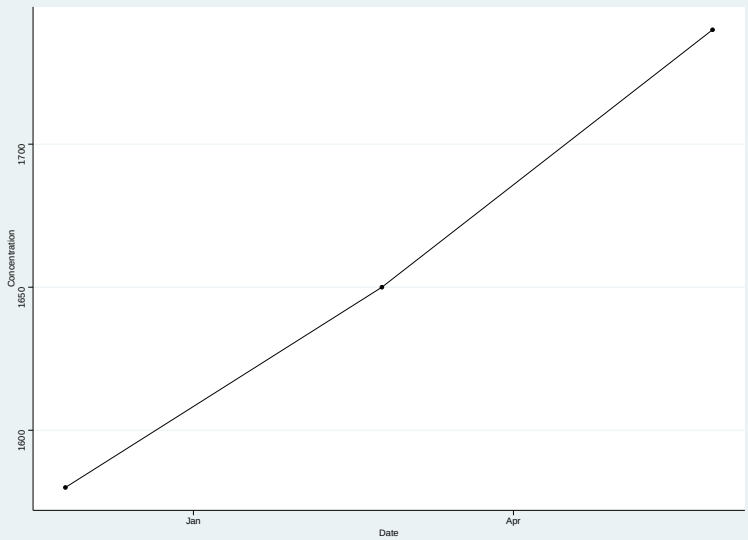
Bore GW90 (Regolith) – pH_Field pH (pH Value)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



Bore GW91 (Regolith) – EC_Field Concentration (µS/cm)

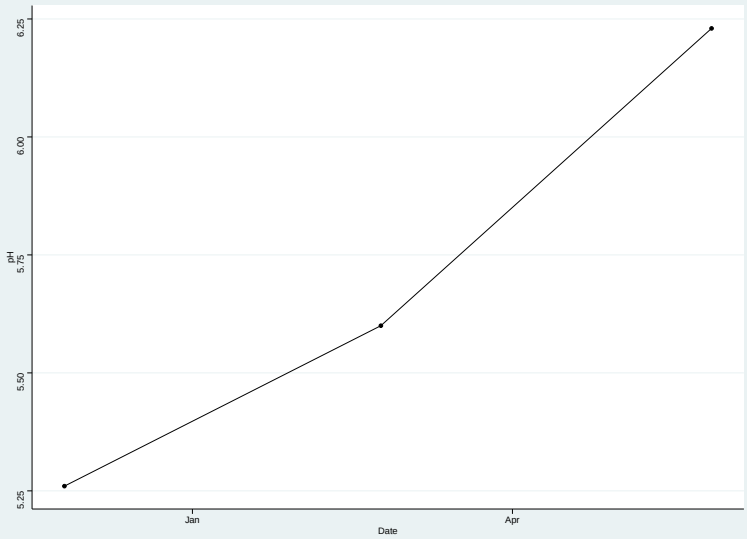
Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



Appendix C Groundwater Quality Time Series

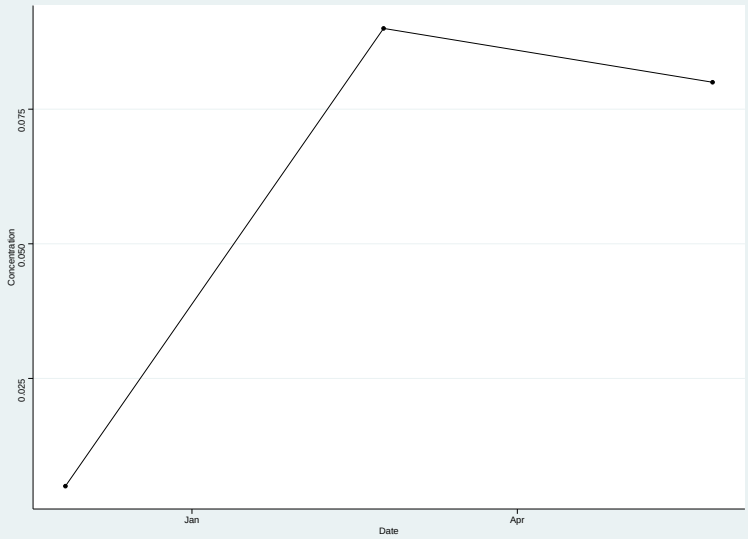
Bore GW91 (Regolith) – pH_Field pH (pH Value)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



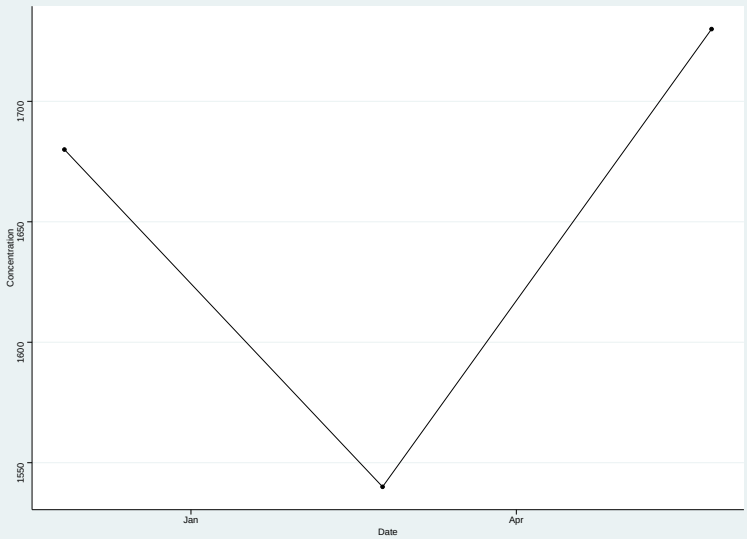
Bore GW92 (Coal Measures Below Queen Seam) – Al_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



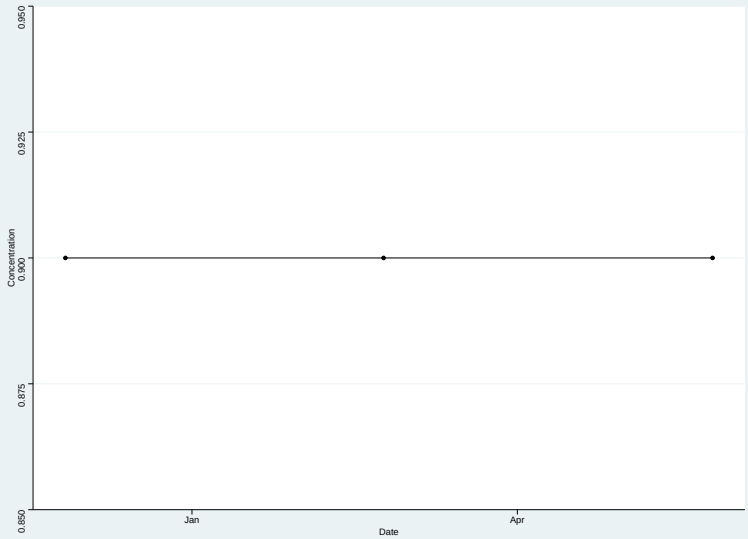
Bore GW92 (Coal Measures Below Queen Seam) – EC_Field Concentration (µS/cm)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



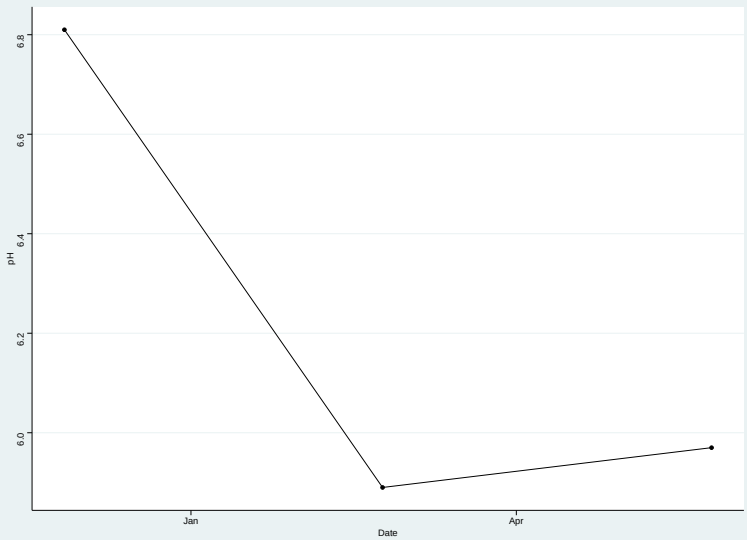
Bore GW92 (Coal Measures Below Queen Seam) – Fluoride Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



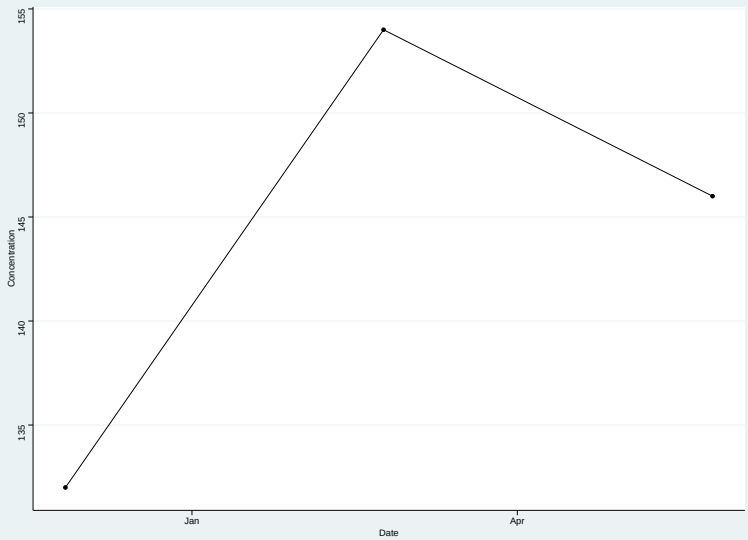
Bore GW92 (Coal Measures Below Queen Seam) – pH_Field pH (pH Value)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated

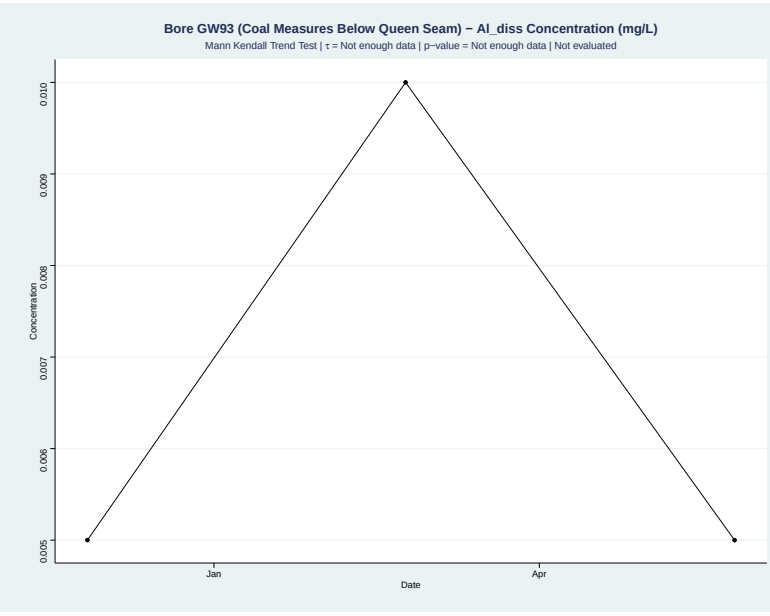


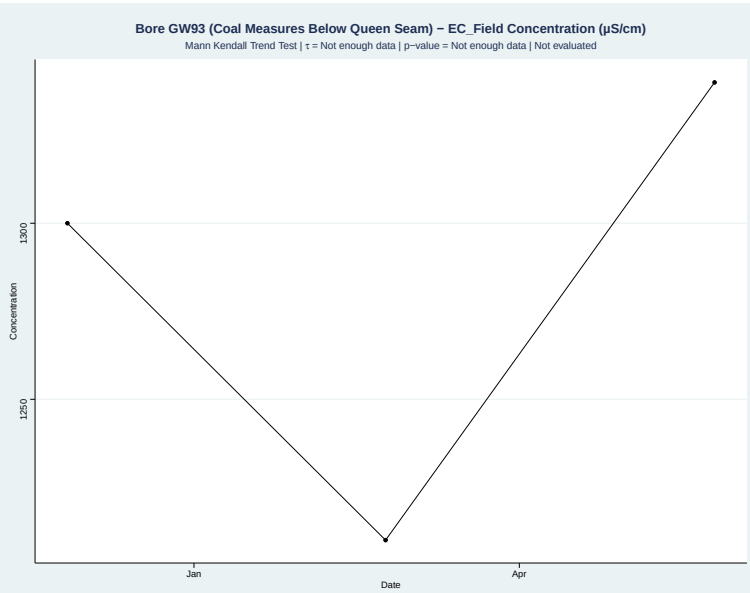
Bore GW92 (Coal Measures Below Queen Seam) – SO4 Concentration (mg/L)

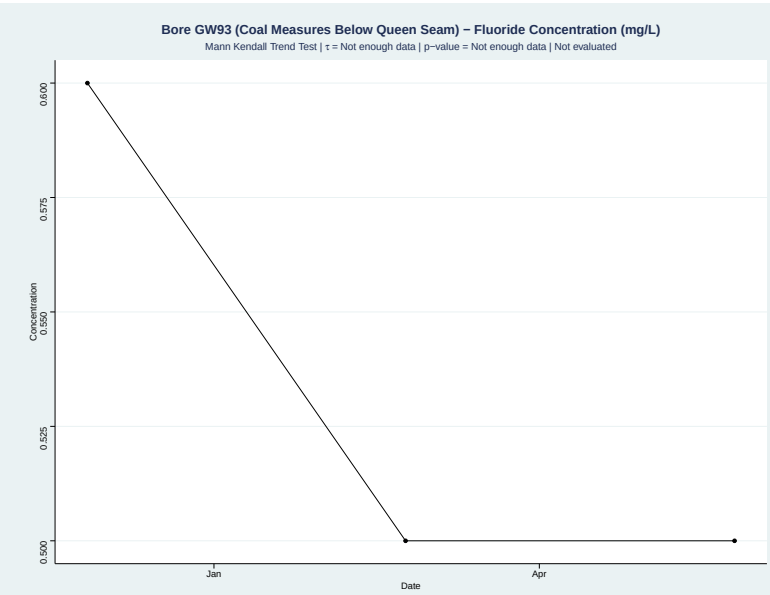
Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated

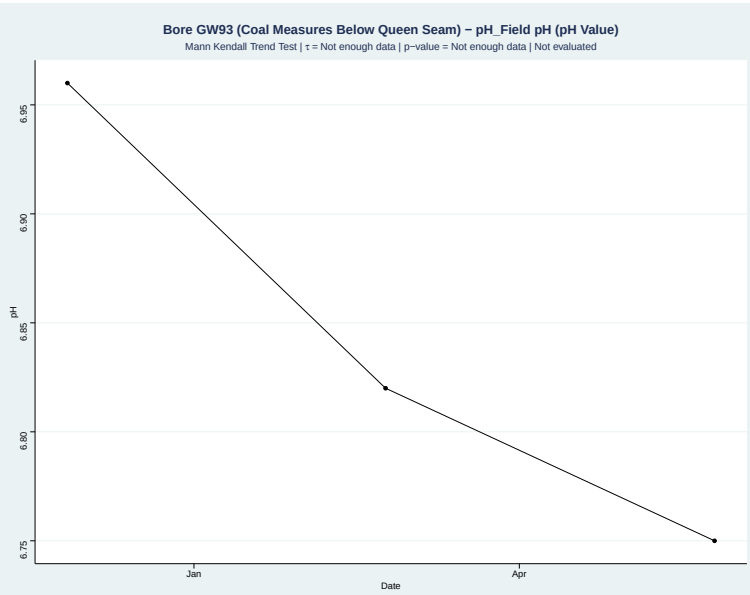


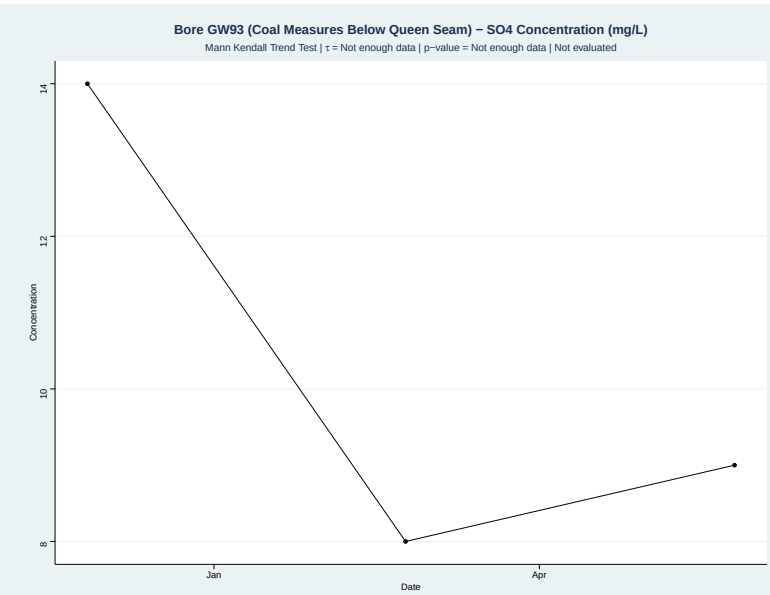
Appendix C Groundwater Quality Time Series

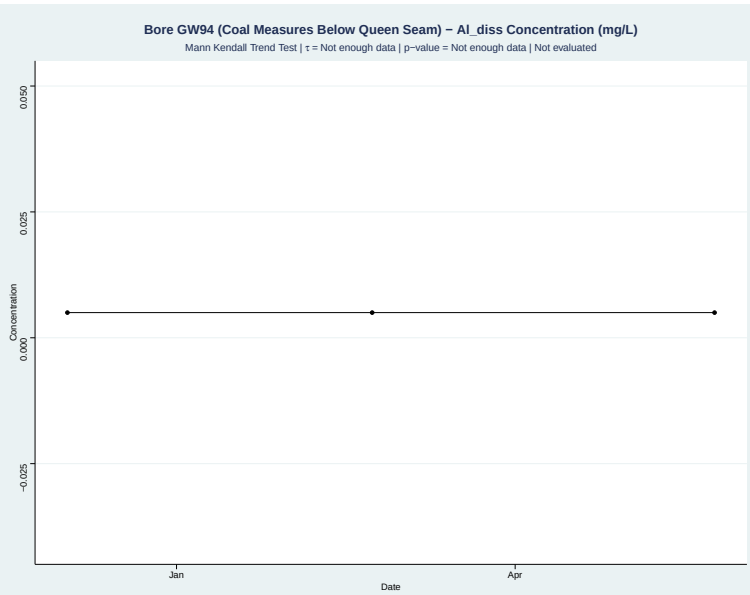




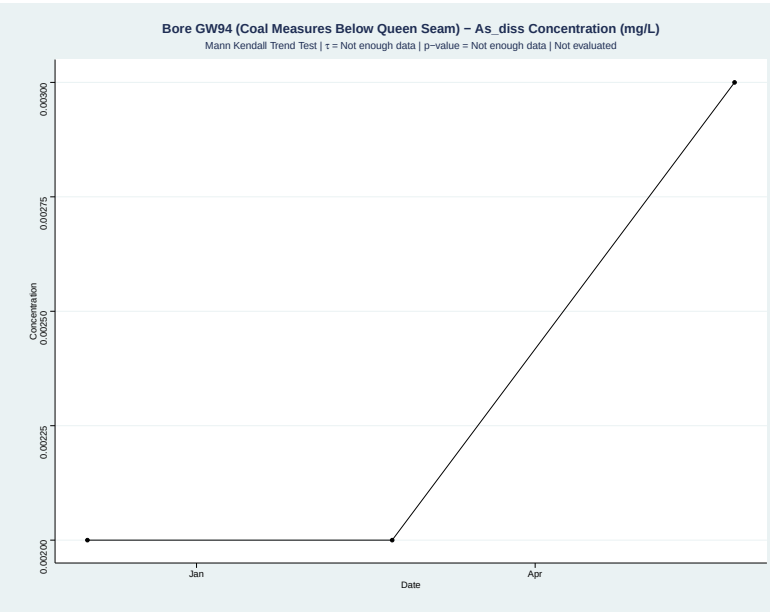


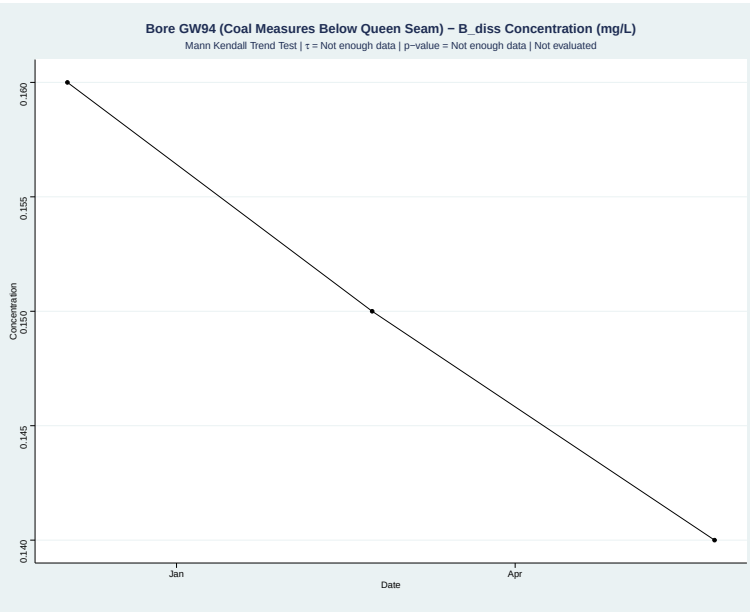


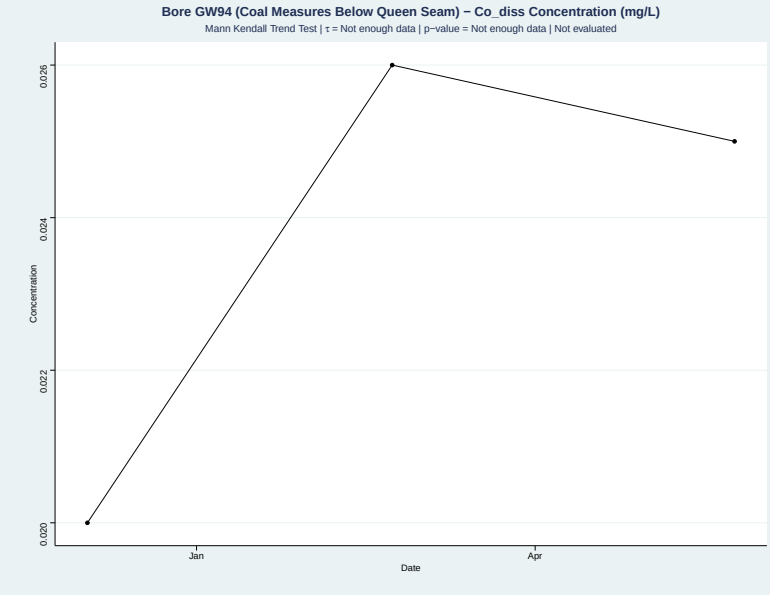


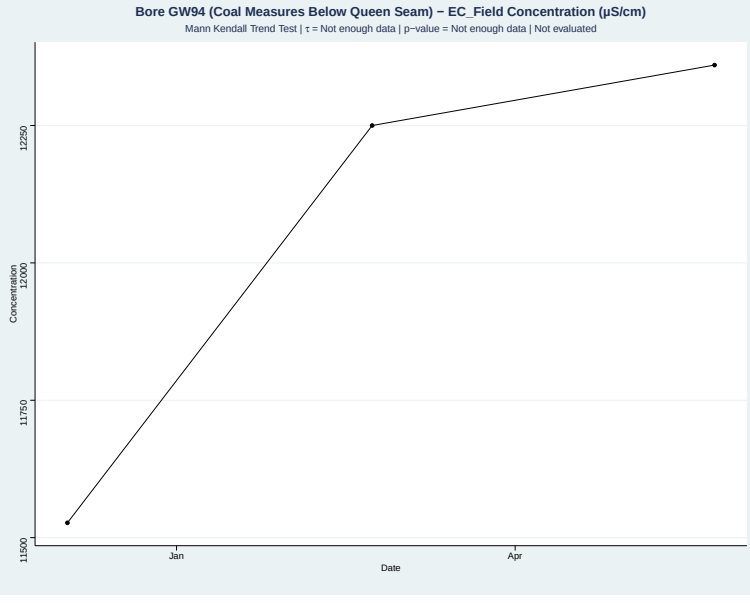


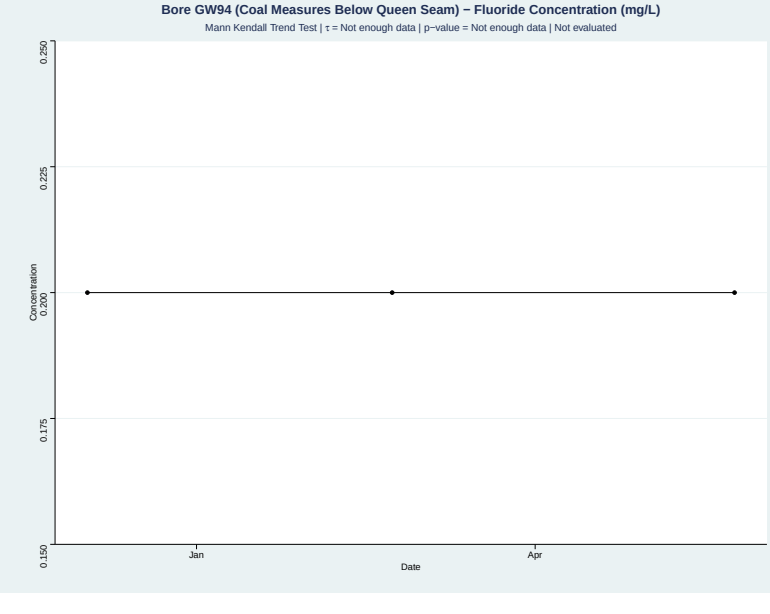
Appendix C Groundwater Quality Time Series

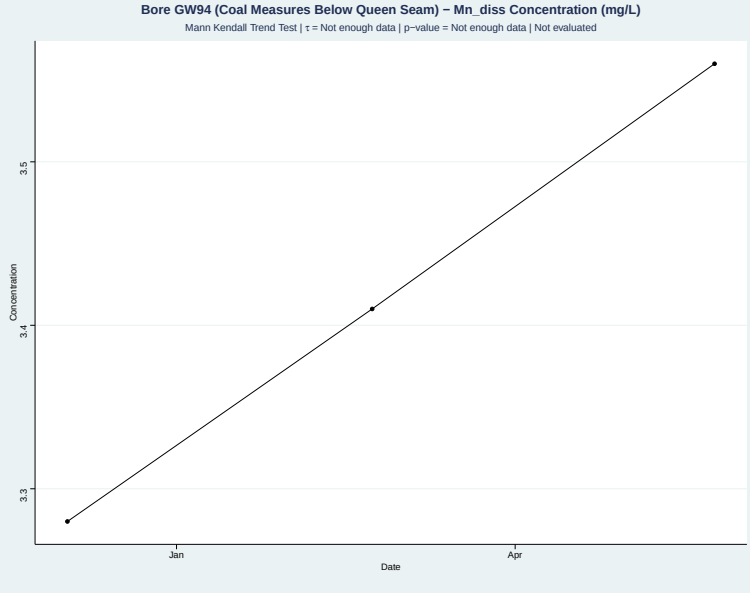




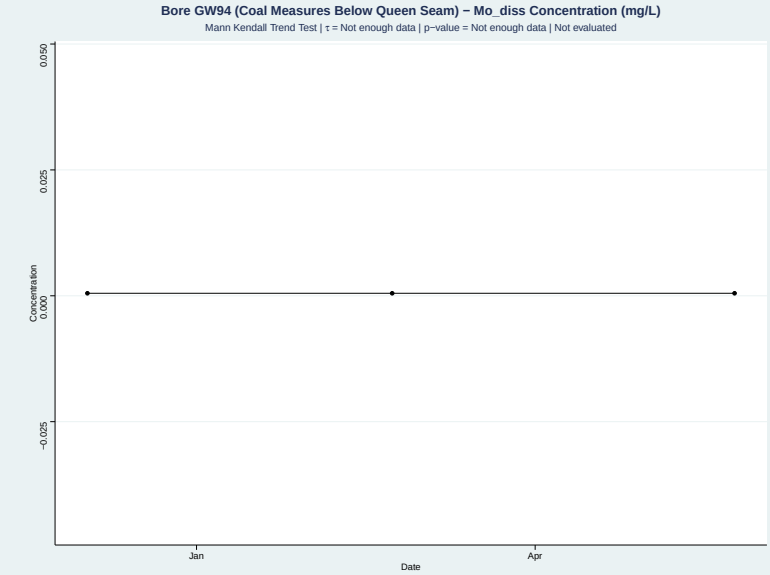


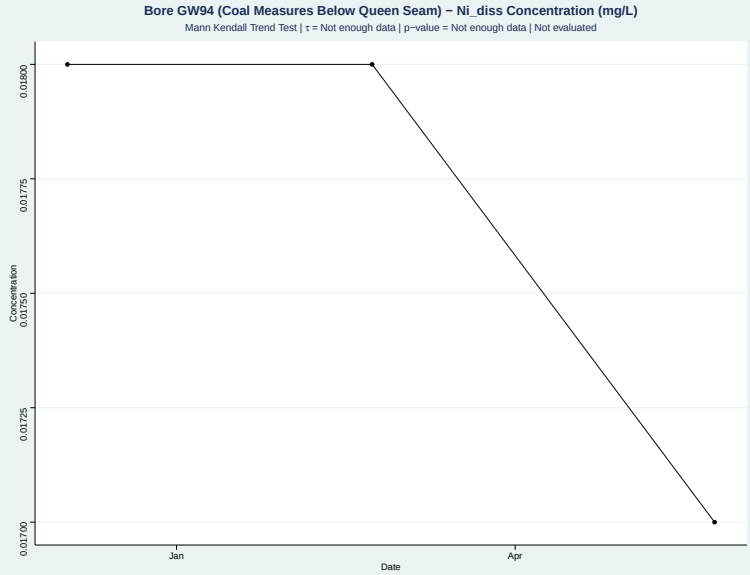


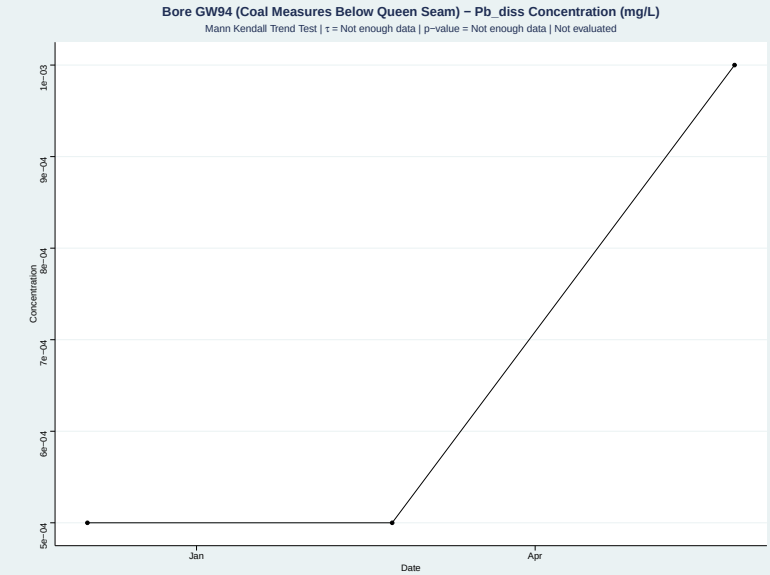


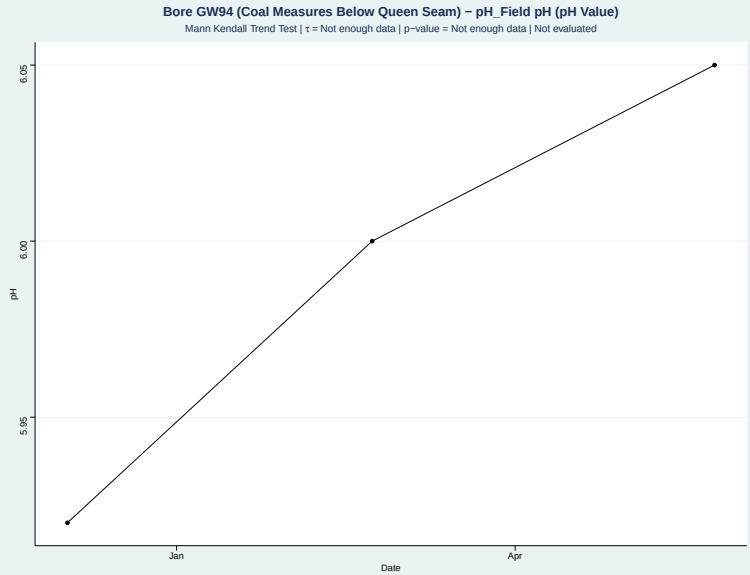


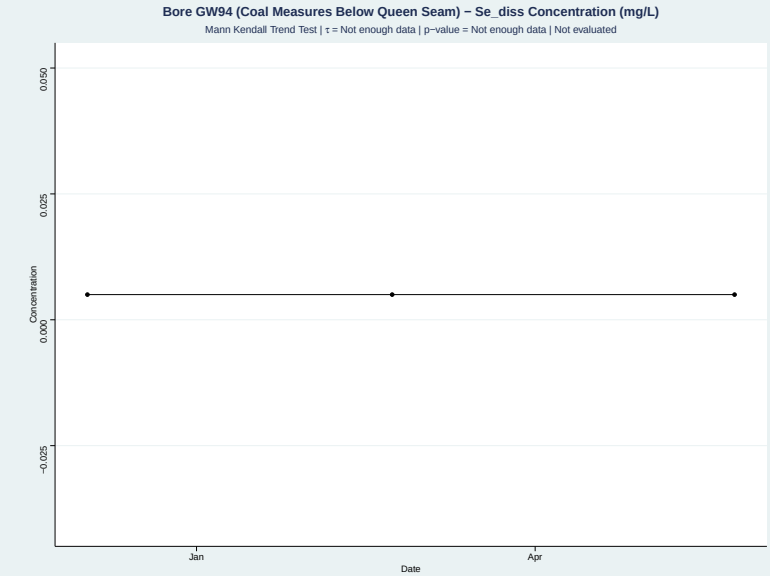
Appendix C Groundwater Quality Time Series

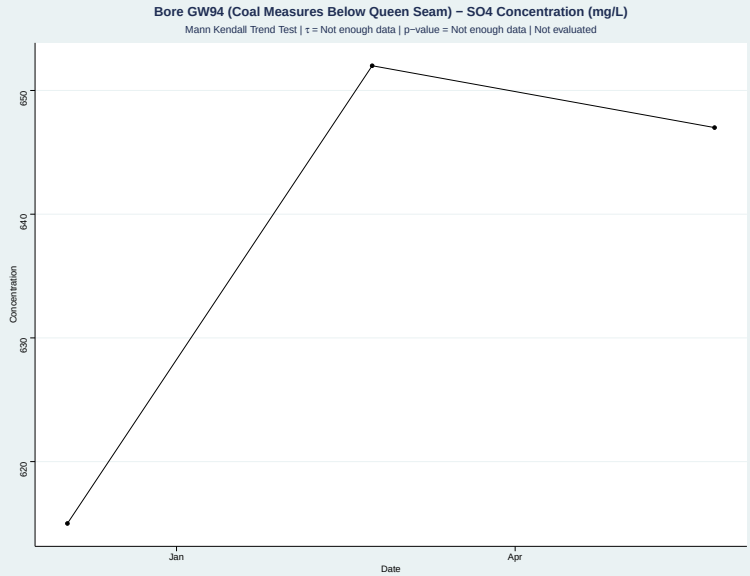








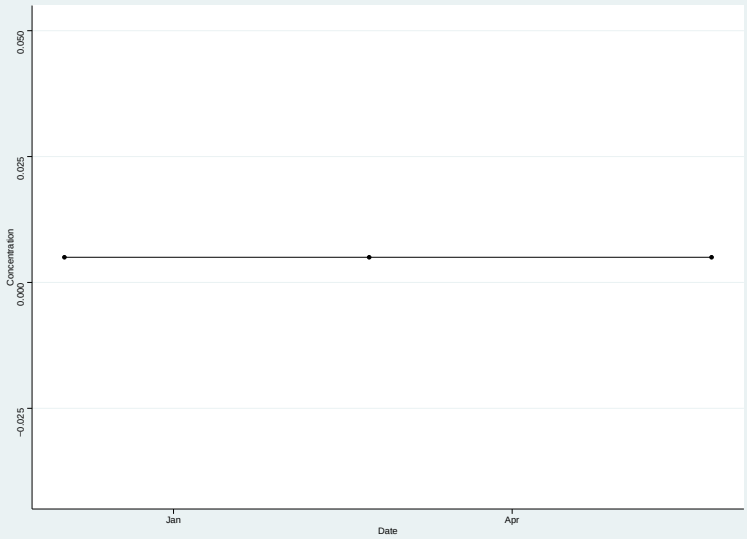




Appendix C Groundwater Quality Time Series

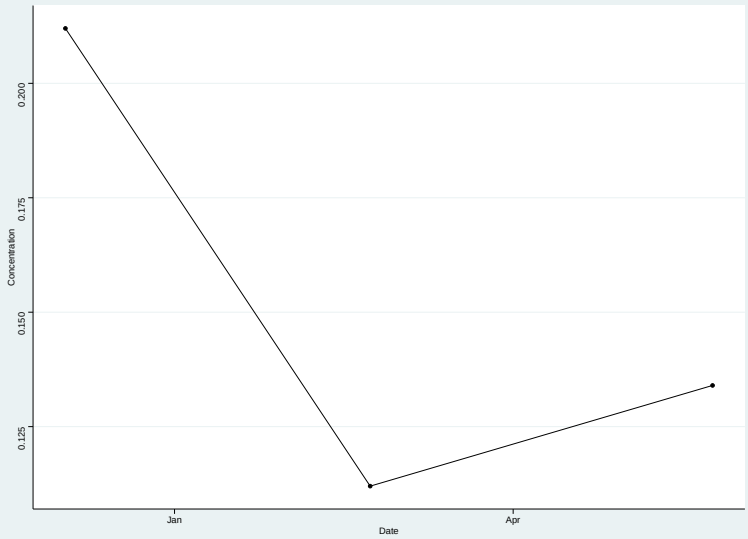
Bore GW94 (Coal Measures Below Queen Seam) – V_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p–value = Not enough data | Not evaluated



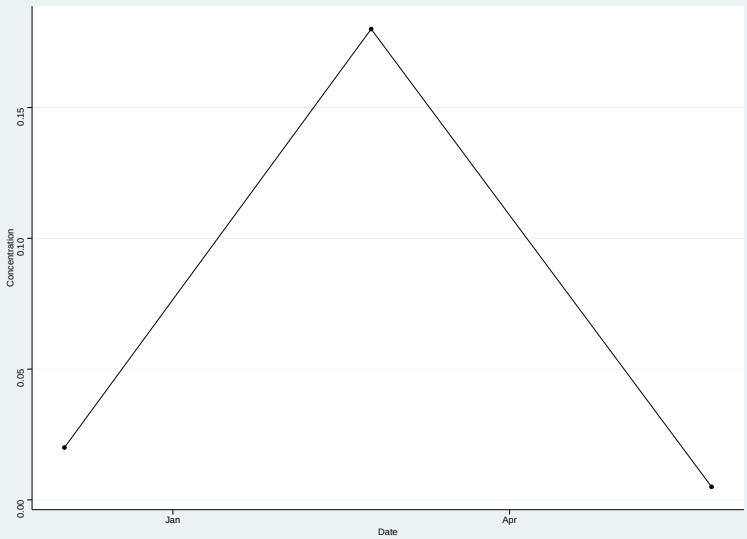
Bore GW94 (Coal Measures Below Queen Seam) – Zn_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p–value = Not enough data | Not evaluated



Bore GW95 (Coal Measures Below Queen Seam) – Al_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p–value = Not enough data | Not evaluated



Bore GW95 (Coal Measures Below Queen Seam) – As_diss Concentration (mg/L)

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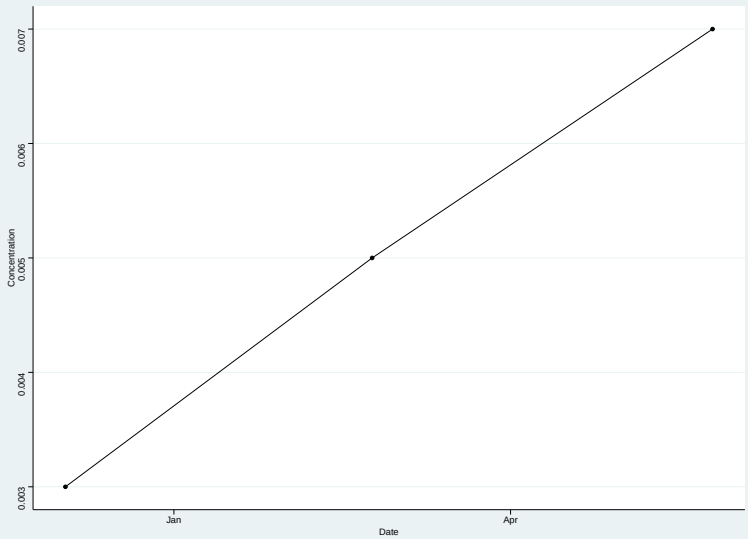
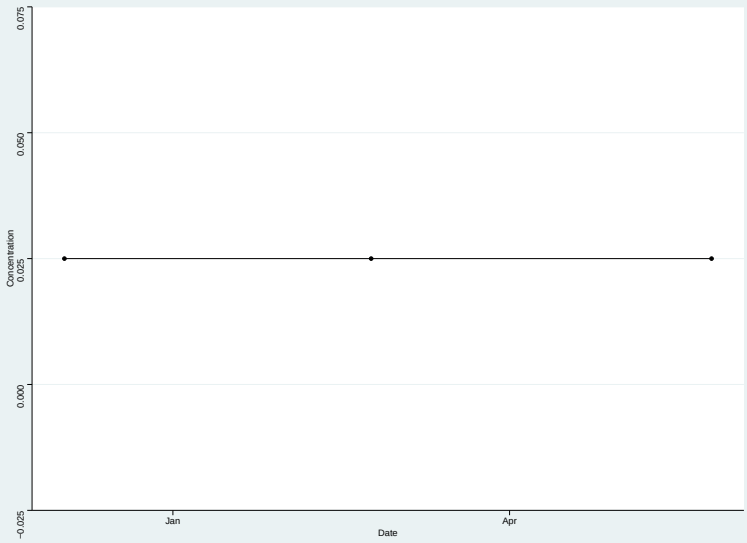


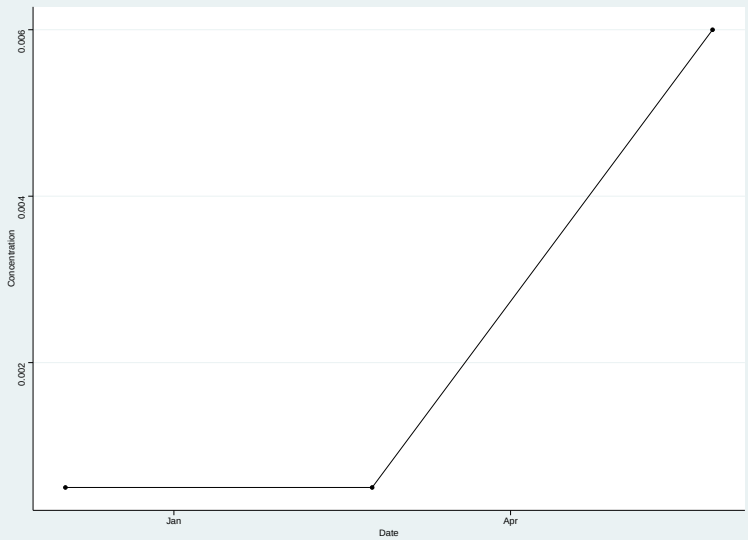
Bore GW95 (Coal Measures Below Queen Seam) – B_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p–value = Not enough data | Not evaluated

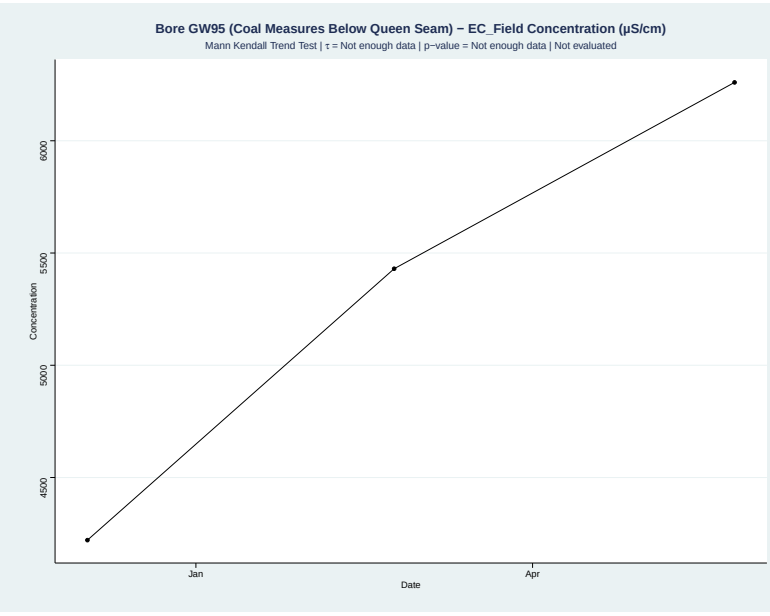


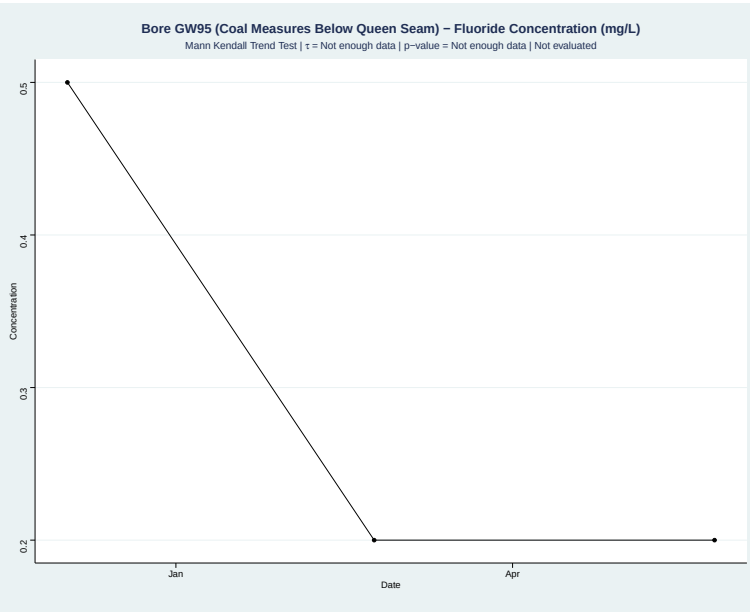
Bore GW95 (Coal Measures Below Queen Seam) – Co_diss Concentration (mg/L)

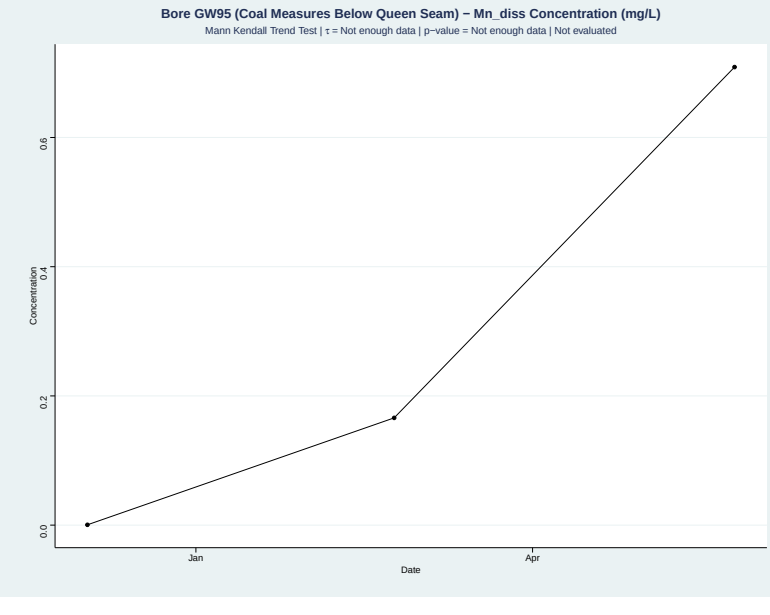
Mann Kendall Trend Test | τ = Not enough data | p–value = Not enough data | Not evaluated

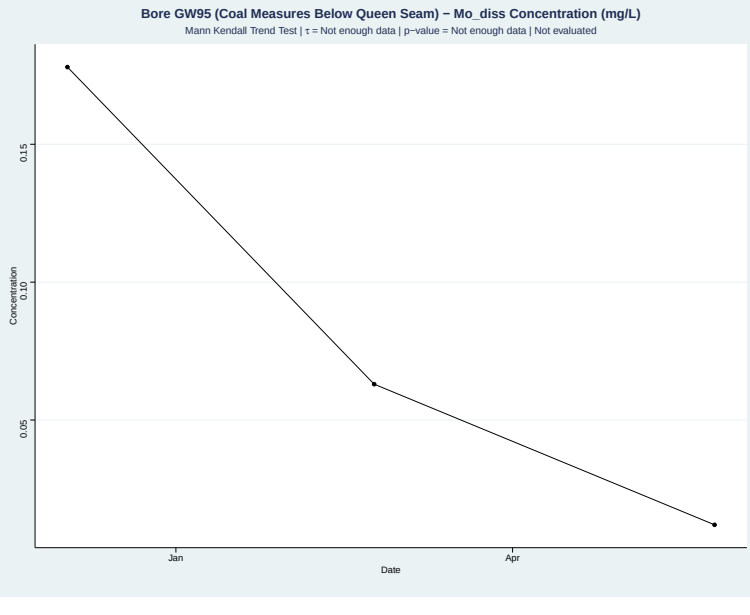


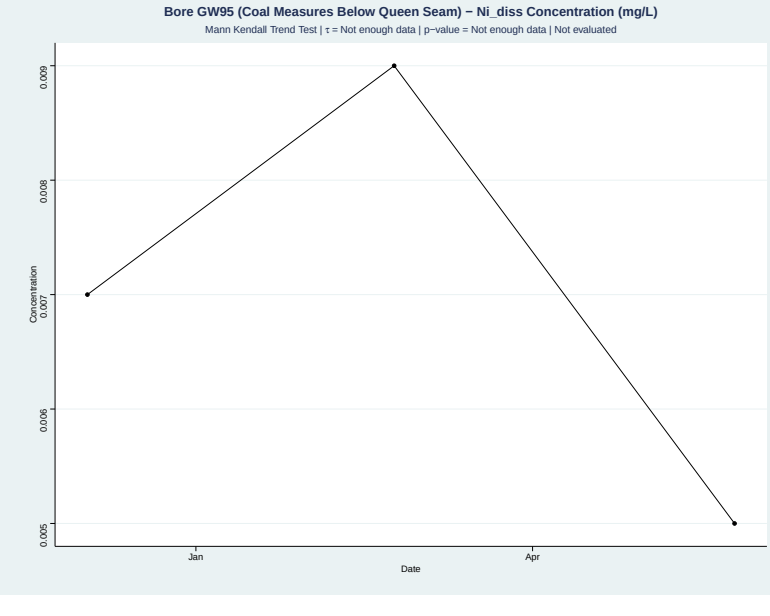
Appendix C Groundwater Quality Time Series

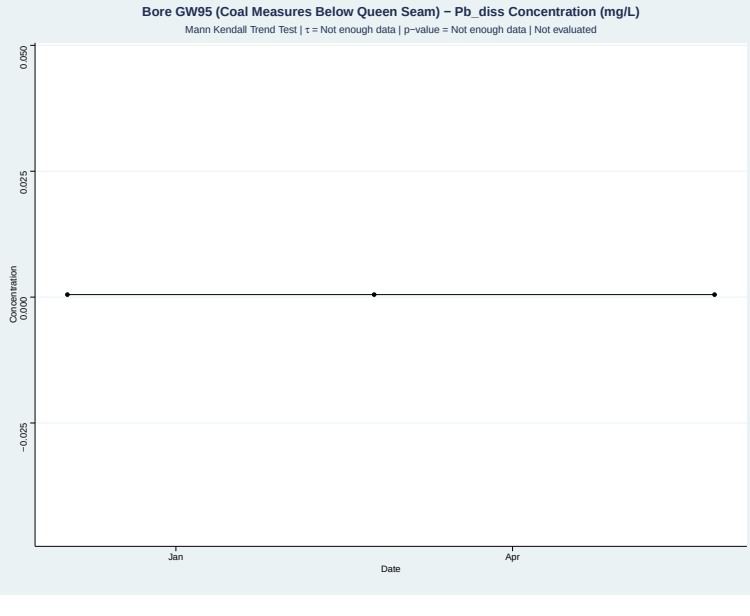




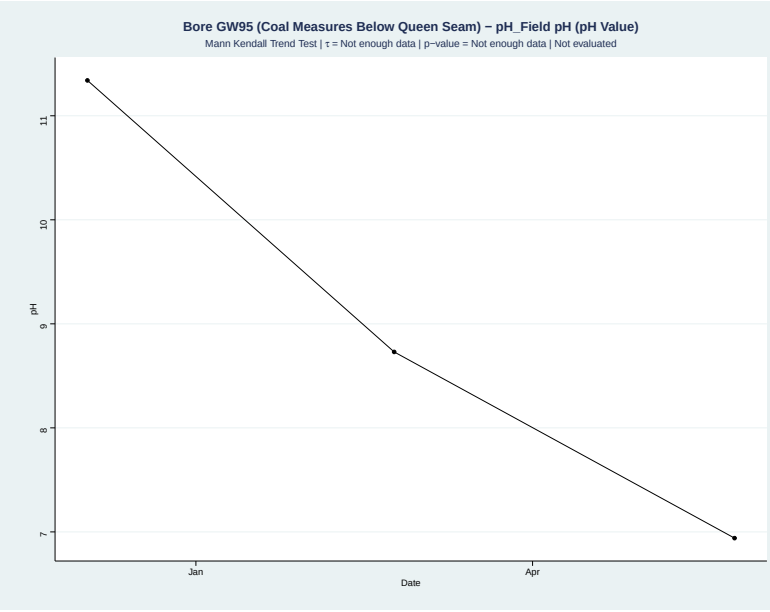


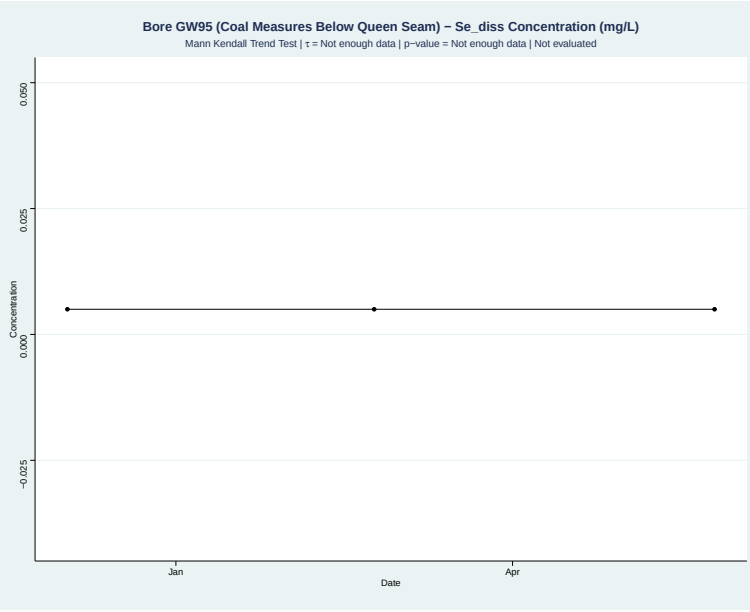


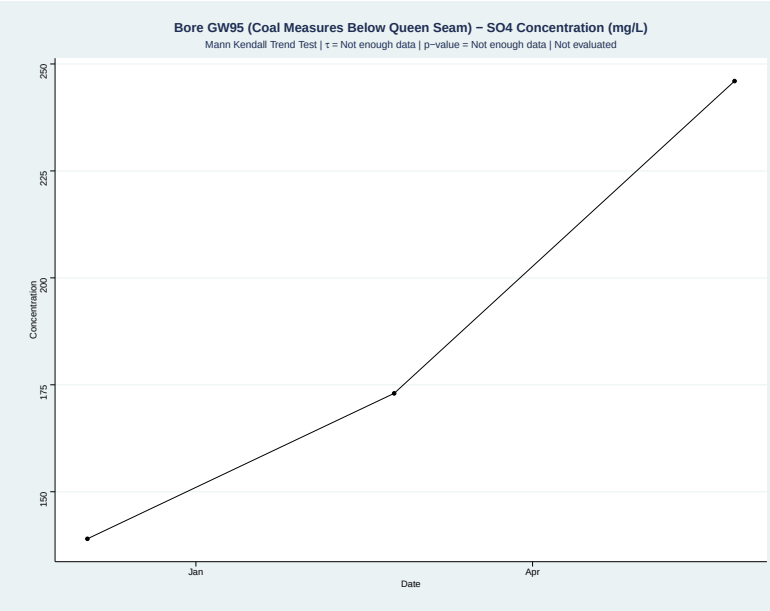


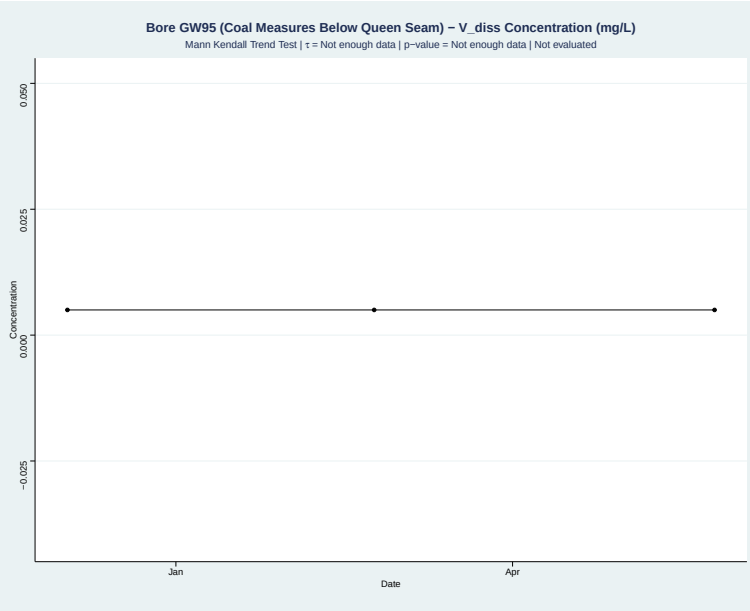


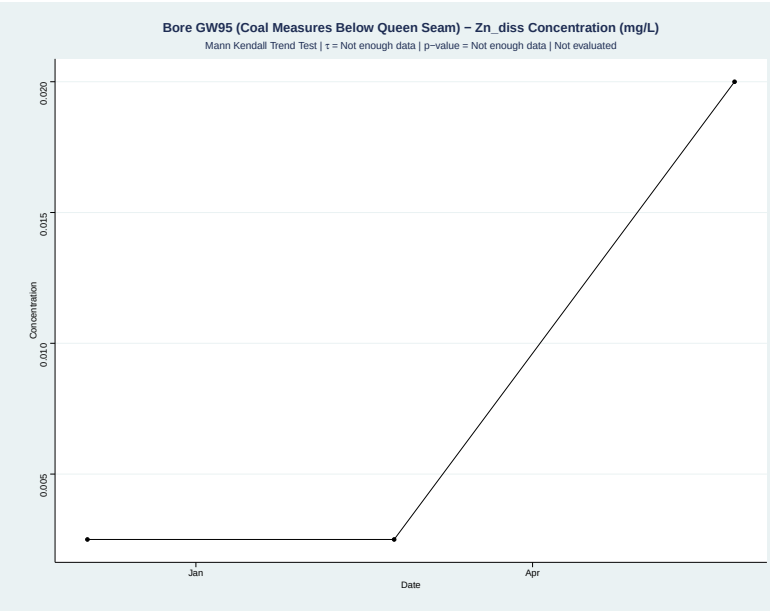
Appendix C Groundwater Quality Time Series

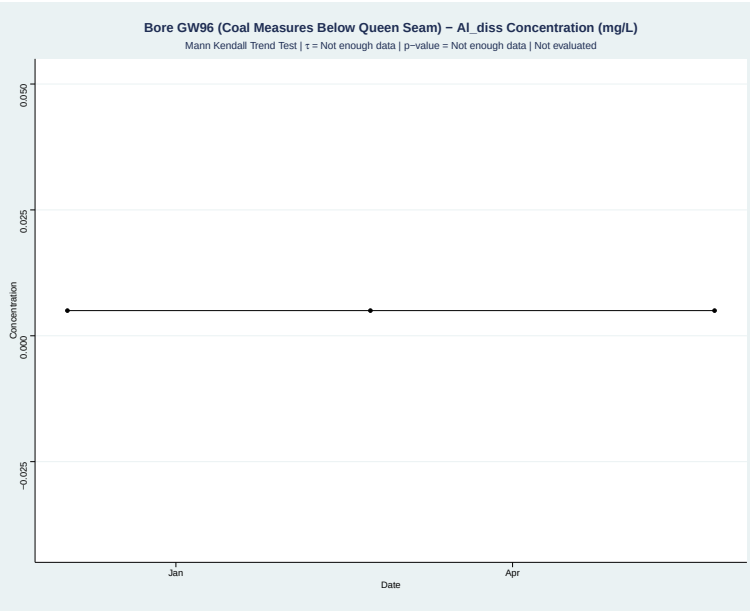








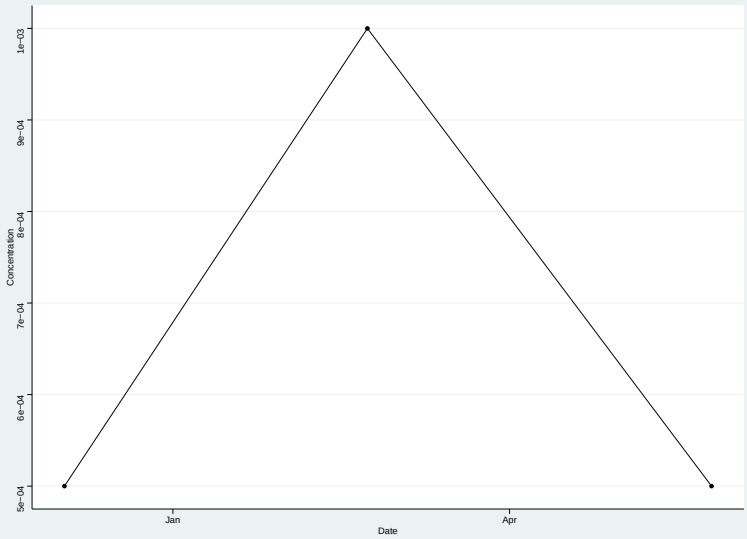




Appendix C Groundwater Quality Time Series

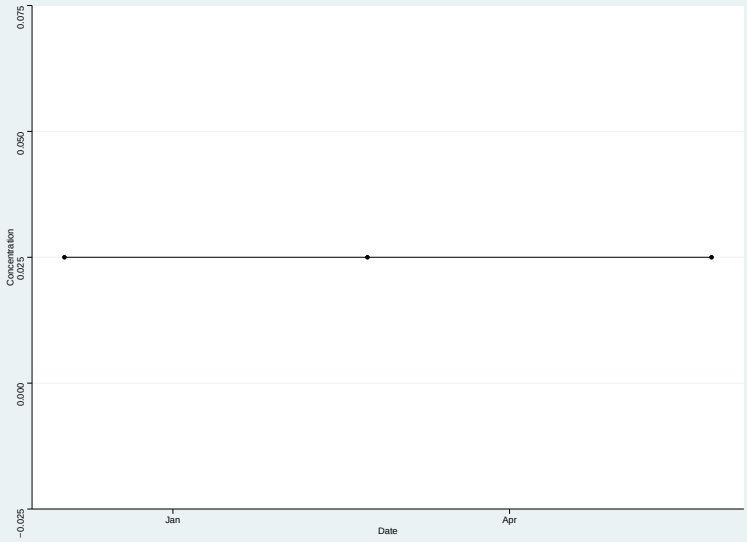
Bore GW96 (Coal Measures Below Queen Seam) – As_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



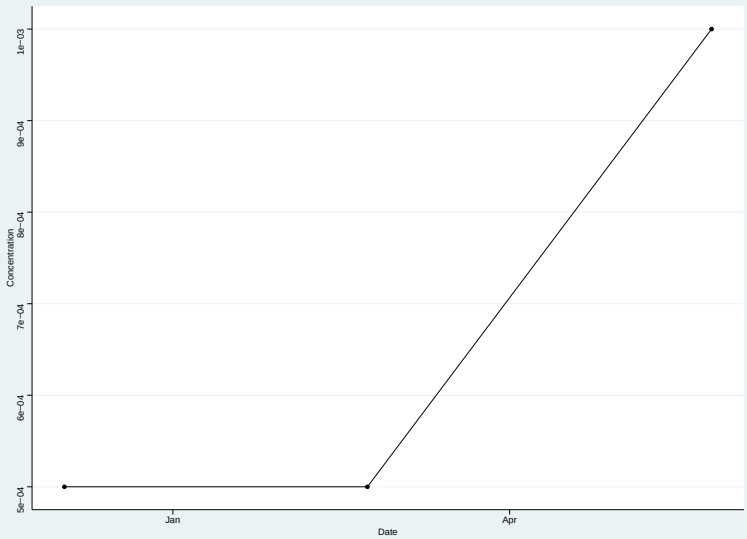
Bore GW96 (Coal Measures Below Queen Seam) – B_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



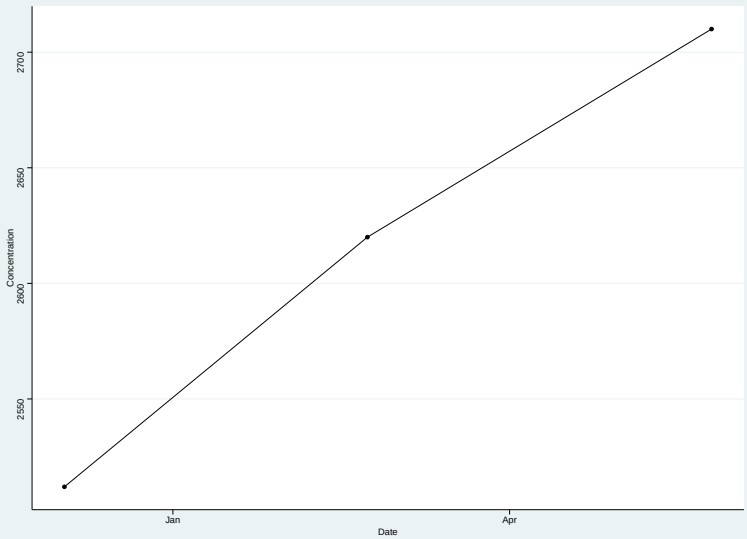
Bore GW96 (Coal Measures Below Queen Seam) – Co_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



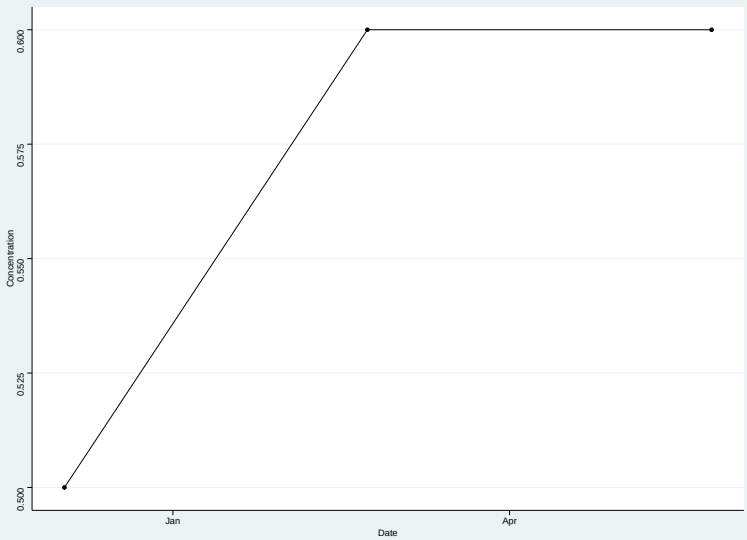
Bore GW96 (Coal Measures Below Queen Seam) – EC_Field Concentration (µS/cm)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



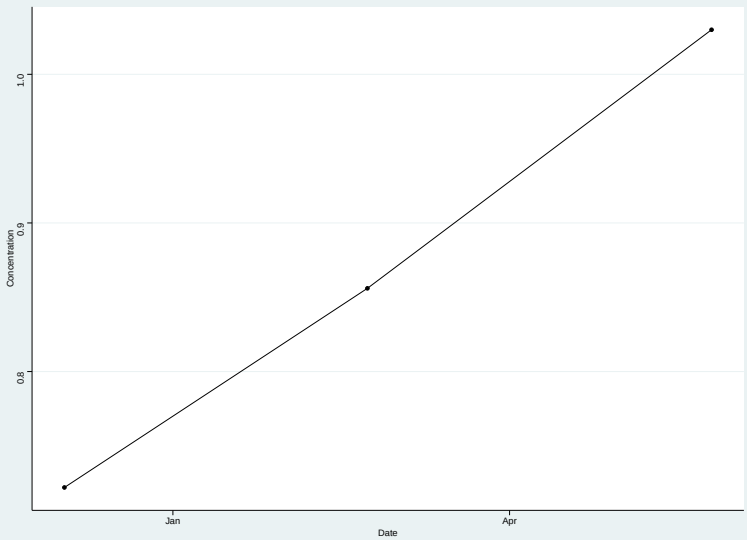
Bore GW96 (Coal Measures Below Queen Seam) – Fluoride Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



Bore GW96 (Coal Measures Below Queen Seam) – Mn_diss Concentration (mg/L)

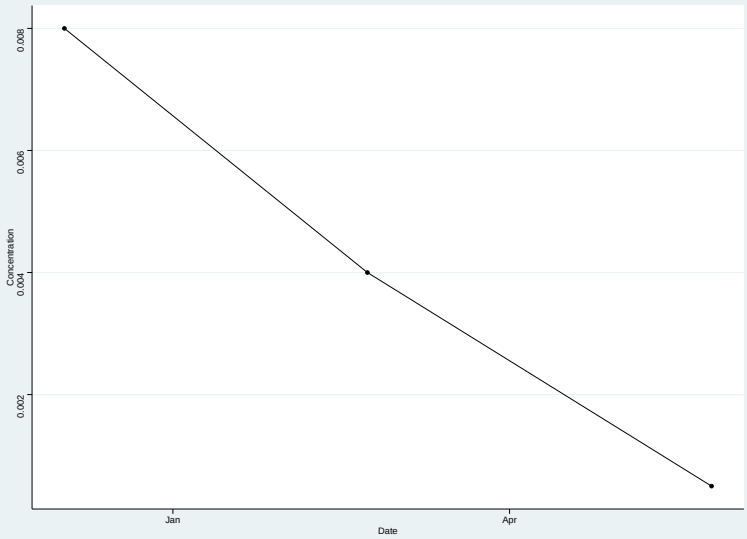
Mann Kendall Trend Test | τ = Not enough data | p-value = Not enough data | Not evaluated



Appendix C Groundwater Quality Time Series

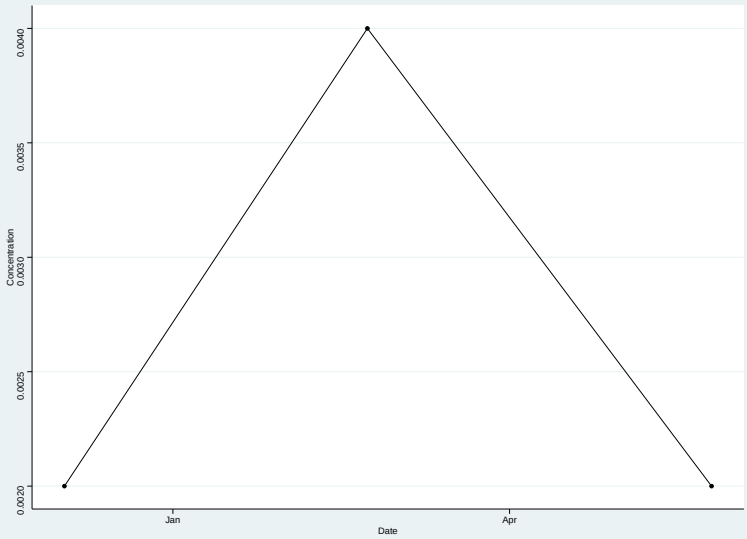
Bore GW96 (Coal Measures Below Queen Seam) – Mo_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p−value = Not enough data | Not evaluated



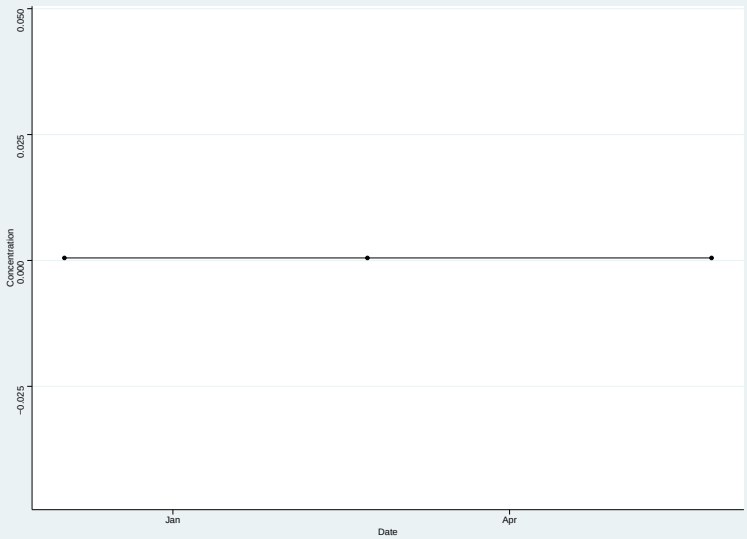
Bore GW96 (Coal Measures Below Queen Seam) – Ni_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p−value = Not enough data | Not evaluated



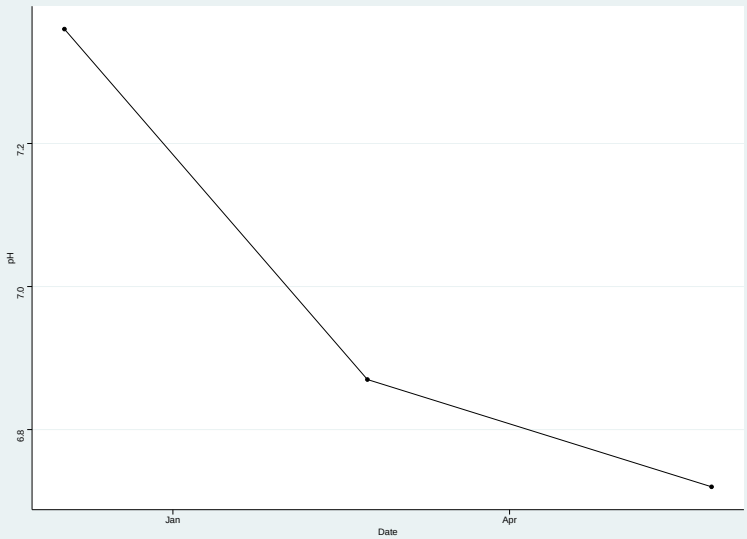
Bore GW96 (Coal Measures Below Queen Seam) – Pb_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p−value = Not enough data | Not evaluated



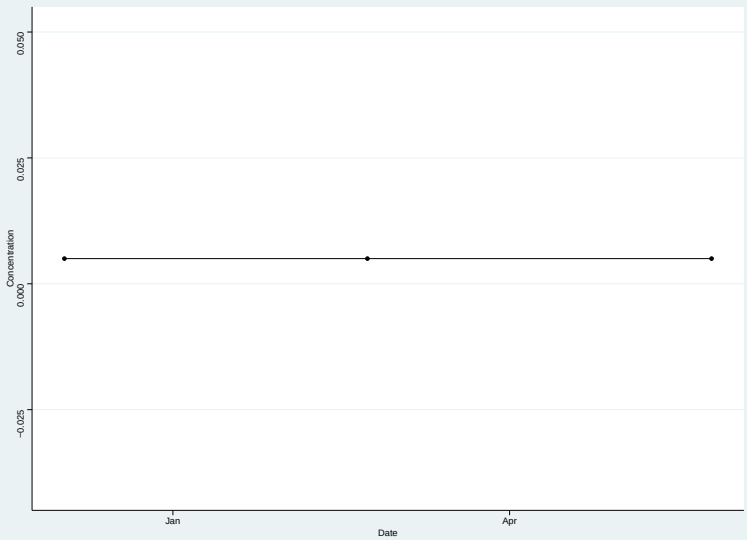
Bore GW96 (Coal Measures Below Queen Seam) – pH_Field pH (pH Value)

Mann Kendall Trend Test | τ = Not enough data | p−value = Not enough data | Not evaluated



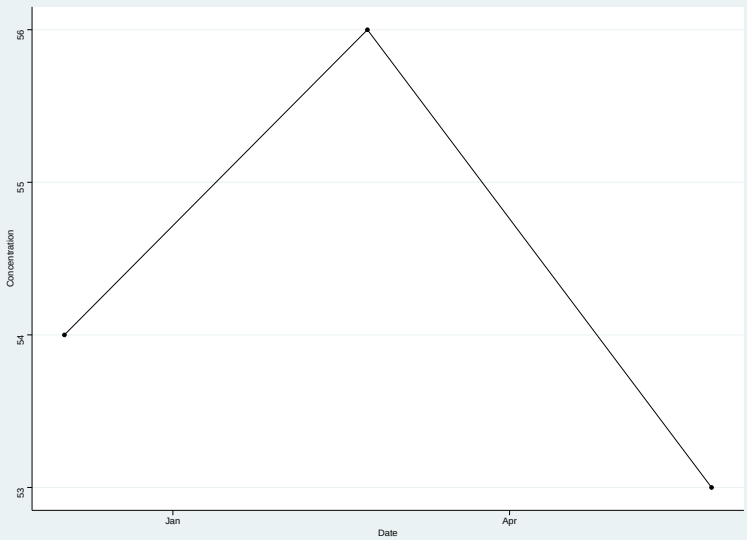
Bore GW96 (Coal Measures Below Queen Seam) – Se_diss Concentration (mg/L)

Mann Kendall Trend Test | τ = Not enough data | p−value = Not enough data | Not evaluated

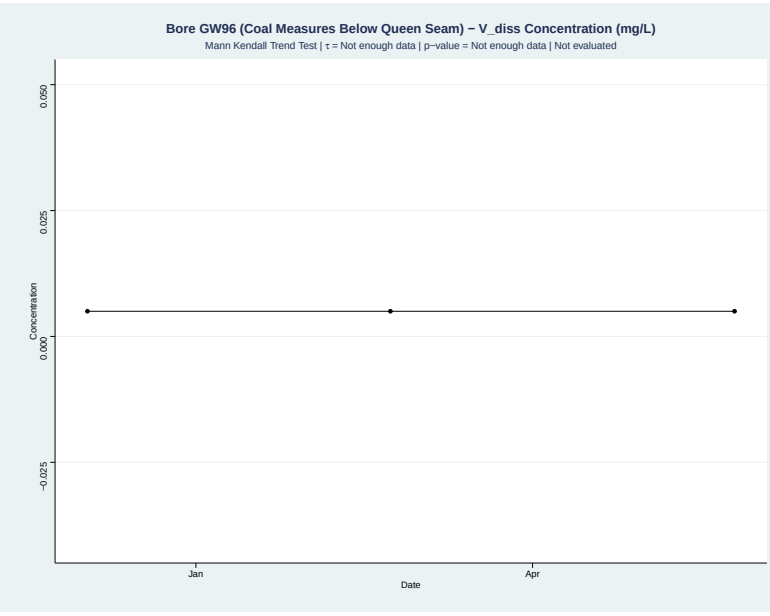


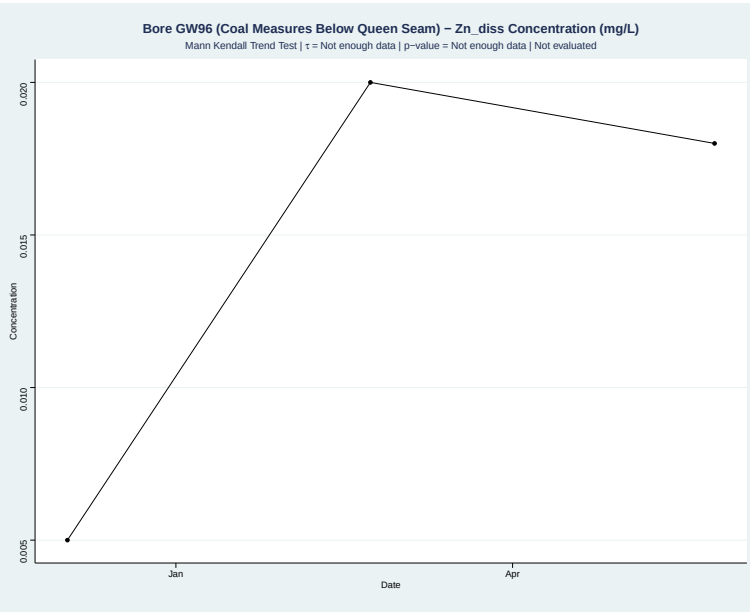
Bore GW96 (Coal Measures Below Queen Seam) – SO4 Concentration (mg/L)

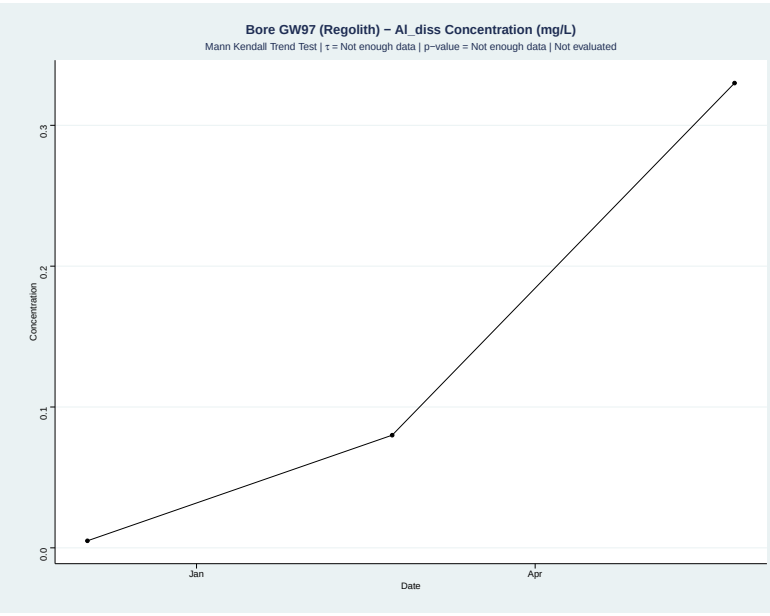
Mann Kendall Trend Test | τ = Not enough data | p−value = Not enough data | Not evaluated

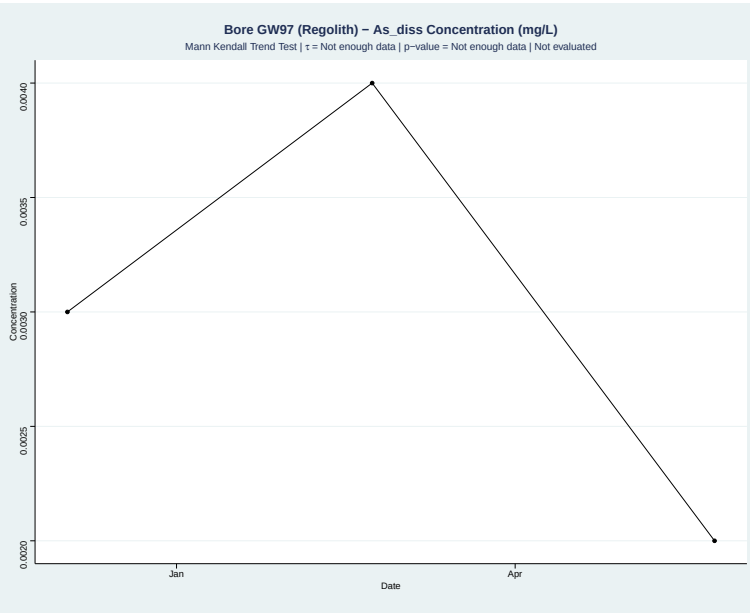


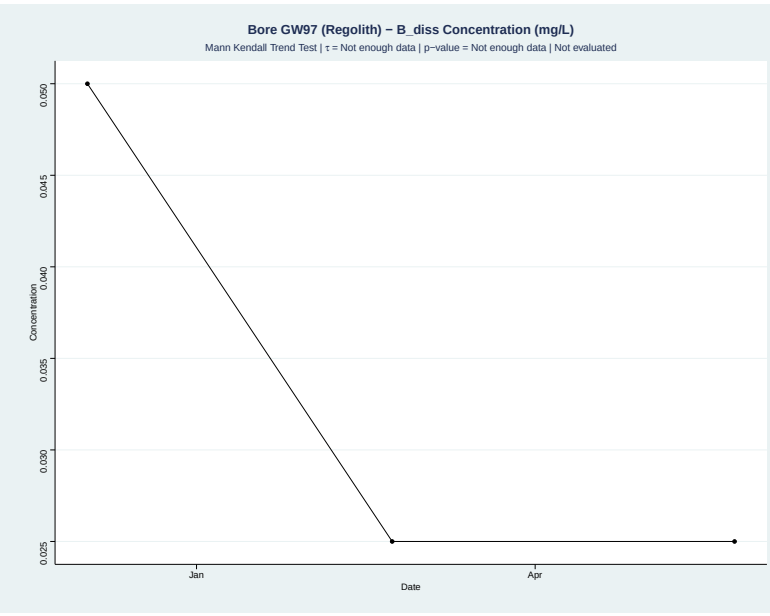
Appendix C Groundwater Quality Time Series

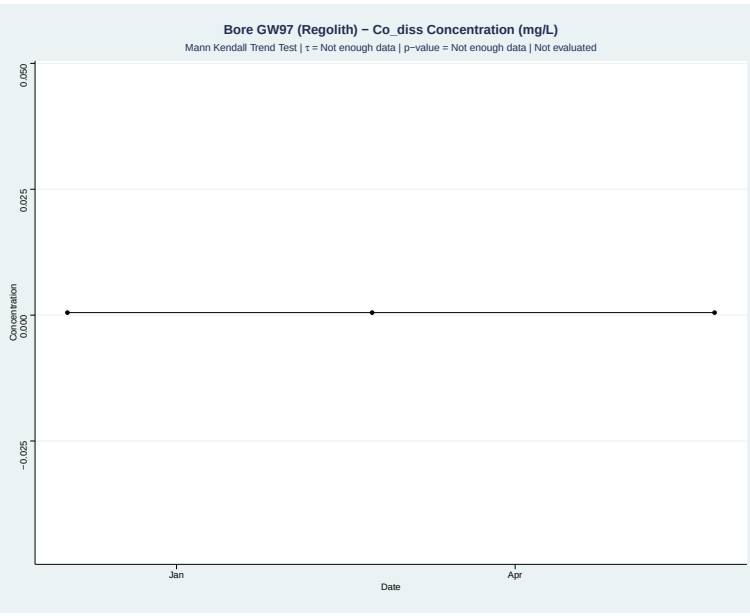




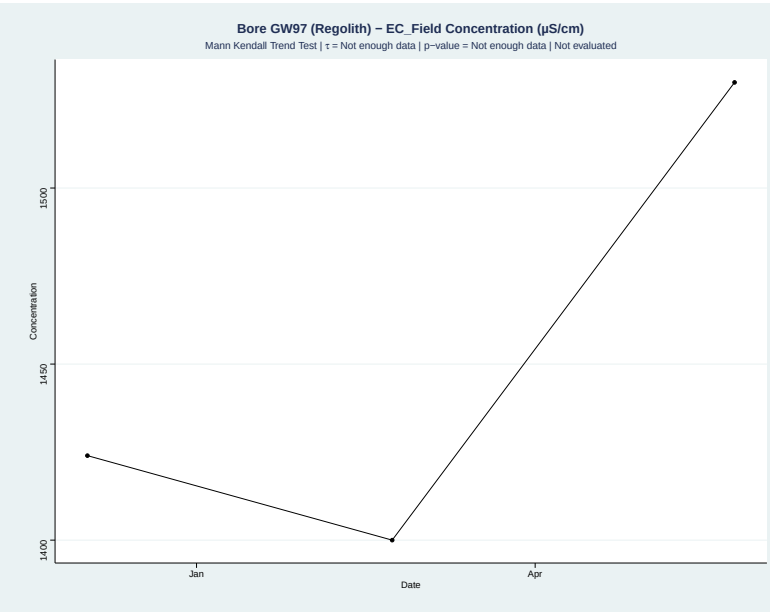


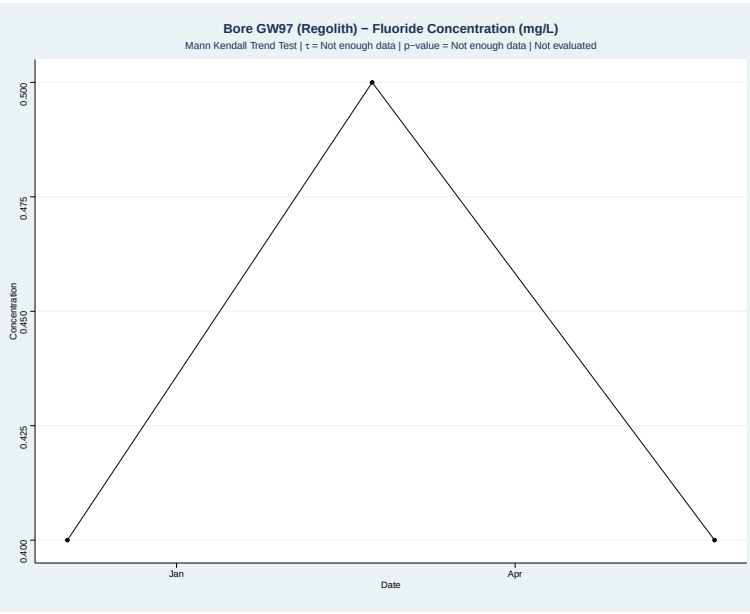


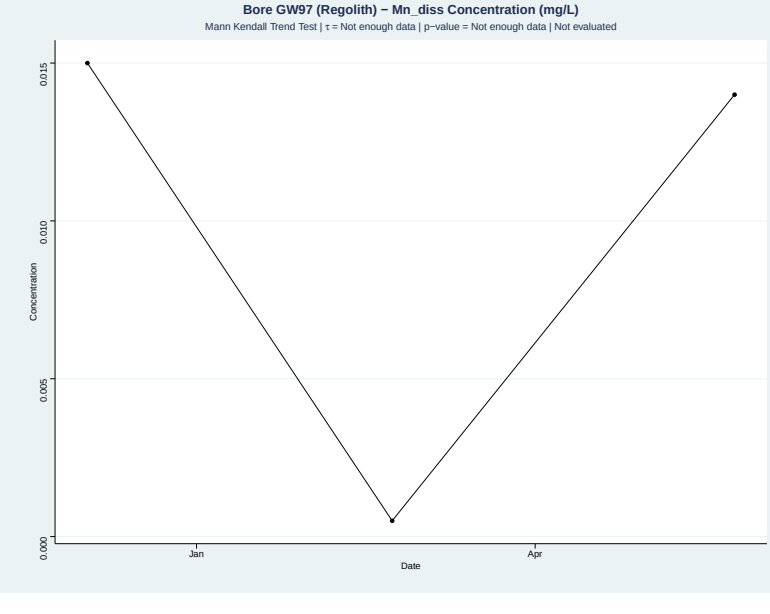


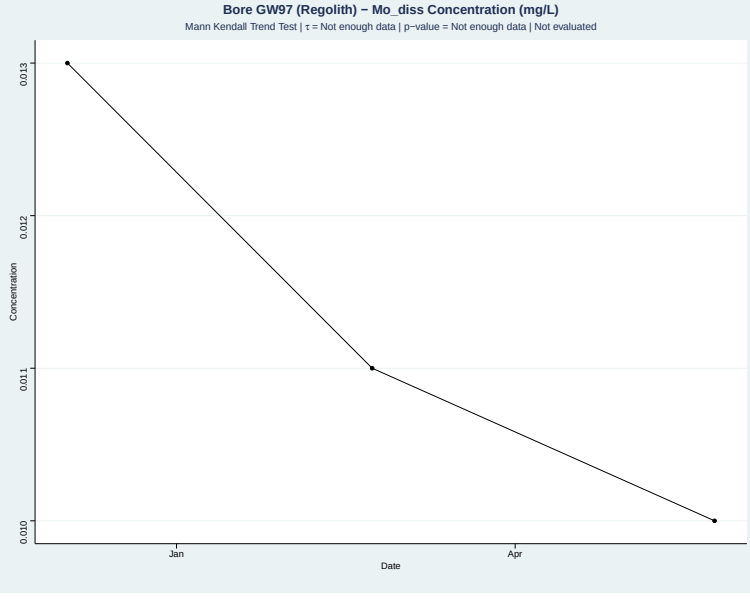


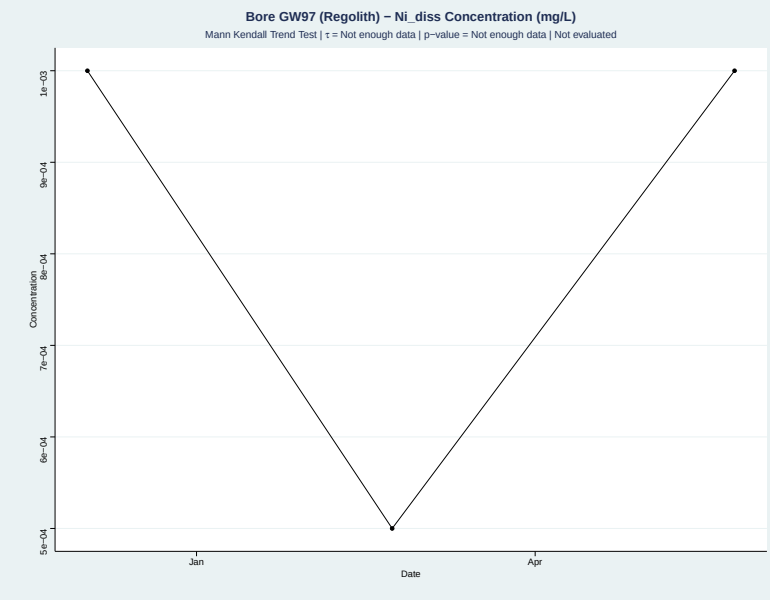
Appendix C Groundwater Quality Time Series

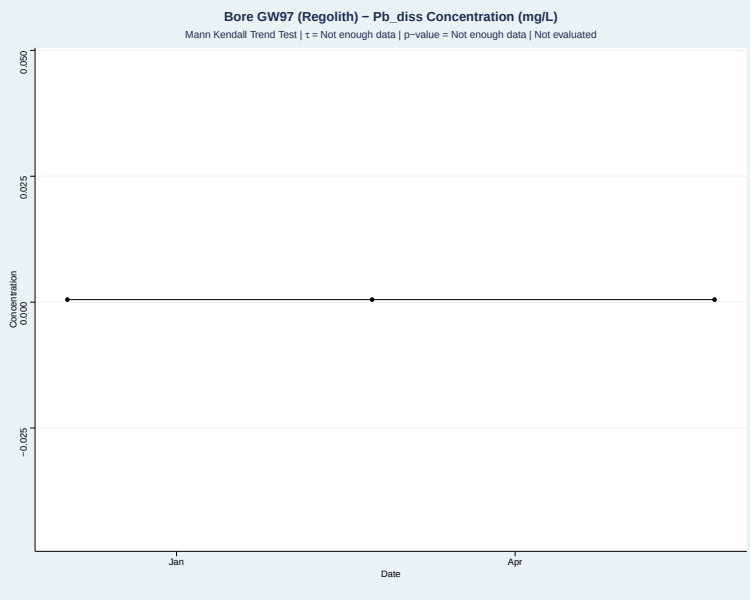




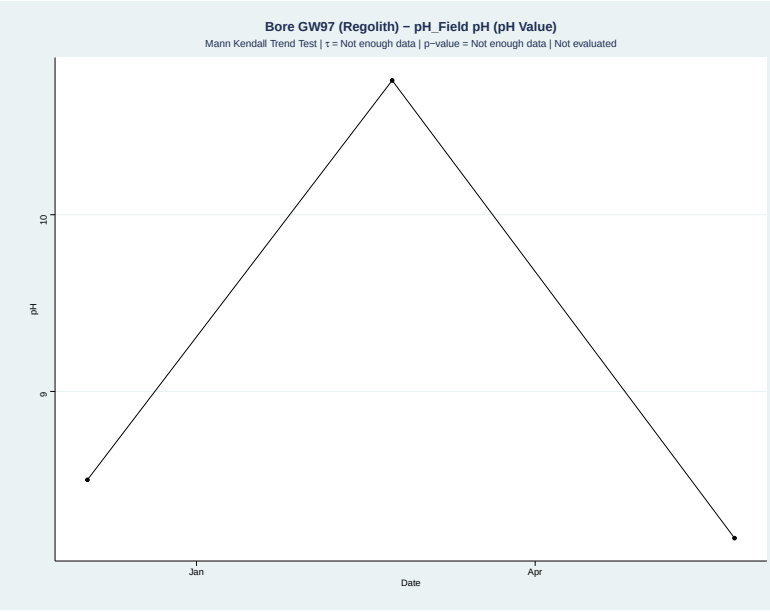


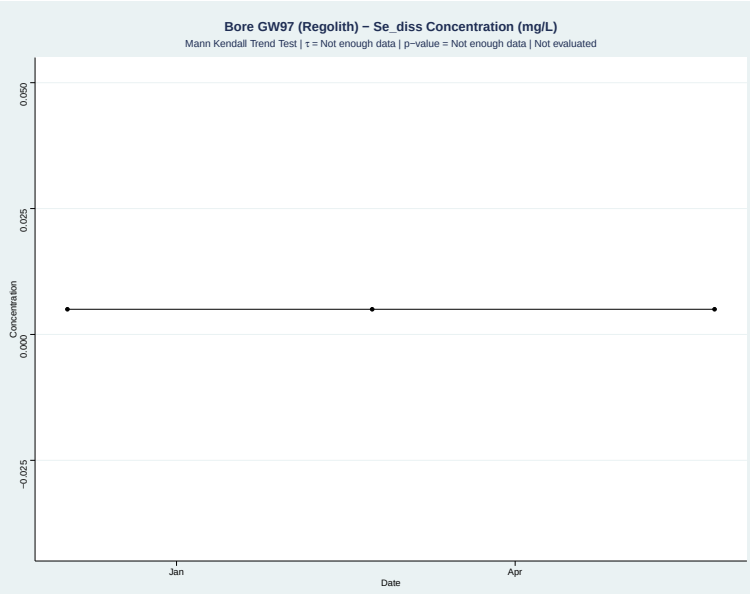


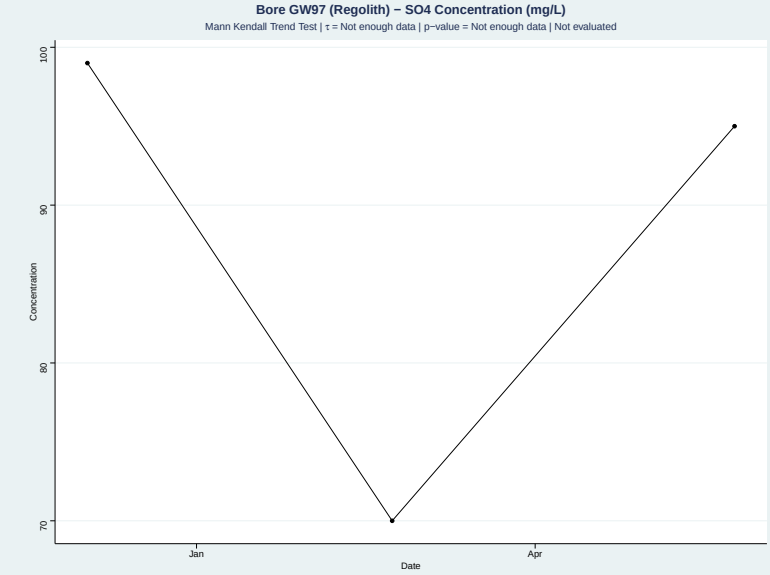


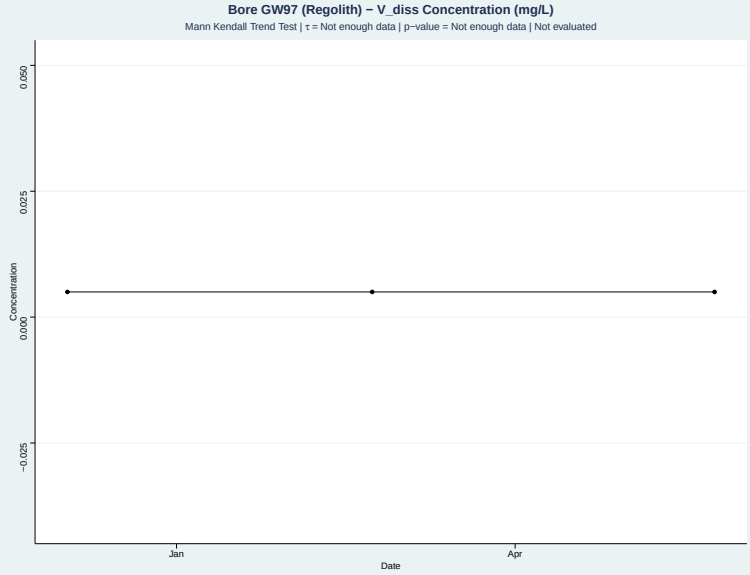


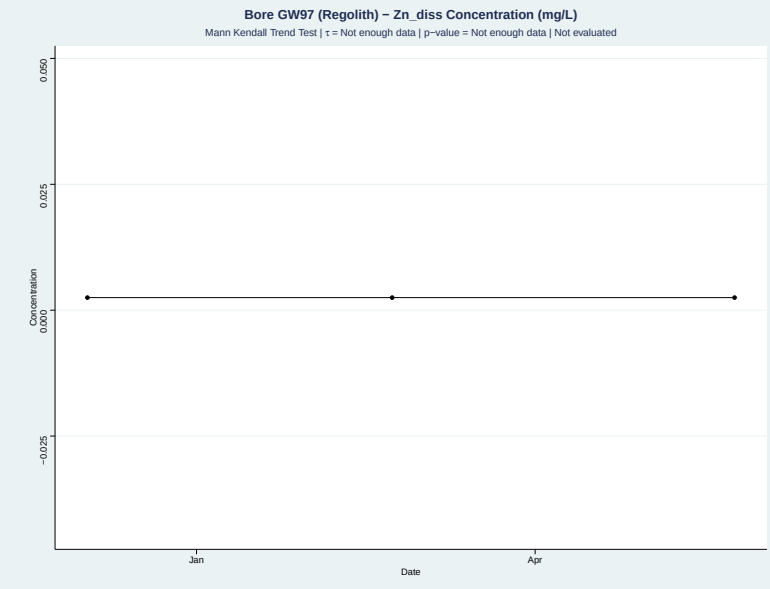
Appendix C Groundwater Quality Time Series











APPENDIX D

Contaminants of Concern - Post Closure Concentrations



0 0.5 1 km

Coordinate System:	AGD 1984 AMG Zone 56
Scale:	1:40,000 at A4
Project Number:	620.30536
Date:	06-Dec-2021
Drawn by:	JG

SLR

Alluvium Extent

Meandu ML

Concentration (mg/L)

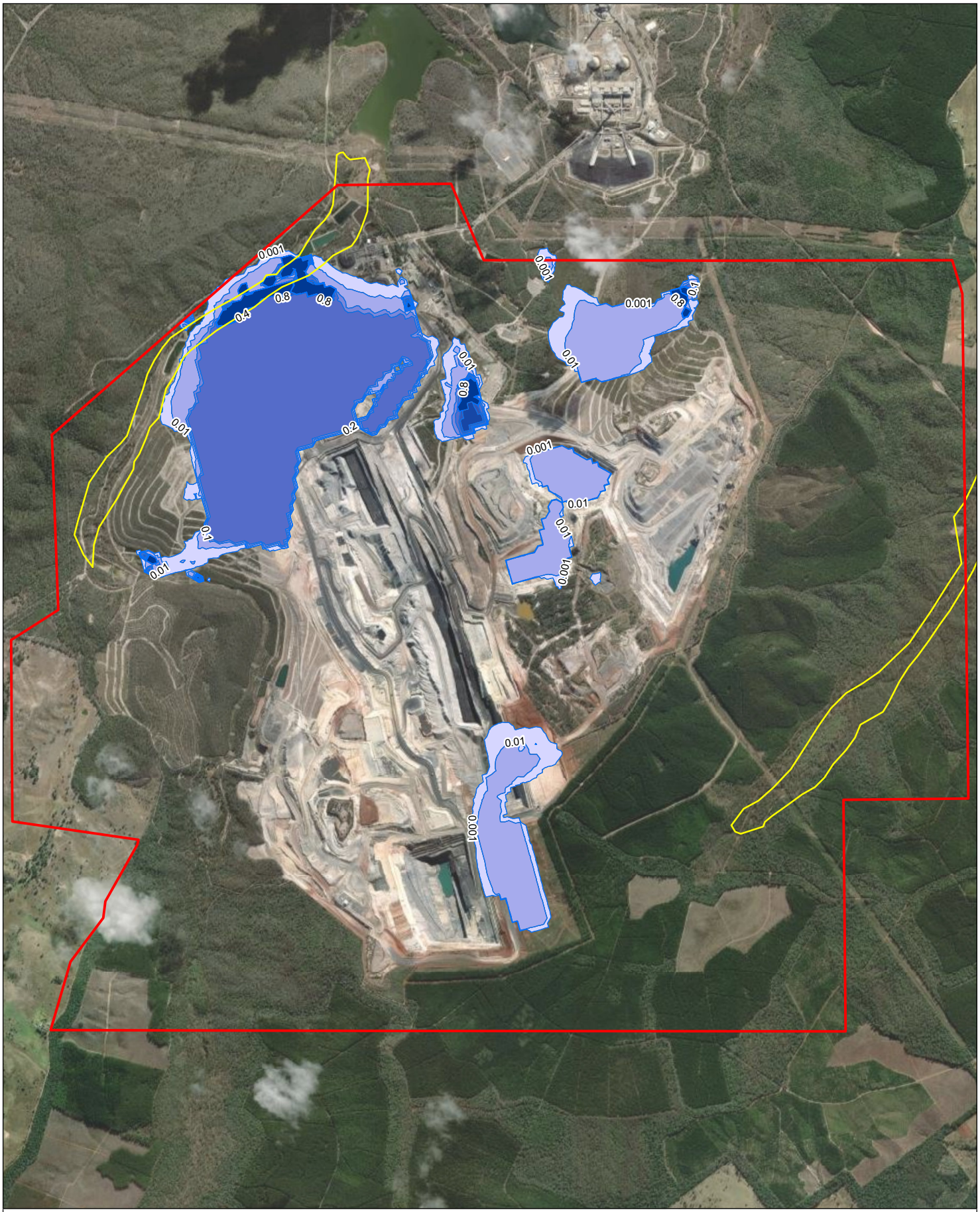
- 0.0 - 0.1
- 0.1 - 1.0
- 1.0 - 3.0
- 3.0 - 5.0
- 5.0 - 7.0
- 7.0 - 10.0
- > 10.0

MEANDU PRCP

Aluminium Concentration
700 Years Post Closure

FIGURE 1

H:\Projects-SLR\620-BNE\620-BNE\620.30536.00000 Meandu PRCP Water Modelling\06 SLR Data\01 CADG\GIS\GIS\Concentration 700 years post closure\620305536 FXX Al concentration 700 years post closure.mxd



0 0.5 1 km

Alluvium Extent

Meandu ML

Concentration (mg/L)

- 0.0 - 0.01
- 0.01 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- > 0.8

Coordinate System:	AGD 1984 AMG Zone 56
Scale:	1:40,000 at A4
Project Number:	620.30536
Date:	06-Dec-2021
Drawn by:	JG

SLR

MEANDU PRCP

Cobalt Concentration
700 Years Post Closure

FIGURE 2

H:\Projects-SLR\620-BNE\620-BNE\620.30536.00000 Meandu PRCP Water Modelling\06 SLR Data\01 CADG\GIS\GIS\Concentration 700 years post closure\620.30536 FXX Co concentration 700 years post closure.mxd



0 0.5 1 km

Coordinate System:	AGD 1984 AMG Zone 56
Scale:	1:40,000 at A4
Project Number:	620.30536
Date:	06-Dec-2021
Drawn by:	JG

Alluvium Extent

Meandu ML

Concentration (µS/cm)

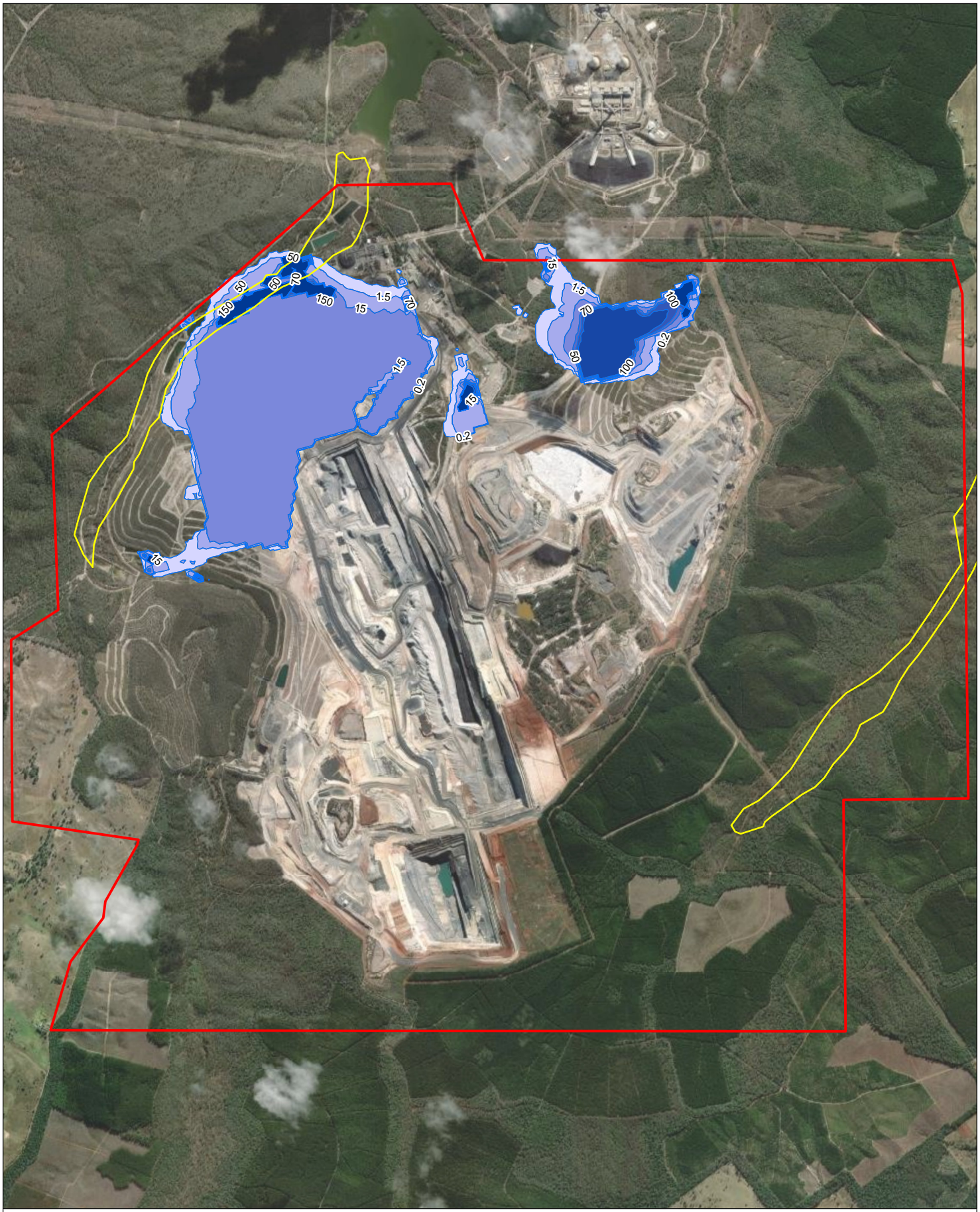
- 30.00 - 300.00
- 300.00 - 3000.00
- 3000.00 - 7100.00
- 7100.00 - 14200.00
- 14200.00 - 21400.00
- 21400.00 - 28500.00
- > 28500.00

MEANDU PRCP

Electrical Conductivity Concentration
700 Years Post Closure

FIGURE 3

H:\Projects-SLR\620-BNE\620-BNE\620.30536.00000 Meandu PRCP Water Modelling\06 SLR Data\01 CADD\GIS\GIS\Concentration 700 years post closure\620305536 FXX EC concentration 700 years post closure.mxd



0 0.5 1 km

Coordinate System:	AGD 1984 AMG Zone 56
Scale:	1:40,000 at A4
Project Number:	620.30536
Date:	06-Dec-2021
Drawn by:	JG

SLR

Alluvium Extent

Meandu ML

Concentration (mg/L)

- 0.2 - 1.5
- 1.5 - 15.0
- 15.0 - 50.0
- 50.0 - 70.0
- 70.0 - 100.0
- 100.0 - 150.0
- > 150.0

MEANDU PRCP

Iron Concentration
700 Years Post Closure

FIGURE 4

H:\Projects-SLR\620-BNE\620-BNE\620.30536.00000 Meandu PRCP Water Modelling\06 SLR Data\01 CADG\GIS\GIS\Concentration 700 years post closure\620305536 FXX Fe concentration 700 years post closure.mxd



0 0.5 1 km

Coordinate System:	AGD 1984 AMG Zone 56
Scale:	1:40,000 at A4
Project Number:	620.30536
Date:	06-Dec-2021
Drawn by:	JG

Alluvium Extent

Meandu ML

Concentration (mg/L)

- 0.1 - 0.5
- 0.5 - 5.0
- 5.0 - 10.0
- 10.0 - 20.0
- 20.0 - 30.0
- 30.0 - 50.0
- > 50.0

MEANDU PRCP

Manganese Concentration
700 Years Post Closure

FIGURE 5

H:\Projects-SLR\620-BNE\620-BNE\620.30536.00000 Meandu PRCP Water Modelling\06 SLR Data\01 CADD\GIS\GIS\Concentration 700 years post closure\620.30536 FXX Mn concentration 700 years post closure.mxd



0 0.5 1 km

Alluvium Extent

Meandu ML

Concentration (mg/L)

- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- > 0.50

Coordinate System:	AGD 1984 AMG Zone 56
Scale:	1:40,000 at A4
Project Number:	620.30536
Date:	06-Dec-2021
Drawn by:	JG

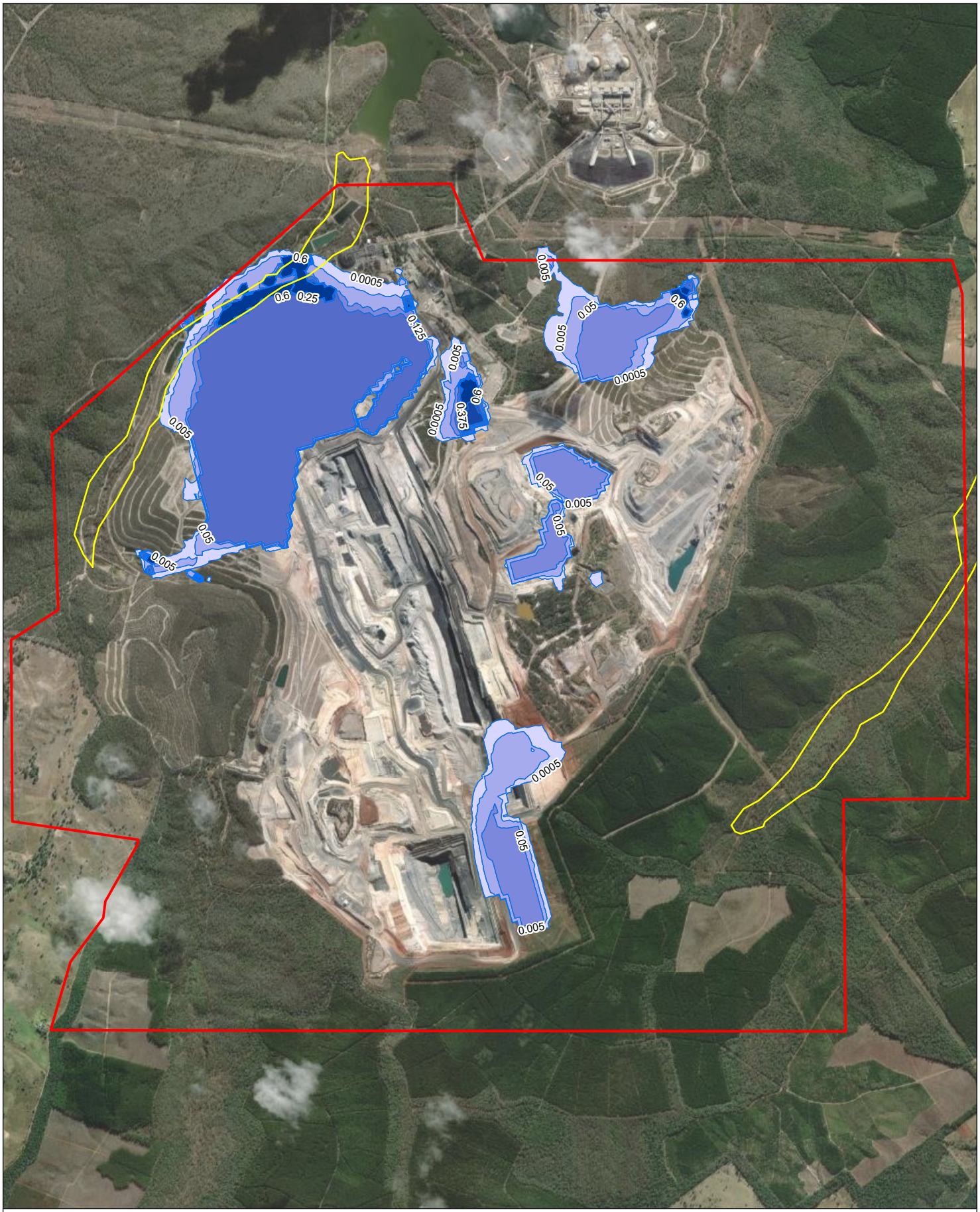
SLR

MEANDU PRCP

Molybdenum Concentration
700 Years Post Closure

FIGURE 6

H:\Projects-SLR\620-BNE\620-BNE\620.30536.00000 Meandu PRCP Water Modelling\06 SLR Data\01 CADD\GIS\GIS\Concentration 700 years post closure\620305536 FXX Mo concentration 700 years post closure.mxd



0 0.5 1 km

Coordinate System:	AGD 1984 AMG Zone 56
Scale:	1:40,000 at A4
Project Number:	620.30536
Date:	06-Dec-2021
Drawn by:	JG

Alluvium Extent

Meandu ML

Concentration (mg/L)

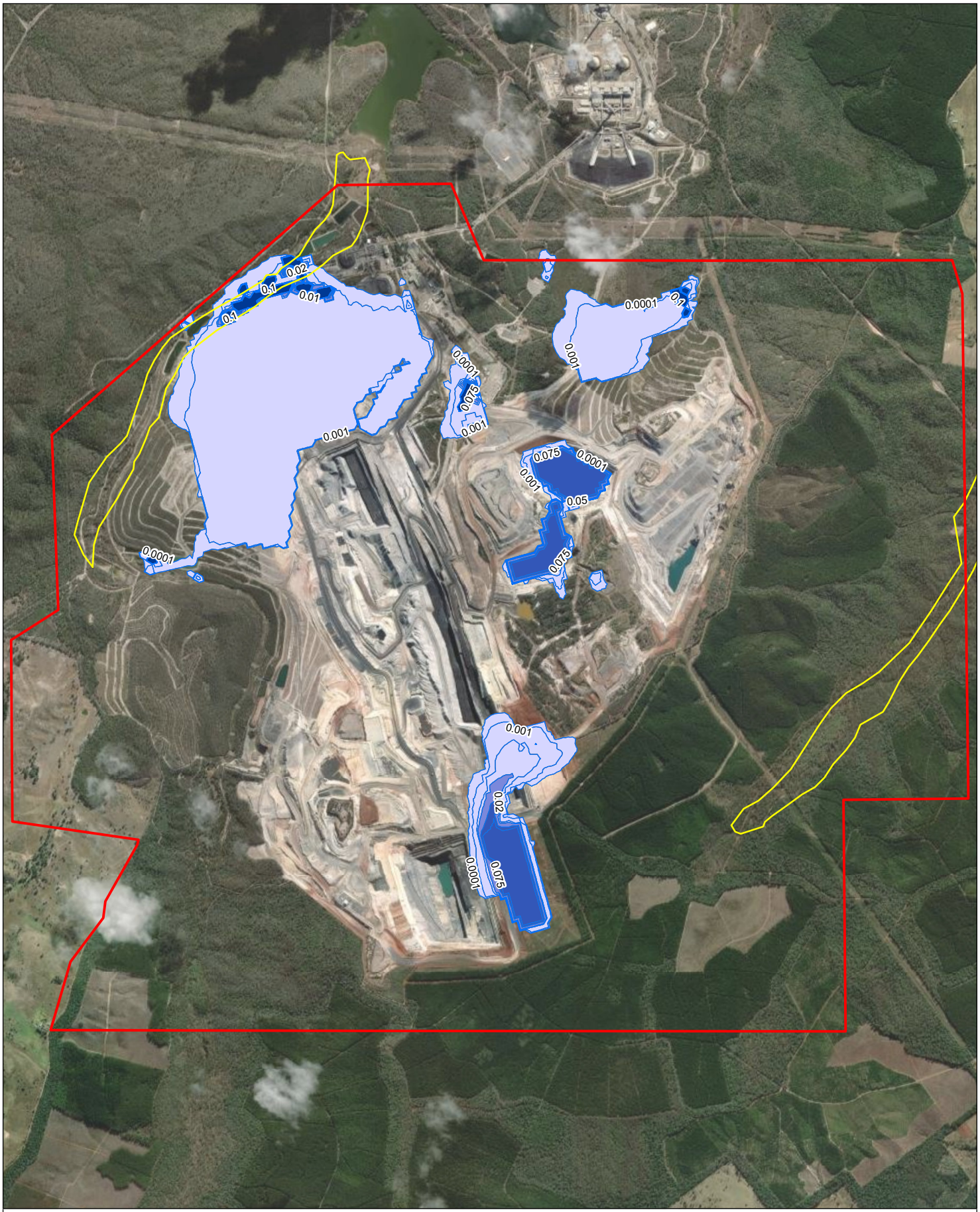
- 0.0 - 0.005
- 0.005 - 0.1
- 0.1 - 0.125
- 0.125 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- > 0.6

MEANDU PRCP

Nickel Concentration
700 Years Post Closure

FIGURE 7

H:\Projects-SLR\620-BNE\620.30536.00000 Meandu PRCP Water Modelling\06 SLR Data\01 CADG\GIS\GIS\Concentration 700 years post closure\620305536 FXX Ni concentration 700 years post closure.mxd



0 0.5 1 km

Alluvium Extent

Meandu ML

Concentration (mg/L)

- 0.0 - 0.02
- 0.02 - 0.1
- 0.1 - 0.1
- > 0.1

Coordinate System:	AGD 1984 AMG Zone 56
Scale:	1:40,000 at A4
Project Number:	620.30536
Date:	06-Dec-2021
Drawn by:	JG

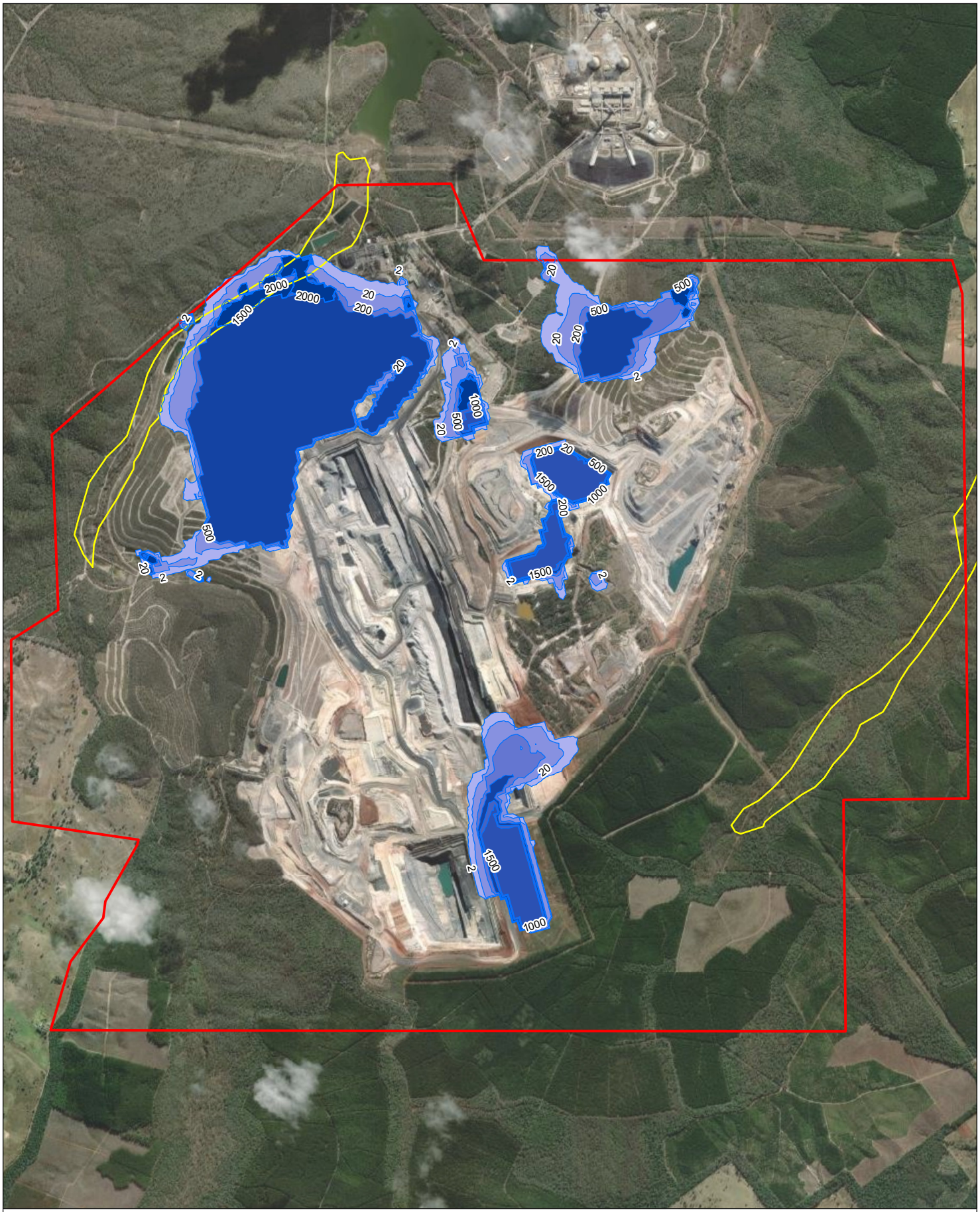
SLR

MEANDU PRCP

Selenium Concentration
700 Years Post Closure

FIGURE 8

H:\Projects-SLR\620-BNE\620-BNE\620.30536.00000 Meandu PRCP Water Modelling\06 SLR Data\01 CADG\GIS\GIS\Concentration 700 years post closure\620.30536 FXX Se concentration 700 years post closure.mxd



0 0.5 1 km

Alluvium Extent

Meandu ML

Concentration (mg/L)

- 2.0 - 20.0
- 20.0 - 200.0
- 200.0 - 500.0
- 1000.0 - 1500.0
- 1500.0 - 2000.0
- 500.0 - 1000.0
- > 2000

Coordinate System:	AGD 1984 AMG Zone 56
Scale:	1:40,000 at A4
Project Number:	620.30536
Date:	06-Dec-2021
Drawn by:	JG

SLR

MEANDU PRCP

Sulphate Concentration
700 Years Post Closure

FIGURE 9

H:\Projects-SLR\620-BNE\620-BNE\620.30536.00000 Meandu PRCP Water Modelling\06 SLR Data\01 CADG\GIS\GIS\Concentration 700 years post closure\620305536 FXX SO4 concentration 700 years post closure.mxd



0 0.5 1 km

Alluvium Extent

Meandu ML

Concentration (mg/L)

- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.50
- > 0.50

Coordinate System:	AGD 1984 AMG Zone 56
Scale:	1:40,000 at A4
Project Number:	620.30536
Date:	06-Dec-2021
Drawn by:	JG

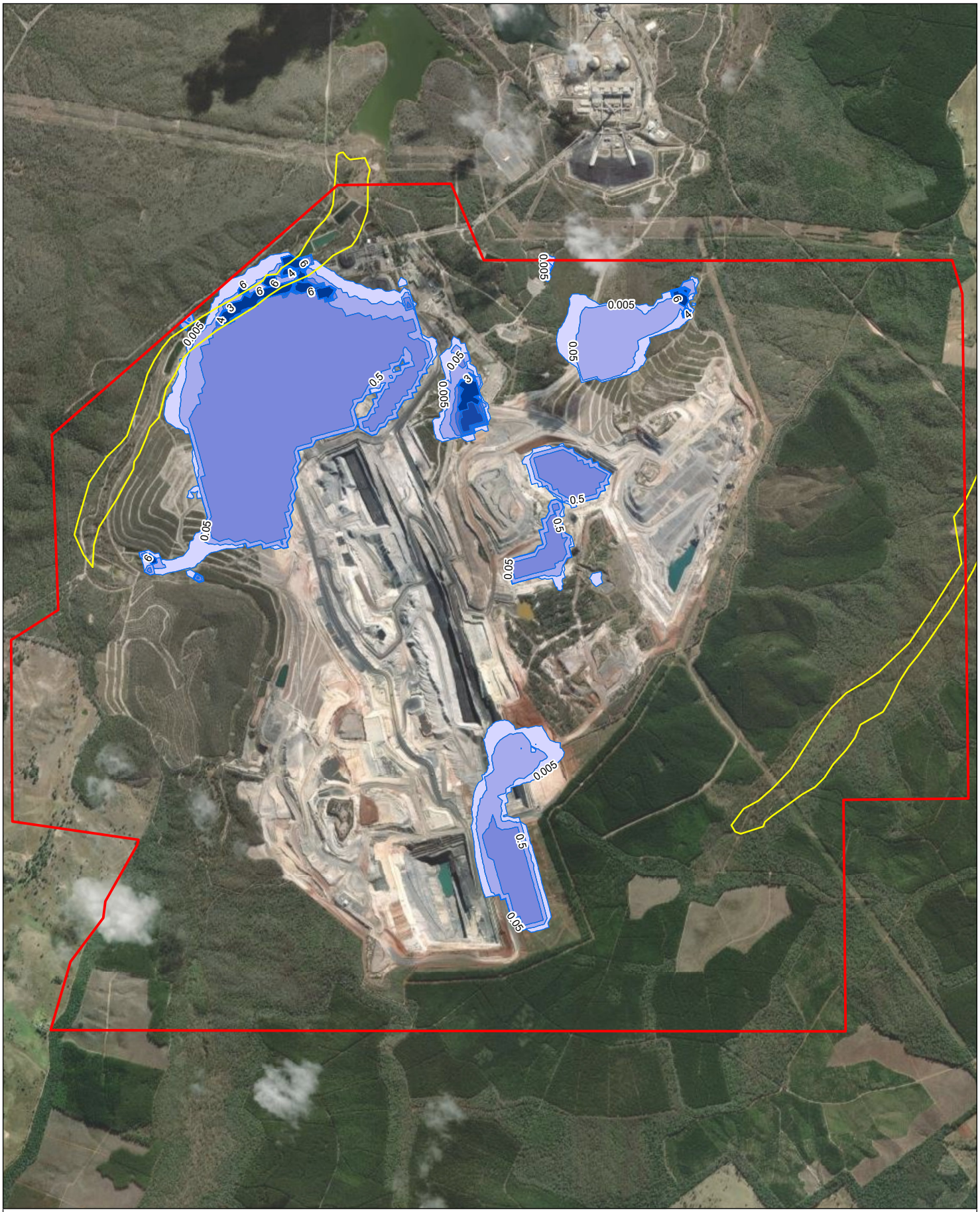
SLR

MEANDU PRCP

Vanadium Concentration
700 Years Post Closure

FIGURE 10

H:\Projects-SLR\620-BNE\620-BNE\620.30536.00000 Meandu PRCP Water Modelling\06 SLR Data\01 CADG\GIS\GIS\Concentration 700 years post closure\620305536 FXX V concentration 700 years post closure.mxd



0 0.5 1 km

Alluvium Extent

Meandu ML

Concentration (mg/L)

- 0.0 - 0.1
- 0.1 - 0.5
- 0.5 - 1.5
- 1.5 - 3.0
- 3.0 - 4.0
- 4.0 - 6.0
- > 6.0

Coordinate System:	AGD 1984 AMG Zone 56
Scale:	1:40,000 at A4
Project Number:	620.30536
Date:	06-Dec-2021
Drawn by:	JG

SLR

MEANDU PRCP

Zinc Concentration
700 Years Post Closure

FIGURE 11

H:\Projects-SLR\620-BNE\620-BNE\620.30536.00000 Meandu PRCP Water Modelling\06 SLR Data\01 CADD\GIS\GIS\Concentration 700 years post closure\620305536 FXX Zn concentration 700 years post closure.mxd

APPENDIX E

IWBM Predicted Water Quality

TDS (mg/l)	10th Percentile			50th Percentile			90th Percentile		
Reporting Point	Min	Median	Max	Min	Median	Max	Min	Median	Max
CP1WQ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.05E+02	0.00E+00	2.56E+02	2.79E+02
CP2WQ	0.00E+00	7.84E+01	2.30E+02	0.00E+00	2.71E+02	2.94E+02	0.00E+00	2.99E+02	5.16E+02
CP3WQ	0.00E+00	1.91E+02	3.03E+02	0.00E+00	3.71E+02	6.40E+02	0.00E+00	7.61E+02	8.42E+02
K2EWQ	0.00E+00	1.83E+03	2.75E+03	0.00E+00	2.13E+03	3.16E+03	0.00E+00	2.46E+03	3.64E+03
K4EWQ	0.00E+00	1.02E+03	1.57E+03	0.00E+00	1.29E+03	2.04E+03	0.00E+00	1.66E+03	2.60E+03

Sulfate (mg/l)	10th Percentile			50th Percentile			90th Percentile		
Reporting Point	Min	Median	Max	Min	Median	Max	Min	Median	Max
CP1WQ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.76E+01	0.00E+00	3.06E+01	3.28E+01
CP2WQ	0.00E+00	2.04E+00	5.53E+01	0.00E+00	7.41E+01	8.28E+01	0.00E+00	8.52E+01	1.08E+02
CP3WQ	0.00E+00	1.51E+01	2.89E+01	0.00E+00	4.72E+01	8.79E+01	0.00E+00	1.05E+02	1.17E+02
K2EWQ	0.00E+00	3.11E+02	4.63E+02	0.00E+00	3.53E+02	5.25E+02	0.00E+00	4.03E+02	5.96E+02
K4EWQ	0.00E+00	3.01E+02	4.99E+02	0.00E+00	3.69E+02	6.28E+02	0.00E+00	4.50E+02	7.79E+02

Aluminium (mg/l)	10th Percentile			50th Percentile			90th Percentile		
Reporting Point	Min	Median	Max	Min	Median	Max	Min	Median	Max
CP1WQ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.62E-01	0.00E+00	1.98E-01	2.19E-01
CP2WQ	0.00E+00	6.54E-02	1.87E-01	0.00E+00	2.25E-01	2.45E-01	0.00E+00	2.49E-01	3.36E-01
CP3WQ	0.00E+00	1.17E-01	2.39E-01	0.00E+00	2.54E-01	3.71E-01	0.00E+00	4.35E-01	4.79E-01
K2EWQ	0.00E+00	1.09E+00	1.64E+00	0.00E+00	1.26E+00	1.88E+00	0.00E+00	1.45E+00	2.16E+00
K4EWQ	0.00E+00	5.66E-01	1.04E+00	0.00E+00	6.93E-01	1.29E+00	0.00E+00	8.39E-01	1.57E+00

Cobalt (mg/l)	10th Percentile			50th Percentile			90th Percentile		
Reporting Point	Min	Median	Max	Min	Median	Max	Min	Median	Max
CP1WQ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.81E-04	0.00E+00	1.25E-03	1.52E-03
CP2WQ	0.00E+00	0.00E+00	5.25E-19	0.00E+00	4.61E-16	8.51E-07	0.00E+00	4.78E-04	8.08E-03
CP3WQ	0.00E+00	1.76E-04	3.51E-03	0.00E+00	6.67E-03	1.31E-02	0.00E+00	1.58E-02	1.76E-02
K2EWQ	0.00E+00	3.32E-02	5.05E-02	0.00E+00	3.93E-02	5.88E-02	0.00E+00	4.60E-02	6.81E-02
K4EWQ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Iron (mg/l)	10th Percentile			50th Percentile			90th Percentile		
Reporting Point	Min	Median	Max	Min	Median	Max	Min	Median	Max
CP1WQ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.76E-01	0.00E+00	8.09E-01	9.91E-01
CP2WQ	0.00E+00	2.70E-02	7.92E-02	0.00E+00	9.60E-02	1.03E-01	0.00E+00	4.98E-01	7.02E+00
CP3WQ	0.00E+00	1.98E-01	2.16E+00	0.00E+00	4.03E+00	7.87E+00	0.00E+00	9.53E+00	1.06E+01
K2EWQ	0.00E+00	2.01E+01	3.06E+01	0.00E+00	2.38E+01	3.56E+01	0.00E+00	2.78E+01	4.12E+01
K4EWQ	0.00E+00	3.79E-01	5.70E-01	0.00E+00	4.87E-01	7.48E-01	0.00E+00	6.35E-01	9.76E-01

Manganese (mg/l)	10th Percentile			50th Percentile			90th Percentile		
Reporting Point	Min	Median	Max	Min	Median	Max	Min	Median	Max
CP1WQ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.35E-01	0.00E+00	6.74E-01	7.33E-01
CP2WQ	0.00E+00	2.03E-01	5.94E-01	0.00E+00	7.03E-01	7.61E-01	0.00E+00	7.74E-01	1.57E+00
CP3WQ	0.00E+00	5.29E-01	7.94E-01	0.00E+00	1.03E+00	1.80E+00	0.00E+00	2.15E+00	2.38E+00
K2EWQ	0.00E+00	5.09E+00	7.68E+00	0.00E+00	5.93E+00	8.83E+00	0.00E+00	6.87E+00	1.02E+01
K4EWQ	0.00E+00	2.15E+00	3.56E+00	0.00E+00	2.64E+00	4.48E+00	0.00E+00	3.22E+00	5.57E+00

Nickel (mg/l)	10th Percentile			50th Percentile			90th Percentile		
Reporting Point	Min	Median	Max	Min	Median	Max	Min	Median	Max
CP1WQ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E-02	0.00E+00	1.29E-02	1.47E-02
CP2WQ	0.00E+00	4.70E-03	1.18E-02	0.00E+00	1.60E-02	1.74E-02	0.00E+00	1.79E-02	1.89E-02
CP3WQ	0.00E+00	3.12E-03	9.16E-03	0.00E+00	1.00E-02	1.63E-02	0.00E+00	1.74E-02	1.79E-02
K2EWQ	0.00E+00	3.69E-02	5.46E-02	0.00E+00	4.15E-02	6.13E-02	0.00E+00	4.68E-02	6.90E-02
K4EWQ	0.00E+00	5.26E-02	8.51E-02	0.00E+00	6.48E-02	1.09E-01	0.00E+00	8.03E-02	1.35E-01

Zinc (mg/l)	10th Percentile			50th Percentile			90th Percentile		
Reporting Point	Min	Median	Max	Min	Median	Max	Min	Median	Max
CP1WQ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.10E-02	0.00E+00	4.95E-02	5.60E-02
CP2WQ	0.00E+00	1.76E-02	4.44E-02	0.00E+00	6.01E-02	6.54E-02	0.00E+00	6.71E-02	7.09E-02
CP3WQ	0.00E+00	1.47E-02	4.14E-02	0.00E+00	4.64E-02	6.33E-02	0.00E+00	6.61E-02	6.72E-02
K2EWQ	0.00E+00	1.61E-01	2.39E-01	0.00E+00	1.82E-01	2.70E-01	0.00E+00	2.07E-01	3.05E-01
K4EWQ	0.00E+00	2.12E-01	3.34E-01	0.00E+00	2.64E-01	4.29E-01	0.00E+00	3.32E-01	5.39E-01

Selenium (mg/l)	10th Percentile			50th Percentile			90th Percentile		
Reporting Point	Min	Median	Max	Min	Median	Max	Min	Median	Max
CP1WQ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-04	0.00E+00	2.48E-04	3.05E-04
CP2WQ	0.00E+00	0.00E+00	6.54E-20	0.00E+00	5.73E-17	1.06E-07	0.00E+00	5.93E-05	1.01E-03
CP3WQ	0.00E+00	2.55E-05	5.08E-04	0.00E+00	9.67E-04	1.89E-03	0.00E+00	2.29E-03	2.55E-03
K2EWQ	0.00E+00	4.80E-03	7.32E-03	0.00E+00	5.70E-03	8.52E-03	0.00E+00	6.66E-03	9.87E-03
K4EWQ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Vanadium (mg/l)	10th Percentile	50th Percentile	90th Percentile

Reporting Point	Min	Median	Max	Min	Median	Max	Min	Median	Max
CP1WQ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.60E-03	0.00E+00	5.56E-03	6.27E-03
CP2WQ	0.00E+00	1.96E-03	4.74E-03	0.00E+00	6.58E-03	7.25E-03	0.00E+00	7.44E-03	7.47E-03
CP3WQ	0.00E+00	7.13E-04	2.10E-03	0.00E+00	2.30E-03	6.52E-03	0.00E+00	7.17E-03	7.43E-03
K2EWQ	0.00E+00	1.10E-02	1.62E-02	0.00E+00	1.22E-02	1.80E-02	0.00E+00	1.36E-02	2.02E-02
K4EWQ	0.00E+00	1.89E-02	3.28E-02	0.00E+00	2.32E-02	4.09E-02	0.00E+00	2.77E-02	5.01E-02

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Memorandum

To:	Robert Gallagher	**At:**	Stanwell Corporation Limited
From:	SLR Consulting	**At:**	SLR Consulting Australia Pty Ltd
Date:	19 May 2022	**Ref:**	620.30930.00000-M01-v2-20220519.docx
Subject:	Meandu Mine PRCP Voids Nil Extraction Case and Additional Parameters		

1 Background

SLR Consulting (SLR) was previously contracted by Stanwell Corporation Limited (SCL) to support the preparation of the Meandu Mine (Mine) Progressive Rehabilitation and Closure Plan (PRCP). The scope of work included various sub-sections of Section 3 of the PRCP guideline and are primarily focused on water modelling and assessment of post mining conditions.

During pre-lodgement discussions, the Department of Environment and Science (DES) provided feedback to SCL on the Meandu Mine PRCP. Based on this, SLR were engaged to undertake further assessments to support SCL to address recent feedback from DES on the preliminary review of the Draft PRCP.

2 Scope of Work

The scope of work consists of the following:

- Run the Water Balance Model (WBM) for a nil extraction scenario and report on the resulting associated water quality.
- Report on the final void water quality for an addition 15 chemical analytes in accordance with the void water quality analytes provided in Appendix 7 of the Meandu Mine Environmental Authority (EA – EPML00709113, 12 January 2022) and the ANZECC livestock guideline. The additional chemical analytes are: calcium, magnesium, nitrate, nitrite, arsenic, beryllium, boron, cadmium, chromium, copper, fluoride, lead, mercury, molybdenum and uranium.

3 Methodology

3.1 Voids Nil Extraction Case

The Water Balance Model was simulated without extraction for stock water from both final voids (i.e., K2E & K4E) with the existing groundwater inflows estimated by the groundwater model. The results are presented in **Table 3.1**. As shown in this table, final void volumes changed up to 2% and 4.5% for the new case (Nil Extraction) when compared to Scenario 1 (SLR, 2022a) because the extraction volume over the entire period was only a small fraction of the total inflow and the evaporation. It was also found that the evaporation rates from the voids as well as the inflows into the voids were slightly higher for the new case than the values in Scenario 1. This is the result of the increased surface water area of the voids when there is no extraction as compared to the previous scenario.

Table 3.1 Final Void Volume

	Extraction (Scenario 1) (SLR, 2022a)			Nil Extraction			Difference		
Volume (ML)	Dry (P10)	Median (P50)	Wet (P95)	Dry (P10)	Median (P50)	Wet (P95)	Dry (P10)	Median (P50)	Wet (P95)
K2E	5513.85	6260.24	7346.03	5594.18	6385.8	7437.71	1.5%	2%	1.2%
K4E	862.699	1087.1	1566.12	901.101	1136.62	1627.37	4.5%	4.6%	4%

3.2 Additional parameters

The initial modelling of analytes (SLR, 2022a) was based on modelling undertaken for the operational Mine (Golder, 2018) which was based on the long-term averages from sampling at site over several rehabilitated areas. These concentrations were adopted as they are considered to provide best representation of the likely water quality conditions for future rehabilitated areas at the site (Golder, 2018). This modelling was extended to include all chemical analytes listed in the EA (DES, 2022) as well as the livestock drinking water guidelines (ANZECC, 2000); various data sources were considered relating to the potential long-term source concentration terms. These are shown for the Contaminants of Concern (CoC) for different land uses in Table 3.2, with the data source for each value provided thereafter.

As outlined in SLR (2022a), direct rainfall entering the lake proportion of the final voids (calculated daily) was assumed to have a negligible contaminant concentration.

It is noted that the contaminants generated from rainfall runoff, over different AWBM Surface land use types, was assumed to be constant over the entire 120-year simulation. This is due to lack of data to support any assumptions around decay of materials and reduced concentrations over time. This differs from modelling in the Operational IWBM which considered changes to the concentration load due to progressive pit dumping and rehabilitation.

Table 3.2 Concentrations of Contaminants of Concern by AWBM Surface Land Use Types (in mg/L)

Analyte	Criteria / Trigger Value	AWBM Surface Land use					
		Pit		Rehabilitated		Natural	
		Value	Data source	Value	Data source	Value	Data source
Appendix 7 of EA EPML00709113							
TDS	<5,000	1000	1	200	1	200	1
Calcium	<1,000	32.4	2	9.7	2	5.6	2
Magnesium	<2,000	37.5	2	15.9	2	4.7	2
Nitrate	<400	2.228	4	1.162	6	0.466	7
Nitrite	<30	0.01	4	<0.01	6	n/a	7
Sulfate	<1,000	144.9	1	72.8	1	5.2	1
Cobalt	<1	0	1	0	1	0	1
Nickel	<1	0.033	1	0.012	1	0.012	1
Zinc	<20	0.169	1	0.045	1	0.045	1

Analyte	Criteria / Trigger Value	AWBM Surface Land use					
		Pit		Rehabilitated		Natural	
		Value	Data source	Value	Data source	Value	Data source
Arsenic	<0.5	0.002	3	Majority of all samples below LOR	5	Majority of all samples below LOR	5
Boron	<5	0.083	3	0.05	5	0.05	5
Selenium	<0.02	0	1	0	1	0	1
Molybdenum	<0.15	0.002	2	0.001	2	0.001	2
Fluoride	<2	0.2	2	0.1	2	0.1	2
ANZECC livestock drinking water guidelines							
Aluminium	5	0.01	1	0.167	1	0.167	1
Beryllium	Not determined	<0.001	4	<0.001	6	n/a	7
Cadmium	0.01	0.0003	4	0.0001	6	<0.001	7
Chromium	1	<0.001	4	<0.001	6	<0.001	7
Copper	0.4-5	0.001	2	0.001	2	0.001	2
Iron	Not sufficiently toxic	0.435	1	0.069	1	0.069	1
Lead	0.1	<0.001	4	<0.001	6	<0.001	7
Manganese	Not sufficiently toxic	1.077	1	0.517	1	0.517	1
Mercury	0.002	<0.0001	4	<0.0001	6	0.00015	7
Uranium	0.2	<0.001	4	<0.001	6	n/a	7
Vanadium	Not determined	0.005	1	0.005	1	0.005	1

Data sources:

1. Table 3-3 IWBM report (SLR, 2022a)
2. Table 12 IWM report (Golder, 2018)
3. Table C.1 (Water and Salt Balance Model, WSP, 2021) Avg pit water monitoring data (2016-2020)
4. WQ monitoring data: Pit Central/Pit K1/Pit K4E/Pit K2E/Pit K4S/Pit NW/Pit NWB 80th percentile value (Stanwell, 2017)
   - Beryllium data available between 2012-2015
   - Cadmium data available between 1998-2015
   - Lead data available between 1998-2015
   - Mercury data available between 2012-2015
   - Nitrate data available between 1985-2015
   - Nitrite data available between 2013-2015
   - Uranium data available between 2012-2015
5. Table 5-3 Contaminant Hydrogeological Assessment (JBT, Sept 2018) Meandu Creek 4 Median Value

6. WQ monitoring data: RD21/RD22A/RD22B (SW runoff from West Rehab area) 80th percentile value (Stanwell 2017)
   - Beryllium data available between 2011-2016
   - Cadmium data available between 2009-2016
   - Lead data available between 2011-2016
   - Mercury data available between 2011-2016
   - Nitrate data available between 2002-2016
   - Nitrite data available between 2010-2016
   - Uranium data available between 2011-2016
7. WQ monitoring data: CKME/CKMF (Forestry catchment) 80th percentile value (Stanwell, 2017)
   - Beryllium data: none available
   - Cadmium data available between 1978-2005
   - Lead data available between 1992-1995 (only Pb(total), Pb(dis) all non-detect)
   - Mercury data available between 1992-2004
   - Nitrate data available between 1992-1996
   - Nitrite data: none available
   - Uranium data: none available

The potential sources, and loading of CoC, were examined and included in the modelling. This is documented in detail in the Groundwater Technical Report (SLR, 2022b). To characterise CoC concentrations at the potential sources, laboratory Kinetic Leaching Colum (KLC) testing of deposited waste conducted by RGS (2020) was compared to measured groundwater quality within the spoil/mine waste.

The CoC concentration was generally found to be greater in the measured (field) groundwater data compared to laboratory results. Therefore, where available, measured groundwater data was used to define CoC source concentration. CoCs were selected based on being representative of potential sources as well as general water quality indicators. This process is described in detail in the Hydrogeological Modelling report (SLR, 2022c). The adopted data for each contaminant source, including how each value was calculated (i.e., 80th percentile or maximum value), is detailed in **Table 3.3**.

Table 3.3 Groundwater contaminant source concentrations (in mg/L)

Contaminant Source	Northern Area + NWB TSF	K2 TSF	K2W TSF	K2W, K2WN and K4S*
Representative data	**GW34, GW35, GW48, GW49, GW75 - 80th percentile**	**GW72 – 80th percentile**	**GW82 – 80th percentile**	**KLC#1 - max**
Appendix 7 of EA EPML00709113				
TDS	1,790	1,509	15,195	3,458
Calcium	112	87	71.8	Not available
Magnesium	179	102	753.4	Not available
Nitrate	Not available	Not available	Not available	Not available

Contaminant Source	Northern Area + NWB TSF	K2 TSF	K2W TSF	K2W, K2WN and K4S*
Nitrite	Not available	Not available	Not available	Not available
Sulfate	849	568	1524	1980
Cobalt	0.32	0.086	0.715	0.079
Nickel	0.22	0.086	0.5	0.067
Zinc	0.58	0.134	5.29	0.58
Arsenic	0.004	0.002	0.009	Not available
Boron	0.08	0.08	0.442	Not available
Selenium	0.005	0.005	0.01	0.08
Molybdenum	0.0005	0.0005	0.0005	0.46
Fluoride	0.2	0.1	0.8	Not available
ANZECC livestock drinking water guidelines				
Aluminium	0.005	0.02	9.24	1.9
Beryllium	0.001	0.0005	0.0282	Not available
Cadmium	0.0001	0.00005	0.008	Not available
Chromium	0.0005	0.0005	0.005	Not available
Copper	0.002	0.0005	0.1974	Not available
Iron	48.8	146	9.8	0.11
Lead	0.0005	0.0005	0.1194	Not available
Manganese	40.4	11.6	36.7	4.6
Mercury	0.00005	0.00005	0.00006	Not available
Uranium	0.0005	0.0005	0.0021	Not available
Vanadium	0.005	0.005	0.005	0.34

*The original K2W, K2WN and K4S dataset, as used in the original CoC modelling (SLR, 2022a), were based on the results of specific Kinetic tests, which did not extend to the other analytes.

Following the data review task, it was decided that due to insufficient available data or undetectable concentrations, the following analytes will not be included in the modelling:

- Lead: majority of SW samples below detection limit;
- Mercury: majority of SW samples below detection limit;
- Nitrate: no groundwater data available;
- Nitrite: no groundwater data available; and
- Uranium: majority of SW samples below detection limit.

The mass balance modelling results of the remaining analytes is provided in Section 5.

4 Results

The modelled concentrations of CoC in the two final voids are shown in **Figure 4-1** through to **Figure 4-12** for the chemical analytes in the EA and **Figure 4-13** through to **Figure 4-19** according to ANZECC (2000) livestock drinking water guidelines. The water quality results showing the maximum 10th, 50th and 90th percentile results for each analyte over the 120-year simulation are summarised in the following graphs with full tabulated results provided in **Table 4.1** and **Table 4.2** for K2E and K4E respectively.

Importantly, it is noted that the loading of CoC from runoff (including surface and baseflows) is assumed static over the entire 120-year simulation period. This is a conservative assumption as the concentration of many of these contaminates would be expected to decay as they are leached from the material and rehabilitation improves overall water quality. Future modelling could be undertaken to consider this in the predictions. Data from water quality drainage studies of rehabilitated land would be required to support development of such decay relationships.

The modelled void salinity over the simulated period is provided in **Section 4.3**. These results provide an indication of the likely post closure rate of change of the CoC analytes within the pit lakes.

4.1 EA EPML00709113 analytes

The predicted concentrations of CoC in the two pits are shown in **Figure 4-1** through **Figure 4-19** for parameters in the EA EPML00709113.

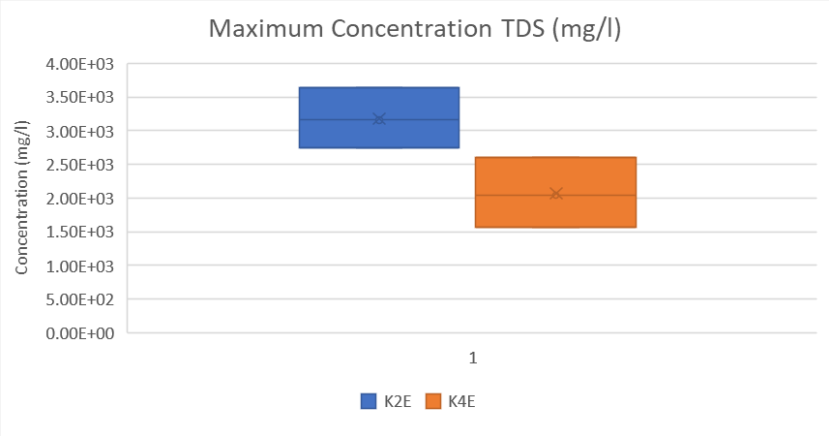

Figure 4-1 10th, 50th, 90th Percentile results for Total Suspended Solids

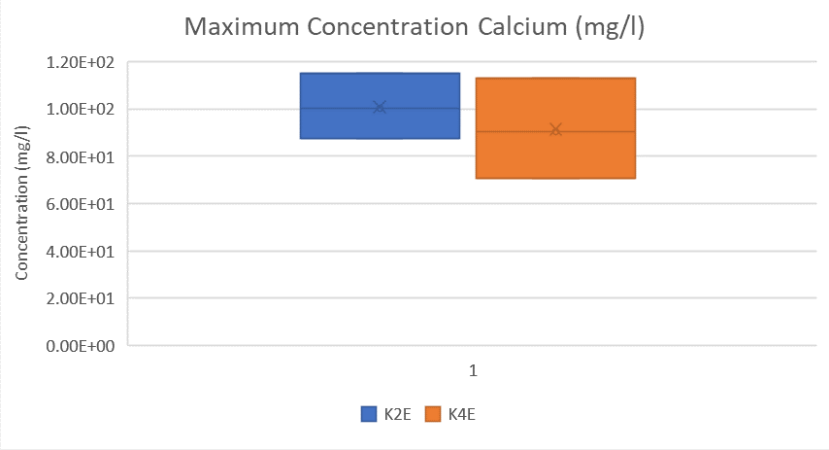

Figure 4-2 10th, 50th, 90th Percentile results for Calcium

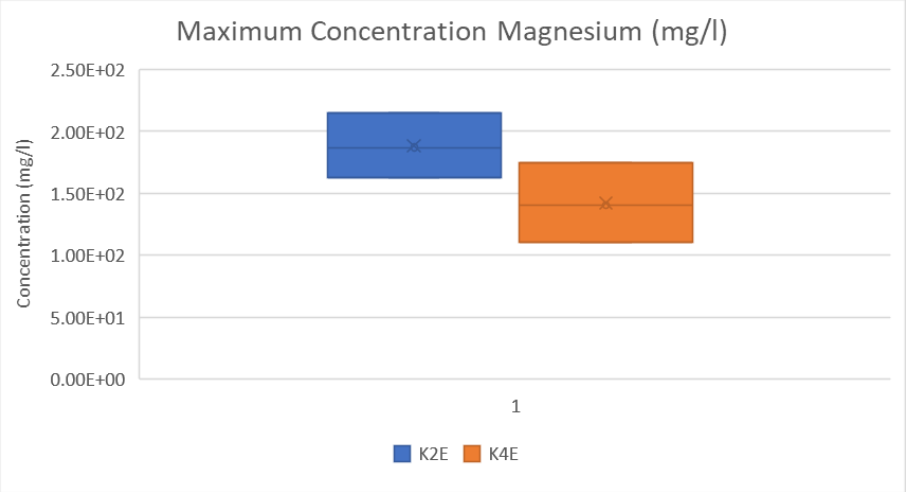

Figure 4-3 10th, 50th, 90th Percentile results for Magnesium

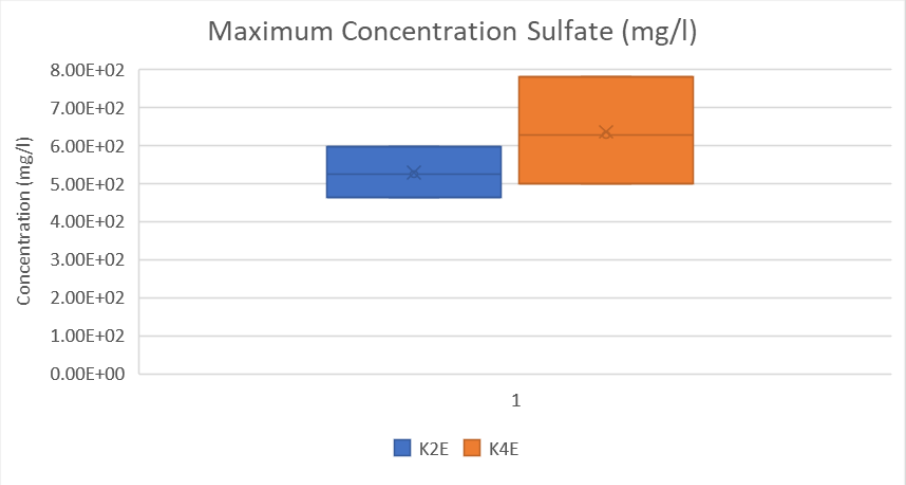

Figure 4-4 10th, 50th, 90th Percentile results for Sulfate

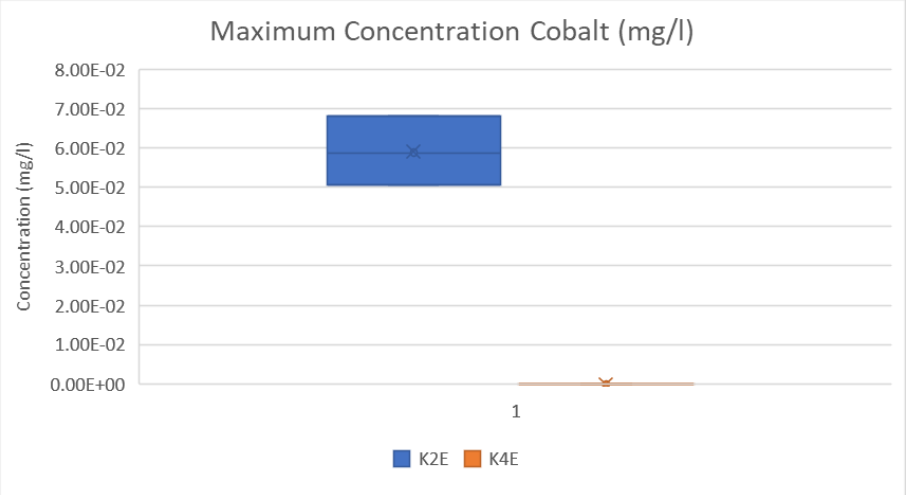

Figure 4-5 10th, 50th, 90th Percentile results for Cobalt

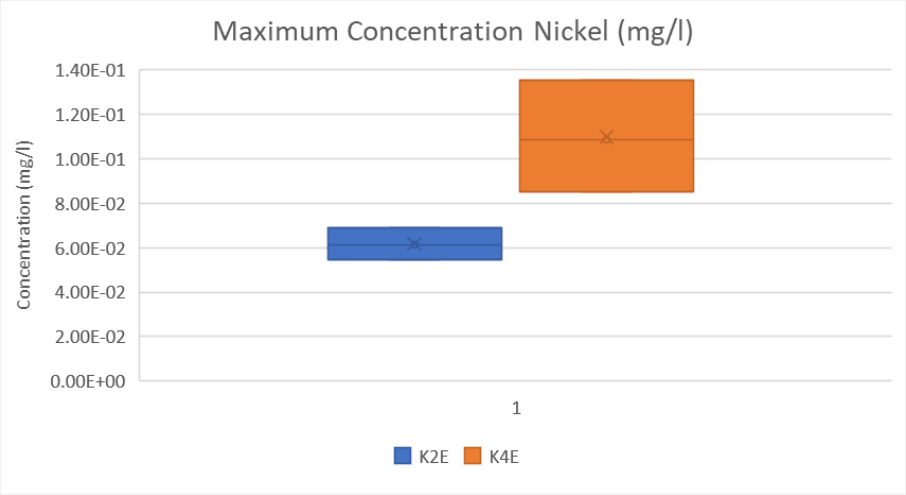

Figure 4-6 10th, 50th, 90th Percentile results for Nickel

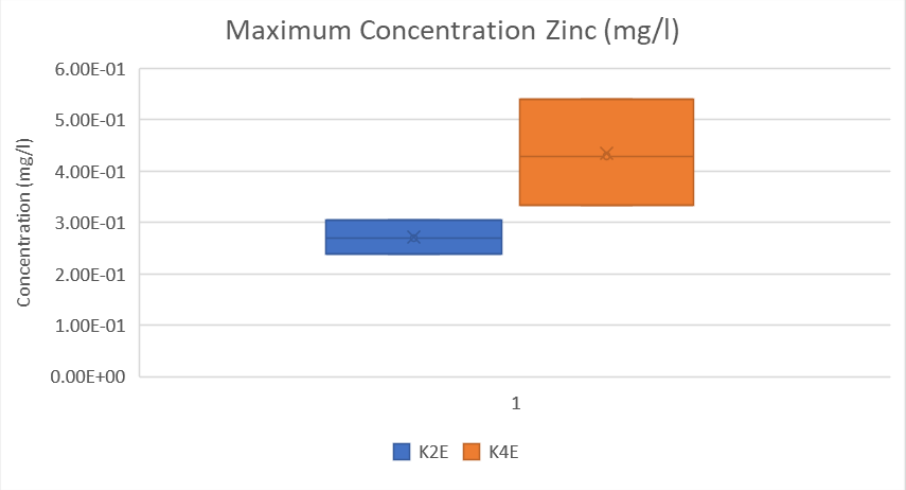

Figure 4-7 10th, 50th, 90th Percentile results for Zinc

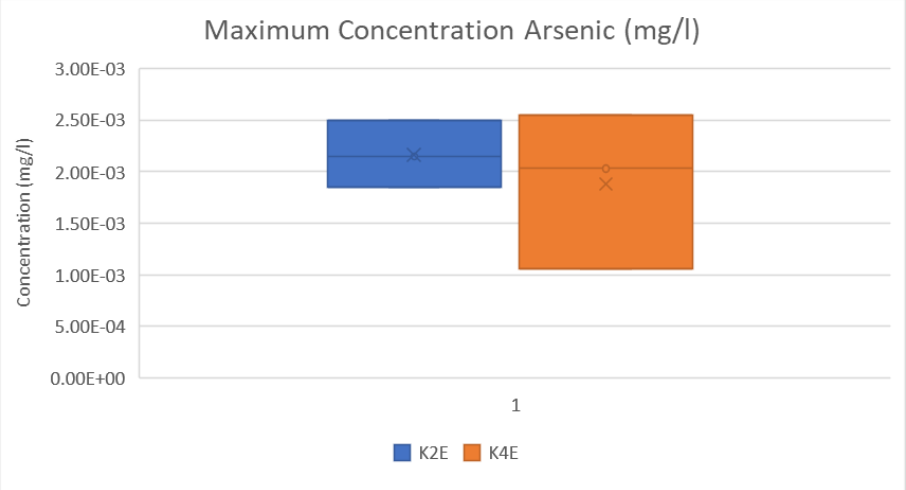

Figure 4-8 10th, 50th, 90th Percentile results for Arsenic

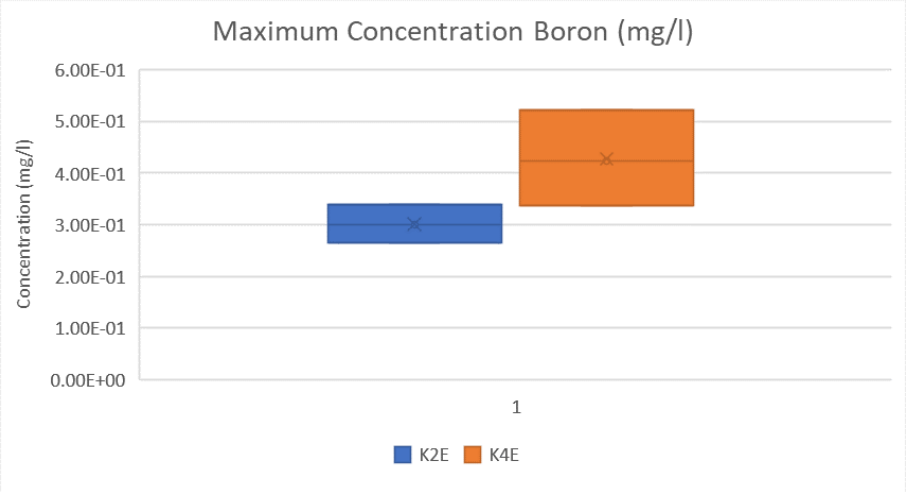

Figure 4-9 10th, 50th, 90th Percentile results for Boron

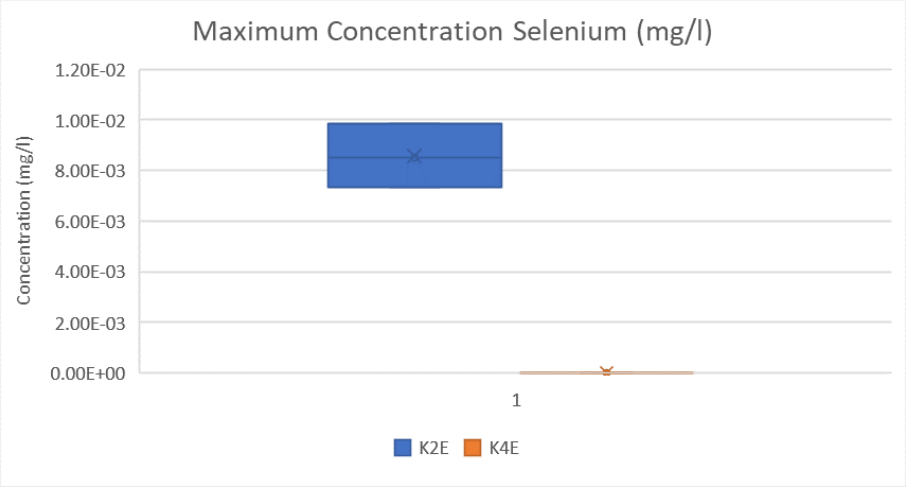

Figure 4-10 10th, 50th, 90th Percentile results for Selenium

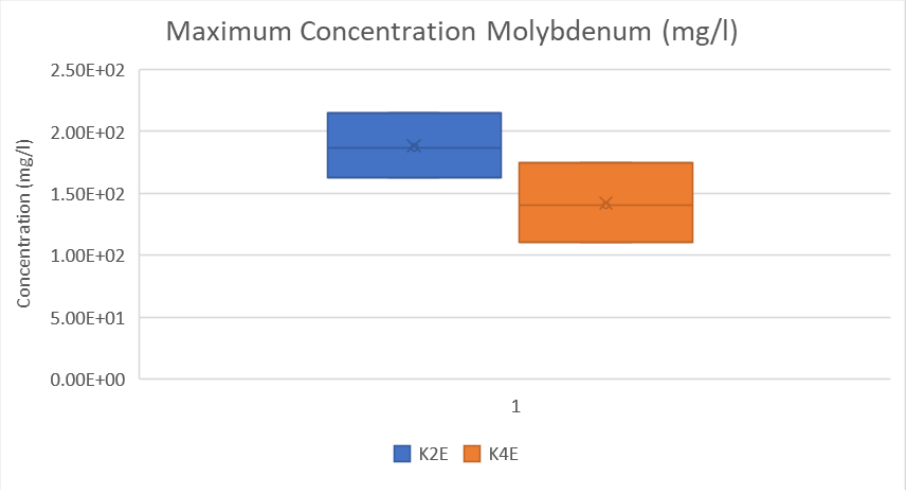

Figure 4-11 10th, 50th, 90th Percentile results for Molybdenum

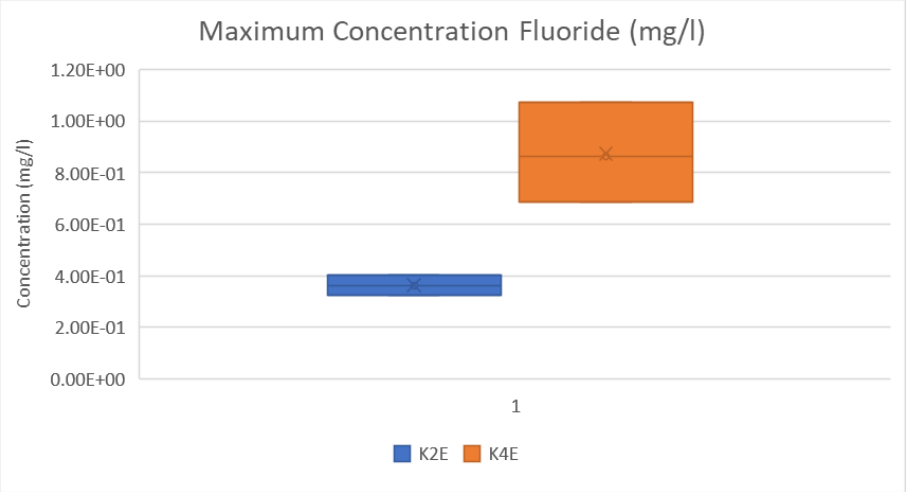

Figure 4-12 10th, 50th, 90th Percentile results for Fluoride

4.2 ANZECC livestock drinking water guidelines

The predicted concentrations of CoC in the two pits are shown in **Figure 4-13** through **Figure 4-19** for parameters in according to ANZECC (2000) livestock drinking water guidelines.

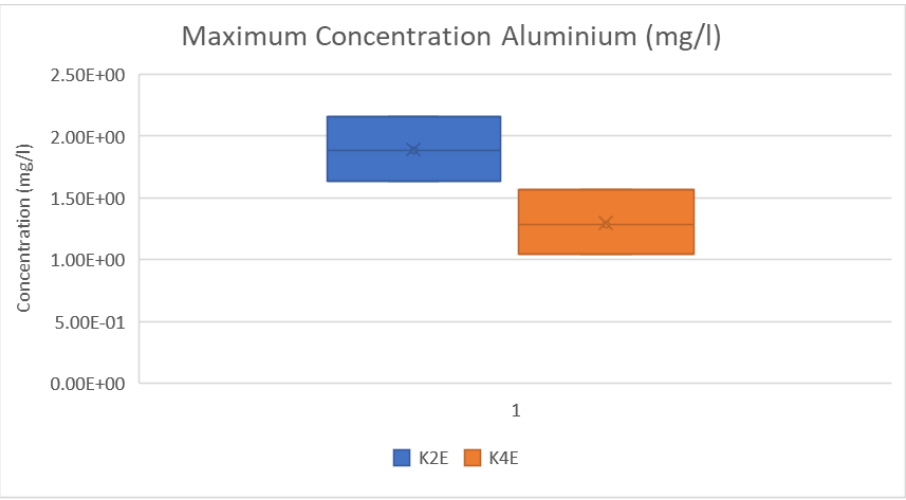

Figure 4-13 10th, 50th, 90th Percentile results for Aluminium

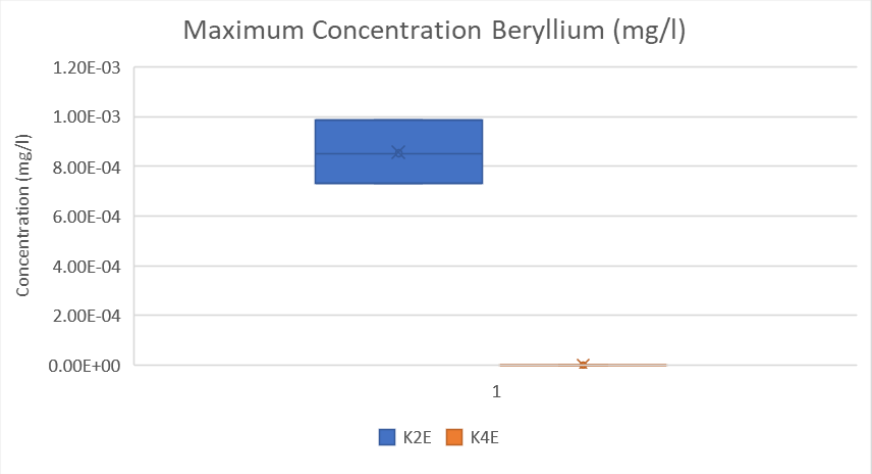

Figure 4-14 10th, 50th, 90th Percentile results for Beryllium

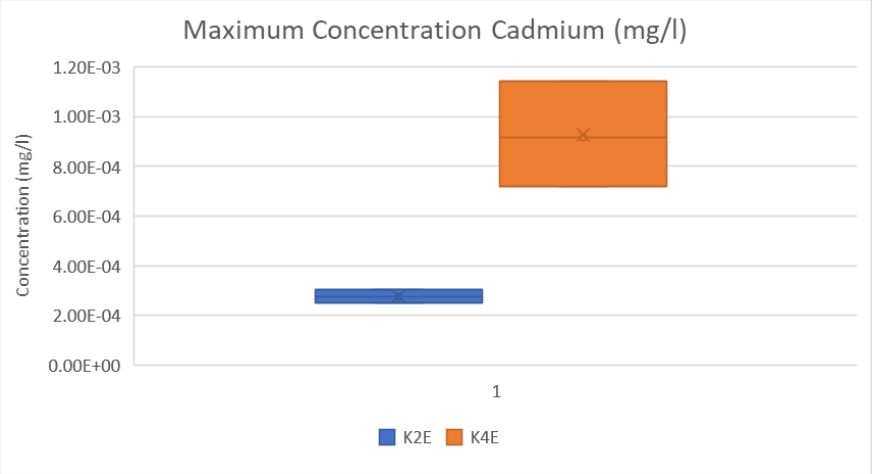

Figure 4-15 10th, 50th, 90th Percentile results for Cadmium

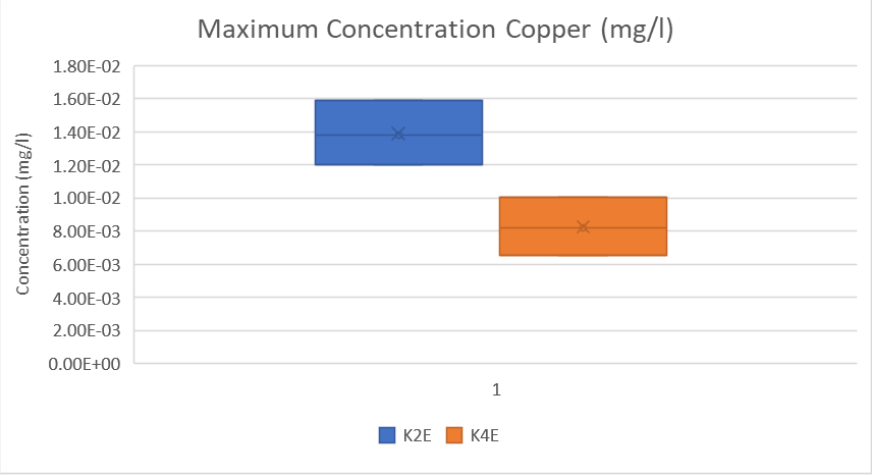

Figure 4-16 10th, 50th, 90th Percentile results for Copper

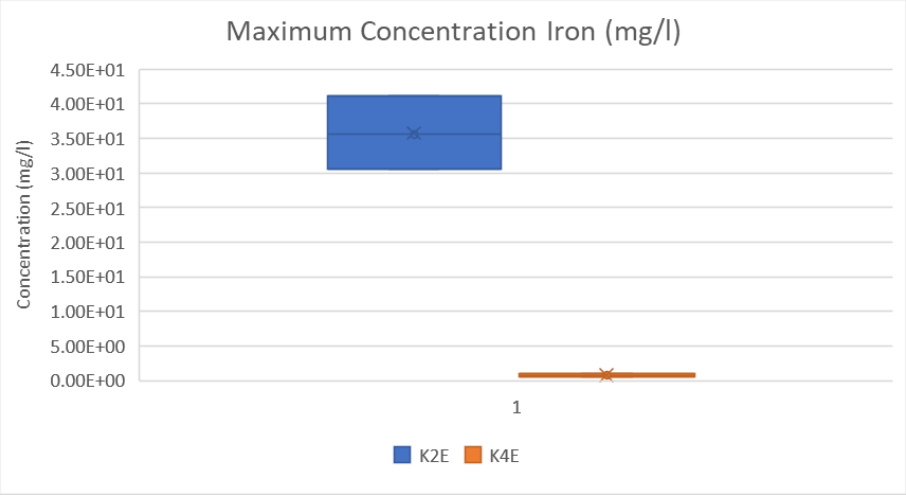

Figure 4-17 10th, 50th, 90th Percentile results for Iron

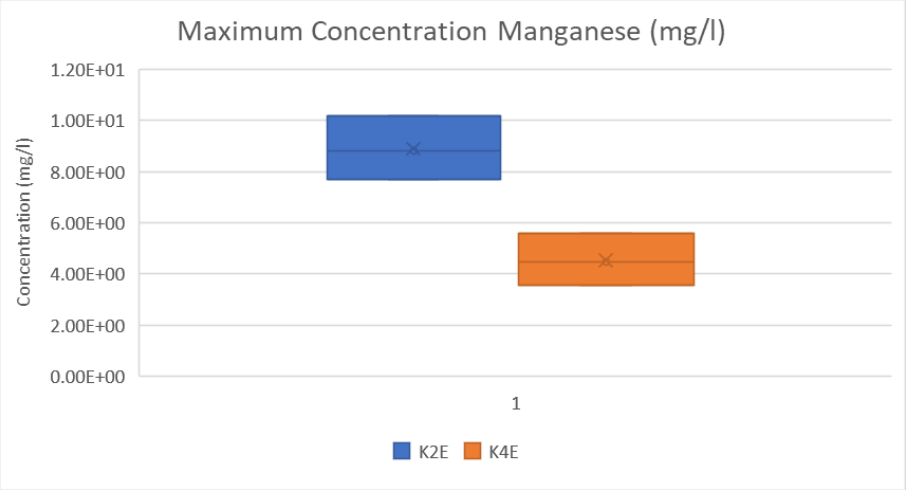

Figure 4-18 10th, 50th, 90th Percentile results for Manganese

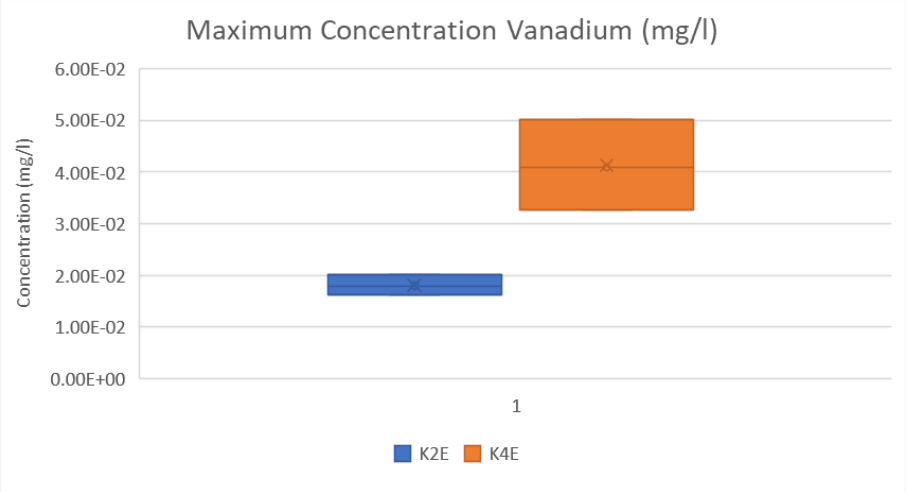

Figure 4-19 10th, 50th, 90th Percentile results for Vanadium

Table 4.1 Predicted 10th, 50th, 90th Percentile results concentrations of CoCs for K2E

		10th Percentile			50th Percentile			90th Percentile		
	Analyte (mg/L)	Min	Median	Max	Min	Median	Max	Min	Median	Max
Appendix 7 of EA EPML00709113	TDS	0.00E+00	1.83E+03	2.75E+03	0.00E+00	2.13E+03	3.16E+03	0.00E+00	2.46E+03	3.64E+03
	Calcium	0.00E+00	5.86E+01	8.75E+01	0.00E+00	6.75E+01	1.00E+02	0.00E+00	7.76E+01	1.15E+02
	Magnesium	0.00E+00	1.09E+02	1.63E+02	0.00E+00	1.26E+02	1.87E+02	0.00E+00	1.45E+02	2.15E+02
	Nitrate	No groundwater data available								
	Nitrite	No groundwater data available								
	Sulfate	0.00E+00	3.11E+02	4.63E+02	0.00E+00	3.53E+02	5.25E+02	0.00E+00	4.03E+02	5.96E+02
	Cobalt	0.00E+00	3.32E-02	5.05E-02	0.00E+00	3.93E-02	5.88E-02	0.00E+00	4.60E-02	6.81E-02
	Nickel	0.00E+00	3.69E-02	5.46E-02	0.00E+00	4.15E-02	6.13E-02	0.00E+00	4.68E-02	6.90E-02
	Zinc	0.00E+00	1.61E-01	2.39E-01	0.00E+00	1.82E-01	2.70E-01	0.00E+00	2.07E-01	3.05E-01
	Arsenic	0.00E+00	1.22E-03	1.85E-03	0.00E+00	1.45E-03	2.15E-03	0.00E+00	1.70E-03	2.49E-03
	Boron	0.00E+00	1.79E-01	2.65E-01	0.00E+00	2.02E-01	3.00E-01	0.00E+00	2.29E-01	3.39E-01
	Selenium	0.00E+00	4.80E-03	7.32E-03	0.00E+00	5.70E-03	8.52E-03	0.00E+00	6.66E-03	9.87E-03
	Molybdenum	0.00E+00	1.72E-03	2.52E-03	0.00E+00	1.88E-03	2.76E-03	0.00E+00	2.07E-03	3.04E-03
	Fluoride	0.00E+00	2.22E-01	3.26E-01	0.00E+00	2.45E-01	3.61E-01	0.00E+00	2.73E-01	4.04E-01
ANZECC livestock	Aluminium	0.00E+00	1.09E+00	1.64E+00	0.00E+00	1.26E+00	1.88E+00	0.00E+00	1.45E+00	2.16E+00
	Beryllium	0.00E+00	4.80E-04	7.32E-04	0.00E+00	5.70E-04	8.52E-04	0.00E+00	6.66E-04	9.87E-04
	Cadmium	0.00E+00	1.73E-04	2.53E-04	0.00E+00	1.89E-04	2.77E-04	0.00E+00	2.08E-04	3.05E-04

		10th Percentile			50th Percentile			90th Percentile		
	Chromium	Majority of SW samples below detection limit								
	Copper	0.00E+00	7.99E-03	1.20E-02	0.00E+00	9.27E-03	1.38E-02	0.00E+00	1.07E-02	1.59E-02
	Iron	0.00E+00	2.01E+01	3.06E+01	0.00E+00	2.38E+01	3.56E+01	0.00E+00	2.78E+01	4.12E+01
	Lead	Majority of SW samples below detection limit								
	Manganese	0.00E+00	5.09E+00	7.68E+00	0.00E+00	5.93E+00	8.83E+00	0.00E+00	6.87E+00	1.02E+01
	Mercury	Majority of SW samples below detection limit								
	Uranium	Majority of SW samples below detection limit								
	Vanadium	0.00E+00	1.10E-02	1.62E-02	0.00E+00	1.22E-02	1.80E-02	0.00E+00	1.36E-02	2.02E-02

Table 4.2 Predicted 10th, 50th, 90th Percentile results concentrations of CoCs for K4E

K4E		10th Percentile			50th Percentile			90th Percentile		
	Analyte (mg/L)	Min	Median	Max	Min	Median	Max	Min	Median	Max
Appendix 7 of EA EPML00709113	TDS	0.00E+00	1.02E+03	1.57E+03	0.00E+00	1.29E+03	2.04E+03	0.00E+00	1.66E+03	2.60E+03
	Calcium	0.00E+00	4.45E+01	7.07E+01	0.00E+00	5.50E+01	9.05E+01	0.00E+00	6.88E+01	1.13E+02
	Magnesium	0.00E+00	6.76E+01	1.11E+02	0.00E+00	8.32E+01	1.40E+02	0.00E+00	1.02E+02	1.75E+02
	Nitrate	No groundwater data available								
	Nitrite	No groundwater data available								
	Sulfate	0.00E+00	3.01E+02	4.99E+02	0.00E+00	3.69E+02	6.28E+02	0.00E+00	4.50E+02	7.79E+02
	Cobalt	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

K4E		10th Percentile			50th Percentile			90th Percentile		
	Nickel	0.00E+00	5.26E-02	8.51E-02	0.00E+00	6.48E-02	1.09E-01	0.00E+00	8.03E-02	1.35E-01
	Zinc	0.00E+00	2.12E-01	3.34E-01	0.00E+00	2.64E-01	4.29E-01	0.00E+00	3.32E-01	5.39E-01
	Arsenic	0.00E+00	5.40E-04	1.06E-03	0.00E+00	9.57E-04	2.03E-03	0.00E+00	1.50E-03	2.55E-03
	Boron	0.00E+00	2.01E-01	3.37E-01	0.00E+00	2.47E-01	4.23E-01	0.00E+00	2.98E-01	5.22E-01
	Selenium	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Molybdenum	0.00E+00	4.14E-03	6.86E-03	0.00E+00	5.08E-03	8.63E-03	0.00E+00	6.18E-03	1.07E-02
	Fluoride	0.00E+00	4.14E-01	6.86E-01	0.00E+00	5.08E-01	8.63E-01	0.00E+00	6.18E-01	1.07E+00
ANZECC livestock drinking water guidelines	Aluminium	0.00E+00	5.66E-01	1.04E+00	0.00E+00	6.93E-01	1.29E+00	0.00E+00	8.39E-01	1.57E+00
	Beryllium	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Cadmium	0.00E+00	4.47E-04	7.18E-04	0.00E+00	5.51E-04	9.16E-04	0.00E+00	6.86E-04	1.14E-03
	Chromium	Majority of SW samples below detection limit								
	Copper	0.00E+00	3.77E-03	6.55E-03	0.00E+00	4.63E-03	8.19E-03	0.00E+00	5.54E-03	1.00E-02
	Iron	0.00E+00	3.79E-01	5.70E-01	0.00E+00	4.87E-01	7.48E-01	0.00E+00	6.35E-01	9.76E-01
	Lead	Majority of SW samples below detection limit								
	Manganese	0.00E+00	2.15E+00	3.56E+00	0.00E+00	2.64E+00	4.48E+00	0.00E+00	3.22E+00	5.57E+00
	Mercury	Majority of SW samples below detection limit								
	Uranium	Majority of SW samples below detection limit								
	Vanadium	0.00E+00	1.89E-02	3.28E-02	0.00E+00	2.32E-02	4.09E-02	0.00E+00	2.77E-02	5.01E-02

4.3 Void salinity over modelled period

The ANZECC (2000) Water Quality Guidelines for livestock drinking water quality recommends up to 5,000 mg/L TDS which corresponds to 9,350 µS/cm EC for beef cattle (an Electrical Conductivity (EC) factor of 0.5346 was adopted to convert the TDS to EC (Golder, 2018)). The guideline suggests that animals may experience an initial reluctance to drink or there may be some scouring, with such salinity levels but should adapt without loss of production. This also aligns with the EA listed criteria of 5,000 mg/L for TDS (DES, 2022)

For the purposes of this assessment, EC has been used as an indicator element to show the projected rate of concentration of an element over the modelled period. Although the results for all critical analytes are not provided within this report, the approach provides an indication of the rate of change of concentration which could apply to the other analytes. An assessment of the broader water quality parameters has been outlined in the Meandu Mine PRCP IWBM Report (SLR, 2021a).

Figure 4-20 through to **Figure 4-23** show the expected salinity in the voids over the modelled 120-year period. The model shows that the EC levels in Void K2E and Void K4E increase up to 6,800 µS/cm and 5,000 µS/cm respectively. This is significantly below the ANZECC guidelines of 9,350 µS/cm; suggesting that the water is of suitable quality for stock water demands for at least 120 years based on modelled EC levels as an indicator for water quality.

It is noted that there is a slight upward trend in EC for both voids. This is understood to be due to the minimal clean/rehabilitated catchment runoff entering the voids that can offset groundwater inflows and evaporation that increases the salinity. However, extrapolation of the more saline K2E void trend, shows that it is unlikely to breach the ANZECC guideline for at least 200 years and is considered acceptable.

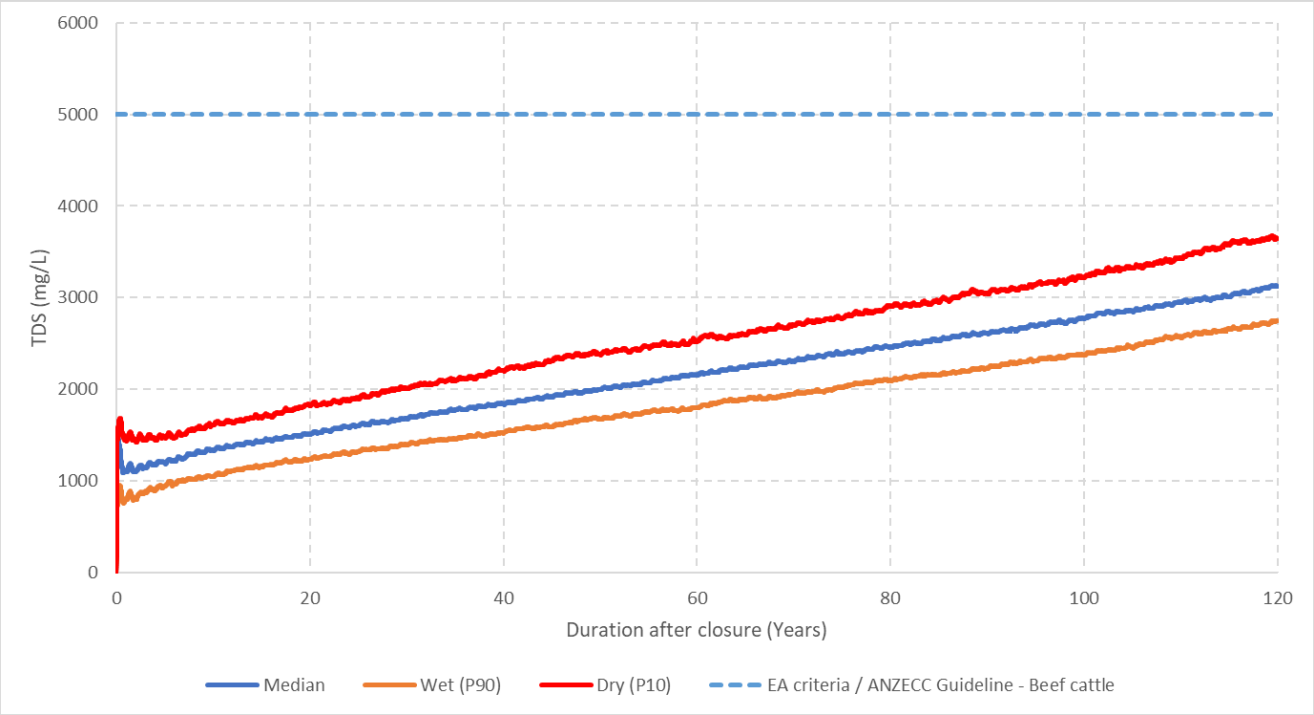

Figure 4-20 K2E – Modelled TDS concentration

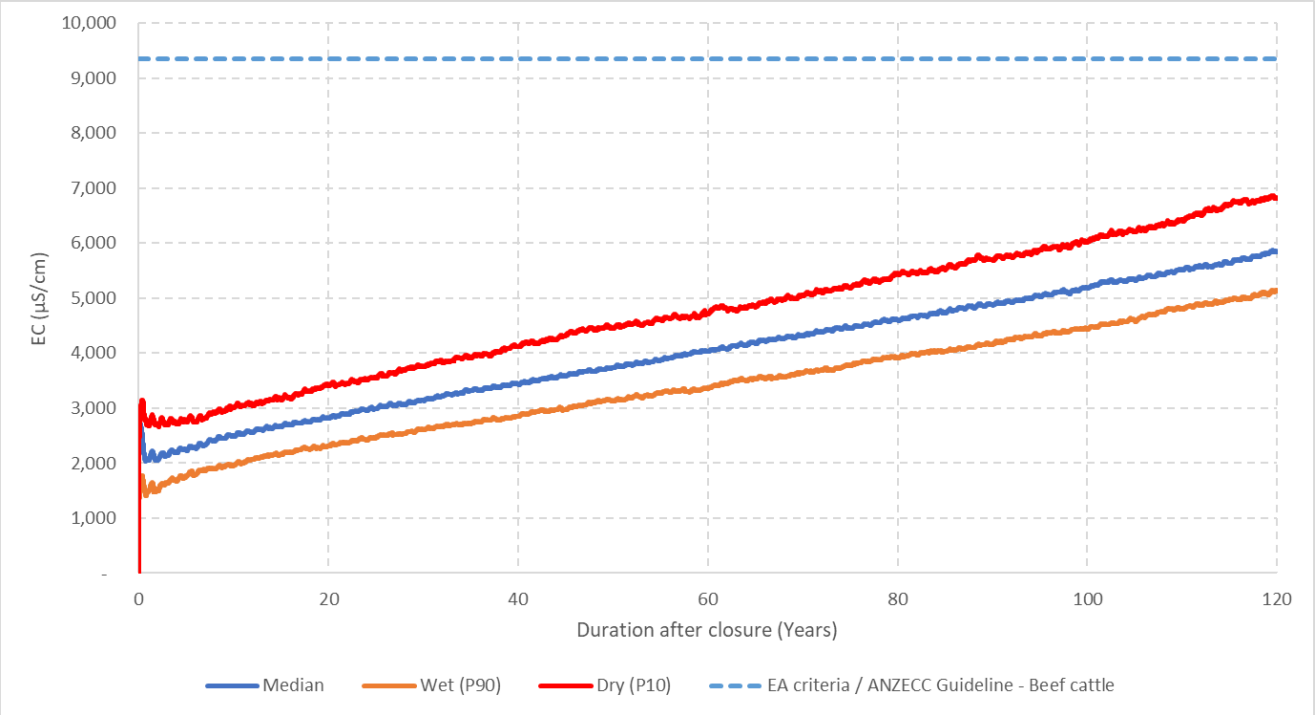

Figure 4-21 K2E – Modelled EC concentration

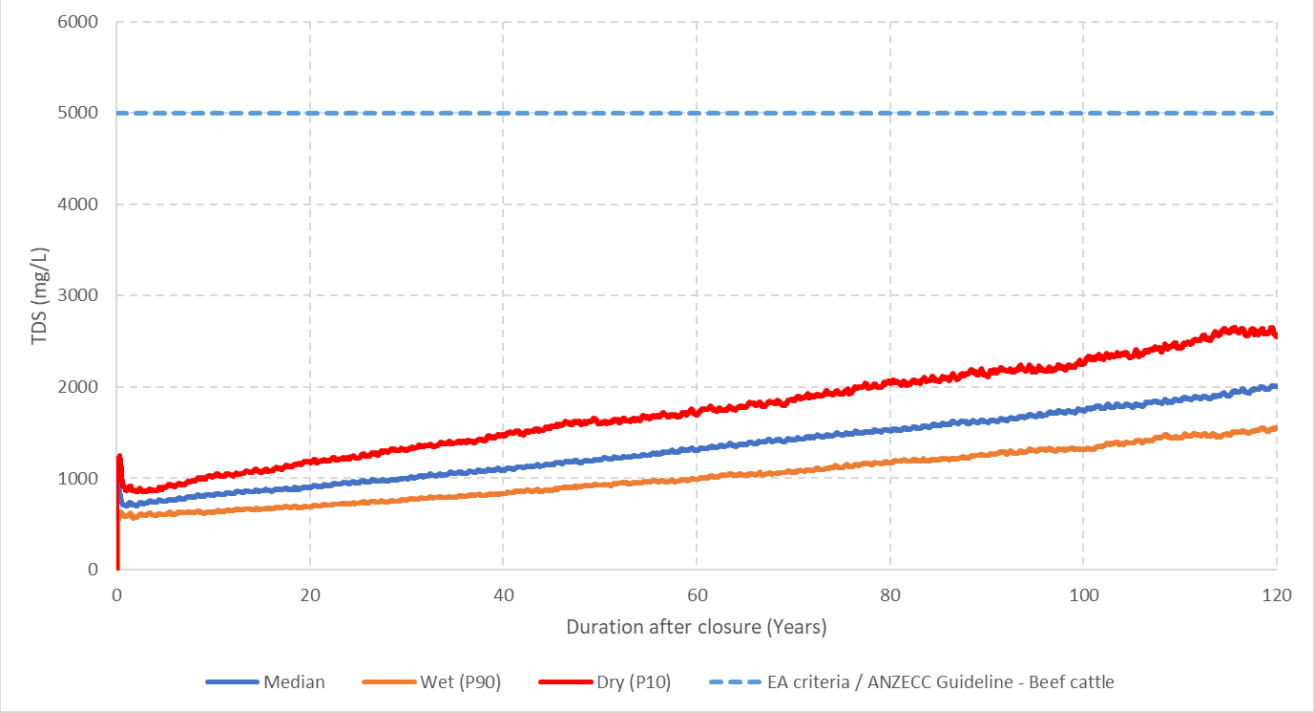

Figure 4-22 K4E – Modelled TDS concentration

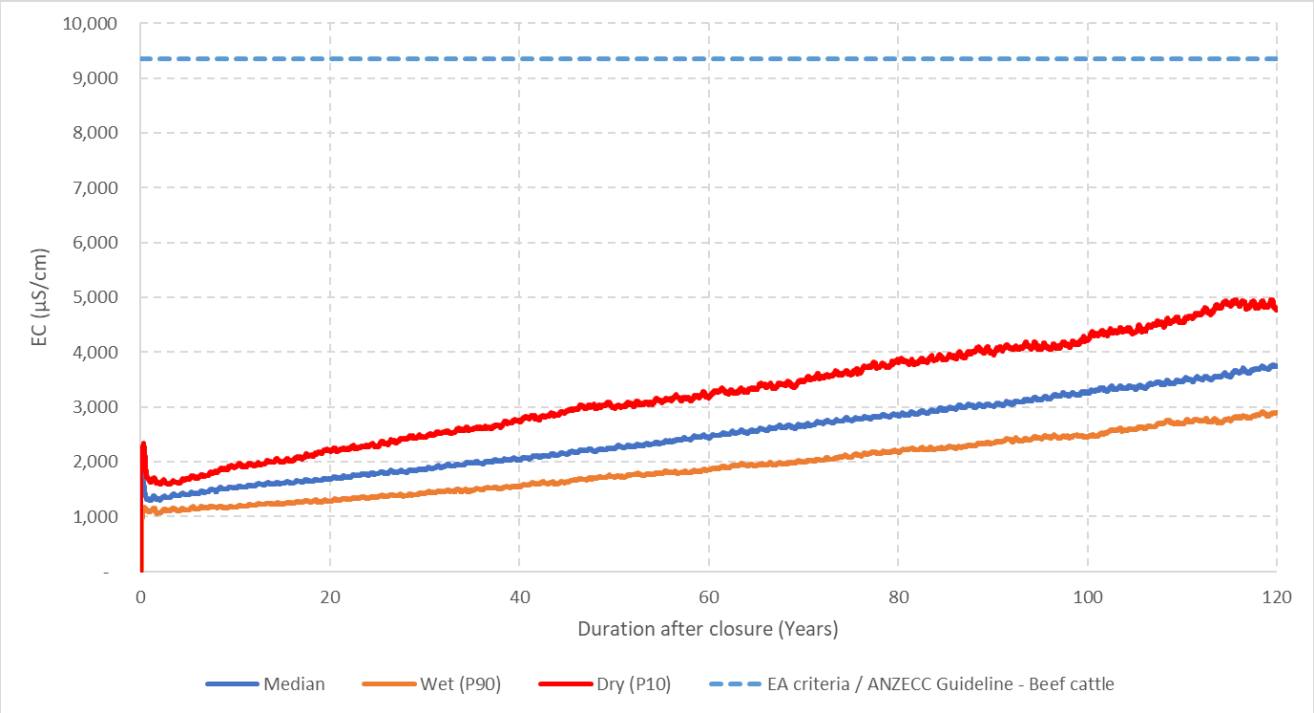

Figure 4-23 K4E – Modelled EC concentration

5 Assumptions and Limitations

The following assumptions and limitation apply to this scope of work:

- The analytes nitrite and nitrate could not be modelled due to there being no groundwater monitoring data representative of contaminant sources (i.e., bores screened in the spoil or the King seam);
- Where the majority of samples had non-detect concentrations for all locations for a specific analyte, this is noted, and the analyte is excluded from any modelling;
    - The purpose of the IWBM is to integrate the modelling the hydrogeological and surface water modelling to provide an integrated prediction of water quality and quantity to support further assessment by others. The model provides predictions of potential concentrations of Contaminants of Concern (CoC) reporting to surface water via runoff and to void waterbodies. This report outlines the development of the IWBM and results of the modelling.
    - In preparing this report, SLR has relied upon and assumed accurate information which was received from the client and other sources. Except where noted, no verification of accuracy of the information has been carried out. In the event that some of the information which was relied upon for this assessment is found to be inaccurate, then the findings may change.
    - Although we have undertaken this report with the usual care and professionalism, this report shall only be used for the purposes intended. This report has been prepared to provide information which can be used to support a Progressive Rehabilitation and Closure Report. This report should be read in full and no excerpts are to be taken as representative of the findings. This report has been prepared on behalf of SCL and we accept no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

- A number of assumptions have been made to inform the development of the IWBM. These assumptions are generally considered conservative. Further studies are required to refine the model inputs, assumptions and improve model accuracy. In particular it is noted that the generation of contaminants from rainfall runoff over different AWBM Surface land uses types was assumed to be constant over the entire 120-year simulation. This is due to lack of data to support any assumptions around decay of materials and reduced concentrations over time. This differs from modelling in the Operational IWBM which considered changes to the concentration load due to progressive dumping.

6 References

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Checked/
Authorised by: KJW

Appendix J

Meandu Mine PRC Plan Void in Floodplain Modelling



MEANDU MINE PRCP

Voids in Floodplain Modelling

Prepared for:

Stanwell Corporation Limited
180 Ann St Brisbane



SLR Ref: 620.30536-R03
Version No: -v4.0
April 2022

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Stanwell Corporation Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

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620.30536-R03-v4.0	26 April 2022	Lilia Criste/Hayden Munck	Nicole Bichel	Brian Rask
620.30536-R03-v3.0	3 December 2021	Lilia Criste/Hayden Munck	Nicole Bichel	Brian Rask
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APPENDICES

Appendix A Des Pre-lodgement Advice on PRCP Flood Modelling Requirements
Appendix B TUFLOW Hydraulic Model Results

1 Introduction

1.1 Scope of Work

SLR was contracted by Stanwell Corporation Limited (SCL) to support the preparation of the Meandu Mine (the Mine) Progressive Rehabilitation and Closure Plan (PRCP). The scope of work includes five key tasks, primarily focused on water modelling and assessment of post mining conditions. Task 2 of the scope of work, which is the focus of this report, includes the hydrologic and hydraulic flood modelling assessment. This work is related to two subsections in the PRCP guideline (Table 1).

Table 1 Scope of Work and Relevant PRCP Guideline Section

Task	Scope	PRCP Guideline Sections
2	Flood modelling	Section 3.4 'Voids in floodplains' Section 3.6.1 General rehabilitation practices 'Flooding'

The assessment detailed in this document was undertaken specifically to address the flooding analyses required as part of Sections 3.4 and 3.6.1 of the PRCP guideline.

1.2 Project Information

Meandu Mine is a thermal coal mine owned by TEC Coal Pty Ltd (TEC Coal), a wholly owned subsidiary of SCL. Meandu Mine is located in Tarong, Queensland; approximately 150km north-west of Brisbane. The Mine is located on Mining Lease (ML) 6674, which is held by TEC Coal, ML6674 was granted on 19 February 1981 and covers an area of approximately 42.7km^2. The Mine operations are regulated through the Environmental Approval (EA) EPML00709113.

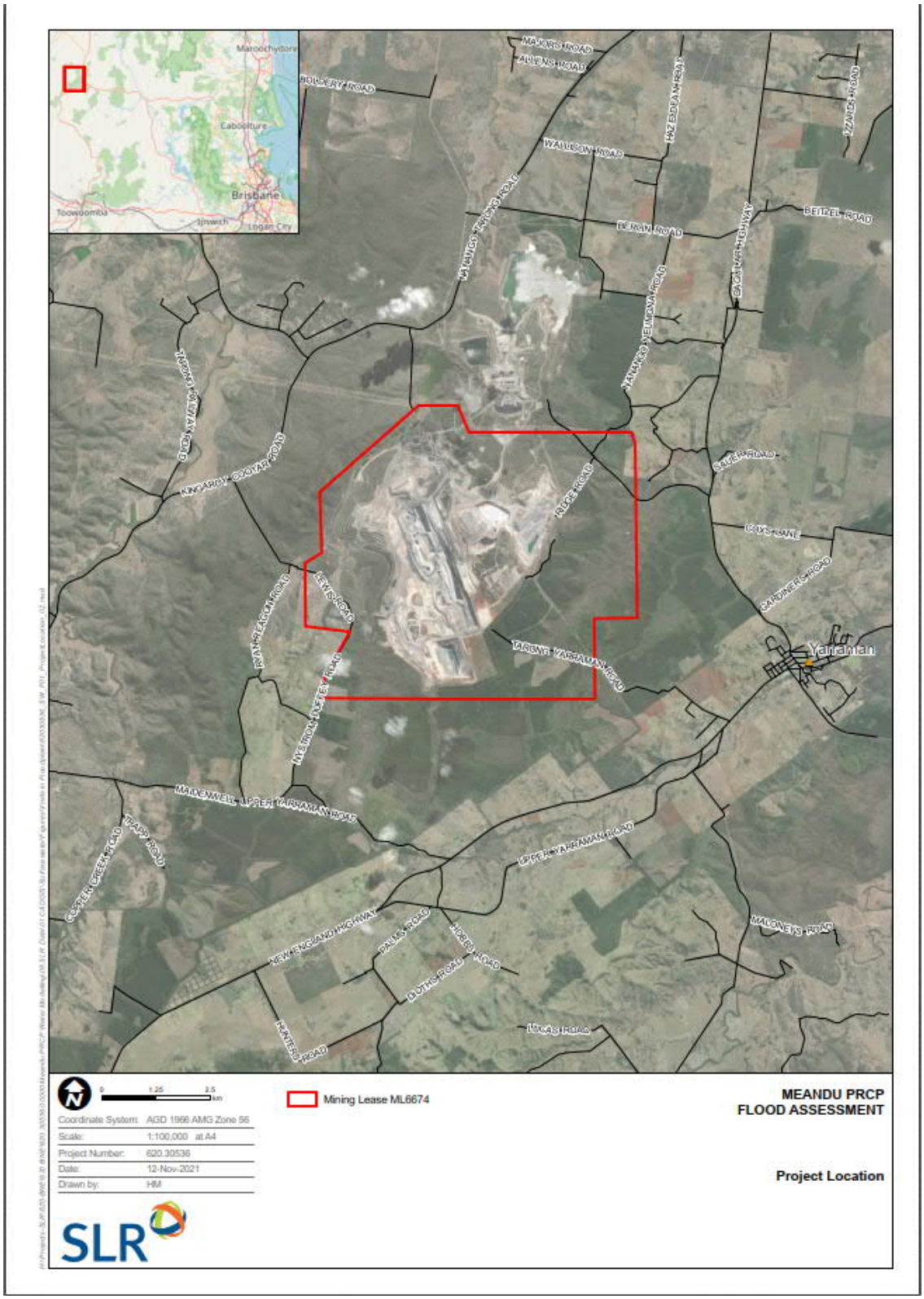
The project location is illustrated in Figure 1.

1.3 Relevant Documentation

This assessment was undertaken in accordance with the following guidelines and documentation:

- Environmental Protection Act 1994;
- Environmental Protection Regulation 2019;
- 'Guideline – Progressive Rehabilitation and Closure Plans', Department of Environment and Science, March 2021 (PRCP Guideline);
- 'Information Sheet – Environmental Protection Act 1994 – Voids in Flood Plains', Department of Environment and Science, March 2020 (Voids in Flood Plains Information Sheet); and
- 'Australian Rainfall and Runoff (2019)' (ARR).
- Specific pre-lodgement advice provided by the Department of Environment and Science (DES) (Appendix A).

Figure 1 Project Location



1.4 Assumptions and Limitations

This assessment was undertaken specifically for the purposes for undertaking floodplain modelling of relevant watercourses in accordance with the requirements of the EP Act and EP Regulation. The following assumptions and limitations apply to this assessment.

- The accuracy of the assessment is reliant on the accuracy of the utilised data, as detailed in Section 3. SLR has assumed all source data to be fit for purpose and sufficiently accurate for the purpose of this assessment. Except where noted, no verification of accuracy of the information has been carried out. In the event that some of the information which was relied upon for this assessment is found to be inaccurate, then some or all of the findings may change.
- Flood modelling was undertaken only for relevant watercourses as defined in the Voids in Floodplain Information Sheet, i.e. Meandu Creek and Rocky Creek.
- Generation of the model landform for the assessment was undertaken in accordance with the Voids in Flood Plains Information Sheet. Flood modelling was undertaken only for the post-mining land form conditions.
- Consideration was made as to the potential effects of groundwater on the floodplain extent. Hydrogeological analysis, detailed in '*Meandu PRCP Water Modelling – Groundwater Modelling Report'*, showed that groundwater / surface water interaction within Meandu Creek and Rocky Creek is negligible. Therefore, it was considered that groundwater will have no significant impact on the extent of the floodplain.
- Although the analyses undertaken as detailed in this report were done so with the appropriate care and professionalism, this report shall only be used for the purposes intended. The analyses detailed in this report were undertaken solely for the purpose of addressing the requirements for voids in floodplain modelling for Meandu Mine in accordance with the relevant documentation as detailed in Sections 1.1 and 1.2.
- This report should be read in full and no excerpts are to be taken as representative of the findings. This report has been prepared on behalf of Stanwell and SLR accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1.5 Document Structure

The structure of this report is set out as follows:

- Section 1 - Introduction
- Section 2 - Relevant legislation and guidelines;
- Section 3 - Data Review and Gap Analysis, including details of the model landform;
- Section 4 - Hydrologic Modelling;
- Section 5 - Hydraulic Modelling of relevant watercourses; and
- Section 6 – Summary of the study and Conclusions.

Details of each component of the assessment are provided below.

2 Legislation and Guidelines

2.1 Relevant Legislation and Guidelines

The relevant documentation for this assessment is detailed in Section 1.3. Key details in the context of the assessment are provided below.

The Environmental Protection Act 1994 states:

'In accordance with section 126D(3) of the EP Act, if land the subject of the proposed PRCP schedule will contain a void situated wholly or partly in a flood plain, the schedule must provide for the rehabilitation of the land to a stable condition.'

The Environmental Protection Regulation 2019 section 41C(3) also states:

'The administering authority must treat the land as a flood plain to the extent the results of the flood plain modelling show that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level 0.1% AEP for a relevant watercourse under the ARR'

Further guidance is provided in the PRCP Guideline and the Voids in Flood Plains Information Sheet.

Sections 3.4 and 3.6.1 of the PRCP Guideline both require a floodplain assessment to be carried out. Specifically, Section 3.4 requires a Void in Floodplain assessment for all unapproved Non-Use Management Area (NUMA) voids (i.e. floodplain assessment of the pre-mining landform), whilst section 3.6.1 requires a post-mining landform assessment irrespective whether a post-mining land use (PMLU) or NUMA is proposed.

2.2 Applicability to the Project

Based on the review of the EP Act, EP Regulation, PRCP Guideline and the Voids in Floodplains information sheets, it is considered that the legislative requirements set out in Table 2 are applicable to the project.

Table 2 Applicable Legislative Requirements

Requirement	Application to the Project	Source
For transitional sites, a floodplain assessment is required where: - A void has been identified as a NUMA in a land outcome document but the location has not been specified; or - Where there are no land outcomes in the land outcome document.	No NUMA voids are proposed as part of the PRCP for Meandu Mine. Therefore, floodplain modelling under Section 3.4 is not required, i.e. modelling of the pre-mining landform within the project extent is not required.	PRCP Guideline Section 3.4

Requirement	Application to the Project	Source
The requirement for a flood assessment under Section 3.6.1 of the Guideline applies to the post mining landform across the whole site irrespective of whether a PMLU or a NUMA are proposed. Furthermore, section 3.6.1 is not only required to indicate flood risk but also to demonstrate the final landform (including waste rock dumps and diversions) will remain in a stable condition in a range of flood flow conditions.	The proposed final voids (K2E and K4E) will form PMLU areas. Therefore, flood modelling under Section 3.6.1 is required as part of the PRCP, i.e. modelling of the post-mining landform within the project extent is required.	PRCP Guideline Section 3.6.1

2.3 Definitions and Terminology

Table 3 provides the definitions and terminology that are utilised in this assessment, in accordance with the PRCP Guideline and the Voids in Flood Plains Information Sheet.

Table 3 Definitions and Terminology

Term	Definition	Source
Voids	An area of land to be excavated in carrying out a mining activity. Therefore, all voids (PMLU or NUMA) are subject to the requirements of the EP Act.	Section 126D of the EP Act
Flood plain	A void is considered to be located in a flood plain if the flood plain modelling shows that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level 0.1% AEP for a relevant watercourse under the guideline Australian Rainfall and Runoff (2019)(ARR).	Section 41C of the EP Regulation.
Stable condition	- The land is safe and structurally stable; - There is no environmental harm being caused by anything on or in the land; and - The land can sustain a PMLU.	Section 126D(3) of the EP Act; and PRCP Guideline Section 3.6.3.
Relevant watercourse	(a) A watercourse classified as stream order 4 or higher under the Strahler stream order classification system; or (b) If a watercourse mentioned in paragraph (a) is permanently diverted under – (i) A condition, or proposed condition, of an environmental authority mentioned in the Water Act 2000, section 98; or (ii) A water license or proposed water license under the Water Act 2000; the watercourse as permanently diverted.	PRCP Guideline Section 8; and Voids in Flood Plains information Sheet Section 5

Term	Definition	Source
Artificial feature	For land the subject of a PRCP schedule, means – (a) A structure or feature that is temporary and, under the PRCP schedule or otherwise, is to be removed from the land; or (b) A structure or feature that, under the PRCP schedule, will require a level of maintenance after the land is surrendered that is greater than the level of maintenance that would be required for the land if the relevant activities the subject of the PRCP schedule had not been carried out; or (c) A feature forming part of the landform of the land, other than the natural landform, if the feature interferes with or affects – (i) A relevant watercourse; or (ii) The natural flow of water on the land.	PRCP Guideline Section 8; and Voids in Flood Plains information Sheet Section 6.

3 Data Review and Gap Analysis

3.1 Data

Data for the assessment was provided by Stanwell and included:

- LiDAR topographic data captured in 2007 (as the most recent available data for the pre-mining topography within the Rocky Creek catchment, prior to extension of the mine into the catchment);
- Final landform design Digital Elevation Model (DEM); and
- Final void extents.

The provided data was assessed for suitability for the purposes of this assessment. The outcomes of the review are detailed below.

Additional data was obtained from publicly available sources for use in development of the hydrologic and hydraulic model. The data utilised in the assessment is as follows:

- 1 second SRTM Derived Hydrological Digital Elevation Model topographic data (Geoscience Australia);
- Rainfall intensity-frequency-duration (IFD) data for the area (Bureau of Meteorology (BoM));
- Catchment specific hydrologic data (ARR Data Hub); and
- Queensland road, rail and place names GIS datasets (Department of Resources (DR), 2021).

3.2 Watercourses

A review of the existing watercourses in the vicinity of Meandu Mine was undertaken using hydrologic streamline data sourced from DR. The dataset contained Strahler Stream Order classifications for each watercourse, which ranged from stream order 1 to order 6 within the extent of the data, as illustrated in Figure 2.

Meandu Creek has been subject to three permanent diversions, and ranges from stream order 1 to stream order 5 within the ML based on the DR streamline data. Therefore it is classed as a relevant watercourse. Meandu Creek drains in a northerly direction, originating south of the ML, before draining through the existing South West and West Rehab areas and continuing along the western edge of the West Rehab area. Meandu Creek discharges from the site directly into Meandu Creek Dam.

Rocky Creek has a stream order of 4 based on the DR streamline data. Rocky Creek originates in the south-east area of the site, with the catchment generally unaffected by mining operations.

Based on the above, Meandu Creek and Rocky Creek are relevant watercourses and flood modelling was undertaken for each.

It is noted that Black Creek is shown as a watercourse with a stream order of 4 in the DR streamline data. However, Black Creek was degazetted as a watercourse under the Water Act 2000 by DNRME because it has been significantly modified from its natural state and is used for industrial purposes. Therefore, it does not constitute a relevant watercourse and was not modelled as part of the assessment.

3.3 Landform

A model landform was developed for the assessment based on the available data as detailed in Section 3.1. The 2007 LiDAR DEM was adopted as the underlying base topography, and is considered appropriate for use due to the lack of development or other major topographic changes in the catchment. The provided post-mining DEM was overlayed on the base topography to form the post-mining model landform, as illustrated in Figure 3.

3.4 Artificial Features

Existing and proposed artificial features within the model domain were identified based on the available information at the time of the assessment. A summary of the identified artificial features considered in the modelling and relevant details are provided in Table 4. It should be noted that the retention dams will be rehabilitated as part of the final landform. The structures are included in the landform for completeness however it is assumed that they do not intercept runoff to the watercourses. This is predominately due to their reduction in capacity as they silt up and are progressively revegetated.

Table 4 Artificial Features

Artificial Feature	Data Source
On-tenure	
K2E Final Void	Meandu PRCP Final Landform (Stanwell)
K4E Final Void	Meandu PRCP Final Landform (Stanwell)
South West Dump	Meandu PRCP Final Landform (Stanwell)
West Dump	Meandu PRCP Final Landform (Stanwell)
Hitachi Hill Dump	Meandu PRCP Final Landform (Stanwell)
K1 Dump	Meandu PRCP Final Landform (Stanwell)
K2 Dump	Meandu PRCP Final Landform (Stanwell)
K4 Dump	Meandu PRCP Final Landform (Stanwell)
Boundary Dump	Meandu PRCP Final Landform (Stanwell)
1985-1986 Meandu Creek Diversion	Stanwell
1991-1992 Meandu Creek Diversion	Stanwell
2000-2005 Meandu Creek Diversion	Stanwell
Nobby Smith Way	DR
Black Creek Stormwater Dam	Meandu PRCP Final Landform (Stanwell)
Meandu Creek Dam	Meandu PRCP Final Landform (Stanwell)
DB1	Meandu PRCP Final Landform (Stanwell)
DB2	Meandu PRCP Final Landform (Stanwell)
DB4	Meandu PRCP Final Landform (Stanwell)
RD1	Meandu PRCP Final Landform (Stanwell)
RD10	Meandu PRCP Final Landform (Stanwell)
RD14A	Meandu PRCP Final Landform (Stanwell)

Artificial Feature	Data Source
RD14B	Meandu PRCP Final Landform (Stanwell)
RD14C	Meandu PRCP Final Landform (Stanwell)
RD15B	Meandu PRCP Final Landform (Stanwell)
RD17A	Meandu PRCP Final Landform (Stanwell)
RD17B	Meandu PRCP Final Landform (Stanwell)
RD18	Meandu PRCP Final Landform (Stanwell)
RD19	Meandu PRCP Final Landform (Stanwell)
RD2	Meandu PRCP Final Landform (Stanwell)
RD21	Meandu PRCP Final Landform (Stanwell)
RD22B	Meandu PRCP Final Landform (Stanwell)
RD24	Meandu PRCP Final Landform (Stanwell)
RD25	Meandu PRCP Final Landform (Stanwell)
RD27	Meandu PRCP Final Landform (Stanwell)
RD3A	Meandu PRCP Final Landform (Stanwell)
RD3B	Meandu PRCP Final Landform (Stanwell)
RD4	Meandu PRCP Final Landform (Stanwell)
RD6	Meandu PRCP Final Landform (Stanwell)
RD7	Meandu PRCP Final Landform (Stanwell)
RD8	Meandu PRCP Final Landform (Stanwell)
RD9	Meandu PRCP Final Landform (Stanwell)
RWD1	Meandu PRCP Final Landform (Stanwell)
RWD2	Meandu PRCP Final Landform (Stanwell)
TIP DAM	Meandu PRCP Final Landform (Stanwell)
Off-tenure	
Meandu Creek Dam	Stanwell
Tarong Power Station Road	DR

Figure 2 Watercourses – Strahler Stream Order Classification

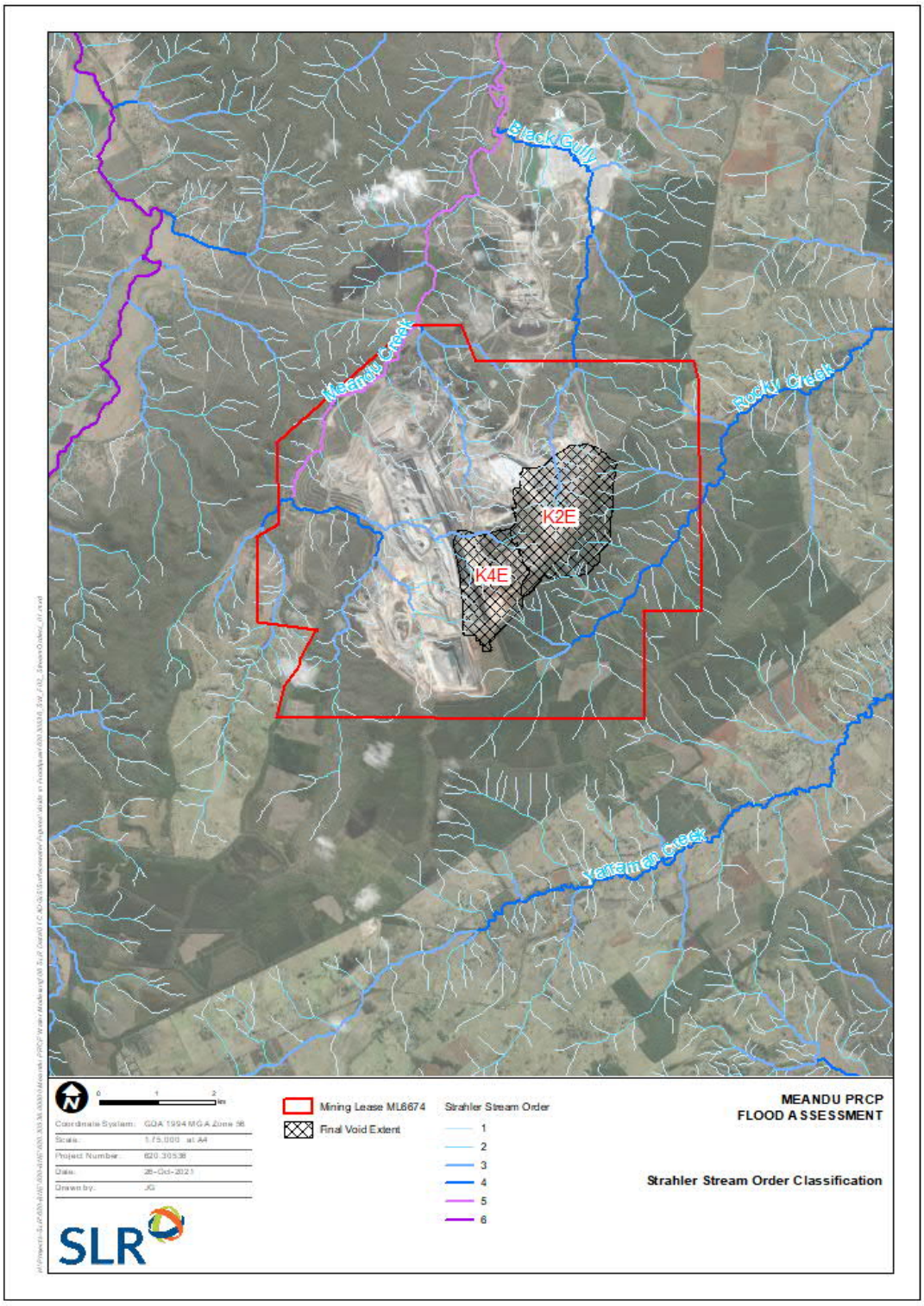
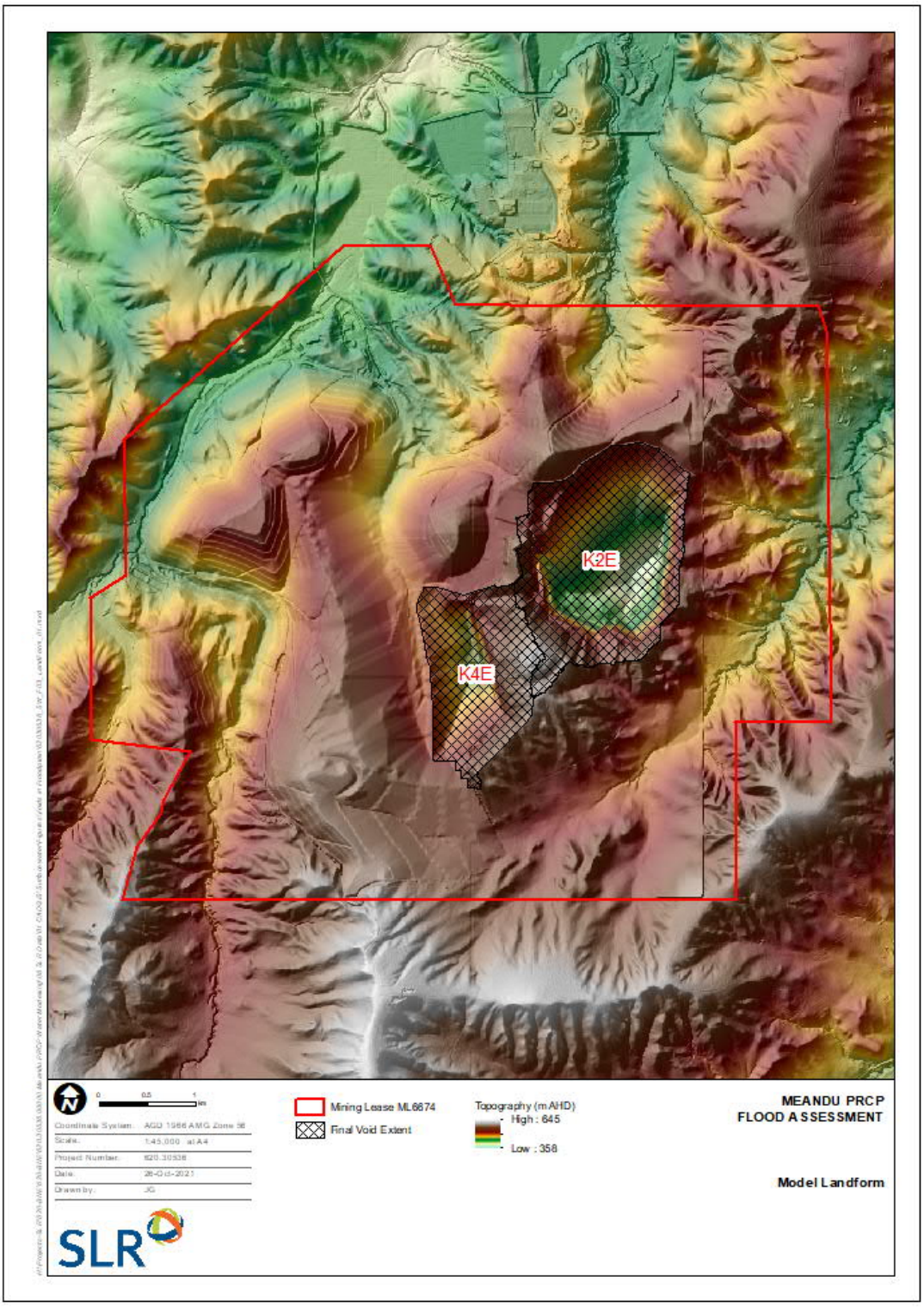


Figure 3 Model Landform



4 Hydrologic Modelling

4.1 Software

Hydrologic modelling was undertaken to estimate runoff hydrographs at various locations throughout the catchments of Meandu Creek and Rocky Creek. A separate model was developed for the Meandu and Rocky Creek catchments. Both models were developed using the Watershed Bounded Network Model Version 2019 (WBNM), which is an industry standard rainfall-runoff routing software package.

Details on the modelling assumptions, methodology and results are provided below.

4.2 Model Setup

4.2.1 Catchments

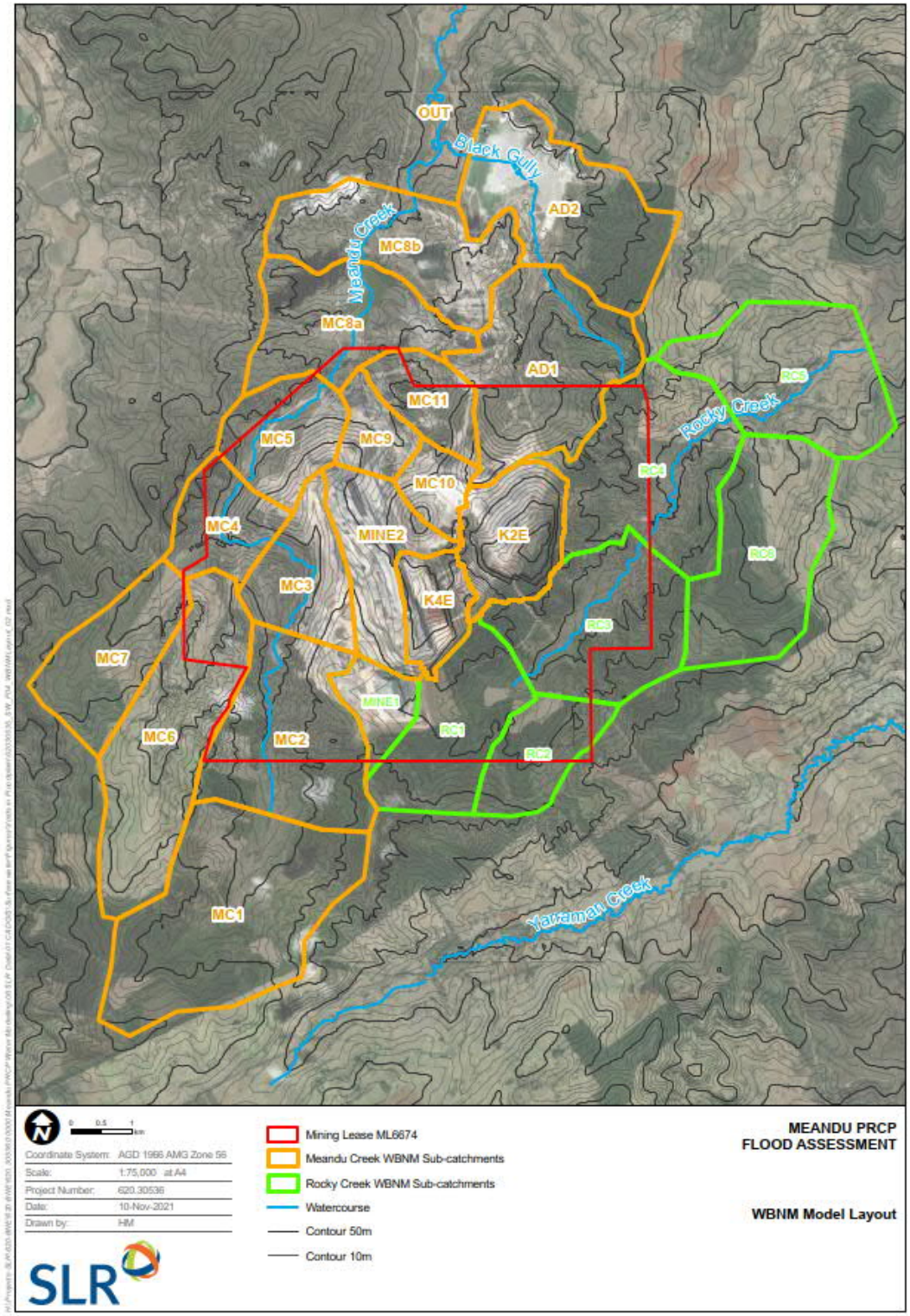
The modelled Meandu Creek catchment covers a total area of approximately 75 km^2, 55 km^2 of which drains to Meandu Creek Dam, with the remainder draining to the final voids and the Ash Dam associated with the Tarong Power Station(s). Sub-catchments for Meandu Creek were delineated using the post-mining model landform as illustrated in Figure 4. SRTM topographic data was utilised in areas outside the coverage of the model landform and available LiDAR. Details for the Meandu Creek model sub-catchments are provided in Table 5 below.

Table 5 WBNM Model Sub-catchment Details – Meandu Creek

Sub-catchment ID	Downstream Sub-catchment ID	Area (ha)	Fraction Impervious
AD1	AD2	681	0.1
AD2	OUT	668	0.8
K2E	MC10	333	0.1
K4E	MINE2	184	0
MC1	MC2	988	0
MC10	MC9	131	0
MC11	MC8a	209	0
MC2	MC3	662	0
MC3	MC4	318	0
MC4	MC5	260	0
MC5	MC8a	317	0
MC6	MC4	739	0
MC7	MC4	394	0
MC8a	MC8b	501	0.3
MC8b	OUT	563	0.3
MC9	MC8a	148	0
MINE2	MC9	359	0

Sub-catchment ID	Downstream Sub-catchment ID	Area (ha)	Fraction Impervious
OUT	SINK	0	1

Figure 4 WBNM Model Layout



The modelled Rocky Creek catchment covers an area of approximately 35 km^2. Sub-catchments were delineated using the same methodology as was applied for the Meandu Creek model, i.e. using the post-mining model landform with SRTM topographic data utilised in areas outside the footprint of the landform and available LiDAR, as illustrated in Figure 4. Details for the Meandu Creek model sub-catchments are provided in Table 7 below.

Table 6 WBNM Model Sub-catchment Details – Rocky Creek

Sub-catchment ID	Downstream Sub-catchment ID	Area (ha)	Fraction Impervious
MINE1	RC1	145	0.1
RC1	RC3	463	0
RC2	RC3	269	0
RC3	RC4	624	0
RC4	RC5	743	0
RC6	RC5	647	0
RC5	SINK	623	0

4.2.2 Intensity-Frequency-Duration Rainfall Data

Rainfall Intensity-Frequency-Duration (IFD) data for the project area was sourced from the BoM online IFD data portal for a range of AEP events. The adopted design rainfall depths for each AEP event are provided in Table 7.

Table 7 Design AEP Rainfall IFD Data

Storm Duration	Design Rainfall Depth (mm)			
	50%	2%	1%	0.1%
1 hour	34.5	77	85.4	117
1.5 hour	38.7	86.2	95.6	131
2 hour	41.7	92.6	103	140
3 hour	46.1	102	113	153
4.5 hour	51.1	111	124	168
6 hour	55	119	132	179
9 hour	61.2	132	147	198
12 hour	66.2	142	159	214
18 hour	74.1	161	179	243

4.2.3 Losses

Initial and continuing rainfall loss data for the project area was obtained from the ARR data hub (Table 8), as well as pre-burst rainfall depths for each design storm event. The initial loss for each design storm event was calculated by subtracting the median pre-burst rainfall depth from the global catchment initial loss, in accordance with the methodology outlined in ARR.

Table 8 Design Rainfall Losses – ARR Data Hub

Global Storm Loss	Loss
Initial loss (pervious)	20 mm
Continuing loss (pervious)	1.6 mm/h

4.2.4 Lag Parameter

A catchment lag parameter of 1.60 and 1.30 was adopted for the Meandu Creek and Rocky Creek catchments respectively. The WBNM documentation recommends a lag parameter value between 1.40 and 1.80 is suitable for most catchments, therefore the adopted value of 1.60 for Meandu Creek is within the recommended range.

The lower lag parameter value of 1.30 adopted for Rocky Creek is reflective of the steep terrain of the catchment. Sensitivity analysis using values between 1.40 and 1.80 was undertaken, which showed that the adopted value was appropriate and produced peak flows which were consistent with empirical calculation methods, as outlined in Section 6

4.2.5 Aerial Reduction Factor

In accordance with ARR, aerial reduction factors (ARF) were applied based on the overall catchment area for each catchment i.e. 75 km^2 for Meandu Creek and 35 km^2 for Rocky Creek.

Table 9 WBNM Model – Aerial Reduction Factor

Storm Duration	Aerial Reduction Factor – 0.1% AEP	
	Meandu Creek	Rocky Creek
1 hour	0.7587	0.8096
1.50 hour	0.7689	0.817
2 hours	0.7716	0.8184
3 hours	0.7781	0.8228
4.50 hours	0.8152	0.8532
6 hours	0.8643	0.8943
9 hours	0.9053	0.9282
12 hours	0.9124	0.9336

4.2.6 Storm Events

The WBNM model was simulated for the 50%, 2%, 1% and 0.1% AEP events. A range of storm durations between 1 hour and 18 hours were analysed for each AEP event.

In accordance with the methodology recommended in ARR for catchments with an area of 75 km^2 or less, a suite of 10 point temporal patterns were applied for each design storm event AEP and duration combination. The results of the model were analysed and the temporal pattern that produced a peak flow nearest to the mean of all 10 temporal pattern peak flows was adopted as the representative design storm. The adopted temporal patterns for each design storm event are provided in Table 10 and Table 11.

Table 10 Adopted Design Temporal Patterns – Meandu Creek

Storm Duration	Adopted Design Temporal Pattern			
	50% AEP	2% AEP	1% AEP	0.1% AEP
1 hour	5313	5295	5295	5295
1.5 hour	5343	5324	5324	5324
2 hour	5387	5362	5362	5362
3 hour	5417	5399	5399	5399
4.5 hour	5452	5317	5358	5358
6 hour	5477	5299	5299	5400
9 hour	5521	5492	5440	5427
12 hour	5547	5493	5493	5300
18 hour	5580	5528	5528	5562

Table 11 Adopted Design Temporal Patterns – Rocky Creek

Storm Duration	Adopted Design Temporal Pattern			
	50% AEP	2% AEP	1% AEP	0.1% AEP
1 hour	5311	5295	5295	5212
1.5 hour	5343	5324	5324	5324
2 hour	5387	5362	5363	5362
3 hour	5419	5399	5369	5369
4.5 hour	5452	5358	5358	5358
6 hour	5477	5299	5400	5400
9 hour	5521	5471	5427	5411
12 hour	5550	5493	5300	5300
18 hour	5591	5562	5562	5528

4.2.7 Probable Maximum Flood Analysis

A Probable Maximum Flood (PMF) assessment was undertaken for both Meandu Creek and Rocky Creek using the respective WBNM models. Results of the WBNM model showed the critical duration for both the Meandu and Rocky Creek catchments to be less than 6 hours. Therefore, the Generalised Short Duration Method (GSDM) was adopted to estimate the Probable Maximum Precipitation (PMP) rainfall depths for each storm duration from 1 hour to 6 hours in accordance with ARR.

The adopted parameters are provided in Table 12. The estimated PMP rainfall depths for each catchment are provided in Table 13.

Table 12 PMF GSDM Parameters

Parameter	Meandu Creek	Rocky Creek
Fraction Smooth (S)	0	0
Fraction Rough (R)	1	1
Moisture Adjustment Factor (MAF)	0.825	0.825
Mean Elevation (m AHD)	500	500
Elevation Adjustment Factor (EAF)	1.00	1.00
Catchment Area (km^2)	75	35

Table 13 PMP Rainfall Estimates

Storm Duration (h)	PMP Rainfall Depth (mm)	
	Meandu Creek	Rocky Creek
1	321	419
1.5	414	538
2	478	625
2.5	538	697
3	581	757
4	657	860
5	720	944
6	769	1007

The WBNM models were utilised to simulate the PMF events using the GSDM temporal patterns for each catchment.

4.3 Results

Rainfall-runoff hydrographs were extracted from the WBNM models at appropriate locations. The hydrograph for the 0.1% AEP 2 hour duration event for Meandu Creek at sub-catchment MC5 is illustrated in Figure 5. The hydrographs were then utilised as inflow boundaries for the hydraulic model, as detailed in Section 5.2.3.

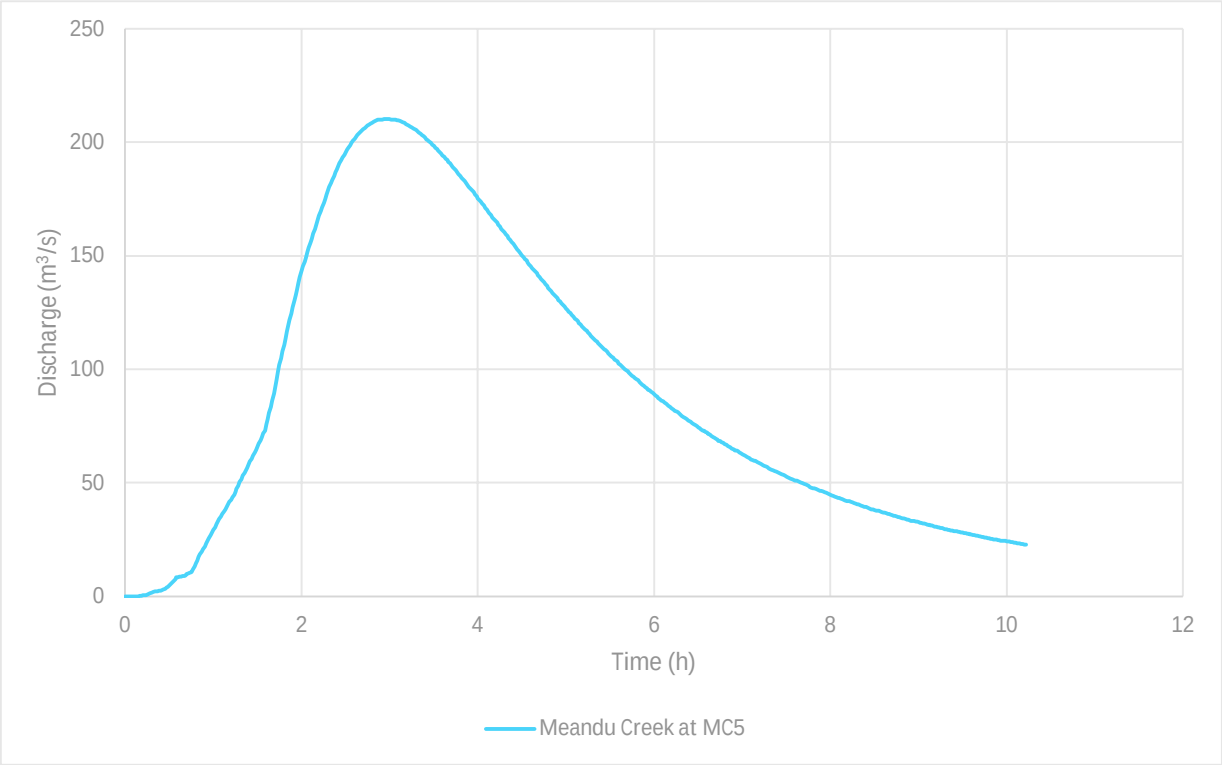


Figure 5 WBNM Model Results – 0.1% AEP 2 Hour Duration Flow Hydrograph - Meandu Creek at MC5

5 Hydraulic Modelling

5.1 Software

A hydraulic model covering both the Meandu Creek and Rocky Creek catchments was developed for the purpose of assessing the post-mining flooding conditions.

The industry standard hydrodynamic modelling software TUFLOW (build 2020-10-AA) was utilised for the hydraulic modelling. The sub-grid sampling (SGS) feature of TUFLOW suited the modelling required for the assessment. SGS provides an increased definition of model terrain and subsequently an improved estimate of flow conveyance, enabling model resolution to be improved without significant increases in model runtimes.

5.2 Model Setup

5.2.1 Topography

The model landform DEM as detailed in Section 3.3 was utilised as the topography for the model. A model grid cell size of 10 meters was adopted. A sub-grid sampling distance of 2 meters was adopted, which was considered to provide adequate model resolution for the purposes of the assessment, given Meandu Creek and Rocky Creek have base widths of approximately 5 meters or more. The model DEM is illustrated in Figure 6

5.2.2 Hydraulic Roughness

The hydraulic roughness for the model was developed based on available aerial imagery and the model landform, and was based on a land use distribution consistent with fully rehabilitated site conditions. The model hydraulic roughness is illustrated in Figure 7. The Manning's n values adopted for the various land uses in the model are detailed in Table 14. Rocky Creek was modelled as dense vegetation whilst Meandu Creek was modelled as grass lined. This was based off aerial photographs.

Table 14 Tuflow Model Manning's n Values

Land use	Manning's n
Voids	0.04
Grass	0.05
Dense Vegetation	0.06

5.2.3 Inflows

Flow hydrographs for the model were extracted from the Meandu Creek and Rocky Creek WBNM models for relevant sub-catchments. The hydrographs were applied as inflow boundaries via source area polygons as either total or local inflows where relevant to the hydraulic model at appropriate locations, as shown in Figure 6.

5.2.4 Downstream Boundaries

Downstream model boundaries were applied as stage-discharge relationships based on the water surface gradient in the vicinity of the boundaries. The stage-discharge relationships were calculated using the in-built functionality within the Tuflow software.

5.2.5 Critical Duration Assessment

In accordance with the recommendations of ARR, a suite of design storm events were simulated in the hydraulic models for the range of AEP events and durations between 1 and 6 hours. The results of the various storm durations were cross-referenced to determine the critical durations for points of interest in the model, as shown in Table 15.

Table 15 Critical Storm Durations

Watercourse	AEP Events	
	0.1%	PMF
Meandu Creek	120	150
Rocky Creek	120	90

6 Model Verification

6.1 Verification Methodology

Adequate stream gauge data was not available for the Meandu Creek or Rocky Creek catchments in the vicinity of the project. Therefore, detailed model calibration using historic flow and/or flood level data or calibration to a Flood Frequency Analysis was not possible.

Therefore, peak discharges for the 1% AEP and PMF events were extracted from the WBNM model and compared to the peak flow estimates produced by Rational Method calculations and World Catalogue of Maximum Observed Floods method, as detailed below. This is an industry standard approach to model verification in absence of available calibration data.

6.2 Design Events

6.2.1 Rational Method

The peak flow for the 1% AEP was verified using the rational method. Table 16 provides the outcome, illustrating that the WBNM model produces consistent flows when compared to the results of the rational method. Table 16 also shows that the Tuflow model is adequately representing flows produced by the WBNM model.

Table 16 Model Verification – 1% AEP Peak Flows – Rational Method Comparison

	Area (ha)	C_{10}	t_c	Rational Method (m^3/s)	WBNM (m^3/s)	TUFLOW (m^3/s)	Difference (%)
Meandu Creek (MC5)	3638	0.46[1]	2 h	172	154	188	9%
Rocky Creek (RC4)	2244	0.46[2]	3.3 h	165	182	172	4%
1 Rehabbed, medium density catchment with good grass cover, low permeability 2 Dense Bushland, with low permeability							

6.3 Probable Maximum Flood

Peak flows for the PMF as produced by the WBNM and Tuflow models were compared to the results of peak flow estimation produced by the methodology outlined in *'World Catalogue of Maximum Observed Floods'*, International Association of Hydrological Sciences, 2003. As detailed in the documentation, a relationship between catchment area and peak discharge for extreme flood events was derived based on a dataset of 54 historical flood events that were recorded across 120 countries. The relationship for catchments less than 100 km^2 in area is as follows:

$$Q = 100\ A^{0.8}$$

Where:

Q = Discharge (m^3/s)

A = Catchment Area (km^2)

The results of the comparison are illustrated in Table 17.

Table 17 Model Verification – PMF Peak Flows – World Catalogue Method Comparison

Method	Peak Flow (m^3/s)	
	Meandu Creek	Rocky Creek
WBNM	1536	1195
World Catalogue Method	1639	1185

As shown, the models produced results within 10% of the magnitude of peak PMF flows produced by the World Catalogue Method.

Flows extracted from the Tuflow model results for the PMF event were compared to flows at relevant locations produced by the WBNM model. The comparison showed that flows in the Tuflow model were consistent with the WBNM model, as illustrated in Table 18.

Table 18 Tuflow Model Flow Verification Results

Model	PMF Discharge (m^3/s)	
	Meandu Creek	Rocky Creek
WBNM	1536	1195
Tuflow	1585	1204

6.4 Verification Summary

As detailed in Section 6 above, verification of the hydrologic and hydraulic models was undertaken using industry accepted methodologies. Results of the WBNM hydrologic model were compared to the results of Rational Method and World Catalogue of Maximum Observed Floods flow estimations, which showed the model produced adequate results. Flow hydrographs from the verified WBNM model were applied to the Tuflow hydraulic model. Results of the Tuflow model were compared to the WBNM model at consistent locations, which illustrated that flows in the Tuflow model were adequately representing those produced by the WBNM model.

Based on the findings of the verification detailed above, the models were considered appropriate for use in the assessment.

7 Results

Peak water surface levels, depths and velocities across the model domain for each AEP event were extracted from the Tuflow model. The results for all parameters for all simulated flood events are illustrated in Appendix B. Figure 8 and Figure 9 illustrate the peak flood depths for the 0.1% AEP event for Meandu Creek and Rocky Creek respectively.

The results show that both the K4E and K2E voids are not subject to inundation due to flooding in Meandu Creek or Rocky Creek in any of the AEP events assessed, including the 0.1% AEP and PMF. The existing natural ridge line located between Rocky Creek and the voids is situated at an elevation some 50 meters above the peak PMF flood level in Rocky Creek. Similarly, the ridge line of the stable landform formed by the K4 Dump area has an elevation approximately 60 – 80 meters above the peak PMF flood level within Meandu Creek. The results also show that other features of the final landform including rehabilitated spoil dumps are not significantly affected by flooding in Meandu Creek.

As illustrated by the Tuflow model results, flows in Rocky Creek are generally contained to the watercourse, with little to no breakout flows occurring. The inundation footprint is located at least 800 meters from the voids, with the aforementioned ridge occurring within this distance. Therefore, based on the results of the model, flooding in Rocky Creek will not result in inundation of the final voids which could impact their structural integrity.

The model results show that flows in Meandu Creek are generally contained within the waterway. Velocities up to 5 m/s occur in localised areas within the waterway in the 0.1% AEP event. In the same locations, velocities of 3 m/s and 4 m/s occur in the 50% and 2% AEP events respectively. Velocities of these magnitudes have the potential to cause scour, however given the localised nature, the stable landforms will not be adversely affected. The stability and rehabilitation of the Meandu Creek diversions is being investigated by others and is not contained in the scope of this assessment.

With regard to potential downstream impacts, the following factors were considered:

- The catchment area and land use coverage of Rocky Creek will be effectively unchanged following rehabilitation in comparison to pre-mining conditions.
- The catchment area of Meandu Creek will be reduced by approximately 0.05 km^2 (less than 8% of the overall catchment area) i.e. the local catchment area of the final voids.
- Meandu Creek drains to the existing Meandu Creek Dam immediately downstream of the project extent.

Therefore, it can be reasonably expected that the hydrologic regimes downstream of the project extent will not be significantly impacted due to the proposed post-mining conditions in both Meandu Creek and Rocky Creek. This is a result of little change to the overall catchment area (<8% catchment reduction) due to the containment of the catchments immediately surrounding the voids. Furthermore, any change to flow regime is interrupted and prevented from propagating further downstream past the spillway of Meandu Creek Dam.

Additionally, the model results illustrate that hydrologic regime upstream of the project extent will not be materially impacted given the existing conveyance conditions of both Meandu Creek and Rocky Creek will not be significantly altered.

Based on the results of the modelling as described above,, the results indicate that there is no significant risk of ingress of flood waters to the final voids, and that the stability of stable landforms are not significantly impacted. Therefore, it was considered that the flood risk profile for the project is acceptable.

Figure 6 Tuflow Model Layout

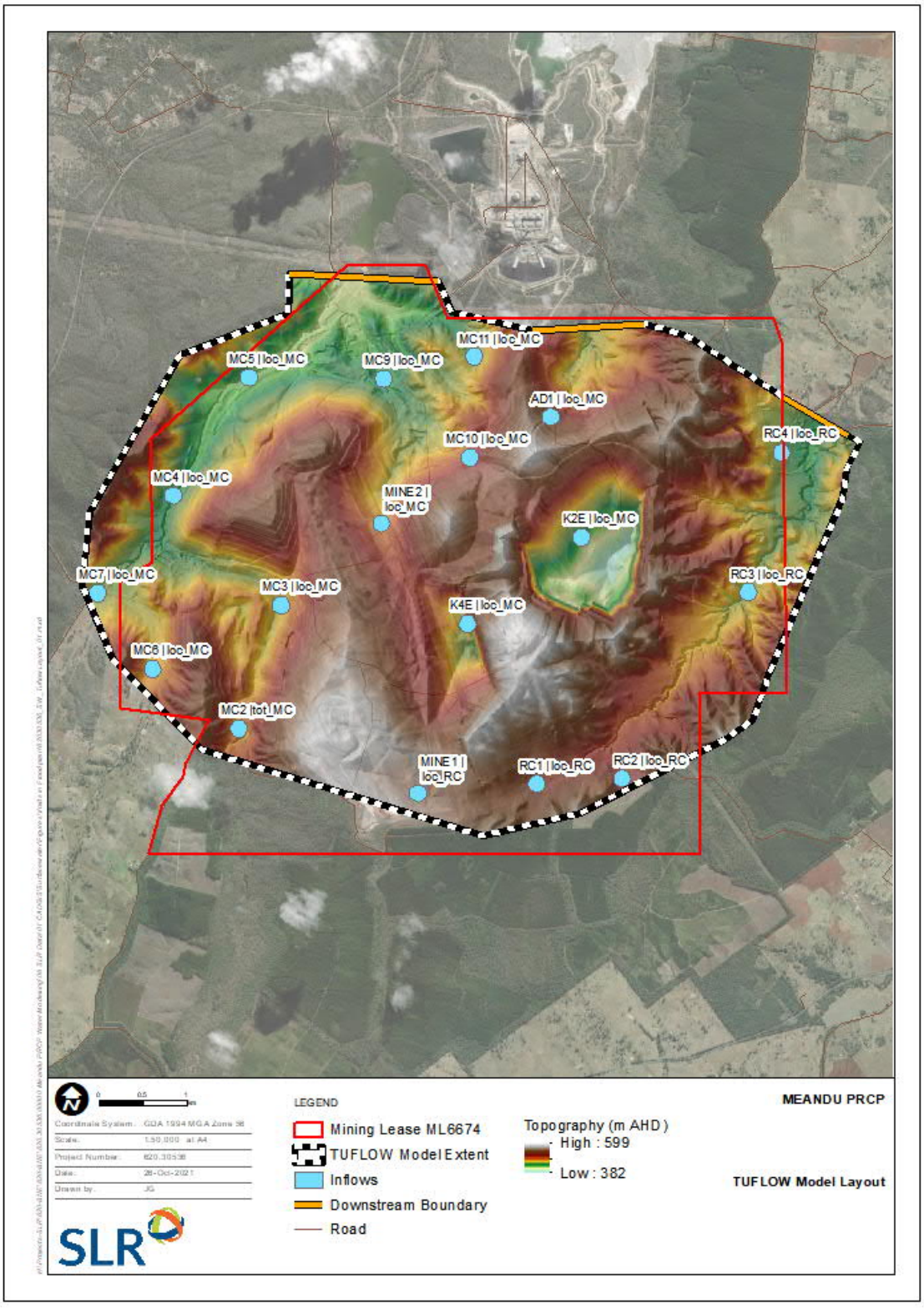


Figure 7 Tuflow Model Hydraulic Roughness

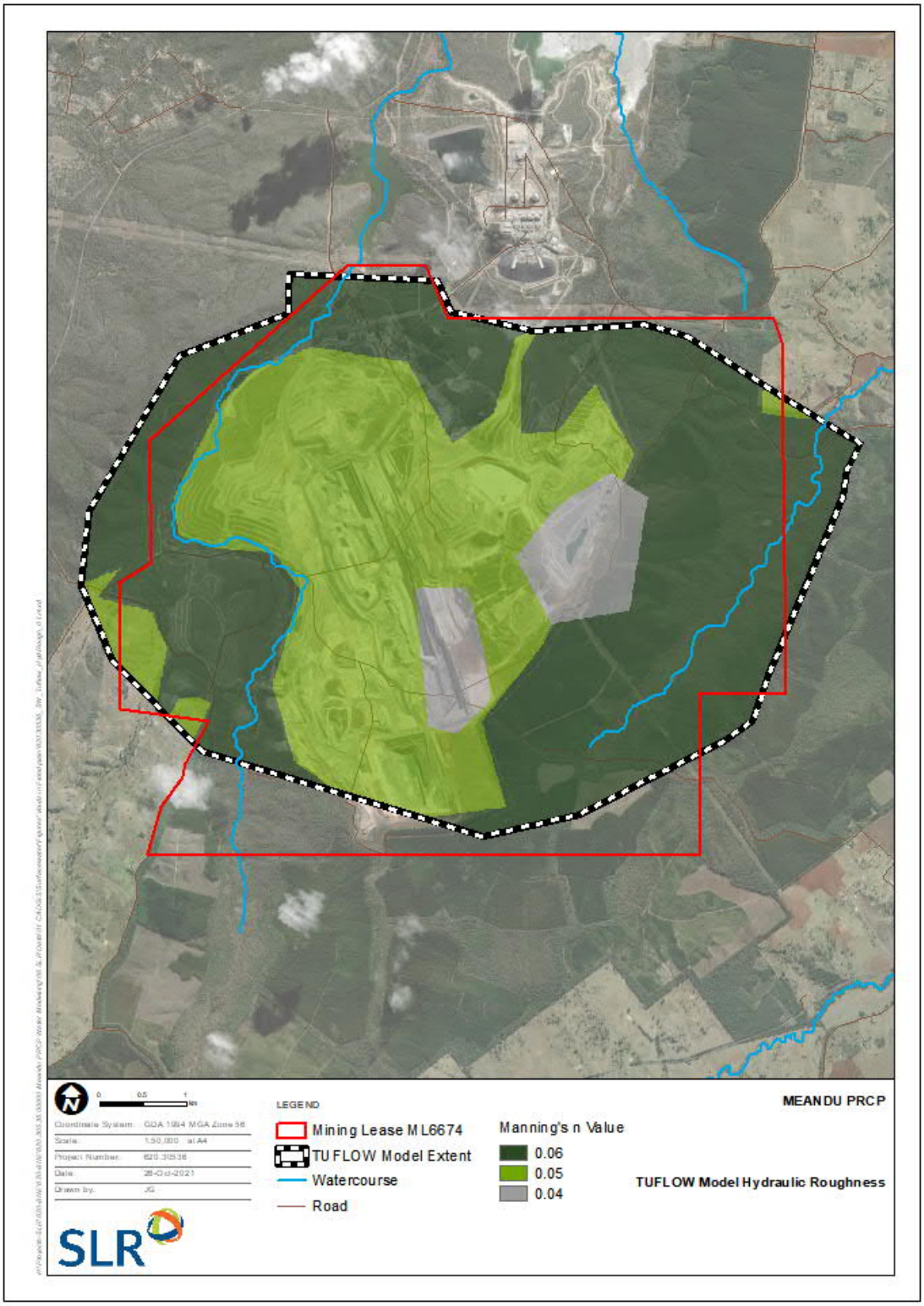


Figure 8 Tuflow Model Results – Meandu Creek

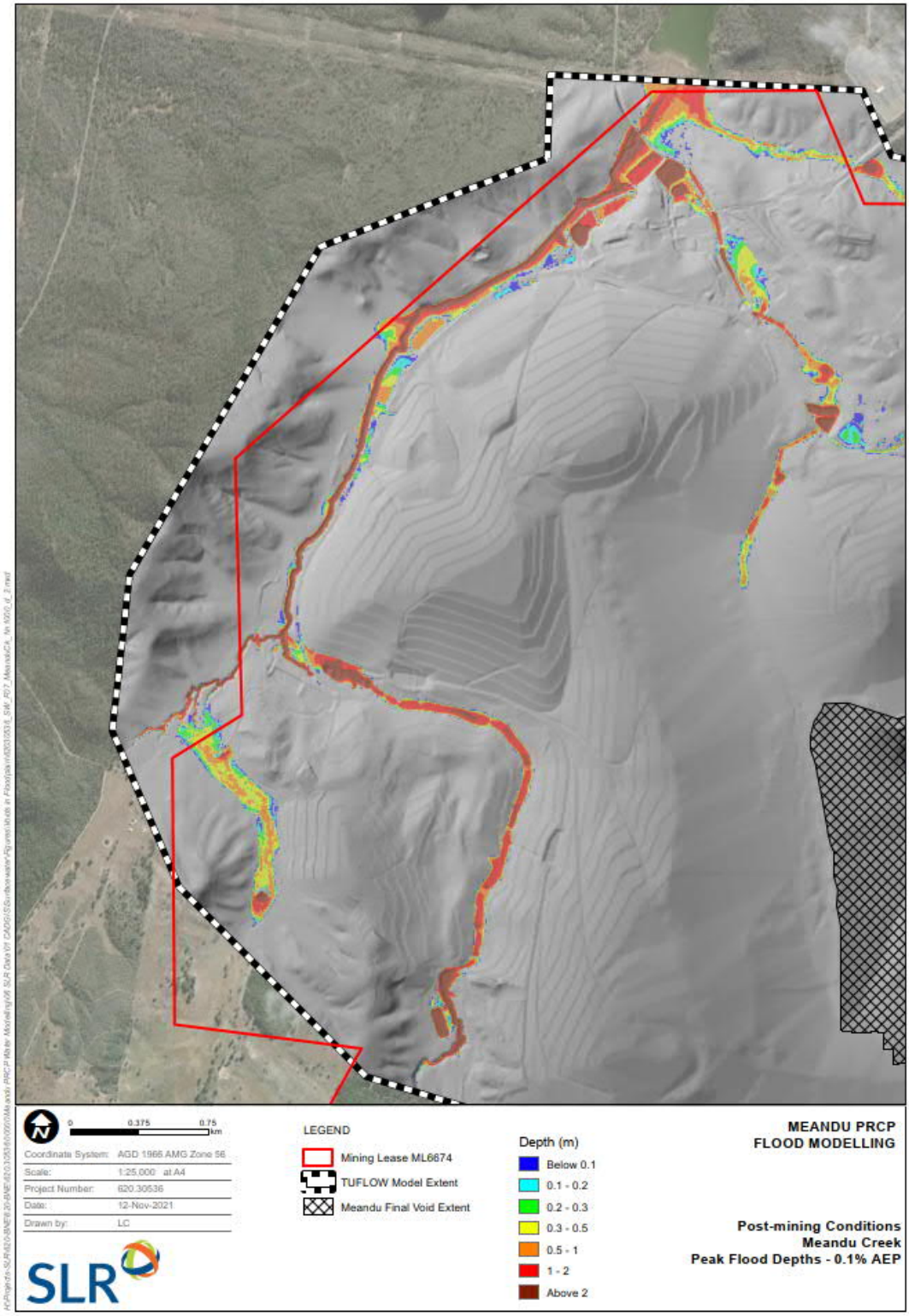


Figure 9 Tuflow Model Results – Rocky Creek



8 Conclusion

SLR was contracted by Stanwell Corporation Limited (SCL) to support the preparation of the Meandu Mine (the Mine) Progressive Rehabilitation and Closure Plan (PRCP). The assessment detailed in this report was undertaken specifically to address Sections 3.4 and 3.6.1 of the PRCP Guideline, which relate to the analysis of flooding as part of the PRCP.

A review of the watercourses in the vicinity of the project showed that two relevant watercourses exist under the classification system outlined in the PRCP Guideline, i.e. Meandu Creek and Rocky Creek. Therefore, in accordance with the requirements of the PRCP Guideline, flood modelling was undertaken for both relevant watercourses.

A model landform was developed for the project, which was based on the post-mining surface provided by Stanwell and included the proposed final voids and rehabilitated dump areas. LiDAR data dated 2007, also provided by Stanwell, was used to supplement the model landform for areas outside the project extents.

Using the model landform, hydrologic models were developed for both the Meandu Creek and Rocky Creek catchments. The results of the models were verified against results of empirical flow estimation methods. The hydrologic models were simulated for a suite of design storm events including a range of temporal patterns, storm durations and AEP events including the 0.1% AEP and PMF.

A hydraulic model covering both the Meandu Creek and Rocky Creek catchments was developed. The model topography was based on the model landform for the purpose of assessing the post-mining flooding conditions in accordance with Section 3.6.1 of the PRCP Guideline. Flow hydrographs produced by the hydrologic models were utilised as inflows for the hydraulic model.

The results of the hydraulic model showed the proposed voids are located outside of the flood inundation footprint of both Meandu Creek and Rocky Creek for the modelled flood events up to and including the PMF. The hydraulic model results also illustrated that the integrity of the rehabilitated waste rock dumps that form part of the stable landform (i.e. post-mining landform) are not located within the floodplain extent of Meandu Creek or Rocky Creek.

Based on the above, the outcome of the assessment indicates that the post-mining flood risk profile for the project is acceptable.

APPENDIX A

DES Pre-lodgement Advice

From: O'BRIEN Alison <Alison.OBrien@des.qld.gov.au>
Sent: Tuesday, 15 June 2021 3:37 PM
To: Emma Williams <ewilliams@slrconsulting.com>
Cc: Brad Radloff <bradloff@slrconsulting.com>; Nicole Bichel <nbichel@slrconsulting.com>; NICOLSON Louisa <Louisa.Nicolson@des.qld.gov.au>; WAKE Chris <Chris.Wake@des.qld.gov.au>
Subject: RE: PRCP Flooding Enquiry

Hi Emma, thanks for your enquiry. Chris has asked me to respond in his behalf and I am happy to provide further clarification and respond to each of your points below.

- For transitional sites, section 3.4 of the Guideline applies where:
  - a void has been identified as a NUMA in a land outcome document but the location has not been specified, or
  - where there are no land outcomes in the land outcome document.
- For the purposes of section 3.4 of the Guideline the floodplain associated with a stream order 4 or greater is required to be modelled. The modelling must not include any artificial features on the site (the pre-mining landscape). However, the modelling must include permanent diversions that are located upstream of the site. Further discussion regarding artificial features is provided in the Information Sheet Voids in flood plains, which can be accessed at https://environment.des.qld.gov.au/__data/assets/pdf_file/0024/95442/rs-is-modelling-flood-plain.pdf
- The requirement for a flood assessment under section 3.6.1 of the Guideline applies to the post mining landform across the whole site irrespective of whether a PMLU or a NUMA are proposed. However, there may be some sites where it is not considered relevant and it may be omitted where sufficient justification has been provided (for example, if the site is demonstrated to be at the top of a catchment of a stream order 1 watercourse).
- The flood assessment set out in section 3.6.1 is not only required to indicate flood risk but also to demonstrate the final landform (including waste rock dumps and diversions) will remain in a stable condition in a range of flood flow conditions.

I trust this information is of assistance.

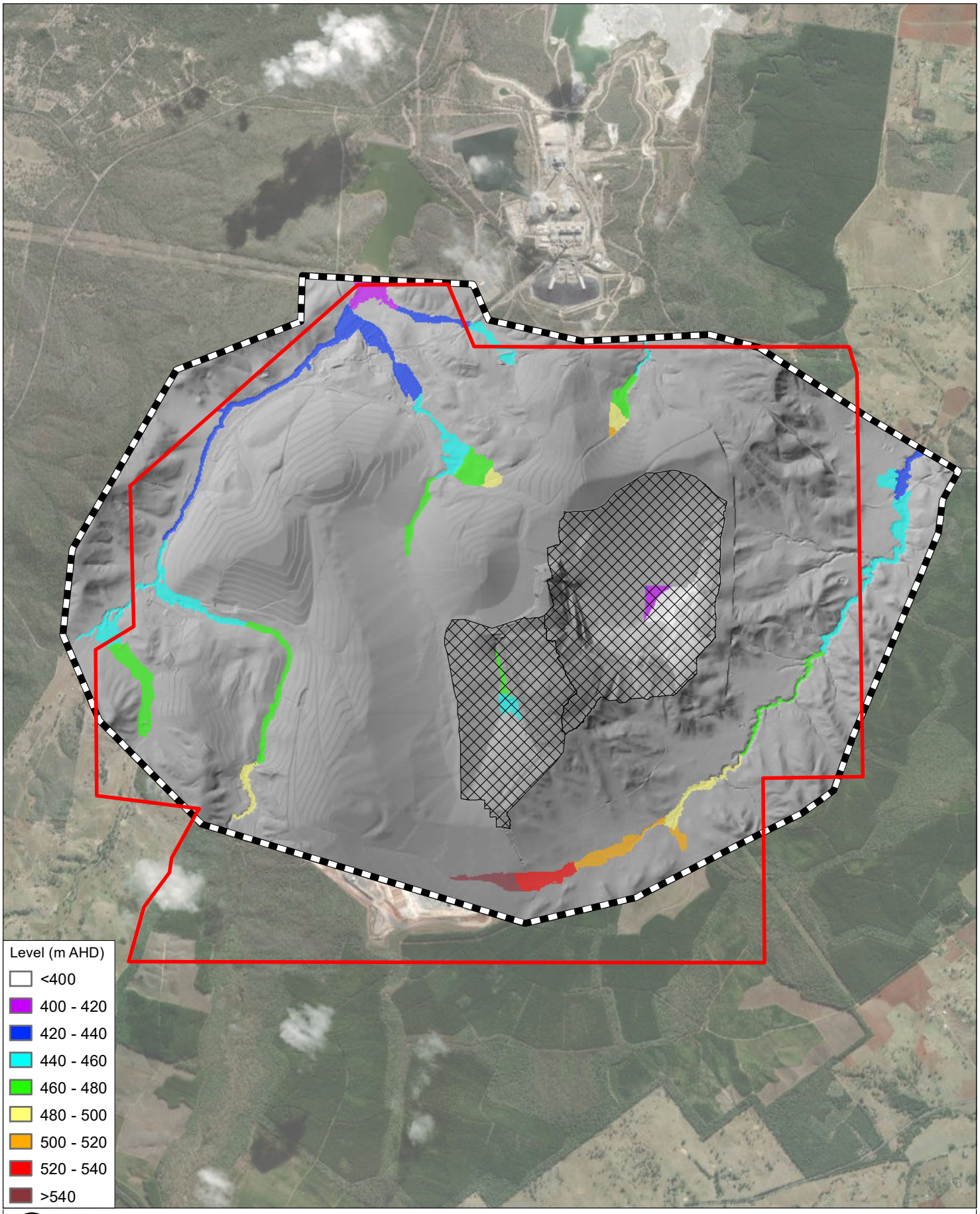
Cheers,

Alison O'Brien
Principal Environmental Officer
Minerals & Northern Compliance | Environmental Services and Regulation
Department of Environment and Science

P 07 4222 5327
5B Sheridan Street, Cairns QLD 4870
PO Box 7230, Cairns QLD 4870

APPENDIX B

Tuflow Model Results



0 1 2 km

LEGEND

Mining Lease ML6674

TUFLOW Model Extent

Meandu Final Void Extent

Coordinate System:	AGD 1966 AMG Zone 56
Scale:	1:50,000 at A4
Project Number:	620.30536
Date:	12-Nov-2021
Drawn by:	HM

SLR

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Levels - 50% AEP

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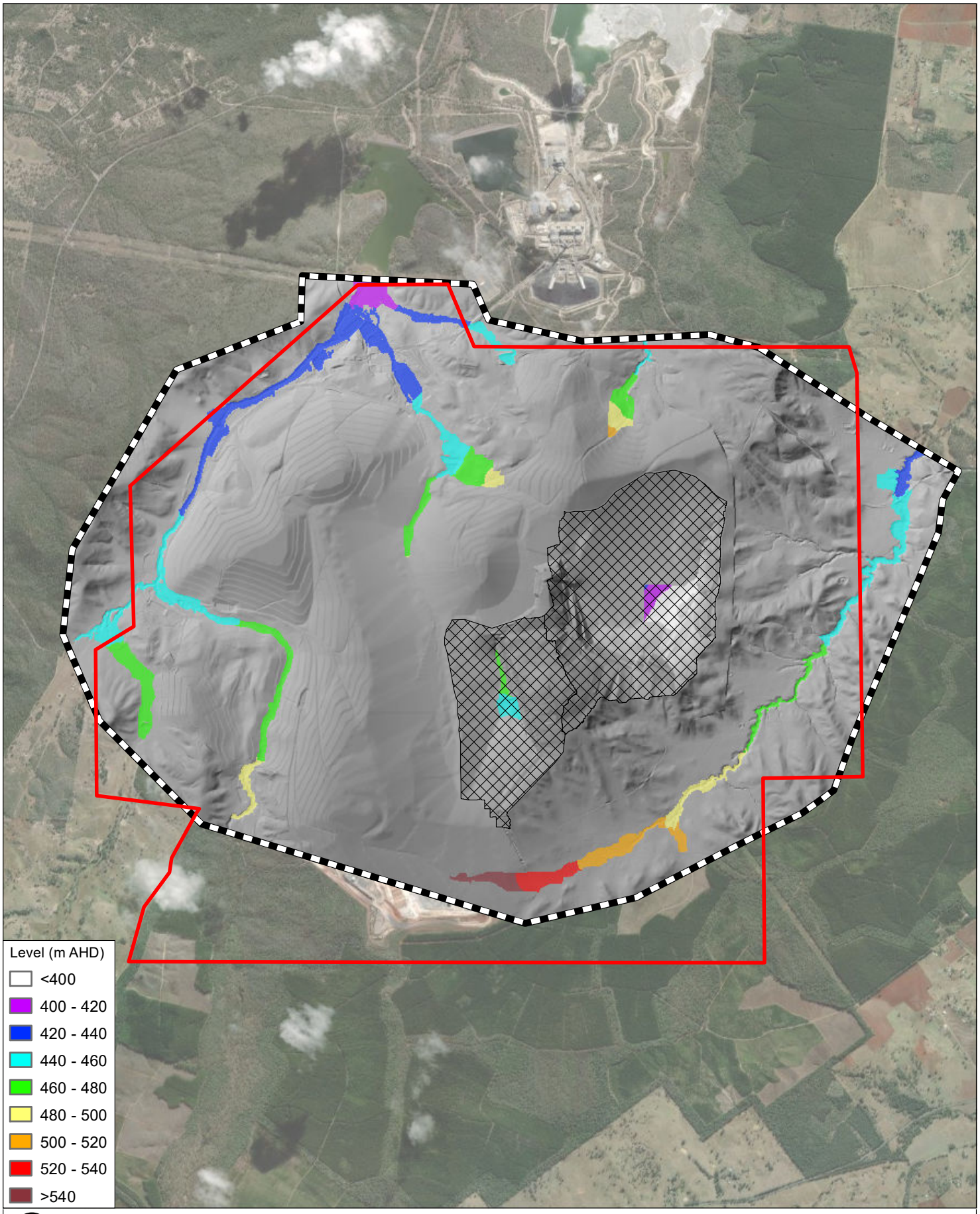

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Coordinate System:	AGD 1966 AMG Zone 56
Scale:	1:50,000 at A4
Project Number:	620.30536
Date:	12-Nov-2021
Drawn by:	HM

LEGEND

- Mining Lease ML6674
- TUFLOW Model Extent
- Meandu Final Void Extent

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Levels - 2% AEP

SLR

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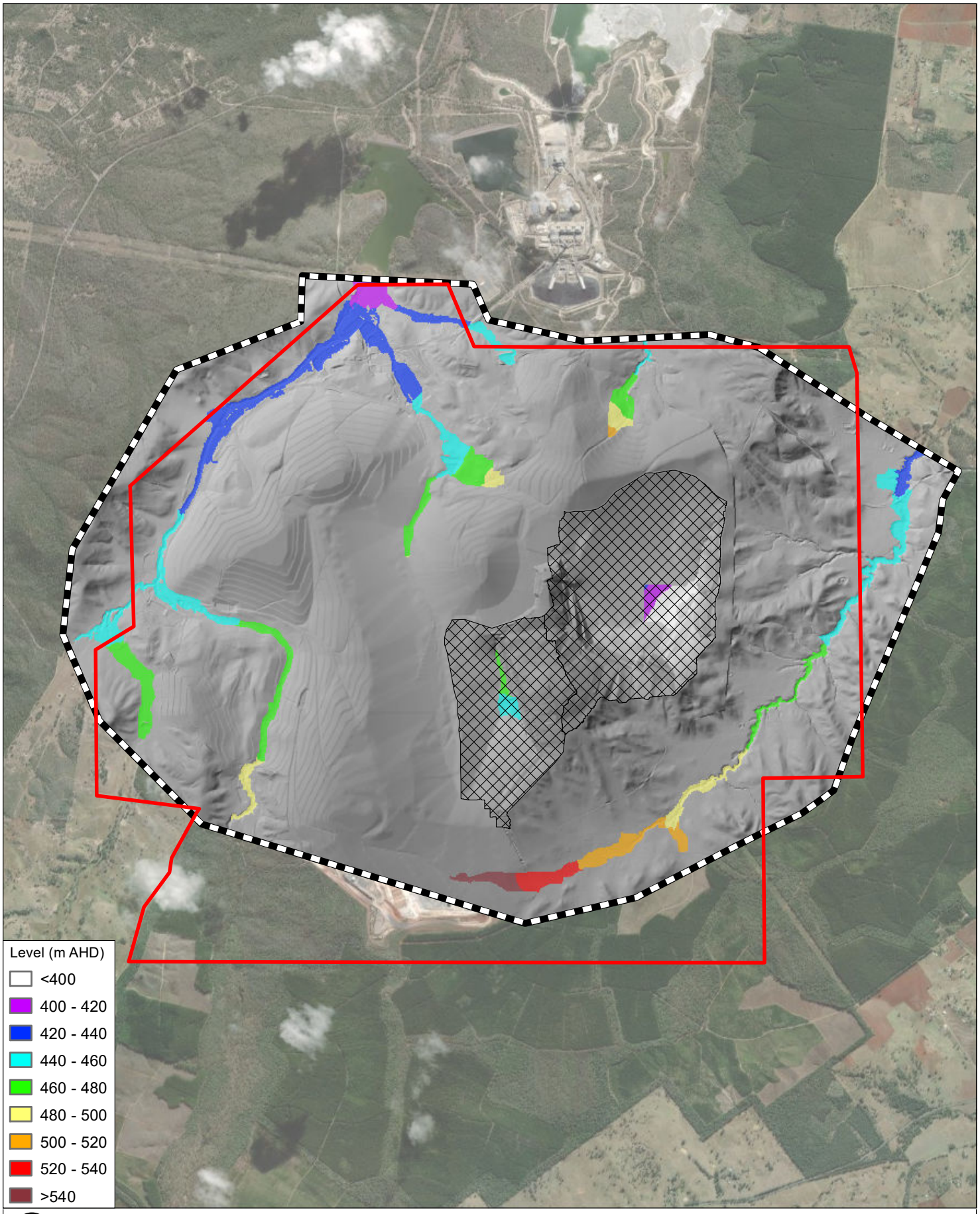

0 1 2 km

LEGEND

Mining Lease ML6674

TUFLOW Model Extent

Meandu Final Void Extent

Coordinate System:	AGD 1966 AMG Zone 56
Scale:	1:50,000 at A4
Project Number:	620.30536
Date:	12-Nov-2021
Drawn by:	HM

SLR

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Levels - 1 % AEP

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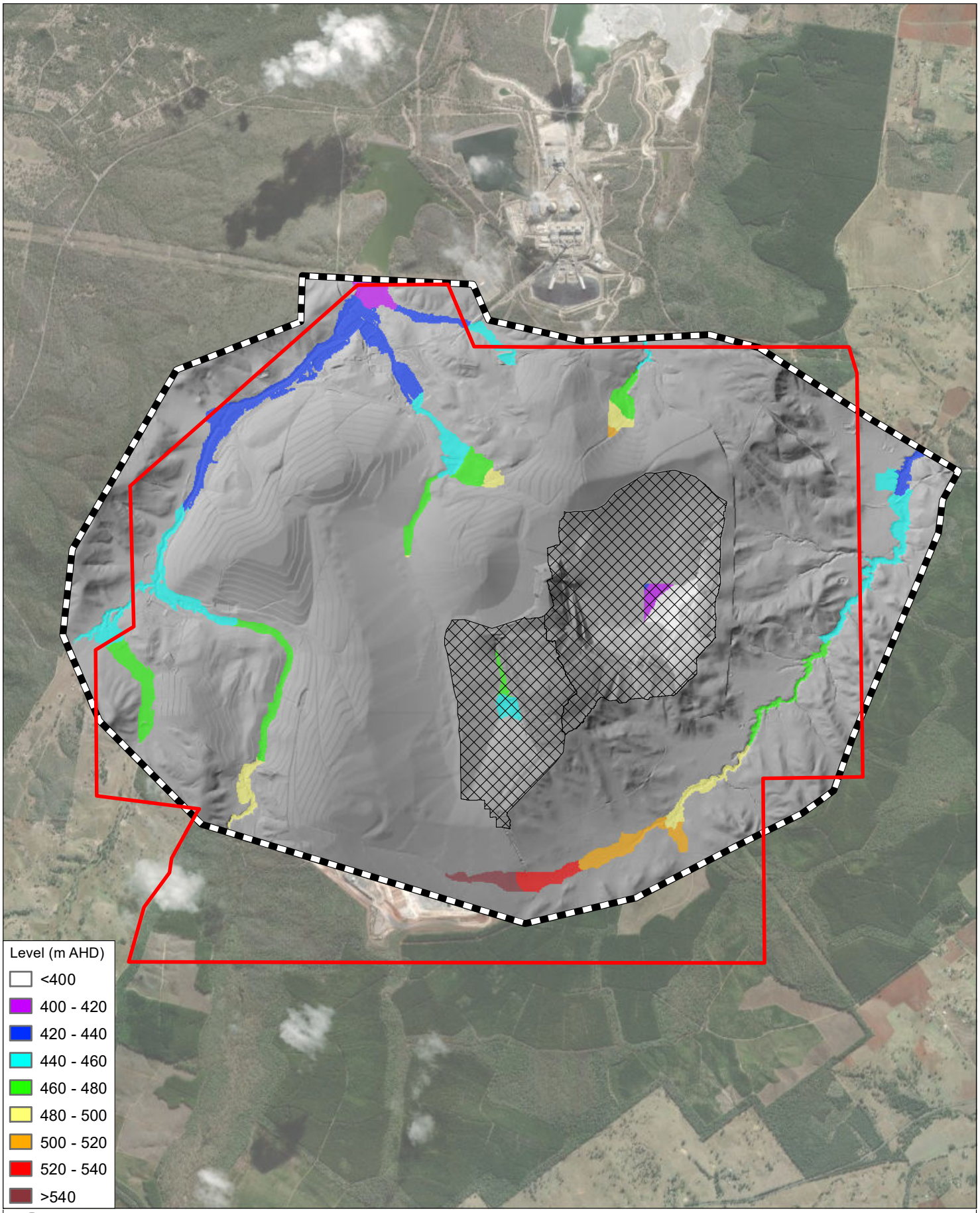

0 1 2 km

LEGEND

Mining Lease ML6674

TUFLOW Model Extent

Meandu Final Void Extent

Coordinate System:	AGD 1966 AMG Zone 56
Scale:	1:50,000 at A4
Project Number:	620.30536
Date:	12-Nov-2021
Drawn by:	HM

SLR

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Levels - 0.1% AEP

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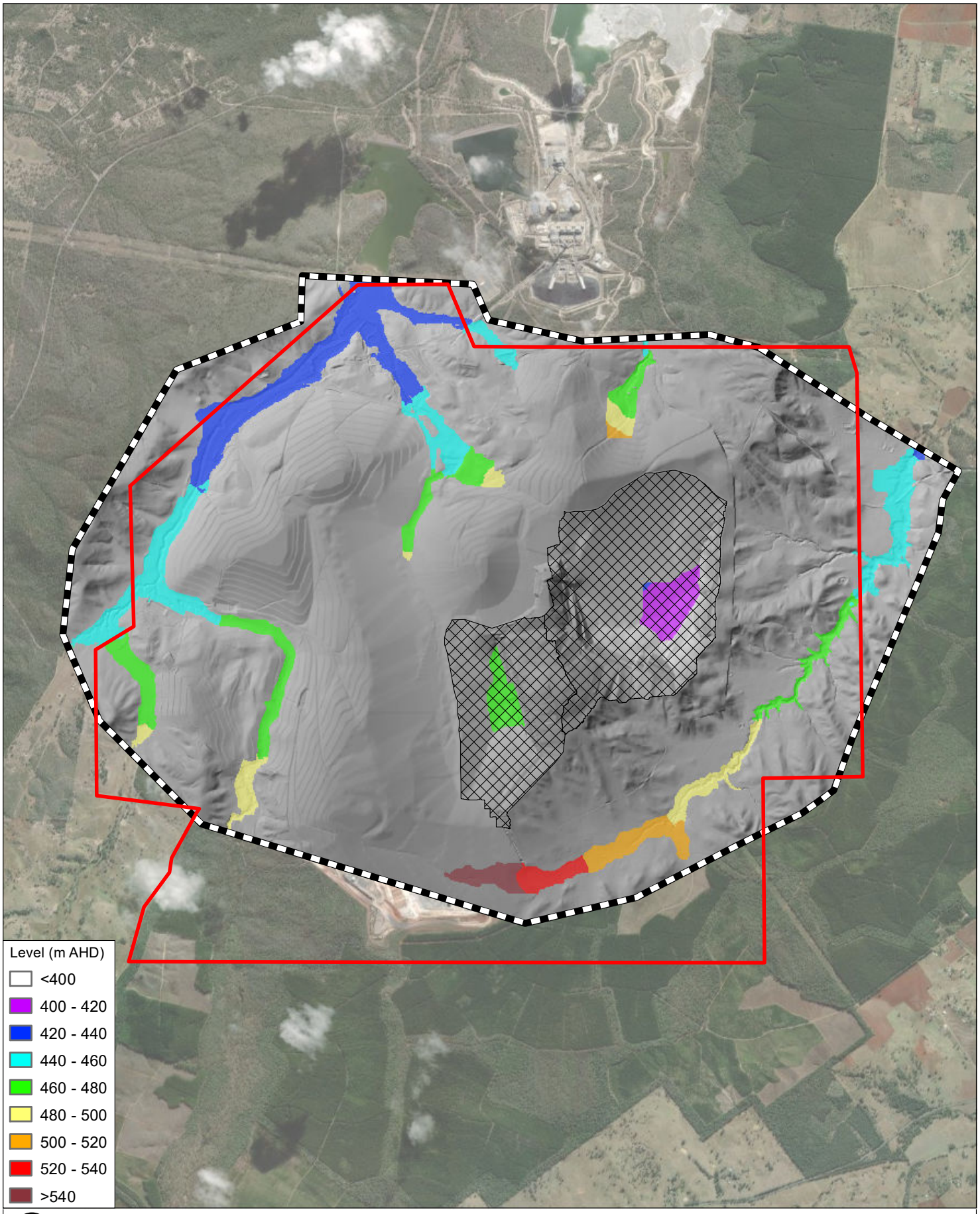

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Coordinate System:	AGD 1966 AMG Zone 56
Scale:	1:50,000 at A4
Project Number:	620.30536
Date:	12-Nov-2021
Drawn by:	HM

LEGEND

- Mining Lease ML6674
- TUFLOW Model Extent
- Meandu Final Void Extent

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Levels - PMF

SLR

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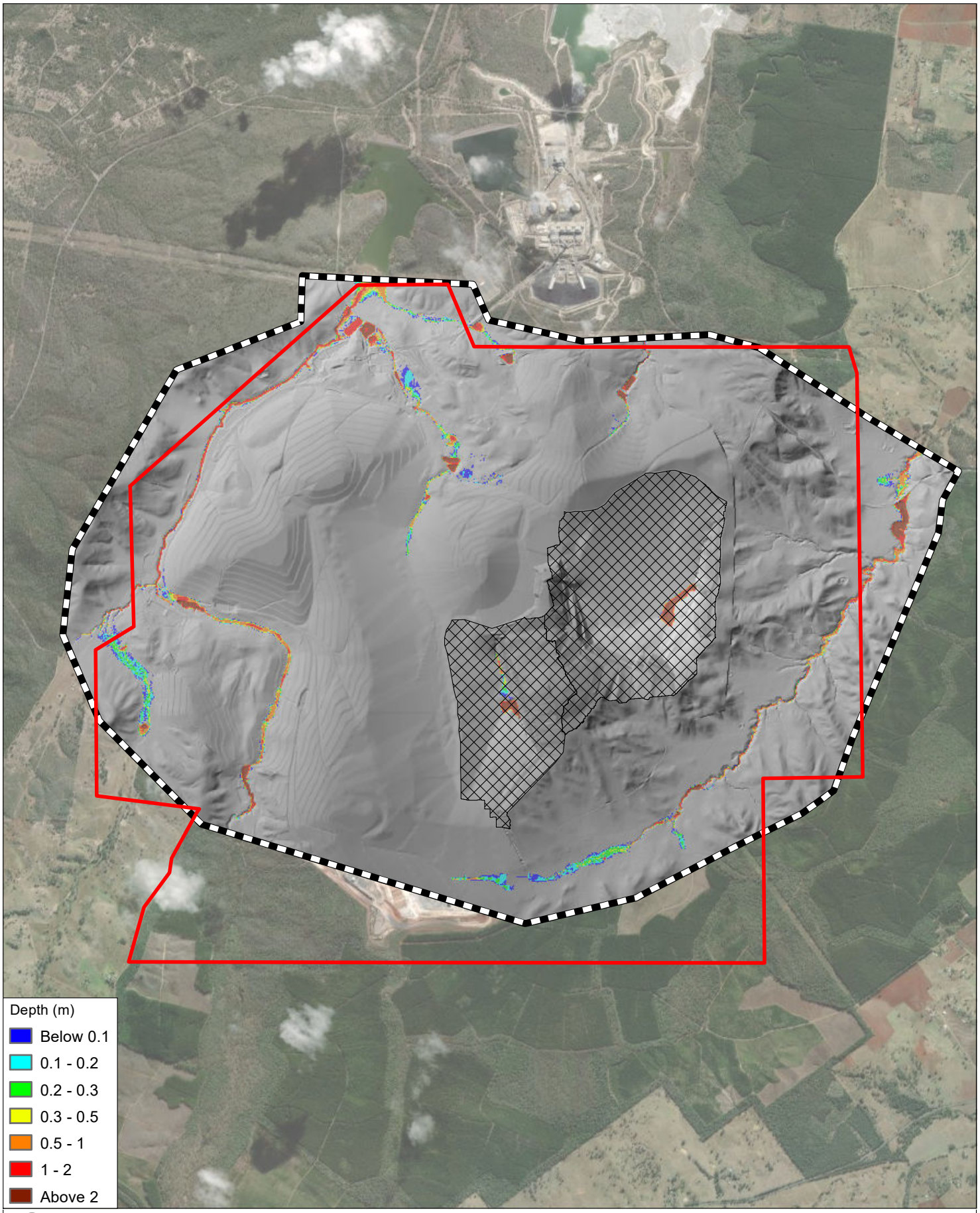

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Coordinate System:	AGD 1966 AMG Zone 56
Scale:	1:50,000 at A4
Project Number:	620.30536
Date:	12-Nov-2021
Drawn by:	HM

LEGEND

- Mining Lease ML6674
- TUFLOW Model Extent
- Meandu Final Void Extent

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Depths - 50% AEP

SLR

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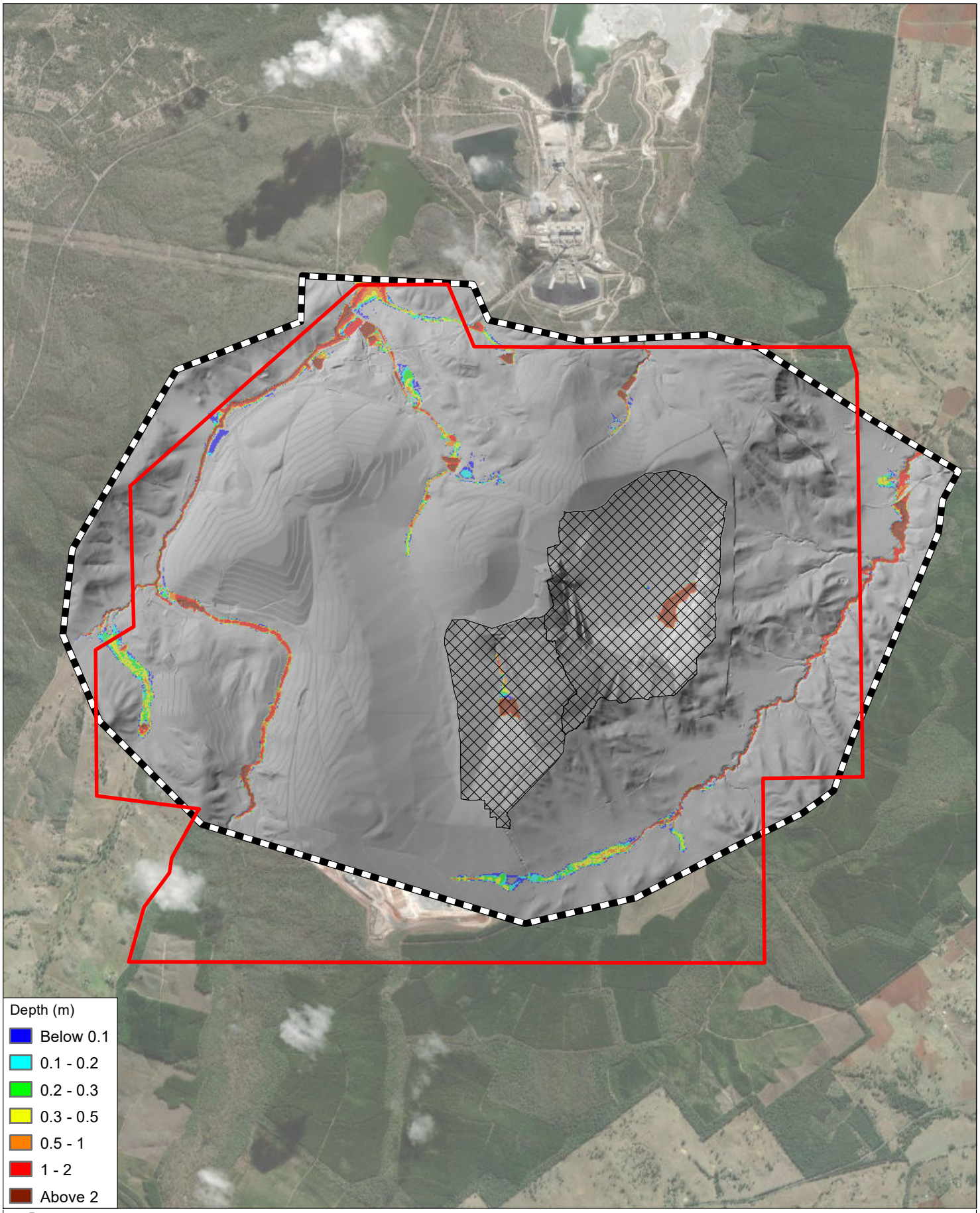

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Project Number:	620.30536
Date:	12-Nov-2021
Drawn by:	HM

LEGEND

- Mining Lease ML6674
- TUFLOW Model Extent
- Meandu Final Void Extent

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Depths - 2% AEP

SLR

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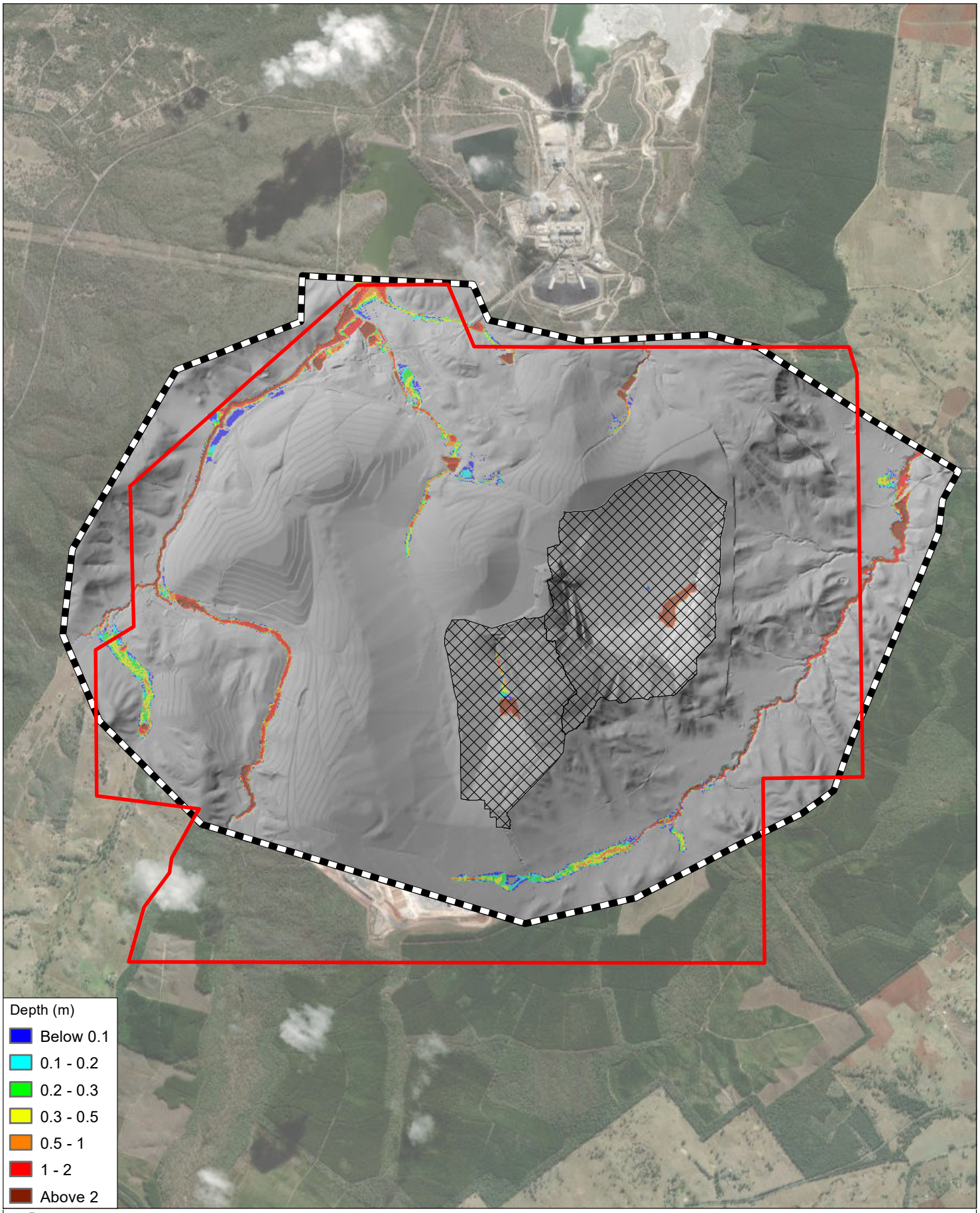

0 1 2 km

LEGEND

Mining Lease ML6674

TUFLOW Model Extent

Meandu Final Void Extent

Coordinate System:	AGD 1966 AMG Zone 56
Scale:	1:50,000 at A4
Project Number:	620.30536
Date:	12-Nov-2021
Drawn by:	HM

SLR

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Depths - 1 % AEP

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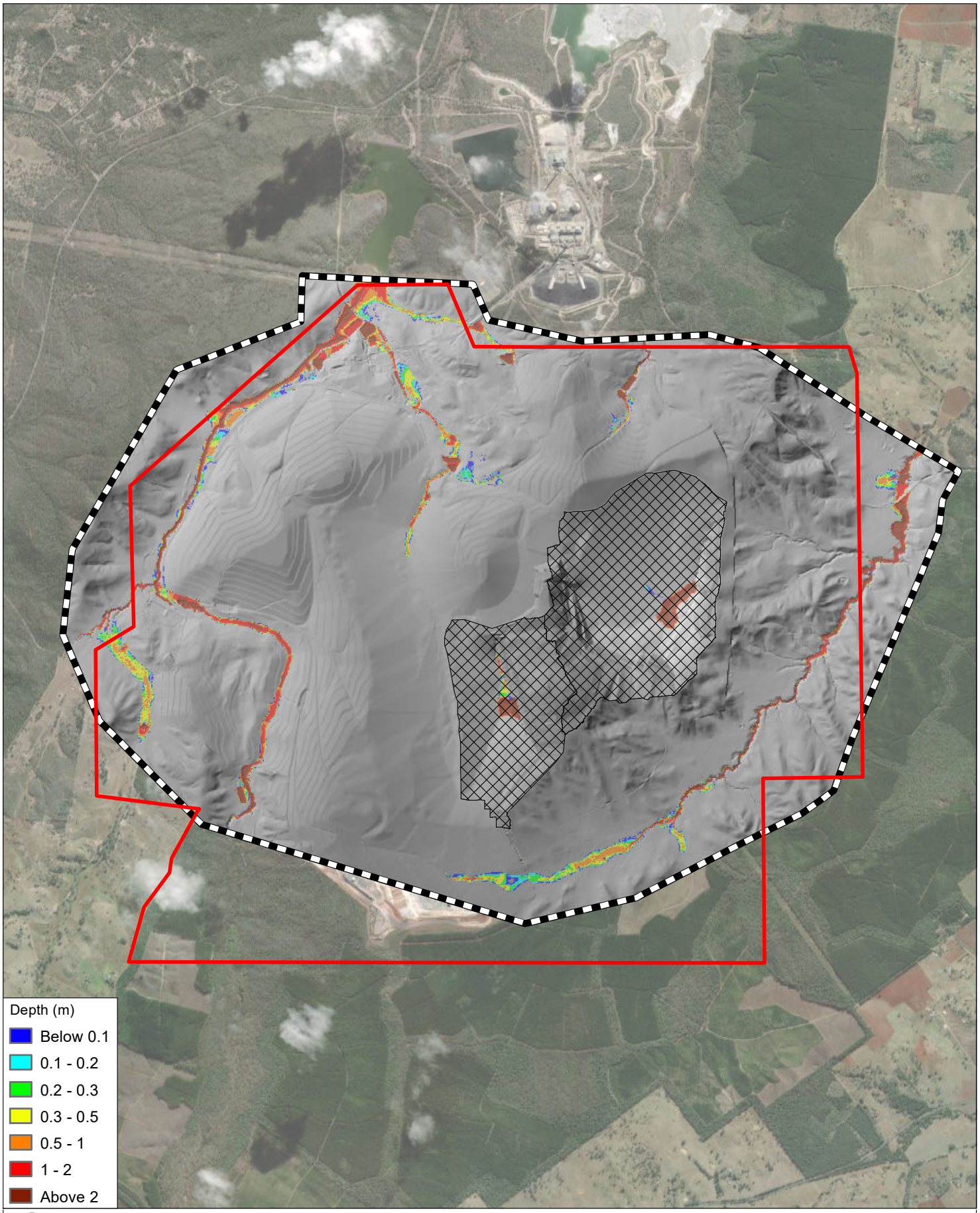

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Date:	12-Nov-2021
Drawn by:	HM

LEGEND

- Mining Lease ML6674
- TUFLOW Model Extent
- Meandu Final Void Extent

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Depths - 0.1% AEP

SLR

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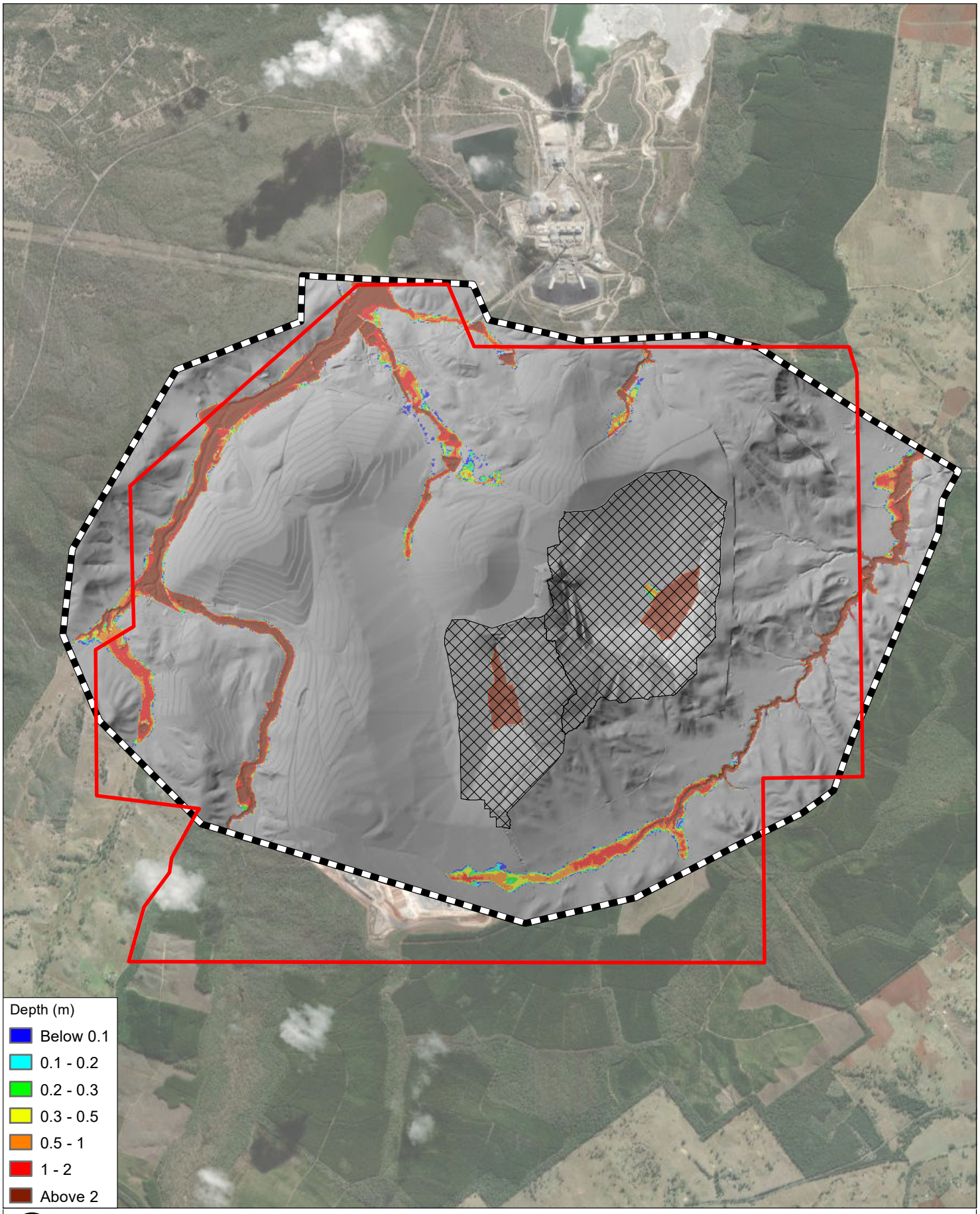

0 1 2 km

LEGEND

Mining Lease ML6674

TUFLOW Model Extent

Meandu Final Void Extent

Coordinate System:	AGD 1966 AMG Zone 56
Scale:	1:50,000 at A4
Project Number:	620.30536
Date:	12-Nov-2021
Drawn by:	HM

SLR

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Depths - PMF

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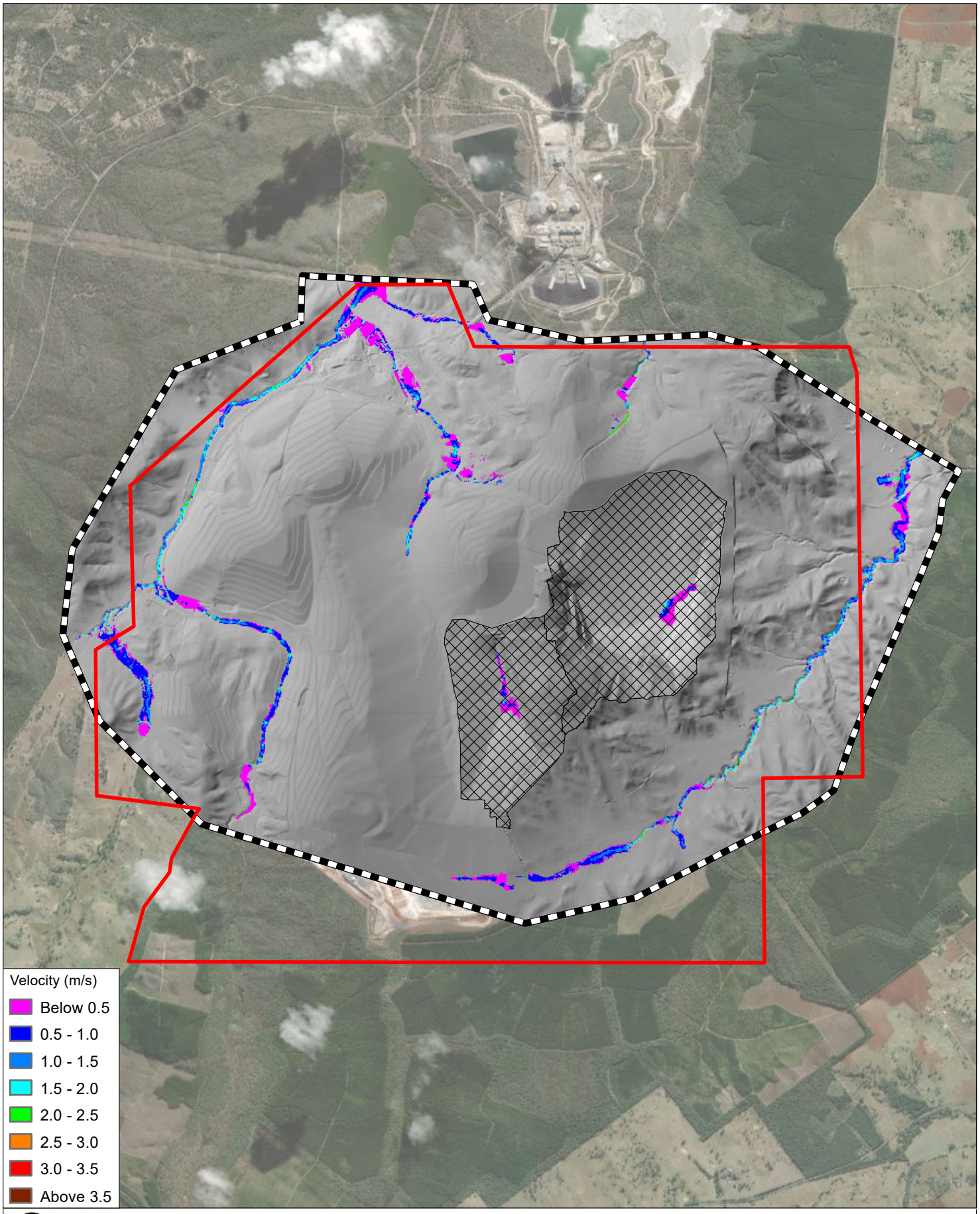

0 1 2 km

LEGEND

Mining Lease ML6674

TUFLOW Model Extent

Meandu Final Void Extent

Coordinate System:	AGD 1966 AMG Zone 56
Scale:	1:50,000 at A4
Project Number:	620.30536
Date:	12-Nov-2021
Drawn by:	HM

SLR

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Velocities - 50% AEP

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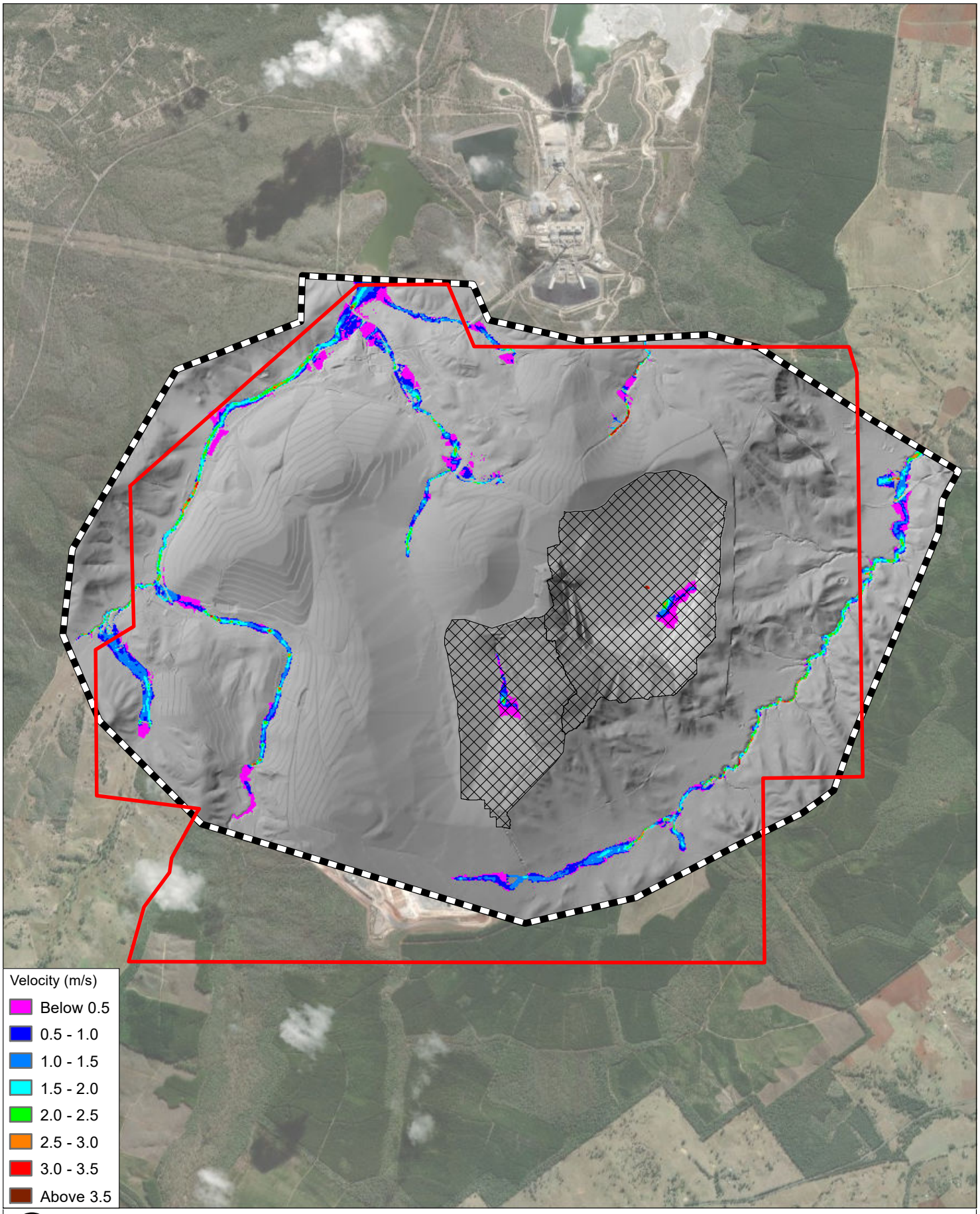

0 1 2 km

Coordinate System:	AGD 1966 AMG Zone 56
Scale:	1:50,000 at A4
Project Number:	620.30536
Date:	12-Nov-2021
Drawn by:	HM

LEGEND

- Mining Lease ML6674
- TUFLOW Model Extent
- Meandu Final Void Extent

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Velocities - 2% AEP

SLR

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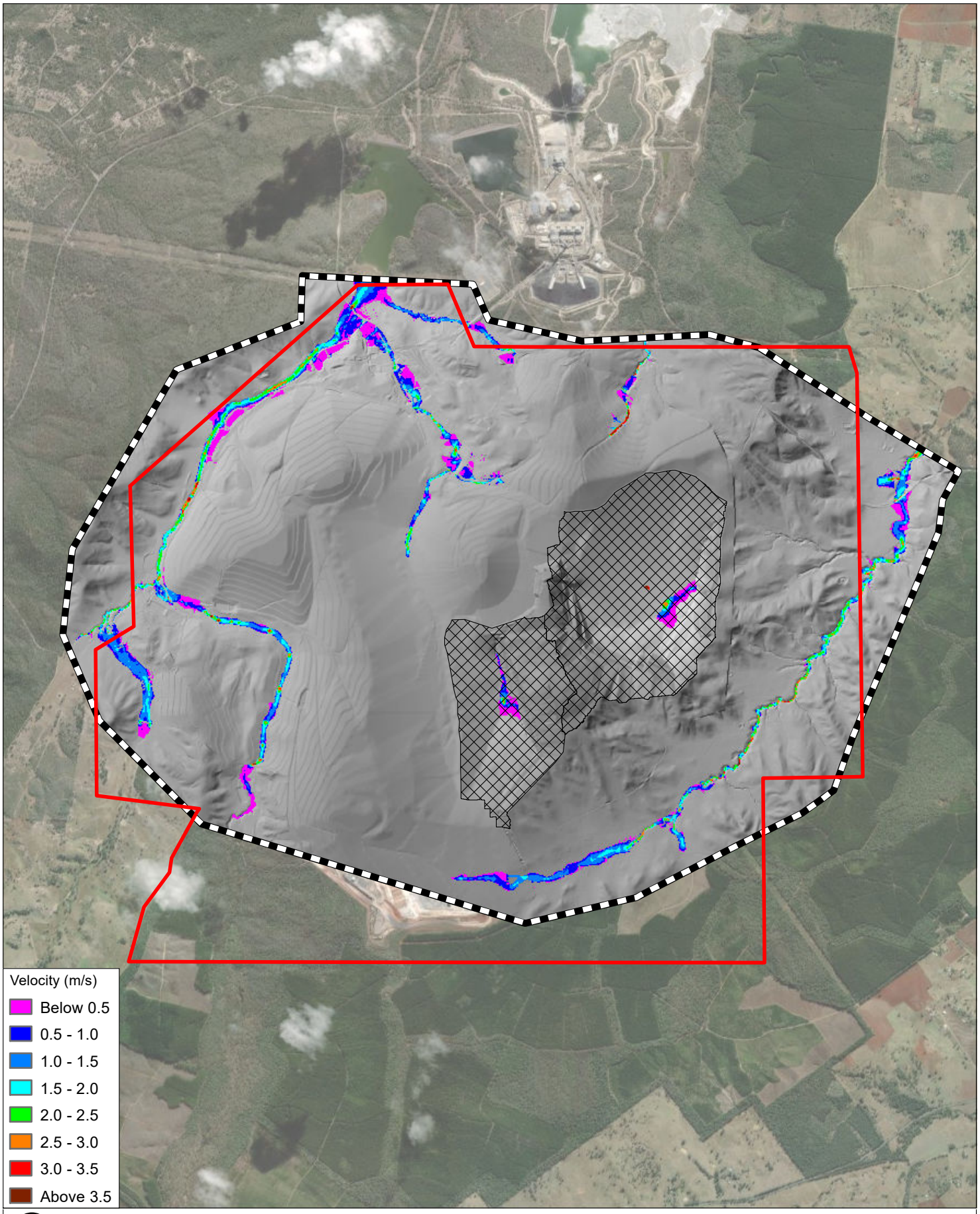

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Coordinate System:	AGD 1966 AMG Zone 56
Scale:	1:50,000 at A4
Project Number:	620.30536
Date:	12-Nov-2021
Drawn by:	HM

LEGEND

- Mining Lease ML6674
- TUFLOW Model Extent
- Meandu Final Void Extent

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Velocities - 1 % AEP

SLR

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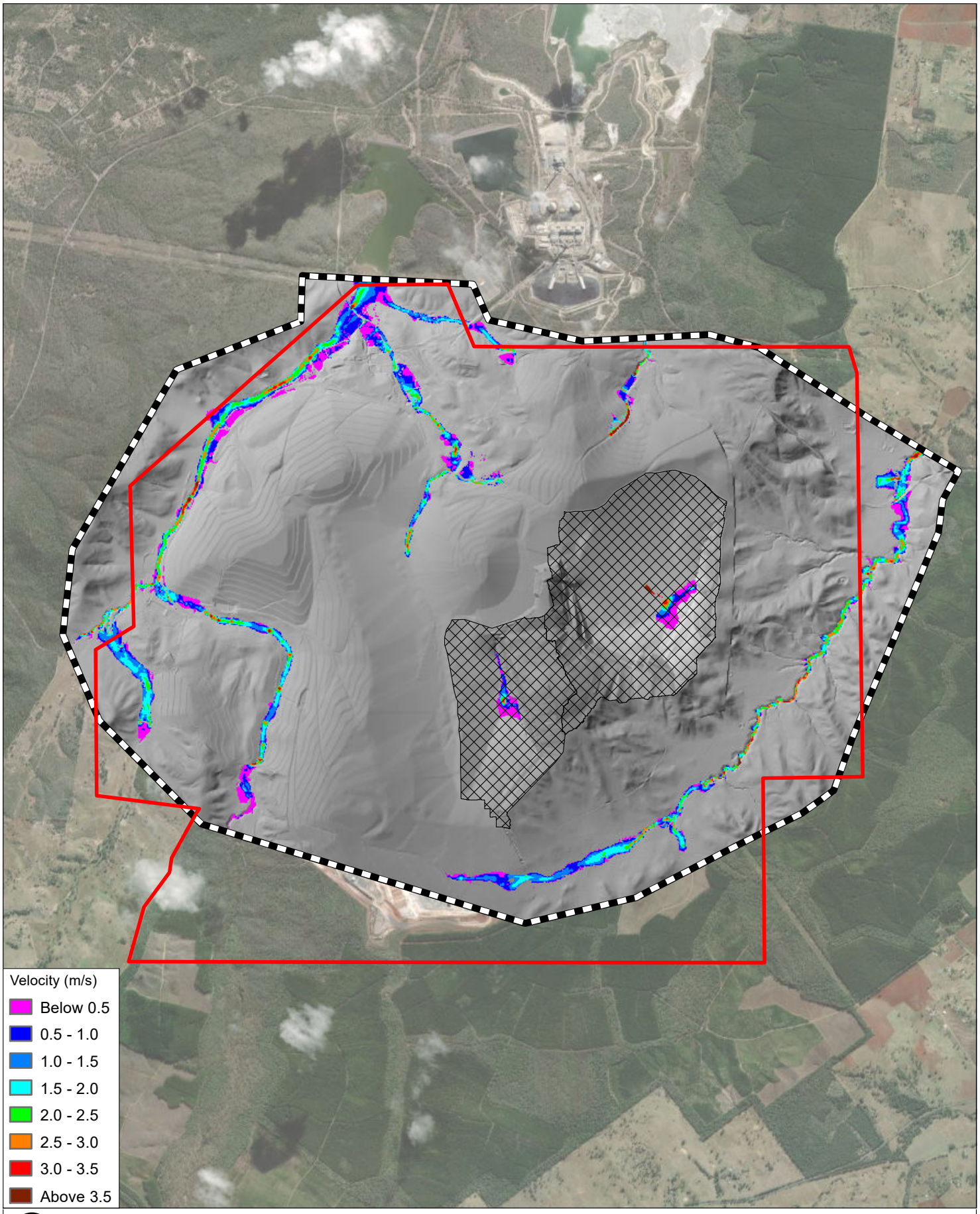

0 1 2 km

Coordinate System:	AGD 1966 AMG Zone 56
Scale:	1:50,000 at A4
Project Number:	620.30536
Date:	12-Nov-2021
Drawn by:	HM

LEGEND

- Mining Lease ML6674
- TUFLOW Model Extent
- Meandu Final Void Extent

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Velocities - 0.1% AEP

SLR

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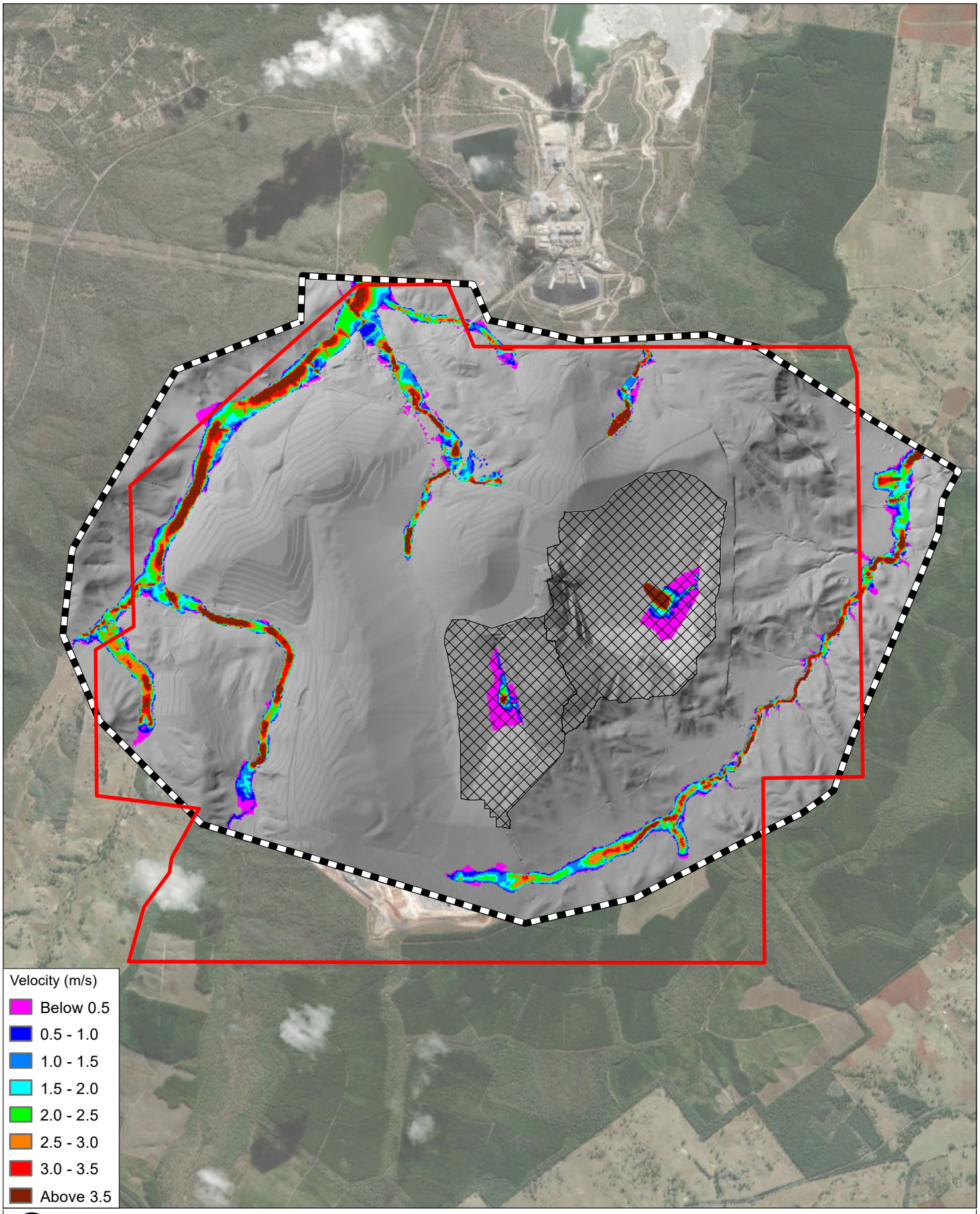

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Coordinate System:	AGD 1966 AMG Zone 56
Scale:	1:50,000 at A4
Project Number:	620.30536
Date:	12-Nov-2021
Drawn by:	HM

LEGEND

- Mining Lease ML6674
- TUFLOW Model Extent
- Meandu Final Void Extent

MEANDU PRCP
FLOOD MODELLING

PRCP Conditions (D004)
Peak Flood Velocities - PMF

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Appendix K

Meandu Mine PRC Plan Waste Characterisation Report



TEC COAL PTY LTD

MEANDU MINE: PROGRESSIVE REHABILITATION AND CLOSURE PLAN

WASTE CHARACTERISATION REPORT

NOVEMBER 2021



wsp

Question today
Imagine tomorrow
Create for the future

Meandu Mine: Progressive Rehabilitation and Closure Plan
Waste Characterisation Report

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A	22 September 2020	Preliminary Draft
B	16 September 2021	Final Draft
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GLOSSARY OF TERMS AND ACRONYMS

ABA	Acid base accounting: an analytical technique applied to mine waste and geological material that evaluates the balance between acid-generating processes (oxidation of sulphide materials) and acid-neutralising processes. It is used to predict the potential of that material to be acid-producing or acid-neutralising.
ABCC	Acid buffering characteristic curve: analytical test involving titration with acid providing an indication of the kinetics of ANC in a sample.
Ag	Silver
Al	Aluminium
AMD	Acid and metalliferous drainage (also referred to as acid mine drainage and acid rock drainage): any contaminated discharge emanating from mine waste materials formed through a series of chemical and biological reactions, when geological strata is disturbed and exposed to oxygen and moisture as a result of mining activity, characterised by low pH, elevated metal concentrations, high sulphate concentrations and high salinity.
ANC	Acid neutralising capacity: a measure of a sample's maximum potential ability to neutralise acid. Expressed as kg H_2SO_4 equivalent per tonne of sample.
As	Arsenic
Ba	Barium
$Ca(OH)_2$	Calcium hydroxide
Co	Cobalt
Cr	Chromium
CRS	Chromium reducible sulphur
Cu	Copper
DES	Department of Environment and Science (Queensland)
DoR	Department of Resources (Queensland)
dS/cm	deciSiemens/centimetre
EA	Environmental authority
EC	Electrical conductivity
Fe	Iron
ha	Hectares
Hg	Mercury
kbcm	thousand bank cubic metres
km	Kilometres
MERFP Act	*Mineral and Energy Resources (Financial Provisioning) Act 2018* (Queensland)

mg/L	milligrams per litre
ML	Mining lease
Mn	Manganese
MPA	Maximum potential acidity: calculated by multiplying the total sulphur or sulphide sulphur content by 30.6 (stoichiometric factor) and expressed as kg H_2SO_4 per tonne.
NAF	Non-acid forming: geochemical classification of material calculated not to generate acid conditions.
NAG	Net acid generation
NAPP	Net acid producing potential: calculated by subtracting the ANC from the MPA, expressed as kg H_2SO_4 per tonne.
Ni	Nickel
NMD	Neutral mine drainage: neutral and metalliferous discharge from mine waste materials, typically as a result of oxidation of sulphide minerals and subsequent neutralisation by carbonate minerals, characterised by neutral pH, high salinity, sulphate and metals.
NPR	Neutralising potential ratio: calculated by dividing ANC by MPA.
PAF	Potentially acid forming: geochemical classification of material calculated to have the potential to generate acid conditions.
Pb	Lead
pH	power of hydrogen – a measure of hydrogen ion (H^+) concentration
PMLU	Post-mining land use
PRCP	Progressive rehabilitation and closure plan
ROM	Run-of-mine: Coal as it comes from the mine prior to screening or processing
S	Sulphur
SMD	Saline mine drainage: salt-contaminated discharge from mine waste materials, characterised by neutral pH, high salinity and sometimes high sulphate.
SO_4^-	Sulphate
TCLP	Toxicity Characteristic Leaching Procedure
U	Uranium
V	Vanadium
XRD	X-ray diffraction
Zn	Zinc
µS/cm	microSiemens per centimetre

ABBREVIATIONS SPECIFIC TO MEANDU MINE

CHPP	Coal Handling and Preparation Plant
CP	Compliance point
K1	King 1
K2	King 2
K2E	King 2 East
K2N	King 2 North
K2TSF	King 2 Tailings Storage Facility
K2W	King 2 West
K2WN	King 2 West North
K4E	King 4 East
K4S	King 4 South
NWA	North-West A
NWATSF	North-West A Tailings Storage Facility
NWB	North-West B
NWBFP	North-West Backfilled Pit
NWBTSF	North-West B Tailings Storage Facility
QWBFP	Queen-West Backfilled Pit
RD	Retention dam
RSA	Rejects Storage Area
Stanwell	Stanwell Corporation Limited
Tarong power stations	Tarong Power Station and Tarong North Power Station
TEC Coal	TEC Coal Pty Ltd
TSF	Tailings storage facility

1 INTRODUCTION

1.1 BACKGROUND

On 30 November 2018, the Queensland parliament passed the *Mineral and Energy Resources (Financial Provisioning) Act 2018* (MERFP Act) with the intention of improving rehabilitation and financial assurance outcomes in the resources sector. A crucial component of the MERFP Act is that it amends the *Environmental Protection Act 1994* through the introduction of new requirements for the progressive rehabilitation and closure of mined land.

A progressive rehabilitation and closure plan (PRCP) is a critical element of the Queensland Government's mined land rehabilitation policy. The main purposes of the PRCP are to:

- require the holder of an environmental authority (EA) to plan how and where activities will be carried out on land in a way that maximises the progressive rehabilitation of the land to a stable condition
- provide for the condition to which the EA holder must rehabilitate the land before the EA may be surrendered.

The PRCP requires the support of a number of technical inputs to provide evidence and justification of the rehabilitation methodologies and techniques to be used at the site, one of which is waste characterisation. Waste characterisation is a crucial contributing factor when choosing appropriate rehabilitation strategies and suitable post-mining land uses (PMLU). This report forms the waste characterisation report supporting the Meandu Mine PRCP.

1.2 PROGRESSIVE REHABILITATION AND CLOSURE PLAN - WASTE CHARACTERISATION

The Guideline: Progressive rehabilitation and closure plans (PRCP guideline) (Version 2.0, 17 March 2021) (DES, 2021b) details the required contents of a waste characterisation report supporting a PRCP for a site, and proscribes the extent, type of testing and material tested for the waste characterisation program. Overall, the report must describe the likely physical behaviour and chemical reactivity of the waste materials under the conditions in which they would be stored and must address the constituent elements present, and their likely future speciation and mobility.

Waste characterisation at a site should meet the following criteria:

- contain representative sampling identifying the number and type of lithologies, along with the alteration and weathering of sub-variants that constitute the bulk of the material to be excavated or exposed to oxidising conditions
- allow for classification of the material on its propensity to be potentially acid or non-acid forming and to generate neutral or saline drainage and its susceptibility to weathering.

Specific waste characterisation should include the following:

- Static tests to indicate the potential to generate acid and metalliferous drainage (AMD) – also known as Acid Mine Drainage and Acid Rock Drainage, such as:
  - chemical composition (whole rock and elemental analysis)
  - mineralogical analysis
  - acid base accounting (ABA) (paste pH, sulphur speciation, neutralising potential ratio (NPR) or acid neutralising capacity (ANC) and total inorganic carbon)
  - net acid generation (NAG)
  - water extraction (batch extraction) tests – with solution assay.

- Kinetic tests to predict the rate of oxidation and concentrations of contaminants that may be leached from the material under the relevant environmental conditions, such as:
  - humidity cell leach testing
  - column leach testing.

The waste characterisation report should achieve the following outcomes:

- demonstrate that the sampling regime meets best practice standards, is spatially representative of all material being mined (i.e. the ore body, exposed pit walls and overburden etc) and representative of all lithologies
- be capable of confidently classifying mine waste streams based on environmental risk and management requirements
- be capable of generating block models and estimating the volume of mine waste based on waste type (i.e. level of environmental risk)
- provide recommendations for the management and mitigation of waste streams to manage environmental risk and achieve proposed rehabilitation methods and objectives.

The waste characterisation report should also contain a conceptual site model, which for waste rock dumps, low-grade ore stockpiles, heap leach pads and tailings storage facilities (TSFs) must also identify site-specific factors that may result in geochemical risks, including consideration of the interaction of natural and anthropogenic processes that influence management controls.

Overall, the waste characterisation at the site must be capable of informing other technical inputs to the PRCP, including but not limited to:

- waste placement strategies developed to mitigate environmental and rehabilitation risks
- final landform design, including potential cover designs, seepage collection systems, liners, etc
- water quality modelling, incorporating geochemical outputs to hydrological and hydrogeological models that predict post-closure surface water, groundwater, final void and TSF water qualities.

2 SITE DESCRIPTION

2.1 SITE SETTING

Meandu Mine is located in Queensland's South Burnett region, approximately 150 kilometres (km) north-west of Brisbane, 14 km south-west of Nanango and 1.5 km to the south of the Tarong and Tarong North power stations (Tarong power stations). The nearest town to the mine site is Yarraman, which is located approximately 6 km south south-east from approved mining activities. TEC Coal Pty Ltd (TEC Coal), a wholly owned subsidiary of Stanwell Corporation Limited (Stanwell), owns the Meandu Mine and is the holder of Mining Lease (ML) 6674 and EA EPML00709113.

Meandu Mine is an open-cut coal mine that is operated for the purpose of supplying black thermal coal to the adjacent Tarong power stations. Meandu Mine has been supplying coal to the Tarong Power Station since 1983 and the Tarong North Power Station since 2003. During the period 1983 to 2007, Rio Tinto Coal Australia owned and operated the mine. TEC Coal purchased Meandu Mine in 2008. The long-term plan is for mining operations to continue at Meandu Mine through until at least 2037.

Meandu Mine operates within the approved surface rights area (2,640 hectares (ha)) of the Department of Resources (DoR) granted ML6674 (4,267 ha) (refer Figure 2.1).

The Department of Environment and Science (DES) issued EA EMPL00709113 (4 August 2021) (DES, 2019a) provides for annual run-of-mine (ROM) coal production of up to 11 million tonnes per annum.

Coal is mined from multiple seams including the Ace, King and Queen seams (variable by pit). Non-economic seams (typically thinner and/or of poorer quality) occur below the Queen seam.

Mining operations currently advance the existing Central, Ramp 5, King 4 East (K4E) and King 4 South (K4S) pits. Operations are planned to recommence in the King 2 East (K2E) pit in calendar year 2024, with the pit remaining active for the remainder of the mine life. The location of these pits is shown on Figure 2.2.

In addition to the mining operation, Meandu Mine includes a coal handling and preparation plant (CHPP), where mined coal is stockpiled, screened, washed and transported to the Tarong and Tarong North power stations via overland conveyor. The coal is combusted at the Tarong power stations, which generate coal combustion products (or ash), that is transported back to the mine in a concentrated slurry form for in-pit storage. Ash is currently stored in the King 2 West - North (K2WN) void, with longer-term storage planned in the depleted K4S void after fill level is achieved in the K2WN void.

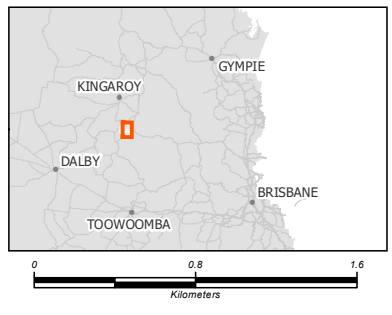
Meandu Mine

Figure 2.1
Meandu Mine lease boundary and surface rights area

Legend

- Existing Feeder 831 Transmission Line
- Ridge Road
- Watercourse
- Cadastre
- Local Government Areas
- K2E ASA
- Mining Lease (ML6674)
- Approved Surface Rights Area
- Yarraman State Forest

TARONG AND TARONG NORTH POWER STATIONS
MEANDU MINE
ML 6674
K2E ASA
SOUTH BURNETT REGIONAL COUNCIL
TOOWOOMBA REGIONAL COUNCIL
Yarraman State Forest
NORMAN ROAD
RAYMOND ROAD
NOBBY SMITH WAY
CHIPPENDALE ROAD
NANANGO NEUMGNA ROAD
REEVE ROAD
TARONG POWER STATION ROAD
RIDGE ROAD
LEWIS ROAD
NYSTROM DUFFEY ROAD
MAIDENWELL UPPER YARRAMAN ROAD
TARONG YARRAMAN ROAD
UPPER YARRAMAN ROAD
Meandu Creek
Rocky Creek
Yarraman Creek



Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

1:37,500 Date: 15-Sep-21

Data sources: - DNRME, TMR, Translink, Geoscience Australia

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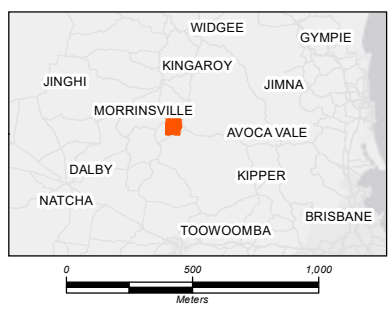
Meandu Mine

Figure 2.2
Meandu Mine key features

Tarong Ash Dam
Black Creek Dam
Cooling Dam
Meandu Creek Dam
TARONG AND TARONG NORTH POWER STATIONS
Yarraman State Forest
CP 1
CP 2
CP 3
CP 4
RD1
RD2
RD3
RD4
RD6
RD7
RD8
RD9
RD10
RD14A
RD14B
RD14C
RD15B
RD17A
RD17B
RD18
RD21
RD22B
RD24
RD25
RD26
RD27
RWD
CHPP
ROM
K2 TSF
K2E Rehab
NORTH WEST BACKFILLED PIT
North West A Tailing
North West B Tailings Dam
QUEEN WEST VOID
K2N Ash Void
K2W Ash Void
West Dump
CENTRAL PIT
RAMP 5 PIT
K4E PIT
K4S PIT
K2E PIT
K2E ASA
ML 6674
Rocky Creek
Meandu Creek
Yarraman State Forest

Legend

- Compliance Points
- Drainage
- Watercourse
- K2E ASA
- Mining Lease (ML6674)
- Retention Dams
- Yarraman State Forest
- Approved Surface Rights Area
- Ash Storage Boundaries
- Rejects Storage Area
- Active pits/tailings storage facility/ash storage
- Tailings
- Future Ash Storage



Coordinate system: GDA 1994 MGA Zone 56

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1:30,000 Date: 19/11/2021

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2.2 OVERVIEW OF OPERATIONS

2.2.1 MINING ACTIVITIES

Mining at Meandu Mine is undertaken using both dragline and excavator/truck open-cut techniques. Prior to the removal of waste rock or coal, overlying vegetation is cleared, and topsoil is stripped to an appropriate depth. The topsoil is either directly placed onto re-contoured landforms or stockpiled for later use during rehabilitation.

Waste rock material is removed by dragline and/or excavator and truck in advance of coal mining, being comprised of:

- overburden, which is waste located above the uppermost coal seam targeted for mining (and may include oxidised or uneconomic coal)
- interburden, which is waste located between adjacent coal seams (including both rock and coal)
- near coal roof waste, near coal floor waste and coal partings waste, which are located adjacent to or within coal seams (partings being waste between individual plies of a coal seam, whether separable or not)
- spoil material, which is overburden that has previously been mined and dumped as waste, which is being rehandled in the mining process to provide access to the targeted coal seam.

Interburden is competent material which is drilled and blasted to allow efficient handling by equipment, while overburden can be either “free dig” material or drilled and blasted. The majority of overburden (over 90%) is blasted.

Waste rock material is moved by dragline and excavator/haul truck fleets to in-pit or ex-pit overburden dumps, appropriate to the mine plan and mining location.

Projected waste rock volumes scheduled to be produced in 2021 – 2023 are shown in Table 2.1. These volumes are representative of current and ongoing annual volumes for the next 10 years of production to meet coal production requirements for the Tarong power stations.

Table 2.1 Waste Rock projected volumes at Meandu Mine, 2021 – 2023 – thousand bank cubic metres (kbcm)

MATERIAL TYPE	FY2021	FY2022	FY2023
Total prime (prime kbcm)	27,109	30,878	33,923
Prime waste (kbcm)	23,494	26,318	29,374

Coal from the Ace, King and Queen seams is mined by excavator and truck. Under EA EMPL00709113, Meandu Mine is authorised to extract up to 11 million tonnes per annum of ROM coal per annum. ROM coal is transported by rear dump truck to either the ROM stockpile or directly tipped to the ROM bin at the CHPP.

ROM coal typically has ash content at levels above that specified for the boilers at the Tarong power stations and so requires coal processing, although a variable portion of ROM coal may directly bypass processing if of superior quality (reflecting geological variation throughout the deposit).

2.2.2 COAL PROCESSING

The CHPP processes the ROM coal by destoning and by removing higher ash/inferior quality fractions of the ROM coal. The processing stages include breakage/sizing/screening, crushing and washing (using gravity separation), to achieve product coal ash, energy and moisture content compliant with the Tarong power stations’ boiler specifications.

ROM coal tipped or reclaimed to the CHPP feed bin is sized in primary and secondary breakers, during which raw coal is separated from coarse breaker rejects. During the CHPP process, raw coal is separated into coal product and non-coal product materials using a washing and flocculent method.

Product coal is then transported via a 1.5 km overland conveyor to the Tarong power stations.

CHPP coarse rejects are co-mingled with dewatered fine rejects, then loaded and hauled to celled in-pit rejects dumps located in the advancing waste dump. Small volumes of ultra-fine coal rejects may be periodically slurry pumped to the active TSF.

2.2.3 PROCESS WASTE STREAMS

The CHPP process generates waste streams that are classified as tailings (ultra-fine) or coal mixed plant (mixed fine to coarse) rejects (MPR).

Ultra-fine, high ash slimes are bled out of the process water circuits and gravitate to the tailings thickener via the thickener feed launder. These tailings are thickened and treated with calcium hydroxide ($Ca(OH)_2$) to attain a broadly neutral pH in the CHPP thickener and pumped in slurry form to solid bowl centrifuges, where they are dewatered to the required moisture content for transport.

Dewatered tailings are co-mingled with coarse rejects and the resulting MPR stockpiled at the CHPP before being loaded and trucked to the MPR dump locations.

Wet tailings disposal will continue to occur when the solid bowl centrifuges are off-line or not able to process 100% of the tailings stream. These are pumped as slurry to a dedicated TSF, which is currently located within two (joined) mine voids at Meandu Mine; known as King 2 West (K2W) and King 2 North (K2N) (known collectively as K2WN).

Prior to 2017, the coarse rejects and tailings were disposed of separately, with the coarse rejects hauled to dedicated rejects dumps in the Rejects Storage Area (RSA) located in the North-West Backfilled Pit (NWBFP), and the tailings pumped in slurry form to the site in-pit TSF. Between 1986 and 1995 tailings were disposed as a slurry into the King 2 TSF. Tailings were also deposited into converted ramps (Ramp 2, Ramp 3) and former NWA Pit between 1992 and 2006. Some of these areas have been rehandled with the expansion of the Central Pit. Between 2006 and 2019 tailings were deposited in NWB Pit and from 2017 to 2019 were also deposited in the re-purposed RD16 TSF.

Projected coal and coal waste volumes scheduled for production in 2021 – 2023 are shown in Table 2.2. Future volumes may vary depending on the burn requirements in response to market demand for the Tarong power stations in future years.

Table 2.2 Projected coal waste volumes at Meandu Mine, 2021 – 2023

MATERIAL TYPE	FY2021	FY2022	FY2023
Raw coal mined (k tonnes)	5,960	7,525	7,507
Total rejects (k tonnes)	1,866	1,879	2,059
Hauled (co-disposal) (k tonnes)	1,800	1,784	1,964
Pumped tailings dam (contingency) (k tonnes)	66	95	95

Ash, or coal combustion products are produced during the coal combustion process at the power stations as a by-product of burning coal for power generation. Ongoing storage facilities for coal combustion products are critical to the operation of the Tarong power stations. They are also beneficial for placement at Meandu Mine to minimise the volume and number of final voids and to restore total waste volumes (including coal) towards the originally mined volumes – thereby achieving an overall final landform of average elevation closer to the natural landscape pre-mining.

Approximately 10% of the coal combustion products are sold off-site from the Tarong power stations as useable products. Unsold coal combustion products are concentrated (water content reduction) and then pumped as slurry by pipe to in pit ash storage facilities at Meandu Mine. The current storage facility is the K2WN mine void, which is dual purposed for ash and tailings. Once this facility achieves target fill level, the ash will be allowed to settle and harden and the facility will be capped. After this time the depleted K4S void will become the ash and tailings storage facility at the Meandu Mine.

Tailings/coal combustion product supernatant water is decanted from the surface of the ash void and transported back to the power stations for reuse. The coal combustion products are initially acidic and are neutralised at the Tarong power stations with $Ca(OH)_2$ in the ash thickener to bring the pH of the ash stream to between pH 6 – 8. Total annual production of ash generated by the Tarong power stations varies from year to year according to electricity market demands, planned and unplanned shutdowns and chemical composition of the coal. A typical year produces approximately 1.35 million tonnes of coal combustion products (Stanwell, 2020).

A new ash offtake facility at the Tarong power stations to facilitate increased sales is undergoing commissioning in September – December 2021, and once at full production has the ability to increase the reuse of coal combustion products by approximately 400,000 tonnes per annum, or approximately 30% of coal combustion product production.

2.2.4 LANDFORM AND REHABILITATION

Waste (spoil) dumps (including MPR cells) are progressively rehabilitated during ongoing mining operations. The rehabilitation process involves selective placement of suitable material in sufficient volume to allow regrading and contouring the spoil to the design slope of final landforms, followed by vegetation establishment. This is assisted by the strategic use of topsoil, which has been stripped ahead of the overburden removal.

Rehabilitation activities include:

- **Landform preparation**: Reshaping is performed by dozers and scrapers to achieve the final landform.
- **Erosion control**: Rehabilitation at Meandu Mine is designed to minimise erosion. Where needed, contour banks slow the water sufficiently to allow for penetration to assist with vegetation growth.
- **Topsoil placement**: Topsoil is sourced using direct-placed topsoil removed from cleared areas in advance of mining operations or recovery from existing topsoil stockpiles at Meandu Mine.
- **Ripping and seeding**: Ripping of the area is performed post-topsoiling and pre-seeding (or in conjunction with seeding) to aid in erosion control and assist with root and moisture penetration.

Specifically-designed decommissioning and rehabilitation plans are developed for historical and existing TSFs and capping standards have been established for areas of spoil where potential for seepage (acid mine drainage (AMD), saline mine drainage (SMD) and metalliferous or neutral mine drainage (NMD)) has been identified.

3 GEOLOGY

The coal reserves exploited at the Meandu Mine form part of the Triassic-aged Tarong Basin, a north north-west/south south-east trending elongate basin approximately 75 km long and 15 km wide. The mine is located near the centre of the basin, which has been interpreted by Flood & Garces (1995) to be formed by a dextral, strike-slip, pull-apart mechanism. In the vicinity of the mine, areas of the Triassic sediments have been overlain by Tertiary Main Range Volcanics and thin layers of Quaternary sediments restricted to the existing drainage lines. Detailed descriptions of the geological units, including a stratigraphic column of the mine geology (Figure 3.1) follow.

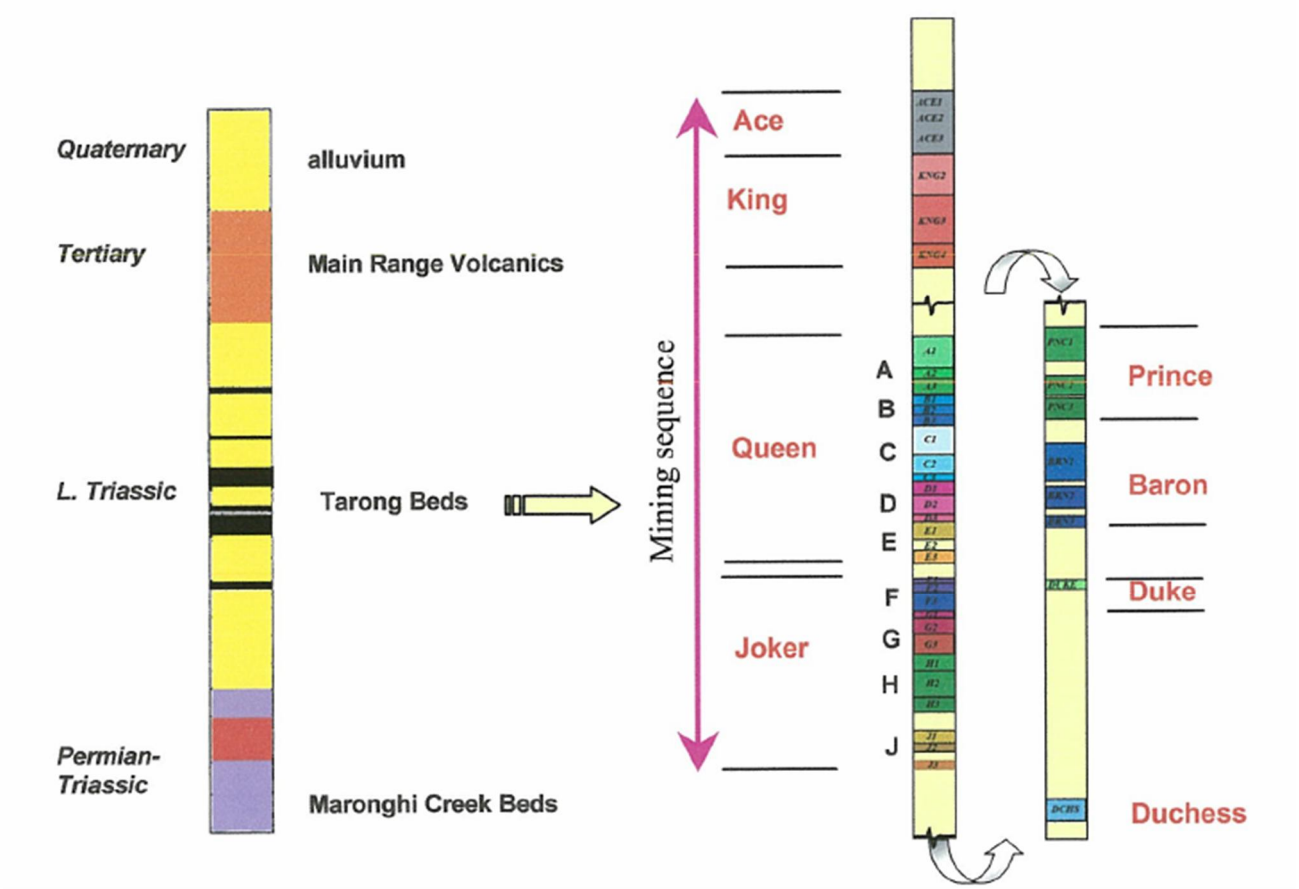


Figure 3.1 Stratigraphic section of the Tarong Basin at Meandu Mine (Geo-Environmental Management, 2005).

3.1 TRIASSIC

The Tarong Basin has been in-filled by the Tarong Beds which comprise clastic sedimentary rocks ranging in grainsize and bedding characteristics from laminated mudstone to massive cobble-boulder polymictic conglomerate and includes thick coal accumulations (Cranfield *et al.*, 2001). The Tarong Beds have a preserved thickness of approximately 450 m (Pegrem, 1995).

The coarse-grained sediments of the Tarong Basin represent high-energy fan and braided stream deposits. The sediments are composed of massive to thinly bedded clast supported, sheet-flow gravel fan conglomerates, sandy matrix-supported distal-flow conglomerates and horizontally stratified, cross-bedded to massive distal fan braid-plain sandstones (Flood and Garces, 1986). Thick deposits of laminated mudstones are also present within the Basin, most notably stratigraphically near to the coal seams. These are interpreted as representing waning flood sedimentation in a lacustrine environment (Cranfield *et al.*, 2001).

The geology of the Meandu Mine is predominately labile, poorly sorted fine-grained sandstones associated with polymictic conglomerates, minor siltstones and mudstone. The coal seams are inter-bedded with fine grained sedimentary bands that are often highly variable in both thickness and composition. The Ace, King and Queens seams are the actively mined units at Meandu Mine. The coal within the basin has been classified by Pegrem (1995) as high ash, high volatile, bituminous, low sulphur steaming coal with weak coking properties.

In the vicinity of the Meandu Mine, the Tarong Beds have been affected by strike-slip faults that are generally oriented north north-west/south south-east. Vertical displacements of up to 80 m have been interpreted, whilst horizontal displacements are unknown. The faults within the coal measures generally have normal displacements ranging from 30-60 degrees forming horst and graben structures (RGS, 2018).

3.2 TERTIARY

Parts of the deposit are unconformably overlain by the Tertiary-aged Main Range Volcanics which are dominated by thick basalt flows intercalated with poorly consolidated lithic sediments, including claystone, sandstone and lignite. The unconformity at Meandu Mine is very undulose. It is not always readily identifiable in cuttings and boreholes, especially as the weathered Triassic strata appears very similar to the Tertiary lithic sediments. The Main Range Volcanics are generally found in the topographically high areas but can also be found in deeply incised valleys resulting in the deep basalt occurrences such as that dividing the K4E and K4S pits. The basalts are frequently deeply lateritised and weathered.

3.3 QUATERNARY

The Quaternary Alluvium at the Meandu Mine site is present as current valley fill deposits of unconsolidated gravels, sands and silts. The alluvium is present as a thin veneer confined to the beds of watercourses and associated floodplains (JB Mining Services, 2016). Within the Meandu Mine area, the alluvium is relatively thin and unsaturated (WSP, 2018).

4 PREVIOUS INVESTIGATIONS

Multiple geochemical waste characterisation studies have been undertaken at the Meandu Mine since 1990, which has led to an evolving understanding of the geochemical behaviour of the rock at the mine, particularly the various waste streams. Many of the investigations were in response to AMD events and were focussed on identifying the source of the AMD; however, a more systematic program of geochemical testing has been implemented since 2016, creating a generally thorough database of geochemical behaviours of the specific rock units and waste streams at the mine.

The information presented in this report has been collated from the investigations summarised in Table 4.1. A summary of geochemical sampling, testing and analysis from these previous investigations is presented in Table 4.2.

Table 4.1 Summary of finding from previous geochemical waste characterisation studies at Meandu Mine

REPORT	SUMMARY OF FINDINGS
Pegram, B. J, 1990. **Report on the Acid mine Drainage Potential at the Meandu Mine, Tarong, ML6674**	— Meandu Mine sediments deposited in a fluvial environment resulting in low sulphur/pyrite and high siderite compositions. — Pyritic sulphur in overburden and associated sediments is negligible. — Pyritic sulphur in washplant rejects is approximately 0.01%. Rejects are stored and covered in spoil and revegetated. — Pyritic sulphur in raw coal averages approximately 0.07% and total sulphur (S) averages approximately 0.29% at 5.3% moisture. — Potential for AMD forming at Meandu Mine considered extremely low.
AGC Woodward Clyde Pty Ltd (AGCWC), **February 1993.** **Geochemical Characterisation of Waste Rock Meandu Coal Mine, Tarong**	— Investigation into the development of AMD in King 1 (K1) open pit and retention dams (unspecified). — Overall sulphide contents in waste rock are low; however, ANC of most material is low to very low. — Net acid producing potential (NAPP) results suggest that acid conditions could be expected to develop in oxidised coal, tailings, rejects and overburden/interburden rocks containing minor coal bands. — Overburden/interburden with low or no organic carbon contents are considered benign with respect to potential acid generation. — Oxidised coal in the exposed faces of K1 open pit and in waste (spoil) dumps (unspecified) considered the source of AMD. — Initial tests suggest AMD could be managed by application of lime at an average rate of 12 kg/t of limestone.
AGCWC, **September 1993.** **Waste Rock Characterisation Results – Spoil Heap**	— Spoil samples have a low level of sulphide sulphur, low ANC and low NAPP. — NAG tests suggested higher levels of maximum potential acidity (MPA) than the NAPP results, which was thought to be a result of organic acids present in the rock. — Spoil samples were considered to have low acid producing potential.

REPORT	SUMMARY OF FINDINGS
AGCWC, **Jan 1994.** **Acid Producing Potential of Rejects – Meandu Coal Mine, Tarong**	Report not viewed. Summary below from EGi 2016. — 15 samples taken of rejects. — Low total S of approximately 0.1%. — NAPP results mostly positive but NAG testing inconclusive due to presence of organic acids.
Kilah, E, **February 1995.** **Mine Spoil, Coal Tailings and Coal Rejects Characterisation at Tarong Coal, Meandu Mine. Tarong Coal**	— 52 samples taken (43 spoil, 6 tailings and 3 reject). — Results interpreted as soils not rock. — Moderate to strongly acidic paste pH (3.5 – 7.7) may cause problems with low pH runoff.
Bethune K.J, **1996.** **Acid Mine Drainage – Comparison of Laboratory Testing to Mine Site Conditions**	— Four field leach tests commenced on coarse reject “heaps”. — 12 samples taken of rejects for static testing. — Static tests suggested the rejects had the potential to produce acid, despite the low total S%. — Leachate from heap leach tests returned low pH (~3-4) and significant sulphate. — Only pH and sulphate results of leaching tests reported and not available after 450 days.
AGCWC, March 1996. **North-West Pit Rejects Dump – Seepage Assessment**	Report not viewed. Summary below from IMEMS 2015. — In October/November 1995 a significant rainfall event occurred and a drain under the haul road blocked causing inundation of the toe of north-west rejects storage area (NW RSA1) and overtopping of the haul road. After drain was unblocked and area drained, seepage continued from the toe of waste dump over about 50 m in area of inundation. — Water quality of seepage from the toe of waste dump area – clear water with iron (Fe) staining was observed, pH 3.0 - 3.5, elevated electrical conductivity (EC), sulphate and metals. — Toe of waste dump was exposed due to erosion, rejects exposed and appeared coarsely graded as expected from dumping over a slope causing segregation of course material towards the base of slope. — Possible causes of seepage – either drainage of stored water in rejects due to erosion of waste dump toe area, or infiltration of rainwater due to rejects waste dump being uncapped and not revegetated. — Commented that typically the largest contributor to seepage in partially covered waste dumps is infiltration of rainwater.

REPORT	SUMMARY OF FINDINGS
Fulloon L, **January 1997.** **pH and Electrical Conductivity Investigation at Varying Depths - NW 2 Rehabilitation Area, Meandu Mine.**	— Study into the potential impact of low pH rejects on overlying capping soils at north-west 2 rehabilitation area (NW RSA1). — Approximately 40 samples taken, but only of the capping soils; no samples collected from the rejects beneath the capping. — Capping was found to be generally less than 1 m in thickness, contrary to the then existing environmental management overview strategy. — Despite the capping soil showing slight influence from the underlying rejects (increased EC and decreased pH), it was considered that this had little significance with regard to plant growth and establishment.

Geo-Environmental Management,
November 2005.
Acid Rock Drainage Prediction and Control Strategy Review for Tarong Coal – Meandu Mine.
	— Review of Meandu Mine waste management practices current and historical against the Rio Tinto Environmental Standards for AMD prediction and control.
	— Review of previous reports states that overburden has been shown to be low-slightly saline, is mostly Non Acid Forming (NAF) with low ANC, and some Potential Acid Forming (PAF) materials may occur.
	— Oxidised coal, spoil (mixed overburden and oxidised coal), course rejects and tailings are all likely PAF, and low pH may develop in exposed material but have a low capacity for acid generation.
	— Coal is likely PAF and may create water quality issues in final pit voids.
	— Management recommendations to align with the Standards included:
	  — Overburden requires geochemical characterisation ahead of mining to determine whether to segregate. PAF to be buried at > 1 m with benign soil cover.
	  — The practice of using 1 m of spoil cover and 100-200 mm of topsoil cover may not significantly reduce water infiltration and oxygen ingress. Recommend review of current cover design/performance and evaluate alternatives for reject dumps.
	  — Tailings are expected to be predominantly PAF and require a water cover. It is planned to cover the tailing with >10 m of spoil material.
	  — Final voids may develop acid water conditions due to low buffering capacity of water and pit strata. Recommend closure planning include ARD risk.

REPORT	SUMMARY OF FINDINGS
Environmental Geochemistry Pty Ltd, **March 2006.** **ARD Assessment of Tarong Coal Rejects.**	— Study regarding AMD assessment of coarse rejects in north-west dump (NW RSA1). Rejects samples collected from near surface with varying ages of approximately 1 to 15 years post dumping. — Paste results suggested material is only slightly acidic and slightly saline and unlikely to limit plant growth. — Static tests showed low total S and generally NAF. Acidic NAG results were blamed on high organic carbon content creating organic acids during the test. A modified NAG test returned circum-neutral results. — Multi-elemental analysis of solids and water leachates showed no significant elemental enrichment in the rejects, but suggested aluminium (Al), manganese (Mn) and zinc (Zn) could selectively mobilised in runoff at pH <5. — Reject management described as placement into spoil "valleys" with capping of 2 m of inert topsoil. This practice was considered adequate for rejects represented by the samples; however, it was acknowledged previous studies (Bethune, 1996) had identified AMD potential in the rejects and recommendations were made for additional sampling/testing.
Environmental Geochemistry Pty Ltd, **May 2007.** **Leach Column Test Results for Rejects from the Tarong Coal Mine.**	— Column leach testing of one composite sample of coarse rejects collected as part of the EGi (2006) study. — Column leached for 52 weeks; leachate remained circum-neutral confirming static testing designation of NAF. — Initial EC results relatively low (0.8 deciSiemens/centimetre (dS/cm)) and continued to decline, suggesting the material would not produce significant salinity. — Sulphate concentrations were initially ~400 milligrams/litre (mg/L) and rapidly declined to <100 mg/L, indicating an early flushing of oxidation products from the column. — Conclusion states "the 1 – 2 m cover of inert spoil material used to cap the rejects is likely to be sufficient".
Environmental Geochemistry Pty Ltd, **December 2008.** **Geochemical Test Results for Coal Washery Tailings from the Meandu Mine.**	— Static testing of surface tailings samples and column leach testing of one composite sample of tailings. — Static testing suggested tailings were NAF and positive NAPP and acidic NAG results were created by high organic C content. — Column leached for 52 weeks; leachate remained circum-neutral confirming static testing designation of NAF. — Initial EC results relatively high (3.8 dS/cm) but decreased rapidly, suggesting an early flushing of accumulated salts from the column. — Sulphate concentrations were initially ~1,900 mg/L and rapidly declined to <100 mg/L. — Multi-elemental analysis of solids and water leachates showed no significant elemental enrichment in the tailings. — Conclusion states seepage from the material sampled is unlikely to be a concern; however, the samples were all surface samples that may have been oxidised and may underrepresent the AMD potential of tailings beneath the surface.

REPORT	SUMMARY OF FINDINGS
PW Baker & Assoc. Pty, **December 2011.** **Meandu Mine Contaminant Source Investigation.**	— Review of potential contaminant sources on the mine, summarising previous investigations. — Overall levels of contaminants such as salts and metals are relatively low. — Pit water more saline than other areas of the mine, but pH is generally neutral and metal concentrations low. — Ash contains concentrated levels of several potential contaminants; however, disposal into pit voids and capping with benign spoil should make discharge of contamination very unlikely. — Investigation into low pH in retention dam (RD)17 summarised, indicating the bulk of the spoil is benign, but isolated areas of low pH and salinity were identified (original report not referenced or viewed). — K2E TSF assessed as having low potential for saline seepage due to cover of ~25 m of benign spoil. Groundwater impacts could not be ruled out.

Environmental Geochemistry Pty Ltd,
August 2016.
Geochemical Assessment of the Meandu Mine, Queensland
	— Geochemical sampling and analysis of overburden/interburden spoil and washery rejects to assess the potential of existing and future mine materials to produce AMD, SMD and NMD.
	— Assessment of geochemical processes causing the observed AMD at NW RSA1 and RD7.
	— Coal, rejects and tailings in NW RSA1 are the most likely cause of the observed AMD.
	— AMD criteria developed based on total S%: NAF = Total S% <0.1, PAF-low capacity = Total S% >0.1 and <0.3, PAF = Total S% >0.3.
	— Results of sampling/testing indicated:
	  — Most of the overburden/interburden (97%) expected to be NAF and not require special management.
	  — Most coal (82%), rejects (70%) and tailings (100%) likely to be PAF-low capacity and will require preventative management to prevent a repeat occurrence of the NW RSA1 AMD.
	  — In-situ coal may influence pit water quality when exposed in pit floors and walls during operation and after mine closure. High S coal may have been responsible for acid runoff water in the King 1 Pit reported by AGCWC in 1993 (AGCWC 1993a).

QGESS, **March 2017.** **Geochemical analysis of spoil using drill samples – Meandu Mine. Indicators for AMD potential in areas of historic fill.**	— On-site sampling and analysis of spoils samples in the area ahead of proposed Central Pit mining. — Sampling of small (5 – 20 g) drill chip samples from exploration holes, analysis restricted to on-site laboratory paste pH and EC. — Majority of results were indicative NAF, some significant intersections of indicative PAF (lowest paste pH of 2.62) identified in the northern section of the proposed Central Pit extension. Indicative PAF less severe and less common further south. — Spoil identified as highly heterogeneous.

REPORT	SUMMARY OF FINDINGS
QGESS, **May 2018.** **Reject Storage Area #1 Excavation and Sampling Program. Determination of surface and subsurface conditions of rehabilitated dump – Meandu Mine.**	— Excavation of 16 test pits across the surface of the north-west dump to investigate capping thickness and nature of underlying rejects. — Cover thickness ranged from 0.5 to >6.6 m and was highly variable. Vegetation in excellent condition and no signs of erosion. — Rejects showed signs of weathering, with more intense weathering (Fe-oxide staining and gypsum crystals) in areas with thinner cover. — Paste pH results generally slightly acidic (mean of 5.45) with the lowest recorded pH of 4. — Study indicates current capping on north-west dump has been ineffective in preventing oxidation of stored rejects in NW RSA1.
PW Baker & Assoc. Pty, **July 2018.** **Meandu Mine King 2 West Spoil Dump – Review and Assessment of Chemical and Physical Analyses of Spoil Material for Rehabilitation and Erosion.**	— Geochemical sampling and analysis of interburden spoil at K2W dump to assess the acid forming potential and rehabilitation capability of the material. — Material predominately carbonaceous shale, relatively well weathered post-deposition. — Overall the material is NAF, with relatively high neutralising capacity when compared with other rock at Meandu. — Chromium reducible sulphur (CRS) results indicated over 50% of the S present was sulphate, not acid forming sulphide. — Material is non-sodic, exhibits low salinity and is recommended for use in the rehabilitation programs at the mine.
PW Baker & Assoc. Pty, **August 2018.** **Meandu Mine North West RSA1 Rehabilitation Area – Assessment of Cover Materials and Buried Reject.**	— Laboratory analysis of samples collected by QGESS (2018) and interpretation of results. — Spoil had very low S and was all NAF. — Rejects highly variable S and NAPP results, with 26% of samples considered PAF. — Seepage from the NWBFP, including the NWA and NWB tailings filled pits may be reporting to NW RSA1. — Extensive weathering of some rejects may have already exhausted their acid generating capacity and are now NAF. — Potential for significant additional acid leachate from NW RSA1 remains uncertain as the extent of weathering and PAF status of deeper reject material remains unknown.
RGS, **September 2018.** **Mine Material Characterisation, Meandu Mine, Geochemical Assessment of Mine Waste, Process Waste and Rehabilitation Material.**	— Study in response to an Environmental Notice issued by DES to conduct an evaluation of the source and extent of AMD and potential environmental harm caused by AMD at the mine. — Detailed historical review of mine history and AMD history at RSA1. — Development of geochemical classification system at the mine, 6 categories using total sulphur and NPR to classify mine material. — Static and kinetic geochemical testing results discussed in detail in Section 7.

REPORT	SUMMARY OF FINDINGS
SRK, **November 2019.** **Meandu AMD – Geostatistical Assessment.**	— Reconsideration of the geochemical classification system at the mine, the system was simplified to three classes: NAF, Uncertain and PAF, using total S and NPR. — Reassessment of the static geochemical testing undertaken by EGi and RGS concluded that the non-organic overburden and interburden lithologies at the mine are all NAF, and PAF in overburden/interburden is related to organic material within the samples. — Geostatistical analysis was undertaken to assess the adequacy of geochemical sampling at the mine, based on lithology averages with respect to the relative thresholds of the classification system. Recommendations on the adequacy of spatial coverage were assessed by evenness of coverage rather than the ability to locally predict the respective variabilities within the lithologies. — Discussion of results in Section 7 and Section 10.
RGS, **January 2020,** **Technical Report – Kinetic Leach Column Testing Program, Meandu Mine and Tarong Power Station.**	— Report on extension of column leaching program reported in RGS 2018. 12 columns of the original 23 were extended from 14 months to 31 months. — Kinetic testing results discussed in detail in Section 7.
SLR, **September 2020, Meandu Creek Saline Plume Investigation.**	— Hydrogeological investigation into the extent of the saline groundwater plume in the vicinity of Queens West Backfilled Pit (QWBFP) and preliminary assessment of remediation options for the plume. — Saline plume extends within site regolith from QWBFP to the north-west in the direction of Meandu Creek, but does not extend to the Meandu Creek and presents a low risk to the creek. — Remediation not considered necessary at this point and ongoing monitoring recommended, with installation of additional bores to firm up the lateral extent of the plume and hydrogeological testing to better define aquifer characteristics and remediation feasibility.
QGESS, **November 2020, K2E Spoil Excavation and Sampling Program**	— Excavation of 16 test pits with collection of 61 samples from varying depths in the K2E waste dump. — Lithology of material identified, and samples analysed for static AMD testing and rehabilitation suitability parameters. — Results not reported but laboratory certificates supplied. — Triassic interburden most common material with lesser overburden sandstone/conglomerate and weathered basalt.
Landloch, **March 2021, Characterisation of Meandu Mine Material for Rehabilitation Suitability.**	— Review of available sample results in the Meandu Mine database for overburden and spoil samples with regard to a variety of physical and chemical characteristics focussed on suitability of material for use as rehabilitation resources, plus AMD characterisation. — Assessment of material against criteria for pH, EC, CEC, ESP and chloride. — Development of waste material classification and placement recommendations for final rehabilitation. — Discussion of results in Section 7.

REPORT	SUMMARY OF FINDINGS
SRK, June 2021, Technical Memorandum – Meandu Material Assessment Update	— Update on 2019 geostatistical assessment incorporating additional 61 samples collected and analysed in 2020 to fill spatial gaps identified in 2019 report. — Additional carbonaceous material analysed to fill lithological gaps identified in 2019 report. — Statistical analysis of mixing interburden carbonaceous and non-carbonaceous material conducted to refine classification of interburden material and identify carbonaceous content allowed before a PAF classification of material is given. — Discussion of results in Section 7 and Section 10.
QGESS, August 2021, In-Situ Reject Cell Investigation	— Two boreholes partially cored through reject cells in Central West Dump, bore logs and photos. — 22 samples collected for geochemical testing. — Specific testing and results pending.

Table 4.2 Summary of Geochemical Characterisation Testing at Meandu Mine

REFERENCE	MATERIAL SAMPLED	NO. OF SAMPLES & TESTING	ANALYSIS	TOTAL S%	ANC (kg/H_2S0_4/t)	COMMENTS
Pegrem 1990	Overburden/interburden – K1 highwall, K2 spoil	24 grab samples 5 drill cores	Total S	0.01 – 1.24	-	High Total S results considered mostly organic and isolated in occurrence
	Coal – K1, K2 & K4, south-west, west & north-west mining areas	109 drill cores	sulphide S, sulphate S, total S	0.19 – 0.61	-	K1 sulphidic S up to 0.36%,
AGCWC 1993a	Overburden/interburden – K1 & K2	9 grab samples 24 drill cores	paste pH, EC Sulphide S ANC, MPA, NAG, NAPP	0.01 – 0.15	0 – 10	NAPP -9 – 3 kg H_2SO_4/t, average -2 kg H_2SO_4/t
	Coal (oxidised) – K1 & K4	4 grab samples 16 drill cores		0.01 – 0.42	-15 – 4	NAPP -4 – 19 kg H_2SO_4/t, average 4 kg H_2SO_4/t
	Rejects – K1, Ramp 3 & north-west stockpile (NW RSA1)	12 grab samples		0.04 – 0.11	0.1– 5	NAPP -4 – 4 kg H_2SO_4/t, average 1 kg H_2SO_4/t
	Tailings – Ramp 3	4 grab samples		0.23 – 0.34	-4 – 7	NAPP 2 – 15 kg H_2SO_4/t, average 9 kg H_2SO_4/t
AGCWC 1993b	Overburden/interburden spoil – Ramps 1 & 2	8 grab samples	paste pH, EC Sulphide S ANC, MPA, NAG, NAPP	-	-1.18 – 0.88	NAPP -0.57 – 1.3 kg H_2SO_4/t, average 0.66 kg H_2SO_4/t

REFERENCE	MATERIAL SAMPLED	NO. OF SAMPLES & TESTING	ANALYSIS	TOTAL S%	ANC ($kg/H_2S0_4/t$)	COMMENTS
AGCWC 1994	Rejects – Unknown location	15 grab samples	Sulphide S ANC, MPA, NAG, NAPP	0.05 – 0.46	0 – 2	NAPP results mostly positive.
Kilah 1995	Overburden/interburden spoil – K1, K2& K4, NW RSA1	43 grab samples	paste pH, EC, Total S Cations, anions, Zn, Fe, Al.	<0.01 – 0.17	-	Interpreted as soils not rock
	Rejects – NW RSA1	3 grab samples		0.1 – 0.22	-	
	Tailings – Main Tailings Dam	6 grab samples		0.2 – 0.6	-	
Bethane 1996	Coarse rejects – unknown location	12 grab samples	paste pH, Total S, ANC, MPA, NAG, NAPP	0.09 – 0.22	2.42 – 4.81	NAPP results mostly positive
		4 field heap leach tests	pH, EC, TDS, sulphate, Fe, Ca, Mg, Al, alkalinity	-	-	pH of leachate dropped to 3-4 after 450 days testing
EGi 2006	Coarse rejects – north-west flank of NW RSA1	32 grab samples	paste pH, EC, total S, C, ANC, NAPP, NAG	0.03 – 0.11	1 – 10	NAPP results mostly negative, 6 returned slightly positive results
EGi 2007	Coarse rejects – NW RSA1	1 column leach – 52 weeks	paste pH, EC, cations, anions, metals	0.09	4	Leach results ~neutral pH, low salinity
EGi 2008	Tailings – decommissioned north-west pit tailings storage	6 grab samples 1 column leach – 52 weeks	paste pH, EC, Total S, ANC, NAPP, NAG pH, EC, cations, anions, metals	0.21 – 0.29	4 – 11	NAPP results marginally positive for 5 samples Leach results ~neutral pH, initially saline
PW Baker 2011	Overburden/interburden spoil – RD17 catchment, exact location not specified	6 grab samples	paste pH, EC, metals; Total S, ANC, NAG (one sample only)	0.04	2.6	pH 3.5 – 6.9, EC 137 – 2,680. Total S, ANC & NAG only analysed on most alkaline sample.

REFERENCE	MATERIAL SAMPLED	NO. OF SAMPLES & TESTING	ANALYSIS	TOTAL S%	ANC ($kg/H_2S0_4/t$)	COMMENTS
	Ash – K2W void and power station	2 grab samples and one Toxicity Characteristic Leaching Procedure (TCLP)	pH, EC, metals, Total S (one sample only)	<0.01	-	Elevated barium, vanadium and zinc in solid and leachate
EGi 2016	Overburden/interburden, coal – Central pit, K2E & K4E/S and SRE	747 rotary chip and drill core samples	paste pH, EC, Total S, ANC, NAG, NAPP (all samples); Acid buffering characteristic curve (SBCC) (26 samples), speciated S (72 samples), kinetic NAG (5 samples), multi-element (65 samples),	<0.01 – 1.2 (median 0.04)	0 – 215 (median 3)	Coal higher median S of 0.25% and mostly positive NAPP. Overburden/interburden negative NAPP.
	Overburden/interburden, rejects, tailings – north-west dump	212 rotary chip samples		0.02 – 0.36 (median 0.1)	0 – 23	NAPP generally positive.
	Rejects and tailings – process plant; Historic tailings – central pit.	39 grab samples; 5 grab samples		0.1 - 0.3	1 - 7	Tailings NAPP slightly positive (2 – 7 kg H_2SO_4/t); rejects NAPP variable (-5 – 5 kg H_2SO_4/t)
QGESS 2017	Overburden/interburden – central pit extension	777 drill chip samples	paste pH, EC	-	-	pH ranged from 2.62 to 7.97; EC ranged from 180 – 2,070 microSiemens/centimetre (µS/cm).
PW Baker 2018a	Interburden – K2W Dump	8 grab samples	paste pH, EC, Total S, CRS, ANC, NAG, NAPP	0.02 – 0.09	1.9 – 15.7	NAPP negative, ANC 1.9 15.7 kg H_2SO_4/t
PW Baker 2018b	Overburden/interburden – NW RSA1	87 test pit samples	Total S, NAG, NAPP	0.002 – 0.013	-	NAPP negative in most samples, all considered NAF
	rejects – NS RSA1	49 test pit samples		0.004 – 0.109	-	NAPP positive and considered PAF in 26% of samples

REFERENCE	MATERIAL SAMPLED	NO. OF SAMPLES & TESTING	ANALYSIS	TOTAL S%	ANC ($kg/H_2S0_4/t$)	COMMENTS
RGS 2018	Tailings – process plant	12 grab samples, 1 column leach	paste pH, EC, total S, CRS, ANC, NAPP, major ions, metals; Leach columns: pH, EC, total S, ANC, NPR, major ions, metals	0.15 – 0.37 (median 0.27)	0.3 – 5.1 (median 2.8)	Static testing tailings are PAF, leach column suggests NAF
	Ash – process outfall K2W and K2N TSF	16 grab samples, 1 column leach		0.01 – 0.02 (median 0.02)	0.3 – 5.0 (median 1.1)	Static testing NAF, leach column NAF
	Rejects – process plant; Hitachi Hill	12 grab samples; 2 column leach 18 test pit samples, 1 column leach		0.11 – 0.36 (median 0.21)	1.8 – 20.7 (median 5.0)	Coarse rejects PAF with 6 month lag time, fine rejects PAF-UC Hitachi rejects PAF and turned rapidly acidic in column leach
	Overburden/interburden – Hitachi Hill spoil; K2E; QWBFP; K2TSF	25 test pit samples 122 drill core samples, 5 column leach; 19 drill core samples 20 drill chip samples		<0.01 – 0.07; 0.01 – 0.13; <0.01 – 0.04; <0.01 – 0.05	0.5 – 5; 0.3 – 35; 0.8 – 4.7; <0.5 – 4.0	Spoil generally NAF. Column leach results indicate some samples PAF with a relatively short lag time, possibly not representative of general mine material.
RGS 2020	Tailings, rejects, ash, overburden (RGS 2018)	12 column leach extended from RGS 2018.	pH, EC, major ions, metals	-	-	Column leachate chemistry trends followed the results reported in RGS 2018, with the exception of tailings, in which the pH decreased to <5 after approximately 120 weeks of testing.
QGESS 2020 (sampled) Landloch 2021 (report)	Spoil; K2E.	16 test pits; 61 samples	pH, EC, CEC, Total S, CRS, NAPP, NAG, ANC, TOC Cl.	0.01 – 0.06	0.6 – 20.3	NAPP negative in all but 8 of 61 samples, the 8 with positive NAPP had no ANC. 2 samples uncertain classification, remainder NAF

REFERENCE	MATERIAL SAMPLED	NO. OF SAMPLES & TESTING	ANALYSIS	TOTAL S%	ANC ($kg/H_2S0_4/t$)	COMMENTS
Stanwell 2021 (unreported – statistics in SRK 2021)	Overburden – K4S, K4E	61 drill core samples	pH, Total S, CRS, NAPP, NAG, ANC, TOC	<0.01 – 0.13	3.5 – 55.5	All samples had negative NAPP, 4 sample uncertain classifications, remainder NAF. Selected samples from the drilling program are being tested by column leach – results due in 2022.

5 SURFACE WATERS AND SHALLOW GROUNDWATER

A comprehensive surface water quality monitoring program has been in place at Meandu Mine since 1978 (WSP, 2018). Water quality has been monitored at numerous locations through the mine water management system and in associated natural watercourses (Meandu Creek). Potential shallow seepage has also been monitored in the site's groundwater monitoring network.

Historic site water data provides an indicative idea of long-term run-off water qualities from exposed overburden spoil and pit-walls, and seepage water quality from older waste (spoil) dumps, TSFs and in the underlying aquifer. However, because the mine's water management system includes an extensive network of pump and pipe systems that manage pit dewatering, storage of process waters and recycling of water to the CHPP, not all of the surface water quality data is relevant to waste characterisation.

In addition, water qualities in retention dams and in-pit voids can be heavily influenced by evaporation, diversion of fresh waters and inter-pit/retention dam transfers, therefore, the surface water quality data cannot be used to provide quantitative water quality data for waste characterisation purposes. However, certain monitoring locations can provide useful indications of likely broad-scale behaviours of specific areas of the mine.

Historic surface water quality data for the 11 existing and former open pits and TSF supernatant at Meandu Mine have been assessed below, with implications provided from a waste characterisation perspective. Seepage water quality data has also been assessed, where available.

5.1 OPEN PITS

KING 1 PIT

King 1 Pit (K1) was the first location coal was mined at the Meandu Mine in 1983. Pit water chemistry at varying intervals and analytes is available for most years from 1983 to February 2005. The pit water in K1 demonstrated acidic values (pH <4) for much of the pit life, with pH values below 3 recorded in 1984, 1990 and 1992 (Figure 5.1). These acidic conditions triggered an investigation into the source of the AMD (AGCWC 1993a). The pit water had moderate EC (~1,000 – 2,000 µS/cm -average 1,637 µS/cm), the majority of which was due to dissolved sulphate (SO_4^-) (100 – 1,000 mg/L) (Figure 5.2 and Figure 5.3). Metals analysis was not undertaken regularly during the first 8 years of operation, but results from 1999 to 2004 indicate elevated total concentrations of aluminium (Al) (0.04 – 2.15 mg/L), copper (Cu) (0.002 – 0.038 mg/L), iron (Fe) (<0.04 – 8.01 mg/L), lead (Pb) (0.001 – 0.035 mg/L), manganese (Mn) (1.97 – 2.29 mg/L), nickel (Ni) (0.087 - 2.25 mg/L) and zinc (Zn) (0.822 – 11.2 mg/L). Metal concentrations generally decreased with time.

NWA PIT

Mining commenced at North-West A Pit (NWA) in 1984 and continued until 1995. Areas of the pit were used for tailings storage from 1992 to 2006. At the completion of tailings deposition, spoil and rejects were disposed into each area of the pit from approximately 1995 to 2013, when capping was completed creating the topographic feature known as Hitachi Hill.

Water quality records from 1984 – 1996 indicate periods with acidic pit water (pH <5) in 1984 and 1986; however, pH in this pit has increased with time, averaging 5.5 from 1984 – 1990 and 6.3 from 1993 -1996 (Figure 5.1). With the exception of some very high EC readings early in the pit life, EC was low to moderately high (800 – 2,000 µS/cm – average 1,547 µS/cm) with a low concentration of SO_4^- (119 – 381 mg/L) (Figure 5.2 and Figure 5.3). No metal analysis is available before 1992 for this pit, but post 1993 results indicate slightly elevated total concentrations of Al (0.03 - 0.95 mg/L), Fe (0.02 – 5.14 mg/L), Mn (0.425 – 1.84 mg/L), Ni (<0.01 – 0.129 mg/L) and Zn (<0.001 – 1.39 mg/L).

NWB PIT

Mining at North-West B Pit (NWB) commenced in 1996 and operated until 2005, after which it was used as a TSF (NWBTSF) from 2006 to 2019. Water quality records are only available from 2003 to 2006 and, apart from a slightly acidic period in 2004 (pH 4.75) the pit water was circum-neutral (pH 5.49 – 8.12) (Figure 5.1). Pit water EC was relatively high in 2003 (~5,000 µS/cm) but decreased with time to ~2,200 µS/cm. Sulphate concentrations were relatively low (169 – 377 mg/L) throughout the pit life (Figure 5.2 and Figure 5.3). Metals analyses indicate slightly elevated total concentrations of Al (0.03 – 1.02 mg/L), Fe (0.02 – 3.26 mg/L), Mn (0.142 – 1.13 mg/L), Ni (<0.001 – 0.117 mg/L) and Zn (0.007 – 1.2 mg/L).

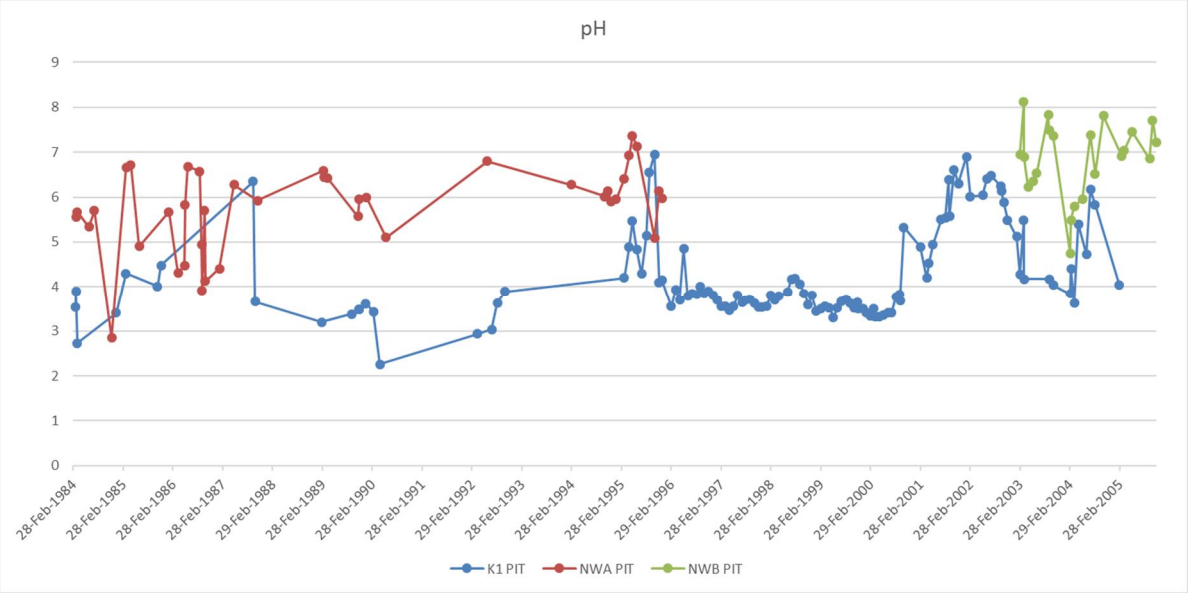


Figure 5.1 K1 Pit, NWA Pit and NWB Pit pH in pit water over life of mine

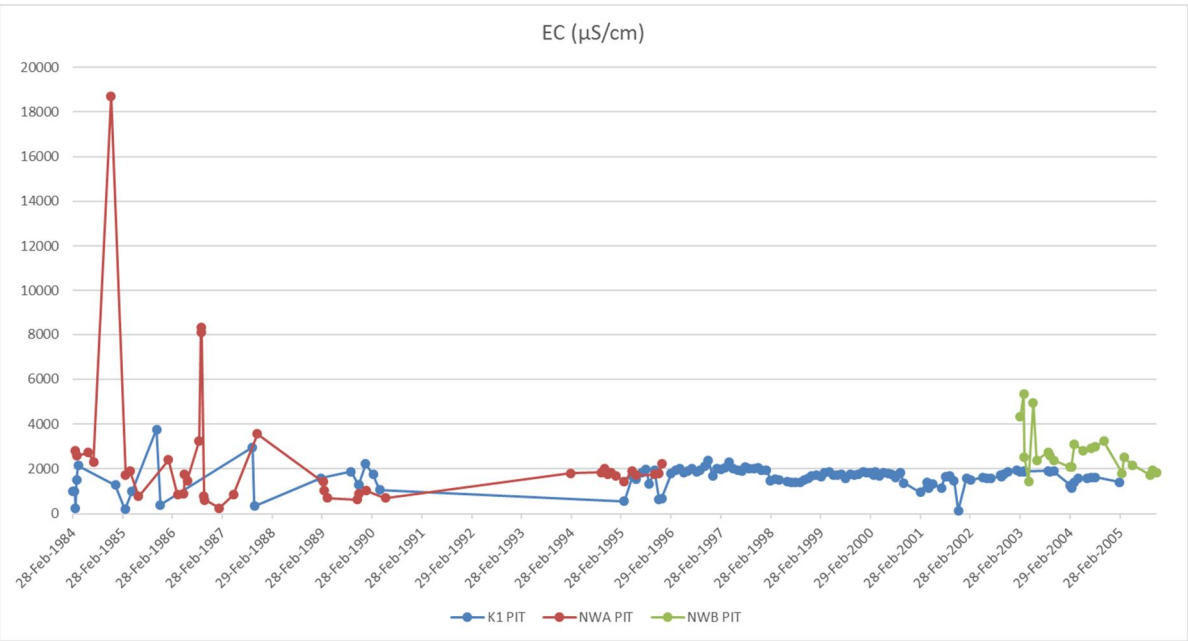


Figure 5.2 K1 Pit, NWA Pit and NWB Pit EC in pit water over life of mine

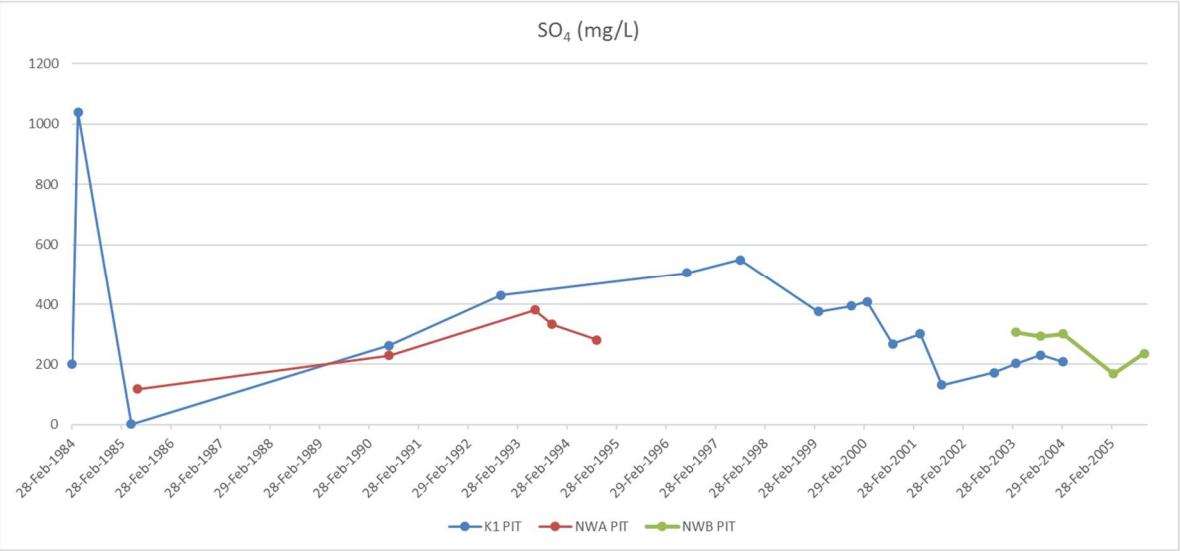


Figure 5.3 K1 Pit, NWA Pit, NWB Pit sulphate in pit water over life of mine

CENTRAL PIT

Mining at Central Pit commenced in 2007 and is expected to continue until 2031. The pit water has been circum-neutral for the life of the pit, with the exception of the most recent sample which was uncharacteristically acidic (pH 3.41 – 8.18) (Figure 5.4), has had moderate EC (914 – 1,784 µS/cm) (Figure 5.5) and moderate to low SO_4^-concentrations (64 – 307 mg/L) (Figure 5.6). Pit water metal concentrations are low, with dissolved concentrations of Al, arsenic (As), chromium (Cr), Cu, Pb, mercury (Hg), silver (Ag), uranium (U) and vanadium (V) all below the laboratory detection limit. Slightly elevated dissolved concentrations of barium (Ba) (0.043 – 0.108 mg/L), cobalt (Co) (0.005 – 0.079 mg/L), Fe (<0.05 – 10.1 mg/L), Mn (0.511 – 1.66 mg/L), Ni (0.005 – 0.065 mg/L) and Zn (0.006 – 0.291 mg/L) were detected in the pit water.

WEST PIT

Mining occurred at West Pit from approximately 2001 through to 2011. The pit was then used as a repository for spoils, rejects and tailings (re-worked tailings from the Ramp 2 TSF, which was excavated as part of the expansion of Central Pit). Pit water was been slightly acidic to circum-neutral (pH 4.09 – 7.54) throughout the pit life (Figure 5.4). The EC averaged 1,534 µS/cm throughout the pit life (Figure 5.5), with low SO_4^- concentrations (52 – 199 mg/L) (Figure 5.6). Total metal concentrations were slightly elevated for Al (0.01 – 0.26 mg/L), Fe (0.07 – 3.01 mg/L), Ni (0.004 – 0.049 mg/L) and Zn (<0.005 – 0.403 mg/L).

SW PIT

South-west Pit (SW Pit) was in operation from 1995 – 2007, after which the pit was filled with spoil. The pit water was initially slightly acidic (pH 4.23 – 4.5) but increased with time to an average pH of 6.1, although occasional (slightly) acidic conditions (pH <5) were recorded in 2001 and 2003 (Figure 5.4). The pit water EC was quite variable (110 – 3,110 µS/cm; average 1,678 µS/cm) but no trends were obvious during the life of the pit (Figure 5.5). The pit water SO_4^- concentrations were relatively low throughout the pit life (64 – 163 mg/L) (Figure 5.6). Total metal concentrations in the pit water were elevated for Al (<0.01 – 7.73 mg/L), Fe (0.09 – 20.2 mg/L), Ni (0.005 – 0.065 mg/L) and Zn (0.005 – 0.282 mg/L).

SW13A PIT

A sub-catchment of SW Pit, SW13A Pit was monitored independently of SW Pit from 2004 – 2010. The pit water pH was circum-neutral in this location (pH 6.83 – 8.79) throughout operation (Figure 5.4). The pit water had moderate EC (799 – 2,690 µS/cm) (Figure 5.5) and low SO_4^- (112 – 152 mg/L) (Figure 5.6). No metal water quality data is available for the first two years of operation at this location; however, total metal concentrations in 2006 – 2010 are low, with minor detections of Al, Fe, Mn, Ni and Zn. The one sample analysed for dissolved metals only detected Ba (0.02 mg/L), Co (0.002 mg/L), Mn (0.213 mg/L) and Ni (0.002 mg/L).

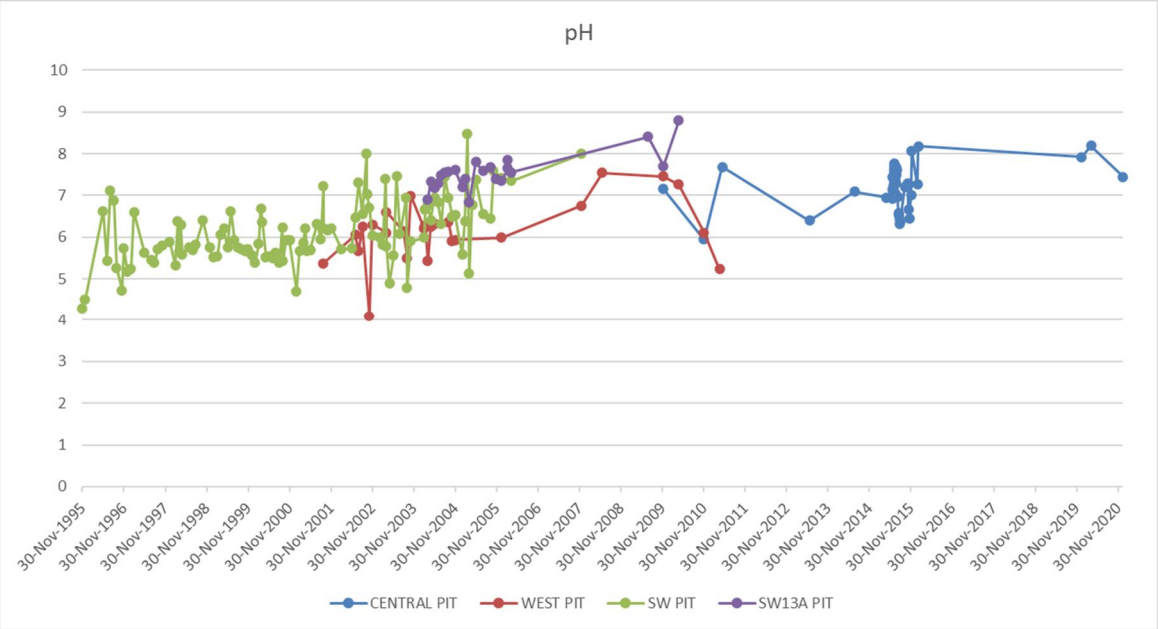


Figure 5.4 Central Pit, Pit West, SW Pit and SW13A Pit pH in pit water over the life of mine

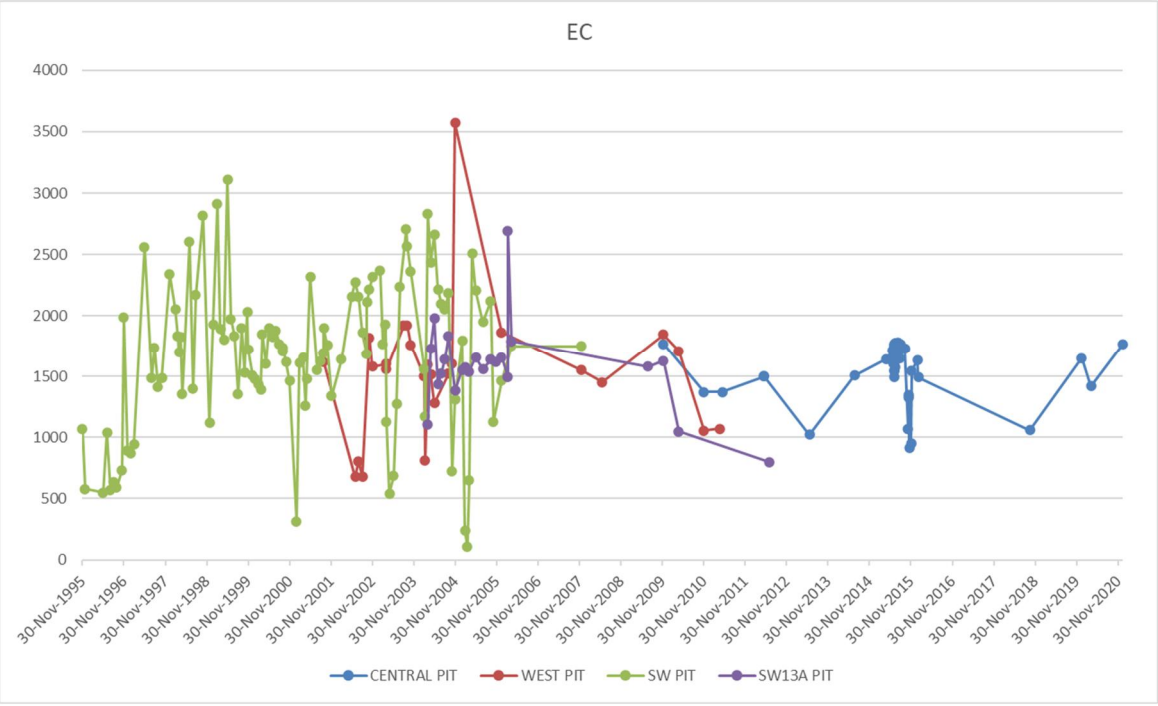


Figure 5.5 Central Pit, Pit West, SW Pit and SW13A Pit EC in pit water over the life of mine

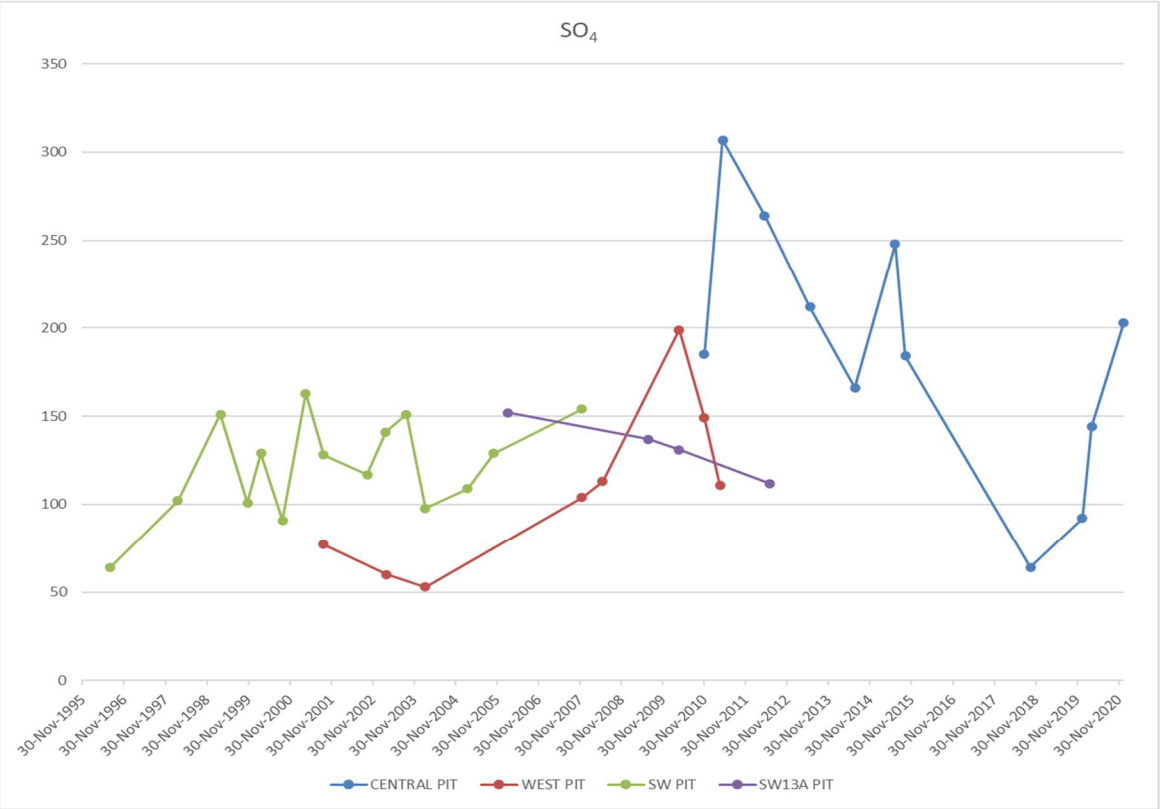


Figure 5.6 Central Pit, Pit West, SW Pit and SW13A Pit sulphate in pit water over the life of mine

KING 2/KING 2 NORTH PIT

Mining at King 2/King 2 North (K2N) Pit was commenced early in the history of the mine, with water quality results first collected in 1985. The pit water was acidic throughout the life of the pit (pH 3.38 – 5.87) (Figure 5.7) and EC values were quite elevated (~2,000 – 3,000 µS/cm) (Figure 5.8). Major ion and metals analysis are limited from this pit; however, elevated Fe (0.62 mg/L), Pb (0.02 mg/L), Ni (1.49 mg/L) and Zn (7.02 mg/L) were recorded in 1996. The pit has been used as a depository for Tarong power station coal combustion products since 2015 and ash storage continues to the present (K2N PIT on Figure 5.7, Figure 5.8 and Figure 5.9).

KING 2 WEST PIT

King 2 West (K2W) Pit was operational from 2004 to 2007, after which coal combustion products from the Tarong power stations were placed into the pit void as a dense slurry. Pit water data is limited to three pH and EC analyses as the post 2008 analyses are ash supernatant liquid. The pit water and supernatant were circum-neutral (pH 6.07 – 8.35) for the life of the pit (Figure 5.7). The EC of the pit water and supernatant was generally approximately 1,000 µS/cm, however the EC increased post 2010 to an average of 2,750 µS/cm (Figure 5.8). Sulphate concentrations in the supernatant were initially low (~160 mg/L) but increased to 1,170 mg/L in 2012 (Figure 5.9). The ash supernatant metal concentrations differed from the open pit waters, with elevated dissolved Al (0.74 mg/L), As (0.16 mg/L). Ba (0.158 mg/L), B (5.27 mg/L), Cd (0.0013 mg/L), Co (0.046 mg/L), Mn (0.207 mg/L), Mo (2.3 mg/L), Ni (0.089 mg/L), Se (0.12 mg/L), V (1.82 mg/L) and Zn (0.311 mg/L).

KING 2 EAST PIT

Mining has been conducted at King 2 East (K2E) Pit from 1996 to 2016 and has been idle since that date, pending potential expansion and ongoing mining until the end of the mine life in 2037. Pit water quality data is available from 1996 to 2021 and indicates circum-neutral pH (5.96 – 8.48) throughout the pit life, with the exception of one acidic pH of 4.31 in 2000 (Figure 5.7). The pit water EC was initially relatively high (5,000 – 7,000 µS/cm), but has decreased with time, averaging 1,700 µS/cm from 2001 – 2021 (Figure 5.8). Sulphate concentrations are relatively low, ranging from 151 – 374 mg/L (Figure 5.9). Dissolved metal concentrations were below the laboratory detection limit, with the exception of B (0.26 mg/L), Co (0.007 mg/L), Mn (0.153 mg/L), Ni (0.023 mg/L) and Zn (0.015 - 0.035 mg/L).

QUEEN WEST PIT

Queen West Pit (QW Pit) was in operation from 2002 to 2004 after which the mine void was filled with spoil from K2W pit. The pit water was circum-neutral for most of the pit life; however acidic conditions were recorded in September 2003 (pH 3.84) and April 2004 (pH 3.42) (Figure 5.7). The EC of the pit water was initially high (6,710 µS/cm) but steadily declined to approximately 2,000 µS/cm with time (Figure 5.8). Sulphate concentrations were generally low (123 – 382 mg/L), with one elevated result (1,100 mg/L) (Figure 5.9). Total metal concentrations in the pit water returned relatively elevated Al (0.07 – 3.24 mg/L), Fe (0.01 – 7.95 mg/L), Mn (1.53 - 2.31 mg/L), Ni (0.014 – 0.058 mg/L) and Zn (0.033 – 0.696 mg/L).

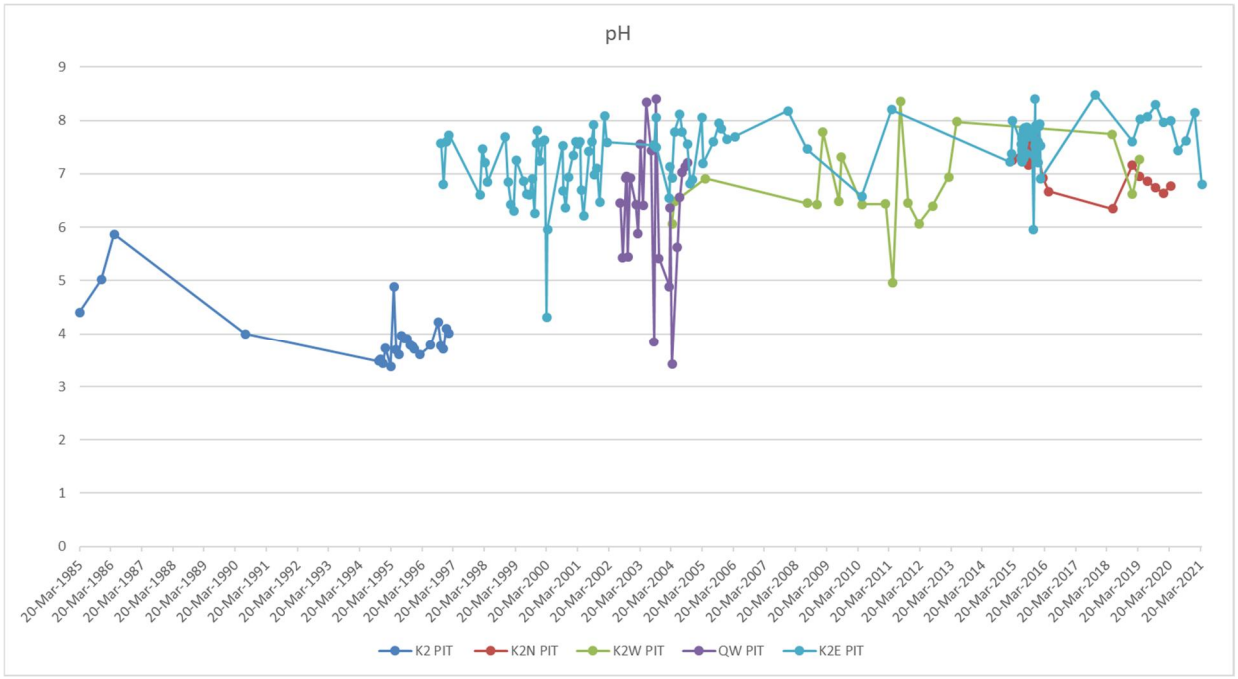


Figure 5.7 K2 Pit, K2N Pit, K2W Pit, QW Pit and K2E Pit pH in pit water over the life of the mine

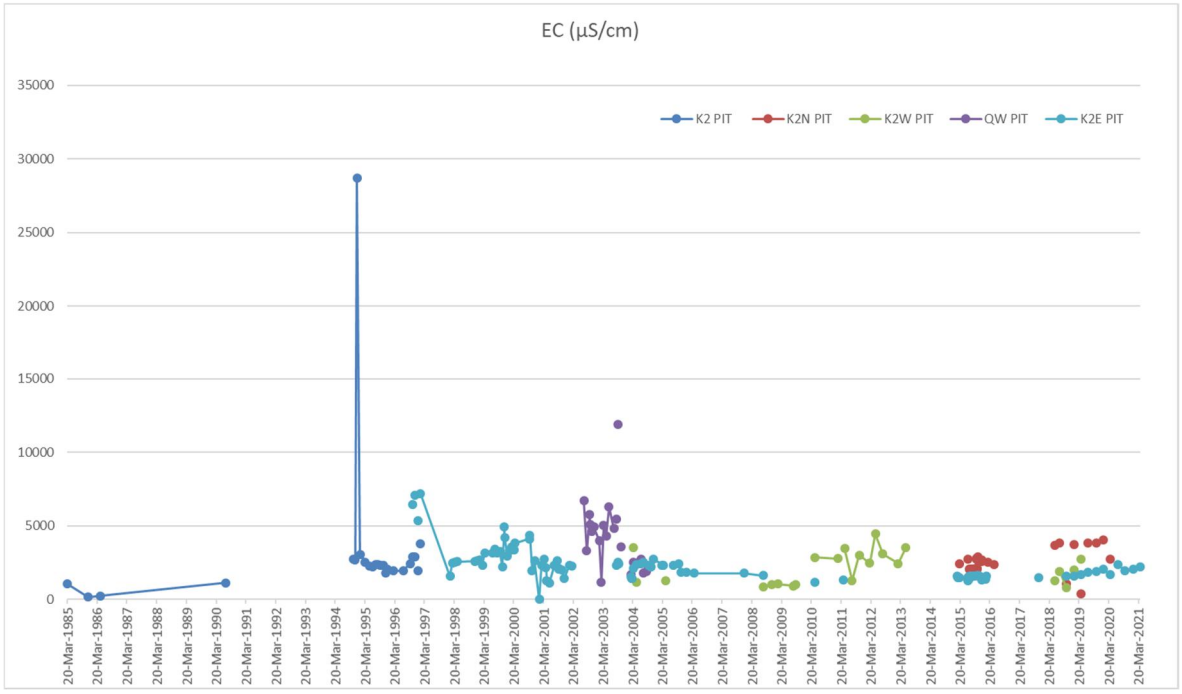


Figure 5.8 K2 Pit, K2N Pit, K2W Pit, QW Pit and K2E Pit EC in pit water over the life of the mine

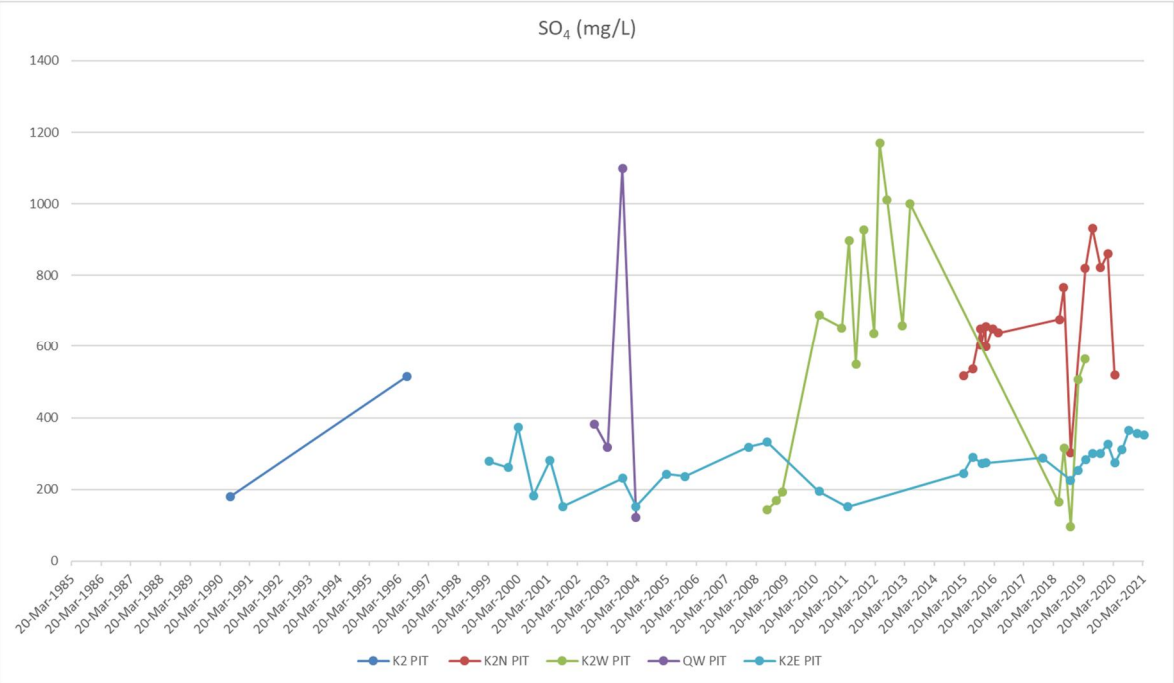


Figure 5.9 K2 Pit, K2N Pit, K2W Pit, QW Pit and K2E Pit sulphate in pit water over the life of the mine

KING 4 EAST PIT

Mining has been conducted at King 4 East (K4E) pit from 1985 to the present day, with mining expected to continue until 2032. Pit water quality data is available from 1986 to 2021. The pH of the pit water has been circum-neutral (pH 5.95 – 8.62) throughout the pit life (Figure 5.10). The pit water EC was initially very high (11,600 µS/cm) but declined from 1986 to 1994, after which is has remained relatively stable with an average of 2,285 µS/cm (Figure 5.11). Sulphate concentrations have been relatively low during the pit life, ranging from 77 to 470 mg/L (Figure 5.12). Dissolved metal concentrations were below the laboratory detection limit, with the exception of Ba (0.07 mg/L), B (0.12 mg/L), Co (0.023 - 0.102 mg/L), Mn (0.256 - 1.63 mg/L), Ni (0.038 - 0.114 mg/L) and Zn (0.031 - 0.171 mg/L).

KING 4 SOUTH (K4S) PIT

Mining has been conducted at K4S from 2008 to the present day, with mining expected to continue until 2029. The pit water pH has ranged from 6.53 – 8.08 during the pit life (Figure 5.10), and EC has been low, decreasing from 1,935 µS/cm in 2008 to 874 µS/cm in 2013 with a slight rise back to 1,322 µS/cm in 2021 (Figure 5.11). Sulphate concentrations have also been low and generally decreasing, ranging from 214 to 69 mg/L over the pit life (Figure 5.12). Dissolved metal concentrations were below the laboratory detection limit, with the exception of B (0.11 mg/L), Co (0.029 mg/L), Fe (4.37 mg/L), Mn (0.003 - 0.498 mg/L), Mo (0.012 mg/L), Ni (0.005 - 0.024 mg/L) and Zn (0.002 - 0.044 mg/L).

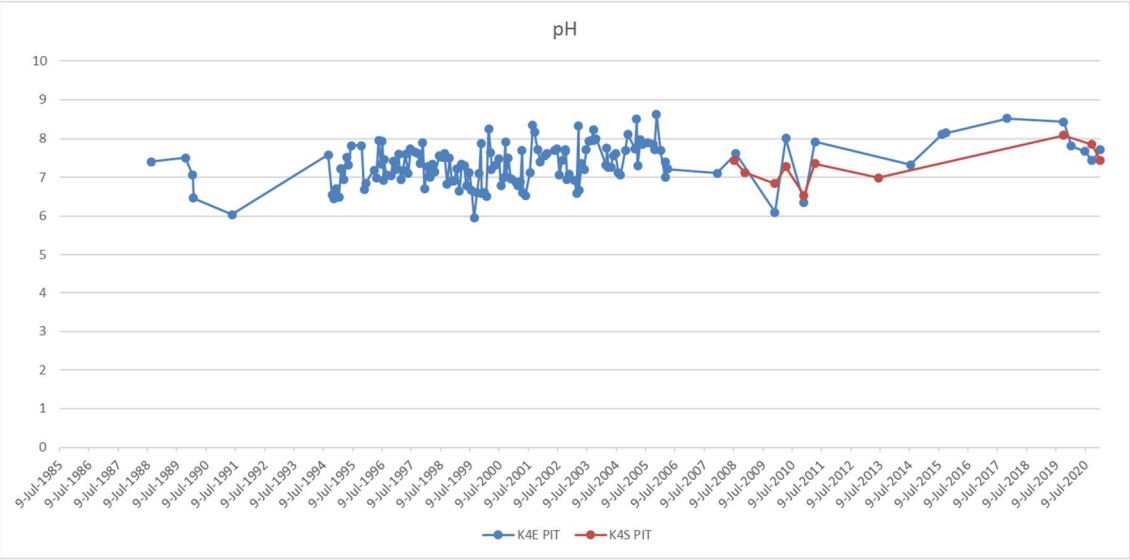


Figure 5.10 K4E Pit and K4S Pit pH in pit water over the life of mine

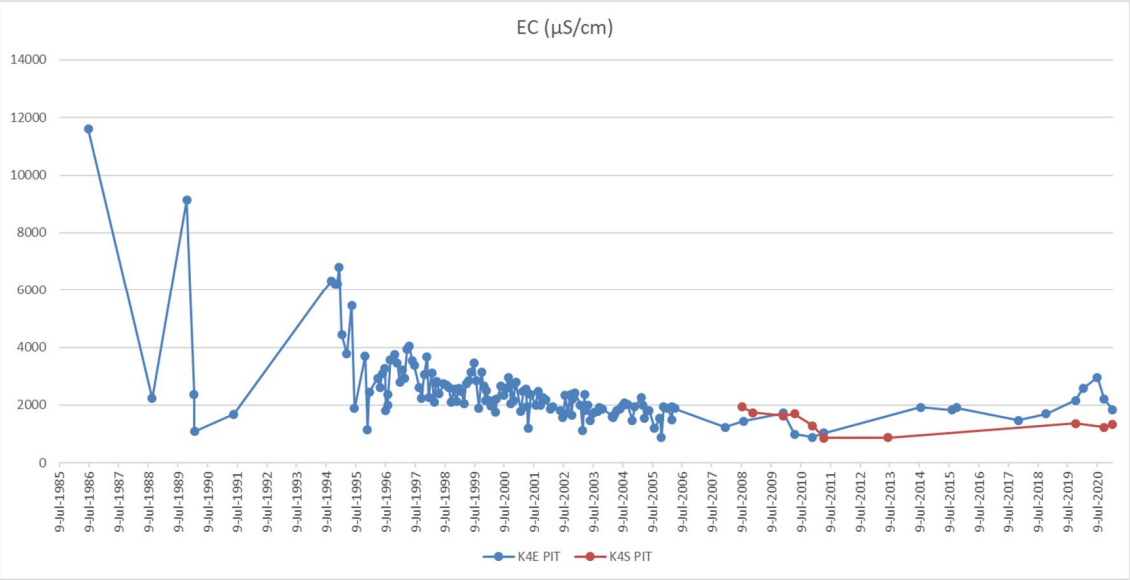


Figure 5.11 K4E Pit and K4S Pit EC in pit water over the life of mine

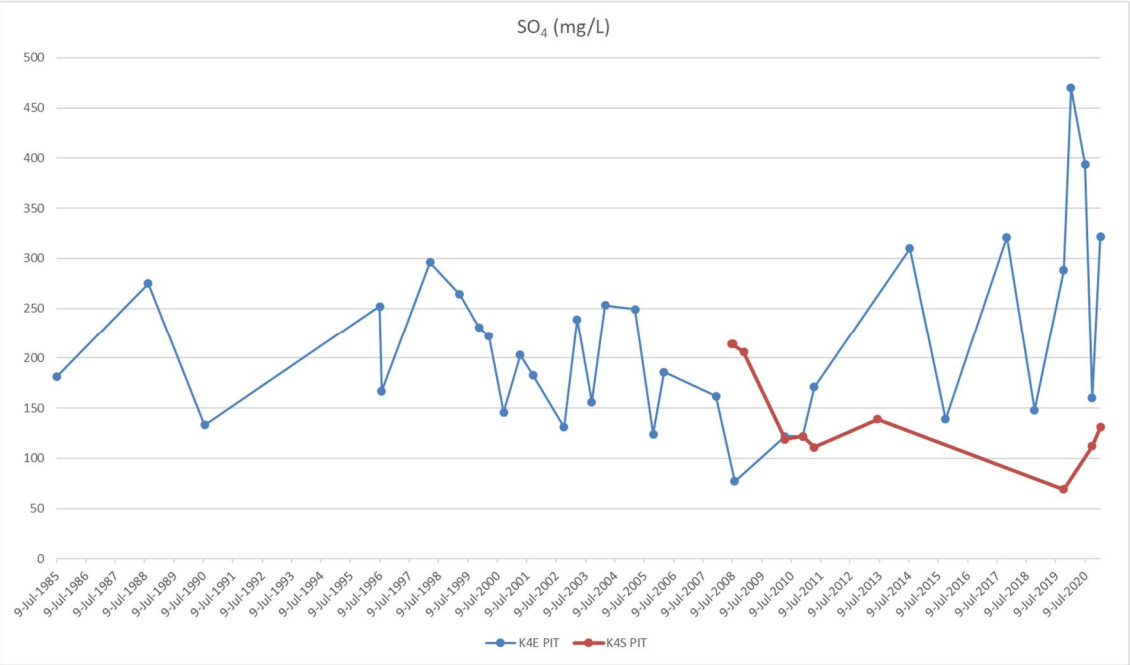


Figure 5.12 K4E Pit and K4S Pit sulphate in pit water over the life of mine

SUMMARY

The historical pit water chemistry indicates that some units within the lithology at Meandu Mine have the capacity to generate acid. The propensity for acidic pit water appears to be geographically influenced, and possibly related to mine history and process. The lowest pH and most persistent acidic pit waters were recorded early in the mine life in the northern (K1 and K2 pits) and north-western (NWA pit) areas of the mine. The investigation into the acidic pH in K1 pit water concluded the source of the AMD was exposed oxidised coal in the pit face and mined overburden (AGCWC, 1993a). The acidity appears to be associated with the upper Ace and King coal seams early in the mine life (RGS, 2018).

Acidic conditions have not been measured in any pit water since 2004, which may reflect water management processes in the mine, but is also an indication that the lithologies mined since 2004 have a lower acid generating potential. Overburden/interburden spoil and exposed hanging wall pit faces have not created acidic conditions in Central Pit, K4E and K4S pit waters for the life of these pits. In-pit acidic conditions have not been recorded in the K2E pit since March 2000, despite the highwalls having been exposed to oxidation for several years.

Saline drainage may be attributed to sulphate release from the oxidation of sulfidic mine waste and overburden; however, the mobilisation of sodium chloride from both Tertiary and Triassic overburden/interburden will occur in the absence of AMD. Comparison of pit water quality with the EA water contaminant limits (EA - Table C2) and release contaminant trigger investigation levels (EA Table C3) indicates that salinity (measured as EC) in pit waters has generally been lower than the release limits in most pits not influenced by ash or tailings disposal. However, EC was often elevated (>3,000 µS/cm) early in the life of pits before steadily declining to lower levels, which suggests initial run-off into the pits might be saline due to mobilisation of easily dissolved salts on the rock and waste. Isolated later elevated EC readings may be caused by evapoconcentration rather than run-off or seepage, particularly in periods of extended dry conditions.

In-pit SO_4^- concentrations have been below the EA release point criteria (1,000 mg/L) in all pits throughout the mine life with only three exceptions, two of which (K2W and QW pits) are likely related to ash disposal rather than AMD. The other exceedance occurred early in the life of K1 Pit in acidic conditions. This indicates that:

1 Acidic pit waters have not led to elevated SO_4^- concentrations.

2 Elevated ECs are a result of sodium chloride mobilisation in surface run-off, seepage and process waters, plus evapoconcentration.

NMD is the occurrence of elevated dissolved metals and sulphate in surface waters at circum-neutral pH. NMD generally occurs where the acidity produced by AMD has been neutralised by carbonates; however, some elements can become mobile in waters with circum-neutral pH where no acid generation has occurred. Elevated total concentrations of a number of metals have been detected in the pit waters; however, the older metals data available for the pit waters is total metals rather than dissolved metals, which cannot be compared with the release criteria. Recent pit water data recorded dissolved concentrations of Ni (Central, K2E, K4E, K4S pits), Fe (Central, K4S pits), Co, (K4E pit) and Zn (Central, K4E, K4S pits) in exceedance of the release contaminant trigger investigation levels. Whilst the pit waters will not be released to the environment and the trigger levels are therefore not strictly relevant, the metal results indicate that the waste and overburden/interburden material at the mine does has the capacity to generate elevated dissolved metal concentrations in run-off and or seepage.

5.2 TAILINGS SUPERNATANT

Fine tailings generated by the CHPP were originally transported and deposited as a wet slurry suitable for transportation by pipe. On deposition into a TSF, a supernatant forms on the top of the solids in the TSF. Water quality analysis of this supernatant can provide an indication of the geochemical behaviour of the tailings and their potential leachate water quality (noting the impacts of on-site water management as discussed above).

Initially tailings were deposited into the Meandu Mine's dedicated TSF at King 2 (K2TSF). On the completion of mining of NWA Pit, tailings were then deposited into the mining void from 1996 onward (NWATSF). From 2006 the tailings were then deposited into the NWB Pit void (NWBTSF), until December 2019.

From January 2020 the current Meandu site practice is as follows:

- dewatered tailings are co-mingled with coarse rejects and the resulting mixed plant rejects stockpiled at the CHPP before being loaded and trucked to the rejects dump cells located in the waste dumps
- at times when the tailings dewatering centrifuges are unavailable due to breakdown or maintenance, or the thickener bed requires purging, ultrafines are slurry pumped to the TSF at the North West void (NWTSF).

K2TSF

The pH of the supernatant ranged from 4.86 to 8.68 with no clear temporal trend. EC ranged considerably from 871 µS/cm to 7,750 µS/cm; however, only two readings had an EC >3,000 µS/cm, and the supernatant averaged 1,333 µS/cm from 1995 to 1997. No sulphate or metals concentrations are available for K2TSF.

NWATSF

The supernatant in NWATSF was generally slightly acidic to circum-neutral, ranging from pH 5 – 7.5 with only one acidic reading of pH 4.66 in June 2004 (Figure 5.13). Initial EC was moderately high (~2,200 µS/cm), but this dropped to the range of 750 – 1,850 µS/cm for the remainder of the TSF life (Figure 5.14). Sulphate concentrations were also low, ranging from 100 – 350 mg/L over the life of the facility (Figure 5.15). Occasional slightly elevated total concentrations of Al (0.12 – 0.22 mg/L), Fe (0.3 – 1.3 mg/L), Ni (0.01 – 0.12 mg/L) and Zn (0.03 – 1.39 mg/L) were detected in the supernatant, but generally metal concentrations were at or below detection levels.

NWBTSF

Intermittent water quality data exists for NWBTSF supernatant (also recorded as Pit tailings void between 2015 and 2016). The pH of the supernatant was circum-neutral for most of the facility's operation, ranging between pH 5.8 – 8.1; however one acidic measurement at pH 3.77 was recorded in April 2020 (Figure 5.13). The supernatant EC has ranged between 1,100 and 2,600 µS/cm for most of the facility's operational life, with an elevated measurement of 4,120 µS/cm recorded in January 2020 (Figure 5.14). Sulphate trends match the EC trend (Figure 5.15). Dissolved metal concentrations in the supernatant were generally low or below detection, with the exception of occasional elevated Mn (0.692 mg/L), Ni (0.03 mg/L) and Zn (0.01 – 0.342 mg/L).

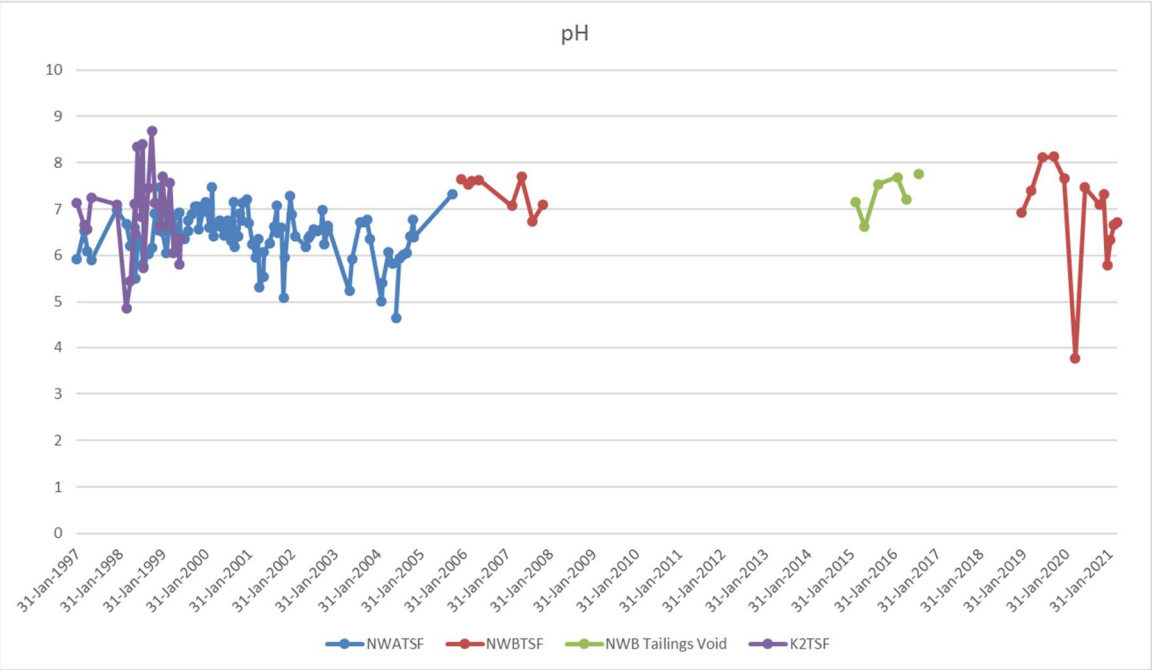


Figure 5.13 NWATSF and NWBTSF (recorded as NWB Tailings Void in 2015-2016) pH in tailings supernatant

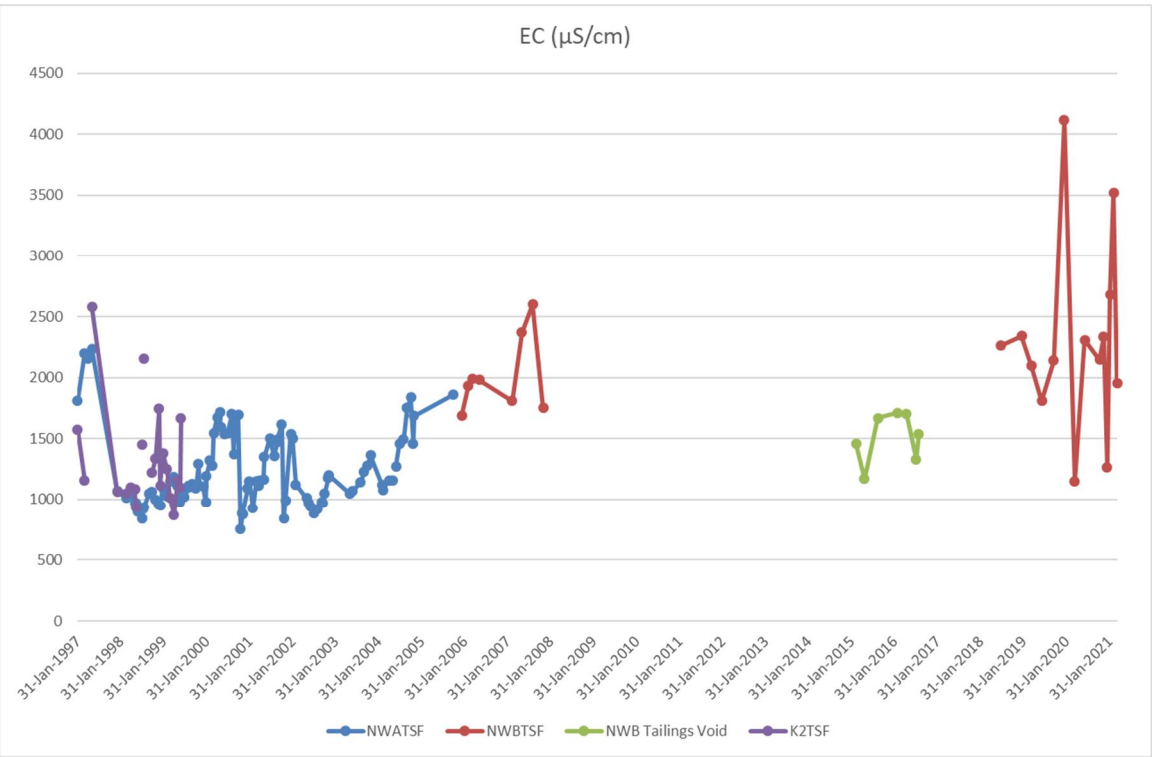


Figure 5.14 NWATSF and NWBTSF (recorded as NWB Tailings Void in 2015-2016) EC in tailings supernatant

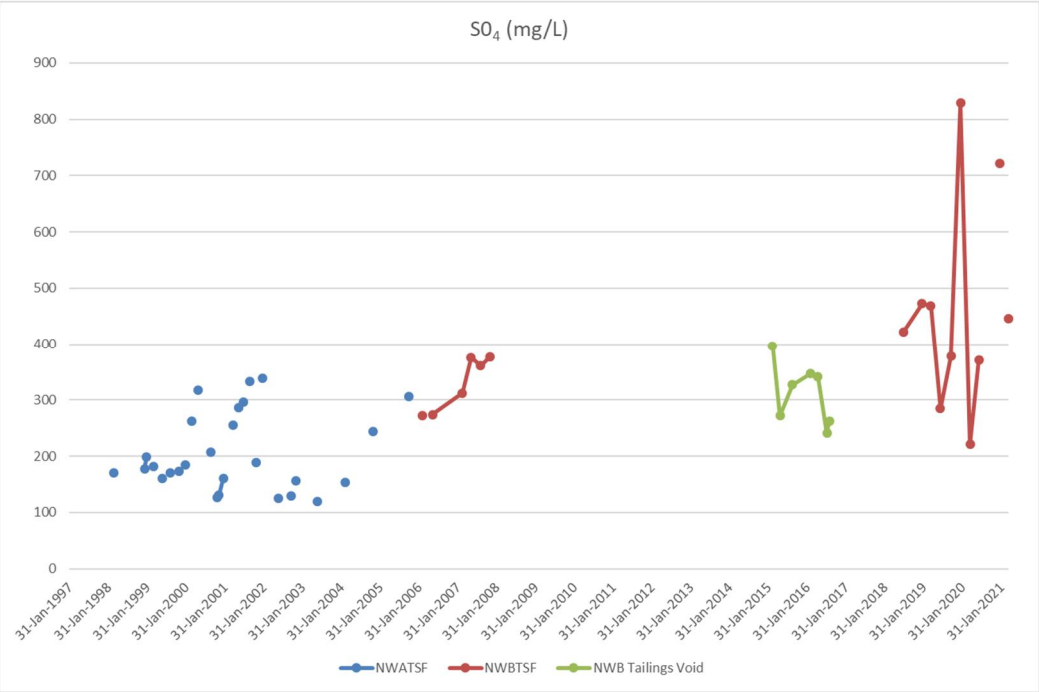


Figure 5.15 NWATSF and NWBTSF (recorded as NWB Tailings Void from 2015 – 2016) sulphate in tailings supernatant

SUMMARY

Tailings supernatant water qualities suggest that the tailings are unlikely to generate acidic drainage in the short term due to their saturated state, preventing significant oxidation of any entrained sulphides. However, run-off waters and leachates are likely to have salinities in excess of the Meandu Mine's release contaminant release criteria. Dissolved Ni and Zn concentrations in exceedance of the discharge contaminant trigger levels have also been detected in the supernatant. The tailings supernatant is recycled when possible at the Meandu Mine, and the TSFs have no discharge points; therefore, the supernatant will not be released to the environment. However, the water quality results indicate that the tailings do have the capacity to generate elevated EC and dissolved metal concentrations in run-off and or seepage.

The current tailings disposal practice as outlined in Section 2.2.3 is for tailings to be thickened and treated with Ca(OH)2 to attain a broadly neutral pH in the CHPP thickener before being pumped in slurry form to solid bowl centrifuges, where they are dewatered to the required moisture context for transport. The dewatered tailings are co-mingled with coarse rejects and the resulting mixed plant rejects stockpiled at the CHPP before being trucked to the rejects dump locations.

Wet tailings disposal will continue to occur when the solid bowl centrifuges are off-line or not able to process 100% of the tailings stream. These are pumped as slurry to the dedicated TSF, which is currently two (joined) mine voids at Meandu Mine; known as King 2 West (K2W) and King 2 North (K2N) (known collectively as K2WN). The subsequent storage facility for wet tailings (to be co-mingled with ash) is in K4STSF. Proposed management strategies for tailings storage are discussed in Section 9.3.

5.3 SEEPAGE

A number of seeps have been identified at the site over the life of the mine, usually at the toe of active or rehabilitated spoil/reject dumps. The most problematic and persistent of these is the expression of AMD on Ramp 7 and in Bullgang Drain at or near the toe of RSA1 (refer Figure 5.16), which have been identified as the root cause for the non-conformance of surface water quality compliance conditions and resultant environmental notice issued by DES in 2016 (WSP, 2018). The nature and cause of the AMD expression at RSA1 has been the subject of several investigations (AGCWC, 1996; PW Baker, 2011; EGi, 2016; RGS, 2018) and much of the earlier waste characterisation at Meandu Mine.

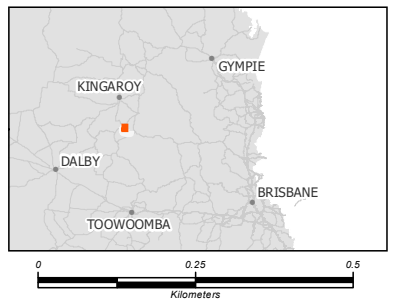
Meandu Creek Dam
RD2
RD1
RD8
RD7
CHPP
RD27
Ramp 7 Haul Road
Bullgang Corner
ROM
RD9
RD4
RD10
RSA 1
NORTH WEST BACKFILLED PIT
North West B Tailings Dam
ML 6674
West Dump
CENTRAL PIT
RD21
RD14B
RD22B
RD24
RD14A
RD14C
Meandu Creek

Meandu Mine

Figure 5.16
The north-west area of Meandu Mine showing RSA1, Ramp 7 and Bullgang Corner

Legend

- Drainage
- Watercourse
- Mining Lease (ML6674)
- RSA1
- Retention Dams



Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

1:12,000 Date: 16-Sep-21

Data sources: - DNRME, TMR, Translink, Geoscience Australia

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RAMP 7 & BULLGANG DRAIN

Seepage at Ramp 7 was initially identified in 1995 after a period of above average rainfall. The seepage water quality had a pH of 3 – 3.5, EC of 4,350 µS/cm, SO_4^- concentration of 3,450 mg/L and elevated Cd, Fe, Ni, Pb and Zn (likely total metal concentrations). No seepage was recorded at this location from 1995 to 2013; however, water quality records from downstream retention dams RD7 and RD8 show periods with acidic conditions during 1997, 1998, 2001 and 2004 (RGS 2018). In 2013, following three years of above average rainfall, AMD seepage was observed at both Ramp 7 and Bullgang Drain, with resultant acidic conditions in RD7 and RD8.

The seepage shows slightly acidic pH at the Ramp 7-1 and Bullgang Drain (average pH 5.2 and 6.09, respectively) (Figure 5.17); however both locations show elevated EC (~3,000 µS/cm) (Figure 5.18), SO_4^- concentrations above 1,000 mg/L (Figure 5.19) and elevated dissolved Fe (70 – 179 mg/L) and Mn (9.2 – 50.3 mg/L) concentrations, which is indicative of NMD. Elevated dissolved Al (0.06 – 4.52 mg/L), Co (0.439 – 1.21 mg/L), Fe (9.93 – 172 mg/L), Mn (30.1 – 38.5 mg/L), Ni (0.261 – 0.892 mg/L) and Zn (0.201 – 11.7 mg/L) were present in the seepage at concentrations well above the release contaminant trigger investigation levels.

As the seepage travels downstream into RD7 and RD8, the pH dropped to <3.5, whilst the concentrations of Fe and Mn also tended to decrease. EGi (2016) explained these phenomena as being caused by changing redox conditions, whereby the seepage exiting RSA1 was under reducing conditions, containing latent acidity in the form of dissolved Fe and Mn. As the seepage was oxidised in the drain and the retention dams, the Fe and Mn oxidised, precipitated as Fe and Mn oxy-hydroxides, which released acid and lowered the pH.

RGS (2018) determined that the most probable cause of the historic and recent AMD at Ramp 7 and Bullgang Drain was oxidation of the contained sulphide minerals and subsequent leaching of the AMD weathering products from the rejects stored in RSA1 (see Section 7.4).

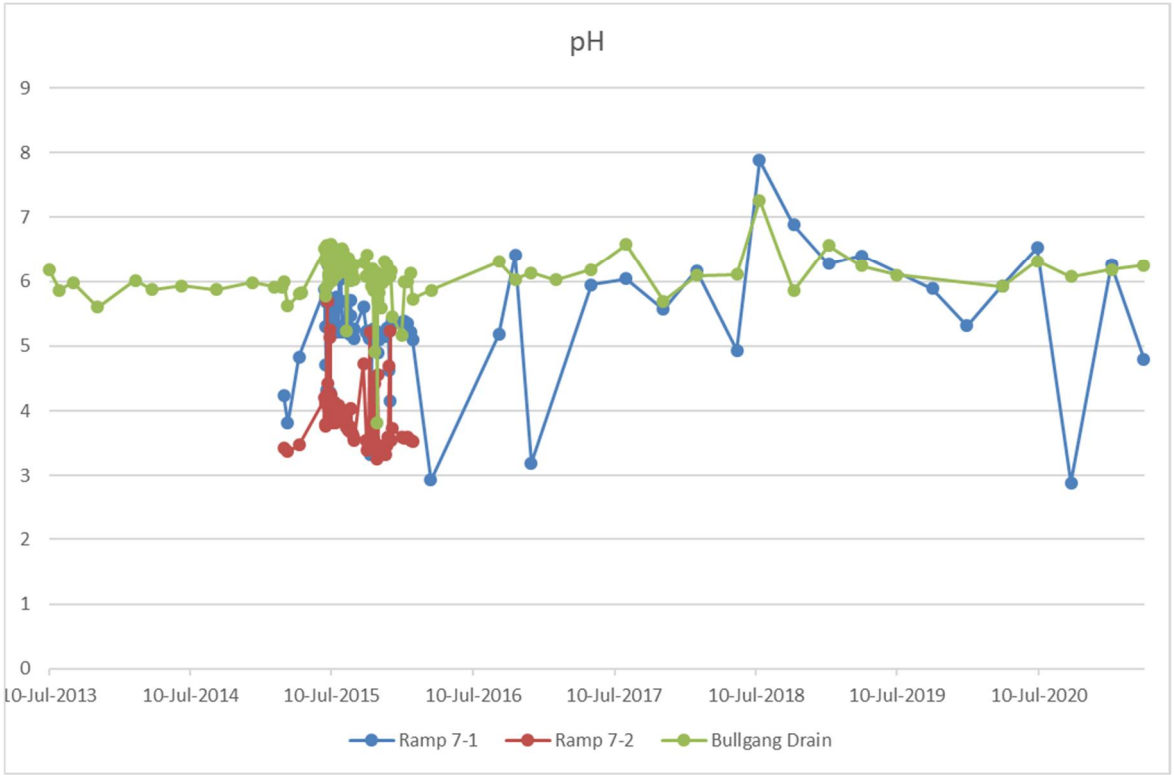


Figure 5.17 Seepage pH at Ramp 7-1, Ramp 7-2 and Bullgang Drain

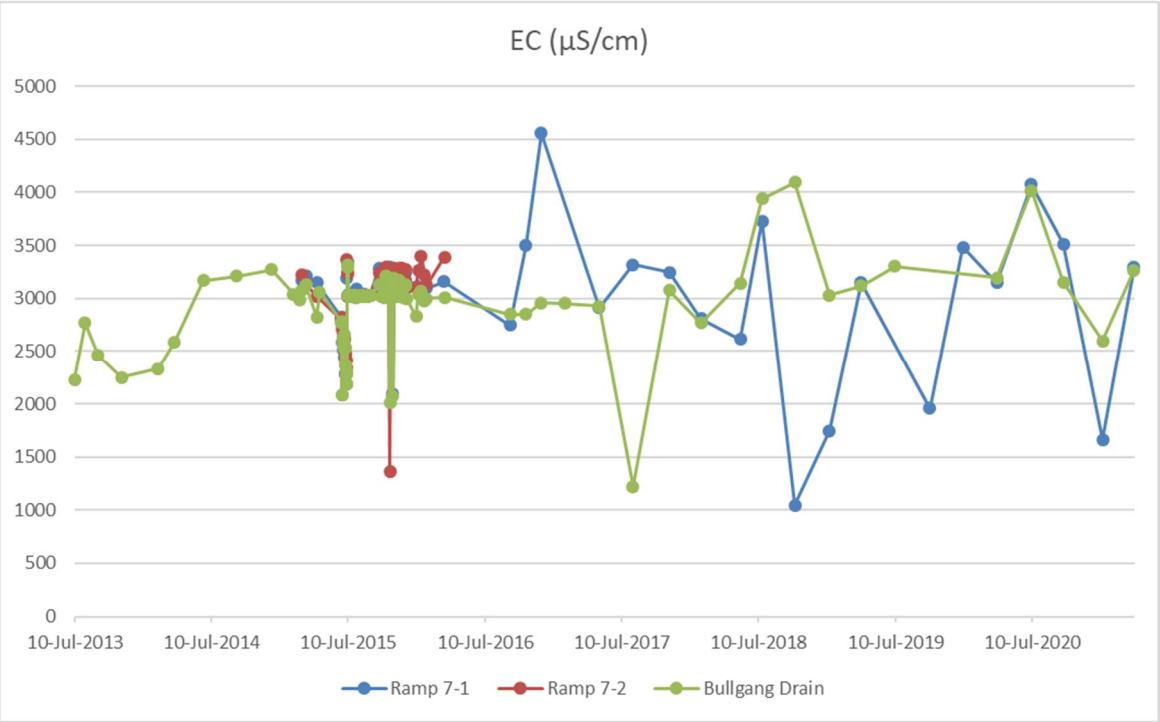


Figure 5.18 Seepage EC at Ramp 7-1, Ramp 7-2 and Bullgang Drain

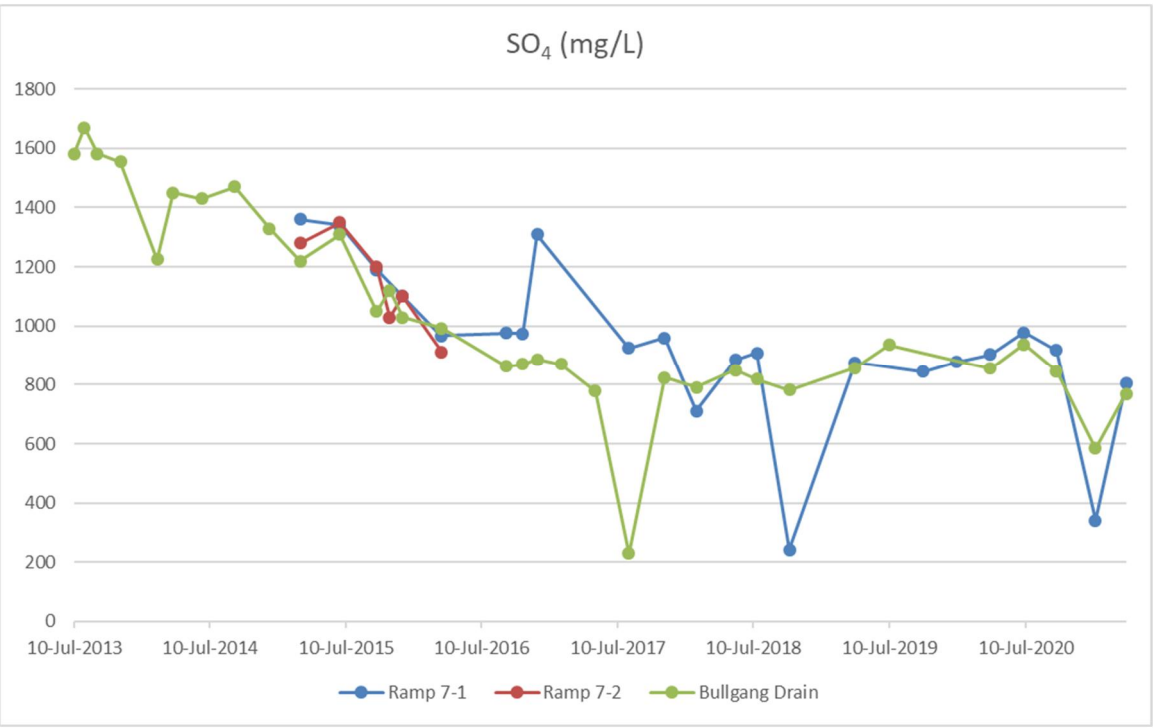


Figure 5.19 Seepage sulphate at Ramp 7-1, Ramp 7-2 and Bullgang Drain

OTHER SITE SEEPAGE

Water quality data exists for three other seepage occurrences on the mine:

- West Seepage 3, located on the west dump seeping into an internal drain, monitored on three occasions in November and December 2010. Seepage water had a pH of 5.3 – 6.3, EC of 189 – 1,920 µS/cm, a moderate SO_4^- concentration of 304 mg/L and a slightly elevated total Fe concentrations of 18 mg/L.
- K2N seep, located between K2W and K2N ash voids, monitored from July 2015 until December 2015. Seepage was circum-neutral (pH ~7.6), moderately high EC that increased from 2,000 µS/cm to 2,910 µS/cm during monitoring, moderate SO_4^- concentration (~600 mg/L) and dissolved metal concentrations of B (0.9 mg/L), Co (0.012 mg/L), Fe (0.05 mg/L), Mn (0.294 mg/L), Ni (0.033 mg/L) and Zn 0.064 mg/L).
- Central 06 seepage, located in Pit Central, with one recording in January 2016. This seepage was acidic (pH 2.98), moderately high EC (1,950 µS/cm) and SO_4^- (628 mg/L), with elevated dissolved Al (4.16 mg/L), Co (0.242 mg/L), Cu (0.058 mg/L), Fe (26.4 mg/L), Pb (0.104 mg/L), Mn (9.66 mg/L), Ni (0.204 mg/L) and Zn (2.7 mg/L).

SUMMARY

The seepage water quality results indicate that the geology at the mine is capable of generating AMD (and NMD) from certain materials and under certain conditions. However, significant and persistent AMD at the site is limited to that issuing from RSA1 on Ramp 7 and Bullgang Drain and the problem at that location is considered to have been a result of the concentration of sulphidic coal rejects with little to no ANC and insufficient landform management to prevent water (rainfall or seepage) or oxygen ingress and subsequent sulphide oxidation. The limited information on other surface seepage at the mine indicates that seepage is not a widespread or common occurrence at Meandu Mine.

In the acidic discharge, significant concentrations of dissolved metals are contained in the water, which would be greatly in excess of the site's EA release criteria. In the non-acidic seepages salinity (as measured by EC) is potentially problematic at K2N seep; however, this appears to be a localised issue, resulting from entrained ash water seeping from ash storage in K2W through the separating wall into K2N (SGRS, 2015). Dissolved Ni and Zn in the saline drainage were also elevated, reinforcing the potential for seepage and run-off associated with ash storage at the site to contain metals, even if the seepage is not acidic.

5.4 SHALLOW GROUNDWATER

The mining area contains an extensive network of groundwater monitoring bores that have been installed between 1993 and 2020, most with the objective of monitoring downgradient groundwater impacts from TSFs, mining voids and waste (spoil) dumps. However, a number of bores have been installed for future mine expansion planning purposes, which provide valuable background groundwater quality data.

As part of the investigations into the AMD occurrence at RSA1 (WSP, 2018) (see Figure 5.16), a site-wide groundwater investigation was undertaken to investigate potential mine impacts on shallow groundwater (JBT, 2018). This study established concentrations for major water quality parameters in the background geological units at the site (where possible) and compared site-wide groundwater results against the background values to provide an indication of mining impacts to groundwater water quality at the site. Interestingly, pH was not found to be a useful indicator of mine impact, as there appeared to be no significant difference between background bores and mine-impacted bores. The investigation's findings are summarised below for each mining area of interest.

NORTH-WESTERN MINING AREA (RSA1, NWBFP, RAMP 7)

A number of shallow groundwater bores on and downgradient of the spoil and reject dumps in the north-western area of the mine show evidence of AMD impact (GW25, GW34, GW35, GW36, GW38 and GW75), with water level rises and elevated EC (2,000 – 5,000 µS/cm) (Figure 5.20), SO_4^- (450 – 1,000 mg/L) (Figure 5.21), Fe (up to 90 mg/L) and Mn (up to 16 mg/L) when compared with background groundwater. Concentrations of Al, Co, Ni and Zn are also elevated compared with the background in some of the bores. GW 34 and GW76, located on RSA1, show little to no evidence of AMD, indicating that not all of the groundwater in the north-western mining area is impacted by AMD.

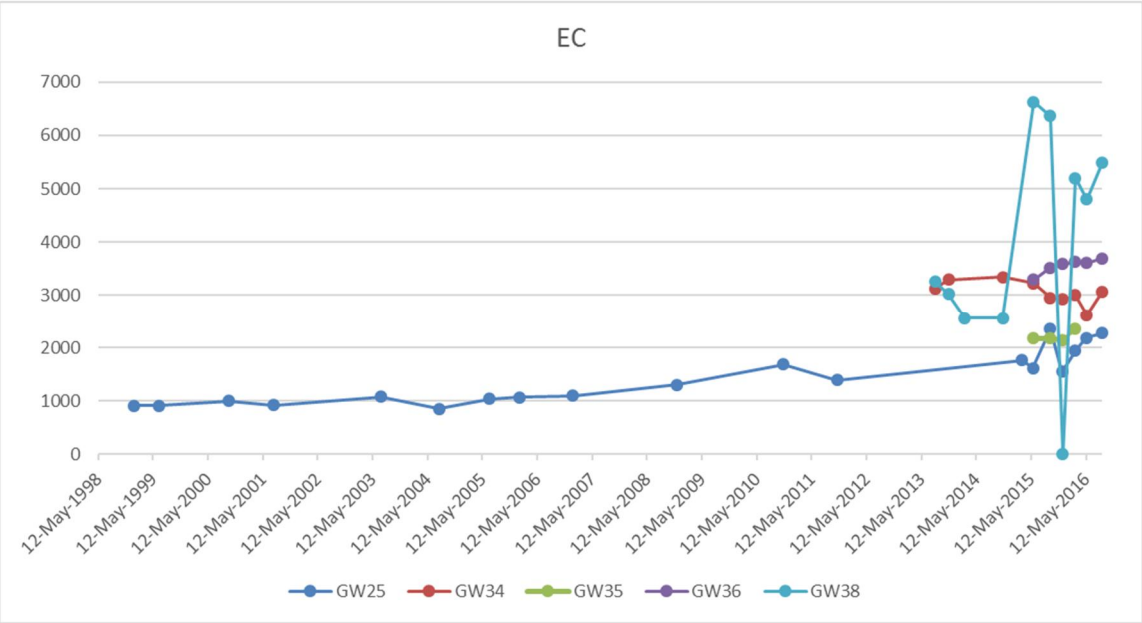


Figure 5.20 EC in groundwater in the north-western mining area

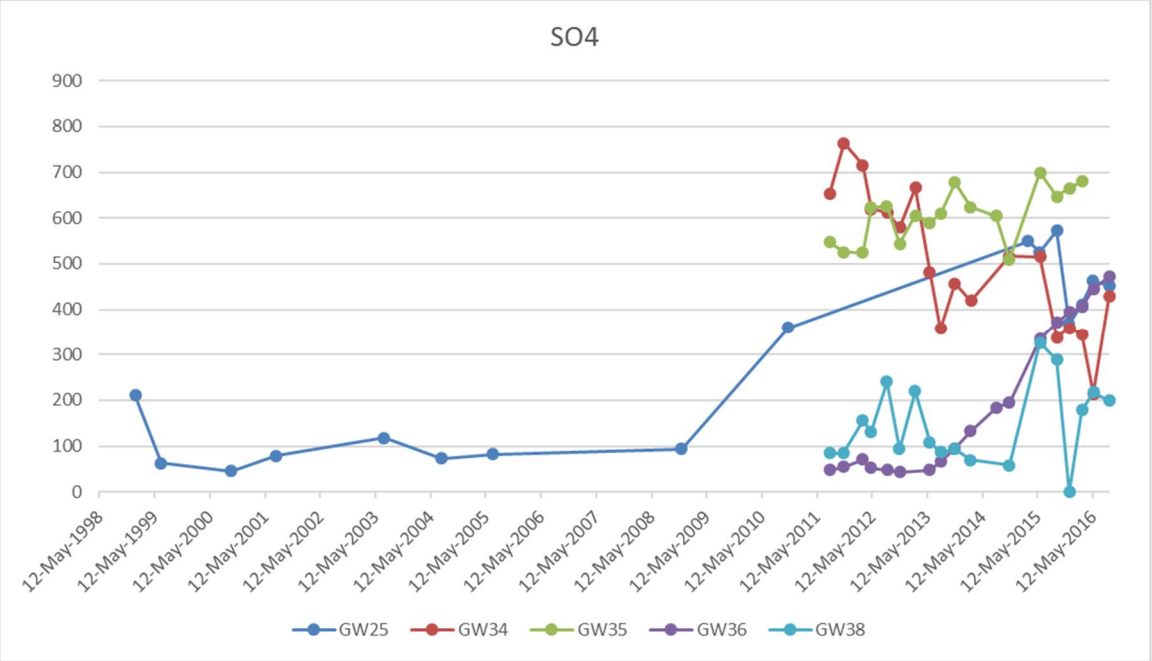


Figure 5.21 Sulphate in groundwater in the northwestern mining area

K2W PIT

Three monitoring bores at the site monitored potential impacts from the K2W Pit (GW53, GW55d, GW59d and GW59b), which has been used as a depository for coal combustion products from the Tarong power station since 2007 (note GW53 and GW55d have been decommissioned and replaced and GW59b replaced GW59d when it became inaccessible in 2011) The bores show moderately elevated EC (2,000 – 8,000 µS/cm) (Figure 5.22) and SO_4^- (500 - 900 mg/L) (Figure 5.23) and elevated dissolved Al, Fe, Mn, Ni, As, Mo and B in comparison with background bores.

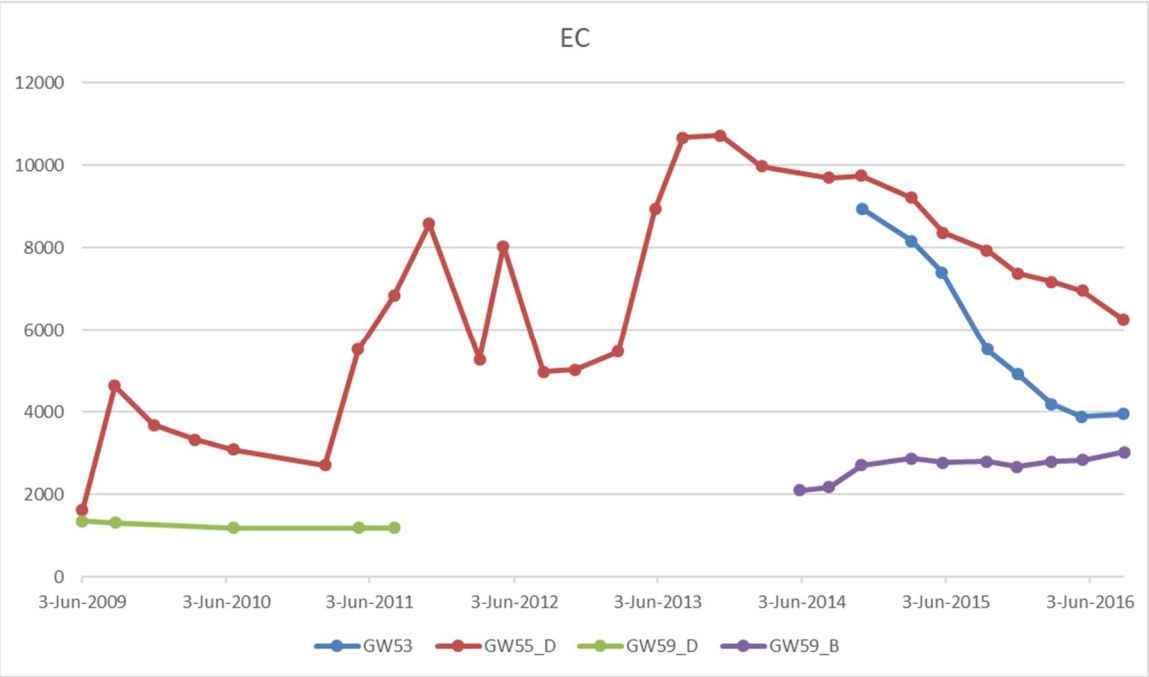


Figure 5.22 EC in groundwater in the vicinity of K2W Pit

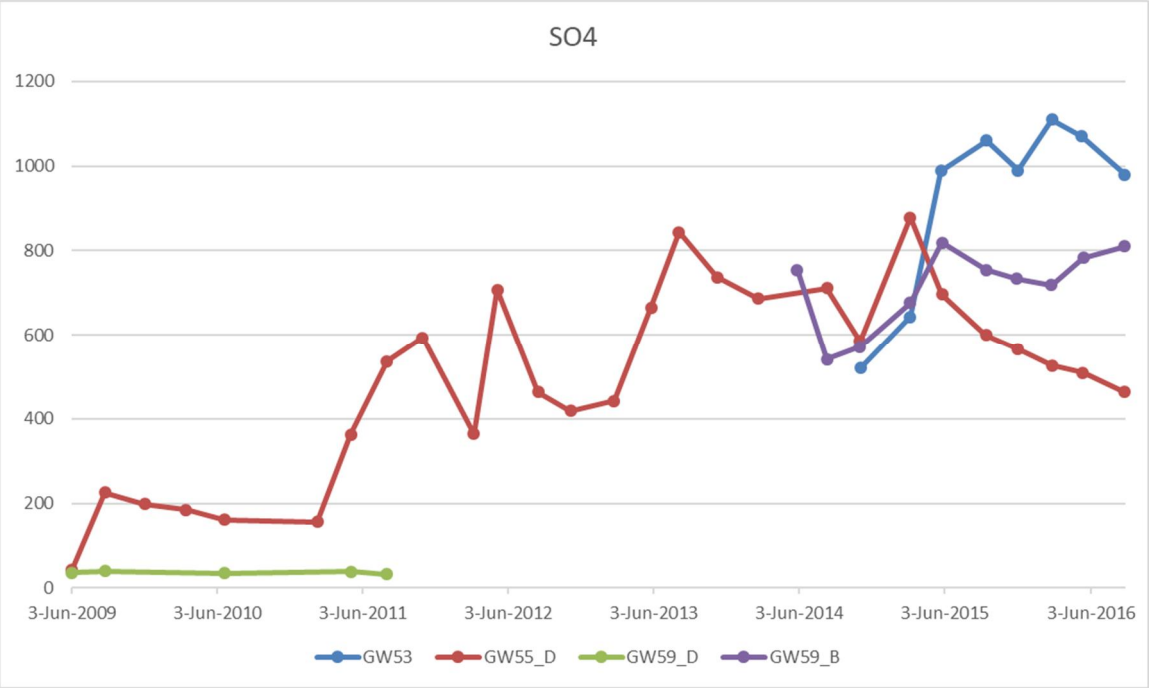


Figure 5.23 Sulphate in groundwater in the vicinity of K2W Pit

K2 TSF AND K2E REHABILITATION AREA

The K2E rehabilitation area, including the former K2TSF, is monitored by three groundwater monitoring bores, GW70 – GW72. A further four monitoring bores (GW61s, GW61d, GW73 and GW74) are located to the north of the rehabilitation area, which is down topographic gradient. The bores located within the spoil and tailings (GW72) have moderate EC (3,000 – 8,000 µS/cm), low SO_4^- to moderate (130 – 500 mg/L) and elevated Fe (100 – 200 mg/L) with Al, Ni and Zn also elevated in the spoil monitoring bores (GW70 and GW71).

Immediately downgradient of the rehabilitation area, groundwater appears to have no mining impacts, as GW61s and GW61d contain no elevated parameters compared with background. However, GW73, located approximately 400 m further north of GW61 returned a high EC of ~10,000 µS/cm (Figure 5.24)and a SO_4^- concentration of 800 mg/L (Figure 5.25), though this bore had low concentrations of all other analytes.

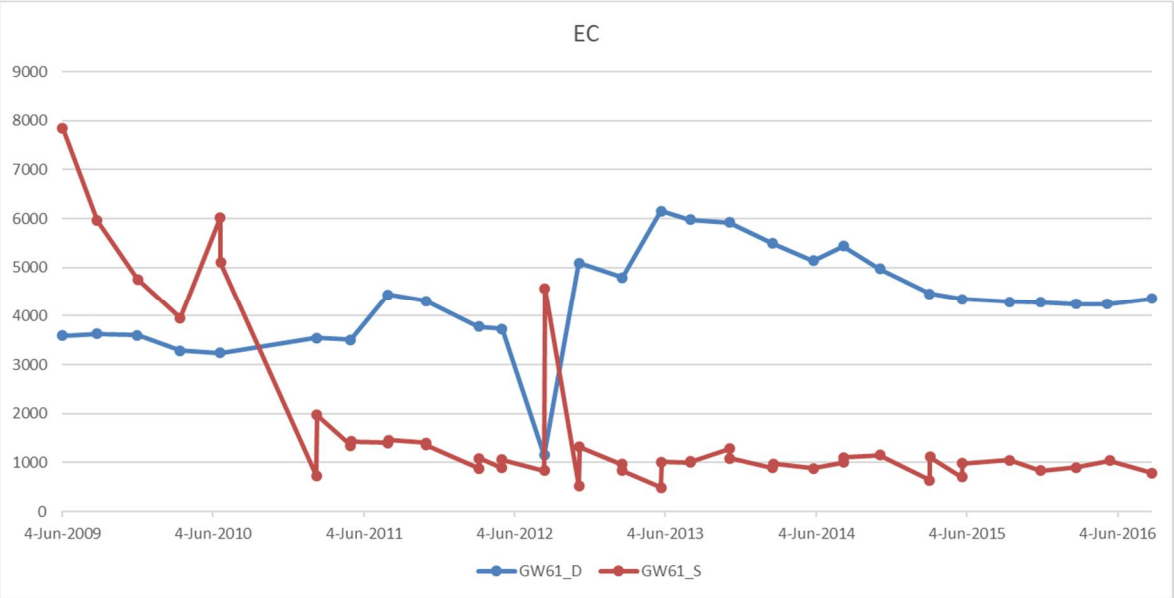


Figure 5.24 EC in groundwater downgradient of K2TSF and rehabilitation area

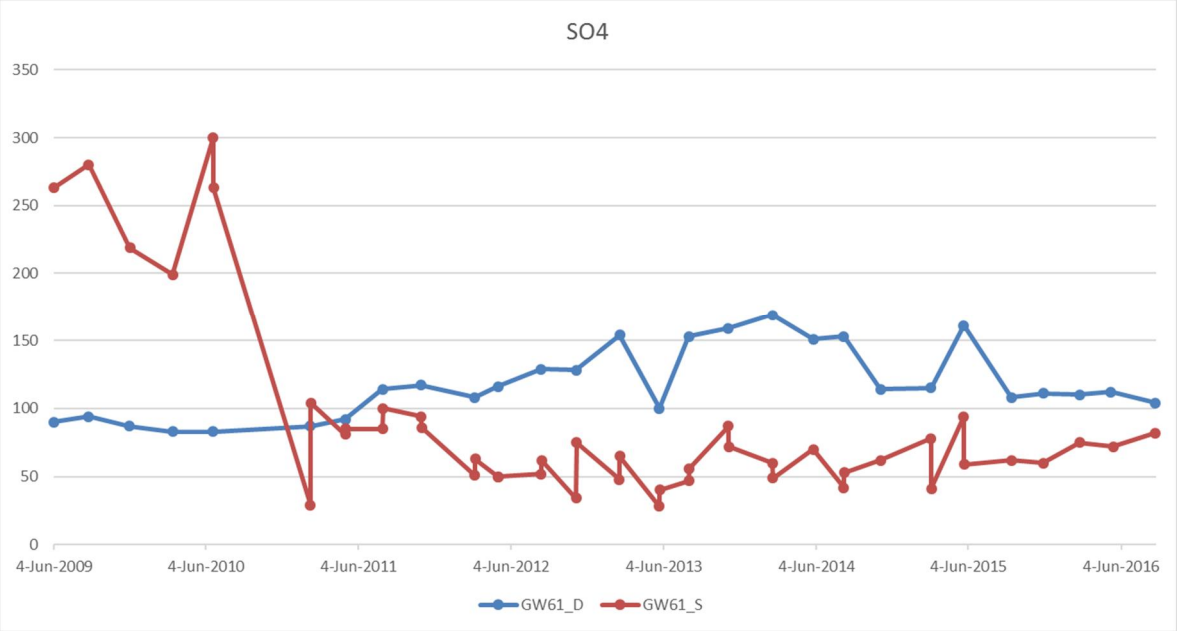


Figure 5.25 Sulphate in groundwater downgradient of K2TSF and rehabilitation area

QW PIT

The area immediately surrounding and down hydraulic gradient of the former QW Pit was monitored by six groundwater monitoring bores, GW50, GW52, GW54 and GW66 - GW68, with an additional four bores installed in 2020 (GW94 – GW97) to further delineate the extent of a saline plume that extends within site regolith from immediately north-west of (but is not related to) QWBFP to the north-west in the direction of Meandu Creek (SLR, 2020). There appears to be little to no impact to groundwater within or to the west and immediate north-west of QW Pit as GW54a, GW54b and GW66 have no elevated parameters when compared with background. However, to the north-west of the void, the groundwater has very high EC (12,000 – 20,000 µS/cm) (Figure 5.26) associated with moderately high SO_4^- (500 – 900 mg/L) (Figure 5.27), and elevated Al, Fe, Mn, Ni and Zn. This zone of high EC extends up to two kilometres from the pit along a pre-mining drainage line in natural regolith (SLR, 2020).

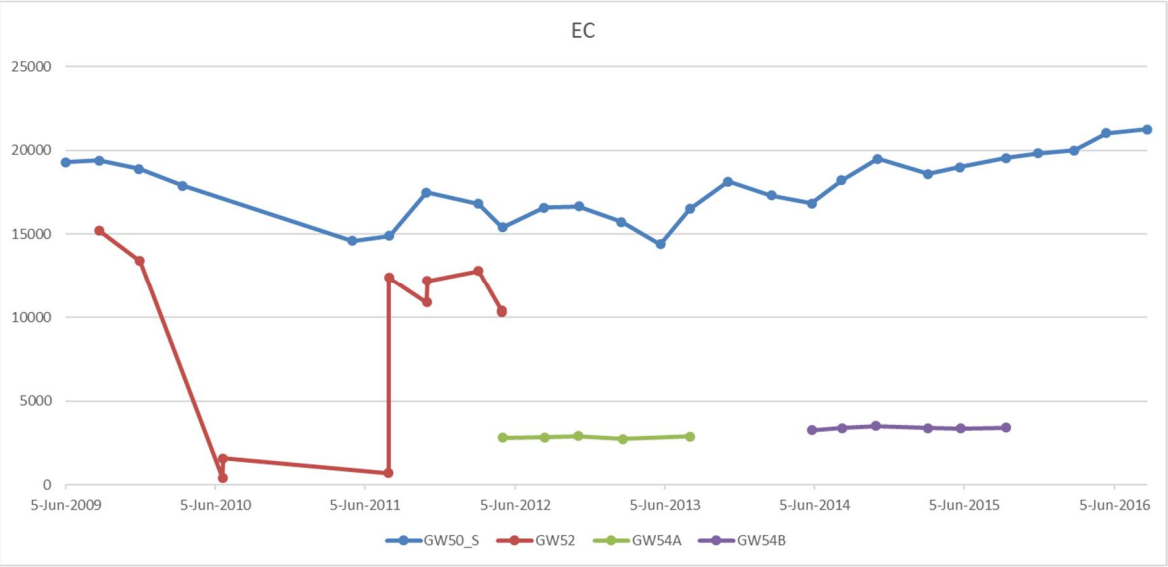


Figure 5.26 EC in groundwater in the vicinity of QW Pit

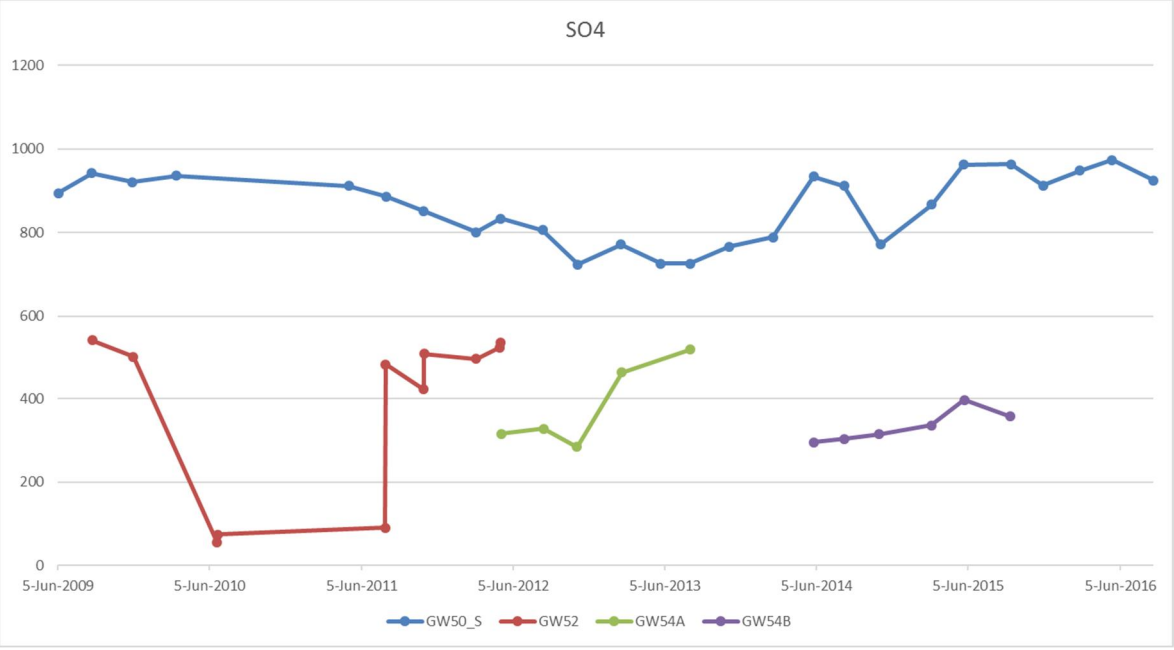


Figure 5.27 Sulphate in groundwater in the vicinity of QW Pit

SUMMARY

The groundwater data reinforces the pit water and seepage chemistry results, demonstrating that the potential for AMD generation exists in certain lithologies and under certain conditions. The seepage at Ramp 7 and Bullgang Drain is interpreted to be the surface expression of groundwater that has seeped through the rejects at RSA1, mobilising pyrite oxidation products (SO_4^-, Fe, Mn) and driven westwards by head from the groundwater beneath the NWBFP and NWBTSF along the base of the rejects/spoil (RGS 2018, WSP 2018).

The groundwater associated with spoil across the site generally has slightly elevated EC but only moderately elevated SO_4^-. Dissolved metal concentrations in spoil are variable across the mine, with elevated Fe fairly common, but Al, Mn, Ni and Zn also displaying the capacity to be mobilised into groundwater from the spoil.

The source of the elevated EC groundwater plume north-west of QW Pit is unknown but may be a result of unrecorded deposition of saline spoil and or rejects being deposited in the area during the rapid development of QW Pit. The elevated EC in GW73 is also unknown. The saline groundwater plume has been characterised in more detailed by SLR (2020).

It should be noted that with the exception of the AMD at Ramp 7 and Bullgang Drain, no surface expressions of groundwater seepage are present at the mine and the elevated EC, SO_4^- and metals concentrations reported above reflect the aquifer pore water hydrochemistry and do not imply that environmental impact will result from the groundwater impact.

6 MINERALOGY

Limited mineralogical analysis had been conducted on the lithologies at Meandu Mine due to the relative simplicity and homogeneity of the site's geology. The conclusions of early studies (Pegrem 1990) that the low sulphur and pyrite percentages at the site coupled with the presence of common carbonate minerals inferred an extremely low potential for the generation of AMD at the site. This is likely to have resulted in a downplaying of the importance of mineralogy and the distribution of sulphides within the mined material at the site until investigations into the surface expression of AMD at Bullgang Drain and RD7 were commenced (EGi, 2016).

Pegrem (1990), in describing the lithology of the Meandu Mine, stated "…there exists effectively no pyrite in the overburden at the Meandu Mine." The amount of pyrite in the reject material was also considered to be negligible and visible pyrite was considered limited to the top of coal seams and within the coal itself. Four petrographic descriptions of rocks from undefined units at the site are referenced in the report (Pegrem, 1990). All four descriptions discuss the presence of siderite (iron carbonate) as a cement matrix in claystone, sandstone and siltstone, with siderite comprising from 2% to 70% of the rock. X-ray diffraction (XRD) analysis on two of the specimens identified kaolinite as the majority mineral in the rock, with minor quartz and altered biotite and feldspar the only other minerals present. Unfortunately the report only referenced petrological reports of rocks containing siderite, so an assessment of the abundance of siderite and the presence/absence of other minerals in the rock at the mine cannot be made.

Aside from a mention of the potential formation of jarosite (yellow-green crust on overburden) in relation to AMD seepage in K1 Pit (AGCWC 1993a) (Section 5), none of the waste characterisation reports at the mine refer to mineralogy until EGi (2016). The EGi report provides a description of pyrite occurrences in cored hole 8010C, which was drilled for geochemical sampling and was considered representative of the mine stratigraphic sequence to be mined up to 2018. Pyrite appeared to be generally absent from overburden/interburden, apart from rare pyrite spheroids in sandstone Figure 6.1, which are usually within one metre of coal occurrences. Pyrite was more commonly observed in the coal intervals, with pyrite particularly common in Queen seams A1 to C1, occurring as coatings on joints Figure 6.2 and coatings and layers parallel to bedding planes Figure 6.3, thin veinlets Figure 6.4 and nodules Figure 6.5 (EGi, 2016).

During inspection of the core, 10% hydrochloric acid (HCl) was applied intermittently to sections of the core to provide an indication of the presence of reactive carbonate through vigourous fizzing. None of the overburden/interburden or coal showed any significant fizzing, indicating low abundance of reactive carbonate.

The drill core from bore 8010C was later submitted to the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and analysed using the Hylogger™ technology by short wave infrared (SWIR) and thermal infrared (TIR) reflectance spectroscopy. Results are discussed below and summarised in Table 6.1. Drilled cores 8104C and 8029C, from the highwall of K2E pit, were also submitted for Hylogger™ analysis (RGS, 2018), with results summarised in Table 6.2 and Table 6.3.

RGS (2018) assumes that the iron sulphide at Meandu Mine is marcasite or fine-grained framboidal pyrite, but does not provide a reason for this assumption. The distinction between marcasite or framboidal pyrite and normal crystalline pyrite is important because marcasite and framboidal pyrite oxidise and generate acid much more rapidly than crystalline pyrite (Klein and Hurlbut, 1985).

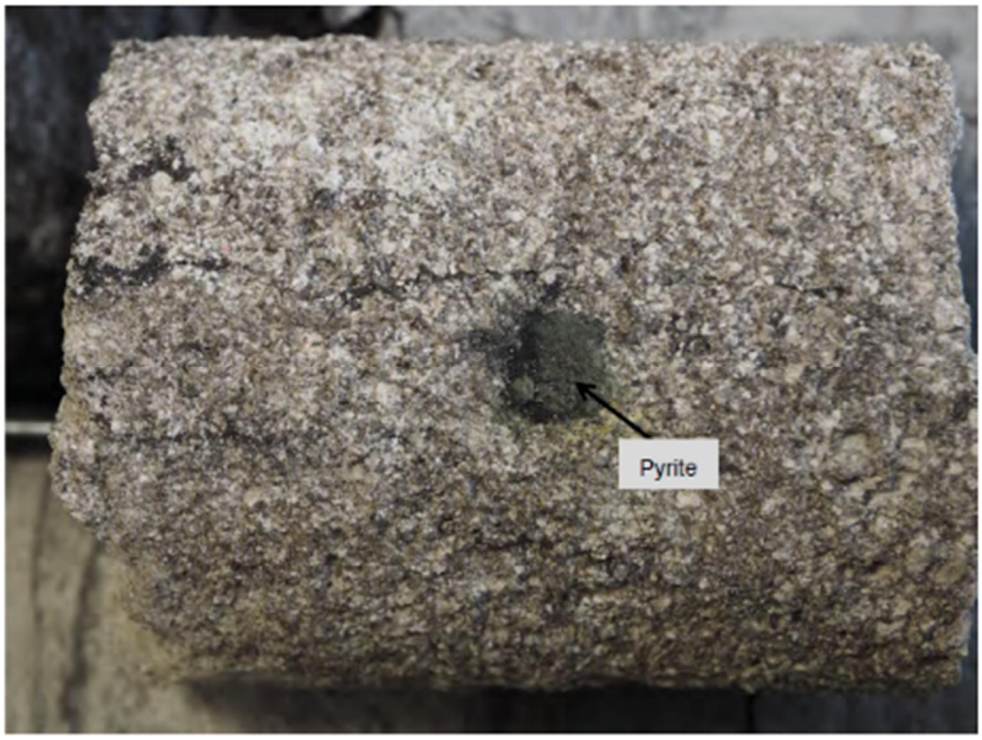


Figure 6.1 Pyrite spheroid in sandstone. Drilled core 8010C, 26.75m depth (EGi 2016).

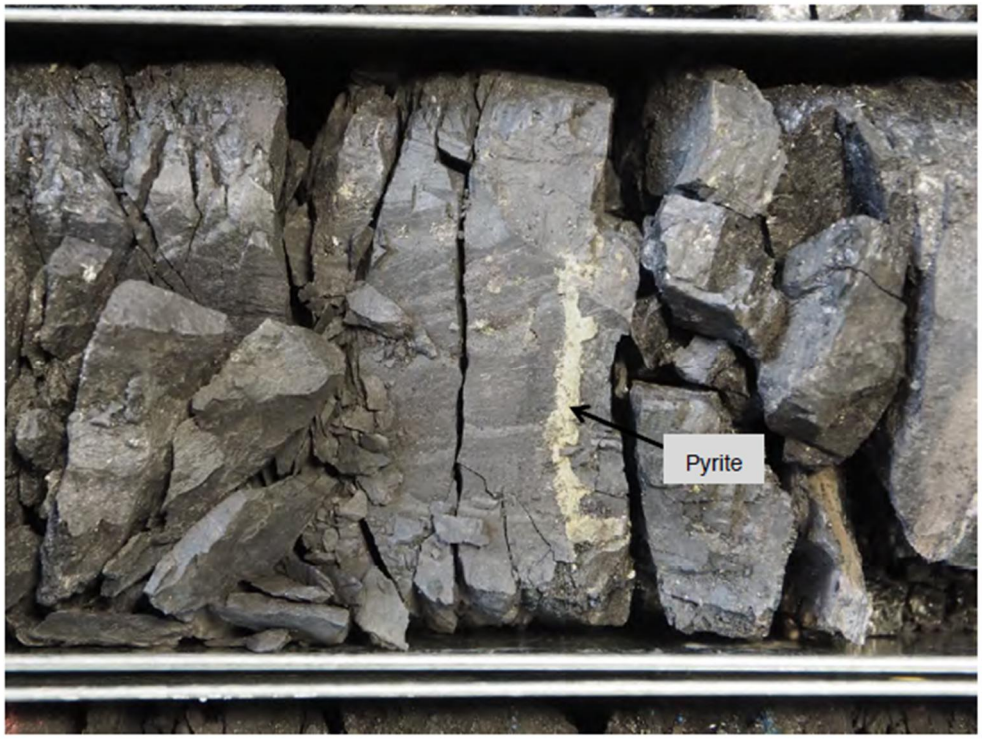


Figure 6.2 Pyrite coatings on coal joints. Drilled core 8010C, 79.3m (EGi 2016).



Figure 6.3 Pyrite layer parallel to bedding in coal. Drilled core 8010C, 82.6m (EGi 2016).

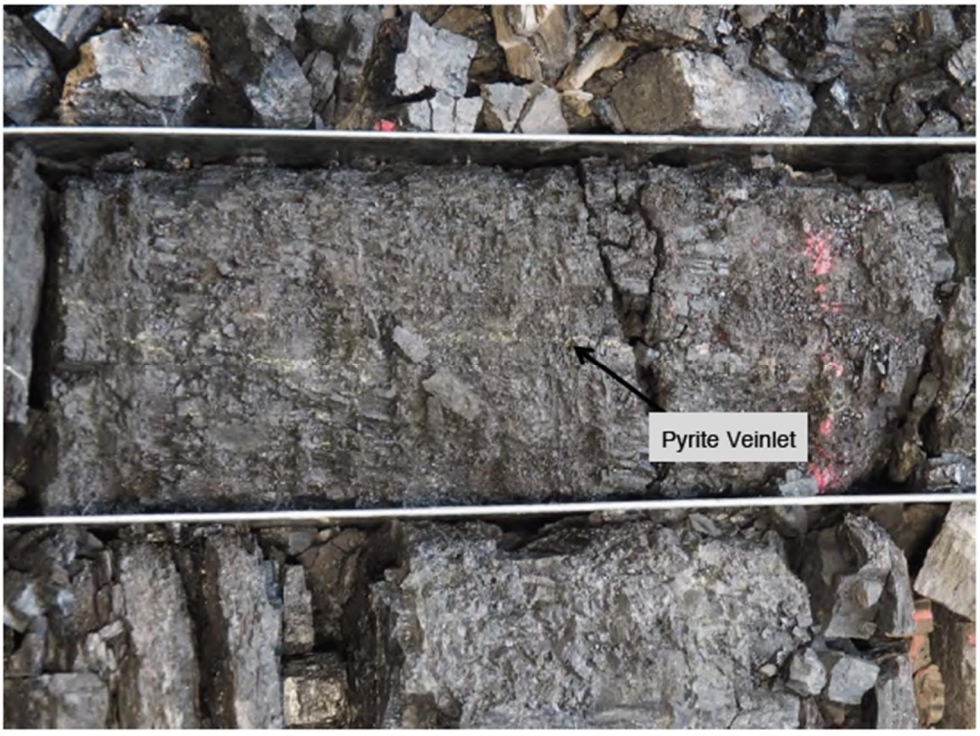


Figure 6.4 Thin pyrite veinlet in coal. Drilled core 8010C, 36m (EGi 2016).

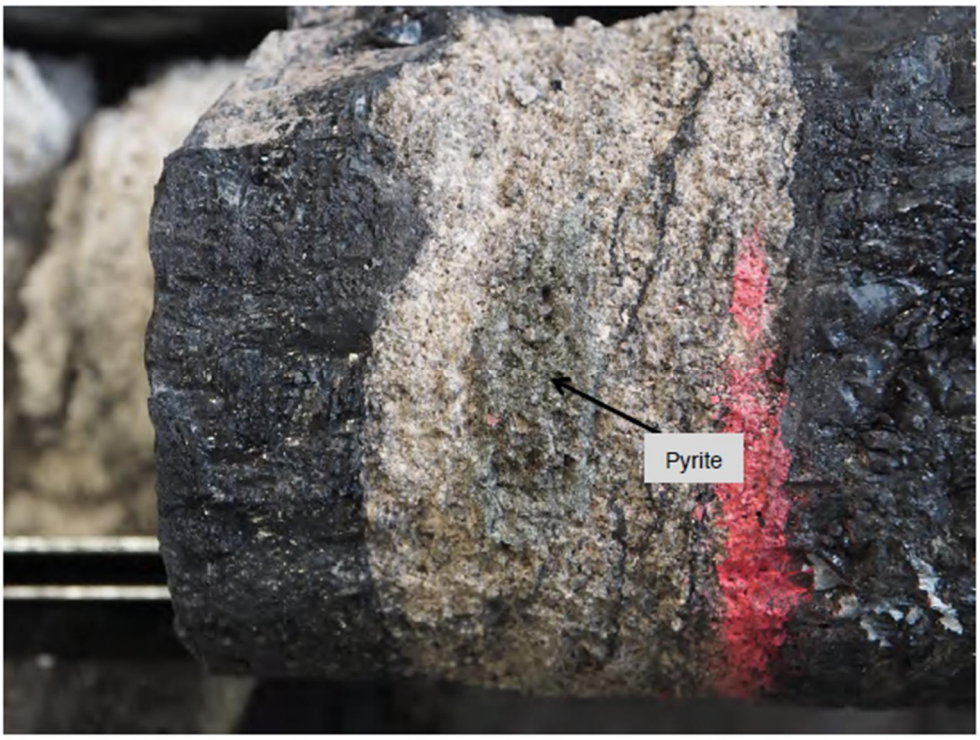


Figure 6.5 Pyritic nodule in a sandstone parting within coal. Drilled core 8010C, 19m (EGi 2016).

Table 6.1 Hylogger™ mineralogical results from drilled core 8010C.

UNIT	LITHOLOGY	MAJOR MINERALOGY	MINOR MINERALOGY	TRACE MINERALOGY	COMMENTS (EGi 2016)
Overburden	Conglomerate	quartz, kaolinite,	microcline, orthoclase, montmorillonite, illite	albite, labradorite, magnesite, hematite	Highly weathered
	Sandstone, Siltstone	quartz, kaolinite	microcline, albite, gypsum	montmorillonite	Slightly weathered
Ace	Coal, sandstone	kaolinite, albite	quartz, microcline, orthoclase, labradorite, illite, muscovite, chlorite	montmorillonite, nontronite, gypsum, jarosite, dickite, siderite, dolomite	Pyrite logged at 17.28 – 17.43, 17.90 -17.95 m
Interburden	Sandstone, Siltstone, coal	quartz, kaolinite	microcline, albite, illite, dickite,	orthoclase, labradorite, muscovite, montmorillonite, nontronite, chlorite, siderite, dolomite, gypsum, jarosite, goethite	Pyrite logged at 26.57 – 26.98 m associated with coal

UNIT	LITHOLOGY	MAJOR MINERALOGY	MINOR MINERALOGY	TRACE MINERALOGY	COMMENTS (EGi 2016)
King	Coal	quartz, kaolinite	microcline, orthoclase, albite, labradorite, muscovite, montmorillonite, illite, chlorite	nontronite, gypsum, jarosite, hematite, siderite, dickite, ankerite, dolomite	pyrite logged at 35.54 – 36.59 and 39.51 – 40.22 m.
Interburden	Sandstone, Siltstone	quartz, kaolinite	microcline, orthoclase, albite, illite	labradorite, muscovite, montmorillonite, siderite, gypsum, goethite, hematite, siderite, ankerite, gypsum	
Queen	Coal	quartz, kaolinite	microcline, orthoclase, albite, labradorite, muscovite, illite, chlorite, montmorillonite. nontronite, jarosite	gypsum, jarosite, hematite, siderite, ankerite, calcite, dolomite	pyrite logged at 76.74 – 77.51, 78.94 – 79.97, 81.31 – 84.94, 85.70 – 86.51 and 123.49 – 125.48 m.
Interburden	Sandstone, Siltstone	quartz, kaolinite	microcline, orthoclase, albite, illite, muscovite, montmorillonite	labradorite, chlorite, siderite, gypsum, hematite	

Table 6.2 Hylogger™ mineralogical results from drilled core 8029C.

UNIT	LITHOLOGY	MAJOR MINERALOGY	MINOR MINERALOGY	TRACE MINERALOGY	COMMENTS
Overburden	Clay, Highly Weathered Basalt	albite, biotite, kaolinite	gypsum, hematite, muscovite, siderite	calcite, goethite, hornblende, magnesite, quartz	
	Basalt	biotite, montmorillonite, muscovite	albite, andesine, augite, biotite, bytownite, hedenbergite, hematite kaolinite, labradorite, orthoclase	actinolite, anorthite, diopside, edenite, enstatite, fayalite, forsterite, gypsum, oligoclase, siderite	

UNIT	LITHOLOGY	MAJOR MINERALOGY	MINOR MINERALOGY	TRACE MINERALOGY	COMMENTS
	Conglomerate, Sandstone, Siltstone	kaolinite, quartz	albite, gypsum	biotite, orthoclase, labradorite, siderite, muscovite, montmorillonite, oligoclase, siderite	
Ace	Coal	No TSA703/TSA704 data	-	-	
Interburden	Sandstone, Siltstone	kaolinite, quartz	albite, illite, muscovite, orthoclase,	biotite, orthoclase, gypsum, hematite, labradorite, montmorillonite, oligoclase, siderite	
King	Coal	No TSA703/TSA704 data	-	-	pyrite logged at 161.43 – 161.56 and 164.91 – 165.19 m.
Interburden	Claystone, Sandstone, Siltstone	kaolinite, quartz	albite, illite, muscovite, orthoclase, siderite	biotite, orthoclase, gypsum, hematite, labradorite, montmorillonite, riebeckite	pyrite logged at 171.15 – 171.51 m in siltstone.
Queen	Coal/Stoney Coal	kaolinite, quartz (Hylogger data only for 190.75 – 191.75 m	muscovite,	biotite, siderite	pyrite logged at 225.82 – 226.11, 226.40 – 226.43, 226.82 – 226.98 and 238.89 - 239.00 m.
Interburden	Sandstone, Siltstone	kaolinite, quartz,	orthoclase, albite, illite, muscovite, montmorillonite, siderite	biotite, gypsum, hornblende, oligoclase	

Table 6.3 Hylogger™ mineralogical results from drilled core 8104C.

UNIT	LITHOLOGY	MAJOR MINERALOGY	MINOR MINERALOGY	TRACE MINERALOGY	COMMENTS
Interburden	Clay, Highly/ Extremely Weathered	kaolinite,	albite, microcline, chlorite, goethite, hematite, illite, montmorillonite, muscovite, orthoclase,	calcite, jarosite, nontronite, siderite	
	Conglomerate, Claystone, Sandstone, Siltstone	kaolinite, quartz	illite, montmorillonite, muscovite,	hematite	
King 2	Coal	No TSA703/TSA704 data	-	-	
Interburden	Claystone, Sandstone, Siltstone	kaolinite, quartz	albite, microcline, goethite, hematite, illite, montmorillonite, muscovite, orthoclase	siderite	
King 3	Coal	No TSA703/TSA704 data	-	-	pyrite logged at 75.55 – 75.94 m.
Interburden	Claystone, Sandstone, Siltstone	kaolinite, quartz	albite, microcline, illite, montmorillonite, muscovite, orthoclase	chlorite, goethite, hematite, labradorite, siderite	
Queen	Coal	No TSA703/TSA704 data	-	-	pyrite logged at 146.98 – 147.12, 147.17 – 147.33, 197.70 – 197.77 and 200.46 – 200.57 m.
Interburden	Claystone, Sandstone, Siltstone	kaolinite, quartz	albite, microcline, illite, montmorillonite, muscovite, orthoclase	chlorite, goethite, hematite, oligoclase, siderite	

The Hylogger™ results are largely as expected for a fluvial sedimentary domain with interbedded coal seams (note that the Hylogger™ technology does not detect coal macerals as mineralogy). The dominant minerals throughout are quartz and kaolinite, with secondary quantities of feldspar (microcline, albite, orthoclase, labradorite) and other clays (illite, montmorillonite, dickite, nontronite). Of interest with respect to waste characterisation is the detection of carbonates (siderite, dolomite, ankerite, calcite, magnesite) at trace levels only, with only a few detections of calcite in the coal and overburden/interburden. The presence of jarosite (iron sulphate) and gypsum (calcium sulphate) is also important as these two minerals are common by-products of pyrite oxidation (jarosite) and subsequent acid neutralisation (gypsum).

The absence of pyrite in the Hylogger™ results is of interest, given the common identification of pyrite in the geological logs. This highlights the low quantities of pyrite in the Tarong Beds at Meandu Mine; however, it also shows the limitations of the Hylogger™ technology to detect all minerals at trace levels. Pyrite was only identified in the geological logs in association with coal, with the exception of a 0.36 m thick interval of siltstone in the interburden of drill core 8029C. The Hylogger™ results have not resolved whether the iron sulphides are marcasite or pyrite. Additional mineralogical investigations including X-ray diffraction are proposed to better inform iron sulphide reactivity and acid generation lag times to inform water quality modelling and waste management at the mine (Section 10).

The speciation of carbonates in the Tarong Beds at Meandu Mine is of crucial importance for understanding the ANC and buffering capacity of the material. Of the relatively minor amounts of carbonate identified, siderite was the most plentiful, being detected in approximately 270 intervals of the three drill cores. Calcite, ankerite, and dolomite were only detected in 18, 15 and 7 intervals of the drill core, respectively. Siderite has the lowest reactivity and buffering capacity of the carbonates present at the mine (EGi, 2016). Therefore, the aggressive oxidation reactions used in NAG testing and to calculate ANC in ABA may overestimate the readily available ANC in static test results (refer Section 7.1.2 for limitations of ABA), potentially leading to false classification of some material as NAF (EGi, 2016).

7 GEOCHEMISTRY

A summary of previous investigations undertaken at the Meandu Mine is included in Section 4, including a summary of geochemical characterisation testing (Table 4.2). A detailed discussion of the testing methodologies conducted at the mine for the systematic geochemical sampling program undertaken from 2016 – 2018 is included below, followed by a breakdown of the geochemical results per waste stream.

7.1 TESTING METHODOLOGIES

7.1.1 SAMPLING

Prior to 2016 the majority of geochemical sampling at Meandu Mine has comprised targeted programs aimed at identifying AMD occurrences in pit lakes (AGCWC 1993a) or in seepage from the NWBFP (AGCWC, 1993b; 1994; 1996; EGi, 2006; 2007; 2016). As extensive geochemical characterisation was required to investigate the source of the observed AMD seepage at RSA1 in 2016 (EGi, 2016; RGS 2018; WSP 2018), a systematic geochemical sampling program was commenced at the mine at the same time to provide geochemical characterisation of future waste material and existing waste (spoil) dumps (EG1, 2016; RGS, 2018).

The majority of samples collected for the systematic geochemical sampling program were open hole rotary chip samples (811 samples, including composites), supplemented by a further 309 diamond drill core samples (EGi, 2016; RGS, 2018). A further 61 drill core samples were added to the dataset in 2020 (SRK, 2021). The bore holes were mainly drilled through *in-situ* formation in the forward mine planning area, with samples of overburden, interburden and coal collected; however, a number of bores were drilled through existing waste dumps to provide samples of older spoil, rejects and tailings. Figure 7.1 shows the location of the chip holes and core holes used for waste characterisation. Additional samples of historic spoil, rejects and tailings were collected from test pits and grab samples from waste dump and TSF surfaces. Representative samples of current process wastes (coal combustion products, tailings and rejects) were collected directly from the waste stream at the point of production (CHPP and power station) over a period of 12 – 14 months.

The sampling strategy for the drilling program aimed to screen the entire mine stratigraphy for acid potential, identify horizons of concern and look for correlations between holes that indicate continuity. Drill chip samples were generally collected at 1 m intervals, although some longer sample intervals from the spoil dump bore holes were required due to poor recovery. In the laboratory approximately one third of the drill chip were composited. Composite intervals ranged from 1 m to 5 m and averaged 2 m. Drill core samples were collected at intervals of 0.5 to 1.8 m, averaging 1 m.

SRK (2019) conducted a review of the Meandu Mine geochemical dataset with the objective of ascertaining the adequacy of the sampling program for waste classification and forward mine planning purposes. The evaluation was undertaken by defining material types present at the mine, and then using:

a) geostatistics to determine the adequacy of sample frequency per material type such that the natural variability of geochemistry within the sample set is captured by the size of the sample set (volumetric representativity), and

b) variography, to determine the adequacy of sample locations spatially for each *in-situ* material type (spatial analysis was not undertaken on the process waste sample sets as location data was not available for most samples) such that the spatial variability of the sample set is captured by the spacing of the sample set (spatial representativity).

SRK (2019) determined that many of the composite samples collected by EGi (2016) and RGS (2018) contained mixed lithologies and that these samples were logged as the majority lithology (e.g. sandstone or siltstone,) but may have been classified as PAF by the static testing because of minor entrained pyritic carbonaceous material. This may have resulted in the classification of the overburden/interburden lithology of sandstone or siltstone as PAF, whereas the acidity in the composite sample was generated by the organic material. Therefore, to ensure that the lithological classifications used in the statistical evaluation were of one lithology only, 334 out of 1,210 overburden and interburden samples that contained mixed lithologies in the detailed logging were removed from the data set that SRK assessed (2019).



Figure 7.1 Chip and core hole locations used for waste characterisation

Following additional drilling, sampling and analysis of overburden samples from the hanging wall of K4S and K4E in 2020, SRK revisited the statistical assessment, particularly with reference to the carbonaceous lithologies previously classified as uncertain with regard to potential for acid formation (SRK 2019).

VOLUMETRIC REPRESENTATIVITY

The geostatistical assessment by SRK (2019) concluded that all non-organic lithologies had sufficient samples to support the geochemical classification assigned to them. Of the organic lithologies, carbonaceous mudstone was the only lithology with significant volume in the overburden/interburden for which insufficient samples were considered to exist to statistically support the geochemical classification. The lithologies sooty coal, carbonaceous sandstone, carbonaceous shale and carbonaceous claystone were assessed to have insufficient sample numbers to support their geochemical classification; however, these lithologies represent insignificant proportions of the overburden/interburden at the mine. Following the additional sampling in 2020, SRK (2021) re-evaluated the representativity of the carbonaceous lithologies as a whole package and determined that there were sufficient samples to support their geochemical classification.

The geostatistical assessment of the process waste streams at the site (rejects, tailings and coal combustion products) concluded that all waste streams had sufficient samples to support their geochemical classification.

SPATIAL REPRESENTATIVITY

Insufficient sample numbers existed to inform meaningful lithology-specific variography for AMD predictive analyses. Using the larger data sets for total S and ANC, variography established a correlation of approximately 150 m, inferring a minimum required sample spacing of 300 m to capture variation of these analytes. Assessment of the existing sampling locations led to the conclusion that spatially all lithologies would benefit from additional infill sampling to give greater confidence in sample representativity. Generally, the centre and north-east of the forward mine planning area were considered less densely sampled than other areas and should be prioritised for future sampling programs. Additional sampling in 2020 in the K4E and K4S forward mine planning area has improved the spatial representativity in this area.

SUMMARY

With respect to the PRCP guidelines (DES 2021) and industry best practice (INAP 2014), the geochemical sampling program is considered to be suitable with regards to being volumetrically and spatially representative of all material being mined and all process waste streams, although additional sampling would be beneficial in the forward mining area and certain lithologies. A gap analysis has been conducted and additional static testing conducted in 2020/2021 has enabled the mine model to be refined in the K4E and K4S areas. Future in-fill drilling and periodic testing will be conducted in the forward mine planning area for K2E (Section 10).

7.1.2 STATIC

Static procedures involve a single measurement in time and are the most commonly used methods to assess the acid forming characteristics at most mines due to cost and time efficiencies. A number of different static procedures have been conducted on rock and process waste streams from Meandu Mine to assess the acid generating potential of the material.

ACID BASE ACCOUNTING (ABA)

ABA involves using static laboratory results to evaluate the balance between acid generation processes and acid neutralising processes (EGi 2016). The value arising from ABA is the net acid producing potential (NAPP) of a sample, which is calculated as the maximum potential acidity (MPA) minus the acid neutralising capacity (ANC) or as a ratio of ANC/MPA. A negative NAPP (i.e. MPA < ANC) indicates the sample may have sufficient ANC to neutralise its contained acid (i.e. NAF) and *vice versa*. In addition, the higher the ANC/MPA ratio, the greater the margin of safety that the ANC is sufficient to neutralise contained acid.

The MPA is calculated using the total S% of a sample. This assumes all S in a sample is in the form of sulphide, and therefore, acid generating, which is conservative as S is commonly present in coal mines in the form of organic S and sulphate S, which do not generate acid. Differentiation of the S speciation in a sample by analysing for chromium reducible S (CRS) can reduce this conservatism.

ANC of a sample is determined by titration with hydrochloric acid and back titration with sodium hydroxide to determine the amount of acid consumed by the sample (modified Sobek method – EGi 2016).

The results of ABA are often presented graphically with lines indicating divisions between positive and negative NAPP and ANC/MPA ratios (Figure 7.2). An ANC/MPA ratio of 2 or more generally signifies there is a high probability that the material will remain circum-neutral in pH and should not be problematic with respect to AMD (EGi 2016).

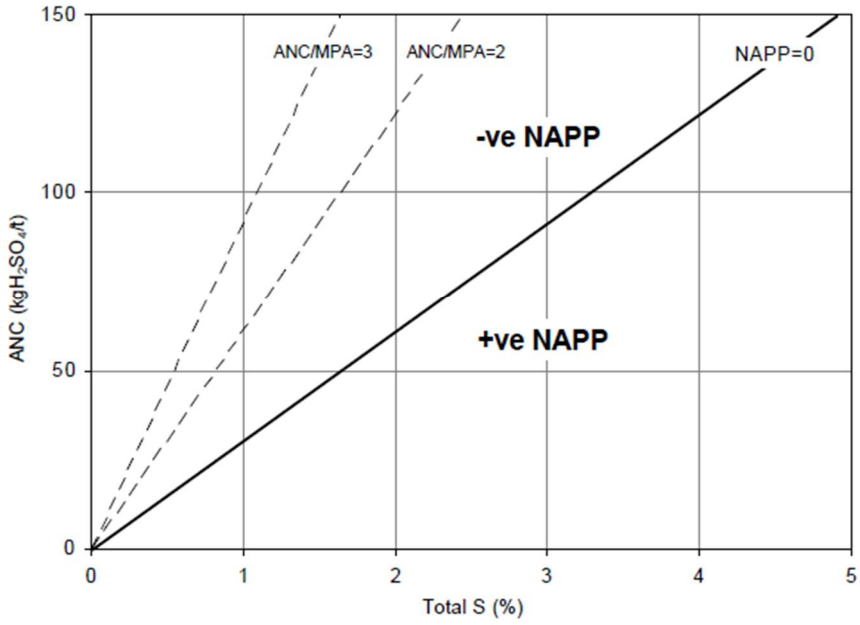


Figure 7.2 Acid-base account (ABA) plot (from EGi 2016)

ABA was conducted on the majority of geochemical samples collected at the Meandu Mine since 1993 (AGCWC 1993a, 1993b, 1994; Bethane 1996; EGi 2006, 2008, 2016; PW Baker 2018a, 2018b; RGS 2018, Unpublished 2020).

NET ACID GENERATION (NAG) TESTS

The NAG test involves the reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals within a sample. During a NAG test acid generating and acid neutralising reactions can occur simultaneously, with the end result representing a direct measurement of the net acid generated by the sample, expressed as NAGpH (final solution pH) and NAG capacity (in kg H_2SO_4/t). Several variations of the NAG test have been developed in the industry to deal with variable geochemical conditions at specific mine sites. The NAG tests conducted on Meandu Mine materials were single addition NAG tests, extended boil and calculated NAG tests, and kinetic NAG tests (Section 7.1.3).

The single addition NAG test involves the addition of one dose of hydrogen peroxide to the samples, which is left overnight to react then gently heated to complete oxidation of all sulphides in the sample. The pH of the solution is then measured and the solution is titrated back to pH 4.5 and pH 7 to calculate acidity due to free acid and soluble iron and aluminium, and soluble metallic ions that precipitate as hydroxides, respectively.

The single addition NAG test can be unreliable for samples with high organic carbon, such as coals and carbonaceous sediments, as organic acids unrelated to sulphide oxidation can be generated by the NAG tests, leading to erroneously low NAGpH values and incorrect classification as PAF. The extended boil and calculated NAG test can differentiate the acidity between that generated by organic acids and sulphide oxidation. The extended boil and calculated NAG test involves boiling the filtered solution from a single addition NAG test and measuring the final pH. The extended boil decomposes the organic acids and the final solution pH is measured to indicate acid forming potential. Analysis of S may also be required to calculate the amount of H_2SO_4 generated and analysis of major cations/anions is then used to estimate the amount of acid neutralised. Eighty samples with high organic carbon were selected for extended boil and calculated NAG testing (EGi 2016).

OTHER METHODS

Paste pH and EC were measured from the majority of geochemical samples collected over the life of the mine. This measurement gives an indication of the inherent acidity and salinity of the waste material when initially exposed to the environment in a waste depository or stockpile.

Speciated S analysis was conducted using CRS in more recent studies at the mine (PW Baker 2018a, RGS 2018, Unpublished 2020) to quantify the proportions of sulphide S, sulphate S and organic S in the mined material. These

results can be used to indicate whether the cheaper and easier analysis for total S provides an adequate representation of the acid generating potential of waste rock and process waste.

SUMMARY

Static testing using ABA and NAG testing has been the most commonly used method to determine the AMD characteristics of the mined material and process wastes at Meandu Mine. The static geochemical testing at Meandu Mine is considered to meet best practice standards as proscribed in the PRCP guidelines (DES 2021) with reference to sampling procedures, analytical suites and data analysis. SRK (2019) did identify potential issues with sample classification and sample lithological assignation of the sampling undertaken by EGi (2016) and RGS (2018) (Section 7.1.1); however, this is not a reflection on the sampling, testing and analysis of the static testing, only the final lithological classification. The implications of the potential classification issues are discussed in Sections 7.3-7.6. Data gaps with regard to the static testing sample data set are discussed in Sections 7.1.1 and 10.

7.1.3 KINETIC

Static testing only provides a snapshot in time of the acid generating potential of rock or process waste. Kinetic testing enables the prediction of oxidation and neutralisation rates within mined material and provides concentrations of contaminants that may be leached from the material under environmental conditions. The information gained from kinetic testing can be used as input into water quality models, inform waste management strategies, storage facility and cover designs and potential future leachate liabilities. Kinetic testing should also be used to confirm the results gained from static testing.

Three forms of kinetic test have been conducted on the mined material at Meandu Mine, kinetic NAG testing, acid buffering characteristic curve (ABCC) and kinetic column leach testing.

KINETIC NAG TESTS

The kinetic NAG test is the same as the single addition NAG test except that the temperature and pH of the liquor are recorded. Variations in these parameters during the test provide an indication of the kinetics of sulphide oxidation and acid generation. This, in turn, can provide an insight into the behaviour of the material under field conditions. For example, the pH trend gives an estimate of relative reactivity and may be related to prediction of lag times and oxidation rates similar to those measured in leach columns. Also, sulphidic samples commonly produce a temperature excursion during the NAG test due to the decomposition of the peroxide solution, catalysed by sulphide surfaces and/or oxidation products. Five samples at Meandu Mine have had kinetic NAG testing conducted (EGi 2016).

ACID BUFFERING CHARACTERISTIC CURVE (ABCC)

The ABCC test involves the slow titration of a sample with acid while monitoring the pH. The drop in pH graphed against the quantity of acid added provides an indication of the portion of ANC within a sample that is readily available for acid neutralisation and potential lag in a sample before acid is generated. EGi (2016) conducted ABCC testing on 22 samples of overburden/interburden and one sample of coal rejects.

KINETIC COLUMN LEACH TESTS

Ten rock and process waste stream materials were selected for kinetic column leach testing by RGS (2018) from drill cores or grab samples from the CHPP and ash voids. Ten columns were constructed filled with one material only and a further 13 columns were filled with variable mixes of overburden and waste streams or addition of an agricultural limestone (calcium carbonate) as an acid ameliorant (RGS 2018).

The experimental method used by RGS (2018) involved placement of waste/spoil material that had been crushed to pass a 20 mm sieve into a polycarbonate column of 20 cm diameter and 50 cm height (volume of 18.5 L) with a leachate collection tap at its base. A monthly leach cycle was conducted on each column, with each leach event comprising the addition of 1.4 L of deionised water (equating to a rock:water ratio of approximately 10:1), which was left to percolate and remain in the column for 24 hours. After 24 hours the tap was removed and the leachate collected for submission to a laboratory and analysis for pH, EC, acidity, alkalinity, major ions and metal(loid)s.

One column (weathered basalt) was impermeable and did not generate a leachate and was discontinued after one month of testing. Ten of the columns were discontinued after 15 months as the leachates were considered to have stabilised and stopped reacting. The remaining 12 columns were leached for a total of 32 months before being discontinued.

Additional kinetic column leach testing has been commenced in September 2021, the scope and objectives of which are discussed in Section 10.

SUMMARY

There are no formal standards available for column leach testing (INAP 2014), although suggested methodologies do exist in the literature and saturated leaching standards do exist (ASTM D4874 – 95). The methodology developed by RGS has been designed to maximise range of particle sizes thereby creating more flow paths in the columns and allowing more water-rock interaction. This is considered to generate a leachate more representative of field conditions (RGS 2020). SRK (2019) raised concerns regarding whether the columns containing finer-grained material such as tailings were sufficiently drying out between leach events to sufficiently oxidise the sample. However, the concern was driven by the fact that at the time of reporting the tailings column had not generated acid, which contradicted the static testing results for the tailings. With additional time the leachate from the tailings column has become slightly acidic (RGS, 2020), indicating the tailings were being oxidised in the column and addressing the concerns made by SRK (2019). The methodology of the kinetic testing and analysis of rock/process wastes is considered suitable for the Meandu Mine waste material and of sufficient standard to satisfy the PRCP guidelines (DES 2019).

Regarding the sample data set on which kinetic testing has been conducted, kinetic testing only exists for individual weathered basalt, shale, conglomerate and sandstone samples collected from the overburden in the proposed future K2E mining area. Therefore, several lithologies and units are not represented by kinetic testing, including carbonaceous mudstone, which has an uncertain acid generating classification under the SRK (2019a) scheme (Section 7.2). In addition, the sample set is considered by SRK (2019a) to under-represent the overburden and interburden at the site both spatially and numerically and additional kinetic testing was recommended by SRK to verify the classification of non-acid forming (NAF) and PAF materials at the site more accurately.

Kinetic testing has been done on all process waste streams and although only one or two leaching columns have been conducted on each process waste stream, the consistency of results and the alignment of the kinetic results with the static testing suggests that the existing kinetic testing is sufficient to predict waste behaviour and inform current and future waste management.

A gap analysis has been conducted and additional kinetic testing has started in September 2021 (Section 10 and Figure 7.3), results of which will enable refinement of the static waste classifications and is expected to fill data gaps in the forward mine planning area.

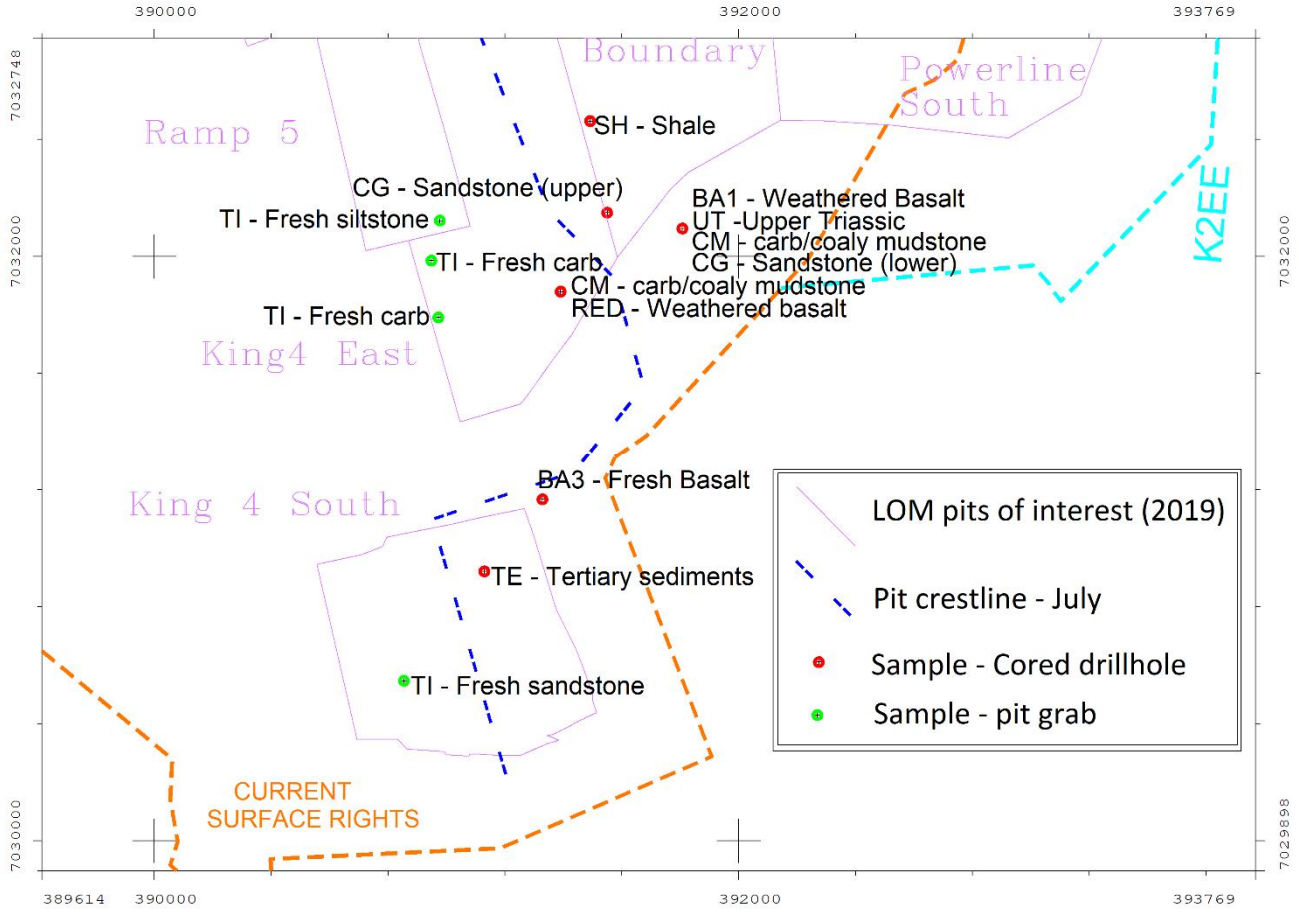


Figure 7.3 Mine forward planning area – Target material of kinetic leach column sample locations

7.2 WASTE CLASSIFICATION SCHEME

RGS (2018) developed a site-wide geochemical classification system based on industry standard practice ABA accounting methods, using total sulphur content and the NPR (maximum potential acidity divided by ANC).

A review of the waste characterisation results of EGI (2016) and RGS (2018) led SRK (2019) to suggest that the waste classification system could be simplified and made more practical for site management purposes. The AC class of material was found to comprise <1% of the total number of samples and was not considered a practical proportion of the material for waste categorisation and management. The NAF-UC class was found not to generate acid in the kinetic tests and it was considered that incorporating it into the NAF class would not compromise the integrity of the classification system. Likewise, the combination of PAF-UC and PAF-LC into one uncertain (UC) class was considered suitable for mine management requirements. The simplified AMD classification system is shown in Table 7.1.

Table 7.1 Updated geochemical classification system for mine waste materials (SRK 2019)

MATERIAL TYPE	CLASSIFICATION CRITERIA
Non-Acid Forming (NAF)	TS < 0.05% or 0.05% TS <0.2% and NPR > 2, or weathering logs extremely weathered (XW) and highly weathered (HW)
Uncertain (UC)	0.05 < TS% < 0.2% and NPR ≤ 2
Potentially Acid Forming (PAF)	TS% > 0.2%

The three class waste classification system is considered functional in an operational setting and will align with mine's waste management strategy. As such, the system has been adopted by Meandu Mine for ongoing waste classification (including rejects, tailings and coal combustion products) and has been incorporated into the operating mine block model to manage waste disposal and rehabilitation requirements (Section 9).

7.3 WASTE ROCK (OVERBURDEN/INTERBURDEN)

The interburden at Meandu Mine consists of sediments of the Tarong Beds, whereas the overburden consists of Tarong Beds, Main Range Volcanics and minor Quaternary Alluvium (Section 3). For the purposes of waste characterisation, lithotypes as used in the geological logging were used, with the assumption that each lithotype has similar geological and chemical properties regardless of its position in the stratigraphic profile (SRK 2019). The results of the lithotype classification were applied to a simplified mine model, which divided up the stratigraphy at the mine into stratigraphic units and assigned an average classification for the unit based on the logged lithotypes.

The lithotypes used for waste characterisation of the overburden/interburden are shown in Table 7.2, noting several lithotypes used by Meandu Mine were not included as they comprised an insignificant part of the mined material.

Table 7.2 Lithotypes used for waste characterisation at Meandu mine

COAL LITHOTYPES	ORGANIC LITHOTYPES	NON-ORGANIC LITHOTYPES
CN – stony coal	XC – carbonaceous claystone	AG – agglomerate
CO - coal	XH – carbonaceous shale	BA – basalt
CU – coal undifferentiated	XM – carbonaceous mudstone	CG – conglomerate
CW – coal weathered	XS – carbonaceous siltstone	CL – clay
CY – sooty coal	XX – carbonaceous sandstone	CS - claystone
LG - lignite		SL – siltstone
		SO – soil
		SS - sandstone

No significant difference could be established for each lithotype between the geochemical results for both overburden and interburden; therefore, the characterisation results are discussed by lithotype with no distinction between overburden and interburden.

The majority of overburden/interburden geochemical samples collected at Meandu Mine prior to 2016 were samples of spoil from previously mined material. These studies were generally undertaken as part of investigations into the source of AMD expressions in K1 pit (AGCWC 1993a, 1993b) and Ramp 7 (Kilah 1995, Bethane 1996). Whilst providing important information on the behaviour and geochemistry of spoil post-mining and storage, this data is of little use when assessing the geochemistry of the *in-situ* overburden/interburden by lithotype or for mine modelling purposes. Therefore, the geochemical information presented in this section is mostly based on the work by EGi (2016), RGS (2018, 2020) and SRK (2019, 2021).

7.3.1 AMD POTENTIAL

SPOIL

139 spoil samples comprising overburden/interburden and some weathered coals were submitted for ABA analysis prior to 2016 at Meandu Mine. The spoil showed a large range in total S%, ranging from <0.01% to 1.24%; however, lithological information is lacking for the samples that returned the highest S percentages and it is likely those samples contained appreciable coal and would likely be classified as rejects if sampled today. ANC and NAPP also showed high variability, ranging from -15 – 10 kg H_2SO_4/t and -9 to 19 kg H_2SO_4/t, respectively. However, most samples returned a slightly negative NAPP, indicating little to no AMD generating potential, but also little to no ANC.

Analysis of spoil in the NWBFP was conducted by EGi (2016) and RGS (2018); however, the results were difficult to interpret because differentiation between rejects, tailings and spoil in the samples was not always possible. The samples that were positively identified as spoil returned total S% of 0.06 – 0.36% with sulphide S being <0.02% CRS in all but one sample, indicating a low acid producing potential.

An extensive spoil field screening exercise conducted by QGESS (2017) involved the sampling of 1,135 drill chip samples collected from previously mined spoil proposed for re-mining in the Central Pit and Ramp 5. The chips were analysed for paste pH with results ranging from 2.62 to 7.96. Despite the large range in results, 89% of the Central Pit samples returned a pH >5 and 96% of the Ramp 5 samples returned a pH>5, indicating the majority of the spoil is unlikely to be acid generating. However, zones of low pH, caused by actual acidity (i.e. sulphide oxidation in these areas had already generated acidic conditions) and PAF material were identified in the northern section of the Central Pit. Areas of PAF material were less common and less severe further south in the Central Pit and Ramp 5.

Test pit sampling of spoil in the K2E low wall (QGESS 2020) involved the analysis of 61 samples from 16 test pits of varying lithologies, though most of the samples were of Triassic interburden with lesser amounts of Upper Triassic overburden (sandstone, conglomerate and claystone) and weathered basalt. With the exception of two Triassic interburden samples that were classified as UC, all samples returned a classification of NAF.

STATIC TESTING

The systematic *in-situ* geochemical sampling programs of EGi (2016) and RGS (2018), coupled with the geostatistical analysis by SRK (2019, 2021), has enabled waste characterisation of the overburden/interburden without the lithological and provenance uncertainties associated with the spoil sampling. A breakdown of the overburden/interburden classifications by lithotype is presented in Table 7.3.

Table 7.3 Acid generation potential classification of overburden/interburden by lithotype at Meandu mine (after SRK 2019)

ORGANIC LITHOTYPES	NUMBER OF SAMPLES			NON-ORGANIC LITHOTYPES	NUMBER OF SAMPLES		
	NAF	UC	PAF		NAF	UC	PAF
CO	3	11	44	BA	13	1	0
CU	0	2	0	CG	38	1	0
XM	6	7	1	CL	21	16	0
XS	33	10	1	CS	48	15	1
CN	0	1	1	SL	197	47	1
CW	0	1	1	SS	272	46	4
LG	0	0	3	AG	1	0	0
XX	1	1	0	SO	1	1	0
TOTALS	43	33	51	TOTALS	591	127	6

The results in Table 7.3 demonstrate that 81% of the samples collected from non-organic lithotypes in the overburden/interburden are NAF, with <1% returning a PAF classification. Pyrite at Meandu Mine appears to be solely associated with organic material (Section 6), which explains the number of organic lithotype samples classified as PAF. SRK (2019) observed that 45 of the non-organic lithotype samples that returned a UC classification were adjacent to organic lithotypes, which may have led to some organic and pyritic material being present in the sample and a UC classification resulting.

Geostatistical analysis of the ABA results has established that all non-organic lithotypes are NAF on average and at a 95% confidence interval, whereas all coal lithologies (CO, CN, CW, CU, LG) are PAF on average. Carbonaceous mudstone (XM) is UC on average and XS and XX are NAF on average.

SRK (2021) re-assessed the ABA results for the carbonaceous lithologies (X group) by combining all results for XC, XH, XM, XS and XX and geostatistically assessing the group as a whole, which resulted in an overall classification of the group as NAF.

The results of the ABA were also applied to a simplified geological model to attempt to categorise overburden/interburden units at the mine by acid generation potential.

Table 7.4 Acid generation potential classification by geological unit at Meandu Mine (after SRK, 2019)

GEOLOGICAL UNIT	NUMBER OF SAMPLES		
	NAF	UC	PAF
Clay	20	16	0
Basalt	12	1	0
Conglomerate sandstone	102	14	0
Triassic	26	5	0
Tertiary (including lignite)	22	7	3 (all lignite)
Shale	102	18	2
Interburden Tarong Upper	75	45	24
Interburden King 4 to Ai	98	21	4
Interburden Tarong Lower	179	33	32

The breakdown of results by unit demonstrates that, excluding the lignite in the Tertiary, no PAF material was identified in the overburden. Geostatistical analysis of the results indicated all overburden units (excluding lignite) are NAF on average. Appreciable percentages of the samples from Tarong Upper and Lower interburden Units returned PAF classifications (16% and 13%, respectively); however, geostatistical analysis indicated that the Tarong Upper Unit was UC on average and the Tarong Lower Unit was NAF on average. This analysis did not differentiate between coal and non-coal in the interburden and the PAF classifications are all associated with carbonaceous material (SRK 2019). Geochemical modelling of the interburden conducted by mixing PAF (highly carbonaceous) material with non-PAF (NAF or UC) material established that an upper threshold mixing ratio of 25% PAF material would result in an average sulphur content of 0.1% and would be considered NAF (SRK 2021).

KINETIC TESTING

The static testing results support the theory that the non-organic lithotypes at Meandu Mine do not contain any PAF material and all PAF samples and the majority of UC samples originate from fresh material related to organic lithologies (SRK 2019). To confirm the static testing results by assessing the reactivity of the samples over time, kinetic leach testing was undertaken on five overburden samples comprising weathered basalt (two samples), conglomerate, sandstone and shale (RGS 2018, 2020).

The weathered basalt column containing material from the base of the Tertiary was impermeable and did not generate leachate. The other column containing weathered basalt generated an acidic leachate initially, which rose steadily to stabilise at a pH of approximately 5.5. The acid was attributed to soluble and exchangeable Al and Mn rather than sulphide oxidation (RGS 2018), although moderate (212 mg/L) concentrations of SO_4 were measured in the leachate initially. The sample used for this column was the only basalt sample which static testing returned a classification of UC due to the slightly elevated total S% of 0.18% and minimal ANC of 0.3 kg H_2SO_4/t. The column leach results confirm the NAF classification for basalt at Meandu Mine, although the material may leach mildly acidic leachate due to the soluble Al and Mn.

Two columns containing weathered basalt mixed with coal rejects established that the weathered basalt was ineffective at slowing acid production from the rejects (RGS 2020), indicating that the basalt has insignificant ANC.

The column containing overburden logged as a mixture of conglomerate and coarse-grained sandstone generated a leachate that remained circum-neutral throughout the testing period, with the pH climbing slightly from 7.7 to 8.3 over 62 weeks. The static testing classified the sample as NAF and the column testing confirmed the classification.

The column containing overburden logged as weathered sandstone generated an initial acidic leachate of pH 4.16 which steadily decreased to approximately 2.8 and then stabilised at pH ~3 for the duration of the testing (132 weeks). The low pH and duration of acid generation from this sample was surprising, as the static testing results for this sample indicated a UC classification due to the low total S% (0.06%) and minimal ANC of 0.25 kg H_2SO_4/t. The column results indicate that the absence of ANC in the sample means that even small concentrations of sulphide minerals can generate AMD and infers that some of the overburden classified as UC may generate acid. It should be noted that the material contained within this column is not considered representative of most sandstone at the mine as a relatively S-rich sample was chosen for use in the column.

The column containing overburden logged as mudstone and claystone, modelled within the shale overburden unit, generated a neutral leachate (pH 7.16) initially, which dropped to pH 5 after 12 weeks and then fluctuated between 5.5 and 6 for the remainder of the testing (132 weeks). The sample was classified as UC by the static testing. The sulphide S content of the sample had minimally decreased from 0.033% CRS to 0.023% CRS during the 132 weeks of testing, which suggests that acid generation may occur with ongoing leaching. However, there is a lag time of at least 132 weeks before acid generation. It should be noted that the material contained within this column is not considered representative of most mudstone and claystone at the mine as a relatively S-rich sample was chosen for use in the column.

Additional kinetic testing has started in September 2021 (Section 10) to address identified gaps in the kinetic testing data set, results of which will enable refinement of the static waste classifications and is expected to fill data gaps in the forward mine planning area.

SUMMARY

The results of the static testing of the overburden/interburden indicate that the great majority of the overburden material and approximately 85% of the interburden is classified as NAF. The static testing results of the spoil also suggest the majority of the spoil is NAF, although the material is highly heterogeneous and isolated areas of actual acidity and PAF have been identified (QGESS 2017). Sulphidic material is limited almost exclusively to organic lithotypes in the Mine stratigraphy (SRK 2019). However, the results of the kinetic testing suggest there are exceptions to the rule, with the weathered sandstone column generating appreciable acidic leachate for the duration of the testing.

Surface water (in pit and seepage) monitoring at Meandu Mine supports the above findings, with limited and occasional acidic conditions found in some areas of the mine, particularly in the first 5 years of operation, but generally surface water conditions have been circum-neutral. Spoil from the overburden is considered unlikely to generate significant AMD and any small pockets of acid generated should be diluted by non-acidic drainage from the majority of rock. Spoil from the interburden units has a higher potential for AMD generation due to the higher content of organic material in the rock; however, significant AMD generation is considered unlikely due to the majority of NAF rock in the units. Ongoing management strategies for the overburden/interburden are detailed in Section 9.2.

7.3.2 NMD/SMD POTENTIAL

Whilst the AMD generation potential of the overburden/interburden is considered low, concern regarding the potential for SMD to be generated by the overburden/interburden has been raised (PW Baker 2011, RGS 2018). Static testing of the waste rock by EGi (2016) included EC testing of rock chips and water extraction tests on a subset of 30 samples, including analysis of major ions and metals/metalloids. This provided an indication of the inherent salinity of a large number of samples and an indication of potential NMD from a representative subset of overburden/interburden samples. Ninety five percent of the rock chips returned non-saline ECs of <400 µS/cm with the highest result being 800 µS/cm (EGi 2016), indicating low immediately available salinity in the overburden/interburden. The water extraction tests returned similar results, with extractant ECs ranging from 110 to 1,250 µS/cm. In addition, no broad elevated metal trends were observed in the extractants, with isolated elevated concentrations of Al, Co, Cu, Fe, Ni and Zn (EGi 2016).

The solubility of metals/metalloids will largely be determined by pH and therefore control of acid generation will generally control metal leaching. Samples with elevated S (>0.5%S) also have the potential to produce circum-neutral leachates during the lag phase with slightly elevated Co and Zn. Overall, results indicate circum-neutral leachates from low S (<0.3%S) materials represented by the samples tested are likely to contain low concentrations of metals and metalloids (EGi 2016).

The samples collected during spoil field screening exercise conducted by QGESS (2017) from previously mined spoil proposed for re-mining in the Central Pit and Ramp 5 had EC ranging from 136 to 1,557 µS/cm. Ninety seven % of the Central Pit samples and 92% of the Ramp 5 samples returned EC <1,000 µS/cm, indicting the material is unlikely to generate saline drainage. Sampling from K2E spoil (QGESS, 2020) returned EC results ranging from 66 to 3,720 µS/cm; however, 57 of the 61 samples had an EC <500 µS/cm and the three weathered basalt samples had an average EC of 1,460 µS/cm. This indicates that the majority of the interburden and overburden samples are unlikely to generate saline drainage; however, the weathered basalts may generate drainage with more-elevated EC.

The column leach testing provides an indication of potential drainage water qualities over a longer term from the individual lithotypes tested in each column.

The leachate generated by the column leach test containing weathered basalt initially had an elevated EC of 3,600 µS/cm, which was dominated by NaCl and SO_4^-. The EC (and associated NaCl) dropped within 24 weeks to <1,000 µS/cm, suggesting the salinity was a result of flushing of easily dissolved salt within the weathered rock. Aluminium (2 mg/L) and Mn (0.2 mg/L) were also present in the initial weeks of testing due to disassociation of soluble and exchangeable Al and Mn from the clays in the weathered basalt. The leachate results indicate the weathered basalts are likely to generate moderately saline drainage with elevated Al when first mined and deposited on waste (spoil) dumps, but ongoing leachate will likely have low salinity and metal concentrations.

The leachate generated by the conglomerate/coarse grained sandstone column also initially had a relatively elevated EC (2,400 µS/cm) dominated by elevated NaCl; however, the leachate dropped at the first leaching event to ~1,000 µS/cm as the readily dissolved salts were flushed from the column. The initial saline flush was low in all metals except Selenium (0.36 mg/L), which decreased with ongoing leaching but remained at concentrations above compliance point trigger values. After four to eight weeks of testing dissolved Al and Fe became elevated in the column leachate. The results indicate the conglomerate/coarse sandstone will likely generate a short-lived saline first flush but has the potential to generate drainage with slightly elevated Se, Al and Fe. It should be noted that as this sample was collected from the very top of the Triassic at the unconformity with the overlying weathered basalt, some leaching of salts from the basalt may have contributed to this initial saline flush from the column.

The leachate generated by the column containing weathered sandstone had elevated EC, SO_4^- and metals (Al, Co, Fe, Ni, Se, U and Zn) associated with the acidic conditions generated in the column. The salinity and elevated metals in this leachate are not considered NMD/SMD.

The leachate generated by the column containing mudstone/claystone from the shale unit generated moderate EC (~2,000 µS/cm) at the commencement of the testing, which steadily decreased with ongoing leaching, dropping below 1,000 µS/cm after 52 weeks of testing. The salinity was dominated by NaCl and SO_4^- but did not show a rapid decrease indicative of a rapid flush of readily dissolved salts as seen in the basalt and conglomerate/sandstone columns. The leachate showed a steady decline in EC, driven by Na and SO_4^- concentrations, suggesting ongoing sulphide oxidation is occurring in the material. The leachate shows elevated Co and Zn, which appears to be related to the highest SO_4^- concentrations from week 9 to 30 and is likely related to sulphide oxidation.

In summary, the overburden/interburden appears to have variable potential for generating NMD/SMD, with static testing suggesting most material has a low potential for generating saline drainage and that isolated parts of the Meandu Mine may generate leachate with one or more elevated metal concentrations. The column leach testing indicated the potential exists for saline metalliferous flushes being generated from overburden when first mined and exposed to rainfall. Ongoing drainage with elevated Se, Al and Fe may also be generated by the overburden; however, other elevated metal leaching appears to be related to sulphide oxidation. It should be noted that the material used in the column leach testing might not be representative of the greater rock mass at Meandu Mine (Section 7.1.3 and 0).

7.3.3 FINAL VOID WALLS

The current Life of Mine Plan indicates that the K2E and K4E Pits will become final residual voids that may contain water beyond closure. There has been extensive static geochemical testing of material from the highwalls of these pits, collected from bore holes located near the final pit shells (bore holes 7942R, 7951R, 7952R, 8034C, 8035C, 8043C, 8050C, 8082C, 8088C, 8089C, 8106C, 8111C, 8113C, 8439C, 8440C, 8454C, 8456C, 8458C, 8460C and 8461C). The static testing verifies that at least two thirds of the samples, including some of the coal are NAF and that the majority of the PAF material is present in the coal (RGS 2018). There is also an extensive history of water present in these pits (Section 5.1) and the data verifies that the water body has retained circum-neutral pH and low to moderate salinity.

The water extraction tests conducted by EGi (2016) used drill core material from bore holes 7942R, 7951R and 7952R to provide an indication of likely first flush and short to medium term run-off from the K2E highwall. As described in Section 7.3.2, the results indicated low immediately available salinity or elevated metal concentrations in the overburden/interburden. Coal samples were analysed from the Central Pit future mining area but are considered representative of remnant coal layers that will be present in the final K2E and K4E pit walls. The extractants from the coal samples returned slightly acidic values (pH 4 – 5.8) with associated elevated concentrations of Al, Co, Fe, Mn, Ni and Zn.

Selected material used in the overburden static testing described above was selected to provide kinetic leach data indicating potential final void water quality in Pit K2E. The specific results of each lithotype are described in Sections 0 and 7.3.2, which suggests that longer term drainage from the overburden/interburden is potentially highly variable, with some AMD, SMD and NMD potential. It should be noted that the material used in the column leach testing might not be representative of the greater rock mass at Meandu Mine and the general pit water quality over the mine life suggests that drainage and/or runoff from pit walls at the Meandu Mine does not tend to be highly saline, acidic or metalliferous. Additional kinetic testing has been commenced as of September 2021 to provide more certainty on the likely long-term drainage water quality from the final pit highwalls.

7.4 COARSE REJECTS

The potential for the coarse rejects waste stream to generate acid was recognised relatively early at the mine (AGCWC, 1993a) and that, coupled with the identification of coarse rejects potentially being responsible for the AMD at Ramp 7 (AGCWC, 1996) has resulted in multiple geochemical studies characterising the coarse reject waste stream and previously deposited rejects *in situ* at the RSA (AGCWC, 1993a; 1994; 1996; Kilah, 1995; Bethune, 1996; EGi, 2006; 2007; 2016; QGESS, 2018; PW Baker, 2018; RGS, 2018; 2020; SRK, 2019). However, the majority of the earlier studies only included static testing; therefore, the geochemical information presented in this section is mostly based on the work by EGi (2016) and RGS (2018, 2020)

7.4.1 AMD POTENTIAL

The expression of AMD in King 1 Pit in 1992/1993 triggered the investigations by AGCWC (1993a; 1993b) into the geochemistry of the coarse rejects waste stream at Meandu Mine. The rejects were found to contain relatively low total S (0.04 – 0.11%), with NAPP results of -4 – 4 kg H_2SO_4/t, averaging 1 kg H_2SO_4/t, indicating variable acid generating potential with a low capacity.

Since that study a total of 175 coarse reject samples collected at Meandu Mine have had ABA conducted, returning total S% ranging from 0.004 – 0.46, ANC ranging from 0 – 20.7 kg H_2SO_4/t and NAPP ranging from -9.7 – 11.6 kg H_2SO_4/t. The low total S of the rejects and uncertainties associated with impacts of organic S on the NAPP results have led to variable conclusions regarding the acid generating potential of the coarse rejects at the mine (e.g. EGi (2006, 2007) concluded the rejects were NAF). However, PW Baker (2018b) recognised that some of the earlier results suggesting the rejects were NAF may have been caused by the rejects having been extensively weathered prior to sampling.

Sampling and analysis of the coarse rejects waste stream at the CHPP by EGi (2016 and RGS (2018) indicated the majority of samples were PAF with some uncertain results. Classification of *in-situ* coarse rejects from Hitachi Hill (NWBFP) and RSA1 are less conclusive, returning mainly uncertain results. However, this is likely to reflect either *in-situ* weathering, co-mingling with NAF overburden, or both (SRK 2019). Geostatistical analysis by SRK (2019) concluded that sufficient kinetic sampling has been conducted to support the PAF classification for coarse rejects at Meandu Mine.

The static testing classification of coarse rejects as PAF necessitates detailed knowledge of the kinetic behaviour of the rejects to support AMD prevention and waste management. Kinetic testing of coarse rejects prior to 2016 was contradictory, with field heap leach trials conducted by Bethane (1995) generating leachate with pH ~3 – 4 and SO_4^- concentrations up to 3,200 mg/L, whereas in the column leach test on coarse rejects collected from RSA1 by EGi (2007) the leachate remained circum-neutral throughout the 52 weeks of testing and contained negligible acidity. The kinetic leach testing conducted by RGS (2018, 2020) included three columns containing coarse rejects in an effort to resolve the uncertainties of earlier testing. In addition, 12 columns containing mixtures of rejects and other materials (tailings, ash, spoil, basalt, limestone) were tested to simulate potential management strategies to mitigate/prevent AMD generation from the rejects.

The three columns containing coarse reject generated acidic leachate within 21 weeks of testing, with the leachate stabilising at a pH of approximately 3 after 1 year to 18 months of testing. These results confirm the PAF classification of the coarse rejects and indicate a relatively short lag time (within 6 months) before the generation of acid.

The results of the columns containing mixtures of coarse rejects and other mine waste material indicated that mixing coarse rejects with overburden (weathered basalt and sandstone) doubled the lag time to acid generation to approximately 60 weeks and mixing with fine grained tailings increased the lag time to acid generation to approximately 90 weeks. In the coarse reject column to which lime was added the leachate remained circum-neutral for the duration of the testing (132 weeks).

Current consensus is that the expression of AMD at Ramp 7 and Bullgang Drain is a result of the oxidation and subsequent flushing of oxidation products from historically placed coarse rejects on RSA1 and in the NWBFP generally (WSP 2018). Static and kinetic testing confirms the coarse reject waste stream to be PAF and ongoing waste management is required to prevent further occurrences of AMD at Meandu Mine through preventing the oxidation of the coarse rejects. Ongoing management strategies for the coarse rejects are detailed in Section 9.3.

7.4.2 NMD/SMD POTENTIAL

As the coarse rejects are PAF, the generation of drainage with elevated EC, SO_4^- and dissolved metals is expected, as evidenced by the water quality data from Ramp 7, Bullgang Drain, RD7 and RD8 (Section 5.2). The coarse reject column leach tests (RGS 2020) also generated leachates with elevated metals (Al, Cu, Pb, Ni and Zn); however, EC and SO_4^- were not greatly elevated in the column leachates. RGS (2020) concluded this was likely the result of precipitation of secondary sulfate minerals, most likely jarosite, within the column. These secondary minerals retain some metals (particularly Fe), acidity, salinity and SO_4^- until they become unstable at higher pH (~4.5). The precipitation of these secondary minerals results in the continued release of oxidation products (acidity, Fe, SO_4^-) long after pyrite has been depleted and oxidation has ceased. Prevention of oxidation of the rejects on disposal is the optimal management strategy to avoid this scenario (Section 9.3).

The generation of NMD and/or SMD is also possible in the scenario whereby leachate from coarse rejects is kept neutral through the addition of lime or tailings; however, oxidation products are still released into the leachate despite the pH remaining circum-neutral. The results of mixed column leach testing undertaken by RGS (2020) suggests that this is not likely to be an issue with regard to lime addition, as the leachate contained dissolved metal concentrations at or near the laboratory limit of reporting (excepting strontium (Sr), which was at concentrations of 0.1 – 0.176 mg/L for the first 6 months of testing) and low leachate EC (~600 µS/cm) and SO_4^- (~190 mg/L).

The results were similar in the column with mixed coarse rejects and tailings, excepting that dissolved leachate concentrations of Mn (1.05 – 1.71 mg/L) and Zn (0.068 – 0.241 mg/L) were elevated in the first 26 weeks of testing, despite the pH being at 6.5 – 7.15.

These results indicate that there is the potential for the coarse rejects to generate NMD, even if co-mingled with tailings; therefore, prevention of oxidation of the coarse rejects is important regardless of the co-disposal strategy of the waste streams. Ongoing management strategies for the coarse rejects are detailed in Section 9.3.

7.5 TAILINGS

The tailings (or fine rejects) have been the focus of numerous geochemical studies at the site since 1993 (AGCWC 1993, Kilah 1995, Geo-Environmental Management 2005, EGi 2008, PW Baker 2011, EGi 2016, RGS 2018, SRK 2019 and RGS 2020). Whilst results have been similar in most of the studies, interpretations have evolved with time. Therefore, the geochemical information presented in this section is mostly based on the work by EGi (2016) and RGS (2018, 2020).

7.5.1 AMD POTENTIAL

The potential for the tailings stream at Meandu Mine to generate acid was recognised in the first study to test the tailings for ANC, MPA and NAG (AGCWC 1994), which reported a NAPP of 2 – 15 kg H_2SO_4/t for the four tailings grab samples collected from Ramp 3. Of the ~45 tailings samples tested for all studies the total S has ranged from 0.1 – 0.6%, with the most recent studies returning total S of 0.1 – 0.37% (EGi 2016, RGS 2018) from the 34 samples tested. The available data suggests that, aside from a possible slight decrease in total S%, the geochemistry of the tailings has not changed significantly over the life of the mine.

ABA on tailings has consistently classified the tailings as PAF, despite the low S content, because of the very low ANC, ranging from 0 – 11 kg H_2SO_4/t, with an average of 2.9 kg H_2SO_4/t (EGi 2016, RGS 2018). The calculated NAPP of the tailings were all positive, with values of 2 – 7 kg H_2SO_4/t (EGi 2016). Geostatistical analysis by SRK (2019) indicated that sufficient sampling with limited variability supported the PAF classification.

Initial kinetic testing by EGi (2008) and RGS (2018) did not support the static classification of tailings as PAF, because both column leach tests continued to have circum-neutral leachates after 12 months of leaching. However, continuation of the column leach test containing tailings showed that the leachate pH dropped slowly but eventually produced acidic leachate (pH<5) after 28 months of leaching (RGS 2020).

In summary, the tailings at Meandu Mine are considered to be PAF; however, a combination of the addition of $Ca(OH)_2$ at the CHPP and the fine grain and low permeability of the tailings creates a significant lag time (>24 months) before the onset of acid production. The supernatant water quality from the TSFs (NWATSF and NWBTSF) (Section 5.2) support the conclusion that the tailings are unlikely to generate acid provided they remain saturated. Ongoing management strategies for the tailings are detailed in Section 9.3.

7.5.2 NMD/SMD POTENTIAL

Although the tailings are considered to have a considerable lag time before acid is generated if exposed to an oxidising environment, the potential for discharges with elevated salinity to be generated from the tailings was raised by Kilah (1995). Column leach testing by EGi (2008) indicated the tailings leachate initially had moderately high salinity (EC of 3,800 µS/cm), sodium (890 mg/L), chloride (1,480 mg/L) and SO_4^- (1,900 mg/L), but all analytes rapidly declined, suggesting a flushing of accumulated salts from the column. The samples used in the column leach test were collected from the dried surface of the NWBTSF and may have been oxidised prior to sampling.

The tailings used by RGS (2018) in their column leach testing were collected directly from the process stream, which may explain the different leachate characteristics to that recorded by EG1 (2008). The RGS (2018) column leachate showed a fluctuating EC with a general decrease over the testing period; the EC did not show evidence of flushing of salts as the highest EC was recorded in week 17 of the test (2,100 µS/cm). The EC also reflected SO_4^- concentrations rather than Na and Cl, indicating sulphide oxidation was occurring. Despite the oxidation of sulphide and the eventual acidity of the leachate, the EC and sulphate concentrations in the leachate were only moderately high, reflecting the low acid generating capacity of the tailings.

The steady decrease in pH of the leachate from the tailings column did result in the mobilisation of some dissolved metals at relatively elevated concentrations, particularly towards the end of the testing. Of particular concern were Zn (1.502 mg/L), Mn (6.619 mg/L) and Ni (0.046 mg/L), which leached at concentrations greater than the discharge criteria for the site.

It should be noted that the column leach test results represent a worst-case scenario and representative potential discharge water qualities after >24 months of oxidation and wetting/drying cycles. Monthly sampling of the tailings stream supernatant (RGS 2018) returned circum-neutral pH (average 7.4) and moderate salinity (average EC of 1,598 µS/cm). Average concentrations of Na (195 mg/L) and Cl (303 mg/L) were similar to average concentrations of SO_4^- (334 mg/L) verifying salinity derived from NaCl in the tailings supernatant is of as much significance as sulphate derived from sulphide oxidation. Dissolved metal concentrations in the supernatant were also significantly lower than in the acidic leachate from the latter part of the column leach tests (average Mn 0.472 mg/L, Zn 0.072 mg/L and Ni 0.011 mg/L) (RGS 2018). These values are similar to the dissolved metal concentrations recorded in the limited supernatant water quality data from the TSFs.

In summary, the tailings are considered to have a low potential for the generation of SMD in the short and long term. There is the potential for the tailings to generate NMD, particularly with regard to dissolved Mn, Zn and Ni; however, this will be reduced if oxidation of the tailings is prevented. Ongoing management strategies for the tailings are detailed in Section 9.3.

7.6 COAL COMBUSTION PRODUCTS (ASH)

Coal combustion products from the Tarong power stations were stored in a dedicated ash dam to the north of the power stations until 2008, after which they were stored in the K2W Pit until 2016, the K2N Pit until 2021 and currently in the combined K2WN pit. As per the Life of Mine Plan, once the capacity of K2WN is filled, coal combustion products will be placed in K4S. The geochemical information presented in this section is based on the work by RGS (2018) as limited geochemical data existed prior to their investigation.

7.6.1 AMD POTENTIAL

The 16 coal combustion product samples that have had static testing all returned a classification of NAF due to their low total S (<0.02%) and very low sulphide S (<0.008% CRS). Therefore, the coal combustion products are not considered liable to produce acid through sulphide oxidation processes. However, because the coal at Meandu Mine typically has some sulphide and little to no ANC, combustion of the coal produces acidic (<pH 4) coal combustion products. The coal combustion products are therefore neutralised in the slurry thickeners by the addition of $Ca(OH)_2$, increasing the pH of the ash stream to pH 6 – 8. The ANC of the coal combustion products was minimal (0.3 – 5 kg/H_2SO_4/t).

The kinetic leach column containing ash returned a circum-neutral leachate throughout the 32-month period of the leaching, with a pH that fluctuated between 6.67 and 7.85. The sample had low and decreasing acidity, initially leaching at 26 mg/L which rapidly reduced to <10 mg/L within three months and stabilised at ~2 mg/L after 15 months of leaching.

The findings of the geochemical assessment of the coal combustion products are quite definitive with regards to AMD potential, as all samples were classified as NAF and will not generate acid through sulphide oxidation. The actual acidity of the coal combustion products is neutralised during processing at the Tarong power stations.

7.6.2 NMD/SMD POTENTIAL

Although the coal combustion products are not considered a risk with regards to AMD development, concerns have been raised that elevated levels of dissolved heavy metals in the ash slurry might lead to NMD (PW Baker 2011). Leachate studies conducted by Ward *et al.* (2007) suggest that trace elements and salinity may be leached out of the coal combustion products; however, mine spoil appeared to attenuate the dissolved trace elements. Groundwater monitoring surrounding the K2W and K2N voids show minimal elevated metal values (Section 5.4), indicating that the coal combustion products do not appear to be having any impacts beyond the immediate storage area.

Static geochemical testing on the coal combustion products indicated the material contained low to moderate concentrations of salts (EC of 1,000 – 6,000 µS/cm) and leached metals and metalloids in the low mg/L range, including elements not significantly present in other rock or waste streams at the mine (V, Mo, Sr and lithium (Li)).

The coal combustion products column leach test generated a relatively saline leachate in the initial flushing (6,570 µS/cm), which was comprised mostly of $SO4^-$ (1,910 mg/L), Cl (1,280 mg/L) and Na (756 mg/L). The initial flush also contained elevated (>1 mg/L) concentrations of Al, Li, Mn, Mo, Sr, V and Zn. However, the salinity and most metals rapidly flushed from the system, with the EC reducing to <1,000 µS/cm within two months. Ongoing testing did identify some elements that continued to leach into solution at relatively high concentrations after two years of leaching with deionised water (V ~0.75 mg/L; Mo ~0.21 mg/L; Sr ~0.05 mg/L).

In summary, coal combustion products appear to have the potential to generate a slightly saline "first flush" with elevated metals; however, the potential for ongoing SMD is considered low. The potential for coal combustion products to develop NMD is considered low, with the exception of V, Mo and Sr. Ongoing management strategies for the coal combustion products are detailed in Section 9.4.

8 CONCEPTUAL SITE MODEL

Conceptual site models have been developed illustrating waste characterisation aspects of Meandu Mine in its current configuration (Figure 8.1) and as planned at closure (Figure 8.2).

8.1 CURRENT

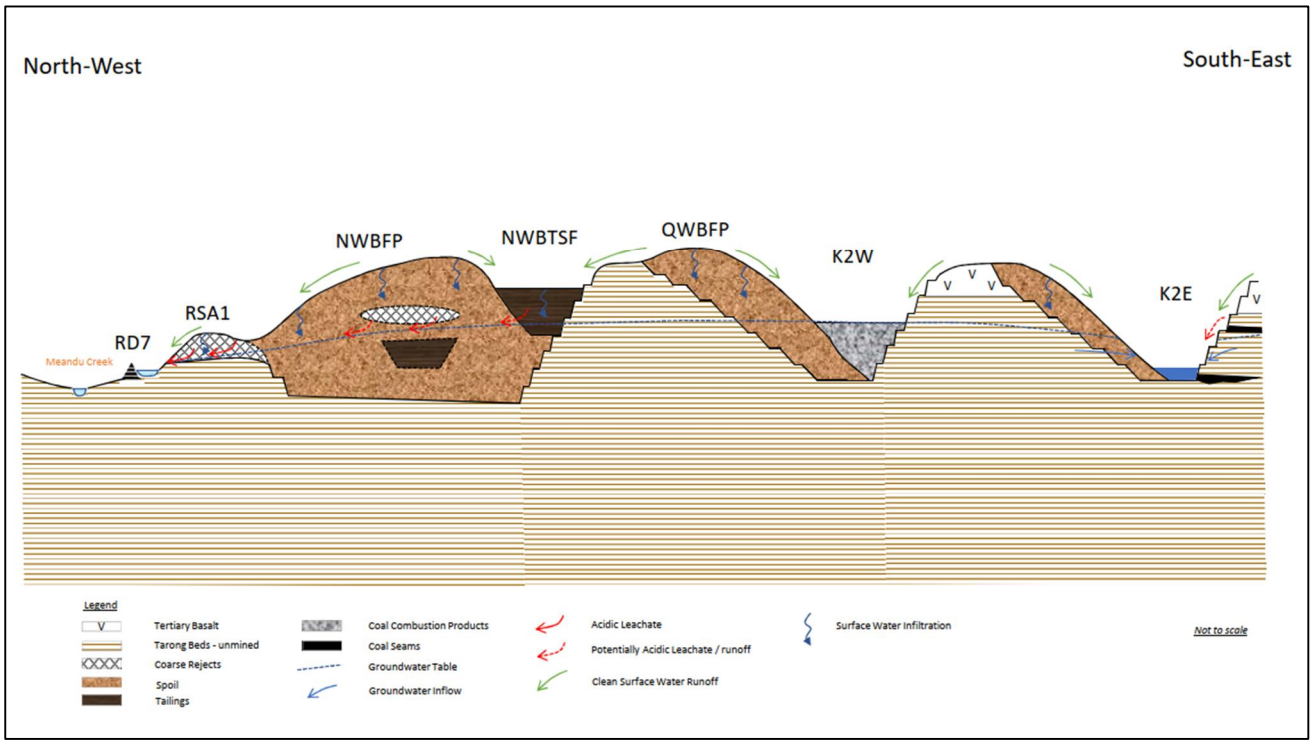


Figure 8.1 Conceptual site model of waste material at Meandu Mine

8.2 FINAL CLOSURE

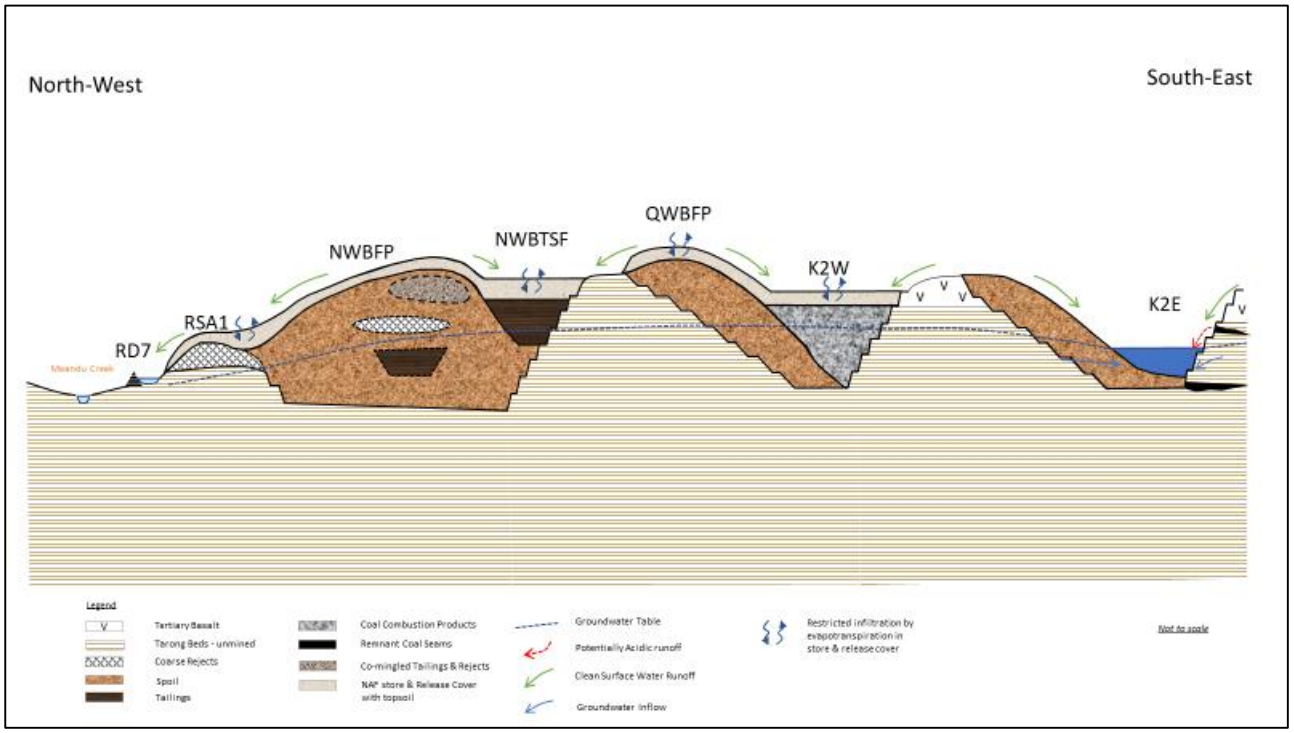


Figure 8.2 Conceptual site model for waste material (Note NWBTSF and K2W will be designed such that surface water will drain off the surface of the final landforms rather than pooling)

9 MANAGEMENT/MITIGATION

The potential for some rock and waste streams at Meandu Mine to generate AMD has led TEC Coal to develop management and mitigation procedures specifically to minimise the risk of AMD generation across the mine. The Mine's Waste Management Plan (WMP) forms the overarching framework for AMD prevention at the site, with the AMD Management Plan (AMDMP) (Downer Mining Document 8512-OC-PLA-1001 – Downer EDI 2021a) acting as the management tool outlining the responsibilities, guidelines and methods for managing potential AMD at the site. The waste characterisation work described in Section 7 has been used to develop Material Design Parameters (Downer Mining Document 8512-OC-R1028 – Downer EDI 2021b) to guide the material handling and placement of waste streams at the Mine. Specific management procedures are detailed in the sub-section for each waste stream.

Table 9.1 Material Design Parameters (Downer Mining 2021b).

MATERIAL	NAF	PAF[1]	SUITABLE FOR DUMP COVER	DEPTH BELOW FINAL LANDFORM	NOTES
Topsoil	■		■	-	Average stripping depth 0.20 m
Weathered Basalt[2]	■		■	-	BA1 lithology and red clay unit. Suitable for use as grazing subsoil.
Fresh Basalt	■		■	-	BA3, BA5 lithologies. Suitable for rock lining and riprap.
Other Tertiary rock types[2]	■		■	-	Includes TE lithologies (Tertiary sediments) and BA2, BA4 lithologies (partially weathered basalt). Excludes LG which is PAF.
Weathered Upper Sandstone[3]	■			2 m	Includes UT and CG(1/2) which are dispersive, erodible and exhibit low PAWC.
Weathered Triassic Carb Mudstone		■		6 m	CM unit, consisting carbonaceous and inferior coal units. Currently limited to K4E between CG(1) and CG(2).
Fresh Triassic Non-coal rock	■		■	-	SH and TI units, consisting of non-organic and carbonaceous non-coal lithologies.
Fresh/weathered Triassic Coal[4]		■		6 m	Major modelled coal seams (CO) and transitional/inferior coal units (CU, CN, CW, CY lithologies).
Spoil (NAF)	■		■	-	Material quality in historical dumps and rehab areas is variable and to be assessed as required.
Spoil (PAF)		■		6 m	
Rejects		■		6 m	EA requirement. Not to be dumped on pit floors. Includes mixed plant rejects and rehandled coarse rejects.
Tailings		■		6 m	EA requirement. Stored in designated portion of ash storage facility.

MATERIAL	NAF	PAF[1]	SUITABLE FOR DUMP COVER	DEPTH BELOW FINAL LANDFORM	NOTES
Power Station Coal Combustion Products	■			2 m	EA requirement. To be stored in specific voids only

1. Where possible PAF material should be dumped within pit void catchments.

2. Weathered basalt preferred for use as subsoil in grazing rehab areas (1.5 m placed depth). TE may be suitable as grazing subsoil if required, pending assessment.

3. May be used as dump cover in native vegetation rehab if other controls are in place, i.e. shallower slopes, blending with other material and/or amelioration. Blocky conglomerate in lower portion of CG units is more erosion resistant.

4. Transitional coal bands are concentrated adjacent to the major coal seams (within 2 m of roof and floor of the modelled coal seams). Coal units can be mixed at a rate of 15% with NAF units to produce an overall NAF blend, that is to be kept at least 6 m below final landform.

9.1 GEOLOGICAL BLOCK MODEL

A geological block model of Meandu Mine has been developed focussing on coal units for mine planning purposes. This model was refined into a structural block model of the Mine overburden stratigraphy by JB Mining Services in 2016 to facilitate mine planning by incorporating the material design parameters into the ongoing Life of Mine Plan. Yearly iterations have built on the original model to incorporate the most up-to-date data. The model (JB Mining 2021) contains the following units:

- Soil – assumed to be 0.2 m thick
- Tertiary – virgin topography to Base of Tertiary (BUTE):
  - Red clay interval (formally laterite)
  - Basalt flows
  - Lignite
  - Other rock types
- Triassic – BUTE to top of Ace Seam:
  - Upper Triassic (finer grain rocks – claystone, mudstone, sandstone, siltstone)
  - Conglomerate/sandstone (predominately conglomerate and coarse sandstone with minor fine-grained rock bands)
  - Carbonaceous mudstone (thin unit of carbonaceous mudstone, claystone and inferior coal contained within larger conglomerate/sandstone unit); and
  - Shale – (carbonaceous shale and mudstone with minor other rock types).

The model (JB Mining 2021) currently classifies the carbonaceous mudstone unit (CM) as PAF and all other overburden as NAF as the amount of non-CM overburden classified as PAF during waste characterisation was considered insignificant at the scale of mining. Conservatively, all interburden within 2 m of the roof and floor of modelled coal seams has been classified as PAF in the model and will be placed >6 m below final landform as per the Life of Mine Plan. The remainder of the interburden has been classified as NAF. To improve the reliability of the model so that PAF units can be identified ahead of mining and managed appropriately, drilling, sampling and analysis is ongoing (Section 10).

9.2 WASTE ROCK SPOIL

Waste rock material is moved by dragline and excavator/haul truck fleets to in-pit or out-of-pit overburden dumps, appropriate to the mine plan and mining location. Disposal of mined material is undertaken in accordance with the requirements of Procedure Material Movement – Mine Planning (Downer EDI Document 8512-OC-P1004 – Downer EDI 2020), which requires material type to be known ahead of dumping and matched to suitable disposal locations. In determining suitable disposal locations, the Material Design Parameters (Downer EDI 2021b) are used to guide how specific material should be disposed of, with PAF material being deposited at least 6 m below the final landform. This document is updated on an annual basis or as more material characterisation information becomes available.

Material identified as PAF in the geological block model and Material Design Parameters is subject to strict dump location criteria. That is, it must be located at minimum 6 m depth from the final landform design surface (and where possible, is located at a greater depth than 6 m). The material covering the PAF will be NAF rock as confirmed by waste classification. The material placement and cover requirements are continually reviewed as additional information becomes available from the material characterisation program. The Life of Mine Plan confirms that there is sufficient volume of NAF material to provide adequate cover and compliance.

The final landform will be constructed in accordance with the requirements of EA EPML00709113.

Isolated occurrences of PAF material were identified in the overburden and have been incorporated into the model for separate handling (lignite within the Tertiary units and carbonaceous mudstone within the Triassic units). Other PAF material in overburden is generally encountered in quantities too small to be separated out from the NAF overburden for the purposes of long to medium term mine planning. Where feasible, these PAF waste units identified in the highwall during mining will be segregated and placed at least 6 m under the final landform and covered by NAF material. Ongoing refinement of the geological block model should further increase the feasibility of segregating small areas of PAF within the overburden/interburden.

9.3 TAILINGS AND COAL REJECTS

Tailings and coal rejects generated by the CHPP at Meandu Mine are now co-mingled and disposed together in dedicated disposal areas, although some excess tailings continue to be placed into K2WN when the solid bowl centrifuges require maintenance or cannot process the entire tailings stream. Therefore, this section covers storage and disposal of tailings, coarse rejects and mixed plant rejects as a whole, rather than independently. Disposal of tailings and rejects is regulated by conditions G9, G14 and G15 of EA EPML00709113 as shown in Table 9.2.

Table 9.2 EA EPML0070913 – reject requirements

CONDITION NUMBER	REQUIREMENTS
G9	**Tailings Deposition Areas** When the deposition of tailings into an area ceases, the holder of this environmental authority must install a final cover system to the tailings dam which effectively minimises: a) infiltration of water into the tailings deposition area; and b) the likelihood of any erosion occurring to the final cover system.
G14	Reject disposal areas must be covered by a minimum of 6 (six) metres capping designed in accordance with criteria determined by a suitably qualified and experienced person.
G15	Reject disposal areas capped in accordance with **Condition G13** must include an upper layer of earthen material design and maintained to sustain plant growth.

Geochemical characterisation of the coal rejects and tailings indicated that the material was PAF with a low potential for the development of SMD or NMD. Lag times for the generation of acid are in excess of two years for the tailings material but are less than 6 months for the coarse rejects. Therefore, specific waste management strategies are required for the coal rejects and tailings beyond the requirements within the EA.

Current management procedures in place at the Meandu Mine to control the risk of acidic drainage generation include:

- Limiting storage/exposure time of coarse reject materials at the reject stockpile to less than two weeks.
- Mixing of coarse rejects with fine-grade rejects and dewatered tailings, whereby pore voids within the coarse rejects will be filled with highly plastic low permeability tailings limiting oxidation and permeability. The combined reject and tailings stream (mixed plant rejects) are placed into the waste (spoil) dumps and progressively encapsulated with NAF overburden of at least 6 m thickness.

9.3.1 STORAGE AND DISPOSAL

MIXED PLANT REJECTS

Rejects material placement focuses on:

- limiting storage exposure time of coarse reject materials
- combining rejects and tailings streams
- placement of reject materials at least 6 m beneath the final landform profile.

The mixed plant rejects dump/storage areas will be contained in the active mine dump areas.

Placement of mixed plant rejects in the rejects storage area is undertaken in accordance with the process outlined in Placement of Mixed Plant Rejects Procedure 8512-OC-WI1020.

In determining mixed plant rejects dump locations, geotechnical and slope stability considerations are taken into consideration to determine whether it is a suitable location for mixed plant rejects emplacement. During the design phase this may also include reviewing the surrounding dumps, the type of waste material, haul roads and drainage points.

Prior to emplacement, Mining Engineers/Supervisors/Operators are required to visually assess moisture content of the mixed plant rejects material being produced by the CHPP and at proposed tip head/dump location. The material is then classified as:

- **Low Moisture** (dry to moist) – material that is mostly coarse reject rock material and is able to be easily trucked to the dump and will retain integrity in dump/tip head and is suitable for co-disposal.
- **Moderate to High Moisture** (“wet”) – material contains significant wet fines with some coarse rejects and is able to be contained by cells and trucked to mixed plant rejects dump with minimal spillage.
- **Very High Moisture** (“very wet”/“sloppy”) – material not suitable for emplacement within cells will require a tiphead will need to be established, following formulation of a risk assessment (JHA) that considers geotechnical and environmental controls.

This classification determines the appropriate disposal process as described in the Placement of Mixed Plant Rejects Procedure 8512-OC-WI1020.

WET TAILINGS DISPOSAL

Wet tailings disposal is required during periods when the solid bowl centrifuges are not operational. Contingency tailings disposal into the K2WN void commenced in early 2020.

In order to maintain stability of the ash dam wall, tailings deposition will be managed so that the tailings do not come into contact with the embankment as follows:

- construct tailings cell on K2W dust suppression layer using material already in place
- deposit ash (dense phase slurry) via multiple discharge piping system and beach away from K2W embankment/spoil
- ash will inundate and cover tailings when the level exceeds the tailings cell crest level
- when that occurs, ash deposition will be managed so that tailings are confined to the south-west corner of the highwall of K2W and continually encased by the ash.

Tailings disposition into the cell in the K2W portion of the K2WN ash dam away from the RL520 ash dam wall will be followed by staged co-disposal with coal combustion products in line with the process illustrated in Figure 9.1.

Future co-disposal of ash and wet tailings is proposed to be conducted into the K4S void in January 2029 on completion of mining from that pit.

Supernatant water at K2WN will be managed as follows:

- Prior to ash covering the initial tailings cell, ash supernatant water will be returned to the ash dam at the Tarong power stations and tailings supernatant water will either be pumped to the Meandu Mine water management system, or to the Tarong ash dam.
- After ash covers the tailings cell, supernatant water streams will be combined, and the combined supernatant water will be pumped to the Tarong power stations or directed to Meandu Mine's water management system. TEC will identify location to flexibly pump water to the destination where it provides most benefit (i.e. supernatant from ash or tailings could be pumped to either Tarong power stations or Meandu Mine storages depending on water quality and demand).

9.3.2 CONTROL OF LEACHATE AND SEEPAGE

The current Meandu Mine management procedures of limiting storage/exposure time of coarse reject materials at the reject stockpile to less than two weeks, has been an effective way of controlling the risk of AMD generation. The potential for sulphide oxidation is further reduced through the incorporation of fine-grade rejects and tailings, whereby pore voids within the coarse rejects are filled with highly plastic low permeability tailings limiting oxidation and permeability. The combined reject and tailings stream are placed into the waste (spoil) dumps and progressively co-mingled or encapsulated with overburden and interburden and placed at least 6 m under the final landform and covered by NAF material and rehabilitated as per EA EPML00709113 requirements and the Meandu Mine Rehabilitation Plan (8512-SE-PLA1022).

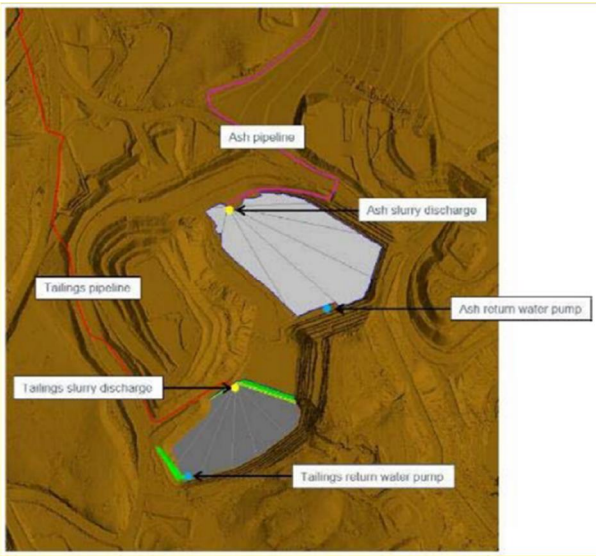
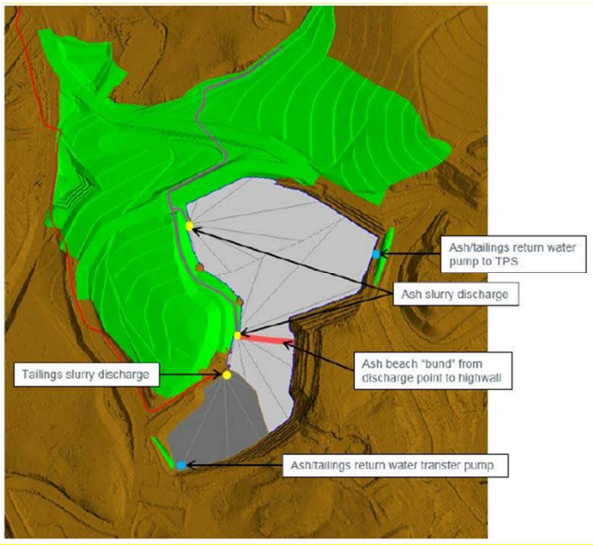
	**Phase 1: K2WN Initial Ash (CCP) discharge with tailings deposition into a cell on the capped K2W ash: January 2020 to December 2021.**
	**Phase 2: Co-disposal of tailings with ash (CCPs) in K2WN – staging with ash covering cell: January 2022 to June 2023.**
	**Phase 3: Co-disposal of tailings with ash (CCPs) in K2WN – staging with ash covering cell: After June 2023.**

Figure 9.1 Phases of staged co-disposal of tailings in K2WN ash dam

9.3.3 DECOMMISSIONING AND REHABILITATION

TAILINGS STORAGE FACILITIES

In accordance with Condition G9 of the EA (EPML00709113), the NWB-TSF and RD16-TSF will be capped with a NAF material to form the initial layer that is in contact with the tailings, and at least 6 m of the final landform surface to minimise infiltration of water and the likelihood of any erosion occurring to the final cover system. Rehabilitation of these tailings storage facilities will occur in accordance with:

— NWB-TSF Decommissioning and Rehabilitation Plan.

— RD16-TSF Decommissioning and Rehabilitation Plan.

Rehabilitation of these tailings storage facilities will commence with a period of desiccation and consolidation. RD16-TSF has been decommissioned, capped and is being monitored for settlement, with final rehabilitation works scheduled for end of 2021.

CONTINGENCY TAILINGS

Contingency tailings disposal will occur in conjunction with coal combustion products disposal in K2WN (refer Section 9.4). Decommissioning and rehabilitation of this and other future coal combustion products disposal facilities with contingency tailings co-disposal is covered in the Section 9.3.1.

MIXED PLANT REJECTS

At the mixed plant rejects emplacement areas (when not within 6 m of the final landform surface) cells are progressively capped with at least 5 m of overburden/interburden. Where mixed plant rejects are placed 6 m from the final landform surface, the 6 m capping will consist of NAF material.

The areas will be topsoiled, ripped and seeded as per requirements in Schedule G of EA EPML00709113 and in accordance with the rehabilitation management practices as per current Plan of Operations and future Progressive Rehabilitation and Closure Plan:

— Incorporation into final landform design

— Drainage works (graded banks and rock waterways)

— Topsoil placement (200 mm)

— Contour ripping and seeding

— Ongoing maintenance and monitoring.

Investigations into co-mingled material properties will continue to optimise rehabilitation strategies.

9.3.4 MONITORING AND MAINTENANCE

DURING LANDFORM CONSTRUCTION

For the NWB-TSF the rate and volume of seepage exiting the north-western corner of NWBFP will continue to be monitored through decommissioning and rehabilitation of NWB-TSF. Management controls will be maintained at least until the seepage rate becomes negligible.

AFTER COMPLETION OF REHABILITATION

Post-seeding, the rehabilitated area will be assessed as per the site Land Rehabilitation Inspection Checklist (8512-SE-F1125) to ensure it meets the relevant quality criteria as stated in Schedule G of the Environmental Authority. The final landforms for the NWB-TSF and RD16-TSF will be included as part of the site rehabilitation monitoring program which will be used to determine success in terms of erosion, stability, groundcover and vegetation development. Annual rehabilitation monitoring is undertaken in accordance with the Meandu Mine Rehabilitation Monitoring Programme.

If during the rehabilitation monitoring period, any major cracking or differential settlement is observed, a geotechnical engineer will be engaged to assess the landform and recommend remedial works.

9.4 COAL COMBUSTION PRODUCTS

This section covers current and future storage of coal combustion products from the Tarong power stations in identified mine voids. The storage of coal combustion products at the Meandu Mine is regulated under the mine's EA (EPML00709113), with specific conditions for operation, detailed in Table 9.3. Coal combustion products from the Tarong power stations are currently stored in K2WN; however, EA EPML00709113 (DES 2019) does allow future storage in Central Pit, K4S Pit, K4E Pit, K2E Pit and Ramp 5.

Table 9.3 EA EPML0070913 – Coal combustion products requirements relevant to waste storage/management (DES 2019)

CONDITION NUMBER	REQUIREMENTS
A18	**Coal Combustion Products Storage and Management** The holder of this environmental authority may store coal combustion products generated primarily from the combustion of pulverised black coal at the Tarong Power Station and Tarong North Power Station in voids defined in **Table A1 - Authorised coal combustion product storage locations** and **Appendix 2 - Meandu Mine Voids, Drainage System and Monitoring Network.**
A19	Coal combustion products stored in voids defined in **Table A1 – Authorised coal combustion product storage locations**, and **Appendix 2 - Meandu Mine Voids, Drainage System and Monitoring Network** must comply with contaminant limits defined in **Table A2 – Maximum Allowable Leaching Contaminant (TCLP)) levels** (refer Table 9.4**).**
A20	In addition to meeting the criteria in **Table A2 – Maximum Allowable Leaching Contaminant (TCLP) levels (Table 9.4),** the coal combustion products must not have any properties or contain any other contaminants at concentrations which may cause environmental harm
G9	**Tailings Deposition Areas** *When the deposition of tailings to an area ceases, the holder of this environmental authority must install a final cover system to the tailings dam which effectively minimises:* *(a) Infiltration of water into the tailings deposition area; and* *(b) The likelihood of any erosion occurring to the final cover system.*
G11	**Final Cover** When deposition of coal combustion products into voids defined in **Table A1 – Authorised coal combustion product storage locations** ceases, unless otherwise agreed to by the relevant landowner, any relevant land manager and the administering authority, the holder of this environmental authority must install a final cover system over the coal combustion products following sufficient time for ash consolidation and desiccation

CONDITION NUMBER	REQUIREMENTS
G12	The final capping system over coal combustion products in the voids defined in **Table A1 – Authorised coal combustion product storage locations** must be at least 2 m deep and must include an upper layer of earthen material that is capable of sustaining plant growth, and must be designed and maintained to minimise erosion occurring to either the final capping system or the coal combustion products in the void
G13	Materials used in the construction of the capping layer over the coal combustion products in the voids defined in **Table A1 – Authorised coal combustion product storage locations** must achieve an in-situ permeability which is sufficiently low and/or be sufficient thickness so as to minimise infiltration of water into the landform.
G14	*Reject disposal areas must be covered by a minimum of 6 (six) meters capping designed in accordance with criteria determined by a suitably qualified and experienced person.*
G15	*Reject disposal areas capped in accordance with **Condition G13** must include an upper layer of earthen material designed and maintained to sustain plant growth.*

TCLP – Toxicity Characteristic Leaching Procedure

Table 9.4 EA EPML0070913 Table A-2 – Maximum allowable leaching contaminant (TCLP) levels in coal combustion products (DES 2019)

CONTAMINANT	MAXIMUM TCLP VALUE (mg/L)
Silver	0.5
Arsenic	0.5
Barium	10
Cadmium	0.05
Total chromium	0.5
Copper	10
Nickel	0.5
Lead	0.5
Antimony	0.5
Thallium	0.1
Zinc	50
Selenium	0.1
Mercury	0.01

Geochemical characterisation of the coal combustion products indicated that the material was NAF with no acid generation potential and a low potential for the development of SMD or NMD (RGS 2018). Therefore, no specific waste management strategies are required for the coal combustion products beyond the requirements within the EA and the mine operations plan.

9.4.1 WASTE MINIMISATION

Approximately 10% of the Tarong power stations coal combustion products are collected and sold as useable products under contractual arrangements between Stanwell and ash off-takers. Stanwell is proactively exploring initiatives to significantly increase the proportion of coal combustion products that are sold for beneficial reuse. A new offtake facility at the power stations is undergoing commissioning in September – December 2021, and once at full production has the ability to increase the reuse of coal combustion products by approximately 400,000 tonnes per annum, or approximately 30% of coal combustion product production.

Cenospheres are a by-product of the coal combustion process and are entrained in the ash slurry and liberated from the material once the slurry has been deposited in the void. Cenospheres are small, hollow, silica balls that float on the surface of water. They are marketable due to their heat-resistant properties. Cenospheres are periodically harvested from the K2WN ash storage facility for beneficial reuse in accordance with End of Waste Code for Coal Combustion Products Approval Number ENEW07359717, further reducing the volume of coal combustion products stored at Meandu Mine.

9.4.2 STORAGE AND DISPOSAL

CURRENT STORAGE

Coal combustion products from the Tarong power stations are currently stored in K2WN. An ash pipeline has been constructed to transport the coal combustion products in the form of, a slurry, from the Tarong power stations to Meandu Mine. Due to settling of this slurry in the K2WN void after transportation from the power stations, a large body of water is formed on the surface of the void. This supernatant water is reclaimed from the K2WN Ash Storage and pumped in a closed-loop system back to the Tarong power stations ash dam for recovery and reuse in accordance with Condition C15 of EA EPML00709113.

Storage and management of coal combustion products in the K2WN Pit is undertaken in accordance with the requirements of the certified design plan (K2WN Ash Storage 520 mRL Raise Construction Certification Report) and operations plan (K2WN Ash Storage 520 mRL Crest Raise Operational Plan).

Coal combustion product placement in the K2WN Pit will continue until this storage facility reaches capacity (currently 518 m RL (crest level 520 mRL)). This is anticipated to be in approximately 2028 (depending on power station generation rates).

REGULATED STRUCTURES

Because the ash storage is contained within a regulated structure, specific inspection and reporting procedures are already in place in accordance with existing EA Conditions H10, H12 and H22 to H25 (DES 2019).

The certified design report (incorporating the 520 mRL crest and tailings disposal) outlines the current plans for decommissioning of the tailings/ash storage facility. This structure will remain as a regulated structure until decommissioning works have been certified as satisfactorily completed.

The K2WN void and the Queen West (QW) Sump will remain regulated structures after capacity is reached and until it is fully decommissioned. Spillway functionality will be maintained during the post-ash deposition period until completion of capping and re-shaping works, including final capped landform surface drainage. Inspection and reporting requirements for the regulated structure will be continued in accordance with the design report, operational plan, consequence category assessment and relevant EA conditions until the regulated structure has been certified to be effectively decommissioned.

FUTURE STORAGE

Following completion of ash and contingency tailing storage in K2WN, placement of ash and tailings in a void within K4S will then be undertaken. Appropriate design and consequence category assessments of K4S Pit will be undertaken in due course. The manner in which ash transfer will occur may be as a dense phase slurry, as currently occurs, or by taking dredged ash from the Tarong Ash Dam, by truck or slurry, to the Meandu Mine voids to increase the capacity of the Tarong Ash Dam.

9.4.3 CONTROL OF LEACHATE AND SEEPAGE

Part of the ash storage containment is formed by dumped spoil backfill. Seepage of groundwater from the ash storage will also displace groundwater within the backfill spoil. Seepage within the spoil will be collected and managed using the QW Sump, which has been constructed on the north-west corner of the K2W dump. QW sump will be operational as part of the certified K2WN storage design to intercept seepage reporting to QW backfilled void. This seepage will be pumped back to K2WN Pit.

9.4.4 CONTROL OF FUGITIVE AIR EMISSIONS

Following the temporary cessation of coal combustion product disposal in the K2W Pit, a dust suppression layer consisting of mine spoil was place over the deposited ash to prevent dust lift off. This spoil layer will be in place until ash in the K2WN facility increases above this level. This temporary layer does not represent a final cap and therefore has not been designed to meet those specifications.

Active coal combustion product disposal in the northern section of K2WN has not had any significant fugitive dust emissions due to the moisture content of the deposited ash and the body of decant water over a significant portion of the deposited ash.

Following cessation of ash disposal, the period of desiccation is likely to have a high potential for fugitive dust emissions. Dust suppression mechanisms that will be used to minimise dust transmission during this phase will include:

- placement of a dust suppression layer
- install water sprays over the area
- apply chemical sealant to the surface.

The determination of dust control measures will be made prior to cessation of ash disposal. Ultimately all ash storage facilities will be capped by NAF material to prevent dust generation.

9.4.5 DECOMMISSIONING AND REHABILITATION

A decommissioning and rehabilitation plan will be prepared for the K2WN storage in accordance with EA EPML00709113 conditions G9 and G11 to G15 (Table 9.3).

The decommissioning and rehabilitation plan will address the following:

- desiccation phase (drying out/crusting), (if required)
- cover materials identification (NAF material will be used as a cover material, where some material will come from K2W spoil dump with the balance from either K2E or Ramp 5/K4E. The material will be assessed for suitability, including having permeability as per the design criteria)
- construction design:
    - geo-mechanical analysis
    - verification testing
- final cover system
- capping depth:
    - planned construction sequence
    - first spoil layer
    - subsequent dumping to final landform

— landform surface drainage

— topsoiling

— final rehabilitation works (ripping and seeding)

— monitoring and maintenance.

The final landform design for the K2WN void will be designed to the requirements of the K2WN Ash Storage Operation Plan (December 2019). Channels will be built as part of the final surface above the ash dam cover system, draining from a high point near the centre to the north, east and south-west, where they will join the main drainage features adjacent to K2WN and the Central Pit.

In summary, rehabilitation will comprise a period of desiccation/consolidation following by capping with spoil to a level that fits in with the surrounding final landform and which will be free-draining (i.e. final surface constructed on a slope to prevent pondage).

This final surface will be topsoiled, ripped and seeded, in accordance with the final land-use plan, proposed for the area in the future Meandu Mine Progressive Rehabilitation and Closure Plan.

9.4.6 SAMPLING, MONITORING AND MAINTENANCE

Regular monitoring and maintenance will be conducted on the coal combustion product storage facilities, both during operation and in the post rehabilitation phase. Operational monitoring will include:

— regular geochemical sampling and analysis of the coal combustion product stream

— supernatant water quality sampling of the K2WN void

— potential seepage sampling in QW sump

— groundwater monitoring as prescribed in the EA, conditions D3 – D10.

Exceedances of trigger values detailed in the EA or the operational plan will prompt further investigation and, if necessary, seepage mitigation actions such as pumping water from QW sump.

During the construction of the final landform, topographic survey and regular inspections will be undertaken to ensure excessive settling of the landform is not occurring and any significant erosion gullies are filled and re-graded.

Post rehabilitation monitoring requirements are detailed in the Land Rehabilitation Inspection Checklist and plan of operations. The final landform will be included as part of the site rehabilitation monitoring program which will be used to determine success in terms of erosion, stability, groundcover and vegetation development and ensure the final landform meets the relevant quality criteria as stated in Schedule G of the EA.

If during the rehabilitation monitoring period, any major cracking or differential settlement is observed, a geotechnical engineer will be engaged to assess the landform and recommend remedial works.

9.5 FINAL PIT VOID

The current Life of Mine Plan proposes to limit the final pit voids post-mining completion to K2E and K4E. This is to be achieved by scheduled mine planning filling in completed pits with the overburden spoil from active pits, with K2E and K4E being the final areas mined. TEC Coal propose to minimise the area of the final voids by using interburden spoil to form the low walls of the pits that will act as remediated designed final landforms. The planned post-mining land use (PMLU) of the residual voids is for steep rocky ecosystems and water storages (EA Condition G6), with the aim of containing water of a suitable quality for native wildlife and/or livestock ingestion. Initial pit water quality modelling indicates that final pit water qualities are likely to be suitable for stock water (WSP, 2021). However, AMD management requirements for pit voids will depend on the leaching characteristics of the coal and its interaction with other pit wall materials and fill, the amount of coal exposed in the pit wall, location of the coal relative to the long-term water table level and the nature and physical/hydrological properties of any backfill. Further geological modelling and geochemical characterisation work is intended for what will be the final pit wall at the end of the mine life to ensure that the inputs to the residual water void are be understood (in detail).

The final highwalls for K2E and K4E Pits are planned to form the PMLU of Steep Rocky Ecosystem, comprising a diversity of slopes including mix of predominately flat benches and batters up to 80 degrees that create a varied environment for the future establishment of niche habitats. Specific AMD, SMD and/or NMD management of the final highwalls is not expected to be required as geochemical testing suggests the relative volume of potentially problematic rock is insignificant at the scale of mining. Detailed geological mapping will be undertaken on the final pit walls near mine closure to confirm the geochemical testing program and identify any potentially problematic PAF and/or saline/metalliferous horizons, such as remnant pyrite-rich coal layers. Closure management of horizons containing significant PAF may be utilised to minimise the risk of unacceptable water quality in the final pit voids.

10 PROPOSED ADDITIONAL TESTING

10.1 GAP ANALYSIS

A gap analysis of the available waste characterisation data for Meandu Mine was conducted against the prescriptive requirements detailed in the PRCP Guidelines (DES 2019b). The gap analysis heavily relied upon the geostatistical analysis of SRK (2019, 2021) in determining the representativity of the existing database by lithotype and spatially across the deposit. The findings of the gap analysis are contained in Table 10.1.

Table 10.1 Assessment of Meandu Mine waste characterisation data against PRCP Guidelines

PRCP REQUIREMENT	SITE FINDINGS
Sampling regime meets best practice standards	**Static:** The static geochemical testing at Meandu Mine meets best practice standards with reference to sampling procedures, analytical suites and data analysis. However, SRK (2019a) identified potential issues with sample classification and sample lithological assignation. Interpretation of the static testing dataset identified potential sample contamination by adjacent/interbedded organic lithologies, which led to SRK to conclude that all PAF material at the Mine was related to organic lithologies. Geostatistical analysis was conducted on samples without potential organic contamination. **Kinetic:** The sample collection and leaching/analysis methodology utilised in the column leach testing was considered suitable for the Meandu Mine waste material.
Sampling is spatially representative of all material being mined	**Static:** Geostatistical analysis by SRK (2019, 2021) concluded that the spatial coverage of static AMD sampling was adequate for all significant lithologies likely to be mined at the site, with the exception of carbonaceous mudstone and the lignite lithology in the overburden. However, considering the carbonaceous group as a single package statistically provides adequate coverage for these lithologies. Greater certainty in the statistical representativity of the overburden/interburden in the centre and north-east of the mine forward planning area would be achieved with some infill drilling in these areas. The geostatistical assessment of the process waste streams at the site (rejects, tailings and coal combustion products) concluded that all process waste streams had sufficient samples to support their geochemical classification. Sample density in the vicinity of the final void walls in now sufficient to inform detailed final pit void water quality modelling following the 2020 drilling and analytical program. **Kinetic:** The sample selection for kinetic testing at the site (RGS 2018) is considered by SRK (2019) to under-represent the overburden and interburden at the site both spatially and numerically. No kinetic testing is available for material representative of the K4S final pit highwalls or the K2E interburden highwalls. However, column leach testing has commenced on samples representative of the K4S final highwall, results of which will be available in approximately April 2022.

PRCP REQUIREMENT	SITE FINDINGS
Sampling is representative of all lithologies	**Static:** Static testing exists for all lithologies, although carbonaceous mudstone and lignite are under-represented. The testing is spatially adequate, but not necessarily able to predict the respective variables within lithologies (SRK 2019). However, considering the carbonaceous group as a single package statistically provides adequate coverage for these lithologies (SRK 2021). **Kinetic:** Kinetic testing only exists for individual weathered basalt, shale, conglomerate and sandstone samples. Therefore, several lithologies are not represented by kinetic testing, including carbonaceous mudstone, which has an uncertain acid generating classification under the SRK (2019) scheme. No kinetic testing exists for remnant coal that is likely to be present in the residual highwalls. Additional kinetic testing of overburden/interburden lithologies has been commenced in September 2021.
Sampling is capable of confidently classifying mine waste streams based on environmental risk and management requirements	**Static:** Sufficient static testing has been conducted to classify most waste streams at the site; however, some uncertainties exist regarding the acid generating potential of some lithologies in the overburden and interburden (see above). **Kinetic:** Kinetic testing has been done on all processed waste streams but not on all lithologies found in overburden and interburden (see above). Although only one or two leaching columns have been conducted on each process waste stream, this should be sufficient to predict waste behaviour provided the static testing results show that the properties of the process waste streams are consistent.
Sampling is capable of generating block models and estimating the volume of mine waste based on waste type	The geochemical sampling at the site is considered sufficient for the refinement of the existing mining block model into a geo-environmental block model. The existing model has recently been updated and refined (JB Mining 2021) to include PAF lithologies in the overburden and classify the interburden into blocks according to percentage of carbonaceous material, which satisfies site requirements and will improve Mine waste management and further reduce the risk of AMD generation.
Static testing: Chemical composition Mineralogical analysis Acid base accounting Net acid generation	The data gap analysis suggest that adequate analysis has been undertaken on the samples at the site (chemical composition, mineralogical analysis, ABA, NAG).
Kinetic Testing: Column leach testing	The methodology of the kinetic testing and analysis of leachates from the testing is considered sufficient to satisfy the PRCP guidelines. Additional kinetic testing is required to ensure spatial and volumetric representativity across the Mine, particularly in the vicinity of final pit highwalls.

10.2 SAMPLING/TESTING PROGRAM

Exploration and resource definition drilling programs are conducted at the Mine on a regular basis. TEC Coal propose to utilise these drilling programs to collect additional geochemical samples to fill the data gaps identified in the gap analysis. Additional geochemical sampling and testing proposed includes:

- Additional sampling and static testing of sections of the mine forward planning area (north-east of K2E Pit) identified by SRK (2019) as having low sample densities).
- Comprehensive sampling and kinetic testing program of:
  - overburden/interburden lithologies to verify the classification of non-acid forming (NAF) and PAF materials at the site more accurately, particularly lithotypes with UC classification.
  - Material representative of the final pit highwalls (K2E and K4E Pits) to verify the geochemical kinetic properties of the final pit walls to inform residual void water quality modelling. This will include remnant coal samples as this material has been classified as PAF will likely have the highest risk for AMD generation.

Data gained from the additional sampling/testing program will be used to refine the geological mine model and site water quality models.

Ongoing additional geochemical sampling and testing is expected to be undertaken opportunistically throughout the operation of the Mine so that any changes to the long term mine plan can be incorporated into ongoing waste and AMD management planning.

Kinetic testing will have a duration of at least one year; however as significant lag times to acid generation have been identified in some lithotypes and waste streams, selected materials may be tested for 2 – 3 years.

Drilling and analysis of the area east and north-east of K2E is proposed for 2021 – 2022. Additional kinetic testing columns have been commissioned and started in September 2021.

11 CONCLUSIONS

This waste characterisation report has been compiled to support the PRCP for Meandu Mine through to planned closure in 2037 - 2039. The data and interpretations of previous investigations and sampling/testing programs have been assessed against the PRCP guideline requirements for waste characterisation reports (DES, 2019) to derive the conclusions below and recommendations for future geochemical sampling and testing.

The waste characterisation of Meandu Mine is considered to meet the PRCP requirements for AMD/SMD/NMD planning and management, with minor data gaps in geochemical static and kinetic testing from a lithological and spatial perspective. Sampling and testing programs proposed for 2021 – 2022 are expected to close these gaps.

SURFACE WATERS

Assessment of historic surface water quality data for the 11 existing and former open pits, TSF supernatant and seepages at Meandu Mine indicated that the lithology at Meandu Mine has the capacity to generate acid, at least in some units. The propensity for acidic pit water appears to be geographically influenced, and possibly related to mine history and process. The lowest pH and most persistent acidic pit waters were recorded early in the mine life in the northern (K1 and K2 Pits) and north-western (NWA Pit) areas of the mine. The investigation into the acidic pH in K1 pit water concluded the source of the AMD was exposed oxidised coal in the pit face and mined overburden (AGCWC 1993a). The acidity appears to be associated with the upper Ace and King coal seams early in the mine life (RGS 2018).

Acidic conditions have not been measured in any pit water since 2004, which may reflect water management processes in the mine, but is also an indication that the lithologies mined since 2004 have a lower acid generating potential. Overburden/interburden spoil and exposed hanging wall pit faces have not created acidic conditions in Central Pit, K4E and K4S pit waters for the life of either pit. In-pit acidic conditions have not been recorded in K2E since March 2000, despite the highwalls having been exposed to oxidation for several years.

Salinity was often elevated (EC >3,000 µS/Cm) early in the life of pits before steadily declining to lower levels, which suggests initial run-off into the pits might be saline due to mobilisation of easily dissolved salts on the rock and waste. Isolated later elevated EC readings may be caused by evapoconcentration rather than run-off or seepage. Saline drainage may occur due to the mobilisation of sodium chloride from both Tertiary and Triassic overburden/interburden, even in the absence of AMD.

In-pit SO_4^- concentrations have been below the EA release point criteria (1,000 mg/L) in all pits throughout the mine life with only three exceptions, two of which (K2W and QW Pits) are likely related to ash disposal rather than AMD. This indicates that:

1. Acidic pit waters have not led to elevated SO_4^- concentrations.
2. Elevated ECs are a result of sodium chloride mobilisation in surface run-off, seepage and process waters, plus evapoconcentration.

Elevated total concentrations of a number of metals (Ni, Fe, Co and Zn) have been detected in the pit waters, indicating that the waste and overburden/interburden material at the mine does has the capacity to generate elevated dissolved metal concentrations in run-off and or seepage.

Comparison of pit water quality with the EA water contaminant limits and release contaminant trigger investigation levels indicates that salinity, sulphate and metal concentrations in pit waters have generally been lower than the release limits in most pits not influenced by ash or tailings disposal.

Tailings supernatant water qualities suggest that the tailings are unlikely to generate acidic drainage in the short term due to their saturated state, preventing significant oxidation of any entrained sulphides. Run-off waters and leachates are likely to have salinities in excess of the Mine's release contaminant release criteria. Dissolved Ni and Zn concentrations in exceedance of the discharge contaminant trigger levels have also been detected in the supernatant. The tailings supernatant is recycled when possible at the Mine, and the TSFs have no discharge points; therefore, the supernatant will not be released to the environment. However, the water quality results indicate that the tailings do have the capacity to generate elevated EC and dissolved metal concentrations in run-off and or seepage.

The surface water quality results indicate that the geology at the mine is capable of generating AMD (and NMD) from certain materials and under certain conditions. However, significant and persistent AMD at the site is limited to that issuing from RSA1 on Ramp 7 and Bullgang Drain and the problem at that location is considered to have been a result of the concentration of sulphidic coal rejects with little to no ANC and no landform management to prevent water (rainfall or seepage) or oxygen ingress and subsequent sulphide oxidation.

In the AMD discharge, significant concentrations of dissolved metals are contained in the water. In the non-acidic seepages salinity (as measured by EC) is potentially problematic at K2N seep; however, this appears to be a localised issue, possibly resulting from the historic deposition of saline spoil in the QW Pit (RGS 2018). Dissolved Ni and Zn in the saline drainage were also elevated, reinforcing the potential for seepage and run-off at the site to contain metals, even if the seepage is not acidic. The limited information on other surface seepage at the mine indicates that seepage is not a widespread or common occurrence at Meandu mine.

GROUNDWATER

The groundwater data reinforces the pit water and seepage chemistry results, demonstrating that the potential for AMD generation exists in certain lithologies and under certain conditions. The seepage at Ramp 7 and Bullgang Drain is interpreted to be the surface expression of groundwater that has seeped through the rejects at RSA1, mobilising pyrite oxidation products (SO_4^-, Fe, Mn) and driven westwards by head from the groundwater beneath the NWBFP and NWBTSF along the base of the rejects/spoil.

The groundwater associated with spoil across the site generally has slightly elevated EC but only moderately elevated SO_4^-. Dissolved metal concentrations in spoil are variable across the mine, with elevated Fe fairly common, but Al, Mn, Ni and Zn also displaying the capacity to be mobilised into groundwater from the spoil.

The source of the elevated EC groundwater plume north-west of QW Pit is unknown but may be a result of unrecorded deposition of saline spoil and or rejects being deposited in the area during the rapid development of QW Pit.

It should be noted that with the exception of the AMD at Ramp 7 and Bullgang Drain, no surface expressions of groundwater seepage are present at the mine and the elevated EC, SO_4^- and metals concentrations reported above reflect the aquifer pore water hydrochemistry and do not imply that environmental impact will result from the groundwater impact.

MINERALOGY

The Hylogger™ mineralogical results are largely as expected for a fluvial sedimentary domain with interbedded coal seams, with the dominant minerals throughout being quartz and kaolinite, with secondary quantities of feldspar and other clays. Carbonates (siderite, dolomite, ankerite, calcite, magnesite) were detected at trace levels only, with only a few detections of calcite in the Queen coals. Siderite has the lowest reactivity and buffering capacity of the carbonates present at the mine (EGi 2016). The presence of jarosite (iron sulphate) and gypsum (calcium sulphate) is also important as these two minerals are common by-products of pyrite oxidation (jarosite) and subsequent acid neutralisation (gypsum).

The absence of pyrite in the Hylogger™ results is of interest, given the common identification of pyrite in the geological logs. This highlights the low quantities of pyrite in the Tarong Beds at Meandu Mine. Pyrite was only identified in the geological logs in association with coal, with the exception of a 0.36 m thick interval of siltstone in the interburden of drill core 8029C.

GEOCHEMISTRY

The results of the static testing of the overburden/interburden indicate that the great majority of the overburden material and approximately 85% of the interburden is classified as NAF. The static testing results of the spoil also suggest the majority of the spoil is NAF, although the material is highly heterogeneous and isolated areas of actual acidity and PAF have been identified (QGESS 2017). Sulphidic material is limited almost exclusively to organic lithotypes in the Mine stratigraphy (SRK 2019, 2021). However, the results of the kinetic testing suggest there are exceptions to the rule, with the weathered sandstone column generating appreciable acidic leachate for the duration of the testing.

Spoil from the overburden is considered unlikely to generate significant AMD and any small pockets of acid generated should be diluted by non-acidic drainage from the majority of rock. Spoil from the interburden units has a higher potential for AMD generation due to the higher content of organic material in the rock; however, significant AMD generation is considered unlikely due to the majority of NAF rock in the units.

The overburden/interburden appears to have variable potential for generating NMD/SMD, with static testing suggesting most material has a low potential for generating saline drainage and isolated parts of the Mine may generate leachate with one or more elevated metal concentrations. The column leach testing indicated the potential exists for saline metalliferous flushes being generated from overburden when first mined and exposed to rainfall. Ongoing drainage with elevated Se, Al and Fe may also be generated by the overburden; however, other elevated metal leaching appears to be related to sulphide oxidation.

Current consensus is that the expression of AMD at Ramp 7 and Bullgang Drain is a result of the oxidation and subsequent flushing of oxidation products from historically placed coarse rejects on RSA1 and in the NWBFP generally (WSP 2018). Static and kinetic testing confirms the coarse reject waste stream to be PAF and ongoing waste management is required to prevent further occurrences of AMD at Meandu Mine through preventing the oxidation of the coarse rejects. There is also the potential for the coarse rejects to generate NMD, even if co-mingled with tailings; therefore, prevention of oxidation of the coarse rejects is important regardless of the co-disposal strategy of the waste streams.

The tailings at Meandu Mine are considered to be PAF; however, a combination of the addition of $Ca(OH)_2$ at the CHPP and the fine grain and low permeability of the tailings creates a significant lag time (>24 months) before the onset of acid production. The supernatant water quality from the TSFs support the conclusion that the tailings are unlikely to generate acid provided they remain saturated.

The tailings are considered to have a low potential for the generation of SMD in the short and long term. There is the potential for the tailings to generate NMD, particularly with regard to dissolved Mn, Zn and Ni; however, this will be reduced if oxidation of the tailings is prevented.

The findings of the geochemical assessment of the coal combustion products are quite definitive with regards to AMD potential, as all samples were classified as NAF and will not generate acid through sulphide oxidation. The actual acidity of the coal combustion products is neutralised during processing at the Tarong power stations. The coal combustion products appear to have the potential to generate a slightly saline “first flush” with elevated metals; however, the potential for ongoing SMD is considered low. The potential for coal combustion products to develop NMD is considered low, with the exception of V, Mo and Sr.

MANAGEMENT/MITIGATION

Conservative waste management procedures have been developed at Meandu Mine to minimise the risk of AMD generation across the Mine during operation and post-closure. Each significant rock unit at the Mine has been classified according to material design parameters, the management of which is assigned in mine planning procedures. Specific management procedures for each mine waste material are as follows:

- Waste – interburden: all interburden within 2 m of the roof and floor of modelled coal seams has been classified as PAF in the model and will be placed >6 m below final landform as per the Life of Mine Plan. The remainder of the interburden has been classified as NAF.

- Waste – overburden: classified as NAF in the forward mine plan except for separate units of carbonaceous mudstone (CM) and lignite (LG), classified as PAF, which will be placed >6 m below final landform. NAF overburden will be used as cover material generating a capping of NAF at least 6 m thick across the final landform design. Isolated occurrences of PAF in the overburden are generally too small to be of consequence at a mine scale, but where feasible these PAF units will be segregated and placed at least 6 m below the final design landform.
- Tailings/coal rejects: classified as PAF. Tailings have a significant lag time before acid generation. Solid bowl centrifuges have been installed to dewater tailings which will allow the majority of tailings to be co-mingled and disposed with coal rejects into dedicated disposal areas. Coal rejects to be placed within the disposal area less than two weeks after stockpiling. Rejects disposal area to be capped with at least 6 m of NAF material and final earthen capping to promote plant growth and restrict moisture ingress.
- TSF: Contingency tailings disposal will occur when the solid bowl centrifuges are off-line, with the tailings disposed into the K2WN Pit and later into K2-W Pit. Tailings will be kept saturated to prevent oxidation. In order to maintain stability of the ash dam wall, contingency tailings deposition will be managed so that the tailings do not come into contact with the embankment. The final TSFs will be capped with a NAF material to form the initial layer that is in contact with the tailings, and at least 6 m of the final landform surface to minimise infiltration of water and the likelihood of any erosion occurring to the final cover system.
- Coal Combustion Products: classified as NAF, coal combustion products are stored in the dedicated ash storage void K2WN, which has a planned operational closure in 2028. Following completion of ash and contingency tailing storage in K2WN, placement of ash and tailings in a void within K4S pit will then be undertaken. Rehabilitation will comprise a period of desiccation/consolidation following by capping with NAF spoil to a level that fits in with the surrounding final landform and has a minimum thickness of 6 m, which will be free-draining and minimise infiltration of water into the landform.

Final Pit Voids: The current Life of Mine Plan proposes to limit the final pit voids post-mining completion to K2E and K4E Pits. The planned post-mining land use (PMLU) of the residual voids is for steep rocky ecosystems and water storages (EA Condition G6), with the aim of containing water of a suitable quality for native wildlife and/or livestock ingestion. The initial pit water quality modelling indicates that final pit water qualities are likely to be suitable for stock watering (WSP, 2021). The final highwalls for K2E and K4E Pits are planned to the PMLU of Steep Rocky Ecosystem, comprising partially vegetated terraces, mimicking natural sandstone cliffs. Specific AMD, SMD and/or NMD management of the final highwalls is not expected to be required as geochemical testing suggests the relative volume of potentially problematic rock is insignificant at the scale of mining.

GAP ANALYSIS AND ADDITIONAL SAMPLING/TESTING

The gap analysis identified the requirement for additional geochemical sampling and testing as described below:

- Additional sampling and static testing of sections of the mine forward planning area identified as having low sample densities (north-east of K2E Pit).
- Comprehensive sampling and kinetic testing program of:
  - overburden/interburden lithologies to verify the classification of non-acid forming (NAF) and PAF materials at the site more accurately, particularly lithotypes with UC classification.
  - Material representative of the final pit highwalls (K2E and K4E Pits) to verify the geochemical kinetic properties of the final pit walls to inform residual void water quality modelling. This will include remnant coal samples as this material has been classified as PAF will likely have the highest risk for AMD generation.

Ongoing additional geochemical sampling and testing is expected to be undertaken opportunistically throughout the operation of the Mine so that any changes to the long term mine plan can be incorporated into ongoing waste and AMD management planning.

Drilling and analysis of the area east and north-east of K2E is proposed for 2021 – 2022. Additional kinetic testing columns have been commissioned and started in September 2021.

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Appendix L

Meandu Mine PRC Plan Revegetation Plan



TEC Coal Pty Ltd

Meandu Mine Progressive Rehabilitation and Closure Plan

Revegetation Plan

MAY 2022



Question today
Imagine tomorrow
Create for the future

Meandu Mine Progressive Rehabilitation and Closure Plan
Revegetation Plan

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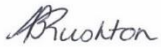
Approved by:	Allison Rushton	27/05/2022	

WSP acknowledges that every project we work on takes place on First Peoples lands.
We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

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Appendix A Progressive rehabilitation certification notice

Glossary of terms and acronyms

AMD	Acid mine drainage
BoM	Bureau of Meteorology
BHWE	Base of weathering
BUTE	Base of Tertiary
CHPP	Coal handling and preparation plant
CEC	*cation exchange capacity*: a measure of a soil's ability to hold positively charged ions; provides an indication of the ability of the soil to hold nutrients.
CQU	Central Queensland University
CORVEG	Queensland CORVEG Database, Department of Science, Information Technology and Innovation (2017)
CSBP	CSBP Limited (Chemical supplier)
CSIRO	The Commonwealth Scientific and Industrial Research Organisation
CWD	Climatic Water Deficit
DAF	Department of Agriculture and Fisheries (Queensland)
DBH	Diameter at Breast Height
DES	Department of Environment and Science
DNRM	Department of Natural Resources and Mines (now Department of Resources)
DSITIA	Department of Science, Information Technology and Innovation
EA	Environmental Authority
EC	Electrical Conductivity
ESP	Exchangeable sodium percentage
EW	Extremely Weathered
FoS	Factor of Safety
HQPlantations	Licence holder for Hoop Pine Plantation
IPCC	Intergovernmental Panel on Climate Change
K2E ASA	King 2 East Additional Surface Area
ML	Mining Lease
MPR	Mixed Plant Reject
m/s	metres per second
MW	Megawatts

NAF	*Non-acid forming*: geochemical classification of material calculated not to generate acid conditions.
NUMA	Non-use management area
PAF	*Potentially acid forming*: geochemical classification of material calculated to have the potential to generate acid conditions.
PAWC	Plant available water capacity
PC	Principal Component
pls	Pure live seed
PMLU	Post-mining land use
PRC Plan	Progressive Rehabilitation and Closure Plan
PRC Plan Guideline	Guideline – Progressive rehabilitation and closure plans (PRC Plan) (ESR/2019/4964, Version 2.01)
RA	Rehabilitation Area
RE	Regional ecosystem
RM	Rehabilitation Milestone
SILO	Scientific Information for Land Owners
SRA	Surface Rights Area
Stanwell	Stanwell Corporation Limited
Tarong power stations	Tarong and Tarong North power stations
TEC Coal	TEC Coal Pty Ltd

1 Introduction

1.1 Background information

Meandu Mine is an open-cut coal mine that is operated within mining lease (ML) 6674 for the purpose of supplying black thermal coal to the adjacent Tarong and Tarong North power stations (Tarong power stations). Environmental performance at the mine is regulated by the Environmental Authority (EA) EPML00709113 (12 January 2022).

TEC Coal Pty Ltd (TEC Coal) owns the Meandu Mine and is the holder of ML6674 and EA EPML00709113. TEC Coal is a wholly owned subsidiary of Stanwell Corporation Limited (Stanwell). Stanwell is a Queensland Government Owned Corporation under the *Government Owned Corporations Act 1993* and registered under the *Corporations Act 2001*. Stanwell is a substantial provider of electricity to the National Electricity Market and large energy users throughout Australia. It owns assets for the purposes of generating electricity, including the Meandu Mine and Tarong power stations. Through these and other assets, Stanwell has a generation capacity of more than 3,000 megawatts (MW).

1.2 Purpose and scope

The purpose of this Revegetation Plan is to:

- identify options and guide the revegetation works at the Meandu Mine site for different final land uses as proposed in the Meandu Mine EA (EPML00709113) and the Meandu Mine Progressive Rehabilitation and Closure Plan (PRC Plan)
- provide guidance on achieving each progressive rehabilitation milestones as defined in the PRC Plan, and
- describe how revegetation will be carried out at the Meandu Mine site in order to meet the legislative requirements relating to mine closure for land relating to ML6674 (refer to Section 1.3).

The Revegetation Plan is intended to support the Meandu Mine PRC Plan development and execution.

The continual update of the Revegetation Plan will be undertaken in accordance with the current and any future updated version of the *Guideline – Progressive rehabilitation and closure plans (PRC Plan) (ESR/2019/4964, Version 2.01)* (the PRC Plan Guideline). It is intended that this Revegetation Plan will be progressively reviewed and updated over the remaining life of the mine (LOM) to satisfy this requirement.

1.3 Legislative context

1.3.1 Progressive Rehabilitation and Closure Plan (PRC Plan) requirement

Section 3.6.1 of the PRC Plan Guideline states the requirement for, and details the required contents of, a Revegetation Plan. This required content is outlined in Table 1.1 along with where this information can be found within this Revegetation Plan.

In accordance with the PRC Plan guideline the Revegetation Plan must propose activities that will establish self-sustaining vegetation communities that are appropriate for the intended post-mining land uses (PMLUs). Revegetation should, therefore, not only establish a ground cover, but also, in some domains, establish associated fauna habitat and other ecological services.

Table 1.1 PRC Plan Revegetation Plan required content

Revegetation plan requirement	Section where addressed
The Revegetation Plan must (but is not limited to):	
— Clearly articulated revegetation objectives for the site that are consistent with the PMLUs, non-use management areas (NUMAs), and rehabilitation milestones identified in the PRC Plan schedule.	Sections 3 and 9
— Identify key flora species including pasture plants and tree and shrub species representative of the proposed PMLU.	Section 3.3
— Identify any species of conservation significance relevant to the mine's approval.	Section 3.3
— Identify any fauna habitat and use requirements – where fauna habitat is proposed, a management and monitoring plan to describe how the rehabilitated areas will be utilised by fauna and what other management measures would need to be implemented.	Section 3.4
— Include evidence and justification for any analogue sites of the monitoring plan.	Section 3.5
— Describe the works for establishing and managing the revegetation, including a description of proposed site preparation and the timeframe for works.	Sections 5.1, 6.2, 7.2, and 8.4
— Identify what plant/seed mixes are appropriate for the PMLU and where the mixes will be sourced – locally sourced seed should be used where appropriate.	Sections 5.1.3, 6.2.3, 7.2.3 and 8.4.2
— Identify seed density application rate and timing of seeding.	Sections 5.1.3, 6.2.3, 7.2.3 and 8.4.2
— Identify the proposed location of any infrastructure required to protect revegetation.	Applicable to Beef Cattle Grazing PMLU only – Section 6.1.2
— Identify the growth media that would be suitable to sustain the PMLU and whether this is available on site.	Sections 5.1.1, 6.2.1, 7.2.2 and 8.3
— Identify topsoil depth requirements for revegetation success and sustainable PMLU.	Sections 5.1.1, 6.2.1, 7.2.2 and 8.3
The rehabilitation planning part must include details of the site preparation required for rehabilitation activities. The following elements must be included in the site preparation strategies:	
— The application and incorporation of ameliorants (if required for chemical balance) and bulk ameliorants such as gypsum, lime and other organic materials.	Sections 5.1.1.2, 6.2, 7.2.2 and 8.3
— Spreading of growth medium layer (topsoil, topsoil/rock mix, or suitable waste if appropriate) to a depth suitable for the target vegetation.	As Above
— The application of seed, fertiliser and, where applicable, irrigation.	As Above

1.3.2 Environmental Authority (EA) requirements

The Meandu Mine EA conditions outlined in Table 1.2 are relevant to the revegetation works undertaken at the Meandu Mine site. These conditions will be removed from the EA once the PRC Plan is approved, and as such, the PRC Plan and this Revegetation Plan have methods and criteria which are consistent with the EA requirements.

Table 1.2 EA EPML00709113 Conditions relevant to revegetation works

Condition	Requirement
G1	Progressive rehabilitation: Progressive rehabilitation must commence within 12 months of the disturbance activities ending
G3	All areas disturbed by mining activities must be progressively rehabilitated to achieve: a) A landform for final land uses that are: **1** Safe to humans and wildlife **2** Non-polluting **3** Stable; and **4** Able to sustain the final land use; and b) The final land use and rehabilitation success criteria are in **Appendix 5 – Final land use and rehabilitation success criteria for landforms** (refer to Table 3.1 in Section 3.1) and indicative locations of final land uses are shown in **Appendix 5 – Final land uses and indicative locations** (refer to Figure 2.1 in Section 2). c) If the water storage in residual void and Steep Rocky Ecosystem landform shown in **Appendix 5 – Final land uses and indicative locations** (refer to Figure 2.1 in Section 2) that is associated with the future K2E mine extension is not approved by 18 December 2025, it must be removed from **Appendix 5 – Final land uses and indicative locations** (refer to Figure 2.1 in Section 2).
Condition G5	Rehabilitation Outcomes: Areas that are to be progressively rehabilitated to a final land use, as required by Condition G3 of this environmental authority must be rehabilitated using the rehabilitation criteria defined in **Appendix 5 – Final land use and rehabilitation success criteria for landforms** (refer to Table 3.1 in Section 3.1).

1.4 Overview of the Meandu Mine site and operation

1.4.1 Location

Meandu Mine is located in Queensland's South Burnett region, approximately 150 km north-west of Brisbane, 14 km south-west of Nanango and 1.5 km to the south of the Tarong power stations. The nearest town to Meandu Mine is Yarraman, which is located approximately 6 km to the south south-east from the approved mining activities. Figure 1.1 illustrates the locality of Meandu Mine within the surrounding regional area.

Meandu Mine is an open-cut coal mine that is operated within mining lease (ML) 6674 for the purpose of supplying black thermal coal to the adjacent Tarong and Tarong North power stations (Tarong power stations). Environmental performance at Meandu Mine is regulated by EA EPML00709113 (12 January 2022).

Meandu Mine is located in Queensland's South Burnett region, approximately 150 kilometres (km) north-west of Brisbane, 14 km south-west of Nanango and 1.5 km to the south of the Tarong power stations. The nearest town to the Meandu Mine site is Yarraman, which is located approximately 6 km to the south south-east from the approved mining activities.

Figure 1.1 illustrates the locality of Meandu Mine within the surrounding regional area. Meandu Mine is located wholly within coal mining lease ML6674, which was granted on 19 February 1981. ML6674 occupies a total area of 4,267 hectares (ha) partly within both the South Burnett Regional Council and Toowoomba Regional Council local government areas. TEC Coal currently holds surface rights for approximately 2,640 ha of ML6674 (refer Figure 1.2). The remaining land outside of the surface rights area is predominantly State Forrest (Yarraman State Forest) and is held under license for the production of plantation timber. Other small areas outside of the surface rights area include use as high voltage transmission line easements and gazetted or private roads.

At the time of compilation of the PRC Plan in May 2022, TEC Coal has received State Government Approval and is finalising Commonwealth Approval to increase the approved surface rights area at the Meandu Mine. The King 2 East (K2E) Project involves increasing the approved surface rights area within ML6647 by an additional 186 ha which will allow progression of the existing K2E pit to the east. State approval for the K2E Project was sought via an EA amendment application for EPML00709113 under the *Environmental Protection Act 1994* which was approved by DES on 23 November 2021 and incorporated in the current EA (12 January 2022). Consequently, the K2E Project additional surface area (K2E ASA) is included in the PRC Plan. Commonwealth approval for the K2E Project under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is currently being assessed with further information provided via the Preliminary Documentation Assessment Report which was submitted to the Department of Agriculture, Water and the Environment on 17 May 2022.

Figure 1.2 shows the Meandu Mine site layout and key areas of interest relevant to this Revegetation Plan (i.e. limited to within the surface rights area and the extent of mining activities disturbance).

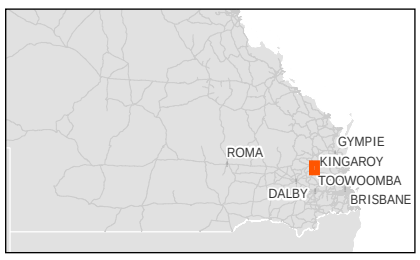
Meandu Mine Revegetation Plan

Figure 1.1
Locality map of Meandu Mine

Legend

- Rail Line
- Highways
- Secondary Roads
- Watercourse
- Mining Lease (ML6674)
- Local Government Areas
- Cadastre
- Approved Surface Rights Area

KINGAROY
REDVALE
HILLSDALE
KINGAROY CREEK
EDENVALE
BOOIE
MALAR CREEK
TAABINGA
HORNLEY
COOLABUNIA
BRISBANE GULLY
HODGLEIGH
HORSE CREEK
BARKER CREEK FLAT
KUNIOON WEST
CAMP CREEK
WATER COURSE
DARLI
GOODGER
KUNIOON
NANANGO
SOUTH BURNETT REGIONAL COUNCIL
MEANDU CREEK
SANDY CREEK
BARKER CREEK
BARKERS CREEK
BROOKLANDS
SOUTH NANANGO
MIDDLE CREEK
PEACH CREEK
TARONG
TARONG AND TARONG NORTH POWER STATIONS
BLACK GULLY
BAINS GULLY
ROCKY CREEK
Rocky Creek
TANDURINGIE CREEK
YARRAMAN CREEK
ML 6674
MORRINSVILLE
TOOWOOMBA REGIONAL COUNCIL
YARRAMAN
BEAR CREEK
COPPER CREEK
NEUMGNA
Yarraman Creek
PETER CREEK



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Meters

Coordinate system:
GDA 2020
Scale ratio correct when printed at A3
1:100,000
Date: 22/03/2022

Data sources: DELWP, Geoscience Australia

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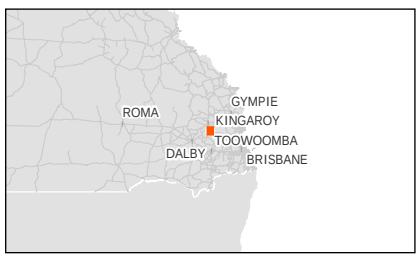
Meandu Mine Revegetation Plan

Figure 1.2
Meandu Mine Lease boundary
and surface rights area

Legend

- Watercourse
- Ridge Road
- Mining Lease (ML6674)
- Local Government Areas
- Ridge Road Closure
- Approved Surface Rights Area
- Yarraman State Forest
- Cadastre



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Coordinate system:
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Scale ratio correct when printed at A3
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Date: 22/03/2022

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1.4.2 Site topography

ML6674 is located on part of the remnants of a once extensive plateau which has undergone minor structural movement, erosion, and weathering to produce a series of land surfaces of varying altitudes and elevations (Hollingsworth, 1979).

The average altitude of the area surrounding the Meandu Mine is approximately 480 metres (m) with the topography reducing in elevation from south to north. The region is predominantly undulating hills of low relief, characterised by steep upper slopes and gentle summits and ridges. These hills are spurs of the Cooyar Range (altitude 600 m above sea level), which lies to the south-east of ML6674. Flat-lying basalt flows and associated sediments form the generally subdued scarp of the Cooyar Range. Remnants of sandstones and conglomerates of the coal measures form isolated knobs and subdued hill scarps.

The topography of the Meandu Mine itself has been altered significantly by mining operations. Within the K2E ASA, the topography is heavily undulating and well drained. Ridge Road, separating the east side of the Meandu Mine and the Hoop Pine plantation (Yarraman State Forest), has been formed along the crest of a deeply weathered basalt ridge. The ridge is reasonably level, with upper slopes typically between 5% and 10%, mid slopes between 15% and 20% and more gentle gradients at the toe of the slope towards the ephemeral drainage line known as Rocky Creek.

The topography of the Meandu Mine prior to mining operations is illustrated in Figure 1.3.

1.4.3 Climate

Climate data for the Meandu Mine site is included Section 2.1.2 of the Meandu Mine PRC Plan. Meandu Mine lies within the subtropical climate zone. The Australian subtropical climate is seasonal with the highest temperature, rainfall and evaporation occurring during the summer months of November to February. Rainfall in the region is seasonal and highly variable. Most rainfall generally falls between October and March (i.e., the wet season) (refer Figure 1.4). The wet season is characterised by short-lived intense rainfall events (i.e., high daily totals) while drier conditions are experienced throughout the rest of the year. Recharge and stream run-off potential is highest during the wet season months, when most rainfall occurs. Similarly, evaporation is higher between October and March (i.e., in the warmer months) and significantly exceeds rainfall year-round. As shown in Figure 1.4, the evaporation rates are strongly linked to temperature variations.

The State of Queensland (2019) climate projections for the Wide Bay-Burnett region predict that the region can generally expect to be hotter and drier, with more frequent hot days, few frosts and harsher fire weather (refer further to Section 2.1.2.2 of the Meandu Mine PRC Plan). The climate change projection data from the region have been considered in the development of this Revegetation Plan particular but not limited to the potential impacts on seed mix establishment, selection of species, erosion control and monitoring and bushfire risk management.

Meandu Mine Revegetation Plan

Figure 1.3
Pre-mining topography of
the Meandu Mine and surrounds

Legend

- Watercourse
- Ridge Road
- Mining Lease (ML6674)
- Local Government Areas
- Cadastre
- Approved Surface Rights Area
- Yarraman State Forest

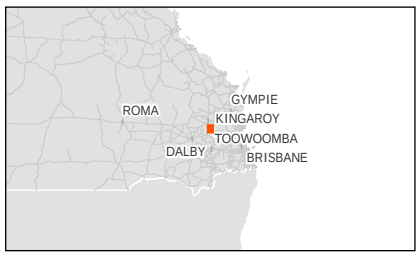
Contours

- 50 m Contour
- 10 m Contour

Elevation

Value

High : 640
Low : 390



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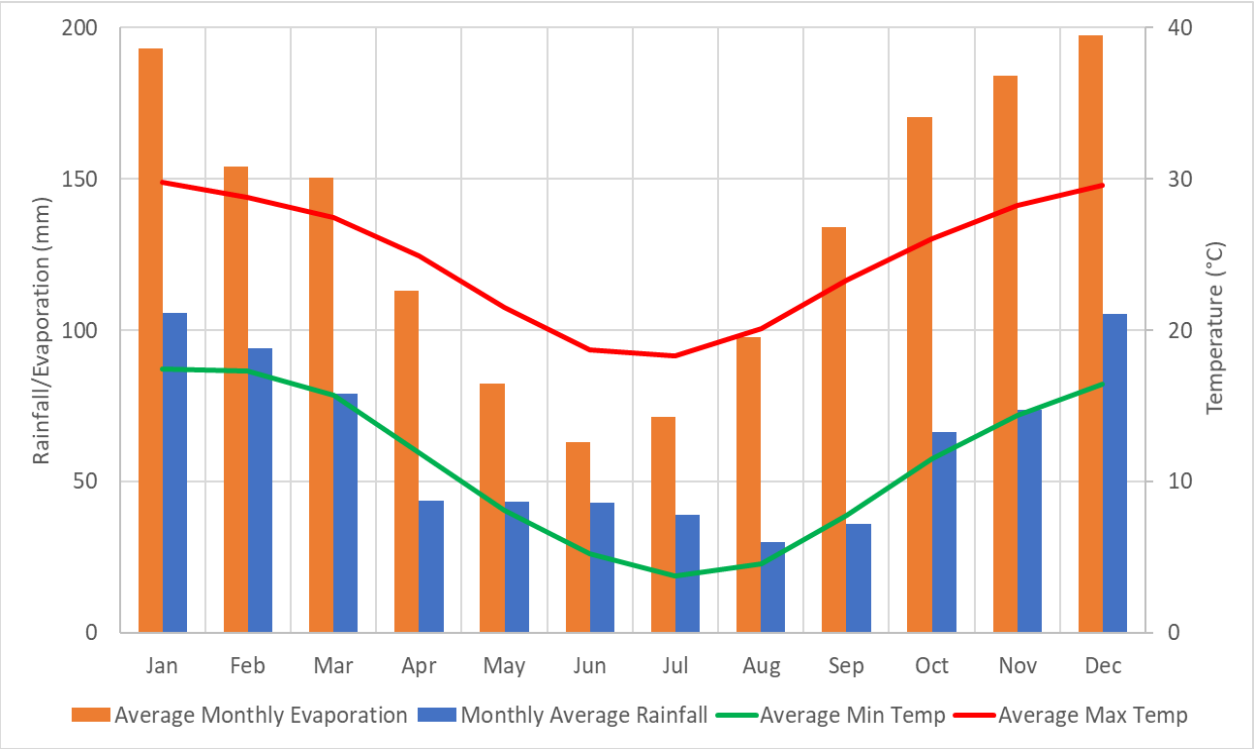


Source: SLR, 2022

Figure 1.4 Meandu Mine average monthly evaporation, rainfall and temperature (BOM data: January 1900 – June 2021)

1.4.4 Land systems and soils

Figure 1.5 illustrates the land systems mapping released by the Queensland Department of Primary Industries for the South Burnett region in 1983 (Vandersee and Kent, 1982) and for Cooyar Shire in 1977 (Vandersee, 1977). This mapping reflects the pre-mining soil conditions of Meandu Mine area. A description of these land system units and the soils located in the corresponding system is provided in Table 1.3.

Table 1.3 Meandu Mine associated soil units and description – pre-mining condition

Land system unit	Soil description
Alluvials (Qa1)	Flat to slightly undulating plains of recent alluvia with associated terraces and swales of rivers and creeks; deep, dark cracking clays (black earths and alluvial soils), minor areas of texture contrast soils with brown or yellowish brown clay subsoils clay subsoils (solodic and solodized solonetz).
Sandstone, siltstones, shales and conglomerates (Ru1)	Undulating to steep hilly terrain on sandstones of the Tarong beds; shallow sandy, stony lithosols with some rock outcrops with areas of texture contrast soils with yellow clay subsoils, often motted (soldics and solodized solonetz).
Laterite (Lt6)	Steep hilly terrain and scarps on lateritised Main Range Volcanics; shallow, loamy lithosols with variable amounts of laterite to shallow, uniform and gradational, red loams and clay loams (Krasnozems and euchrozems).
Upper Yarraman (UY)	Predominantly moderately deep to deep, red, structured earths with minor areas of yellow earths.
Rocky Creek (RC)	Complex area with shallow, stony, lithosols, texture-contrast soils with bright reddish-brown and yellowish-brown clay subsoils and areas of red and brown clays.
Palms (PL)	Vary from shallow, stony, brown-black lithosols to moderately deep, brown or yellowish-brown clays or texture-contrast soils with yellowish-brown clay subsoils.

Meandu Mine Revegetation Plan

Figure 1.5
Pre-mining land systems and
in situ soil mapping
of Meandu Mine and surrounds

Legend

Insitu Soils - Probable Origin

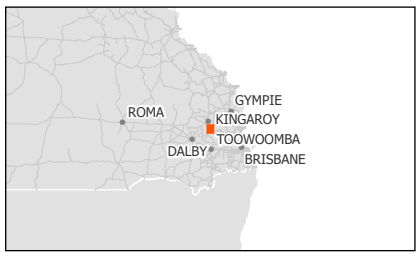
- Sedimentary
- Volcanic
- Volcanic/Disturbed
- Sedimetary
- Volcanic
- Mining Lease (ML6674)
- Approved Surface Rights Area
- K2E ASA

Land systems - land resources of the Burnett region part 1 - South Burnett - ABS

- Lt6 - Land systems on laterite, Type 6
- Qa1 - Land systems on alluvials, Type 1
- Ru1 - Land systems on sandstone, siltstones, shales and conglomerates, Type 8

Land Systems Cooyar Grazing Lands Study ACR

- 1 - Kooralgin
- 10 - Palms
- 15 - Rocky Creek
- 2 - Upper Yarraman
- 9 - Tarong



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Date: 26/05/2022

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Soil survey undertaken by Landloch in September 2021 (Landloch, 2021a) identified two in-situ soil mapping units on areas of the Meandu Mine that had minimal disturbance from mining activities being a Red Ferrosol, derived from volcanic parent material, and a brown complex of Kurosols, Chromosols and Sodosols derived from sedimentary parent material.

The volcanic derived soils: the Red Ferrosols was found on the eastern side of Meandu Mine. This soil unit is defined by its moderate to strong structure, polyhedral peds and bright red colours throughout the profile. Sedimentary derived soils were found on slopes of the basalt plateaus. These soils are a mix of Kurosols, Chromosols and Sodosols, and all are brown.

Table 1.4 summarises the key soil characteristics of these soil types. Further information on soils within and surrounding the Meandu Mine can be found in Section 2.16 of the Meandu Mine PRC Plan.

Table 1.4 In situ soil profile characteristics

Feature	Volcanic derived (Red Ferrosol) soil	Sedimentary derived soil
Brief description	Uniformly textured soil with bright, even reddish tones throughout	Texture contrast and gradationally textured soils with even brown tones throughout
Landform	Undulating plateaus	Side slopes of basal plateaus
Geology	Basalt	Sedimentary
Australian Soils Classification	Red Ferrosol	Brown Kurosols, Brown Chromosols, Brown Sodosols
Structure	Moderate to strong throughout profile, polyhedral peds	Massive to moderate
Surface texture (0–10 cm)	Clay loam to light clay	Sandy clay loam to clay loam
Subsoil texture (>10 cm)	Light clay to medium clay	Sandy clay loam to medium clay
Observations	Site I1, I2, I3, I5, I6, I7 shown in Figure 1.5	Site I4, I8, I9, I10 shown in Figure 1.5

Topsoil for rehabilitation activities is sourced from existing topsoil stockpiles at Meandu Mine or, where possible, directly placed from areas on the mining path being stripped at the time. The topsoil stockpiles vary in their physical and chemical properties reflecting natural variation in the original soil types (for example Ferrosols, Sodosols, Kurosols) across the pre-mining landforms. Properties and constraints of the material types in the geological model used as the basis of the LOM Plan are summarised in Table 1.5.

Table 1.5 Properties and constraints of rehabilitation material sources (adapted from Landloch, 2021a)

Material unit	Description	Properties and constraints	Native vegetation	Grazing
RED	Laterite and subsoil; plastic clays (not claystone). Well drained material. Laterite has low PAWC.	Red clay subsoils have relatively low geotechnical stability, are plastic when wet.	Clay lithology suitable for topsoil. Laterite has high strength and low porosity, best as dump cover below 2 m.	Clay lithology suitable for topsoil. Other RED material may be suitable for cover in areas of low gradient. Laterite has high strength and low porosity, best as dump cover below 2 m except in small quantities.

Material unit	Description	Properties and constraints	Native vegetation	Grazing
WB	Weathered Basalt; clay, claystone where low salinity, low chloride and <20% rock.	Any stripped topsoil has very high rehabilitation value. Clay can contain high salinity and chloride but will rapidly leach below the root zone.	Clay suitable but not highest value use. Save this material for grazing PMLU.	Suitable and preferred for use in grazing PMLU in areas of low gradient (<17%) where $EC_{1:5}$<0.5 dS/m and Chloride levels are marginal or satisfactory. 0.8 m depth of dump cover required plus 200 mm topsoil.
TE	Tertiary Sediments	Low chemical and physical fertility. Can have high salinity and chloride. Can be dispersive.	Clay marginally suitable for dump cover and potentially subsoil. May need Gypsum or lime at 5 t/ha/100 mm layer.	Clay marginally suitable for dump cover and potentially subsoil. May need Gypsum or lime at 5 t/ha/100 mm layer.
BA	Fresh Basalt (unweathered); topsoil may crack and should not be used over dispersive dump cover (conglomerate, sandstone).	Clay suitable for use as dump cover if salinity and clay limits not exceeded and rock content allows effective handling.	Basalt rock can be used for rock armouring steep gradients (18–33%) in native vegetation or steep terraced landforms.	Clays can be used as dump cover below 1 m in grazing PMLU or potentially above PAF cells due to relatively high neutralising capacity.
UT	Upper Triassic; potentially sodic and dispersive. Claystone may be saline.	Potentially sodic, dispersive and saline.	Suitable dump cover to 15% gradient beneath 0.2 m of non-cracking topsoil. Claystone not within 1 m of surface.	Unsuitable within 2 m of surface due to potential dispersion, low PAWC and high erodibility.
CG	Conglomerate Sandstone; conglomerate, sandstone, claystone.	Potentially sodic, dispersive and saline.	Suitable dump cover to 15% gradient beneath 0.2 m of non-cracking topsoil. No Claystone within 1 m of surface. Otherwise suitable dump cover.	Unsuitable within 2 m of surface due to potential dispersion, low PAWC and high erodibility. Claystone unsuitable.
CM	Weathered coaly mudstone/inferior coal.	Coaly mudstone can be PAF.	Unsuitable for dump cover.	Unsuitable for dump cover.
SH	Shale; shale, siltstone, carbonaceous mudstone.	Limited dispersion, chloride, pH and CEC.	Suitable dump cover below 0.2 m if NAF.	Suitable dump cover below 0.8 m if NAF.
TI	Triassic Interburden non-organic; claystone, siltstone, sandstone, mudstone.	Not dispersive, suitable chloride, pH and CEC.	Suitable dump cover below 0.2 m if NAF to 17% gradient, potentially to 20% for select materials.	Suitable dump cover below 0.5 m if high PAWC and confirmed NAF.

Material unit	Description	Properties and constraints	Native vegetation	Grazing
TI	Triassic Interburden organic; carbonaceous siltstone, carbonaceous mudstone.	Suitable sodicity, chloride, pH and CEC, some zones can be PAF.	Suitable dump cover below 0.2 m if confirmed NAF.	Suitable dump cover below 0.8 m if confirmed NAF.
SP	Historic spoil of mixed origin.	Highly variable in composition and attributes. Placement within profile to be determined from characterisation programs.	Basalt suitable for rock armouring steep slopes >17%, otherwise may be unsuitable within 1 m of surface (potential for low PAWC).	May be unsuitable within 4 m of surface due to high variability and potential for high salinity, high dispersion, low PAWC. Testing to be undertaken in advance of mining to confirm suitability.

1.4.5 Vegetation

Prior to mining, vegetation within ML6674 consisted of a mix of native vegetation, forestry plantation and areas of pasture/cropping. The native vegetation comprised predominantly open Eucalypt-forest and semi-evergreen vine thicket communities. The pre-clearing regional ecosystems (REs) outlined in Table 1.6 and shown on Figure 1.6. Further information on vegetation types and communities is provided in Section 2.1.8 of the Meandu Mine PRC Plan.

Table 1.6 Pre-clearing regional ecosystems within ML6674

RE code	RE description	Biodiversity status	Broad vegetation group
BVG: Eucalypt open forests to woodlands on floodplains (16-16d):			
RE 12.3.3./12.3.7	RE:12.3.3 – *Eucalyptus tereticornis* woodland on Quaternary alluvium.	Endangered	16c
	RE: 12.3.7 – *Eucalyptus tereticornis*, *Casuarina cunninghamiana* subsp. *cunninghamiana* +/- *Melaleuca* spp. fringing woodland.	Of Concern	16c
BVG: Eucalyptus woodlands to open forests (mainly eastern Queensland) (9-15):			
RE 12.9-10.18/ 12.9-10.21	RE: 12.9-10.18 – *Angophora leiocarpa*, *Eucalyptus crebra* woodland on sedimentary rocks.	Of Concern	9h
	RE: 12.9-10.21 – *Eucalyptus acmenoides* or *E. portuensis* woodland usually with *Corymbia trachyphloia* subsp. *trachyphloia* on Cainozoic to Proterozoic sediments.	No Concern at Present	9h
RE12.9-10.7	*Eucalyptus crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, *Angophora* spp. and *E. melanophloia* woodland on sedimentary rocks.	Of Concern	13c
RE12.5.1a	*Eucalyptus decorticans* open forest +/- *Corymbia citriodora* subsp. *variegata*, *C. trachyphloia* and *Acacia blakei*. Occurs on remnant Tertiary surfaces often around margins of plateaus.	No Concern at Present	12a
RE12.8.13	Araucarian complex microphyll vine forest on Cainozoic igneous rocks.	Of Concern	5a
RE 12.9-10.3	*Eucalyptus moluccana* open forest on sedimentary rocks.	Of Concern	13d

RE code	RE description	Biodiversity status	Broad vegetation group
BVG: Rainforests and shrubs (1-7b):			
RE12.5.13a/12.5.1	RE12.5.13a – Microphyll to notophyll vine forest +/- *Araucaria cunninghamii*. Characteristic species include *Araucaria cunninghamii, Cupaniopsis parvifolia, Dendrocnide photiniphylla, Rhodosphaera rhodanthema, Flindersia australis, F. schottiana, F. xanthoxyla, Drypetes deplanchei, Olea paniculata, Diospyros geminata, Gossia bidwillii, Excoecaria dallachyana* and *Vitex lignum-vitae*. *Argyrodendron trifoliolatum* sometimes present especially in subregion 6. Occurs on remnant Tertiary surfaces especially lateritised basalt.	Endangered	5a
	RE12.5.1 – Open forest complex with *Corymbia citriodora* subsp. *variegata* on subcoastal remnant Tertiary surfaces. Usually deep red soils.	No Concern at Present	5a

1.4.5.1 Fauna presence and populations

The native fauna of the area has been influenced by clearing of vegetation for plantation forestry and for agricultural purposes, by fire and by the introduction of exotic animals. The overall pattern of habitat change as a result of these activities was a reduction in the area of forest (both vine forest and open forest), a proportionate increase in the area of grassland and cultivation as well as the likely simplification of the remaining eucalypt forest.

Clearing of forested areas had resulted in the wider distribution of largely open country species such as the grey kangaroo, galah, sulphur crested cockatoo and black-backed magpie. Introduced mammal species such as cattle (*Bos taurus*), the hare (*Lepus europaeus*) and the fox (*Vulpes vulpes*) as well as birds like starlings (*Sturnus vulgaris*) were found to inhabit the open forest areas.

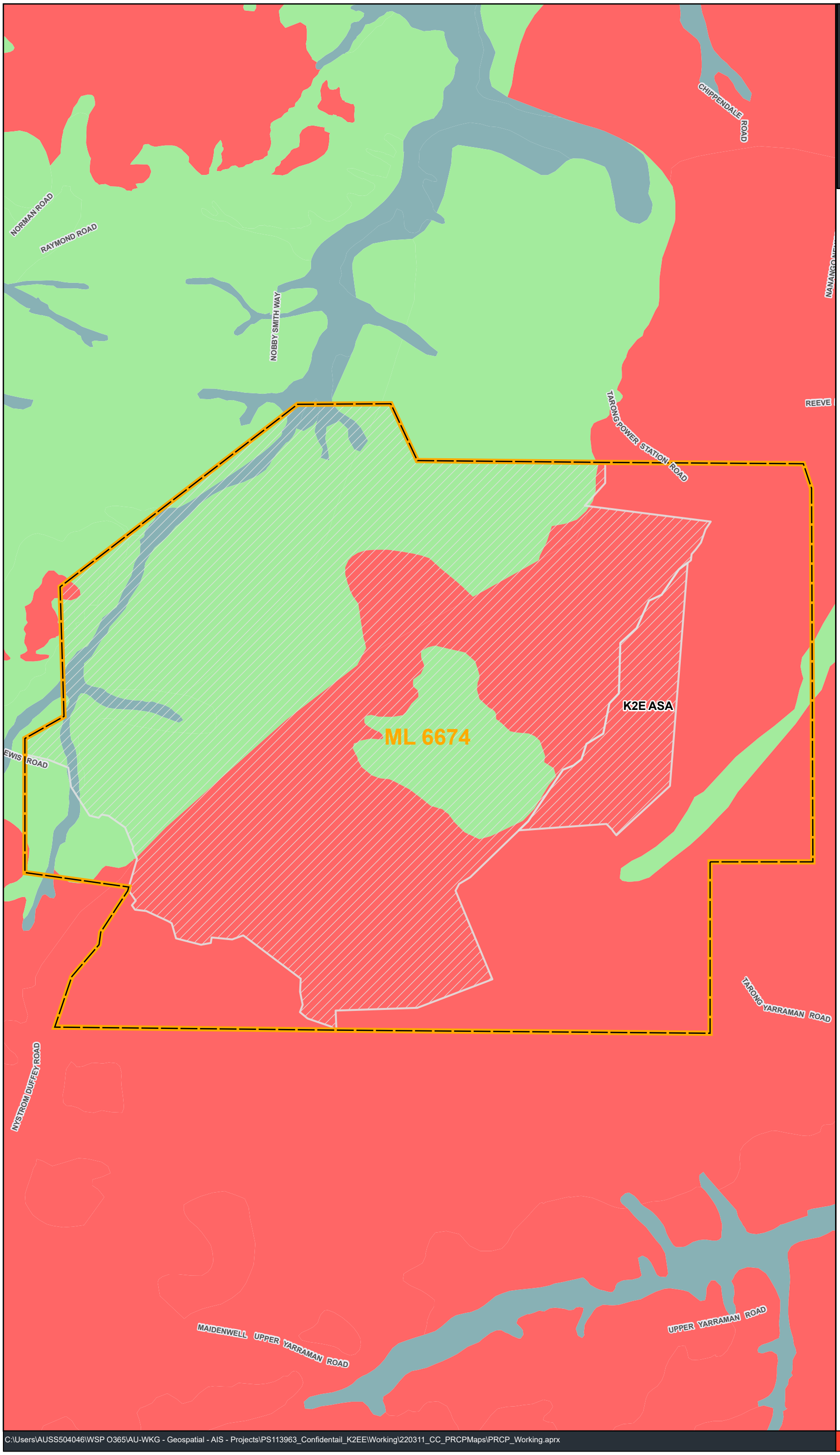
Recent ecological field surveys undertaken during the period of August 2017 to December 2022 identified one hundred and twenty-two (122) fauna species from within either within the K2E ASA or immediate surrounds, including 81 birds, 35 mammals (including 18 microbat species), 3 reptiles and 3 frogs. Two pest animal species (the Feral Dog (*Canis familiaris*) and Feral Cat (*Felis catus*)) were recorded. Birds were the most diverse group of terrestrial vertebrate fauna recorded, followed by mammals.

Six threatened and/or migratory fauna species were recorded from the K2E ASA and immediate surrounds during field surveys. These were:

- Black-breasted Button-quail listed as Vulnerable under the NC Act and EPBC Act
- Greater Glider listed as Vulnerable under the NC Act and EPBC Act
- Powerful Owl listed as Vulnerable under the NC Act
- Short-beaked Echidna listed as Special Least Concern under the NC Act; and
- Black-faced Monarch and Rufous Fantail listed as Special Least Concern under the NC Act and Migratory under the EPBC Act.

Meandu Mine Revegetation Plan

Figure 1.6
Pre-clearing regional ecosystems within ML6674



Legend

- Mining Lease (ML6674)
- Approved Surface Rights Area

Pre-clearing Broad Vegetation Groups

- 1. Rainforests and scrubs
- 3. Eucalypt woodlands to open forests (mainly Eastern)
- 4. Eucalypt open forests to woodlands on floodplains



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Meters

Coordinate system: GDA2020

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1:40,000

Date: 26/05/2022

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Of these species the Black-breasted Button-quail, Short-beaked Echidna, Black-faced Monarch and Rufous Fantail were recorded within the K2E ASA.

Three additional threatened and/or migratory fauna species were assessed as having a moderate or high likelihood of occurring in the K2E ASA (Spotted-tail Quoll, Oriental Cuckoo and Spectacled Monarch). A further five threatened fauna species were assessed as having a moderate or high likelihood of occurring in the study area (but not in the K2E ASA due to the lack of suitable habitat resources). These species are Tusked Frog (*Adelotus brevis*), White-throated Needletail (*Hirundapus caudacutus*), Northern Quoll (*Dasyurus hallucatus*), South-eastern Long-eared Bat (*Nyctophilus corbeni*), Koala (*Phascolarctos cinereus*). None of these species were detected from study area during field surveys.

2 Pre- and Post-mining land uses

2.1 Pre-mining land use

The pre-mining land use of the Meandu Mine and surrounds generally included agriculture (grazing, cropping), rural residential, forestry, and other small mining operations.

2.1.1.1 Immediate surrounds

Within the immediate locality of the Meandu Mine, extensive areas were used for forestry purposes (open eucalypt forest (approximately 21%), plantation forest (23%) and closed vine forest (14%)), by the then Queensland Department of Forestry. State Forest 289 extended around the east, south and west of ML6674. The forest contained stands of rainforest, eucalypt forest and hoop pine plantations which had managed for timber production since the 1930's.

Before the establishment of the Meandu Mine, the extent of mining activity within the sub-region was small. Several small leases for clay, sand and gravel extraction were present.

2.1.1.2 Meandu Mine site

By area, the largest land use at the Meandu Mine site was agricultural purposes, which included two principal activities – beef production and cropping. A mix of agricultural activities was involved (e.g., beef and/or dairy cattle was used to clear away crop residues). Crops such as sorghum and corn were grown within the area, generally located along the flats of the Meandu Creek and Black Creek systems. The Meandu Mine site area had 9 rural residences and associated farm buildings, 5 of which were occupied permanently.

The current mining lease (ML6674) included part of the Cooyar Range Forest (State Forest 289) (now Yarraman State Forest) on its eastern side. The forest contained stands of rainforest, eucalypt forest and hoop pine plantations which had been managed for timber production since the 1930's.

2.2 Nominated post-mining land uses (PMLUs)

ML6674 has seven approved PMLUs under EA EMPL00709113 for available for allocation in the PRC Plan:

- Native Ecosystem
- Creek Diversion
- Beef Cattle Grazing
- Plantation Forestry
- Water Storage
- Landholder Retained Infrastructure; and
- Steep Rocky Ecosystem.

An overview of these PMLUs is provided in the following sections with the allocated geographical extent of each PMLU within ML6674 illustrated on Figure 2.1. The objectives for each of these PMLUs in terms of rehabilitation and revegetation are outlined in Section 3.

2.2.1 Native Ecosystem PMLU

The Native Ecosystem PMLU will include areas of vegetation that are similar to three locally occurring regional ecosystems:

- RE 12-9-10.7: *Eucalyptus crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, Angophora spp., *E. melanophloia* woodland on sedimentary rocks
- RE 12.9-10.18: *Angophora leiocarpa*, *Eucalyptus crebra* woodland on sedimentary rocks; and
- RE 12.11.7: *Eucalyptus crebra* woodland on metamorphics +/- interbedded volcanics.

These regional ecosystems (REs) comprise open woodland or forest and exist in State forests and National Parks surrounding the Meandu Mine. TEC Coal proposes that the Native Ecosystem PMLU rehabilitation will be similar to these remnant vegetation types, but not specific to any particular RE.

The majority of the undisturbed by mining footprint is assigned the PMLU of Native Ecosystem. These areas will continue to be maintained and managed for weeds, bushfire management and feral animal controls, but will otherwise not be subject to the rehabilitation criteria and milestones. The pre-existing vegetation structures and species mix will be retained in their original state without modification or supplementation.

Where appropriate, shallow retention dams within the Native Ecosystem PMLU footprint will be incorporated as essential management structures to support the re-establishment of fauna within the area. Over time the retention dams will be allowed to naturally regress through silting processes and to establish suitable vegetation. These will continue to act as water sinks and natural ponds mimicking the pre-mining ecosystem along the creek and gully alignments. There are no retention dams within the catchment of the North-West Backfilled Void (NWBV) that will be treated in this manner.

In limited areas in the north-east corner of the existing surface rights area, regrowth of semi-evergreen vine thicket has been observed. This area was cleared as part of historical preparatory works for mining activities in the early 2000's that were subsequently not executed. This area will continue to be monitored and should the semi-evergreen vine thicket regrowth be shown to be on trend at cessation of mining to achieve the canopy and undergrowth cover criteria as per the Native Ecosystem milestone criteria then this ecosystem will be retained in preference to the clearing and re-establishment of open eucalypt forest.

2.2.2 Creek Diversion PMLU

Diversions of Meandu Creek are included with the PMLU of Creek Diversion. Three sections of creek diversion have historically been constructed within the Meandu Mine surface rights area since mining commenced including Meandu Creek South (upstream) (completed construction in 2005); Central (completed construction in 1992); and North (downstream) (completed construction in 1986) (refer Figure 4.2 of the Meandu Mine PRC Plan).

All permanent engineering structures and essential management infrastructure associated with the diversion channels have been constructed and certified according to approved designs and will be retained as part of the Creek Diversion PMLU.

2.2.3 Beef Cattle Grazing PMLU

TEC Coal has developed a strategic plan for achieving Beef Cattle Grazing as a sustainable PMLU at Meandu Mine.

The objectives of the strategic plan are to:

- achieve a sustainable Beef Cattle Grazing land use for the area by:
    - demonstrating the suitability of rehabilitation for beef cattle grazing
    - maintaining or improving the land condition of the rehabilitation and prevent land degradation; and
    - integrating the rehabilitated pasture lands with critical grazing management infrastructure to create an economically viable grazing enterprise
- enable fauna connectivity between adjoining Native Ecosystem PMLUs through provision of tree shelter belt/s with relevant and appropriate species selected from the Native Ecosystem PMLU seed mix.

2.2.4 Plantation Forestry PMLU

Plantation Forestry as a PMLU will only be allocated where there are existing mature plantation trees remaining on the surface rights area in undisturbed areas. This only occurs in the residual plantation forestry footprint located against the boundary of the surface rights area at the southern end of the Meandu Mine, where a narrow strip (from 40–90 m, typically 80 m in width), contiguous with the mining lease ML6674 boundary remains unharvested. This area lies adjacent to companion mature plantings.

As there are no plans to establish further Plantation Forestry PMLU footprint, this revegetation plan does not consider in any detail the seeding and planting requirements for this PMLU. General maintenance of the existing plantation areas in terms of weed and feral animal controls, and fire management will however be undertaken.

2.2.5 Water Storage PMLU

Regionally significant water storages, dams and reservoirs occupy less than <0.5% of land within the natural resource management area (Department of Science, Information Technology, Innovation and the Arts, 2012). At a local level, water storages are important for stock and domestic supplies and assist native animals, particularly in times of drought. The Water Storage PMLU will be a minor component of rehabilitation at Meandu Mine, consisting of the final voids (K4E and K2E). This PMLU also includes the littoral zone that is located between the upper and lower modelled water levels, or the actual rebound water level, in each final void.

Stable water supply is a key concern of near neighbours and the broader community. The storage facilities have been assessed across minimum and maximum extraction scenarios in support of the other PMLUs.

2.2.6 Landholder Retained Infrastructure PMLU

The Landholder Retained Infrastructure PMLU will not be allocated at the Meandu Mine. The decision was made to remove all permanent infrastructure prior to surrender of the mining lease and the PRC Plan following community consultation, and assessment against the local planning schemes.

Accordingly, there are no revegetation requirements in relation to this PMLU at Meandu Mine.

2.2.7 Steep Rocky Ecosystem PMLU

The Steep Rocky Ecosystems PMLU is a natural ecosystem as a mosaic of plant and animal assemblages of different structure and composition across a steep rocky post mining landscape and is a specific application for excavated walls that will remain at the end of Meandu Mine life. This represents an approach agreed with the DES during the 2020 negotiations to amend the Meandu Mine EA with respect to allowable PMLUs and their associated success criteria. The Steep Rocky Ecosystem PMLU design considers the requirements for final highwall rehabilitation which includes a combination of steep batters and benches offering variable geometries suitable for the establishment of self-sustaining floral and faunal assemblages.

2.3 PMLU allocation

The allocated geographical extent of each PMLU within ML6674 is illustrated in Figure 2.1. The area of each PMLU allocation and associated area and domains are shown in Table 2.1.

Table 2.1 Meandu Mine PMLUs, allocated area and relevant domains within the surface rights area

PMLU	Area allocated (ha)	Relevant activities
Native Ecosystem	1,902.1	Central pit, Haul Road, K2E Waste Dump(s), K2E pit, K2W-N Ash and Tailings Storage Facility, K4E pit, K4S pit and Ash and Tailings Storage Facility, Meandu Creek, Mine Infrastructure Area, Ramp 5 pit, portion of western waste dumps, undisturbed areas
Creek Diversion	19.0	Creek Diversion
Beef Cattle Grazing	555.8	Central pit, Haul Road, K4E pit, K4S pit and Ash and Tailings Storage Facility, Mine Infrastructure Area, Ramp 5 pit, portion of western waste dumps
Plantation Forestry	18.5	Undisturbed area along K4S boundary
Water Storage	107.4	K2E pit, K4E pit
Steep Rocky Ecosystem	204	K2E pit, K4E pit, K2W-N pit, SW pit
Total PMLU within surface rights area	2,806.9	Total area under responsibility of TEC Coal. Excludes Powerlink easement

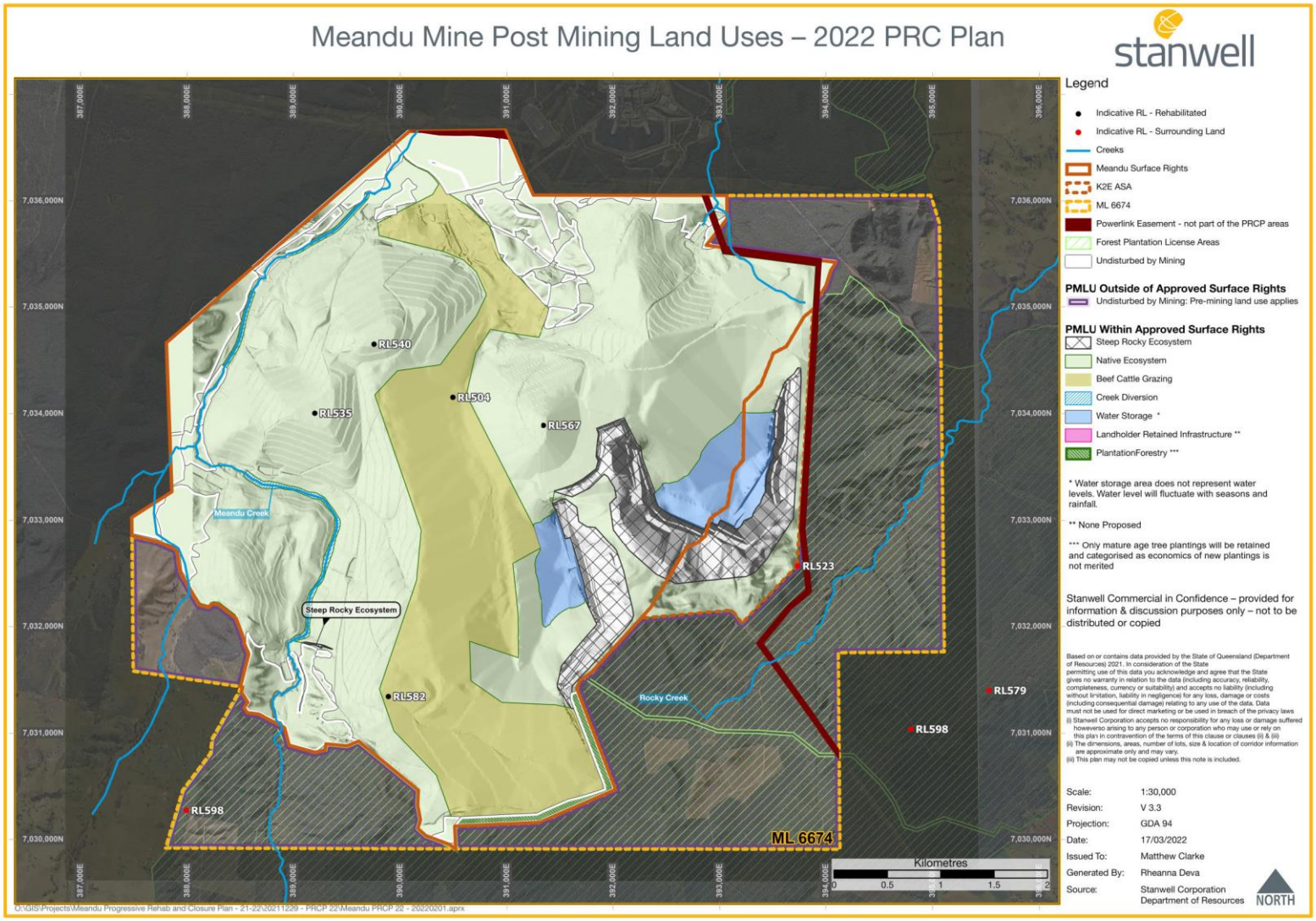


Figure 2.1 Geographic allocation of approved PMLUs

3 Revegetation objectives

3.1 Meandu Mine EA success criteria

In accordance with the current EA EPML00709113 and Meandu Mine PRC Plan, the current rehabilitation objectives, indicators and success criteria for the each of the PMLUs of the Meandu Mine are described in Table 3.1. As the rehabilitation related EA conditions in the current will be removed once the Meandu Mine PRC Plan is approved, these existing criteria are now incorporated in the milestone criteria (refer to Table 2.27 in Section 2.4.2 of the Meandu Mine PRC Plan).

Table 3.1 Rehabilitation success criteria for the proposed PMLUs (adapted from the project EA – EPML00709113 as at January 2022)

Proposed PMLU	Goal	Objective	Indicator	Criteria
Native Ecosystem[1]	Safe to humans and wildlife	Safety hazards in rehabilitation are analogous to local regional ecosystems in surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the Native Ecosystem must have no significant difference to hazards in local regional ecosystems in surrounding unmined landscape.
	Stable	Rehabilitation is geotechnically stable in the long term.	Factor of safety	≥1.5
		Rehabilitation ensures soil surface condition is erosionally stable.	Groundcover to be established and persistent.	>50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 20%. >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 20%.
	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5–9.0 (median) EC: <2037 µS/cm (median)
	Able to sustain an agreed final land use	Vegetation to comprise a mixture of plant species like local regional ecosystems based on benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7[2].	Establishment of Native Ecosystems to resemble a mixture of benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7[2].	A. Native plant species richness: Trees ≥4 count Shrubs ≥6 count Grass ≥4 count B. Cover: Tree canopy cover is at least 20%

Proposed PMLU	Goal	Objective	Indicator	Criteria
Creek diversion	Safe to humans and wildlife	The diversion has been constructed and is operating safely.	Designed and certified, with monitoring of operation by appropriately qualified and experienced person.	Records retained of as-built drawings and certification that creek diversions are operating in accordance with approved design and associated criteria.
		Safety hazards in rehabilitation are analogous to creeks in surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the creek diversions have no significant difference to hazards in creeks in surrounding unmined landscape.
	Stable	Creek diversions are both geotechnically and erosionally stable.	Stability assessed by an appropriately qualified and experienced person.	The assessment shows that the creek diversion is functioning as designed and the integrity of the watercourse diversion and/or adjoining watercourses is not threatened.
	Non-polluting	Diversions do not impact the environmental values of the receiving environment.	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5–9.0 (median) EC: <2037 µS/cm (median)
	Able to sustain an agreed final land use	Creek diversions are functioning as intended.	Assessment by an appropriately qualified and experienced person.	The assessment shows that the creek diversion is functioning as designed and the performance of the watercourse diversion and/or adjoining watercourses is not threatened.
Beef Cattle Grazing	Safe to humans and wildlife	Safety hazards in rehabilitation are analogous to grazing land in the surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the grazing land to have no significant difference to hazards in grazing land in the surrounding unmined landscape.
	Stable	Rehabilitation is geotechnically stable in the long term.	Factor of safety	≥1.5
			Minimal slope greater than 15%	80% of Slopes ≤ 15%. Minor areas up to a maximum of 25% to achieve tie-in with surrounding areas.
		Rehabilitation ensures soil surface condition is erosionally stable.	Groundcover to be established and persistent.	>50% established and persistent groundcover for all slopes less than or equal to 18%. >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 18%.
	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5–9.0 (median) EC: <2037 µS/cm (median)

Proposed PMLU	Goal	Objective	Indicator	Criteria
	Able to sustain an agreed final land use	Rehabilitation is suitable for sustainable beef cattle grazing.	Land suitability assessment by appropriately qualified and experienced person using 'Regional Land Suitability Frameworks for Queensland' (DNRM & DSITIA 2013).	Grazing land to meet Class 1, 2 or 3 land suitability for grazing.
Plantation Forestry	Safe to humans and wildlife	Safety hazards in rehabilitation are analogous to plantations in the surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the plantations to have no significant difference to hazards in plantations in the surrounding unmined landscape.
	Stable	Rehabilitation is geotechnically stable in the long term.	Factor of safety	≥1.5
		Rehabilitation ensures soil surface condition is erosionally stable.	Groundcover to be established and persistent	>50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 20%. >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 20%.
	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5–9.0 (median) EC: <2037 µS/cm (median)
	Able to sustain an agreed final land use	Rehabilitation is suitable for sustainable plantation forestry.	Land suitability assessment by appropriately qualified and experienced person using 'Regional Land Suitability Frameworks for Queensland' (DNRM & DSITIA 2013)[3].	Plantation land to meet Class 1, 2 or 3 land suitability for plantations. For Hoop Pine Plantation greater than or equal to 150 trees per hectare. For Hardwood Plantation greater than or equal to 100 trees per hectare.
Water Storage	Safe to humans, stock and wildlife	Safety hazards are managed for humans, stock and wildlife.	Hazard assessment by an appropriately qualified and experienced person.	Design requirements are determined to ensure water storage is safe for humans, stock and wildlife.
	Stable	Rehabilitation is geotechnically stable in the long term.	Factor of Safety	>1.5

Proposed PMLU	Goal	Objective	Indicator	Criteria
	Able to sustain an agreed final land use	Able to sustain an agreed final land use.	Water storages contain water of a suitable quality for native wildlife and/or livestock ingestion, measured using the indicators of TDS, Calcium, Magnesium, Nitrate, Sulfate, Cobalt, Nickel, Zinc, Arsenic, Boron, Selenium, Molybdenum and Fluoride.	Total Dissolved Solids: <5,000 mg/L Calcium: ≤1,000 mg/L Magnesium: ≤2,000 mg/L Nitrate: ≤400 mg/L Nitrite: ≤30 mg/L Sulfate: ≤1,000 mg/L Cobalt: ≤1 mg/L Nickel: ≤1 mg/L Zinc: ≤20 mg/L Arsenic: ≤0.5 mg/L Boron: ≤5 mg/L Selenium: ≤0.02 mg/L Molybdenum: ≤0.15 mg/L Fluoride: ≤2 mg/L
Landholder Retained Infrastructure	Safe to humans and wildlife	Safety hazards accepted by landholder.	Legally binding agreement.	Agreement executed by both parties.
		Safety hazards in rehabilitation are analogous to surrounding unmined landscape with the same infrastructure.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the landholder retained infrastructure to have no significant difference to hazards in the same infrastructure in surrounding unmined landscape.
	Stable	Landholder accepts condition of infrastructure, including its structural integrity.	Legally binding agreement.	Agreement executed by both parties.
	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5–9.0 (median) EC: <2037 µS/cm (median)
	Able to sustain an agreed final land use	Landholder formally accepts infrastructure for his/her ongoing beneficial use.	Legally binding agreement.	Agreement executed by both parties.
Steep Rocky Ecosystem	Safe to humans and wildlife	Safety hazards are managed for humans and wildlife now and in the foreseeable future	Hazard assessment by an appropriately qualified and experienced person.	Acceptable residual hazard ranking achieved.
	Stable	The landforms are geotechnically and erosionally stable.	Factor of Safety	>1.5 assessed at the projected stable crest.

Proposed PMLU	Goal	Objective	Indicator	Criteria
	Non-polluting	Rainfall runoff from rehabilitation protects stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5–9.0 (median) EC: <2037 µS/cm (median)
	Able to sustain an agreed final land use	Landform that creates native fauna and flora habitat, while still being stable and safe.	Creation of a safe, stable and non-polluting landform that supports flora and fauna habitat.	The landform provides a diversity of slopes including mix of predominately flat benches and batters up to 80 degrees that create a varied environment for the future establishment of niche habitats.
		Vegetation on benches to provide an appropriate environmental outcome and be based on a species composition that ensures geotechnical stability of the benches is not compromised.	A species composition that ensures geotechnical stability of the benches is not compromised.	Native plant species richness per appropriate ecosystem outcome, adjusted to meet geotechnical stability requirements.

(1) Plant species composition of the low wall part of the residual void and the water equilibrium level will be decided by a geotechnical assessment.

(2) Neldner, V. and Ngugi, M. (2012) Assessment of BioCondition scores for three to twenty-year-old regeneration at Meandu Mine, Southeast Queensland. Queensland Herbarium, Department of Science, Information Technology, Innovation and the Arts, Brisbane.

(3) DNRM & DSITIA (2013) Regional Land Suitability Frameworks for Queensland, Queensland Government (Department of Science, Information Technology and Innovation and Department of Natural Resources and Mines), Brisbane, Queensland.

The revegetation of Plantation Forestry PMLU will not be discussed further in the following sections since no new plantings of Plantation Forestry are proposed to be undertaken at Meandu Mine. The only use of the Plantation Forestry PMLU is where pre-existing plantation trees, established by the original plantation licence holder (HQPlantations), remain in place at the end of mining in areas undisturbed by mining activities.

The Landholder Retained Infrastructure is not used as a PMLU in the current Meandu Mine PRC Plan and therefore is also not discussed further in this Revegetation Plan.

3.2 Revegetation objectives

The revegetation objectives for the Meandu Mine, consistent with the proposed PMLUs are outlined in Table 3.2.

Table 3.2 Revegetation objectives

PMLU	Revegetation objectives
Native Ecosystem (Terrestrial)	For the non-riparian Native Ecosystem PMLU, to revegetate with species that are similar to locally occurring regional ecosystems, which comprise open woodland or forest and exist in State forests and National Parks surrounding the Meandu Mine. To provide support to local fauna through: — planned proximity to water sources (both Water Storage and existing creeks); and — inclusion of native ecosystem flora species from the relevant regional ecosystems known to support local native fauna.
Beef Cattle Grazing	— To achieve a sustainable Beef Cattle Grazing land use for the area with the objectives of: — sustainably maintain beef cattle production on the PMLU footprint in accordance with the PRC Plan and Stanwell's Beef Cattle Grazing Strategy — maintaining or improving the land condition of the rehabilitation and prevent land degradation; and — integrating the rehabilitated pasture lands with critical grazing management infrastructure to create an economically viable grazing enterprise. — To enable fauna connectivity between adjoining Native Ecosystem PMLUs through provision of tree shelter belt/s with relevant and appropriate species selected from the Native Ecosystem PMLU seed mix.
Steep Rocky Ecosystems	To achieve the establishment of self-sustaining plant and animal assemblages and associated ecosystem processes across the post-mining steep rocky landscape subject to the over-riding requirement of maintaining geotechnical stability.
Creek Diversion	To achieve the following objectives: — support for a long-term self-sustaining vegetation community — maintain a stable landform create a local microclimate, which will help with wind, temperature, water retention and pollination vectors.
Water Storage (littoral zone in the final voids only)	To achieve the following objectives: — revegetate with species that are similar to locally occurring regional ecosystems and are suitable for infrequent inundation and/or wet ground conditions; and — support for long-term self-sustaining vegetation community — provide stability to created/disturbed surfaces.

3.3 Key flora species

A summary of key flora species for each PMLU has been included in Section 6.1.8.2 of the Meandu Mine PRC Plan. Further details in terms of species lists of preferred species and seeding rates is provided in Sections 5.1.3, 6.2.3, 7.2.3, and 8.4.2 for each PMLUs of this Revegetation Plan.

3.4 Fauna habitat requirements

Section 1.4.5 notes species of conservation significance which have been recorded from the area surrounding the Meandu Mine during recent field surveys. Where consistent with a proposed PMLU, species of conservation significance will be targeted during rehabilitation works. The potential for this to be achieved for certain species of conservation significance is discussed with detail in Section 6.1.8.3 of the Meandu Mine PRC Plan. Targeted species would be confirmed during revegetation trials, particularly for the Steep Rocky Ecosystem PMLU. The species habitat considered for rehabilitation include:

- Short-beaked Echidna (*Tachyglossus aculeatus*)
- Koala (*Phascolarctos cinereus*)
- Greater Glider (*Petauroides voians*)
- Spotted-tail Quoll (*Dasyurus maculatus*)
- Northern Quoll (*Dasyurus hallucatus*)
- threatened and migratory bird species; and
- species of microchiropteran bat.

3.5 Analogue sites for monitoring

Table 3.3 provides a summary of existing information of analogue sites for the proposed PMLUs.

Table 3.3 Analogue sites description for each Meandu Mine PMLUs

PMLU	Analogue sites description
Native Ecosystem	In 2012, the Queensland Herbarium commenced a project funded by the Australian coal industry's research program (ACARP) to develop a local benchmark for Meandu Mine rehabilitation based on an amalgam of three locally dominant regional ecosystems being: — RE 12.9-10.7 *Eucalyptus crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, *Angophora* spp., *E. melanophloia* woodland on sedimentary rocks — RE 12.9-10.18: *Angophora leiocarpa*, *Eucalyptus crebra* woodland on sedimentary rocks; and — RE 12.11.7: *Eucalyptus crebra* woodland on metamorphics +/- interbedded volcanics. A single BioCondition Benchmark was developed for a self-sustaining Eucalypt woodland to open forest from 26 CORVEG sites (Neldner et al. 2012). This benchmark has been used to assess the rehabilitation onsite using an adapted BioCondition methodology and is the basis for the rehabilitation milestone criteria in the Meandu Mine PRC Plan.
Steep Rocky Ecosystem	Analogous landscapes within the footprint of the mine site will be identified and monitored to provide appropriate information to develop growth trends and compare the response to environmental stresses. Analogous sites will be selected from the existing steep rocky ecosystem areas within the K2W-N and SW Pit areas. Characteristics which will be established will include but not be limited to: — vegetation cover mosaics — plant assemblages and ecosystem structure — vertebrate and invertebrate fauna habitat; and — abiotic assemblages. These will constitute the rehabilitation trials for the Steep Rocky Ecosystem PMLU (refer Section 8)

PMLU	Analogue sites description
Creek Diversion	Monitoring against analogue sites is not required. However, methodologies similar to those used for the neighbouring Native Ecosystem PMLU will be utilised to assess vegetation establishment in the Creek Diversion PMLU and compared against the dominant riparian regional ecosystem in the catchment (RE 12.3.3).
Beef Cattle Grazing	Monitoring against analogue sites is not required or relevant to the criteria for success.
Plantation Forestry	Monitoring against analogue sites is not required and no further plantings of Plantation Forestry are planned to be undertaken.
Water Storage (littoral zone of final voids)	Monitoring against analogue sites is not required.

3.6 Rehabilitation milestones

The nominated rehabilitation milestones relevant to Meandu Mine are outlined in Table 3.4. The applicability of rehabilitation milestones to the various rehabilitation areas is also shown in Table 3.4 below. This Revegetation Plan focuses on developing specific success criteria for all of the milestones relevant to the revegetation of Meandu Mine, encompassing RM4 to RM9, and applicable to each type of the proposed PMLU at the Meandu Mine site.

Table 3.4 Rehabilitation reference milestones for Meandu Mine PRC Plan

Milestone reference	Meandu Mine rehabilitation milestone
RM1	Infrastructure decommissioning and removal
RM2	Investigation and/or remediation of contaminated land
RM3	Installation of cover system over coal combustion products, and tailings storage facilities
RM4	Landform development and reshaping
RM5	Surface preparation
RM6	Revegetation (all applicable PMLUs)
RM7	Achievement of initial surface requirements
RM8	Water quality at rehabilitated state
RM9	Achievement of PMLU

3.7 Applicable PRC Plan Revegetation Plan requirements

Table 3.5 outlines which of the items from the PRC Plan guideline requirements apply to each of the approved PMLUs.

No new Plantation Forestry PMLUs will be, or have been, established at Meandu Mine. The only Plantation Forestry PMLU area consists entirely of pre-existing plantation established pre-mining. The Revegetation Plan therefore only considers the requirements for managing and monitoring the PMLU, along with the generic species identification and subsoil requirements, not the details required for establishment of the revegetation or site preparation related to Plantation Forestry.

Table 3.5 Applicable items from the PRC Plan Guideline to each of the PMLU

PRC Plan guideline requirement	Beef cattle grazing	Creek diversion	Native vegetation	Plantation forestry	Steep rocky ecosystem	Water storage[1]
Objectives	☒	☒	☒	☒	☒	☒
Key Flora Species	☒	☒	☒	☒	☒	☐
Species of Conservation significant	☒	☒	☒	☐	☐	☐
Fauna habitat and use	☒	☒	☒	☒	☒	☒
Analogous sites	☒	☐	☐	☐	☒	☒
Works for establishing and managing	☒	☒	☐	☐	☒	☒
Identify plant/seed mixes	☒	☒	☒	☐	☒[2]	☒
Identify seed density	☒	☒	☒	☐	☒[2]	☒
Identify the proposed location of infrastructure	☒	☒	☒	☐	☒	☐
Identify the growth media	☒	☒	☒	☐	☒[2]	☒
Identity the topsoil depth requirements	☒	☒	☒	☐	☒[2]	☒

(1) Requirements are intended to apply to the littoral zone only.

(2) For Steep Rocky Ecosystem the requirements are to develop the appropriate monitoring benchmarks for these steps through the planned trial. No active seeding, establishment, growth media or topsoiling is required for this PMLU.

4 Assessment of the existing rehabilitation

Progressive rehabilitation at Meandu Mine commenced shortly after mining in the mid-1980s (first record in 1985). Up to December 2021, a total of 631 ha of disturbance has been rehabilitated, representing approximately 29% of the total mining disturbance footprint (by December 2021). The majority of the existing rehabilitation has a PMLU of Native Ecosystem. Much of this rehabilitation is contiguous with adjoining Yarraman State Forest and Tarong National Park.

The condition of the rehabilitation at Meandu Mine has been comprehensively monitored over the past 25 years. A monitoring and maintenance program has been developed to support the achievement of the Meandu Mine PRC Plan Rehabilitation Milestones and has been included in Section 8 of the Meandu Mine PRC Plan.

A summary of the history of the existing rehabilitation including the location, general methodology, when the rehabilitation works commenced and were completed (where records are available), area of rehabilitation for each location at the time and the current status of the area is recorded and kept in a site register.

On 7 April 2021, TEC Coal applied for Certification of Progressive Rehabilitation of 214 ha, of which, 153 ha were certified by DES (refer Appendix A: Progressive rehabilitation certification notice). Figure 4.1 shows the proposed progressive rehabilitation at the Meandu Mine along with the certified rehabilitation areas. Rehabilitation dates shown in Figure 4.1 represent the date when the first relevant milestone for each area is scheduled to be completed.

Meandu Mine Revegetation Plan

Figure 4.1
Progressive rehabilitation overview
(first milestone achieved)

Legend

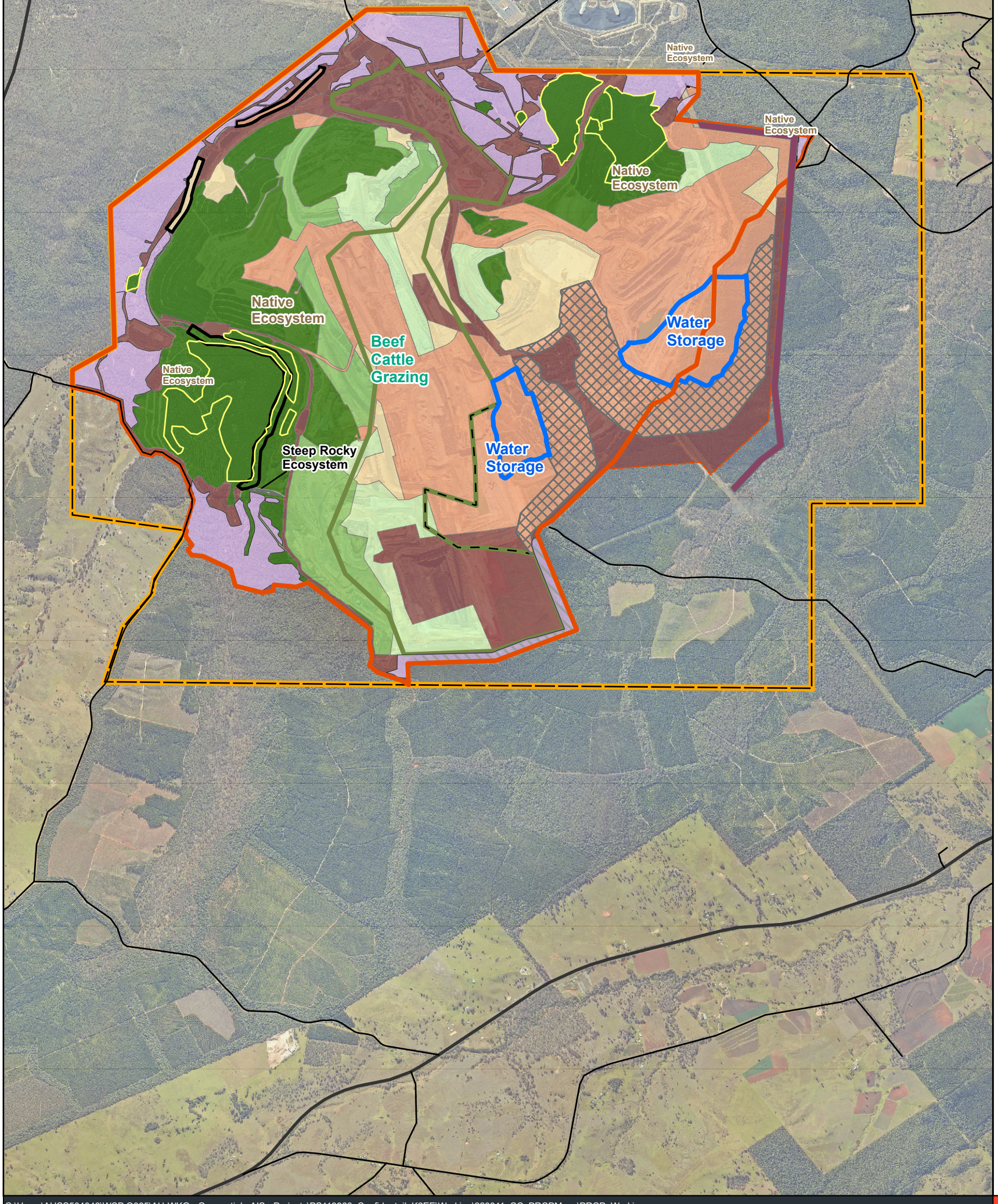
- Progressive Rehabilation Certification Area
- Powerlink Easement - Not a part of PRCP areas
- Approved Surface Rights Area
- K2E ASA
- Mining Lease (ML6674)
- PRCP Undisturbed

PMLU within Surface Rights

- Beef Cattle Grazing
- Creek Diversion
- Native Ecosystem
- Plantation Forestry
- Steep Rocky Ecosystem
- Water Storage

Progressive Rehab

- CY 21
- CY 22 - 26
- CY 27 - 31
- CY 32 - 36
- CY 37 - 41
- CY 42 - 46





0 1,000 2,000
Meters

Coordinate system: GDA2020

Scale ratio correct when printed at A3

GDA 2020

1:44,074

Date: 26/05/2022

Data sources: DELWP, Geoscience Australia

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5 Rehabilitation and revegetation procedure – Native Ecosystem

The following sections provide a summary of key components of rehabilitation for the Native Ecosystem PMLU, including:

- rehabilitation practices; and
- rehabilitation monitoring.

5.1 Rehabilitation practices

Rehabilitation establishment practices at Meandu Mine for the terrestrial Native Ecosystems are based on a seven-stage process to revegetate mined lands. The seven stages include:

1. dumping the bulk landform to the overall target Life of Mine Profile
2. dozer profiling of the bulk landform to achieve final profile and contour systems
3. drain establishment (where required)
4. erosion control works
5. site preparation – topsoil and ameliorants
6. topsoil placement; and
7. ripping and seeding.

The following sections focus on the revegetation procedure once the final landform and associated contour system has been constructed.

5.1.1 Topsoil and topsoil placement

Characterisation according to the material types in the geological model used as the basis of the LOM Plan according to suitability for PMLU is summarised in Table 1.5. Only rehabilitation material that meets the material characterisation requirements for the Native Ecosystem PMLU is used (refer to column 4 in Table 1.5).

Topsoil that has been characterised as suitable for the Native Ecosystem PMLU, is spread to a depth of approximately 200 mm after landform preparation, but as close as possible to ripping/ seeding operations to minimise the erosion risk. Topsoil placement involves:

- preparing the landform in accordance with the Meandu Mine PRC Plan requirements for the final landform with respect to the Native Ecosystem PMLU
- ensuring the surface is suitable for topsoil application (e.g. minimal rill/gully erosion)
- nominating the topsoil stockpile(s) to be utilised for the area (or source location if directly placed from stripped locations) in accordance with the topsoil requirement for the PMLU
- calculating the estimated quantity of suitable topsoil required for the area
- ensuring the equipment operators have been briefed on the topsoiling plan/requirements for the area
- scheduling topsoil placement to avoid heavy rain forecast
- applying the topsoil evenly at the nominated thickness of 200 mm
- if applicable, ensuring that areas where contour banks have been constructed are topsoiled, but excluding the bank inverts; and
- re-surveying topsoil stockpiles after topsoil extraction and deducting this quantity from the topsoil register.

5.1.1.1 Mechanical preparation

Ripping of the area to be rehabilitated to at least 0.3–0.5 m is performed post-topsoiling, normally in conjunction with seeding to aid in erosion control and assist with root and moisture penetration. The furrows create a rough microtopography that helps slow overland flow and therefore increases infiltration, provides protected microsites from desiccating conditions (wind and heat) promoting seed germination, and loosens the soil profile to encourage improved root development.

Ripping is generally undertaken using a small dozer (e.g. D4–D6 size) to minimise compaction and to key the topsoil into the underlying spoil (to reduce slip surface potential).

5.1.1.2 Fertiliser and soil ameliorants

Some soils and mine spoils may have physical and chemical characteristics that will otherwise limit plant establishment and have a high potential for erosion. Where soil suitability is classified as poor, analysis of the soil stockpiles is undertaken to determine the requirements for fertiliser and other ameliorants (Landloch, 2021a).

Currently, for poor quality soils, fertiliser is applied at the same time as ripping and seeding, at a rate of 100-150kg/ha. Since 2017, the fertiliser used is a 60/40 blend of Impact 56 (N-13.5%:P-15.2%:K-12.5%:S-1.1%) and Ozcal (fine granular lime).

To stabilise dispersive sodic subsoils agricultural gypsum or lime may be applied at a rate of 5t/ha/100 mm layer. The gypsum improves the soil structure reducing the dispersiveness and increases the water holding capacity.

5.1.1.3 Timing

Ripping and seeding are undertaken prior to the wet season (target – end of September), but with a limit of no later than December.

5.1.2 Soil management

Soil used for rehabilitation is stripped prior to mining to a depth of approximately 200 mm. The stripped soil is stored in various locations around the mine, with information kept in the site's Topsoil Stockpile Register. Stockpile sizes vary from 1,500 m^3 to about 500,000 m^3 (average 40,000 m^3) with an average height of 6 m. Total volume of Grey Topsoil is 3,020,000 m^3 which has been calculated to be sufficient to cover approximately 1,500 ha with 200 mm topsoil depth. This is currently sufficient to meet the projected requirements of the site (Landloch, 2021a).

5.1.3 Current species selection and seed rates

Species selection for seeding has evolved from a low diversity species mix used in the mid-1980s (Japanese millet, *Acacia fimbriata*, *Eucaluptus crebra*, *E. trachyphloia* and *Corymbia citriodora*) to the current diverse species mix which comprises a range of plant lifeforms, including canopy tree species (Eucalyptus, Corymbia, Angophora and, *Lophostemon confertus*), sub-canopy species (Acacias), shrubs such as Cassinia, Hovea and Dodanea, the vine *Hardenbergia violacea* and native and non-native grass species including the cover crop *Echinochloa utilus*. Species choice reflects species that occur in different stages of stand development of the Native Ecosystem PMLU, including the use of nitrogen fixing legumes, the requirement to establish rapid grown cover to prevent erosion and the Rehabilitation Milestone criteria in the Meandu Mine PRC Plan.

The current seed rate is 13 kg/ha which comprise 3 kg of the cover crop, 5 kg of native and non-native grass seed and 5 kg of mostly trees and shrubs.

The 2021 species mix and seed rates is provided in Table 5.1. As this list is constantly refined/updated as monitoring progresses it should be regarded as indicative only.

Table 5.1 Species selection and seed rates (2021)

Botanical species	Common name	Rate (kg/ha)
Trees, shrubs and forbs		
Acacia macradenia	Zig Zag Wattle	0.10
A. fimbriata	Brisbane Golden Wattle	0.10
A. implexa	Lightwood	0.10
A. nerifolia	Oleander Wattle	0.10
A. leiocalyx	Early Flowered Black Wattle	0.10
Corymbia citriodora ssp. *variegata*	Spotted Gum	0.50
Eucalyptus crebra	Narrow Leaved Ironbark	0.40
E. melanoleuca	Yarraman Ironbark	0.30
E. melanophloia	Silver Leaved Ironbark	0.30
E. moluccana	Gum Topped Box	0.20
E. tereticornis	Blue Gum	0.40
Allocasuarina littoralis	Black She-Oak	0.40
Alphitonia excelsa (clean seed)	Red-Ash	0.40
Angophora leiocarpa	Smooth Barked Apple	0.20
Lophostemon confertus	Brushbox	0.40
Cassinia laevis	Cough Bush	0.10
Dodonaea viscosa	Hop Bush	0.20
Grewia latifolia	Dysentary Plant	0.15
Indigofera australis	Indigo	0.15
Denhamia bilocularis	Orangebark	0.10
Crotalaria mitchelli ssp. Mitchelli	Rattle pod	0.10
Jasminum simplicifolium/Hardenbergia violacea	Stiff Jasmine/False Coal Pea	0.05
Eustrephus latifolius/Derris involuta	Wombat Berry/Native Derris	0.05
Petalostigma pubescens	Quinine	0.05
Pittosporum angustifolium	Native Apricot	0.05
Total Rate (kg/ha)		**5.0**
Grasses		
Bothriochloa bladhii	Forest Blue Grass – cleaned flowable seed	0.6
Bothriochloa decipiens	Pitted Blue Grass – cleaned flowable seed	0.4
Bothriochloa macra	Redleg Grass – cleaned flowable seed	0.6
Cynodon dactylon	Bermuda Grass – coated seed	1
Aristida spp	Three awn grass – cleaned flowable seed	1
Chlorus truncata	Windmill Grass – cleaned flowable seed	0.2

Botanical species	Common name	Rate (kg/ha)
Capillipedium spicgerum	Scented Top – cleaned flowable seed	0.2
Cymbopogon refractus	Barbed Wire Grass – cleaned flowable seed	0.2
Sporobolus creba	Clean flowable seed	0.2
Themeda triandra	Kangaroo Grass – flowable florets	0.6
Echinochloa utilus	Jap Millet – cleaned flowable seed	3
Total Rate (kg/ha)		**8**

5.1.4 Future seed selection considering climate change adaptations

The Queensland Government has produced publications on the impact of climate change on the Wide Bay-Burnett region (State of Queensland, 2019). In future, the region can expect:

- higher temperatures
- hotter and more frequent hot days
- harsher fire weather
- fewer frosts
- reduced rainfall; and
- more intense downpours.

Several climate projections are available (Cobon et al., 2017), and the climate models predict either little change or a slight decrease in rainfall in the Wide Bay Burnett region. Evaporation losses of soil moisture are predicted to rise. Growing substrates contended with often provide exaggerated low water holding capacity or exhibit other qualities which induce water stress significantly. Sites are often conducive to enhanced water losses from evaporation. Erosion is also a serious problem when left unmanaged and can occur where rehabilitation takes place. In summary, the climate change effects on the Meandu Mine's future rehabilitation are expected to mainly impact on the growing substrate and predominantly amount to lower water availability.

The mixture of local taxa utilised in plantings have proven well-adapted to these imposed conditions. The seed mixture has already undergone a selection process over many years where a major underpinning criterion was adaptation to low water availability. This selection process will continue for some time although the bank of locally relevant taxa is already heavily exploited. Alterations to the native seed mix other than to continue selecting seed using the biases relating to lower water availability is not recommended. In addition, fire adaption will become a strong feature for the consideration of future seed selections.

The Native Ecosystem rehabilitation at Meandu Mine is aimed at supporting and increasing the preservation of existing natural ecologies. Sensitive ecological sites exist adjacent to Meandu Mine such as Tarong National Park and State Forests which contain natural areas of value. The current species selection process has already focused on alignment with the range of local taxa at Meandu Mine for their adaptation to low water availability. The introduction of taxa from arid zones or from lower rainfall areas further west will continue to be avoided since some of these would likely escape the local site and degrade the ecologies existing in the neighbouring sensitive areas.

5.1.5 Weed management/spread of invasive plants

Weed monitoring is undertaken regularly by mine personnel and periodically by external consultants for selected sites as a component of the annual rehabilitation monitoring program. Site specific strategies to manage invasive plant are varied and may include:

- regular site inspections for invasive plant outbreaks and occurrences
- identification and mapping of invasive plant locations
- implementation of an invasive plant treatment program in accordance with recommended practices
- identification of environmentally sensitive areas requiring specialised invasive plant control (e.g. riparian and evergreen vine thicket areas). Implement approved invasive plant treatment programs in these sensitive areas
- implementation of invasive plant monitoring and treatment programs in rehabilitation areas to meet Meandu Mine rehabilitation plan requirements
- conduct follow up inspections to ascertain effectiveness of invasive plant control practices
- control spread of invasive plants through good hygiene practices
- all soil and vegetative matter brought onto site is to be accompanied by a weed hygiene/invasive plant declaration
- incorporation of invasive plant hygiene requirements in contracts which involve land clearance and disturbance
- monitoring of invasive plant hygiene wash down bay and areas where mobile washdowns have occurred
- increased awareness of invasive plant identification and locations on sites
- investigation of the use, and monitoring the effectiveness, of biological control agents
- application of herbicides by a licensed pest control contractor in accordance with the *Agricultural Chemicals Distribution Control Act 1966* (ACDC Act) and manufacturer's directions; and
- all cleared and grubbed material to be managed on site and proposed mulching programs will include consideration for management of invasive weeds.

5.2 Rehabilitation monitoring

The condition of rehabilitation at Meandu has been comprehensively monitored over the past 25 years. From 1995 to 2011 monitoring was performed by The University of Queensland, in 2014 and 2015 by Queensland Herbarium, in 2017, 2018 and 2019 by Aurecon consultants, and most recently in 2020 and 2021 by WSP consultants, with the Queensland Herbarium providing forest growth trajectory modelling support.

The current rehabilitation monitoring method is outlined in the following sections.

5.2.1 Site selection

The Meandu Mine site implements age-based rehabilitation monitoring methodologies with varying frequencies based on the method applied. The rehabilitation monitoring schedule for the rehabilitation of Native Ecosystem PMLU at the Meandu Mine site is provided in Section 8.3.1 of the Meandu Mine PRC Plan.

5.2.1.1 Site <1 year old – rapid assessment

Rapid assessment is undertaken within the first year after establishment. The assessment focuses on ground cover establishment, soil characteristics and stability (evidence of major erosion starting i.e. gullies or rills deeper than 100 mm) across the rehabilitated area.

A random meander technique is used through the rehabilitated area recording all species observed, taking note of ground cover patchiness and any evidence of gully and rill erosion. Following this, a representative location towards the centre of the site is chosen and a 1 m x 1 m quadrat is randomly placed in the four compass directions (north, east, south and west). The species assemblage (including declared weeds) and the following groundcover percentages within the quadrats are recorded:

- native grasses
- non-native grasses
- native forbs and others
- non-native forbs and others; and
- bare ground/rock.

5.2.1.2 Sites >1 year old – transect assessment

For sites greater than one year old 50 m transects are established at a rate of one per 10 hectares. The parameters recorded for new and existing transects are based on the adapted BioCondition methodology used by the Queensland Herbarium (Neldner and Ngugi, 2014) and additional information to determine compliance with the EA. Transect establishment and assessment includes the following:

- A 50 m transect is established in representative vegetation. For sloping sites each transect runs at approximately a 45-degree angle downslope, or where the site is flat, a direction is chosen that best captures vegetation representative of the site. Where the vegetation is variable, (e.g. patchy in cover) an additional transect is located. For each transect measurements are undertaken in a 50 m x 4 m plot, a 50 m x 14 m plot and within five 1 x 1 m quadrats.
- GPS waypoints are recorded at the start and end points of each transect. In addition, and where relevant, GPS waypoints are taken of notable features in proximity to each transect, such as erosion and weeds of significance.
- Photographs are taken at the start and end of each transect looking towards the middle of the transect. Photographs are taken in landscape orientation.
- Photographs are taken of each of the five 1 x 1 m ground quadrats located along the transect and of notable issues including soil erosion and weeds of significance.

Data attributes collected in each plot/quadrat are summarised in Table 5.2. Other general observations including soil erosion, incidental fauna observations etc. are also recorded where relevant and photographs taken.

Table 5.2 Summary of data attributes collected for each plot/quadrat

Plot / quadrat	Data attributes collected
50 x 4 m plot	— canopy cover using transect tape and measurement of canopy, sub-canopy and shrub layers where present — stem counts identified into groupings – Eucalypt/Corymbia, Acacia, Other (tree), Shrub — diameter at Breast Height (DBH) measurements of all plants with a DBH greater than 2 cm height and DBH of at least four dominant/co-dominant trees.
50 x 14 m plot	— species richness – total number of different species in each life form layer as described in the BioCondition Methodology (Eyre et al., 2015) — coarse woody debris – total length in metres of all woody debris over 0.5 m length and 0.1 m diameter — tree species recruitment – regeneration of canopy and sub-canopy species.

Plot / quadrat	Data attributes collected
1 x 1 m quadrat	— native perennial grass cover — native other grass — native forbs and other species (non-grass) — native shrubs (<1 m height) — non-native grass — non-native forbs and shrubs — litter — rock — bare ground; and — cryptograms.

5.2.2 Soil sampling

Soil sampling is undertaken at each new monitoring (transect) site. Methodologies on sampling from the *Australian Soil and Land Survey Field Notebook* (National Committee on Soil and Terrain, 2009) and the Rehabilitation Management Plan are used. Soil samples are taken from five locations along the transect (at 10 m intervals from within the bottom left-hand corner of the 1 x 1 m quadrats) from a maximum depth of 300 mm, dug with a hand trowel. The five samples are bulked within a labelled plastic zip lock bag prior to being transferred to the Queensland Herbarium to determine soil texture and water holding capacity.

6 Rehabilitation and revegetation procedure – Beef Cattle Grazing PMLU

This section summarises the technical study/literature review findings for the Beef Cattle Grazing PMLU at the Meandu Mine site.

6.1 Overview of proposed Beef Cattle Grazing PMLU

The total area proposed for this PMLU in the 2022 PRC Plan is 556 ha.

There are two main factors that will bet be considered to ensure the success of this PMLU, which are land suitability and grazing strategy.

6.1.1 Land suitability

Land suitability classes for grazing include classes 1, 2 and 3, with Class 1 being most suitable with negligible limitations and Class 3 being suitable but with moderate limitations (DSITI & DNRM, 2015). For the grazing PMLU land suitability classes 1 and 2 are preferred to minimise ongoing management inputs and to minimise the risk of long-term land degradation post mine closure. Land suitability class descriptions are provided in Table 6.1.

Table 6.1 Land suitability classes

Class	Suitability	Limitations	Descriptions
1	Suitable	Negligible	Highly productive land requiring only simple management practices to maintain economic production.
2	Suitable	Minor	Land with limitations that either constrain production or require more than the simple management practices of class 1 land to maintain economic production.
3	Suitable	Moderate	Land with limitations that either further constrain production or require more than those management practices of class 2 land to maintain economic production.
4	Unsuitable	Severe	Currently unsuitable land. The limitations are so severe that the sustainable use of the land in the proposed manner is precluded. In some circumstances, the limitations may be surmountable with changes to knowledge, economics or technology.
5	Unsuitable	Extreme	Land with extreme limitations that preclude any possibility of successful sustained use of the land in the proposed manner.

For inland South-East Queensland, in which the Meandu Mine is situated rehabilitation to achieve the required land suitability classes will be designed to meet the required threshold values for soil properties listed in DSTI & DNRM (2015). Relevant threshold values include values for slope gradient, plant available water capacity (PAWC), the percentage of stones and boulders, topography and wetness. To meet the threshold values (see Table 6.2) topsoil derived from Ferrosols will be the preferred (but not exclusive) material for construction of soil profiles because of the following:

- proximity of the Ferrosol topsoil stockpiles to the post-mining grazing areas
- high clay content and water storage capacity (PAWC); and
- inherent suitability for improved pasture production.

Table 6.2 Relevant soil and land limitations and threshold values

Limitation	Description	Improved pasture
Water erosion	Very stable soils	<15% slope gradient
	Stable soils	<15% slope gradient
	Unstable soils	<15% slope gradient
	Very unstable soils[1]	<8% slope gradient
Soil water availability	PAWC[2]	100 mm
Rockiness	Coarse gravel	50%
	Cobbles	20%
	Stones	10%
	Boulders	<2%
Salinity	ECe[3]	<4 dS/m
Topography	Slope	20%
Wetness	Soil drainage	Imperfectly drained/moderately permeable

(1) Newly constructed and unvegetated Anthroposols (Isbell and NCST, 2016) are very unstable soils.

(2) Plant available water capacity (PAWC).

(3) Saturated electrical conductivity (ECe).

Although Ferrosols will be the preferred topsoil for rehabilitation of the grazing PMLU, all reconstructed soil profiles are typically inherently unstable. To ensure a conservative approach, , the target overall slope gradient will be 8% which is the threshold for very unstable soils, with some small areas up to 15% gradient to achieve tie-in with surrounding landform (Table 6.2).

6.1.2 Grazing strategies

To guide the implementation and management of the Beef Cattle Grazing PMLU the following grazing strategies outlined in Table 6.3 (Highlands Environmental, 2020) will be used as a guide where practicable.

Table 6.3 Beef Cattle Grazing PMLU – grazing strategies (Highlands Environmental, 2020)

Grazing strategy	Overview
Grazing strategy 1:	Identify areas within the final landform design that have suitable characteristics for sustainable beef cattle grazing (i.e. shape, grade and size).
Grazing strategy 2:	Rehabilitation should be constructed based on Ferrosol topsoil to ensure soil and land suitability for cattle grazing.
Grazing strategy 3:	Considered mine planning is required to construct rehabilitation with land and soil attributes (limitations) that meet or exceed threshold values for land suitability assessment for beef cattle grazing. Where soil attributes do not meet the threshold values, Native Ecosystem will be the preferred PMLU.
Grazing strategy 4:	Sow exotic 3P pasture species (palatable, perennial and productive) and plant shelterbelts of native tree species. Shelterbelt planting should be fenced off until trees are above browse height.
Grazing strategy 5:	Use ridgelines to site fences, lane ways and access tracks, defining paddock size and enabling most-weather access and stock movement.
Grazing strategy 6:	Incorporate laneways of up to 50 m width to connect rehabilitation grazing polygons with unmined grazing areas and farm infrastructure.
Grazing strategy 7:	Construct and maintain firebreaks along permanent fence lines which should be 10 m minimum width or 1.5 times the height of adjacent trees, whichever is the greatest.
Grazing strategy 8:	Exclude stock from dams and watercourses and associated riparian vegetation, and all semi evergreen vine thicket areas to prevent environmental degradation. Cattle impacts on dams reduce water quality impacting cattle health. Cattle impacts on watercourses result in degradation of stream water quality, driven largely by bank erosion and resultant instream, fine sediment deposition. Increased stream nutrient levels from cattle manure also impact water quality resulting in potentially toxic algal blooms, downstream.
Grazing strategy 9:	Plan to retain minor mining infrastructure that is needed for Beef Cattle Grazing management (e.g. for stock water reticulation) post-mining.
Grazing strategy 10:	Use ‘water circles’ of 1,600 m diameter to design and limit stock walking distance to water to about 800 m.
Grazing strategy 11:	Introduce cattle to rehabilitation as early as is feasible and base herd composition on a production model paired to land suitability.
Grazing strategy 12:	Once established, monitor and maintain or improve land condition in rehabilitation used for grazing.

6.2 Rehabilitation method

The rehabilitation establishment method for the Beef Cattle Grazing PMLU presented here provides an outline of the proposed procedures. Currently no areas of Meandu Mine have been rehabilitated for grazing.

The overall rehabilitation method is similar to that used for the Native Ecosystem PMLU and is based on a similar seven stages:

1. dumping the bulk landform to the overall target Life of Mine Profile
2. dozer profiling of the bulk landform to achieve final profile and contour systems
3. drain establishment (where required) and with fencing to exclude/protect cattle from rock armoured drains / steep banks
4. erosion control works
5. site preparation – topsoil and ameliorants
6. topsoil placement; and
7. ripping and seeding.

6.2.1 Topsoil and topsoil placement

Topsoil is sourced from existing topsoil stockpiles at Meandu Mine or, where possible, directly placed from areas on the mining path being stripped at the time. The topsoil stockpiles vary in their physical and chemical properties reflecting natural variation in the original soil types. Only rehabilitation material that meets the material characterisation requirements for the Beef Cattle Grazing PMLU is used (refer to column 5 of Table 1.5). Prior to placement the topsoil stockpiles will be characterised and assessed against target values for Land Suitability Classes 1 and 2. Topsoil, is spread to a nominal depth of approximately 200 mm after landform preparation. Topsoil placement involves:

- preparing the landform in accordance with the Meandu Mine PRC Plan requirements for the final landform with respect to the Beef Cattle Grazing PMLU
- ensuring the surface is suitable for topsoil application (e.g. minimal rill/gully erosion)
- nominating the topsoil stockpile(s) to be utilised for the area, or source location if to be directly placed from stripped areas
- calculating the estimated quantity of and suitability of topsoil required for improved pasture grass growth
- ensuring the equipment operators have been briefed on the topsoiling plan/requirements for the area
- scheduling topsoil placement to avoid heavy rain forecast
- applying the topsoil evenly at the nominal thickness of 200 mm
- if applicable, constructing contour banks where required to convey water to their intended discharge point at no greater than 2% to maintain velocities at levels that will minimise erosion. Banks constructed in sodic soils should have gypsum or lime applied at recommended rates to minimise potential tunnel erosion. Contour banks and drain invert should be topsoiled and managed to promote rapid establishment of perennial vegetation to minimise erosion. Banks should be inspected after significant rain events and ponding water or erosion issues repaired to ensure the long term success of the drainage feature
- re-surveying topsoil stockpiles after topsoil extraction and deducting this quantity from the topsoil register
- locating topsoil stockpiles away from weed species where possible, monitoring for weed establishment and spraying to control weeds if required.

Some of the topsoil salvaged from the K2E ASA may contain a vine thicket soil seedbank of pioneer species. Stockpiles will be monitored to determine if this is likely to result in pasture degradation from woody species establishment.

Post topsoil placement, the surface is to be contour ripped to a depth of 0.3–0.5 m with small dozers to aid in erosion control, root penetration and shallow moisture infiltration.

6.2.2 Seed bed preparation

Seed bed preparation is an important aspect of establishing pasture grass species. Correct seedbed preparation includes:

- preparation of a firm seed bed for small pasture grass species
- provision of shade through practices such as cover crop establishment to prevent desiccation of young seedlings of the pasture grass species
- avoiding ripping of soils that are hard setting or crust after rain (e.g. Inland Burnett forest soils (DAF 2022)). Soils will require testing to determine the likelihood of forming crusts and setting hard after rain
- timing of preparation to avoid the risk of erosion from heavy rainfall events and to minimise weed colonisation. Ripping and seeding will be undertaken prior to the wet season (target – end of September), but with a limit of no later than 10 December.

6.2.3 Seeding

It is important that seeding is undertaken as soon as practicable following topsoil spreading to improve seed germination. Works undertaken more than 2 days after topsoil placement often experience poor and patchy strike compared to areas where seed is sown directly after spreading due to increased soil moisture. Crusting occurring after the seed is laid tend to encapsulate the seed and therefore retain it and often enough to allow for intimate soil/seed contact.

Various options are available for seeding. A common problem with seeding is fluffy seeded grass species, which are seed with appendages (e.g. awns) that are hard to spread with some types of seeding machinery. Fluffy seed can be mixed with fertiliser, cracked grain or sieved sawdust to act as a carrier to improve the spreadability of the seed. Alternatively coated seed can be used that has a smooth surface.

6.2.3.1 Planting depth

Seed should be placed on the surface and lightly covered with soil. To achieve the best strike with most pasture grasses and legumes seed should not be buried more than 10 mm.

6.2.3.2 Seed species and seed rates

Species for improved sown pastures for south-east Queensland include a combination of annuals and perennials. Perennial grasses and legumes that may be used at the Meandu Mine include Rhodes grass (*Chloris gayana* cv. Katambora), Bisset creeping bluegrass (*Bothriochloa insculpta*), glycine (*Neonotonia wightii* cv. Cooper) and Lucerne (*Medicago sativa* cv. Sardi7).

Pasture species selection will be refined based on consultation with appropriate grazing consultants as well as considering the results of the proposed grazing trial (refer Section 6.2.6). This will ensure that improved pasture species are appropriate for the site and include new higher performing varieties and species. In addition, pasture species selection will include assessment of the potential invasiveness for adjacent Native Ecosystem PMLU.

6.2.3.3 Cover crop

The seed mix may include a cover crop such as *Echinochloa esculenta* (Japanese Millet). The cover crop provides various benefits including:

- provides rapid vegetation cover minimising the risk of erosion from intense rainfall events
- improves water retention
- reduces opportunities for weed colonisation; and
- provides a source of organic carbon once hayed off.

Seeding of target species (a combination of annuals and perennials) at a target rate of 3 kg/ha grass excluding the cover crop (this equates to a minimum of 1 kg of pure live seed[1] (pls) per hectare) and 3 kg/ha of legumes per hectare. Target species to include a high percentage of 3P grasses (palatable, productive and perennial), desirable forbs (e.g., native legumes such as Glycine) and a variety of other palatable species. While not being the main focus of the proposed Beef Cattle Grazing monitoring trail, seed rates and species will be confirmed and optimised at that time (refer Section 6.2.6).

6.2.4 Weed management

Depending on the previous vegetation cover of the salvaged topsoil, the existing soil seed bank may result in the regeneration of woody pioneer species, including Acacia species and or a range of weed species where soils are salvaged from previously disturbed sites. A weed management strategy will be developed reflecting the pre-existing vegetation cover type and on-site weeds within the vicinity of the topsoil stockpiles.

For herbaceous weeds in newly sown pastures herbicide-based weed control will be used. A suitable weed management program may involve spraying at about 3–6 weeks after sowing, prior to the first slashing. At this time weeds are still small and there should be approximately 70% or more ground cover.

Herbicide will be used that does not damage the newly established grasses and clover while providing effective weed control.

6.2.5 First year grazing management

Grazing management in the first year is critical to the establishment and long-term viability of sown pastures. There are two general approaches (DAF, 2022):

- no grazing until the pasture seeds; and
- lightly grazing once or twice during the first summer/autumn.

Light grazing is unlikely to be practicable while the mine is operational and may therefore be replaced by slashing. Slashing should encourage the grasses to spread out and will reduce the build-up of too much growth that can smother young grasses and legumes. Allowing the pasture to seed in the first year is important for grasses that reproduce via seed only, rather than runners. Species such as Rhodes grass and others (e.g., creeping bluegrass – *Bothriochloa insculpta*) should fill in the gaps without seeding.

[1] Pure live seed per hectare (excluding seed coating weight) = $germination\ \% \times purity\ \% \div 100$

6.2.6 *Proposed grazing trial*

While a common land use in the region, no prior rehabilitation has been undertaken for Beef Cattle Grazing PMLU at the Meandu Mine. The Meandu Mine PRC Plan risk assessment identified the risk to the development and sustainability of pasture land and grass species due to subsoil and topsoil selection. A monitoring comparison trial of two different subsoil designs utilising available site materials to confirm the preferred makeup for the majority of grazing cover land is proposed (Table 6.4). Depending on results from the trial, subsequent selective waste placement within the Beef Cattle Grazing PMLU allocated polygon may then utilise one or a combination of both subsoil designs.

Table 6.4 Beef Cattle Grazing PMLU trial

Requirement	PMLU Beef Cattle Grazing trial
Objective	To develop/verify the preferred sub-soil source material required to achieve Class 1, 2, or 3 requirements for beef cattle grazing, address land degradation and support an economically viable (weaner fattening) grazing operation.
Trial Design — Location — Underlying land characteristics — Potential issues	**Location:** K4S lowwall spoil dump. Land characteristics: In-pit/out-of-pit spoil dump, comparison trial substrate to consist of: **a** minimum 5.5 m depth rehandled NAF spoil material overlain with 0.5 m topsoil and **b** minimum 5 m depth excavated NAF material, overlain with 0.8 m weathered basalt subsoil and 0.2 m basaltic topsoil. Other practices that may be considered: Periodic slashing frequency to simulate grazing until introduction of cattle in order to maintain pasture quality and enhance natural seeding and germination processes. **Potential Issues:** Insufficient PAWC or elevated salinity. Establishment of minimum reasonable area required prior for a representative trial means that several years may lapse between seeding some areas and trial commencement (creating a risk of deterioration). Species suitability/establishment under site specific conditions.
Commencement	2025
Duration	Up to 5 years
Assessment for trial success	Persistent pasture grass mix under dryland grazing operation, to be simulated by periodic slashing of vegetation. Soil criteria achieves Class 1, 2 or 3 requirements.
Incorporation of results into rehabilitation strategies and milestones	Refinement/verification of species selection and material placement requirements to achieve success criteria. Timing for commencement of grazing following rehabilitation establishment and verification of sustainable stocking rates and production metrics.
Previous trials	Not applicable.
Relevant literature and supporting documents	— Strategies for beef cattle grazing in rehabilitation at Meandu Mine (Highlands Environmental, 2020) — Meandu Mine Soil Survey Phase 1 (Landloch, 2021a) — Characterisation of Meandu Mine Material for Rehabilitation Suitability (Landloch, 2021b); and — Meandu Mine Rehabilitation Management Plan (Stanwell, 2022).

6.2.7 *Beef Cattle Grazing PMLU monitoring*

Once established, land condition monitoring will be undertaken in rehabilitation used for the Beef Cattle Grazing PMLU. The objective of land condition monitoring is to determine the capacity of land to produce useful forage and is therefore, directly related to carrying capacity, livestock production and profitability (FutureBeef, 2018). Land condition monitoring considers both soil and pasture condition and woody regrowth potential and classifies land into four broad categories as outlined in Table 6.5.

Table 6.5 Land condition monitoring – categories

Condition category	Overview
A condition – good condition	— dominance of 3P (palatable, perennial and productive) pasture species with little bare ground (<30%) — few weeds — no erosion and good soil surface condition — 100% long-term carrying capacity.
B condition – fair condition	— fewer 3P species, bare ground 30–50% — signs of previous erosion or potential erosion risk — 75% long-term carrying capacity.
C condition – poor condition	— large amounts of less favoured species, >50% bare ground — signs of previous erosion or current susceptibility to erosion is high — 45% long-term carrying capacity.
D condition – very poor condition	— lack of perennial grasses — severe erosion and scalding — less than 25% of long-term carrying capacity.

Grazing in rehabilitation should aim to maintain or improve land condition. Monitoring is qualitative and can be recorded and reported using one of several available templates, such as the Stocktake Plus App (available at http://stocktakeplus.com.au/). Land condition monitoring should be undertaken alongside pasture yield assessments for forage budgeting, or before and after rehabilitation grazing periods, or more frequently if desired.

6.2.7.1 Dry season pasture yield

Consideration will be given to pasture monitoring to determine the dry season yield per hectare to determine the potential safe stocking capacity that will avoid land degradation. This assessment method is based on collecting pasture samples from 0.5 m x 0.5 m quadrats along 50 m monitoring transect as follows:

- Select five ground cover quadrat locations at random along each transect.
- Harvest the grass from each of the five 0.5 m x 0.5m quadrats. The quadrat should be located adjacent to the centre line, noting if located to the left or right of the centre line and the distance along the centre line.
- Using battery operated shears cut the herbage (grass & herbs) to within approximately 1 cm of the ground level and bag all the harvested material in a large labelled paper bag. Note that if there are large amounts of old dead herbage (typically grey in colour) it should be separated from the sample and discarded to prevent over estimation of the pasture mass.
- Determine the net (wet) weight of each sample (net weight = sample weight minus the bag weight).
- Sub-sample each of the 'wet' sample quadrats. The subsample should be of mostly leafy material since this is mostly what cattle feed on. Incorporating stem material will result in potentially artificially high net weights.
- Measure the wet weight of each of the five sub-samples in grams.
- Oven dry the sub-sample (samples will be dried for 48 hours at approximately 70–80°C using a dehydrator).

- Weigh the oven dried sub-sample (in grams).
- Calculate dry matter percentage of the sub-sample.
- Use this dry matter percentage figure to determine the dry matter weight of each quadrat.
- Calculate the equivalent dry matter weight for each quadrat for one hectare (kg DM/ha).
- Determine dry season pasture budget to provide a guide for the appropriate stocking rate for the proposed light grazing land use (for an example see: *Dry season pasture budget: a guide for stocking rates* (FutureBeef, 2018)).

7 Rehabilitation and revegetation procedure – Creek Diversion and littoral zone in the final voids

This section summarises the existing information and proposed rehabilitation strategy forward for the Creek Diversion PMLU and littoral zone in the lowwall side of final voids (as part of the Water Storage PMLU) at the Meandu Mine site.

7.1 Overview

Former diversions of Meandu Creek are included as the Creek Diversion PMLU and these include three diversions which are Meandu Creek South (upstream) (completed construction in 2005); Central (completed construction in 1992); and North (downstream) (completed construction in 1986). The location of these diversions and the associated retention dams are shown in Figure 4.2 of the Meandu Mine PRC Plan.

Similar revegetation objectives are proposed for the littoral zone in the final voids including:

- support for a long-term self-sustaining vegetation community
- maintain a stable landform create a local microclimate, which will help with wind, temperature, water retention and pollination vectors.

The following sections provide a summary of key components of rehabilitation for the Creek Diversion PMLU and the littoral zone in the final voids, including:

- general rehabilitation practices and species selection; and
- rehabilitation monitoring.

7.2 Rehabilitation method

7.2.1 Site preparation

Site preparation works for the Creek Diversion PMLU areas is consistent with the methodology utilised for rehabilitation of the upstream 2005 (south) diversion, including topsoil placement, surface contouring and ripping.

Surface ripping is undertaken perpendicular to the expected flow of water, to minimise erosion and maximise water retention. The spacing between rip lines is determined by the slope of the land, which acts to reduce soil erosion and increase plant establishment rates. It is planned that the two downstream (central and north) diversions will undergo similar treatment during rehabilitation where required.

For the final void littoral zones, which are located on the lowwall side of the void, the rehabilitation establishment practices will include:

1. reshape the slope into the void consistent with the adjacent PMLU
2. topsoil the zone down to the lower RL of the modelled void water level fluctuation or the actual rebounded water level, whichever is higher
3. contour rip and seeding.

7.2.2 Topsoil requirement

Topsoil or growth media placement is unlikely required for the rehabilitation for creek diversions, though the upper banks may be spread with additional topsoil if required, to assist water retention and vegetation growth. The littoral zones located on the lowwall side of the final voids will be spread with topsoil down to the lower RL of the modelled void water level fluctuation or the actual rebounded water level, whichever is higher.

7.2.3 Species selection and seed rates

Species selection for the Creek Diversion and littoral zones of final voids (located on the lowwall side of the voids) aims to achieve a long-term self-sustaining vegetation community and minimise the long- and short-term risks and maintenance requirements. Species have been chosen to suit the likely soil conditions present in the diversion and littoral zones of final voids, including irregular inundation and/or wet ground conditions.

Species selected are assumed to already be present in the area and the intent is to contribute to the remnant vegetation communities at the upstream and downstream ends of the diversions.

Species selection was undertaken in 2010 based on the approved design plan and Revegetation Plan for the upstream (southern) diversion (URS 2010). Progressive monitoring since completion of seeding has shown that the species selection is appropriate for the Creek Diversion PMLU. Given the similarity in conditions and applications, an internal environmental review concluded that the same list is appropriate to be utilised for the littoral zones of final voids. This species list and seed rate applied is included in Table 7.1.

Table 7.1 2010 Meandu Creek Diversion species selection/recommended species selection for the final void riparian zone

Species	Common name	Low flow	High flow	Rate (kg/ha)
Cynodon dactylon	Couch grass	X	X	1
Paspalum distichum	Water couch	X		1
Phragmites australis	Common reed	X		1
Persicaria lapathifolia	Pale Knotweed	X		1
Baumea articulata	Jointed Twigrush	X		1
Bolboschoenus caldwellii	Clubrush	X		1
Bolboschoenus fluviatilis	Marsh Clubrush	X		1
Carex appressa	Tall Sedge	X		1
Schoenoplectus validus	River Clubrush	X		1
Dichelachne crinita	Long-hair plume grass		X	0.5
Dichelachne micrantha	Short-hair plume grass		X	0.5
Lachnagrostis filiformis	Blown grass		X	0.5
Microlaena stipoides var. stipoides	Weeping grass		X	0.5
Poa labillardieri var. labillardieri	Tussock grass		X	0.5
Bothriochloa bladhii	Forest Blue Grass		X	0.5
Cymbopogon refractus	Barb wire Grass		X	0.5
Gahnia aspera	Red-fruited Sawsedge		X	0.5

Species	Common name	Low flow	High flow	Rate (kg/ha)
Lomandra longifolia	Spiny-headed Matrush		X	0.5
Eulalia aurea	Silky Browntop		X	0.5
Arundinella nepalensis	Reed Grass		X	0.5
Desmodium brachypodum	Large Tick Trefoil		X	1
Angophora floribunda	Roughbark Apple		X	0.3
Casuarina cunninghamiana subsp. cunninghamiana	River Oak		X	0.3
Corymbia tessellaris	Moreton Bay Ash		X	0.3
Eucalyptus melanophloia	Silver-leaf Ironbark		X	0.3
Eucalyptus tereticornis	Blue Gum		X	0.3
Lophostemon suaveolens	Swamp Box		X	0.3
Acacia falcata	Hickory Wattle		X	0.4
Acacia fimbriata	Brisbane Golden Wattle		X	0.4
Acacia implexa	Lightwood		X	0.4
Acacia leiocalyx subsp. leiocalyx	Early-flowering Black Wattle		X	0.4
Alphitonia excelsa	Red Ash		X	0.5
Melaleuca bracteata	River Tea-tree		X	0.5
Melia azedarach	White Cedar		X	0.5
Pittosporum angustifolium	Weeping Pittosporum		X	0.5
Bursaria spinosa subsp. spinosa	Blackthorn		X	0.5
Dodonaea triangularis	Common Hop Bush		X	0.5
Dodonaea viscosa	Sticky hop Bush		X	0.5
Jacksonia scoparia	Dogwood		X	0.5
Acacia glaucocarp	Fern-leaf wattle		X	0.2
Eucalyptus intermedia	Pink bloodwood		X	0.2
Angophora costata spp costata	Smooth bark apple		X	0.2
Corymbia citriodora ssp. varieagata	Spotted gum		X	0.2
Eucalyptus moluccana	Grey box		X	0.2

7.3 Rehabilitation monitoring

This section describes the monitoring that has been developed for the Creek Diversion PMLU. It is based on the monitoring program included in the approved design plan for the upstream (south) diversion. An appropriate program will be developed for the two downstream (north and central) diversions, addressing similar objectives.

The littoral zones located on the lowwall side of the final voids will be monitored using similar methodologies to that used for the Native Ecosystem PMLU but comparing against the dominant riparian regional ecosystem in the catchment (RE 12.3.3) with consideration of the selected species mix (Table 7.1).

7.3.1 Vegetation establishment and sustainability

The objectives for vegetation establishment monitoring are to demonstrate:

- effective control of soil erosion through vegetation establishment
- a minimum ground cover of 50%; and
- vegetation species diversity that reflects existing riparian vegetation common to the catchment.

Monitoring methodologies similar to that used for the neighbouring Native Ecosystem PMLU have been utilised to assess vegetation establishment but comparing against the dominant riparian regional ecosystem in the catchment (RE 12.3.3).

7.3.2 Morphological stability

The specific objective of monitoring morphological stability is to demonstrate that the low flow channel of the diverted river is stable in plan form, and vertical profile, and that there are no significant areas of unstable floodplain and/or bank erosion/deposition.

Ground-based photographic monitoring will be undertaken to provide monitoring for the bed and bank conditions of the low-flow channel and flood bench surfaces:

- monitoring of plan form morphology with aerial photography (approximate 1:10,000 scale); and
- periodic surveys as required and comparison against “as-constructed” survey to identify potential erosion problems.

The general condition of the creek diversion will be monitored over time using appropriate industry standard methods (e.g. Index of Diversion Condition (IDC)).

7.3.3 Local drainage monitoring – creek diversion

The objective of monitoring local drainage is to confirm that local channels are operating as designed and not contributing to instabilities in the rehabilitated bank landform or uncontrolled surface erosion. Visual inspection of the surface drainage works and local flow pattern will be undertaken periodically, in conjunction with rehabilitation monitoring and site dam/ drainage monitoring programs.

Key aspect of the inspections will be to identify:

- overtopping or piping breaching of the contour drains
- excessive sedimentation in the base of drainage channels which reduces the hydraulic capacity of the channel and can cause concentrated overflow and surface erosion of down-slope areas
- inadequate groundcover vegetation in the drainage channel sufficient to cause uncontrolled flow (increasing gully erosion); and
- the integrity of rock-lined drains entering the diversion channel.

The locations of problems areas will be recorded with GPS and photographed for subsequent monitoring to confirm the adequacy of remedial works.

7.3.4 Water quality

Water quality in waterholes or storages downstream of the rehabilitated creek diversions will be monitored annually, to demonstrate that runoff water quality will achieve non-polluting success criteria. This will be undertaken as part of the site water monitoring program.

7.3.5 Other monitoring requirements

Additional to vegetation growth monitoring, other requirements including geotechnical stability and surface erosion monitoring are discussed in Section 8.2.4 of the Meandu Mine PRC Plan.

8 Rehabilitation and revegetation procedure – Steep Rocky Ecosystems

This section summarises the technical study/literature review and current research findings for the Steep Rocky Ecosystem PMLU at the Meandu Mine site.

8.1 Overview

The Steep Rocky Ecosystems PMLU is a natural ecosystem as a mosaic of plant and animal assemblages of different structure and composition across a steep rocky post mining landscape. It is a specific application for the excavated walls that will remain at the end of Meandu Mine life. This represents an approach agreed with the DES during the 2020 negotiations to amend the EA with respect to allowable PMLUs and their associated success criteria. The Steep Rocky Ecosystem PMLU design considers the requirements for final highwall rehabilitation which includes a combination of steep batters and benches offering variable geometries suitable for the establishment of self-sustaining flora and fauna assemblages.

The Steep Rocky Ecosystem rehabilitation objective is to facilitate the establishment of self-sustaining plant and animal assemblages and associated ecosystem processes across the post-mining steep rocky landscape, through key processes including:

- geotechnical and geo-chemical landform evolution
- sediment transport, sorting and soil development
- development of stable hydrological systems
- establishment and reproduction of plant and animal assemblages
- development of structural and tropic complexity; and
- development of diverse plant and animal assemblages in a mosaic reflecting the range of evolved landforms and substrate characteristics across the steep rocky landscape.

Areas planned to be rehabilitated to achieve this PMLU are identified in Figure 2.1 and include the following locations:

- final highwall above water storage level in final voids (K2E and K4E) that are nominated in the 2021 LOM Plan; and
- excavated faces that are not accommodated within the final voids of the final landform in the Meandu Mine PRC Plan (K2W-N and SW13).

8.2 Baseline information/initial investigations

8.2.1 Background and objectives

A research project which aimed at outlining an approach to the establishment of self-sustaining plant and animal communities on high walls and associated benches above final water bodies in the post-mining landscape of Meandu Mine was carried out by Central Queensland University (CQU) in 2021 – 2022 (CQU 2022a). The initial study included the following objectives:

- Objective 1: Develop a conceptual landform model for the steep rocky ecosystem landscape
- Objective 2: Describe naturally evolving anthroposols on existing benches, and develop a conceptual model of soil evolution in this landscape
- Objective 3: Describe the naturally established vegetation assemblages on existing benches; and
- Objective 4: Describe the naturally established invertebrate fauna within vegetation and anthroposols on existing benches.

8.2.2 Methods

Physical soil, vegetation and invertebrate samples were collected during field work in July 2021 (CQU 2022a). Seven sites were chosen within the Meandu Mine lease area, broadly representing the different geological strata potentially exposed in the final walls, and different stages of ecosystem establishment (Figure 8.1). At each site, one to four locations were chosen depending on the size and variability of the site, representing physically different aspects of the site. The sampled site was photographed and the land cover (rock cover, litter cover, ground cover, canopy cover) was determined. Plant, soil and invertebrate samples were collected.



Figure 8.1 Location of the sites used in plant, soil and insect collection (adopted from CQU (2022a))

8.2.2.1 Soil sampling and data analysis

Soil samples were drawn using a metal cylinder (6 cm diameter x 10 cm tall). The cylinder was hammered into the ground to a depth of 10 cm and the core was lifted using a mattock/shovel. The soil from the core was recovered. Three to six such cores were drawn for each location and the soils from all cores were pooled, mixed and a representative sample was taken (~2 kg). These pooled samples were transported to the laboratory and sub-sampled using quartering method. Samples from two opposite quarters were combined and sent to CSBP, Soil and Plant Analysis Lab, Perth, for analysis.

The soil samples were dried at 105°C for 48 hours before being crushed and sieved using a 2 mm sieve. The proportions of the soil that was <2 mm and that >2 mm was quantified. The <2 mm fraction was used in all analyses.

The samples were assessed for colour, texture, pH, EC (conductivity), organic matter content, dispersion, exchangeable elements (Al, Na, Ca, Mg, K), soluble ions (Cl-, K+, NO3-, NH4+) and EDTA extractable elements (B, Cu, Fe, Mn, Mo, Zn) using standard CSBP methods.

To characterise patterns in soil properties, unconstrained ordination analysis was applied to soil chemistry data using the 'vegan' package (Oksanen et al. 2000) in the statistical software R (version 3.6.2; R Core Team 2019). Data were standardised for analysis, and after preliminary detrended correspondence analysis (R function 'decorana') showed that the dataset was sufficiently homogenous for linear ordination methods, principal component analysis (R function 'rda') was applied.

8.2.2.2 Vegetation sampling and data analysis

At each site, photos were taken, and land cover (including vegetation cover) was determined. Plants were collected, conserved as herbarium specimen, and identified to genus level where possible.

To characterise vegetation patterns, unconstrained ordination analysis was applied to vegetation data using the 'vegan' package (Oksanen et al., 2000) in R (version 3.6.2; R Core Team 2019). Vegetation data were presence/absence, and detrended correspondence analysis (R function 'decorana') was deemed appropriate.

8.2.2.3 Invertebrate sampling and data analysis

Invertebrate fauna was sampled using three techniques:

- sweeps of the vegetation with a handheld net (20 duplicate sweeps)
- manual intensive diurnal search (0.5 hr duration); and
- manual sorting of leaf litter and associated duff layer (collected from a single 0.25 m^2 quadrat per site).

The collected material from the sweep net was transferred to a plastic bag and flooded with 70% aqueous ethanol for transport to the laboratory for sorting. Invertebrates encountered during the intensive searches were placed in vials containing 70% aqueous ethanol. Litter samples were collected into plastic bags and sorted on the day of collection. Invertebrates were transferred to 70% aqueous ethanol in vials for future sorting.

In the laboratory collected samples were washed through a fine sieve (150 µm) and transferred into a sorting-trough with 70% ethanol for systematic searching with a stereomicroscope. Specimens encountered were classified to order (Naumann, 1991), counted and vouchered. Exceptions to the order-level classification were:

- Acarina (mites), Chilopoda (centipedes), and Diplopoda (millipedes) were classified to class-level only
- Hymenoptera was divided into family Formicidae (ants) and Other Hymenoptera (wasps and bees)
- Hemiptera was divided into suborder Heteroptera (true bugs) and Homoptera (phytophagous bugs); and
- Gastropods were classified to family.

Data analysis was based on a comparison among the 13 sites using site floristic and environmental factors as components.

In addition, unconstrained ordination analysis was applied to the invertebrate abundance data at order level (with exception given above) using the 'vegan' package (Oksanen et al. 2000) in R (version 3.6.2; R Core Team 2019). Order count data were log-transformed before analysis, and after preliminary detrended correspondence analysis (R function 'decorana') showed that the dataset was sufficiently homogenous for linear ordination methods, principal component analysis (R function 'rda') was applied.

To gain an indication of developing trophic structure amongst the invertebrate assemblages at each site invertebrate taxa likely to be dominated by relatively uniform feeding habits were classified as detritivores, herbivores, or predators (Houston and Melzer, 2018). Although Acarina (mites) include some predators, they are mostly detritivores. Formicidae (ants) and Diptera (flies) have a diverse array of feeding habits and are not included in this classification. Where it was possible to identify the family of the Coleoptera specimens they were included in the classification. Otherwise Coleoptera were excluded.

8.2.3 Investigation results and discussion

In the initial investigation, spontaneously established developing communities were sampled and assessed at selected sites. The interpretation must take into account caveats resulting from the following limitations: Sampling was restricted to one field campaign in winter, which does not allow for a complete assessment of vegetation and invertebrate communities. As the number of sites was limited, confounding effects between a number of potentially relevant underlying variables such as bedrock material, age since last disturbance, or proximity to remnant vegetation must be considered.

The results show that there are functional ecosystem developing on all sites, as shown in plant community structures, invertebrate assemblages and increasing soil carbon with increasing complexity of the vegetation. Some sites demonstrate that vegetation establishment and development can be reasonably fast, leading to established closed shrub structure with signs of more mature ecosystems (such as increasing soil organic C) within ten years. Relevant example sites were possibly favoured by close proximity to remnant vegetation, and a substrate more conducive to rehabilitation (lithology near intact, high water holding capacity).

Being aware of the small sample sizes, there is a tendency for sites on interburden and Triassic sandstone to have lower soil Ca/Mg, and lesser plant species richness, whilst sites on basalt and conglomerate sandstone have higher soil Ca/Mg, and greater plant species richness.

Complex invertebrate assemblages typical of woody Queensland and NSW landscapes have developed within the grasslands, shrublands and woodlands that have naturally colonised the steep rocky mined landscapes at Meandu Mine. These assemblages form a trophic structure that seems to be typical of terrestrial invertebrate assemblages with the expected differences in richness and abundance across three food chain levels. Although there seems to be greater invertebrate abundance on sites with a basalt geology, the investigation has not been able to identify an expected relationship between the assemblages and plant community complexity. This may well be a consequence of the single winter sampling event.

The initial investigation results and conclusions form a basis for the following:

- with reference to the surrounding vegetation and substrate characterisation, develop a list of potential plant species that could contribute to final vegetation assemblages on the landscape (refer Section 8.4.2);
- propose success criteria for the establishment of a self-sustaining ecosystem (refer Section 8.5 and 9.3); and
- propose a set of indicators by which progress towards success can be measured (refer Section 8.5 and 9.3).

8.2.3.1 Conceptual landform model for the landscape

The proposed model for the establishment of a steep rocky landscape supporting a self-sustaining ecosystem based on native species incorporates the following characteristics:

- Natural weathering will occur resulting in the transport of coarse and fine materials (including rock fall from steep slopes) to the lowest part of the landscape. The design of the landform at mine closure takes this into account by restricting personnel or stock access to the final highwalls and final voids. For final voids as water storage, some access and infrastructure will be necessary, but access to highwall benches and areas beneath batters will be physically restricted. For accessible areas, the design will take into account rock fall and slip hazards.
- Accumulation of talus and sediment is a key part of the evolution of the steep rocky landscape and ecosystem. The retention/construction of benches intercepts the transport of weathered and eroded materials and provides a focus for vegetation establishment, soil development, and colonisation by fauna. Figure 8.2 shows cases where relatively narrow benches have been overwhelmed by talus accumulation (accumulation of debris in sheets or cones at the bases of rockwalls). In those cases, there appears to be little secondary development of fine sediment layers as can be seen on wider benches (bottom left of Figure 8.2). The final landform conceptual design includes benches of more than 20 m width. Wider benches may be abutting (a) steep slopes of softer rock, or mechanically weaker structure, or (b) steep slopes of greater height.
- Vegetation will not easily establish on steep rock faces where sediments cannot accumulate. They do, however, establish on more gentle slopes where sediments can accumulate, and soils develop. The top right (4) of Figure 8.2 shows an example of this, whereby it has to be taken into account that profile form and geological material may interact in determining soil and ecosystem development. The conceptual design seeks opportunities, especially on the upper most batter, to slope batters away from 90° where appropriate with consideration for maintaining required stability. Remaining steep batters can contribute to habitat diversity if sufficient structure is available for example for nesting birds or bats and vines.
- The occurrence and movement of stormwater and cracked rock seepages will facilitate sediment separation and deposition as well as soil evolution. The persistence of water for any period of time enables the establishment of more complex plant and invertebrate animal assemblages and better soil evolution. Micro-topographic features in a bench terrain determine the water flow path, and zones of moisture retention. Such features can be constructed to facilitate and enhance water and sediment retention on any bench where such features do not destabilise the bench. These may include:
  - sloping benches back towards the toe of the batter, where material stability is not compromised by accumulating water
  - constructing a series of shallow depressions where water can be retained and sediments precipitate; and
  - directing overland flow to defined discharge areas to the bench below, with consideration for local geotechnical conditions and material types.

Vegetation including exotic species (weeds) has been establishing naturally on the benches at Meandu Mine. The vegetation establishment and any potential need for management thereof will be further monitored in the proposed trial.

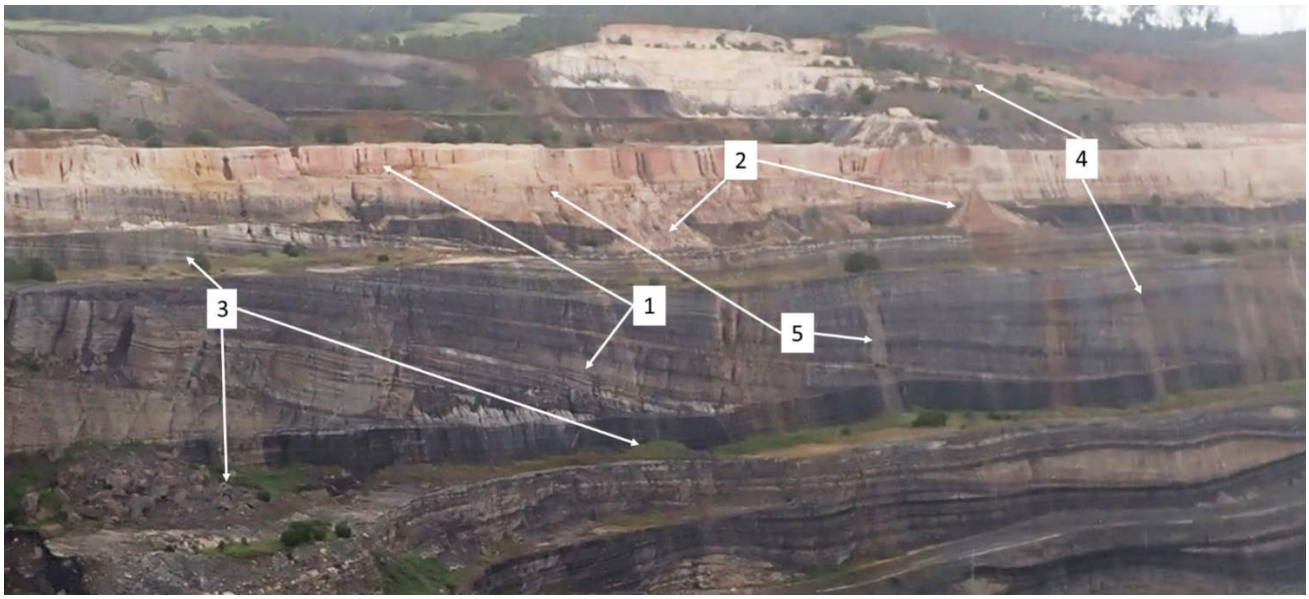

Figure 8.2 A view of a high wall at Meandu Mine showing the complex weathering patterns and major stormwater flow paths (adopted from CQU (2022a))

8.2.3.2 Soil evolution in the landscape

There was a wide range of soil types (viz. texture and colour) across the sampled sites, largely associated with parent materials. Most soils had favourable pH for plant growth (above 4.5) and low conductivity (as a measure of salinity; below 0.2 is ideal for most plants) with exception of sites 3B and 3C (locations shown in Figure 8.1), which are acidic and indicate moderate to high levels of salinity. These sites were also characterised by high chloride, sodium, and sulphur values. On the other hand, most soils had low organic C, comparable to desert soils, which indicates early stages of soil evolution. As a guideline, dryland agriculture as well as many forest soils commonly have between 1–4%, and natural grasslands can have higher values. Higher organic C corresponded well with more mature vegetation establishment.

Microelements were not present in concentrations that would negatively affect plant growth, and neither was extractable aluminium, even where pH was low. In terms of macronutrients, cation exchange capacity was very low in these young soils, and apart from Mg, exchangeable cations, especially Ca and K concentrations were also low. Low Ca/Mg ratio may affect plant growth. Figure 8.3 shows the ordination results summing up the soil properties.

In conclusion, being aware of the small sample sizes, it seems that the sites on interburden and Triassic sandstone have lower soil Ca/Mg, and lower plant species richness, whilst sites on basalt and conglomerate sandstone have higher soil Ca/Mg, and greater plant species richness.

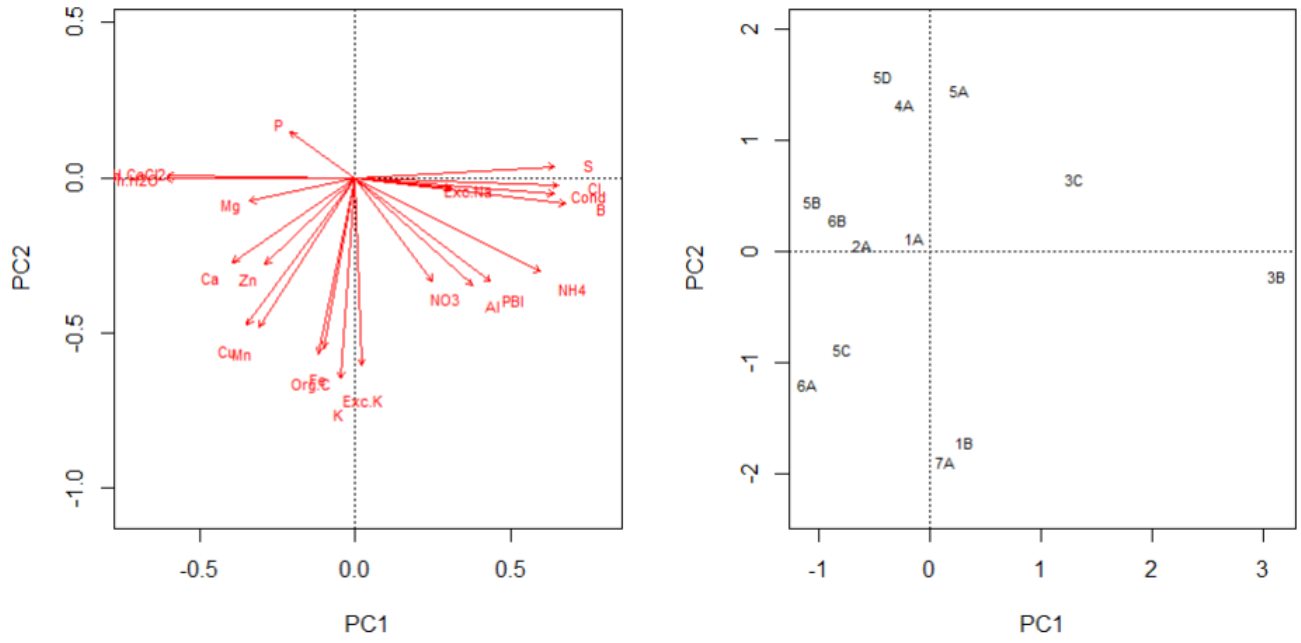

Figure 8.3 Ordination (Principal component analysis) result on soil chemistry parameters (adopted from CQU (2022a))

8.2.3.3 Naturally established vegetation assemblages on existing benches

Most plant specimens that were collected from the mine site in July 2021 did not have flowers or fruits that are commonly required to identify the specimens to species level. Almost all (except grasses) have been identified to genus level. Detailed site descriptions including cover estimates and vegetation photos are presented in CQU (2022a).

Presence of natural colonisation by native and exotic species and the rock cover have played an important role in controlling soil erosion on the sites. Some sites are covered with eroded materials from excavated surfaces or topsoils. Thus, the presence of a plant species at a given site is dictated by many factors such as the seed source, the land surface, site geology, site hydrology and the progressive movement of eroded materials from surrounding areas.

The sites support a variety of native species and introduced grasses and weeds. Important native species are mainly Acacia and Eucalyptus species. The most common exotic grasses are *Melinis repens* (red Natal grass), *Chloris gayana* (Rhodes grass). The common weeds that are found on the site include *Lantana camara* (lantana) and *Asclepias sp.* (milk weed).

Across the sites, plant species richness is related to Ca/Mg ratios rather than soil pH and tends to be greater in basalt and conglomerate sandstone geology although it must be taken into account that sample sizes are small and unequally distributed. More systematic and balanced assessment is required to confirm this tentative trend.

8.2.3.4 Naturally established invertebrate fauna within vegetation and existing benches

The order composition among the sites was broadly dominated by the same taxa that dominate assemblages from woodlands in New South Wales and Queensland (Order Composition-Dominant Taxa, page 38 in Houston 2008). These were:

- Araneae (spiders)
- Arthropleona (elongate springtails)
- Symphypleona (globular springtails)
- Homoptera (phytophagous bugs)
- Heteroptera (true bugs)
- Psocoptera (book-lice)
- Thysanoptera (thrips)
- Coleoptera (beetles)
- Diptera (flies)
- Lepidoptera (butterflies and moths)
- Neuroptera (lacewings, ant lions)
- Formicidae (ants); and
- Wasps.

Ordinal level invertebrate abundance and richness across sites is presented in Table 2 of CQU (2021a) and both abundance and richness vary across sites. Invertebrate abundance and ordinal richness are expected to increase with increasing plant community complexity and increasing plant community productivity (Specht and Specht, 2002). However, neither relationship was evident in these data (using site total cover as an analogue for plant community complexity) – perhaps reflecting the single winter sampling event. There was potential for increased invertebrate abundance with higher concentrations of soil organic carbon. Again, the single sample winter sampling may be masking any relationship. There does seem to be a tendency for invertebrate abundances it be higher on sites with a basaltic parent geology, although the sample sizes are small and unequally distributed. More systematic and balanced assessment is required to confirm this trend (CQU, 2022a).

Trophic levels and food chain

All sites supported invertebrate assemblages in all three primary trophic levels. However, there was a range in abundance and richness across the sites (refer to Table 2 in CQU (2021a)). Detritivores and herbivores are classified as primary consumers. Predators are secondary consumers and can be divided into those that predate primary consumers (primary predators) and those that predate primary predators (secondary predators – Araneae, Mantodea). This constitutes the food chain. The distribution of these levels across sites is shown in Table 3 of CQU (2021a). Most insect food chains have three to five levels (Rosenzweig, 1995) and this is the case across all sites (refer to Table 4 in CQU (2021a)). Further, richness is expected to decline with increasing food chain levels (Rosenzweig, 1995), also apparent across the sites. A note of caution, however, as this analysis is using ordinal or family classification rather than a species level classification. The results are consistent with expectations.

8.3 Proposed strategy

Given that the Steep Rocky Ecosystem PMLU landform will be a series of largely inaccessible benches and steep batters rising from a final void, the proposed rehabilitation would follow a "facilitated natural revegetation" strategy. This strategy will undertake works on each bench, whilst it remains accessible, to facilitate subsequent colonisation of plants and animals from the surrounding natural habitats. The facilitation will include:

- modifying the substrate hydrology (e.g. managing runoff water via a series of depressions along the bench), to facilitate water/sediment retention on benches and assisting the establishment of vegetation via facilitation of soil development
- modifying substrate conditions if shown to be necessary through the proposed rehabilitation trial (existing in-situ material will be assessed against the requirements of the nominated flora and application of suitable growth media and ameliorants may be considered where necessary). For example, species selection should where possible consider soil development for long term sustainability and water availability. Consideration may be given to hydromulching areas where possible, to provide large volume of cover crop to create organic carbon and drive root mass into the bed rock crevices and fissures. The cover crop will become new organic layers allowing for colonisation of the area with macroinvertebrates, Mycorrhizal and bacterial biota. Focusing on soil colonisation will ensure native plants will have suitable soil conditions whilst reducing weed invasion
- monitoring the established vegetation, subject to safe access permitting, and adjusting its structure and composition if necessary based on what is found on the natural analogous sites
- planting or seeding drought (or stress)-tolerant species adapted to shallow soils on rocky substrates if required, to facilitate and enhance the rate of natural ecosystem development.

Once this landform is reasonably stabilised (material weathering and eroding from batters accumulated on benches) and sediment transport, sorting and accumulation have reached their peak, the focus will shift to vegetation establishment, soil development and colonisation by fauna. It should be noted that batters will not be actively revegetated due to safety/ technical constraints, but will contribute to habitat diversity, as sufficient structural complexity develops during the landform evolutionary process.

As the baseline investigations (refer Section 8.2) show that functional communities establish naturally and that this process may be facilitated by planting local keystone species that provide roosts or food sources for seed dispersing birds and bats, subsequent development of flora and fauna assemblages will be largely driven by natural processes with minimal human intervention. Access to benches will then be largely restricted following construction and stabilisation of landform.

8.4 Rehabilitation methodology

8.4.1 Proposed general methodology

It is proposed to undertake rehabilitation work on each final bench prior to excavating the next bench.

Micro-topographical features on benches will be designed and constructed to regulate overland flow and assist water/ sediment retention, that will include:

- sloping the benches to the toe of batters if stability is not compromised (in fresh Triassic material);
- constructing a series of shallow depressions along the bench to allow sediment accumulation and water retention; and
- allowing overflow from depressions to either sheet flow over the bench crest or flow along the bench to a suitably nominated discharge point.

Batters may be raked during excavation and/or benches ripped to leave a rough surface perpendicular to slope, subject to suitability of the material. Selective placement of growth media may be considered on substrates that are proven to be difficult to establish vegetation. Dead logs or mounds of soils/weathered materials may be incorporated into revegetated on a case-by-case basis. sites to promote return of fauna (ants, lizards). Small depressions will be created where possible and suitable, to promote water retention to allow establishment of ephemeral habitats that will attract fauna.

8.4.2 Species selection

A wide range of plant species are likely to establish in the Steep Rocky Ecosystem PMLU which is associated with the highwalls of the proposed final voids. A combination of trees and shrubs, Lianas, grasses, sedges, legumes and ferns may result from the natural repopulation post development of the slopes, based on a number of factors including adjacent natural species, soil type, gradient and moisture conditions.

It is noted that the species selection is subject to the outcome of the trial proposed in Section 8.4.3 in this Revegetation Plan. For instance, the intervention in the natural process with establishment of vegetation will be considered if the trial outcomes show that species recruitment is insufficient as a natural process.

Table 8.1 provides an indicative species list for the Steep Rocky Ecosystems based on the initial natural repopulation survey conducted at Meandu Mine (CQU, 2022b). The current species expected from natural repopulation considers soil development for long-term sustainability and water availability. The effects of predicted changes from climate change have been taken into account. Such effects are mainly produced by the growing substrate and mainly amount to lower water availability. The species list may be revised as more knowledge is gathered (refer to Section 8.4.3 for discussion on proposed rehabilitation trials).

In general, the goal is to support and increase the conservation of natural areas while encouraging the regeneration of degraded areas and the elevation of status of natural places as a social good. It is recommended the species selection process to avoid degrading existing natural ecosystems. However, the utilisation of salt tolerant or drought tolerate taxa for the creation of "novel ecologies" on saline, sodic or saline-sodic mine spoils or other problematic zones is supported (Erskine and Fletcher, 2013).

Table 8.1 List of indicative species that may be established on landscapes within the Steep Rocky Ecosystem PMLU

Form species	Form species
Trees & Shrubs	*Acacia spp.*
	Alectryon diversifolius
	Alectryon subdentatus
	Araucaria cunninghamii
	Brachychiton rupestris
	Bridelika exaltata
	Diospyros geminata
	Elattostachys xylocarpa
	Erythroxylum spp. (southern erythroxylum)
	Eucalyptus spp.
	Flindersia australis
	Flindersia collina
	Mallotus discolor
	Psydrax spp.

Form species	Form species
Lianas	*Cissus oblonga*
	Cissus opaca
	Eustrephus latifolius
	Geitenoplesium cymosum
	Hoya australis
	Jasminum didymium
	Smilax australis
	Pandorea pandorana
	Trophis scandens
Grasses	*Cymbopogon refractus*
	Chloris spp.
	Panicum spp.
Sedges	*Cyperus spp.*
	Juncus spp.
Legumes	*Indigofera spp.*
	Crotalaria spp.
Ferns	*Rumohra adiantiformis*
	Cheilanthes sp.

8.4.3 Steep Rocky Ecosystem trial

A trial will be undertaken in the form of monitoring of a number of exposed final benched pit walls that will form part of this PMLU footprint as part of a longitudinal study to assess elements of native species ecosystem development (soil development, vegetation establishment and fauna development). The trial will assess and support development of the methodology, timing and success of proposed rehabilitation practice, and may explore techniques to enhance substrate development. The detail of the trial proposal for Steep Rocky Ecosystem PMLU is outlined in Table 8.2.

Table 8.2 Trial proposal for the Steep Rocky Ecosystem PMLU

Requirement	Steep Rocky Ecosystem
Objective	To develop/verify rehabilitation success criteria and analogues site for final highwalls at Meandu Mine that will achieve a self-sustaining steep rocky ecosystem based on native species, containing biotic assemblages that populate and persist naturally in the wild, with similar climatic response to regional native assemblages and resilience in the face of environmental change.

Requirement	Steep Rocky Ecosystem
Trial Design — Location — Underlying land characteristics — Potential issues	**Location:** K2W highwall benches, and potentially K2E interim (currently developed within existing surface rights area) and SW13. **Land characteristics:** Excavated benches in Miocene and weathered/fresh Triassic material. Monitoring and compilation of longitudinal on-site analogue reference database indicating the development of parameters over time for use in assessment of milestone criteria for final highwalls developed towards end the LOM Plan. **Potential Issues:** geotechnical/access issues, species selection and success of vegetation establishment. Variability of highwall material and access to appropriate range of material for suitable duration to conduct trial.
Commencement	2024
Duration	Up to 5 years
Assessment for trial success	Successful vegetation establishment that is persistent and provides sufficient data to allow creation of indicative timeframes for development and climatic response for on-site communities. Ecological function indicators on the right trajectory.
Incorporation of results into rehabilitation strategies and milestones	— Refinement of species selection and amelioration for different material types if required. — Optimisation of highwall design including batter height/ bench width and drainage design for different materials. — Establishment of remote monitoring program (verified against field monitoring results) and associated success criteria. — Timing for achieving successful vegetation establishment on benches to inform rehabilitation schedule.
Previous trials	K2E, K2W and SW highwalls (short duration monitoring trials)
Relevant supporting documents	— Planning for the establishment of steep rocky ecosystems on high walls above final void water bodies at Meandu Coal Mine (October 2021) (CQU, 2022a) — Steep Rocky Ecosystems – Project Summary (February 2022) (CQU, 2022b).

8.5 Steep Rocky Ecosystems monitoring

Much of the final steep rocky landform will be inaccessible for on-ground monitoring. However, some landscape elements will be accessible. Consequently, the monitoring of rehabilitation progress is undertaken with a combination of remote-sensed parameters and on-ground assessment at a few permanently marked sample/survey locations. The purpose of the monitoring is to demonstrate the success of the rehabilitation strategy and demonstrate that the conclusions of the rehabilitation trials are valid over the site.

A combination of on-ground and remote monitoring will be required:

- ground-truthing to establish trends (including seasonal and climatic), determine/ verify success criteria, provide comparison to analogue sites, confirm ecosystem functionality/trends and support remote monitoring requirements prior to excavation/ rehabilitation of the final highwalls; and
- remote sensing for monitoring post-construction in areas where access is limited due to safety constraints.

Table 8.3 presents the criteria developed for successful establishment of a self-sustaining natural ecosystem on a steep rocky post-mining landform, along with indicators and proposed measurements/assessment to be undertaken during the trial. The methodology and frequency of proposed monitoring may be amended as the trial progresses.

Table 8.3 Rehabilitation objectives, indicators and proposed measurements for the Steep Rocky Ecosystem PMLU

Relevant EA criteria	Proposed success criteria	Indicator	Proposed method
— Acceptable residual hazard ranking achieved — FoS > 1.5 assessed at the projected stable crest — Indicators for runoff demonstrate suitable water quality for receiving environment: pH 5.5–9.0 (median); EC < 2037 µS/cm (median) — The landform provides a diversity of slopes including mix of predominately flat benches and batters up to 80 degrees that create a varied environment for the future establishment of niche habitats — Native plant species richness per appropriate ecosystem outcome, adjusted to meet geotechnical stability requirements.	Contains biotic assemblages that persist in the wild	The establishment of a mosaic of vegetated and bare land surfaces that is similar to the range in vegetation cover mosaics evident in naturally occurring steep rocky ecosystems of South-East Queensland.	Analysis of vegetation cover (derived from satellite or airborne imagery) on analogous sites with the post-mining landscape demonstrates a similar mosaic on the post-mining landscape.
		A variety of plant assemblages and ecosystem structures (e.g. woodland, shrubland, grassland, encrusting cryptogram) that are consistent with the range of assemblages typically existing in South-East Queensland.	Classification of vegetation assemblages (derived from satellite or airborne imagery) and ecosystem structures on analogous sites with the post-mining landscape demonstrates a similar range of vegetation assemblages and ecosystem structure on the post mining landscape.
		The steep rocky ecosystem provides feeding, and/or roosting and/or breeding habitat for birds and/or terrestrial vertebrates.	Monitoring (e.g. trail cameras) of bird and large mammal activity on and around the steep rocky post-mining landscape demonstrates usage of the landscape for roosting, feeding, or breeding.
		Plant assemblages support an invertebrate assemblage that has a composition and structure that is within the range of that found within in a suite of nearby analogous assemblages.	At assessable indicative locations on the post-mining landscape, standard monitoring of invertebrate assemblages demonstrates an ordinal richness and structure that is within the range demonstrable within a selection of regional analogous environments.
		The plants that successfully reproduce, producing fertile propagules and/or root suckers, and a soil seed bank develops where appropriate.	On-ground assessment at permanently marked locations, in conjunction with wider remote assessment, demonstrates sexual and/or asexual reproduction occurs across the landscape and that a soil seed bank is present.

Relevant EA criteria	Proposed success criteria	Indicator	Proposed method
	Demonstrates seasonal response similar to regional native assemblages	Characteristics of a biotic assemblage that demonstrates seasonal response similar to regional native assemblages	Seasonally measured phenological changes in the plant assemblages and the changes in the plant and invertebrate assemblages in response to seasonal variation fall within the range of that occurring in a range of nearby analogous assemblages.
	Shows resilience in face of environmental change	Characteristics of a biotic assemblage that shows resilience in face of environmental change	Changes in the plant and invertebrate assemblages in response to changes in soil properties that occur on permanently marked monitoring sites will demonstrate if the changes occurring on mine sites will fall within the range of that occurring in a range of nearby analogous assemblages.

Monitoring reports will be prepared describing rehabilitation success (including trends and trajectories), that will provide data on:

- plant assemblages – structure and composition (richness)
- invertebrate composition and abundance
- ant functional groups
- changes in soil erosion and basic soil properties
- phenology of monitored flora
- invasion of weeds and predatory species
- resilience of established vegetation to natural variables such as drought, heavy rains and bush fire
- habitation by larger fauna; and
- linkages established between rehabilitated sites and the surrounding undisturbed sites.

9 Rehabilitation milestone criteria for each PMLU

In accordance with the PRC Plan Guideline, significant events or steps required to achieve a PMLU should be compared to the milestone reference developed for the site. The following milestone criteria have been developed for each PMLU at revegetation, achievement of surface requirement and achievement of PMLU stages based on the information reviewed and assessment undertaken.

9.1 Native Ecosystem

The additional rehabilitation milestones criteria for RM4 through to RM9 (excluding RM8) proposed for the Native Ecosystem PMLU are outlined in the following subsections. Milestone RM8 addresses specific water quality measures and is detailed in Section 2.4.2 of the Meandu Mine PRC Plan.

9.1.1 Landform development and re-shaping – RM4

Slopes constructed such that the overall grade meets the following criteria:

- The majority of slopes are ≤ 17%, minor areas are up to a maximum of 25%
- Geotechnical Factor of Safety ≥1.5 is achieved.

9.1.2 Surface preparation – RM5

Post topsoil placement, the surface is to be contour ripped to a nominal depth of 0.3–0.9 m to aid in erosion control and vegetation root penetration where needed.

9.1.3 Revegetation – RM6

Species selection and seeding rates comprises a mixture of plant species similar to local regional ecosystems (RE), based on benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7.

9.1.4 Achievement of surface requirement – RM7

For the "Achievement of surface requirements" rehabilitation milestone of the Native Ecosystem PMLU, the additional rehabilitation milestones criteria proposed in the Meandu Mine PRC Plan are:

- Rapid assessment in year 1. BioCondition assessment in years 3 and 5 and every 5 years thereafter.
- Number of native species of native trees, shrubs and grasses equals or exceeds the RM9 criteria of > 4, 6 and > 4.

9.1.4.1 BioCondition monitoring

For the Native Ecosystem PMLU the *Queensland Herbarium Methodology for Biocondition Monitoring* (Eyre et. al., 2011) is used to monitor progress towards meeting the milestone criteria in accordance with *A Condition Assessment Framework for Terrestrial Biodiversity in Queensland* (Neldner and Ngugi, 2014). A single BioCondition benchmark was developed for a self-sustaining Eucalypt woodland to open-forest from 26 CORVEG sites (Neldner et. al., 2012). The 26 sites were derived from three local eucalypt woodland Regional Ecosystems (RE 12.9-10.7, RE 12.9-10.18 and RE 12.11.7) to establish an appropriate benchmark.

The benchmarks and the scoring of each benchmark is provided in Table 9.1. Total benchmark scores are summed and compares over time for each attribute to monitor rehabilitation progress. The maximum achievable score is 60.

Table 9.1 Benchmarks and scores

Description	Benchmark criteria	Benchmark	Score
Tree canopy height: Benchmark height = 20.6 m	< 25% of benchmark height	20.6	0
	≥ 25–70% of benchmark height		3
	≥ 70% of benchmark height		5
Tree sub-canopy height: Benchmark height = 10 m	< 25% of benchmark height	10	0
	≥ 25–70% of benchmark height		3
	≥ 70% of benchmark height		5
Recruitment of canopy species	<20% of dominant canopy species present as regeneration	Based on site data	0
	≥20–75% of dominant trees present as regeneration		3
	≥75% of dominant canopy species present as regeneration		5
Percentage of tree canopy EDL cover relative to benchmark	<10% of benchmark	36%	0
	≥10% and <50% of benchmark		2
	≥50% and ≤200% of benchmark		5
	>200%		3
Shrub cover	<10% of benchmark shrub cover	16%	0
	>/= 10 to <50% or >200% of benchmark shrub cover		3
	≥50% or ≤200% of benchmark shrub cover		5
Scores for number of CWD*	<10% of benchmark number of total length of CWD	403	0
	>/= 10 to <50% or >200% of benchmark number or total length of CWD		2
	≥50% and ≤200% of benchmark number or total length of CWD		5
Native plant species richness of each lifeform (recorded separately for each lifeform)	<25% of benchmark number of species within each lifeform	Trees:7 Shrubs:11 Grass:9 Forbs:11	0
	≥25% to 90% of benchmark number of species within each lifeform		2.5
	≥ 90% of benchmark number of species within each lifeform		5

Description	Benchmark criteria	Benchmark	Score
Non-native plant cover	>50% of vegetation cover are non-native plants	0%	0
	≥25 to 50% of vegetation cover are non-native plants		3
	≥5 to 25% of vegetation cover are non-native plants		5
	>5% of vegetation cover are non-native plants		10
Native perennial grass species cover	<10% of benchmark native perennial grass cover	21%	0
	≥10 to 50% of benchmark native perennial grass cover		1
	≥50 to 90% of benchmark native perennial grass cover		3
	>90% of benchmark native perennial grass cover		5
Percentage of organic litter	<10% of benchmark organic litter	57%	0
	≥10 to <50% or>200% of benchmark organic litter		3
	>50% or ≤200% of benchmark organic litter		5
Number of large trees*	No large trees	51	0
	0-50% of benchmark number of trees present		5
	≥50% to 100% of benchmark number of trees present		10
	≥ benchmark number of trees present		15

*Recorded but not used in final benchmark score since large trees /CWD may take decades to reach minimum size and or produce sufficient CWD.

In addition to the BioCondition benchmarks, each rehabilitation site will be classified against the RM9 Criteria as conforming or not conforming when assessed to identify is site remediation is required to meet the PMLU Completion Criteria. The Native Ecosystem related RM9 Criteria are provided in Table 9.2.

Table 9.2 RM9 competition criteria and performance reporting matrix for Native Ecosystem PMLU

EA Criteria	Conforming	Not yet conforming
Groundcover for slopes ≤20%	>50%	≤50%
Groundcover for slopes >20%	>80%	≤80%
Native tree species	≥4	<4
Native shrub species	≥6	<6
Native grass species	≥4	<4
Tree canopy cover	≥20%	<20%

9.1.5 Achievement of post-mining land use – RM9

For the "Achievement of post-mining land use" rehabilitation milestone of the Native Ecosystem PMLU, the following milestone criteria are proposed in the Meandu Mine PRC Plan:

- >50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 20%.
- >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 20%.
- Vegetation comprises a mixture of plant species similar to local regional ecosystems based on benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7.
- Number of native species of native trees, shrubs and grasses equals or exceeds 4, 6 and 4 respectively.
- Tree canopy cover is at least 20%

9.2 Beef Cattle Grazing

Preliminary rehabilitation success criteria for the Beef Cattle Grazing PMLU in relation to rehabilitation milestones relating to landform development and re-shaping, surface preparation, revegetation, achievement of surface requirements and achievement of PMLU are provided as follows. These are indicative only and will be reviewed once the Beef Cattle Grazing PMLU trial has been undertaken.

The additional rehabilitation milestones criteria for RM4 through to RM9 proposed for the Beef Cattle Grazing PMLU are outlined in the following subsections. Noting that RM8 does not apply to the Beef Cattle Grazing PMLU and therefore is not discussed in this section.

9.2.1 Landform development and re-shaping – RM4

Rehabilitation is geotechnically stable in the long term with the following achieved as defined in the Meandu Mine PRC Plan:

- Slopes are constructed such that the overall grade meets the following:
  - 80% of slopes are ≤ 15 % Minor areas are up to a maximum of 25%
  - Geotechnical Factor of Safety ≥1.5 is achieved.
- Subsoil layer placed as part of the 6 m NAF dump cover is of suitable properties and of sufficient thickness to achieve Class 1, 2 or 3 land suitability criteria for beef cattle grazing as described in Table 6.10 of the PRC Plan.

9.2.2 Surface preparation – RM5

Post topsoil placement, the surface is to be contour ripped to a nominal depth of 0.3–0.5 m to aid in erosion control and vegetation root penetration where needed.

9.2.3 Revegetation – RM6

For the "Revegetation" rehabilitation milestone of the Beef Cattle Grazing PMLU the following milestone criteria are proposed in the Meandu Mine PRC Plan:

- Species selection and seeding rates comprise:
  - a mixture of annual and perennial pasture species
  - a high percentage of 3P grasses (palatable, productive and perennial)
  - inclusion of desirable forbs (e.g. legumes)
  - species that flower in different seasons
  - where assessed as necessary, achievement of an initial cover crop.

- Light grazing, or slashing, to take place during the first summer / autumn season after the pasture seeds.
- Species mix and seed rates is adjusted where necessary in line with the results of the Beef Cattle Grazing trial.
- Shelter belts of trees, with appropriate species selected from the Native Ecosystem PMLU species mix to be in 50–100 m widths.

9.2.4 Achievement of surface requirement – RM7

For the "Achievement of surface requirements" rehabilitation milestone of the Beef Cattle Grazing PMLU the following milestone criteria are proposed in the Meandu Mine PRC Plan:

- Regular light grazing/slashing is undertaken to encourage growth and continue self-seeding cycle.
- Rapid assessment in year 1. Monitoring of land capability utilising dry season yield per hectare in years 3 and 5 and every 5 years thereafter.
- Stock fencing is installed where required.

9.2.5 Achievement of post-mining land use – RM9

For the "Achievement of post-mining land use" rehabilitation milestone of the Beef Cattle Grazing PMLU the following milestone criteria are proposed in the Meandu Mine PRC Plan:

- A land suitability assessment is undertaken by an appropriately qualified and experienced person using 'Regional Land Suitability Frameworks for Queensland (2013)', which confirms that grazing land meets either Class 1, 2 or 3 land suitability for grazing.
- >50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 18%.
- >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 18%.

9.3 Steep Rocky Ecosystem

Preliminary rehabilitation success criteria for the Steep Rocky Ecosystem PMLU in relation to rehabilitation milestones of landform development and re-shaping, surface preparation, revegetation, achievement of surface requirements and achievement of PMLU are provided as follows. These will be updated once the Steep Rocky Ecosystem PMLU trial has been undertaken.

The additional rehabilitation milestones criteria for RM4 through to RM9 proposed for the Steep Rocky Ecosystem PMLU are outlined in the following subsections. Noting that RM8 does not apply to the Steep Rocky Ecosystem PMLU and therefore is not discussed in this section.

9.3.1 Landform development and re-shaping – RM4

For the "Landform development and re-shaping" rehabilitation milestone of the Steep Rocky Ecosystem PMLU the following milestone criteria are proposed in the Meandu Mine PRC Plan:

- Slopes constructed such that:
  - the landform provides a diversity of slopes, including a mix of predominately flat benches and batters up to 80 degrees, that create a varied environment for the future establishment of niche habitats.
- Geotechnical Factor of Safety ≥1.5 is achieved at the projected stable crest.
- Install a cover system on exposed residual coal seams where assessed as appropriate by a suitably qualified person.

9.3.2 Surface preparation – RM5

No topsoil is to be placed within the Steep Rocky Ecosystem PMLU and therefore no additional milestone criteria are currently proposed in the Meandu Mine PRC Plan for the "Surface preparation" rehabilitation milestone. This approach may change subject to outcomes of the proposed trial.

9.3.3 Revegetation – RM6

No seeding rate requirements apply for the Steep Rocky Ecosystem PMLU and therefore no additional milestone criteria are currently proposed in the Meandu Mine PRC Plan for the "Revegetation" rehabilitation milestone. This approach may change subject to the outcomes of the proposed trial.

9.3.4 Achievement of surface requirements – RM7

For the "Achievement of surface requirements" rehabilitation milestone of the Steep Rocky Ecosystem PMLU the following milestone criteria are proposed in the Meandu Mine PRC Plan:

- Presence of a mosaic of bare and vegetated land surfaces.
- Presence of a variety of plant assemblages.
- Plant assemblage structure consistent with that occurring on the trial sites.

9.3.5 Achievement of PMLU – RM9

For the "Achievement of PMLU" rehabilitation milestone of the Steep Rocky Ecosystem PMLU the following milestone criteria are proposed in the Meandu Mine PRC Plan:

- A hazard assessment is undertaken by an appropriately qualified and experienced person, which confirms an acceptable residual hazard ranking is achieved.

Note that comparison to an equivalent land use site is not required because no analogous sites are available in the region. The proposed trial will be on the Meandu Mine site already crated within the Meandu Mine surface rights areas and these will be the comparison sites.

Table 9.3 provides the detail in regard to the monitoring method, frequency, area and measurements to be undertaken against each success criteria.

Table 9.3 Success criteria and monitoring detail for the Steep Rocky Ecosystems PMLU

Number	Relevant RM	Success criteria	Method	Frequency	Area	Statistic
1	RM7	Presence of a **mosaic** of bare and vegetated land surfaces	High resolution colour airborne or remotely gathered images analysed with standard GIS tools; Comparison with 3 to 5 south-east Queensland regional examples.	Triennial (every 3 years) monitoring until pattern established and stable	Rehabilitation landscapes inside the mine, including both batters and benches.	Present or absent
2	RM7	Presence of a variety of **plant assemblages**	High resolution colour airborne or remotely gathered images analysed with standard GIS tools; Comparison with 3 to 5 south-east Queensland regional examples.	Triennial (every 3 years until present) monitoring until pattern established and stable	Rehabilitation landscapes inside the mine, including both batters and benches.	Present or absent
3	RM7	Plant assemblage **structure** consistent with that occurring among nearby analogous examples	Standard description of plant assemblage composition and floristics; Comparison with 3 to 5 regional analogous examples. Permanent vegetation belt transects or plots. Species nomenclature follows latest Queensland Herbarium Census of Queensland Plants; Structure follows Specht (1974) as shown in Table 14a Australian soil and Land Survey, Field handbook (2nd Ed). Measured parameters include: species richness (total & by strata), Community height, canopy cover, ground cover, plant density, litter biomass. Measured within each plant assemblage using permanent plots or belt transects depending on the architecture of the assemblage.	Year 0 and then triennial (every 3 years until present) monitoring until pattern established and stable	Accessible benches only.	Parameters trending towards the range among analogous examples.
4	RM9	**Fauna** use steep rocky landscape for feeding, roosting and/or breeding	May be collected incidentally, via periodic campaigns (standard bird watching), anabat recording, and/or deployment of wildlife cameras for nocturnal utilisation. Quantitative assessment cannot be done on the restricted area of the benches, so will be incidental (presence/absence) in nature.	Annual until pattern of usage is established	Rehabilitation landscapes inside the mine, including both batters and benches.	present or absent

Number	Relevant RM	Success criteria	Method	Frequency	Area	Statistic
5	RM9	Plant assemblages support an **invertebrate assemblage** with a structure and composition similar to that occurring in nearby analogous assemblages	Standard collecting methods and times employed to allow comparison among sites and over time. This includes pitfall traps, light traps, malaise traps and Berlese funnel traps. Invertebrates sorted to Order and the abundance to Order recorded. Collected assemblages are then reclassified to functional groups and trophic structure and complexity described. Some Ordinal groups (e.g. ants and beetles) will be subdivided into functional groups. Ants will be further classified to voucher species to allow an estimate of species richness to be derived.	Annual for years 1 to 5, then triennial or quinquennial. Collection occurs in spring or summer after rain and in winter to establish pattern of seasonal changes. Once the pattern is established, collection occurs in spring or summer after rain only.	Standard collection of invertebrates in the rehabilitation landscape and within at least 3 regional analogous plant assemblages. Accessible benches only.	Multivariate analysis of parameters shows rehabilitation sites trending towards similarity with the range among analogous sites.
6	RM9	Successful reproduction and soil seed bank establishment in plant assemblages.	Observation and record of flowering, fruiting and/or root suckering by species; Germination of seedling from collected soil samples.	Quarterly assessment of accessible plant assemblages for flowering and/or fruiting until pattern established. Annual collection of 5 surface soil samples for germination trials.	Accessible benches only.	Presence or absence of flowering, fruiting or suckering per species. Germination of seeds, mean abundance of seedlings and standard deviation (per surface soil sample).
7	RM9	**Seasonal changes** in plant and invertebrate assemblages in a way that is consistent with that occurring among a range of nearby analogous assemblages.	Over whole of landscape, and analogous nearby plant assemblages, remote assessment of change in foliage cover photosynthetic activity (estimated FPC and NDVI) seasonally; Inaccessible plant assemblages and nearby analogous assemblages, measure understorey and overstorey vegetation cover and phenological characteristics; Seasonal standard collection of invertebrates in the rehabilitation landscape and 3 to 5 regional analogous plant assemblages. Once patterns are established, and there is a demonstrable correlation between the site-based parameters and the remotely gathered parameters, monitoring can rely on the remotely gathered parameters.	Once vegetation is established, quarterly assessment of: (1) landscape wide vegetation cover and NDVI; (2) site-based assessment of vegetation cover, leaf flush, flowering and/or fruiting until patterns are established.	Rehabilitation landscapes inside the mine, including site-based assessments accessible benches (i.e. permanent plots or belt transects in Criteria 3).	Common pattern of seasonal change among rehabilitation sites and landscape and the analogous sites.

Number	Relevant RM	Success criteria	Method	Frequency	Area	Statistic
8	RM9	**Responses to environmental stressors in plant and invertebrate assemblages** is consistent with the range of change detected among nearby analogous assemblages.	Over whole of landscape, and analogous nearby plant assemblages, remote assessment of change in foliage cover photosynthetic activity (estimated FPC and NDVI) seasonally; Inaccessible plant assemblages and nearby analogous assemblages, measure understorey and overstorey vegetation cover and phenological characteristics; Seasonal standard collection of invertebrates in the rehabilitation landscape and 3 to 5 regional analogous plant assemblages. Once patterns are established, and there is a demonstrable correlation between the site-based parameters and the remotely gathered parameters, monitoring can rely on the remotely gathered parameters.	Opportunistic sampling after the environmental stressor as triggered by mine management.	Rehabilitation landscapes inside the mine, including site-based assessments accessible benches (i.e. permanent plots or belt transects in Criteria 3).	Common pattern of stressor response among rehabilitation sites and landscapes and the analogous sites. With the exception that if the stressor only occurs on the rehabilitation landscapes and then a before and after model will be used to investigate the response.
9	RM9	**Facilitated species colonisation and establishment.**	Benches are regularly monitored for plant and invertebrate assemblage occurrence. Substrates are regularly sampled for invertebrates.	Plant germinant are assessed annually within fixed plots or along belt transects (depending on the site characteristics). Emerging germinant are counted and species determined where possible. Invertebrate assemblages are monitored at least annually from year 0.	Accessible benches only.	Trend in abundance/frequency of plant colonisers (e.g. trees and shrubs), trend in species richness within plant assemblages. Trend in richness, abundance and structural complexity of invertebrate assemblages over time.

9.4 Creek Diversion

The additional rehabilitation milestones criteria for RM4 through to RM9 proposed for the Creek Diversion PMLU are outlined in the following subsections. Noting that RM8 does not apply to the Creek Diversion PMLU and therefore is not discussed in this section.

9.4.1 Landform development and re-shaping – RM4

For the "Landform development and re-shaping" rehabilitation milestone of the Creek Diversion PMLU the additional milestone criteria proposed in the Meandu Mine PRC Plan are that the landform is constructed in accordance with conditions of the approved design plan.

9.4.2 Revegetation – RM6

For the "Revegetation" rehabilitation milestone of the Creek Diversion PMLU the additional milestone criteria proposed in the Meandu Mine PRC Plan are that vegetation is to be a mixture of plant species substantially reflecting on those found in local riparian regional ecosystem (RE 12.3.3), with species and seeding rates to be suitable for wet ground conditions or irregular inundation.

9.4.3 Achievement of surface requirements – RM7

Additional Creek Diversion PMLU specific criteria for the "Achievement of surface requirements' rehabilitation milestone include:

- Records retained of as-built drawings and certification that creek diversions are operating in accordance with approved design and associated criteria.
- Vegetation establishment and geotechnical stability assessed at years 1, 3 and 5, and every 5 years thereafter. Morphological stability assessed every 5 years.

9.4.4 Achievement of PMLU – RM9

Additional Creek Diversion PMLU specific criteria for the "Achievement of PMLU" rehabilitation milestone include:

- A hazard assessment is undertaken by an appropriately qualified and experienced person, which confirms that the creek diversion is functioning as designed and the performance and integrity of the watercourse diversion and/or adjacent watercourses is not threatened. [Note: Equivalent land use site in the surrounding landscape is creeks.]
- Vegetation is a mixture of plant species substantially reflecting those found in local riparian regional ecosystems (RE 12.3.3), with species suitable for wet ground conditions or irregular inundation.

9.5 Water Storage

The additional rehabilitation milestones criteria for RM4 through to RM9 proposed for the Water Storage PMLU are outlined in the following subsections. Noting that RM8 does not apply to the Water Storage PMLU and therefore is not discussed in this section.

9.5.1 Landform development and re-shaping – RM4

Rehabilitation is geotechnically stable in the long term with the following achieved as defined in the Meandu Mine PRC Plan:

- Geotechnical Factor of Safety ≥1.5 is achieved.

9.5.2 Surface preparation – RM5

The topsoiled area is to be contour ripped to a nominal depth of 0.3-0.9m to aid in erosion control and vegetation root penetration where needed. Only the Littoral zone is to be topsoiled, down to the higher of either (i) the lower RL of the modelled void water level fluctuation or (ii) the actual rebounded water level, whichever is higher.

9.5.3 Revegetation – RM6

Species and seed selection comprises a mixture of plant species substantially reflecting those found in local regional riparian ecosystems (RE 12.3.3), with species and seeding rates suitable for wet ground conditions or irregular inundation. Revegetation requirements only apply to the littoral zone, down to the higher of either (i) the lower RL of the modelled void water level fluctuation or (ii) the actual rebounded water level, whichever is higher.

9.5.4 Achievement of surface requirements – RM7

Additional Water Storage PMLU specific criteria for the "Achievement of surface requirements' rehabilitation milestone include:

- Bi-annual water quality monitoring between years 1-10 with analysis by a NATA accredited laboratory. Analytes monitored are to include: TDS, Calcium, Magnesium, Nitrate, Nitrite, Sulfate, Cobalt, nickel, Zinc, Arsenic, Boron, Selenium, Molybdenum, Fluoride.
- Vegetation establishment for the littoral zone1 assessed at years 1, 3 and 5, and every 5 years thereafter.

9.5.5 Achievement of PMLU – RM9

Additional Water Storage PMLU specific criteria for the "Achievement of PMLU" rehabilitation milestone include:

- A hazard assessment by an appropriately qualified person is undertaken and confirms that the water storages are designed and constructed such that they are safe for humans, stock and wildlife.
- Vegetation in the littoral zone is to be a mixture of plant species substantially reflecting those found in local regional riparian ecosystems (RE 12.3.3), with species to be suitable for wet ground conditions or irregular inundation.
- Water storages contain water of a suitable quality for native wildlife and/or livestock ingestion using the following indicators: TDS: <5,000 mg/L, Calcium: ≤1,000 mg/L, Magnesium: ≤2,000 mg/L, Nitrate: ≤400 mg/L, Nitrite: ≤30 mg/L, Sulfate: ≤1,000 mg/L, Cobalt: ≤1 mg/L, Nickel: ≤1 mg/L, Zinc: ≤20 mg/L, Arsenic: ≤0.5 mg/L, Boron: ≤5 mg/L, Selenium: ≤0.02 mg/L, Molybdenum: ≤0.15 mg/L, Fluoride: ≤2 mg/L.

10 Revegetation Plan summary

Table 10.1 provides a summary of revegetation relevant rehabilitation milestones (RM4, RM5, RM6, RM7 and RM9), indicators, proposed completion criteria and monitoring approach relevant to ground preparation, seeding, planting and vegetation growth.

The relevant activities are grouped by rehabilitation area (RA) in the Meandu Mine PRC Plan. A rehabilitation area is defined in the PRC Plan Guideline as an area of land in the post-mine land use to which a rehabilitation milestone for the post-mining use relates. The RAs are illustrated in Figure 10.1 and detailed in Part B: Section 9 PRC Plan schedule of the Meandu Mine PRC Plan.

Table 10.1 Summary of revegetation relevant rehabilitation milestones, applicable rehabilitation area and milestone criteria and justification

Milestone reference	Rehabilitation milestone	Indicator(s)	Generic milestone criteria	Beef Cattle Grazing PMLU	Native Ecosystem PMLU	Steep Rocky Ecosystem PMLU	Creek Diversion PMLU	Water Storage PMLU
RM4	Landform development and reshaping	Quality assurance and controls on landform construction are in accordance with Section 6.1.5.7 of the PRC Plan and include: — approval of design plans by relevant operations and planning personnel — field verification of construction process by relevant supervisors and technical team members — a survey of the final landform to confirm the overall slope requirements are achieved in accordance with the PMLU specific criteria.	— Bulk earthworks achieve required landform mass balance – excluding allowance for access required for ongoing maintenance or required for PMLU purposes. — For all landforms constructed after 2016, the upper 6 m of material beneath the final landform surface is NAF. Mixed Plant Rejects (MPR) are located a minimum of 6 m beneath the final landform surface. — Subsoil material meets the criteria for the relevant PMLU. — Completed general reshaping achieves the overall landform slope. — Any designed waterways, drains and erosion and sediment control systems are installed. — Non-regulated dams not included as a feature of the final landform design for the PMLU have been filled. — Regulated dams/structures have been decommissioned and profiled according to the requirements of the decommissioning and rehabilitation plan for the structure developed by a suitably qualified and experienced person.	— Slopes are constructed such that the overall grade meets the following: — 80% of slopes are ≤ 15 %, minor areas are up to a maximum of 25% — Factor of Safety ≥1.5 is achieved. — Subsoil layer placed as part of the 6 m NAF dump cover is of suitable properties and of sufficient thickness to achieve Class 1, 2 or 3 land suitability criteria for beef cattle grazing as described in Table 6.10 of the Meandu Mine PRC Plan.	Slopes constructed such that the overall grade meets the following criteria: — the majority of slopes are ≤ 17%, minor areas are up to a maximum of 25% — Factor of Safety ≥1.5 is achieved.	— Slopes constructed such that: — the landform provides a diversity of slopes, including a mix of predominately flat benches and batters up to 80 degrees, that create a varied environment for the future establishment of niche habitats — Factor of Safety ≥1.5 is achieved at the projected stable crest. — Install a cover system on exposed residual coal seams where identified as appropriate by a suitably qualified person.	Landform is in accordance with conditions of the approved design plans.	Slopes constructed such that: Factor of Safety ≥1.5 is achieved.
RM5	Surface preparation	Quality assurance and controls on surface preparation in accordance with section 6.1.5.7 of this PRC Plan, with controls specific to RM5 including: — testing of topsoil to ensure adequate characterisation and allocation to the appropriate PMLU and improvements are undertaken where required — a survey of the final landform to confirm topsoil is spread to the nominal depth — survey reconciliation of topsoil register at the completion of works to ensure accurate tracking of available material.	— Remediate active erosion or subsidence as required prior to the application of topsoil. — Undertake testing of topsoil prior to spreading such that characterisation can be assessed and the topsoil identified to be suitable for the nominated PMLU. Where necessary, improvements to the soil such as amelioration or blending are to be undertaken to achieve the recommendations for the nominated PMLU. — Source, haul and spread topsoil of appropriate properties to a nominal depth of 0.2 m to the applicable footprint (e.g. not including rock armoured areas or constructed drains).	Post topsoil placement, the surface is to be contour ripped to a nominal depth of 0.3–0.5 m to aid in erosion control and vegetation root penetration where needed.	Post topsoil placement, the surface is to be contour ripped to a nominal depth of 0.3–0.9 m to aid in erosion control and vegetation root penetration where needed.	No additional criteria. Note: no topsoil to be placed within the Steep Rocky Ecosystem PMLU [subject to outcomes of the trial].	No additional criteria	For clarity, topsoil is to be placed only in the littoral zone[1]. The topsoiled area is to be contour ripped to a nominal depth of 0.3–0.9 m to aid in erosion control and vegetation root penetration where needed. [1] down to the higher of either (i) the lower RL of the modelled void water level fluctuation or (ii) the actual rebounded water level, whichever is higher

Milestone reference	Rehabilitation milestone	Indicator(s)	Generic milestone criteria	Beef Cattle Grazing PMLU	Native Ecosystem PMLU	Steep Rocky Ecosystem PMLU	Creek Diversion PMLU	Water Storage PMLU
RM6	Revegetation	Monitoring and controls as specified in Section 8 of the PRC Plan and including: — completion of seeding to target rates — visual inspection of revegetation area.	— Species selection is in accordance with the specific criteria for each PMLU. — Species seeding rate and/or tubestock planting rate is in accordance with the requirements of the specific criteria for each PMLU.	— Species selection and seeding rates comprise: — a mixture of annual and perennial pasture species — a high percentage of 3P grasses (palatable, productive and perennial) — inclusion of desirable forbs (e.g. legumes) — species that flower in different seasons — where assessed as necessary, achievement of an initial cover crop. — Light grazing, or slashing, to take place during the first summer/autumn season after the pasture seeds. — Species mix and seed rates is adjusted where necessary in line with the results of the Beef Cattle Grazing trial. — Shelter belts of trees, with appropriate species selected from the Native ecosystem PMLU species mix, to be in 50–100 m widths.	Species selection and seeding rates comprises a mixture of plant species similar to local regional ecosystems (RE), based on benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7.	No additional criteria	Vegetation is to be a mixture of plant species substantially reflecting on those found in local riparian regional ecosystem (RE 12.3.3), with species and seeding rates to be suitable for wet ground conditions or irregular inundation.	Species selection only applies to the littoral zone[1]. Vegetation is a mixture of plant species substantially reflecting those found in local riparian regional ecosystem (RE 12.3.3), with species and seeding rates suitable for wet ground conditions or irregular inundation. 1 down to the higher of either (i) the lower RL of the modelled void water level fluctuation or (ii) the actual rebounded water level, whichever is higher
RM7	Achievement of initial surface requirements	Monitoring and controls as specified in the generic milestone criteria and additional specific criteria for each PMLU.	— Monitoring of vegetation to confirm that species growth and composition is appropriately progressing to meet requirements of the criteria for RM9. — Monitoring of landform condition to demonstrate that the land remains stable and non-polluting. — Intervention and remediation as required to maintain a trajectory that will achieve RM9. — Maintenance of any access required for monitoring and fire safety. — Installation of any required land improvements in accordance with the specific criteria for each PMLU.	— Regular light grazing/slashing is undertaken to encourage growth and continue self-seeding cycle. — Rapid assessment in year 1. Monitoring of land capability utilising dry season yield per hectare in years 3 and 5 and every 5 years thereafter. — Stock fencing is installed where required.	— Rapid assessment in year 1. BioCondition assessment in years 3 and 5 and every 5 years thereafter. — Number of native species of native trees, shrubs and grasses equals or exceeds the RM9 criteria of > 4, 6 and > 4.	— Presence of a mosaic of bare and vegetated land surfaces. — Presence of a variety of plant assemblages. — Plant assemblage structure consistent with that occurring on the trial sites.	— Records retained of as-built drawings and certification that creek diversions are operating in accordance with approved design and associated criteria. — Vegetation establishment and geotechnical stability assessed at years 1, 3 and 5, and every 5 years thereafter. Morphological stability assessed every 5 years.	— Bi-annual water quality monitoring between years 1-10 with analysis by a NATA accredited laboratory. Analytes monitored are to include: TDS, Calcium, Magnesium, Nitrate, Nitrite, Sulfate, Cobalt, nickel, Zinc, Arsenic, Boron, Selenium, Molybdenum, Fluoride. — Vegetation establishment for the littoral zone[1] assessed at years 1, 3 and 5, and every 5 years thereafter. [1] down to the higher of either (i) the lower RL of the modelled void water level fluctuation or (ii) the actual rebounded water level, whichever is higher

Milestone reference	Rehabilitation milestone	Indicator(s)	Generic milestone criteria	Beef Cattle Grazing PMLU	Native Ecosystem PMLU	Steep Rocky Ecosystem PMLU	Creek Diversion PMLU	Water Storage PMLU
RM9	Achievement of PMLU	Assessment by suitably qualified and experienced person.	— A hazard assessment by an appropriately qualified and experienced person is undertaken and concludes that safety hazards in the applicable PMLU are analogous to the hazards in equivalent land use sites in the surrounding unmined landscape Note: Use of an equivalent land use site does not apply to the Steep Rocky Ecosystem or Water Storage PMLUs, however hazard assessments are required for both, consistent with the PMLU specific criteria in this table. — Indicators for runoff demonstrate the following suitable water quality parameters for EC and pH: — pH: 5.5-9.0 (median) — EC: <2037 µS/cm (median)	— A land suitability assessment is undertaken by an appropriately qualified and experienced person using 'Regional Land Suitability Frameworks for Queensland (2013)', which confirms that grazing land meets either Class 1, 2 or 3 land suitability for grazing. — >50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 18%. — >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 18%.	— >50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 20%. — >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 20%. — Vegetation comprises a mixture of plant species similar to local regional ecosystems based on benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7. — Number of native species of native trees, shrubs and grasses equals or exceeds > 4, 6 and > 4 respectively. — Tree canopy cover is at least 20%	A hazard assessment is undertaken by an appropriately qualified and experienced person, which confirms an acceptable residual hazard ranking is achieved. Note: Comparison to an equivalent land use site is not required.	— An assessment by an appropriately qualified and experienced person confirms that the creek diversion is functioning as designed and the performance and integrity of the watercourse diversion and/or adjacent watercourses is not threatened. — Vegetation is a mixture of plant species substantially reflecting those found in local regional riparian ecosystems (RE 12.3.3), with species suitable for wet ground conditions or irregular inundation. Note: For the hazard assessment the equivalent land use site in the surrounding landscape is creeks.	— A hazard assessment by an appropriately qualified person is undertaken and confirms that the water storages are designed and constructed such that they are safe for humans, stock and wildlife. [Note: Comparison to an equivalent land use site is not required]. — Vegetation in the littoral zone is to be a mixture of plant species substantially reflecting those found in local regional riparian ecosystems (RE 12.3.3), with species to be suitable for wet ground conditions or irregular inundation. — Water storages contain water of a suitable quality for native wildlife and/or livestock ingestion using the following indicators: TDS: <5,000 mg/L, Calcium: ≤1,000 mg/L, Magnesium: ≤2,000 mg/L, Nitrate: ≤400 mg/L, Nitrite: ≤30 mg/L, Sulfate: ≤1,000 mg/L, Cobalt: ≤1 mg/L, Nickel: ≤1 mg/L, Zinc: ≤20 mg/L, Arsenic: ≤0.5 mg/L, Boron: ≤5 mg/L, Selenium: ≤0.02 mg/L, Molybdenum: ≤0.15 mg/L, Fluoride: ≤2 mg/L

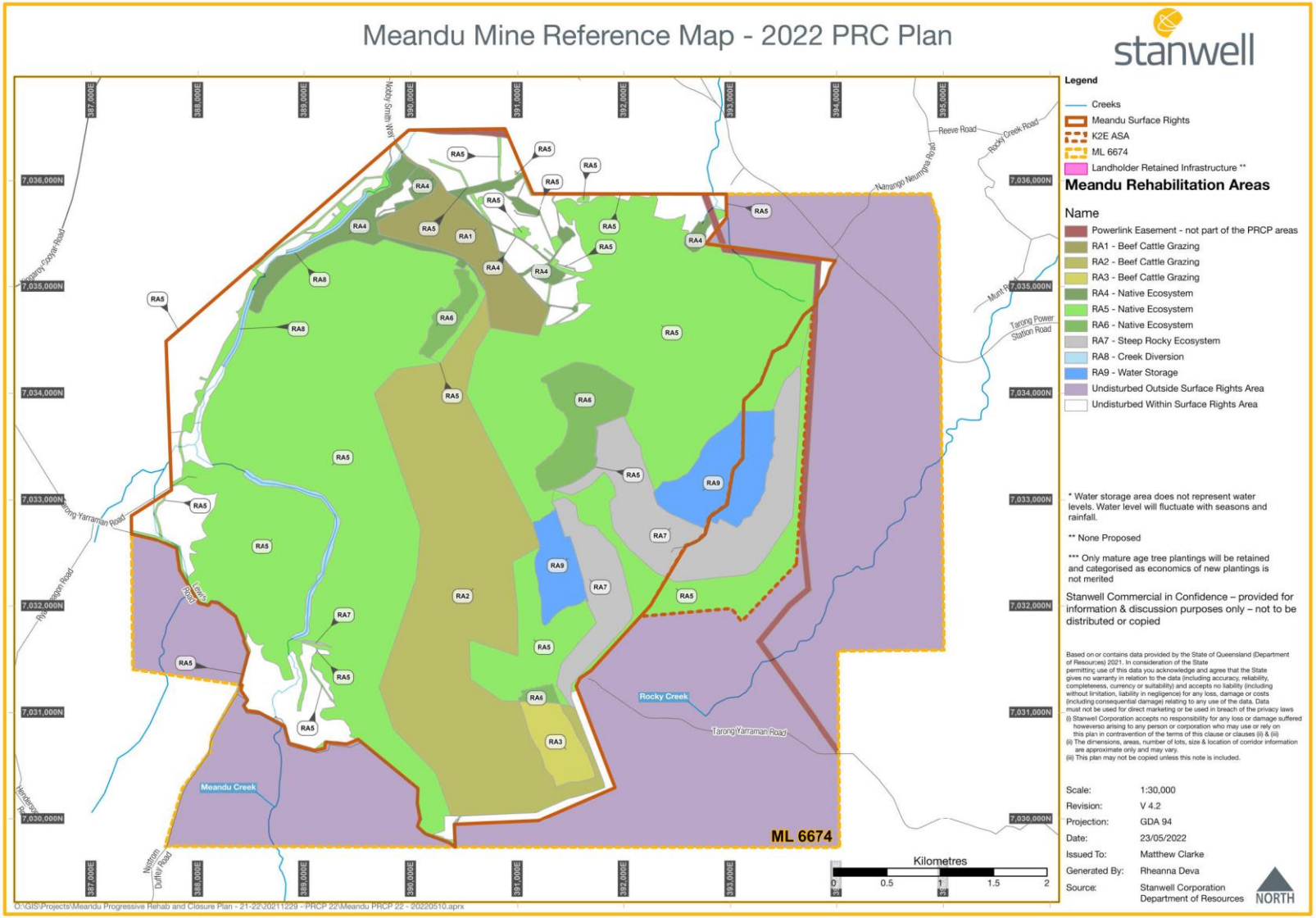

Figure 10.1 Mine Rehabilitation Areas (RAs)

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Appendix A

Progressive rehabilitation certification notice

Notice

Environmental Protection Act 1994

Decision about an application for progressive certification

This notice is issued by the administering authority[1] *pursuant to section 318ZJ of the* Environmental Protection Act 1994 *to advise of a decision made about an application for a progressive rehabilitation certification.*

To: TEC Coal Pty Ltd
Level 2, 180 Ann Street
BRISBANE CITY QLD 4000 Australia

Via email transmission only

ATTN: Troy Cook

Email: troy.cook@stanwell.com

Our reference: EPML00709113

Decision about an application for progressive certification for a resource project

1. Application details

The application for progressive certification of an environmental authority (EA) was received by the administering authority on 7 April 2021.

Land description: Lot 10/SP305494 and Lot 2/RP169258 within ML6674.

2. Decision

The administering authority has considered the criteria for making a decision on the progressive certification application under section 318ZI of the *Environmental Protection Act 1994* and has decided to give the progressive certification under section 318ZH of the *Environmental Protection Act 1994*.

3. Reasons for the decision

The Department of Environment and Science has decided to give approximately 153 hectares (ha) of the approximately 214 ha (as per **Attachment 1** to this Notice) applied for in this application for certification of progressive rehabilitation for the following reasons:

a) The administering authority inspected the site on 4 February 2021.
b) The certified area is considered safe, stable, self-sustaining and non-polluting and has been satisfactorily rehabilitated.

[1] The Department of Environment and Science is the administering authority under the *Environmental Protection Act 1994*.

Queensland Government

c) The administering authority has considered the EA conditions, final land use and rehabilitation success criteria for landforms, progressive rehabilitation report, response to the Information Request Notice including flora monitoring sheets, satellite imagery including a false colour image of the site, photographs from the site inspection on 4 February 2021 and standard criteria.

d) The approved progressive rehabilitation area (see Attachment 1) meets the EA conditions including Appendix 5 (Final land use and rehabilitation success criteria for landforms). The department will undertake an amendment of the EA, by agreement, to include the approved progressive rehabilitation area detailed in Attachment 1 of this Notice and relevant conditions for the management of this area.

e) The holder of the EA must "*maintain the certified rehabilitated area for the relevant tenure under the conditions of the authority in force when the certification was given*", pursuant to section 318ZB of the *Environmental Protection Act 1994*.

f) The risk assessment indicated only low and medium risks and no significant residual risk associated with the rehabilitated area in the decision, so no residual risk payment is required.

g) An area of approximately 61 ha is not to be certified in West and K2 areas due to the amount of exposed land that comprises the benching. The reasons for not certifying these area includes:
   i. During the site inspection and review of satellite imagery, the department visually observed that the benches areas do not comprise the landform for RE 12.9 -10.7; 12.9 -10.18 and 12.11.7.
   ii. The bench areas may result in sediment being transported off-site and impacting water environmental values.
   iii. It was observed on the site inspection on 4 February 2021 and communicated to Stanwell's representatives who were present that the bench areas would not be certified, as they have substantially less vegetation, weeds and less recruitment was occurring.

4. Human rights

A human rights assessment was carried out in relation to this decision and it was determined that the decision is compatible with human rights.



Signature

2 September 2021

Date

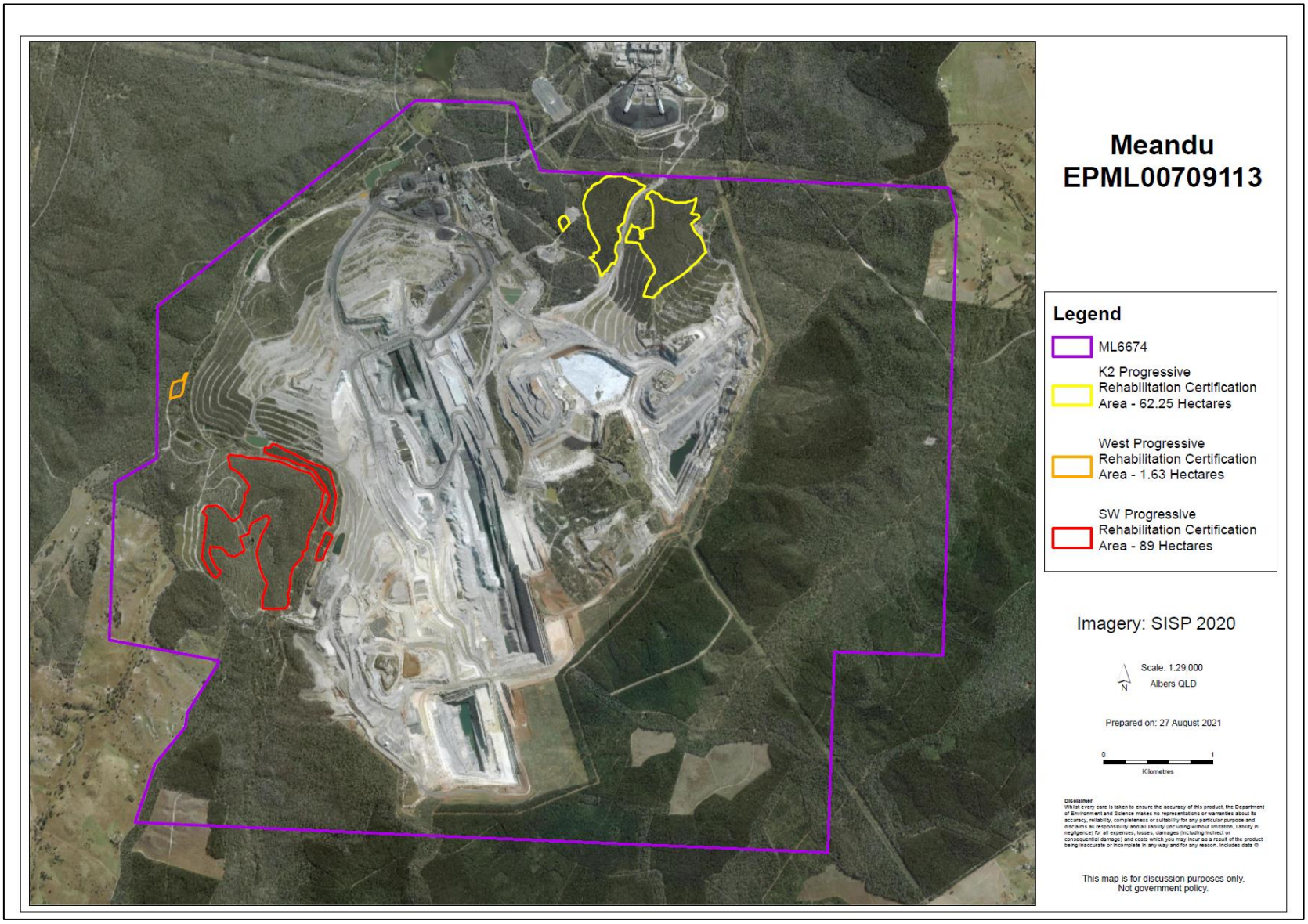
Juliana McCosker
Department of Environment and Science
Delegate of the administering authority
Environmental Protection Act 1994

Enquiries:
Michael Davis
Coal Business Centre
PO Box 3028, Emerald QLD 4720
Phone: (07) 4987 9320
Email: CRMining@ehp.qld.gov.au

Attachments

- Attachment 1: Meandu Mine Progressive Certification Area

Attachment 1: Meandu Mine Progressive Certification Area



Appendix M

Meandu Mine PRC Plan Void Closure Plan



TEC Coal Pty Ltd

Meandu Mine Progressive Rehabilitation and Closure Plan

Void Closure Plan

May 2022



Question today
Imagine tomorrow
Create for the future

Meandu Mine Progressive Rehabilitation and Closure Plan
Void Closure Plan

TEC Coal Pty Ltd

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REV	DATE	DETAILS
A	27/05/2022	Final

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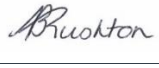
Reviewed by:	Allison Rushton	27/05/2022	
Approved by:	Allison Rushton	27/05/2022	

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Glossary and abbreviations

Al	Aluminium
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AMD	Acid and metalliferous drainage (also referred to as acid mine drainage and acid rock drainage): any contaminated discharge emanating from mine waste materials formed through a series of chemical and biological reactions, when geological strata is disturbed and exposed to oxygen and moisture as a result of mining activity, characterised by low pH, elevated metal concentrations, high sulphate concentrations and high salinity.
ANC	Acid neutralising capacity: a measure of a sample's maximum potential ability to neutralise acid.
BA	batter angle
BCT	Block Centred Transport
BOM	Bureau of Meteorology
BUA	Beneficial Use Agreement
$Ca(OH)_2$	Calcium hydroxide
Co	Cobalt
DES	Department of Environment and Science (Queensland)
DW	distinctly weathered
EA	Environmental authority
EC	electrical conductivity
EP Act	*Environmental Protection Act 1994* (Queensland)
EW	extremely weathered
Fe	Iron
FR	fresh (i.e. unweathered rock)
FoS	Factor of Safety
h	bench height
H	overall slope height
ha	Hectares
IRA	inter-ramp angle
irh	inter-ramp height
IWBM	Integrated water balance model

K	hydraulic conductivity
KLC	kinetic leaching column
kPa	kiloPascal
m_1	discharge component
mg/kg	milligrams per kilogram
mg/L	milligrams per litre
ML/d	megalitres per day
mm	millimetres
Mn	Manganese
Mo	Molybdenum
mRL	metres relative level
NAF	Non-acid forming: geochemical classification of material calculated not to generate acid conditions.
Ni	Nickel
NMD	Neutral mine drainage: neutral and metalliferous discharge from mine waste materials, typically as a result of oxidation of sulphide minerals and subsequent neutralisation by carbonate minerals, characterised by neutral pH, high salinity, sulphate and metals.
NUMA	non-use mining area
OSA	overall slope angle
PAF	Potentially acid forming: geochemical classification of material calculated to have the potential to generate acid conditions.
PCB	Prescribed Concentration Boundary
pH	power of hydrogen – a measure of hydrogen ion (H^+) concentration
PMF	Probable Maximum Flood
PMLU	Post-mining land use
PRCP	Progressive rehabilitation and closure plan
ROM	Run-of-mine: Coal as it comes from the mine prior to screening or processing
Se	Selenium
SILO	Scientific Information for Landowners
SMD	Saline mine drainage: salt-contaminated discharge from mine waste materials, characterised by neutral pH, high salinity and sometimes high sulphate.
SO_4^-	sulfate
Sr	Strontium

SW	slightly weathered
TDS	total dissolved solids
t/ha/y	tonnes per hectare per year
USDA	United States Department of Agriculture
V	Vanadium
WEPP	Water Erosion Prediction Project
WBM	Water Balance Model
Zn	Zinc
°C	degrees Celsius
β_1	sediment transport rate coefficient
µS/cm	microSiemens per centimetre

Abbreviations specific to Meandu Mine

ATP	Ash Thickening Plant
CHPP	Coal Handling and Preparation Plant
K1	King 1
K2E	King 2 East
K2E ASA	King 2 East Additional Surface Area
K2N	King 2 North
K2TSF	King 2 Tailings Storage Facility
K2W	King 2 West
K2W-N	King 2 West North
K4E	King 4 East
K4S	King 4 South
LoMP	Life of Mine Plan
MPR	mixed plant rejects
NWA	North-West A
NWATSF	North-West A Tailings Storage Facility
NWB	North-West B
NWBV	North-West Backfilled Void
NWB TSF	North-West B Tailings Storage Facility
QW	Queen West
RD	Retention dam
RD16 TSF	Retention Dam 16 Tailings Storage Facility
RSA	Rejects Storage Area
SBC	Solid Bowl Centrifuge
Stanwell	Stanwell Corporation Limited
SW	South-West
Tarong power stations	Tarong Power Station and Tarong North Power Station
TEC Coal	TEC Coal Pty Ltd
TSF	Tailings storage facility

1 Introduction

1.1 Background information

Meandu Mine is an open-cut coal mine that is operated within mining lease ML6674 for the purpose of supplying black thermal coal to the adjacent Tarong and Tarong North power stations (Tarong power stations). Environmental performance at the mine is regulated by the Environmental Authority (EA) EPML00709113 (12 January 2022).

TEC Coal Pty Ltd (TEC Coal) owns the Meandu Mine and is the holder of ML6674 and EA EPML00709113. TEC Coal is a wholly owned subsidiary of Stanwell Corporation Limited (Stanwell). Stanwell is a Queensland Government Owned Corporation under the *Government Owned Corporations Act* 1993 and registered under the *Corporations Act* 2001. Stanwell is a substantial provider of electricity to the National Electricity Market and large energy users throughout Australia. It owns assets for the purposes of generating electricity, including the Meandu Mine and Tarong power stations. Through these and other assets, Stanwell has a generation capacity of more than 3,000 megawatts.

1.2 Scope and objective

This Void Closure Plan is intended to support the development of the Progressive Rehabilitation and Closure Plan (PRC Plan) for Meandu Mine. The Void Closure Plan is purposed to evaluate options and identify the preferred configuration and final land use of the voids created by open cut mining at Meandu Mine, including minimisation of final void depth, area and volumes, and to describe how rehabilitation of voids will be carried out to minimise potential environmental impacts and meet the legislative requirements relating to mine closure for land relating to ML6674 (Section 2).

The residual voids have been considered in the design of the post-mining landform as follows:

- maintain or optimise the location and geometry of the two final voids
- where practicable and economically viable, minimise the size, depth and volume of final voids
- ensure drainage into the final voids is in alignment with the water storage requirements (i.e. is internally draining for both surface water and groundwater)
- assess against the final highwall setback criteria, to avoid key assets/ infrastructure between the Factor of Safety (FoS) 1.5 setback line and pit crest and provide adequate standoff from the surface rights area boundary; and
- design final slopes in accordance with geotechnical recommendations to provide long term geotechnical and erosional stability.

The continual update of the Void Closure Plan will be undertaken in accordance with the *Guideline – Progressive rehabilitation and closure plans (PRC Plan) (ESR/2019/4964, Version 2.01)* (the PRC Plan Guideline). It is intended that this Void Closure Plan will be progressively reviewed and updated over the remaining life of the mine to satisfy this requirement.

2 Legislative requirements

The following key legislation and guidelines are relevant to the progressive rehabilitation and closure of the mining voids (past, present and final) at the Meandu Mine.

2.1 Legislative context

2.1.1 Environmental Protection Act 1994

The *Environmental Protection Act* 1994 (EP Act) is the principal legislation for protecting environmental values potentially affected by the resource industry in Queensland. The EP Act grants the Queensland Government the power and means to assess, approve and prescribe conditions on mining projects.

The EP Act requires that all areas of disturbed or undisturbed land within the relevant mining tenure be rehabilitated to a post-mining land use (PMLU) or managed as a non-use management area (NUMA).

Under the EP Act the Department of Environment and Science (DES) has issued the *Progressive Rehabilitation and Closure Plan Transition Notice*, reference number EPML00709113/101/0008031-001(E) to TEC Coal, on 31 August 2020 for land relating to ML6674. The following are relevant sections of the notice that guide the objective of the Void Closure Plan:

Section 2: Action Required

> *'The holder of environmental authority EPML00709113 must submit a proposed PRC Plan that meets the requirements in sections 126C and 126D of the Environmental Protection Act 1994 (EP Act), pursuant to section 754 of the EP Act. The holder (s) must submit the proposed PRC Plan to the administering authority, by 31 May 2022.'*

Section 4: Supporting Information

> *'As detailed in section 2 of this notice, your PRC plan and associated PRC Plan schedule is required to address the relevant legislative requirements and the guideline Progressive Rehabilitation and Closure Plans (ESR/2019/4964) (the PRCP guideline).'*

Under the EP Act, the Queensland Government is responsible for the issuing of an EA to carry out a mining activity and approval of a draft PRC Plan schedule for a proposed PRC Plan. The EA and PRC Plan schedule include all conditions imposed on a mining activity. The EP Act also prescribes the requirements for surrendering an EA, including the preparation of final rehabilitation reports and post-mining management reports. The conditions of EA EPML00709113 relevant to this Void Closure Report are detailed in Section 2.3.

2.2 PRC Plan

The guideline 'Progressive Rehabilitation and Closure Plans' (ESR/2019/4964) prepared by DES, contains information to assist applicants in developing a PRC Plan. The administering authority must consider this guideline when making a decision about a PRC Plan schedule under Section 176A of the EP Act.

Section 3.6.3 of the PRCP Guideline states the requirement for, and details the required contents of, a Void Closure Plan. It should be noted that Section 3.4 of the guideline contains additional requirements for voids partly or wholly situated in flood plains. No final voids at Meandu Mine are located in a flood plain as hydrological modelling (Section 8) has established that, when all relevant activities carried out on the land have ended, the proposed voids are located outside of the flood inundation footprint of Meandu Creek, Black Creek and Rocky Creek for modelled flood events up to and including the Probable Maximum Flood (PMF).

Section 3.6.3 of the PRCP Guideline states:

For mine sites with voids, the rehabilitation planning part must include a Void Closure Plan that includes, but is not limited to, the following:

- *Options available for minimising final void area and volume (where a final void is proposed)* (Section 4.1)
- *Proposed final dimensions of the void (i.e. depth, length and width)* (Section 4)
- *Pit wall geotechnical and geochemical stability, considering the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events* (Sections 5 and 7)
- *Proposed final slope angles of high wall, low wall and end walls of each final void* (Section 5.1.1)
- *Void hydrology, addressing the long-term water balance and water level in the voids, stratification, connections to groundwater resources and potential for overflow* (Sections 8 and 10)
- *Groundwater modelling to determine whether the void is acting as a sink or a source for groundwater* (Section 9)
- *A water balance study including an assessment of void surface and groundwater interactions such as:*
  - *Groundwater lowering/reduction in hydraulic head (from new voids e.g. caves/karst systems) cones of depression and associated impacts* (Section 9)
  - *The drainage and flooding behaviours of surface waters in the vicinity of the void* (Section 8)
  - *The potential extent of flooding and implications of interactions with the void* (Section 8)
  - *A conceptual model that incorporates all projected inflows, outflows, and recharge rates water storage and long-term water balance* (Section 8)
  - *Each of the major water fluxes into and out of the void* (Sections 8 and 9)
  - *The sources of surface water within the mine catchment that are likely to influence the water quality in the void* (Section 8)
- *Predicted water quality in the long-term including potential stratification* (Section 10)
- *A 3D void design plan* (Section 4); and
- *Rehabilitation strategies* (Section 10.6).

A geotechnical report should focus on how the void will achieve post-closure slopes that will exhibit stability characteristics consistent with the planning and design of the post-closure mine void. (Section 5).

Mechanisms for achieving acceptable geotechnical stability must be detailed in the plan. This includes void filling, partial void filling, reshaping and void configuration through earthwork methods such as back filling, regrading, buttressing and benching. Where applicable, methods and techniques for achieving safe slopes must be detailed (Section 5).

If floodwaters are likely to move over backfilled material, an assessment of the hydraulic properties must be conducted to assess whether instability may occur. If instability is possible, modification to the landform design of the backfilled void may be required. If floodwaters are allowed to enter the void this may compromise the stability of the wall, which can increase the volume of floodwater entering the void. Where relevant, consideration must be given to the impacts of floodwater interaction on erosion.

The rehabilitation and management strategies in the plan must include the supervision, verification and auditing of engineering works carried out to achieve the post-closure void landform, to ensure construction is consistent with the geotechnical design. Supervision, verification and auditing can be assisted by developing 'as built' profiles for comparison to the design surfaces. The 'as built' earthworks criteria such as compaction and settlement criteria should also be compared against the design specification and any variances should be analysed and subsequently rectified (Section 11.3).

The rehabilitation and management strategy must also include confirmation that the post-closure landform demonstrates the level of stability as specified by the design. This is best achieved by means of detailed visual assessments in conjunction with surveying of the final landform both during construction phase as well as at the end of construction to ensure all void areas requiring mitigation have been successfully treated and are suitably stable. If exclusion measures are part of the post-closure void management plan, they should be detailed in the rehabilitation strategy.

The above requirements have been used to inform the scope of the technical studies and modelling that support this Void Closure Plan.

2.3 Environmental Authority

Meandu Mine operates under EA EPML00709113 (current version issued 12 January 2022 by DES) under Section 258 of the EP Act. This Void Closure Plan has been developed to provide a strategy and framework for void management at the mine and to meet the legislative requirements under EA EPML00709113. The EA conditions relevant to residual voids that have informed the content of this plan include:

Condition G6 ***Residual Void and Highwall/Low Wall Outcome.***

*The **two (2)** residual voids including highwall and low wall shown in **Appendix 5 – Final land uses and indicative locations,** must comply with the following outcomes:*

(a) *Residual voids including highwall and low wall must not cause any serious environmental harm to land, surface waters or any known groundwater source, other than the environmental harm constituted by the existence of the residual void including highwall and low wall itself, and subject to any other condition within this environmental authority;*

(b) *Residual voids must have a final land uses as steep rocky ecosystem and water storages.*

Condition G7 ***Twelve (12) months** prior to the establishment of a residual void on the mining lease the holder of this environmental authority must complete an investigation into the residual void and submit a report to the administering authority proposing acceptance criteria, including:*

(a) *Proposed landform design criteria for the competent and incompetent slopes;*

(b) *The proposed surface area of the void; and*

(c) *Proposals to meet the requirements of **Condition G6.***

Additional EA conditions which are relevant to back-filled voids include:

Condition A18 **Coal Combustion Products Storage and Management**

*The holder of this environmental authority may store coal combustion products generated primarily from the combustion of pulverised black coal at the Tarong Power Station and Tarong North Power Station in voids defined in **Table A1 – Authorised coal combustion product storage locations** and **Appendix 2 – Meandu Mine Voids, Drainage System and Monitoring Network.***

Condition A19 *Coal combustion products stored in voids defined in **Table A1 – Authorised coal combustion product storage locations** and **Appendix 2 – Meandu Mine Voids, Drainage System and Monitoring Network** must comply with contaminant limits defined in **Table A2 – Maximum allowable leaching contaminant (TCLP) levels.***

Condition A20 *In addition to meeting the criteria in **Table A2 – Maximum allowable leaching contaminant (TCLP) levels,** the coal combustion products must not have any properties or contain any other contaminants at concentrations which may cause environmental harm.*

Condition G9 **Tailings Deposition Area.**

When the deposition of tailings to an area ceases, the holder of the EA must install a final cover system to the tailings dam which effectively minimises:

a) Infiltration of water into the tailings deposition area

b) The likelihood of any erosion occurring to the final cover system.

Condition G10 **Acid Rock Drainage Management**

Measures must be implemented to prevent hazardous leachate being directly or indirectly released or likely to be released as a result of the activity to any ground water or water course.

Condition G11 **Final Cover**

*When deposition of coal combustion products into voids defined in **Table A1 – Authorised coal combustion product storage locations** ceases, unless otherwise agrees to by the relevant landowner, any relevant land manager and the administering authority, the holder of this EA must install a final cover system of the coal combustion products following sufficient time for ash consolidation and desiccation.*

Condition G12 *The final capping system over coal combustion products in the voids defined in **Table A1 – Authorised coal combustion product storage locations** must be at least 2m deep and must include an upper layer of earthen material that is capable of sustaining plant growth, and must be designed and maintained to minimise erosion occurring to either the final capping system or the coal combustion products in the void.*

Condition G13 *Materials used in the construction of the capping layer over the coal combustion products in the voids defined in **Table A1 – Authorised coal combustion product storage locations** must achieve an in-situ permeability which is sufficiently low and/or be sufficient thickness so as to minimise infiltration of water into the landform.*

Condition G14 *Reject disposal areas must be covered by a minimum of 6 (six) metres capping designed in accordance with criteria determined by a suitably qualified and experienced person.*

Condition G15 *Reject disposal areas capped in accordance with **Condition G14** must include an upper layer of earthen material designed and maintained to sustain plant growth.*

Appendix 7 of the EA (refer Table 2.1) contains the final land use and rehabilitation success criteria for final land use landforms at Meandu Mine. The two post-mining final land uses intended for the residual voids are Steep Rocky Ecosystems and Water Storage; however, part of the residual void catchments will be Native Ecosystems and a relatively small area of Beef Cattle Grazing (refer Section 3.2). The area of backfilled voids will have PMLUs of Native Ecosystems and Beef Cattle Grazing.

As a result of both (a) void minimisation and (b) incorporation of final void slopes complying with long term stable geotechnical design criteria since the preceding LOM Plan, the extents and mix of PMLUs associated with the final voids (Steep Rocky Ecosystem, Water Storage, Native Ecosystem) have changed in comparison to the indicative PMLU allocation shown in the Meandu EA.

Table 2.1 EA Appendix 7 – Final land use and rehabilitation success criteria for landforms

Final land use	Goal	Objective	Indicator	Criteria
Water Storage	Safe to humans, stock and wildlife	Safety hazards are managed for humans, stock and wildlife.	Hazard assessment by an appropriately qualified and experienced person.	Design requirements are determined to ensure water storage is safe for humans, stock and wildlife.
	Stable	Rehabilitations is geotechnically stable in the long term.	Factor of Safety	>1.5
	Able to sustain an agreed final land use	Able to sustain and agreed final land use.	Water storages contain water of a suitable quality for native wildlife and/or livestock ingestion, measured using the indicators of TDS, Calcium, Magnesium, Nitrate, Nitrite, Sulfate, Cobalt, Nickel, Zinc, Arsenic, Boron, Selenium, Molybdenum and Fluoride.	TDS: <5,000 mg/L; Calcium: ≤1,000 mg/L; Magnesium: ≤2,000 mg/L; Nitrate: ≤400 mg/L; Nitrite: ≤30 mg/L; Sulfate: ≤1,000 mg/L; Cobalt: ≤1 mg/L; Nickel: ≤1 mg/L; Zinc: ≤20 mg/L; Arsenic: ≤0.5 mg/L; Boron: ≤5 mg/L; Selenium: ≤0.02 mg/L; Molybdenum: ≤0.15 mg/L; Fluoride: ≤2 mg/L
Steep Rocky Ecosystem	Safe to humans and wildlife	Safety hazards are managed for humans and wildlife now and in the foreseeable future.	Hazard assessment by an appropriately qualified and experienced person.	Achievable residual hazard ranking achieved.
	Stable	The landforms are geotechnically and erosionally stable.	Factor of Safety	>1.5 assessed at the projected stable crest.
	Non-polluting	Rainfall runoff from rehabilitation protects stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5 -.90 (median) EC: <2,037 µS/cm (median).
	Able to sustain an agreed final land use	Landform that creates native flora and fauna habitat, while still being stable and safe.	Creation of a safe, stable and non-polluting landform that supports flora and fauna habitat.	The landform provides a diversity of slopes including mix of predominately flat benches and batters up to 80 degrees that create a varied environment for the future establishment of niche habitats.
		Vegetation on benches to provide an appropriate environmental outcome and be based on a species composition that ensures geotechnical stability of the benches is not compromised.	A species composition that ensures geotechnical stability of the benches is not compromised.	native plant species richness per appropriate ecosystem outcome, adjusted to meet geotechnical stability requirements.

Final land use	Goal	Objective	Indicator	Criteria
Native Ecosystem[1]	Safe to humans and wildlife	Safety hazards in rehabilitation are analogous to local regional ecosystems in surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the native ecosystem must have no significant difference to hazards in local regional ecosystems in surrounding unmined landscape.
	Stable	Rehabilitation is geotechnically stable in the long term.	Factor of Safety	≥1.5
		Rehabilitation ensures soil surface condition is erosionally stable.	Groundcover to be established and persistent.	>50% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for all slopes less than or equal to 20%. >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 20%.
	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5–90 (median) EC: <2,037 µS/cm (median)
	Able to sustain an agreed final land use	Vegetation to comprise a mixture of plant species like local regional ecosystems based on benchmarks for RE 12.9-10.7; 12.9-10.18 and 12.11.7[2]	Establishment of native ecosystems to resemble a mixture of benchmarks to RE 12.9-10.7; 12.9-10.18 and 12.11.7[2]	Native plant species richness: — Trees ≥4 count — Shrubs ≥6 count — Grass ≥4 count. Cover: — Tree canopy cover is at least 20%.

[1] *Plant species composition of the low wall part of the residual void and the water equilibrium level will be decided by a geotechnical assessment.*

[2] Neldner, V and Ngugi, M. (2012) *Assessment of BioCondition scores for three to twenty-year-old regeneration at Meandu Mine, Southeast Queensland, Queensland Herbarium, Department of Science, Information Technology, Innovation and the Arts, Brisbane.*

Final land use	Goal	Objective	Indicator	Criteria
Beef Cattle Grazing	Safe to humans and wildlife	Safety hazards in rehabilitation are analogous to grazing land in the surrounding unmined landscape.	Hazard assessment by an appropriately qualified and experienced person.	The hazards in the grazing land must have no significant difference to hazards in grazing land in the surrounding unmined landscape.
	Stable	Rehabilitation is geotechnically stable in the long term.	Factor of Safety	≥1.5
			Minimal slope greater than 15%	80% of slopes ≤15% Minor area up to a maximum of 25% to achieve tie-in with surrounding areas.
		Rehabilitation ensures soil surface condition is erosionally stable.	Groundcover to be established and persistent.	>50% established and persistent groundcover for all slopes less than or equal to 18%. >80% established and persistent groundcover (such as vegetation, rock, mulch, or other surface protection) for slopes greater than 18%.
	Non-polluting	Rainfall runoff from rehabilitation protects aquatic environmental values and stock environmental values (as drinking water for native wildlife and livestock).	Indicators for runoff demonstrate suitable water quality for receiving environment (pH and EC).	pH: 5.5–90 (median) EC: <2,037 µS/cm (median).
	Able to sustain an agreed final land use	Rehabilitation is suitable for sustainable beef cattle grazing.	Land suitability assessment by appropriately qualified and experienced person using 'Regional Land Suitability Frameworks for Queensland' (DNRM & DSITIA 2013)[3]	Grazing land to meet Class 1, 2 or 3 land suitability for grazing.

[3] DNRM & DSITIA (2013) *Regional Land Suitability Frameworks for Queensland*, Queensland Government (Department of Science, Information Technology and Innovation and Department of Natural Resources and Mines), Brisbane, Queensland.

3 Site setting

3.1 Existing environment

The existing environment is described in detail in the PRC Plan (Stanwell, 2022). The following sub-sections are summaries covering aspects relevant to the mining voids only.

3.1.1 Surrounding features and land use

Meandu Mine is located on the remnants of a once extensive plateau which has undergone minor structural movements, erosion, and weathering to produce a series of land surfaces of varying altitudes and elevations (Hollingsworth, 1979).

The region is predominantly undulating hills of low relief, characterised by steep upper slopes and gentle summits and ridges. These hills are spurs of the Cooyar Range (altitude 600 m above sea level), which lies to the south-east of the Mine. Flat-lying basalt flows and associated sedimentary geological units form the generally subdued scarp of the Cooyar Range. Remnants of sandstones and conglomerates of the coal measures form isolated knobs and subdued hill scarps.

The surrounding land use of the Meandu Mine is predominantly for agricultural purposes at varying intensities, involving two principal activities – beef production and cropping. Numerous rural residential holdings are also present. Within the immediate locality of the Meandu Mine, extensive areas are used for forestry purposes (open eucalypt forest, plantation forest and closed vine forest), owned and licensed by the Queensland Government. The mining lease (ML6674) includes part of the Yarraman State Forest on its eastern side. This forest extends around the east, south and west of ML6674. The forest contains stands of rainforest, eucalypt forest and hoop pine plantations which have been managed for timber production since the 1930's.

3.1.2 Climate

Meandu Mine lies within the subtropical climate zone. The Australian subtropical climate is seasonal with the highest temperature, rainfall and evaporation occurring during the summer months of November to February. Historical climate conditions are shown on Figure 3.1 and are summarised below based on climate data obtained from the closest Bureau of Meteorology (BOM) weather stations to the Meandu Mine, including:

- temperature from Nanango Wills Street (#040158) and Kingaroy Airport (#040922) weather stations; and
- rainfall records from Yarraman Post Office (#040258) and Tarong weather stations (#040199).

Average maximum temperatures for the region range from 31.1 degrees Celsius (°C) in January to 19.8°C in July. Average minimum temperatures range from 18.0°C in January and 2.7°C in July.

Rainfall in the region is seasonal and highly variable. Annual rainfall is more than 800 millimetres (mm) at Yarraman Post Office station and approximately 700 mm at the Tarong station. The majority of rainfall generally falls in the wet season between October and March, with an average rainfall of approximately 500 mm (Tarong) to 560 mm (Yarraman Post Office). The wet season is characterised by short-lived intense rainfall events (i.e., high daily totals) while drier conditions are experienced throughout the rest of the year (when average monthly rainfall is less than 50 mm). Recharge and stream run-off potential is highest during the wet season months when most rainfall occurs. Similarly, evaporation is higher between October and March (i.e., in the warmer months).

Based on data generated by the DES Scientific Information for Landowners (SILO), at grid point -26.80; 151.90, for the period January 1900 to June 2021, the total average annual evaporation (1,612 mm/year) is more than double the total annual rainfall (759 mm/year). As shown in Figure 3.1, the evaporation rates are strongly linked to temperature variations.

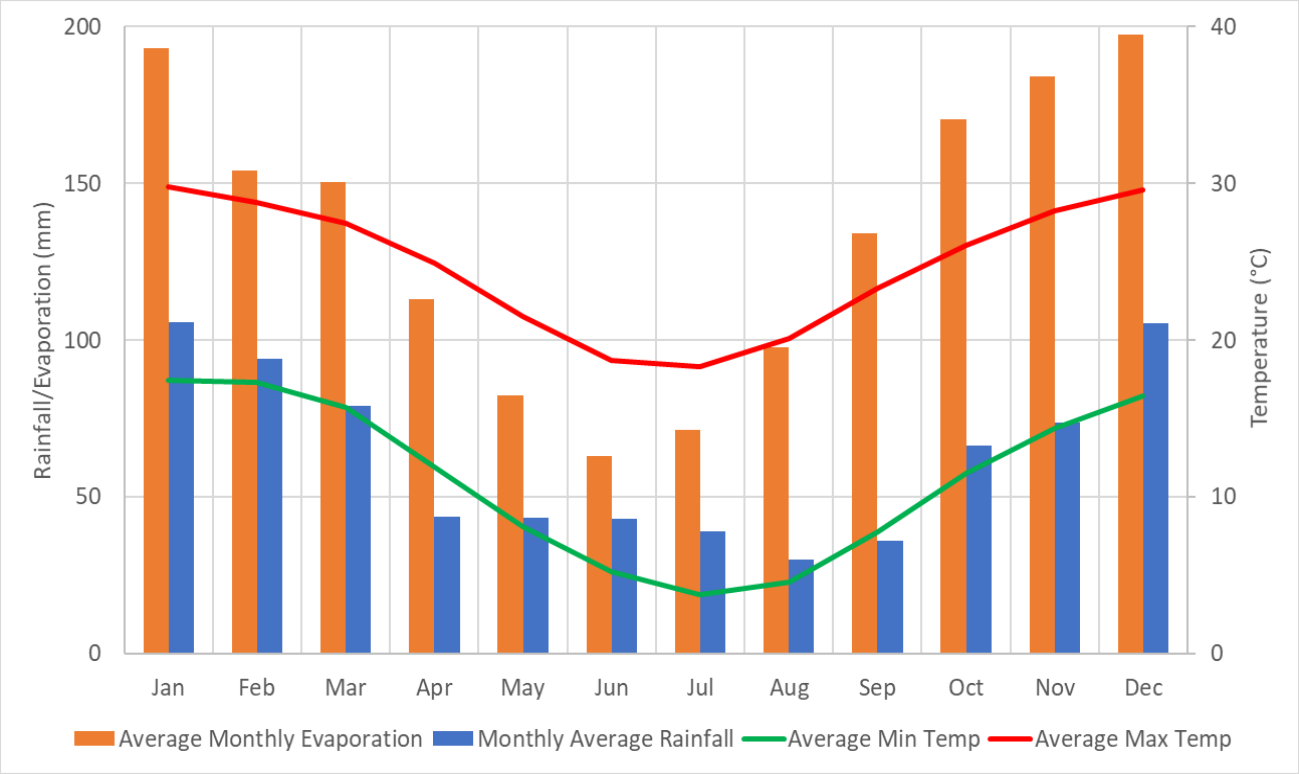


Figure 3.1 Meandu Mine average monthly evaporation, rainfall and temperature (BOM data: January 1900 – June 2021)

3.1.3 Hydrology

Most of the surface rights area of the Meandu Mine is located within the catchment of Meandu Creek, which forms part of the headwaters of the Barker and Barambah Creek sub-basin, which eventually flows into the Burnett River, discharging into the Coral Sea at Bundaberg. A small area along the eastern edge of the Mine surface rights area is located within the Rocky Creek catchment, which forms part of the headwaters of the Brisbane River.

Meandu Creek flows to the north along the western boundary of the Mine area and discharges into Meandu Creek Dam. The area has been significantly modified to facilitate mining and power station operations through the multiple phased diversion of the creek and creation of the Meandu Creek Dam (located outside of the Mining Lease). Meandu Creek is ephemeral and characterised by non-flowing pools of water and is classified as a stream order 2 upstream of Meandu Creek Dam. The creek receives surface runoff waters from the rehabilitated West dump and North-West Backfill Void (NWBV) and operational mine infrastructure areas via numerous retention dams that control flow and sediment loads.

The northern section of the surface rights area is located in the catchment of the former Black Creek (Black Creek was degazetted as a watercourse under the *Water Act 2000* by the former Department of Natural Resources Mines and Energy (DNRME) because it has been significantly modified from its natural state and is used for industrial purposes). The creek is a small tributary of Meandu Creek and joins Meandu Creek north of the power stations (downstream of Meandu Creek Dam) via Black Creek dam. The creek receives runoff from the rehabilitated King 2 East (K2E) dump.

A small part of the forward mine planning area of the King 4 South (K4S) pit is in the Rocky Creek catchment; however, the Meandu Mine water management system currently diverts all mine affected waters away from the Rocky Creek catchment towards the Meandu Creek catchment and only non-mine impacted surface waters run into Rocky Creek. The final landform for the mine allows for restoring a similar balance of catchment between Meandu and Rocky creeks as existed prior to mining.

During current operations, mine-impacted waters are directed into dedicated water storages on the Meandu Mine, which are included in the site-wide water management system for use by the mine or the power stations. The final site hydrology is discussed in Section 8.

3.1.4 Background water quality

Prior to mining operations occurring at Meandu Mine, Meandu Creek and its tributaries were sampled for water quality criteria on a number of occasions since 1976, as well as on a weekly basis when stream flow rates were sufficient from October 1978 (Hollingsworth, 1979). The results are summarised in Table 3.1.

Table 3.1 Summary statistics of available surface water baseline data

During Oct 1978 to May 1983		Parameters measured (mg/L)							
Monitoring sites	**Statistic**	**TDS**	**Calcium**	**Sodium**	**Potassium**	**Chloride**	**Sulfate**	**Hardness**	**Total iron**
Meandu Creek – below RD2 (based on 42 samples)	Minimum	1200	5.9	66	8	115	17.1	62	0.005
	Median	2570	55	620	13	1276	73	600	0.05
	80th percentile	2730	70	688	16	1360	90	670	0.4
Meandu Creek draining forestry catchment – just below (100–200 m) southern lease boundary (based on 10 samples)	Minimum	37	2.2	9.4	0.5	10	0.5	12	0.3
	Median	111	4.9	17.5	2.9	25	4.5	33.5	2.8
	80th percentile	148	7.2	22.7	4.9	37.6	6.2	46.8	7.0
Meandu Creek – opposite RD14 (based on 101 samples)	Minimum	1170	18	250	9	530	15	0.5	0.05
	Median	2600	46	654	16	1260	80	595	0.1
	80th percentile	2840	58	720	19.5	1410	97	650	0.2
Meandu Creek Dam – spillway (only one sample)	–	504	11	91	7.68	161	22.2	119	6.58
Small gully draining into Meandu Creek, just below RD14 (based on four samples)	Minimum	105	7.5	12	0.5	28	7	43	0.3
	Median	180	11.1	19.1	7	32.5	9	52.5	5.1
	80th percentile	235	13.9	20	8.3	47	9.4	67.6	5.9

The results indicate the difference between the relatively undisturbed forestry catchment with total dissolved solids (TDS) with an 80th percentile value of 148 milligrams per litre (mg/L), and the moderately disturbed (by extensive clearing for grazing) catchments, with TDS 80th percentiles of 2,730 mg/L and 2,840 mg/L.

3.1.5 Geology

3.1.5.1 Regional geology

The coal reserves exploited at the Meandu Mine form part of the Triassic-aged Tarong Basin (Figure 3.2), which is characterised as a north-northwest to south-southeast trending pull-apart basin, up to 80 km long and 30 km wide (Pegrem, 1986). The basin is described by Flood & Garces (1986) as originating from a dextral, strike-slip, pull-apart mechanism. Sedimentation within the basin formed an alluvial fan complex known as the Tanduringie Fan (Flood and Garces, 1986). The Tarong Beds and associated coal deposits were formed from Peat swamp depressions to the north and the south of the Tanduringie Fan. The Tarong Beds are up to 450 m thick and comprise coarse grained, clastic sediments and thick coal accumulations (Pegrem, 1986).

Local scale geology at Meandu Mine is summarised in Table 3.2 and comprises (from the surface downwards): Quaternary alluvium, Tertiary basalt and regolith, and Upper Triassic coal measures (the Tarong Beds), with sandstone/siltstone/conglomerate between the coal seams plus minor shale and mudstone. The Triassic sediments dip towards the Southeast at approximately 5° and is heavily faulted by several north-west/south-east trending faults.

In the area of the Mine site, the Ace, King and Queen coal seams are mined. These seams are comprised of a series of seams/plies separated by interburden. Additional coal seams occur below the Queen seam (e.g., Prince seam) but they are not economic nor mined at Meandu Mine.

Table 3.2 Geological summary

Age	Unit	Lithology	Distribution
Quaternary	Meandu Creek Alluvium	Sand, silt and clay	South-west and west of the mining areas beneath and immediately adjacent to Meandu Creek Between 5 to 30 m thick
	Rocky Creek Alluvium	Sand, silt and clay	South-east and east of the mining area beneath and immediately adjacent to Rocky Creek
	Spoil (Anthropogenic)	Reworked material from coal mining operations	Across site associated with mining activities
Tertiary	Main Range Volcanics	Basalt interbedded with minor siltstones, shales, sandstone and silcrete	Remnant ridge top deposits in southern and central areas
	Regolith	Weathered Tarong Beds – sandstone, siltstone, shale and conglomerate	Upper 20 to 30 m of Tarong beds
Upper Triassic Coal Measures	Tarong Beds	Fine to very coarse grained, poorly sorted sandstones and matrix supported conglomerates Includes minor lithology of shale, siltstone, mudstone and coal Coal seam interburden comprises sandstone, siltstone and shale	Across site, up to 450 m thick Economic coal Seams comprise: Ace Seam (~30 m below ground level), King Seam (60 m below Ace Seam), Queen Seam (30 to 40 m below King Seam)
Permian-Triassic	Boondooma Igneous Complex	Medium to coarse grained biotite-hornblende granite with minor quartz diorite	Western site boundary
Devonian-Carboniferous	Maronghi Creek Beds	Mudstone, shale, arenite, chert, jasper, acid to basic metavolcanics	Eastern site boundary

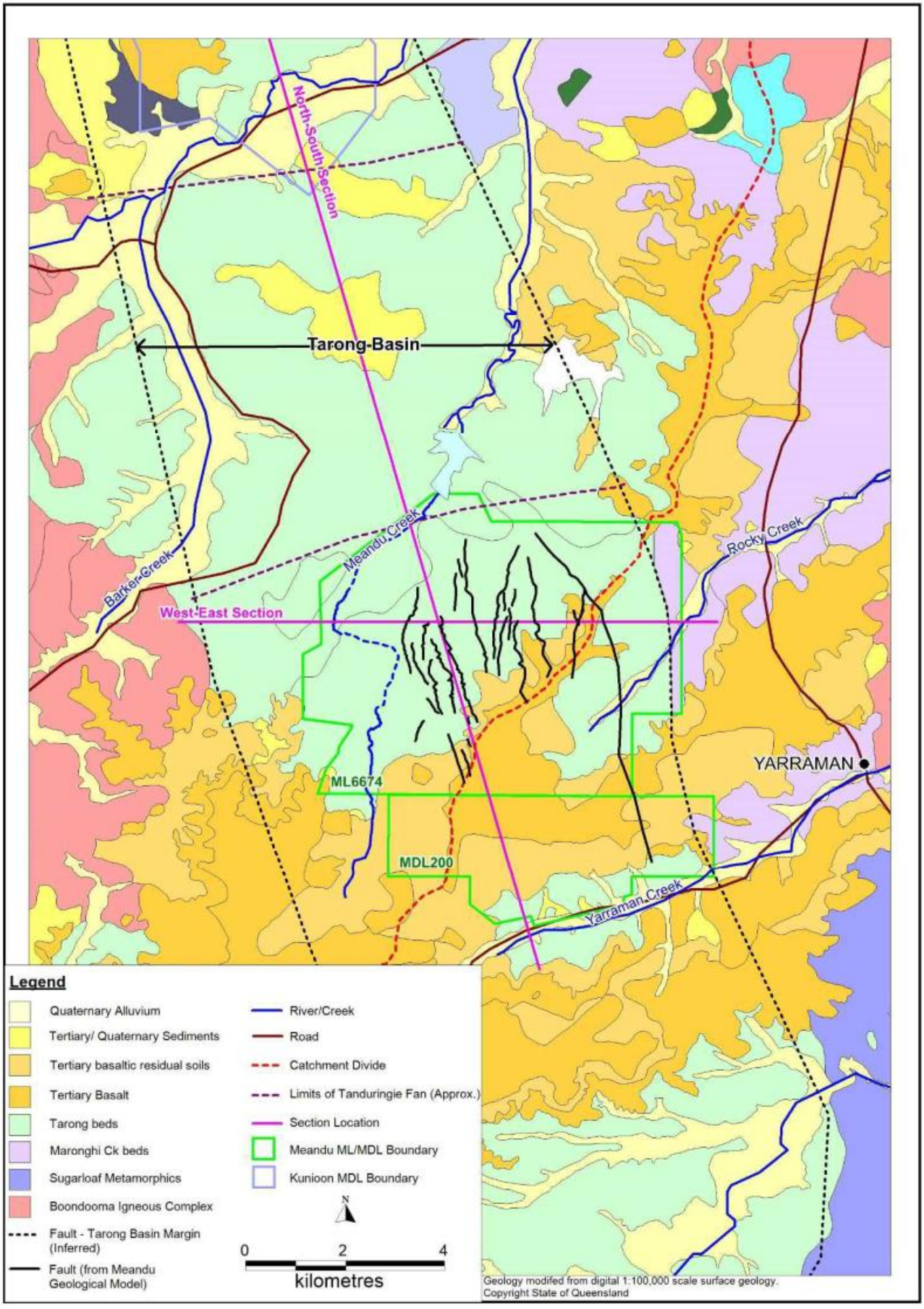


Figure 3.2 Surface and structural geology (JBT, 2021)

3.1.6 Hydrogeology

The hydrogeology of the geological units tabulated in Table 3.2 are summarised in Table 3.3, including properties relevant to void closure at Meandu Mine.

Table 3.3 Summary of hydrogeological units at Meandu Mine

Geological unit	Hydrogeological observations	Aquifer type	Hydraulic conductivity (*K*) *m/day*
Quaternary Alluvium	Aquifers are variable in extent (width and thickness). Permeable zones are often discontinuous and the degree of hydraulic connection throughout the alluvium is variable. No alluvium is located within the catchments of existing or final mine voids.	Unconfined porous medium aquifer.	5.03 (Mean of 2 samples)
Basalt (Main Range Volcanics)	Groundwater occurs within the secondary porosity of fractures, or between and beneath flows where minor strikes of water may occur within interflow sediments. It is noted that all groundwater bores within the Meandu Mine that monitor the basalt have historically been dry. Basalt is located on the top of highwalls of K2E, King 4 East (K4E), K4S and King 2 West (K2W) pits. According to the Life of Mine (LOM) Plan, in the final landform basalt will be exposed in K2E and K4E pits and will be in contact with back-filled spoil and co-deposited coal combustion products and tailings in the K4S Ash Storage Facility (ASF) northern and southern end-walls.	Fractured rock aquifer. Unconfined in upper units. Semi-confined to confined in lower flows (with flows separated by interflow clays/ silts/sands.	0.16 (1 sample)
Regolith, laterite, residual soil and slope wash deposits	The regolith is generally dry, though the unit may become variable saturated following recharge. Regolith is located near the top of the K2E, K4E and K4S highwalls. According to the LOM Plan, in the final landform regolith will be exposed in K2E and K4E pits and will be in contact with back-filled spoil in the K4S pit above the level of coal combustion product and tailings co-deposition.	Unconfined to semi-confined porous medium aquifer.	0.54 (Mean of 11 samples)

Geological unit	Hydrogeological observations	Aquifer type	Hydraulic conductivity (*K*) *m/day*
Tarong Beds – Coal Seams	Ace seam is typically oxidised and dry. King Seam is approximately 60 m below the Ace Seam and generally contained groundwater, though the unit may be dry depending on the reduced level of the strata. Queen Seam is 30–40 m below King Seam and generally contains groundwater. The coal seams are generally the water-bearing units at site and are exposed on most pit highwalls. On closure, coal seams will be exposed on the highwalls of K2E and K4E pits. Relatively small areas of remnant coal seams will be in contact with back-filled spoil in back-filled pits and the low walls of K2E and K4E final voids. Smaller areas of remnant coal seams will be in contact with coal combustion products and tailings in NWBV, King 2 West North (K2W-N) pit and K4S pit on closure.	Fractured rock aquifer Unconfined in upper units Semi-confined to confined in lower flows (with flows separated by interflow clays/silts/sands)	0.22 (Mean of 14 samples)
Tarong Beds – Overburden and interburden	Located above and between the coal seams, the overburden and interburden comprise sandstone, siltstone and shale with minor mudstone and conglomerate. The overburden and interburden is generally hydraulically “tight” and is of lower permeability than the coal seams. Tarong beds are exposed on all pit highwalls. On closure, Tarong Beds will be exposed in the highwalls of K2E and K4E pits and will be in contact with back-filled spoil in back-filled pits and the low walls of K2E and K4E final voids. Smaller areas of Tarong Beds will be in contact with coal combustion products and tailings in NWBV, K2W-N and K4S on closure.	Fractured rock aquifer Unconfined in upper units Semi-confined to confined in lower flows (with flows separated by interflow clays/ silts/sands)	0.0018 (Mean of 6 samples)

Recharge to the groundwater system in the vicinity of the mine voids is predominantly via rainfall, both directly and as downward seepage from ephemeral creeks as well as the vertical and lateral seepage between groundwater units (JBT, 2021).

In addition to the natural groundwater units an anthropogenic groundwater unit at Meandu Mine is the spoil aquifer, which comprises reworked material (waste rock) from coal mining that has been stored within mined-out voids or in out-of-pit storage dumps. The spoil is variably saturated, but available monitoring data shows that the spoil tends to be saturated towards the base of the spoil pile. Seepage of groundwater from the spoil tends to occur in areas where the water level within the spoil has risen to the level of outlets from the pit, for example prior drainage channels.

Groundwater extraction conducted at Meandu Mine is limited to:

- minor rates of pit seepage (generally less than 5 L/s) that is directed via in pit surface drains to pit sumps and removed in conjunction with accumulated surface water runoff; and
- dewatering of the NWBV (which is not expected to continue post-mining).

3.2 Overview of Meandu Mine operations

Meandu Mine is an open-cut coal mine located in Queensland's South Burnett region, approximately 150 km north-west of Brisbane, 14 km south-west of Nanango and 1.5 km to the south of the Tarong power stations. The nearest town to the mine site is Yarraman, which is located approximately 6 km to the south south-east from the approved mining activities. Figure 3.3 illustrates the locality of Meandu Mine within the surrounding regional area.

At the time of compilation of the PRC Plan in May 2022, TEC Coal has received State Government Approval and is finalising Commonwealth Approval to increase the approved surface rights area at the Meandu Mine. The King 2 East (K2E) Project involves increasing the approved surface rights area within ML6647 by an additional 186 ha which will allow progression of the existing K2E pit to the east. State approval for the K2E Project was sought via an EA amendment application for EPML00709113 under the EP Act which was approved by DES on 23 November 2021 and incorporated in the current EA (12 January 2022). Consequently, the K2E Project additional surface area (K2E ASA) is included in the PRC Plan. Commonwealth approval for the K2E Project under the *Environment Protection and Biodiversity Conservation Act 1999* is currently being assessed with further information provided via the Preliminary Documentation Assessment Report which was submitted to the Department of Agriculture, Water and the Environment on 17 May 2022.

3.2.1 Mining

Mining at Meandu Mine is undertaken by open-cut mining using both dragline and excavator/truck open-cut equipment. Prior to the removal of waste rock or coal, overlying vegetation is cleared, and topsoil is stripped to an appropriate depth. The topsoil is either directly placed onto re-contoured landforms or stockpiled for later use during rehabilitation.

Waste rock material is removed by dragline and/or excavator and truck in advance of coal mining, being comprised of:

- overburden, which is waste located above the uppermost coal seam targeted for mining (and may include oxidised or uneconomic coal)
- interburden, (including separable waste partings between coal piles), which is waste located between adjacent coal seams (including both rock and coal)
- near coal roof waste, near coal floor waste and coal partings waste, which are located adjacent to or within coal seams (partings being waste between individual plies of a coal seam, whether separable or not); and
- spoil material, which is overburden that has previously been mined and dumped as waste, which is being rehandled in the mining process to provide access to the targeted coal seam.

Interburden is competent material which is drilled and blasted to allow efficient handling by equipment, while overburden can be either "free dig" material or drilled and blasted. The majority of overburden (over 90%) is blasted.

Waste rock material is moved by dragline and excavator/haul truck fleets to in-pit or ex-pit overburden dumps, appropriate to the mine plan and mining location.

Coal from the Ace, King and Queen seams is mined by excavator and truck. Under EA EMPL00709113, Meandu Mine is authorised to extract up to 11 million tonnes of run-of-mine (ROM) coal per annum. ROM coal is transported by rear dump truck to either the ROM stockpile or directly tipped to the ROM bin at the coal handling and preparation plant (CHPP) (Figure 3.4). ROM coal typically has ash content at levels above that specified for the boilers at the Tarong power stations and so requires coal processing, although a variable portion of ROM coal may directly bypass processing if of superior quality (reflecting geological variation throughout the deposit).

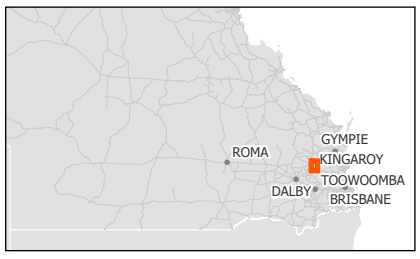
Meandu Mine Void Closure Plan

Figure 3.3
Locality Map of
Meandu Mine (ML6674)

Legend

- Rail Line
- Highways
- Secondary Roads
- Watercourse
- Mining Lease (ML6674)
- Local Government Areas
- Cadastre
- Approved Surface Rights Area

KINGAROY
REDVALE
HILLSDALE
STUART RIVER
KINGAROY CREEK
EDENVALE
BOOIE
MALAR CREEK
TAABINGA
HORNLEY
COOLABUNIA
GLAN DEVON
BRISBANE GULLY
HODGLEIGH
HORSE CREEK
BARKER CREEK
BARKER CREEK FLAT
KUNIOON WEST
MEANDU CREEK
CAMP CREEK
WATER COURSE
DARLI
GOODGER
KUNIOON
NANANGO
SOUTH BURNETT REGIONAL COUNCIL
SANDY CREEK
BARKERS CREEK
BROOKLANDS
MIDDLE CREEK
SOUTH NANANGO
PEACH CREEK
TARONG
TARONG AND TARONG NORTH POWER STATIONS
BAINS GULLY
BLACK GULLY
ROCKY CREEK
TANDURINGIE CREEK
Rocky Creek
Yarraman Creek
ML 6674
MORRINSVILLE
TOOWOOMBA REGIONAL COUNCIL
YARRAMAN
BEAR CREEK
MAIDENWELL
COPPER CREEK
NEUMGNA
PETER CREEK



0 2,500 5,000
Meters

Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

GDA 2020 1:100,000

Date: 25/05/2022

Data sources: DELWP, Geoscience Australia

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Meandu Mine Void Closure Plan

Figure 3.4
Meandu Mine Key Features

Tarong Ash Dam
Black Creek Dam
Cooling Dam
Meandu Creek Dam
TARONG AND TARONG NORTH POWER STATIONS
CHPP
Mine Industrial Area
ROM Stockpile
R3 TSF
NWB TSF
NWA TSF
RD16 TSF
K2 TSF
K2E Rehab
QUEEN WEST SUMP
Active K2W-N ASF
West Dump
CENTRAL PIT
K2E PIT
K2E ASA
RAMP 5 PIT
K4E PIT
K4S Pit
K4S ASF (Future)
Yarraman State Forest

Legend

- Drainage
- Watercourse
- Active MPR storage areas
- Active pits/ voids
- Ash/ tailings storage areas (active and future)
- Historical TSFs in different stages of rehabilitation
- Mining Lease (ML6674)
- Tarong Ash Dam
- K2E ASA
- Approved Surface Rights Area
- Yarraman State Forest



0 1,000 2,000
Meters

Coordinate system: GDA94 MGA zone 56

Scale ratio correct when printed at A3

GDA 2020

1:40,000

Date: 27/05/2022

Data sources: DELWP, Geoscience Australia

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3.2.2 Coal processing

The CHPP processes the ROM coal by destoning and by removing higher ash/inferior quality fractions of the ROM coal. The processing stages include breakage/sizing/screening, crushing and washing (using gravity separation), to achieve product coal ash, energy and moisture content compliant with the Tarong power stations' boiler specifications.

ROM coal tipped or reclaimed to the CHPP feed bin is sized in primary and secondary breakers, during which raw coal is separated from coarse breaker rejects. The CHPP consists of 2 coarse jigs 13–75 mm and 2 small jigs 0–13 mm which rely on air water pulsation to cause separation. During the CHPP process, raw coal is separated into coal product and non-coal product materials using a washing and flocculent method. Product coal is then transported via a 1.5 km overland conveyor to the Tarong power stations.

3.2.3 Process waste streams

The CHPP process generates waste streams composed of residual coal and mineral matter that are classified according to size fraction as tailings (fine to ultra-fine) or coarse (coarse rejects).

Under the current CHPP process, fine to ultra-fine, high ash slimes are bled out of the process water circuits and gravitate to the tailings thickener via the thickener feed launder. These tailings are thickened and treated with calcium hydroxide ($Ca(OH)_2$) to attain a broadly neutral pH in the CHPP thickener and pumped in slurry form to solid bowl centrifuges (SBCs). The SBCs are designed to dewater coal tailings to a moisture content that allows them to be loaded with coarse rejects by excavator into trucks for disposal.

The co-loaded coarse rejects and dewatered tailings (mixed plant rejects – MPR) can then be hauled by truck to dedicated reject cell dump areas or co-disposed in the spoil tiphead within the advancing low-wall spoil within the Meandu Mine operation (Figure 3.4). The water that is recovered from the SBCs is recycled back through the CHPP system or otherwise pumped to site storages for recovery and re-use, minimising raw water use at the Meandu Mine.

Wet tailings disposal will continue to occur when the SBCs are off-line or not able to process 100% of the tailings stream. These tailings are pumped as slurry to a dedicated tailings storage facility (TSF), which is currently located within the K2W pit void, a subsection of the King 2 West – North (K2W-N) ASF (Figure 3.4). Tailings supernatant is pumped from K2W to the Tarong power Stations or to surface water storages at the mine for re-use.

Prior to 2017, the coarse rejects and tailings were disposed of separately, with the coarse rejects hauled to dedicated rejects dumps in the Rejects Storage Area (RSA) located in the North-West dump with smaller volumes deposited in Hitachi Hill, Ramp 5 dump, West dump, Western Haul Road dump and Central dump. The tailings were pumped in slurry form to the site in-pit TSF. Between 1986 and 1995 tailings were disposed as a slurry into the King 2 TSF (K2 TSF). Tailings were also deposited into converted ramps (Ramp 2, Ramp 3) and former North-West A (NWA) pit (also referred to as North-West A TSF (NWA TSF)) between 1992 and 2006. Some of these areas have been rehandled with the expansion of the Central Pit. Between 2006 and 2019 tailings were deposited in North-West B (NWB) pit, forming the North-West B TSF (NWB TSF) and from 2017 to 2019 were also deposited in the re-purposed RD16 TSF. From 2019 tailing have been stored in K2W-N.

Ash, or coal combustion products are produced during the coal combustion process at the power stations as a by-product of thermal power generation. Ongoing storage facilities for coal combustion products are critical to the operation of the Tarong power stations. They are also beneficial for placement at Meandu Mine to minimise the volume and number of final voids and to restore total waste volumes (including coal) towards the originally mined volumes – thereby achieving an overall final landform of average elevation closer to the natural landscape pre-mining.

Approximately 10% of the coal combustion products are sold off-site from the Tarong power stations as useable products. Unsold coal combustion products are transferred to the ash thickening plant (ATP) as a lean slurry, where they are concentrated (water content reduction) and pumped as slurry by pipe to in pit ash storage facilities at Meandu Mine. A small portion is pumped to the Tarong ash dam, when the mine void system is not available. The current storage facility is the K2W-N mine void, which is dual purposed for ash and tailings. Once this facility achieves target fill level, the ash will be allowed to settle and harden and the facility will be capped. After this time the depleted K4S pit will become the ash and tailings storage facility at the Meandu Mine (Figure 3.4).

Coal combustion product supernatant water is decanted from the surface of the ash void and is currently transported back to the power stations for reuse. The coal combustion products are initially acidic and are neutralised at the Tarong power stations with $Ca(OH)_2$ in the ATP to bring the pH of the ash stream to between pH 6–8. Total annual production of ash generated by the Tarong power stations varies from year to year according to electricity market demands, planned and unplanned shutdowns and chemical composition of the coal. A typical year produces approximately 1.35 million tonnes of coal combustion products (Stanwell, 2020b).

A new ash offtake facility at the Tarong power stations to facilitate increased sales was commissioned on 10 December 2021, and once at full production has the potential to increase the reuse of coal combustion products by approximately 400,000 tonnes per annum, or approximately 30% of coal combustion product production.

The waste streams are discussed in more detail in Section 4.1.1. Geochemical characteristics of the waste streams are discussed in Section 7.1.4.

4 Description of voids

The relatively complex structural geology and geometry of the coal seams at Meandu Mine has resulted in the creation of numerous pits across the mine. However, this same complexity and the sequential mining of coal seams generally from the northwest to the south and east has allowed for significant backfilling of exhausted pits with waste generated by mining and coal processing, thereby reducing the volume of final void present at mine closure. The ongoing deposition of coal combustion products into mine voids will further reduce the final void volume present at closure.

It is noted that PMLUs have been allocated for the entirety of final void domains at the Meandu Mine (i.e., no NUMAs are being sought in the PRC Plan).

A summary of the voids created by mining at Meandu Mine is presented in Table 4.1. The locations of the voids are shown on Figure 4.1.

Table 4.1 Summary of void details at Meandu Mine

Void name	Date operational	Back-fill material	Date of back-filling	PMLU(s)	Dimensions of final void	Comments
Back-filled voids						
King 1 (K1) pit	1983 – 1995	Tailings (Ramp 2 TSF), now removed	1995 – 2003	Beef Cattle Grazing	N/A	King 1 pit including Ramp 2 TSF has been re-handled as part of Central pit progression
NWA pit	1984 – 1995	Tailings (NWATSF & Ramp 3 TSF), coarse rejects overburden/ interburden from NWA, NWB Central and West pits,	1986 – 2013 (Ramp 3 TSF 1992 – 1996; NWATSF 1997 – 2006)	Native Ecosystem	N/A	
NWB pit	1996 – 2005	Tailings (NWB TSF), overlying overburden/ interburden from Central pit used as capping	2006 – 2019 (tailings); 2020/2021TSF decommissioned; 2021 – 2026 bulk waste placement to final landform	Native Ecosystem	N/A	
Central pit	2007 – 2031	MPR, overburden/ interburden from Central pit	2007 – 2032	Beef Cattle Grazing & Native Ecosystem	N/A	
West pit	2001 – 2011	Coarse rejects, tailings (from re-mined Ramp 2 TSF), overburden/ interburden from West, Central, Ramp 5, NWB and South-West (SW) pits	2001 – 2019	Native Ecosystem	N/A	

Void name	Date operational	Back-fill material	Date of back-filling	PMLU(s)	Dimensions of final void	Comments
SW pit	1995 – 2007	Overburden/interburden from SW pit	1995 – 2021	Native Ecosystem, Steep Rocky Ecosystem (southern wall)	N/A	Rehabilitation completed and partly signed – off.
Ramp 5 pit	1996 – 2029	MPR, Overburden/ interburden from Ramp 5, K4E and K4S Pits	1996 – 2032	Beef Cattle Grazing, Native Ecosystem	N/A	
King 2 North (K2N) pit	2010 – 2015	Coal combustion products with tailings, co-deposited since 2020	2015 – 2029 tailings and coal combustion products; 2030 – 2034 bulk waste placement to final landform	Native Ecosystem, Steep Rocky Ecosystem (southern wall)	N/A	Currently operating as combined pit K2W-N.
K2W pit	2004 – 2007	Coal combustion products and tailings since 2020	2009 – 2029 tailings and coal combustion products; 2030 – 2034 bulk waste placement to final landform	Native Ecosystem, Steep Rocky Ecosystem (southern wall)	N/A	Currently operating as combined pit K2W-N.
Queen West (QW) pit	2002 – 2004	Overburden/interburden from QW and K2W pits	2002 – 2034	Native Ecosystem	N/A	
K4S pit	2006 – 2029	Overburden/interburden from K4E and K4S pits, future co-deposited coal combustion products and tailings, overburden/ interburden covers stockpiled in spoil dumps (mainly K4E)	2008 – 2020 Overburden/ interburden; 2029 – 2037 tailings and coal combustion products, 2038 – 2041 bulk waste build to final landform	Beef Cattle Grazing	N/A	

Void name	Date operational	Back-fill material	Date of back-filling	PMLU(s)	Dimensions of final void	Comments
Proposed Final Voids						
K2E pit	1996 – 2016; 2023 – 2037	Overburden/interburden from K2E pit	1996 – 2016; 2023 – 2037, 2038 – 2041 low wall spoil push down to final landform (partial backfill)	Native Ecosystem, Water Storage, Steep Rocky Ecosystem	Surface area: 245 ha maximum depth: 143 m Maximum volume: 147 Mm^3	Assumes approval given for K2E ASA in 2022
K4E pit	1992 – 2037	Overburden/interburden from K4E and K4S pits, overburden/interburden cover stockpiled in spoil dumps (mainly K4E)	1989 – 2001; 2006 – 2037, 2038 – 2041 complete partial backfill and profile to final landform	Native Ecosystem, Beef Cattle Grazing, Water Storage, Steep Rocky Ecosystem	Surface area - 66 ha maximum depth: 51 m Maximum volume: 12 Mm^3	

4.1 Final void area minimisation

As described in Section 4, the geometry and geology of the coal seams at Meandu Mine have allowed for significant void minimisation through back-filling of exhausted pits. On closure, the LOM Plan shows that 11 of the 13 voids created throughout the lifespan of the mine will be wholly backfilled and rehabilitated such that it contains similar features and slopes to the surrounding and pre-mining landscapes to surface levels approximating the pre-mining landform. The remaining 2 of the 13 voids developed through the mine life both receive substantial backfill, significantly reducing their depth, enabled through a strategy of stockpiling suitable spoil material above final landform design on the low-wall side of the final void location for subsequent dozer push or excavator and truck relocation in the years after cessation of coal mining LOM operations.

Waste streams used to backfill the pits (where licensed) comprise a combination of:

- overburden/interburden spoil
- coal combustion products
- tailings
- MPR (co-mingled dewatered tailings and coarse rejects); and
- coarse rejects (prior to the installation of the SBCs at the CHPP i.e., before 2017).

Overburden/interburden spoil comprises the vast majority of material used to backfill the voids.

Meandu Mine has specific waste processing technologies and management procedures in place for placement and/or decommissioning that maximise the efficiency of void back-filling whilst minimising the risk of detrimental impacts to the PMLUs and surrounding environmental values.

North-West pit
QW & K2W-N pits
K2E pit
West pit
Central pit
K2E Final void
South-West pit
Ramp 5 pit
K4E Final void
K4E pit
K4S pit

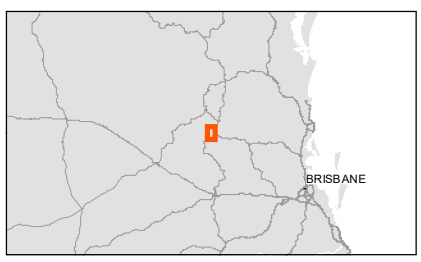
wsp

Meandu Mine Void Closure Plan

Figure 4.1
Extent of voids at Meandu Mine (historical, active and final voids)

Legend

- Drainage
- Watercourse
- Final void at closure
- Projected future mining voids
- Historical / current voids
- Mining Lease (ML6674)
- Meandu Mine Surface Rights Area



0 1,000 2,000
Meters

Coordinate system: GDA94 MGA zone 56

Scale ratio correct when printed at A3

GDA 2020

1:40,000 Date: 27/05/2022

Data sources: DELWP, Geoscience Australia

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4.1.1 Waste processing

Tailings

The CHPP generates ultra-fine, high ash slimes (tailings) and fine-to-coarse rejects that historically were disposed of as separate waste streams; coarse rejects which were trucked to dedicated reject dumps, and tailings, which were pumped as a thickened slurry of approximately 10–20% solid content to dedicated TSFs, initially in a valley fill TSF (K2 TSF) and then to in-pit TSFs when suitable locations became available in exhausted voids.

The high-water content of the tailings results in logistical problems with regards to ongoing operation and closure of the TSF as the tailings require significant area and time to dewater to an extent that allows for capping and rehabilitation. Due to their plastic nature and low load-bearing capacity, saturated tailings present a less stable working surface for installation of initial capping and subsequent bulk waste placement to final landform by mining equipment, introducing complexity into their management during decommissioning (refer Section 4.1.2).

In December 2017, SBC systems were installed and commissioned at the Meandu CHPP to undertake drying and thickening of the fine tailings stream to the extent that they would be able to be co-disposed with the coarse rejects as described in Section 4.1.2. These SBCs are designed to dewater coal tailings to a moisture content that allows them to be co-mingled with course rejects. Both course rejects and dewatered tailings (MPR) can then be hauled by truck to dedicated reject dumps within the Meandu mining operation. The water that is recovered from the SBCs is be recycled back through the CHPP system or otherwise pumped to site storages for recovery and re-use, minimising raw water use at the Meandu Mine.

The MPRs generated by SBCs require less volume for storage on placement but generate a more stable waste mass immediately after placement, minimise the potential for seepage and enable a more flexible waste storage design. A specific management procedure has been developed for the placement of MPR into mining voids at Meandu mine, which is summarised in Section 4.1.2.

Contingency tailings disposal will still be required during periods when the SBCs are under maintenance, or the tailings volume exceeds the operational capacity of the SBCs; however, this is predicted to occur for less than 10% of operational time.

Coal combustion products

Prior to 2009 all coal combustion products generated by the Tarong Power Stations were deposited outside of ML6674 into the above ground storage facility, namely the Tarong Ash Dam within the Power Station Industrial Complex; from Tarong Power Station as a pumped lean phase (5–10% solids) slurry and from Tarong North Power Station as a dense phase (50–55% solids) slurry, with bottom ash transported to the ash dam in articulated dump trucks as a solid. The purchase of Meandu Mine by Stanwell in 2008 allowed the possibility of deposition of coal combustion products into exhausted mine voids rather than the ash dam. In order to minimise above ground storage and minimise the mine void volumes, approval for coal combustion storage at Meandu Mine was originally granted under a Beneficial Use Agreement (BUA) in 2009 with coal combustion product deposition into K2W pit commencing in November 2009. This BUA had a positive environmental impact for both the mine and the power stations as it provided additional back-fill material to minimise the residual void volume at Meandu Mine, whilst removing the need for an extension to the existing Tarong Ash Dam. The Tarong Ash Dam is consequently only utilised for contingency coal combustion product deposition since 2009.

The commissioning of an ash thickening plant (ATP) at Tarong Power Station in 2010 had the result that all ash pumped to Meandu Mine for deposition into K2W was dense phase slurry (an ATP has been operating at Tarong North Power Station since the power station opened in 2002). The main advantage of dense phase coal combustion product disposal is that a more stable final landform is created that is more readily decommissioned and rehabilitated then a lean-phase deposited coal combustion product. Deposition of coal combustion products into the mine void also facilitates the harvesting of cenospheres from the ash surface for resale.

4.1.2 Waste stream management

4.1.2.1 Overburden/interburden

Mining at Meandu Mine is conducted by open-cut strip mining using a combination of dragline and excavator/truck equipment. With the exception of initial "boxcuts" during pit initiation, this method involves dragline removal of blasted spoil from above/between coal seams which is built as an in-pit spoil dump forming the low wall of the pit. This method enables backfill of the up-dip mined section of the pit whilst mining progresses down-dip. The update of the mine geological model, which now differentiates material classified as Potentially Acid Forming (PAF) or Non-Acid Forming (NAF) (refer Section 7), enables scheduling and disposal of spoil such that PAF is placed at depths greater than 6 m from the final landform surface. The application of geochemical classification into the LOM Plan and geological model minimises the risk of PAF being incorrectly placed, which in turn minimises the risk of seepage contacting PAF material and mobilising contaminants into groundwater and/or surface seepage.

4.1.2.2 Mixed plant rejects

Geochemical characterisation has indicated the PAF nature of the coarse rejects and tailings at Meandu Mine (WSP, 2021b); therefore, TEC Coal has developed a specific rejects management procedure to minimise the risk of Acid and Metalliferous Drainage (AMD) generation from placement of rejects within spoil dumps at the mine. Kinetic leach testing of coarse rejects and MPR (WSP, 2021b) showed that after exposure of the materials to atmospheric conditions and water, there was a lag time of approximately 21 weeks before AMD was generated from the coarse rejects; conversely, mixing the coarse rejects with fine-grained tailings (MPR) increased the lag time of AMD generation to approximately 90 weeks. This lag is a result of the pore voids within the coarse rejects filling with the highly plastic low permeability tailings, which retards oxidation. Therefore, reject material placement management focuses on combining rejects and tailings streams to generate MPR, limiting storage exposure time of MPR before covering with NAF material, and placement of reject materials approximately 6 m beneath the final landform profile.

Tec Coal has developed a procedure for the placement of MPR within the in-pit spoil dumps (8512-OC-WI1020 Placement of Mixed Plant Rejects in Stanwell 2020a). The procedure is outlined in the following sections.

Dump design phase

Mine planning ensures sufficient dump space is allocated which meets recommended MPR disposal guidelines. This includes:

- the final mine rehabilitation profile to ensure MPR are not emplaced within 6 m of the final rehabilitation profile
- MPR are not dumped on the pit floor following coal recovery or below a minimum rejects relative level based on the final pit void profile and further that they are not emplaced in a wetting/drying zone
- MPR are placed within the pit footprint (i.e., avoid ex-pit/out of pit dumps) and encapsulated within in-pit dumps to prevent material being transported/washed into the pit void
- geotechnical and slope stability considerations of the dump to determine whether it is a suitable location for MPR emplacement. During the design phase this may also include reviewing the surrounding dumps, the type of waste material, haul roads and drainage points.

Emplacement planning

Mine planning engineers shall liaise with production personnel daily to assess progress and implementation of both waste dump designs and emplacement areas. Factors which need to be considered when deciding on emplacement areas may include, but are not limited to:

- waste dump rehabilitation designs
- day and night-time dumping restrictions e.g., soft dump area/failing tip heads
- weather impacts on the operations
- waste dump progression
- geological composition of the waste dump being on/over adjacent dump areas
- availability of suitable trucks and excavators to load out MPR from the rejects stockpile
- any dust implications as the MPR dry out
- visual aspects (avoid dumping on the outside edge of the dump)
- maximising the capacity of the emplacement areas; and
- ensuring sufficient back-up dumps/tip heads available.

Where MPR are to be placed near the final face of a dump, overflow bunds shall be constructed to ensure material does not spill within 6 m of the final rehabilitation surface.

At least 5 m of suitable overburden capping material is to be placed over the top of the MPR placement area and 6 m where the placement area is within 6 m of the final landform.

Current Meandu Mine management procedures of limiting storage/exposure time of coarse reject materials at the reject stockpile prior to mixing to less than two weeks appears to be an effective way of controlling the risk of acidic drainage generation (Stanwell 2020b).

Classification of MPR prior to emplacement

Relevant personnel are to visually assess moisture content of the MPR material being produced by the CHPP and at proposed tip head/dump location. Material is then classified as:

- **Low Moisture** (dry to moist) – material that is mostly coarse reject rock material and is able to be easily trucked to the dump and will retain integrity in dump/tip head and is suitable for co-disposal
- **Moderate to High Moisture** (“wet”) – material contains significant wet fines with some coarse rejects and is able to be contained by cells and trucked to MPR dump with minimal spillage; or
- **Very High Moisture** (“very wet”/“sloppy”) – material mainly consists of wet fines and is difficult to transport due to high moisture. Material not able to be contained by cells and flows out over flat dump areas. A “mud slide” will need to be set-up with JHA formulated with dump controls implemented.

Placement methods of these three materials is outlined below.

Emplacement of material by “Co-Disposing” (low moisture)

When MPR material is suitable for “co-disposal”, the dump is set up with maximum 10 m high tip heads. The material is dumped as a mixture of 1 MPR load to 3 overburden loads (ideally blasted, blocky rock). The mixture of 1 load of MPR to 3 loads of overburden is a minimum, more overburden loads are better. MPR should be distributed along the whole tip head and not concentrated in one spot (see preferred dump plan in Figure 4.2 and Figure 4.3). The dump should advance over previous paddock dump material or dry/flat benches.

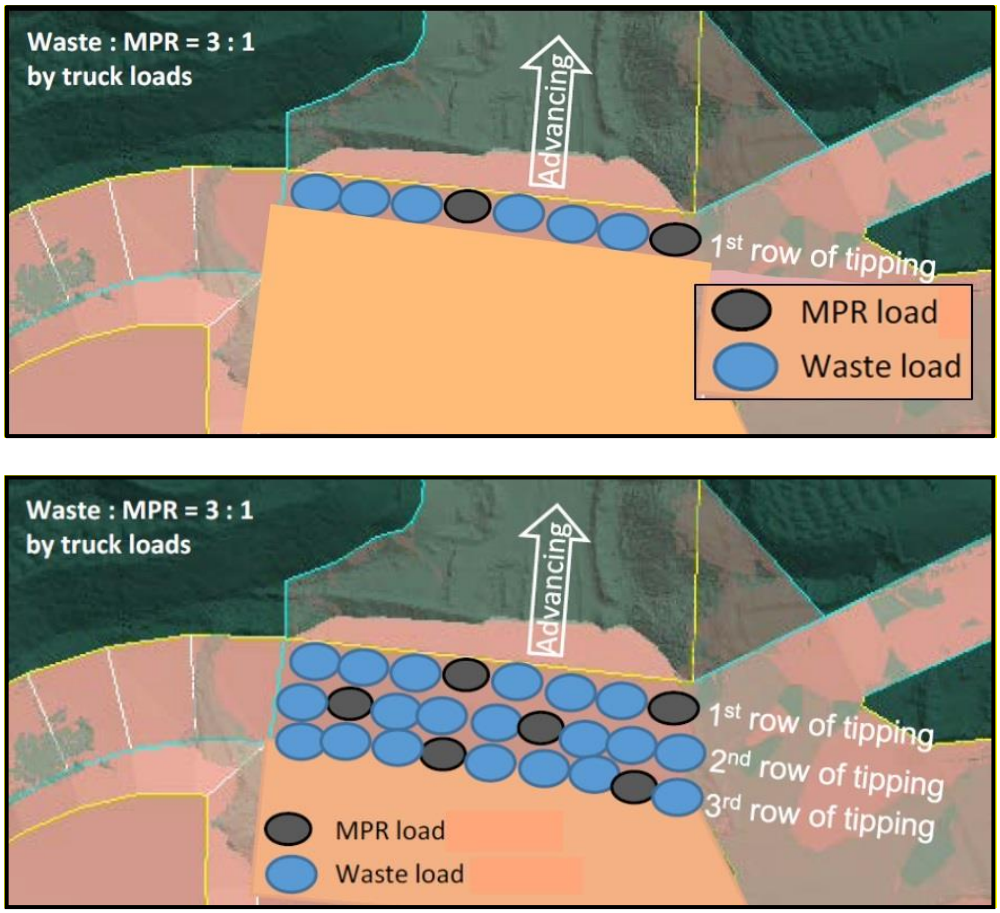

Figure 4.2 MPR co-disposal dump pattern for minimum 3:1 ratio of waste to MPR

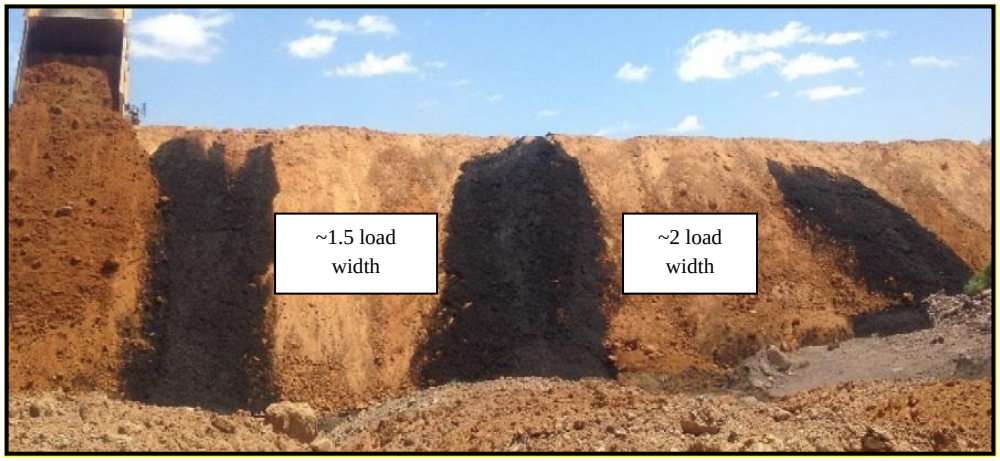

Figure 4.3 MPR Cc-disposal dump pattern for waste to MPR

No MPR/rejects are to be placed on outside/exposed sides of dumps. The best results for co-disposal have previously been obtained from MPR material being placed on tip heads up to 10 m high on blocky, paddock dumped material with a greater than 1 to 5 ratio of MPR to overburden. This enables the MPR to drain and it is less likely for MPR to create a slip surface at the toe of the tip head dump.

Emplacement of material in cells ("wet material")

MPR is placed in cells in the following configurations (See Figure 4.4 to Figure 4.8).

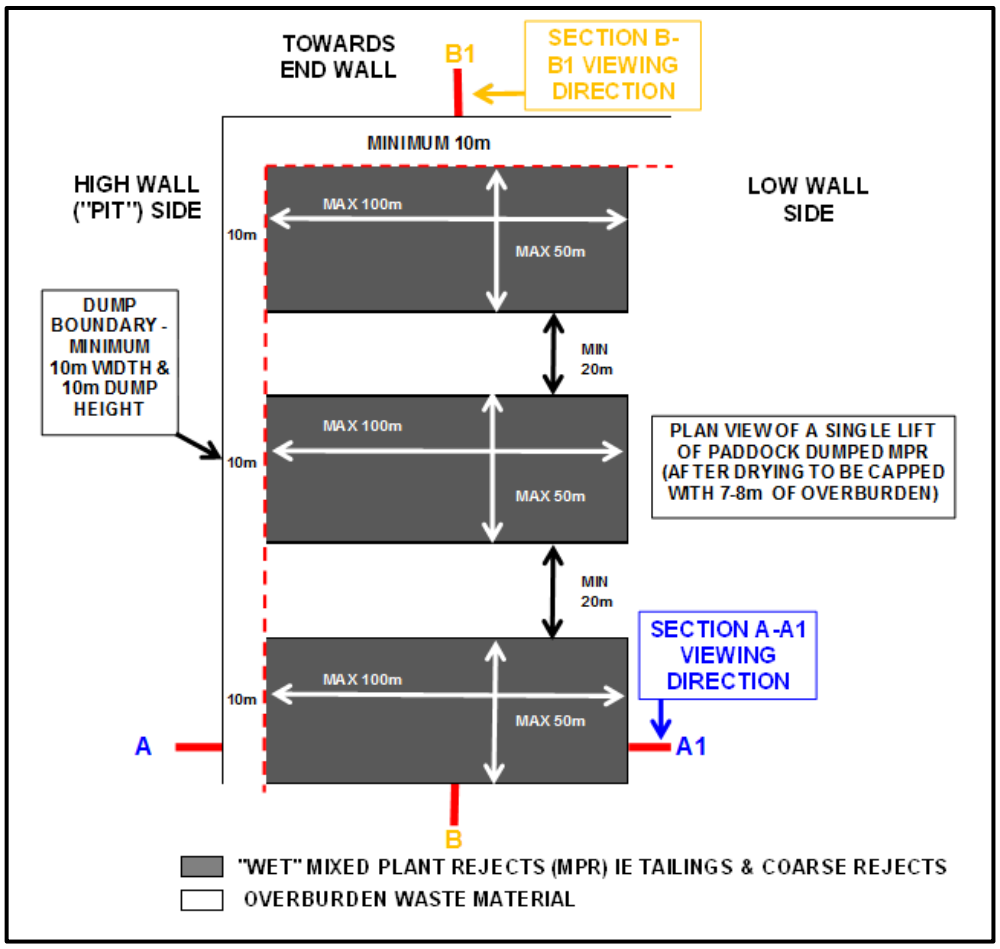

Figure 4.4 "Wet" MPR cell dump layout

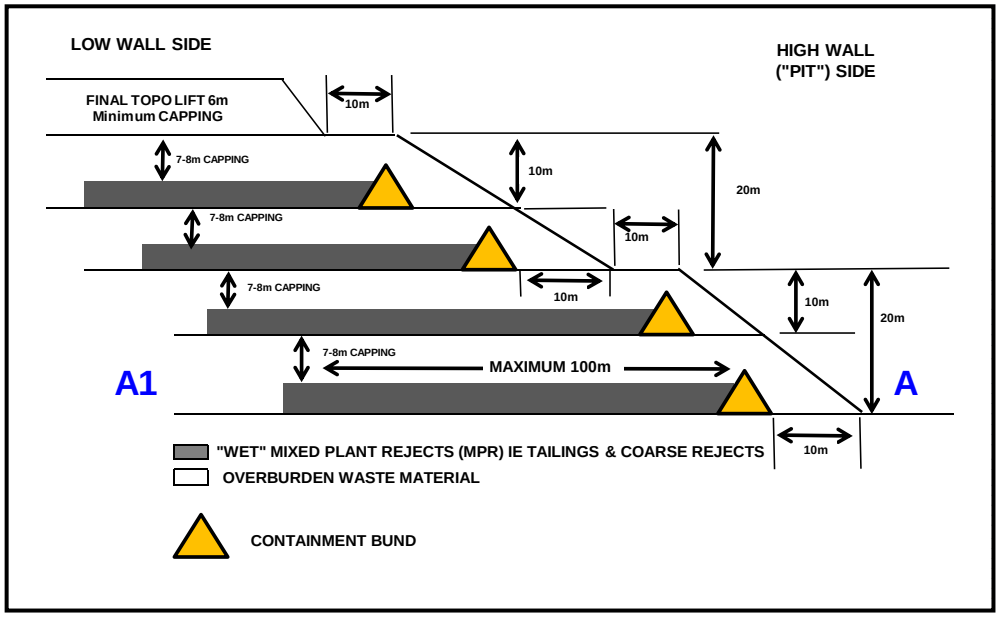

Figure 4.5 Cross section A-A1 of emplacement cell dump for "Wet" MPR

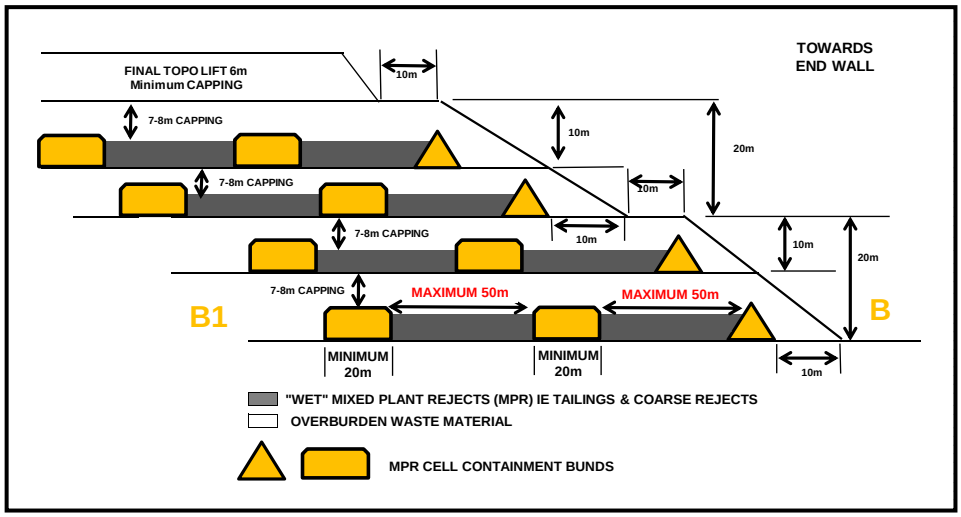

Figure 4.6 Cross section B-B1 of emplacement cell dump for “Wet” MPR



Figure 4.7 Example of MPR emplacement in cells at Central Pit ~442RL looking south-west from northern end wall



Figure 4.8 Central Pit ~448RL capping MPR emplacement (looking south-west from northern end wall)

Alternatively, the MPR can be dumped out as paddock dump lifts with alternating paddock dump rows of overburden waste between the MPR material.

Emplacement of material by "Mud Slide" (high moisture – "sloppy")

When MPR material is assessed as unsuitable for "co-disposal" or cell emplacement due to the very wet nature of the material, a "mud slide" may need to be set-up (see Figure 4.9). The mud slide is to be contained within the in-pit spoil dump and not situated within 6 m of the final landform.



Figure 4.9 "Mud Slide" on ~447RL bench in Central pit

4.1.2.3 Tailings

Tailings at Meandu Mine were initially deposited into K2 TSF, a specifically designed and constructed valley-fill structure built at the headwaters of Black Creek. Once mining ceased in NWA pit, the opportunity to minimise residual void space at the mine was realised by using the NWA pit and Ramp 3 as TSFs. Tailings were deposited sub-aqueously to minimise oxidation of entrained sulphides (notably pyrite) and settled to form a clayey silt of very soft consistency.

Historical rehabilitation of the NWA TSF consisted of initial backfilling the north-west arm of the void with a 5 m thick capping layer of rejects and by completing a high-face spoil dump around the southern margin in an arc joining the rejects dump on the west of the void to the excavated rock slope on the east of the void. The 5 m thick layer of rejects was advanced into the void to the south-east, with overburden/interburden spoil from NWB, Central and West pits placed over the top of the rejects to a level that matched the surrounding spoil dumps. The depth of spoil over the rejects is approximately 40 m thick. The spoil dump in the southern arm was progressively advanced to the north towards the centre of the void. Due to the saturated nature of the tailings and overloading from the spoil, the tailings were displaced vertically by approximately 50 m vertically over the 3 years that back-filling occurred. A small volume of residual tailings was spread over the spoil to dry out before the final landform was constructed over the void. Limited information is available for Ramp 3 TSF; however, it is likely to have been rehabilitated in a similar manner to NWA TSF. On landform construction and rehabilitation of this area in 2015–2017, investigations confirmed that no tailings were within 6 m of the final landform surface.

Decommissioning and rehabilitation of NWB TSF and RD16 TSF (Historical TSFs)

To avoid the technical and logistical issues that arose due to the saturated nature of the tailings when capping the NWA TSF, specific decommissioning and rehabilitation plans have been developed for NWB TSF and RD16 TSF, both of which have been decommissioned and are in the process of being rehabilitated. At the time of reporting, RD16 TSF had been completed to milestone RM6, and the initial 2 m capping layer for NWB TSF had been commenced and was approximately 15% complete. RD16 TSF was located in a converted retention dam rather than in a mining void and is included in this discussion for completeness.

The overarching strategy for rehabilitation of the TSFs is to meet the EA condition of a safe, stable and non-polluting landform. These are addressed at a high level as follows:

- consolidation and settling have been considered
- contribution to seepage and controls implemented and to be maintained have been identified
- a free-draining (i.e. externally draining) final landform is proposed; and
- NAF material shall be used for initial cover (in contact with tailings) and for the cover layer to a minimum of 5.8 m thickness below the final topsoil layer (6 m total thickness of cover).

The first phase of rehabilitation of the TSFs is desiccation. This involves dewatering through self-weight consolidation and recovery of expelled water through pumping from a return water sump. This has been completed at RD16 TSF and is continuing at NWB TSF and will continue until the initial capping layer is completed. A period of approximately 18 months is considered likely to be required to achieve suitable stability based on prior site experience. Once a TSF is deemed to have undergone adequate desiccation, *in-situ* geotechnical testing will be undertaken to verify material strength is sufficient to support the required material and equipment before further rehabilitation is conducted.

The next phase of rehabilitation is the placement of capping material immediately above the tailings. As the spoil immediately over the tailings will experience upward flow of water from the tailings during consolidation, this material needs to be NAF. Consistent with general spoil dump requirements, the outer 50 m horizontally will also be NAF. The cover material on RD16 TSF has had bulk material placed and, following a 12-month settlement period and importation of additional material to balance the settlement that occurred, undergone final profiling and rehabilitation works (to RM6).

Survey calculations indicates NWB TSF requires approximately 7,000,000 m^3 of material to infill the void and raise to the final landform height. A total of 250,000 m^3 of suitable material has been identified for the initial capping layer on the adjacent Hitachi Hill dump. The LOM Plan allocates spoil rehandle and overburden removed from the advance of K2E and potentially Central/Ramp 5 pits as the source of the remaining infill material, with potential for deposition of MPR at a depth greater than 6 m below the final landform surface.

The challenge of placing the first layer of cover material over tailings is that the cover needs to be thick enough to spread the weight of the construction equipment (so that the resultant pressure is low enough to not fail the tailings), without being so thick that the weight of the cover material will fail (through the tailings). Stability analyses can be undertaken to check the geo-mechanical stability of various combinations of layer thickness and equipment weight; however, given the inherent variability of tailings throughout the NWB TSF, it is likely that at least in some areas, performance will vary significantly from analysis. Consequently, construction must proceed on the understanding that the schedule and design may need to be revised during the process.

The tailings strength profile assumed for preliminary design at NWB TSF consisted of a surface layer 2 m thick with 25 kilopascals (kPa) undrained shear strength, and 15 kPa undrained shear strength below that. Slope stability analysis found that a small dozer spreading a 3 m thick layer of spoil would have a FoS close to 1.5. Therefore, it is expected that the initial shallow cap will be placed using small equipment to limit tailings deformation, during 2021–2024, after which the capped surface will drain back to the site retention dam system. Based on geotechnical advice and experience capping the RD16 TSF, placement of the initial cap will potentially be staged to allow each section to rest and settle. Subsequent material up to final rehabilitation surface will be placed by mine production equipment, with material sourced from pit excavation or rehandled spoil material as appropriate, with the potential deposition of MPR at depths greater than 6 m below the final landform surface.

Initial cover construction sequence

Following the cessation of deposition, an individual TSF Decommissioning and Rehabilitation Plan (DRP) will be developed for each individual TSF commissioned at Meandu Mine. Prior to desiccation and geotechnical testing, the DRP will be completed as a draft based on site knowledge and experience. The DRP will be updated to final once geotechnical testing results and subsequent analysis and recommendations are available. The geotechnical analysis and recommendations will include consideration of appropriate construction method, sequence and equipment, which will be incorporated into the DRP.

As an example, the following section discusses the planned construction equipment, method and sequence developed for the NWB TSF initial cover construction (Stanwell 2021).

The planned NWB TSF construction sequence for the initial cover layer of spoil is illustrated in Figure 4.10. Starting from the filter wall at the north, spoil will be stockpiled near the eastern end of the filter wall and a D6-LGP dozer will push the spoil onto the tailings in front of the filter wall up to the height of the filter wall crest. The spoil layer will be advanced across to the low-wall first and then southward down the TSF. As the cover layer is extended:

- The working face will stay aligned across the pit to minimise the length of the working face.
- Incident rainfall and water expressed from the tailings will be continually removed from the tailings surface using a mobile pump or highwall pump as required. A trench on the low-wall side of the tailings surface has been constructed to drain free water back to the northern sump, from where the water is pumped out as required.
- Once the active face moves away from the filter wall, spoil may be stockpiled on the constructed layer at a minimum setback and maximum height to be determined at detailed design. Such stockpiling must only be temporary, and the spoil must be relocated to advance the first layer of cover with minimal delay. Capping activity to date has involved direct rehandling of material from Hitachi Hill dump and has not required stockpiling of the waste material.
- As the active face approaches the southern end of the TSF the low wall side should be swung around to enclose the dewatering sump and finally complete the cover layer.

During construction, the area must be inspected daily by a supervisor and any cracking or significant change in the tailings bow wave should be notified to a geotechnical engineer familiar with the decommissioning project.

Once the initial cover layer of NAF spoil has been placed over the tailings surface, and after a suitable period has passed to allow for settlement and repair, it may be possible to proceed as per normal dumping operations subject to observations of stability and further settlement. The subsequent dumping strategy will be confirmed by geotechnical analysis after the first layer is completed. The spoil will be dumped and spread to maintain a small fall toward the northern end so the rainfall drains away freely to the dewatering sump. The decant pond at the northern end of the TSF may be retained for some time as a sediment basin but will eventually also be backfilled to the final landform shape. As the spoil surface approaches the levels of the final landform, the areas of thickest tailings and spoil (at the south and south-east) may be over-dumped by a couple of metres to counterbalance predicted remaining consolidation settlement. To comply with Rehabilitation Milestone 3 (as per EA Condition G9) a 2 m thick layer of the NAF spoil will be compacted to minimise infiltration through the cover. The specific depth of the compacted layer will be dependent on the geotechnical stability of the tailings once the initial cover layer has been emplaced. A minimum of 6 m of NAF overburden/interburden will be emplaced beneath the final landform design surface.

It is anticipated that the landform will be completed to the end of bulk earthworks then allowed a period of potentially 24–36 months (a conservative timeframe compared to the 12 months required for the smaller-scale RD16 TSF capping process) for consolidation settlement and maintenance as required. When topographic monitoring indicates that the remaining settlement is within a manageable range (nominally <0.3 m), the surface will be cut-and-filled to final design profile.

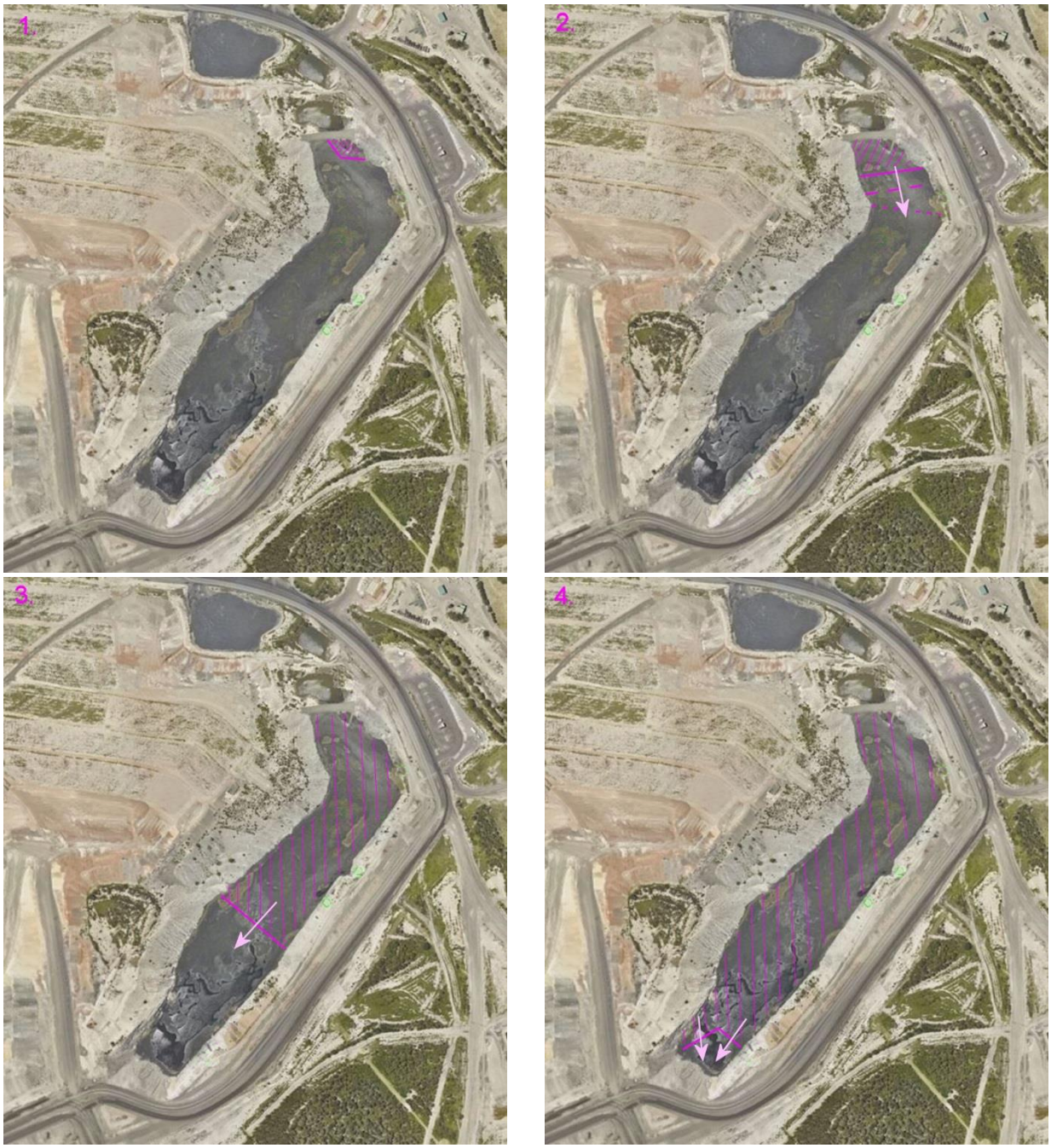

Figure 4.10 Construction progress for first cover layer on NWB TSF

The area will then be rehabilitated in accordance with the final landform design as shown in Figure 4.11 and PMLU requirements as detailed in the Meandu Mine PRC Plan, including construction of contour drains and rock drains, topsoiling, ripping and seeding. If required, temporary surface protection may be provided through use of a grass or cover crop, during the period between bulk earthworks and topsoiling. The proposed final landform over NWB TSF is shown in Figure 4.11.

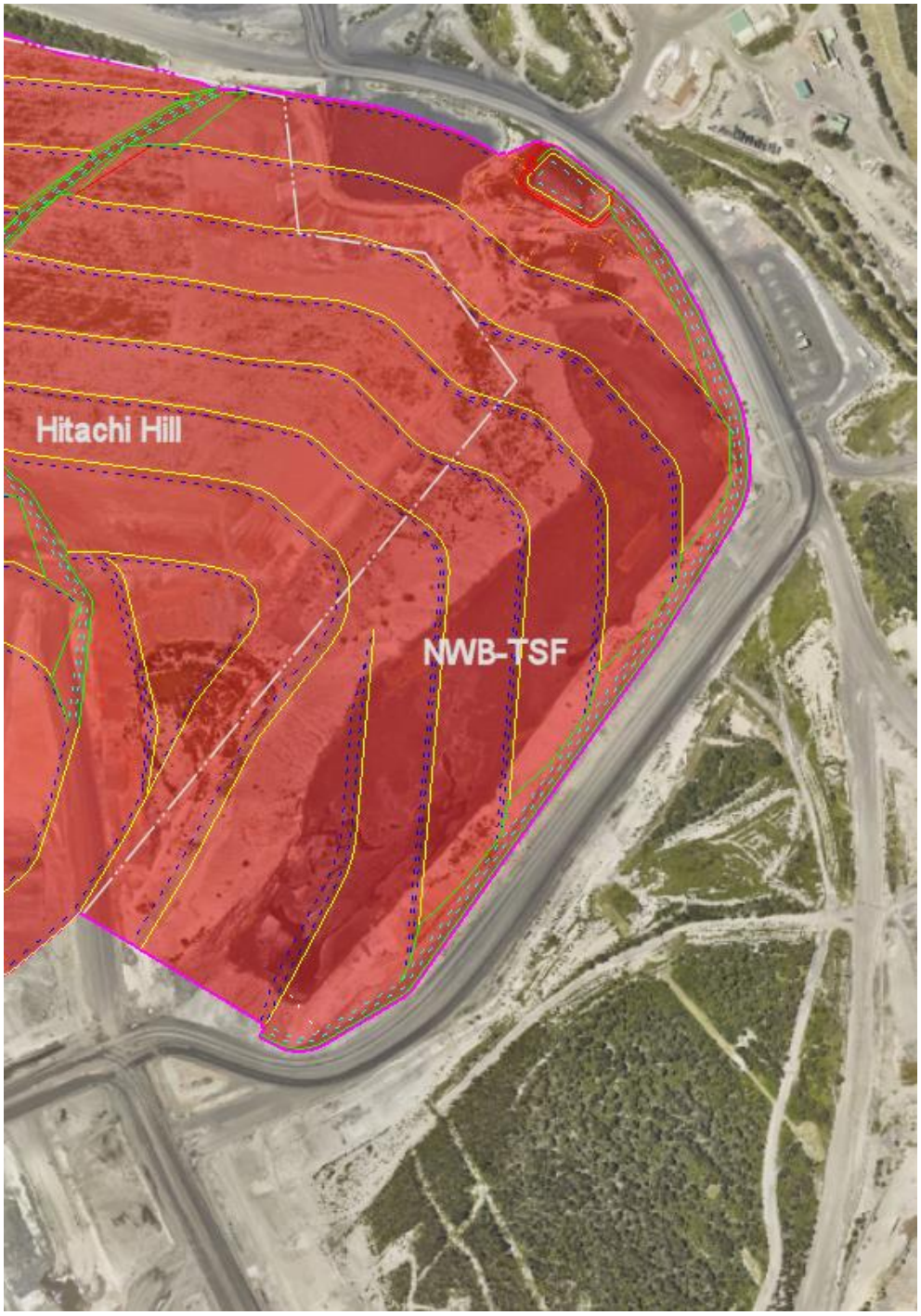

Figure 4.11 Proposed final landform over NWB TSF

As shown in Figure 4.12, the depth of spoil required to achieve the final landform in the 2022 LOM Plan ranges from 10 m at the decant pond filter wall to 60 m against low-wall spoil at the south-western corner. With that depth of burial, in most respects, the tailings will not affect the condition or function of the rehabilitated landform, which will instead be subject to the same surface works and completion criteria as other rehabilitated spoil dumps.

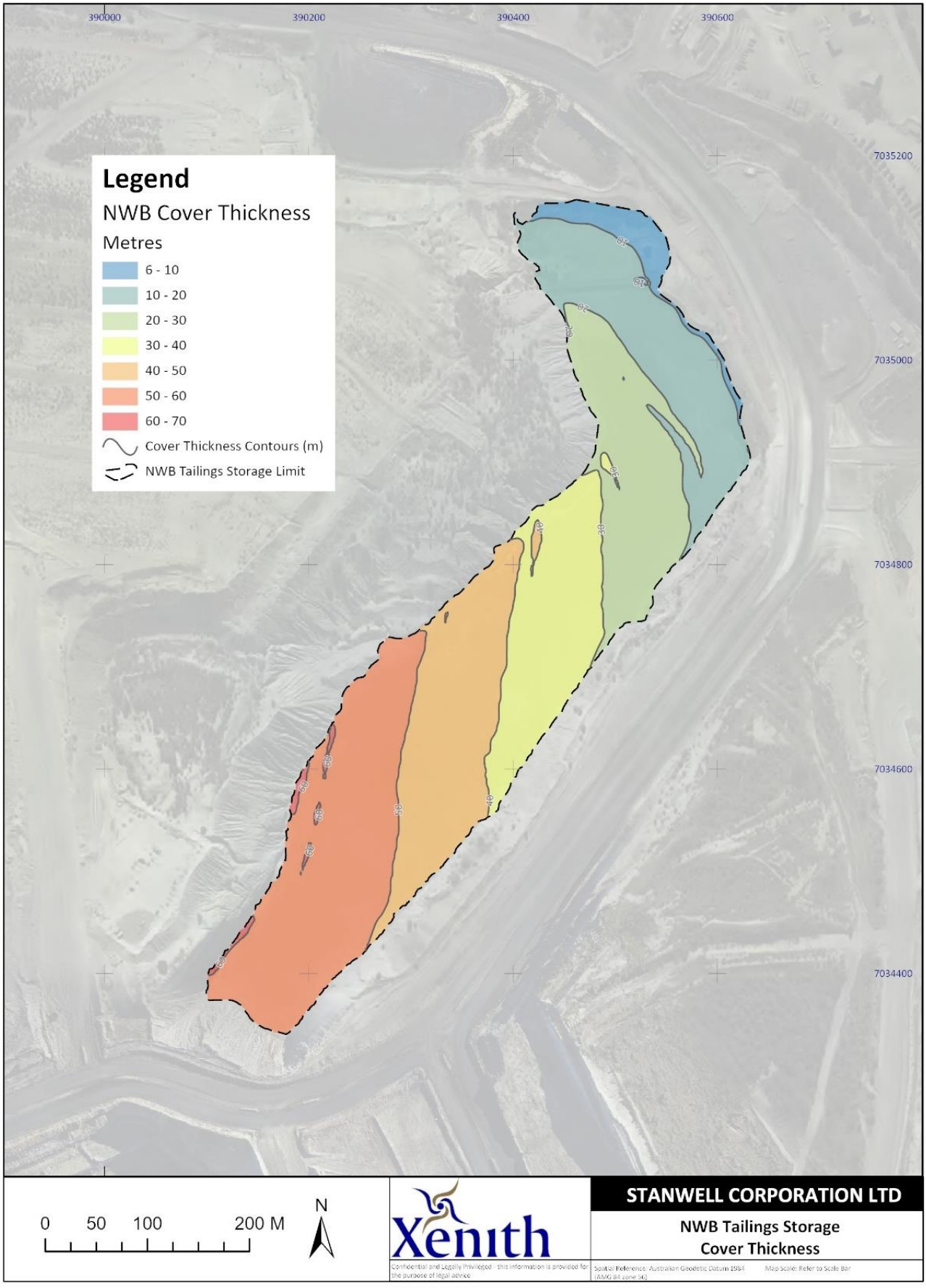

Figure 4.12 Depth of cover over NWB TSF to achieve final landform

With the installation of the SBCs at the CHPP, wet tailings disposal will only be required for approximately 10% of the time. These tailings will be co-deposited with the coal combustion products in dedicated mine voids at K2W and then K4S. Coal combustion product deposition will continue in the K2W-N void and will then transition to K4S following both the transition of tailings deposition into the K4S facility and achievement of target coal combustion product fill level at K2W-N. The placement and decommissioning of both K2W-N and K4S ASFs are discussed below.

4.1.2.4 Coal combustion products

Coal combustion products from the Tarong power stations are currently deposited as a dense phase slurry (~40% solids) in two joined mining voids at Meandu Mine – K2W and K2N (known collectively as K2W-N). Due to settling of this slurry in the K2W-N void after transportation from the power stations, a large body of water is formed on the surface of the void. This supernatant water is reclaimed from the K2W-N ASF and is currently pumped in a closed-loop system back to Tarong Ash Dam for recovery and re-use, in accordance with site procedures for Meandu Mine and the Tarong power stations.

As discussed above, contingency tailings disposal into the K2W area of K2W-N void occurs during periods when the SBCs are unavailable or throughput exceeds capacity. Modelling supporting the LOM Plan indicates that the contingency tailings will add 1–3% to the volume of ash stored in the void. Ash placement in the K2W-N void will continue until this storage facility reaches capacity (currently 518 metres relative level (mRL) (crest level 520 mRL)). This is anticipated to be in approximately 2029 (depending on power station generation rates).

Future disposal

K4S pit is currently scheduled for completion of mining in 2029. Following completion of ash and contingency tailing storage in K2W-N, ongoing ash and tailings will be pumped to the K4S pit for the remaining life of mine. Appropriate design and consequence category assessments of K4S pit will be undertaken prior to commissioning of K4S ASF. The manner in which ash transfer will occur is planned to remain as a pumped dense phase slurry via pipeline.

Rehabilitation strategy

Decommissioning and rehabilitation of the K2W-N void/ash storage has been considered in the K2W-N design plan (including certified design drawings) in accordance with EA EPML00709113 conditions G8, G10 to G14 and H27 (Stanwell 2020b). The decommissioning and rehabilitation plan will not be finalised until coal combustion product deposition has ceased and *in-situ* geotechnical testing conducted and analysis of results and recommendation for initial cover installation are finalised. Rehabilitation will comprise a period of desiccation/consolidation following by initial cover installation with NAF spoil and subsequent NAF spoil lifts to a level in accordance with final landform design, ensuring that the final cover will be free-draining (i.e., final surface constructed on a slope to prevent pondage). Decommissioning and rehabilitation of K4S post mine closure (~2037–2039) will be conducted in a similar manner.

Transition planning for coal combustion product deposition transfer from K2W-N to the K4S ASF will be incorporated into the decommissioning plan for the K2W-N ASF. Tailings deposition transfer to K4S will occur prior to the coal combustion product transfer. This will allow ash to continue to be pumped into K2W-N ASF for a period of approximately 12 months following cessation of tailings deposition, forming a layer over the tailings in K2W prior to capping. Testing has shown that the deposited coal combustion products are inherently stronger than the tailings and it is expected that this methodology will reduce potential deformation associated with the tailings and reduce capping duration, assisting to minimise the decommissioning and rehabilitation timeframe. Additional testing will be undertaken as coal combustion product and tailings levels increase and the proportions of the respective materials become more representative. In-situ geotechnical testing will be undertaken following cessation of coal combustion product deposition to determine suitable cover depths, suitable equipment and construction sequence and methodology.

Desiccation phase

Following cessation of coal combustion product disposal in the storage facilities, a period of desiccation (drying out/crusting) will be allowed. Once the desiccation period has finished and the surface has dried sufficiently to provide access, in-situ geotechnical testing will be undertaken and analysed to develop recommendations for an initial cover construction sequence and method including confirmation of suitable equipment. Previous experience gained at Meandu Mine by placing the temporary dust suppression layer over K2W indicates that a desiccation period of up to 18 months may be appropriate, and that shallow tiphead placement of the initial cover layer can be achieved using existing mine production equipment. The initial cover construction methodology will be refined for the K2W-N decommissioning and rehabilitation plan based on outcomes of in-situ testing, with particular attention given to the K2W area that is currently being used for tailings disposal and which will have a relatively thin thickness of coal combustion products.

Cover materials

NAF material will be used as an initial cover material over the coal combustion products, which will be placed over the coal combustion products in a progressive manner like that described for NWB TSF (Section 4.1.2.3). Once the initial NAF cover has sufficient geotechnical stability; to meet the EA condition of minimising infiltration of rainfall into underlying coal combustion products and tailings, it is necessary to compact a 2 m thick layer of NAF Spoil above tailings and coal combustion products on decommissioning. The compacted cover layer is to be constructed as follows (Sherwood Geotechnical and Research Services, 2015):

- The NAF spoil to act as compacted layer of cover material (2 m thickness) to be placed and spread in 500 mm thick layers (loose). When placed the material shall be sufficiently moist that a hand-sample does not liberate dust when dropped at waist-height.
- Each 500 mm layer shall be compacted using a 100-tonne class dozer or a Cat 825-class padfoot-wheeled compactor. A minimum of two passes of the machined track or wheel print shall cover every component of the compacted surface. The minimum number of passes may have to be increased under certain conditions to achieve effective compaction.
- Effective compaction shall be determined as minimal observable indentation left by normal protective footwear under normal walking conditions. Effective compaction may also be determined by the use of a 9 kg Dynamic Cone Penetrometer as described in Australian Standard AS1289.6.3.2, with a minimum blow-count of 3 blows per 100 mm averaged over the full thickness of the compacted layer.

Where there are no tailings within 4 m of the final level of the coal combustion products, a minimum 2 m of NAF cover will be placed over the coal combustion products, with material potentially sourced from K2W spoil dump, K2E pit or possibly Ramp 5/K4E pits. Where tailings are within 4 m of the final level of the coal combustion products, then a sufficient depth of NAF cover will be placed to achieve a minimum 6 m depth of cover over the tailings, noting that coal combustion products are categorised as NAF (Section 7.1.4.4). Table 4.2 shows the requirements.

Table 4.2 Minimum NAF waste cover thickness over coal combustion products – with near surface underlying tailings

Tailings Depth Below final coal combustion products surface (m)	Minimum NAF waste cover thickness (m)	Criteria
0.0	6.0	Min. 6 m NAF over tailings
0.5	5.5	Min. 6 m NAF over tailings
1.0	5.0	Min. 6 m NAF over tailings
1.5	4.5	Min. 6 m NAF over tailings
2.0	4.0	Min. 6 m NAF over tailings
2.5	3.5	Min. 6 m NAF over tailings
3.0	3.0	Min. 6 m NAF over tailings
3.5	2.5	Min. 6 m NAF over tailings
4.0	2.0	Min 2 m cover over coal combustion products
>4.0	2.0	Min 2 m cover over coal combustion products

Landform design

The 2021 LOM Plan final landform design for the K2W-N void is shown in Figure 4.13. The final landform has been designed with the catchment divide toward the northern end of K2W at approximately 530 mRL and drainage channels reporting to the northern and south-western ends of the K2W-N ASF. As illustrated in Figure 4.13, final depth of cover over K2W-N will range from 2 m at the northern end and 4 m at the southern end, to 30 m on the western side adjacent to the K2W spoil dump.

The final landform for K4S ASF will have a cover thickness ranging from approximately 36 m to approximately 70 m of NAF spoil (Figure 4.14).

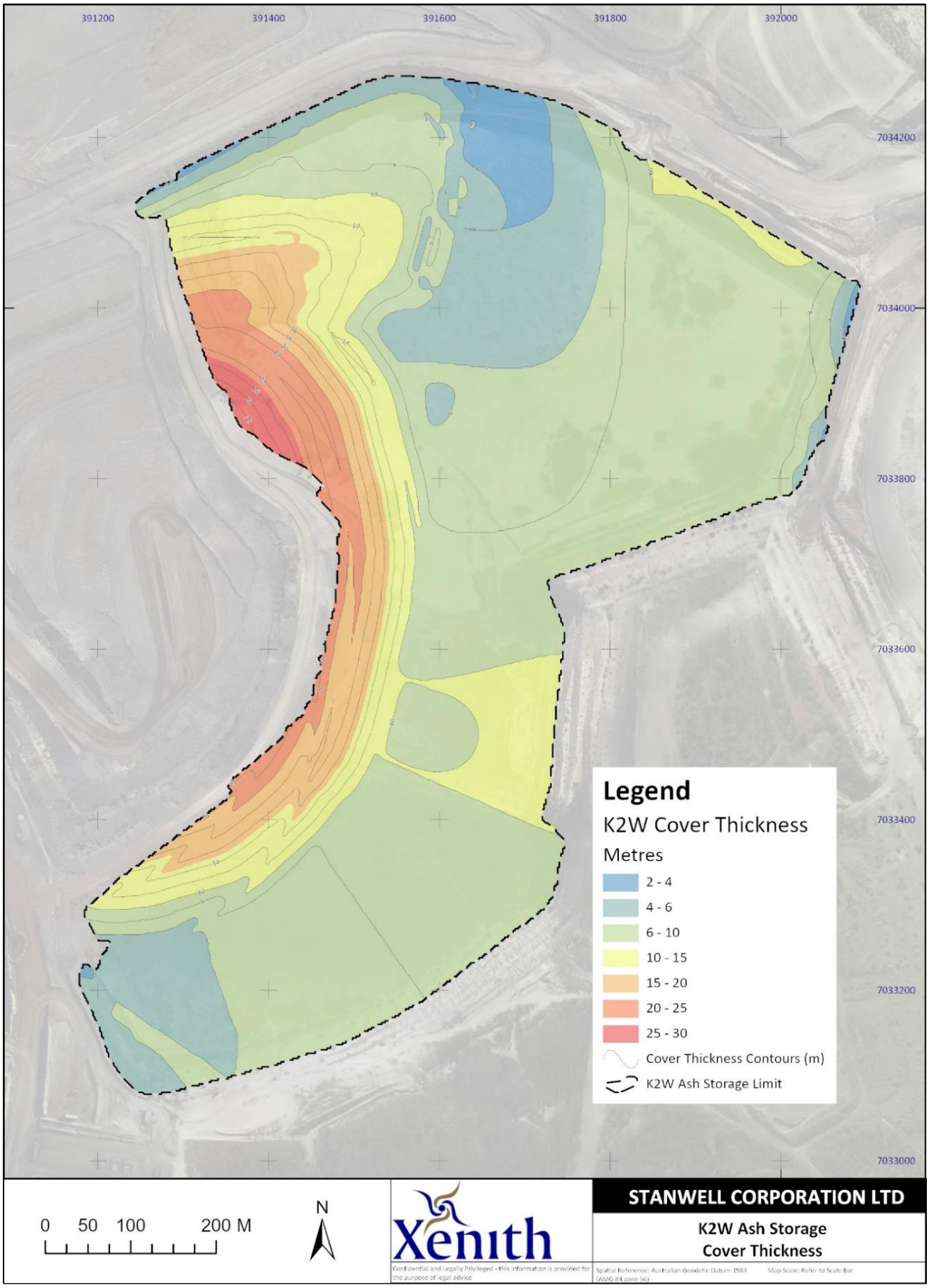

Figure 4.13 Depth of cover over K2W-N to achieve final landform

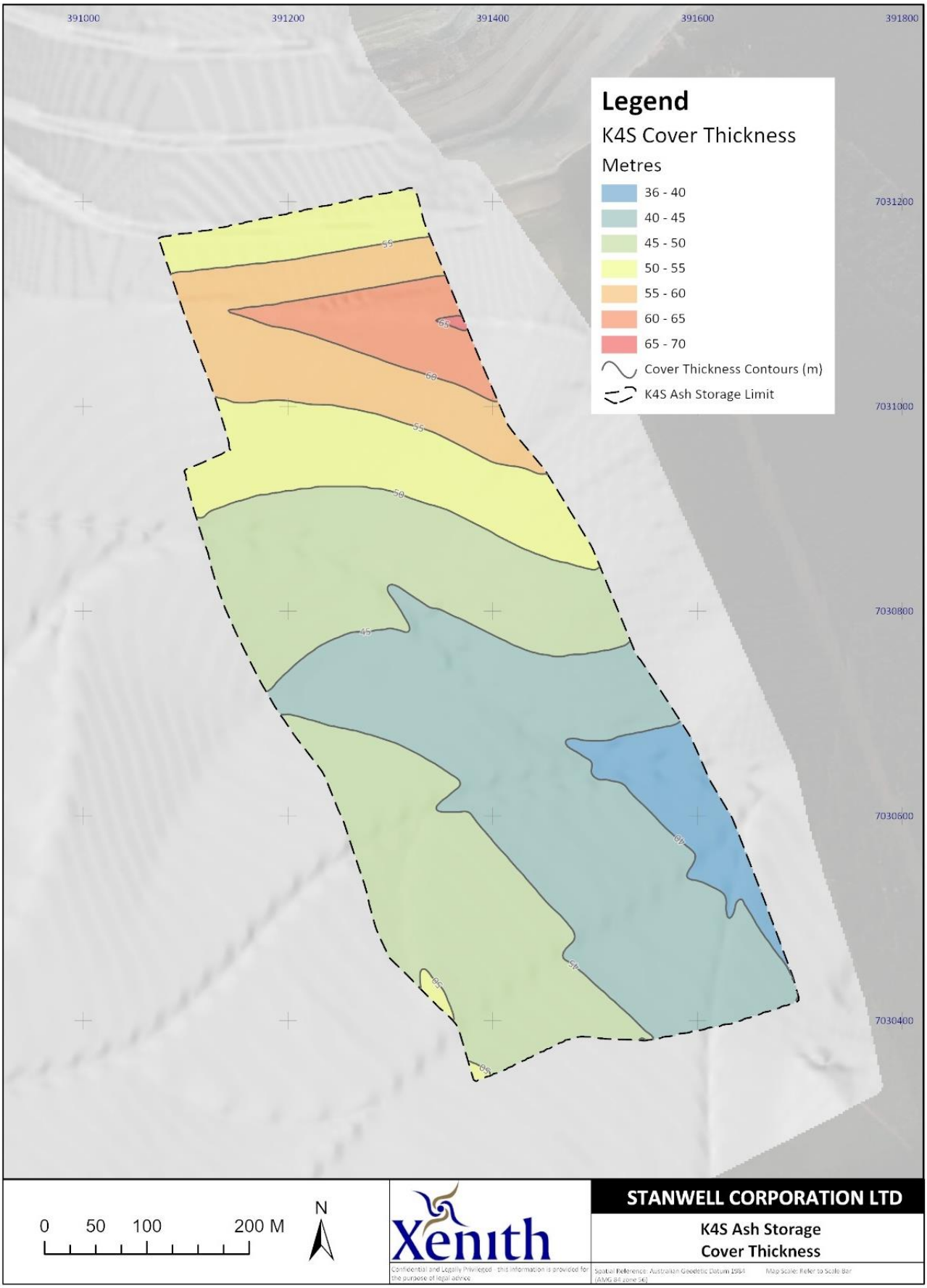

Figure 4.14 Depth of cover over K4S ASF to achieve final landform

4.1.3 LOM Planning

The objectives for the design of the Meandu Mine post-mining landform are listed in Section 1.2. LOM Planning has included specific strategies for reduction of final void sizes, including:

- reduction of the size of K2E boxcuts to reduce out of pit dumping and maximise in-pit dumping. This also results in reducing the volume to be reshaped to final landform
- achieve the coal combustion products placement strategy of K2W-N then confirm suitable LOM coal combustion product storage capacity in K4S
- pit optimisation to reduce final void footprint and volume
- step up the pit floor to the K4 seam in the last strip of K4E and K2E to reduce the depth of the final voids
- minimise overburden in advance to maximise in-pit placement of waste
- improve haulage efficiency for K2E out of pit hauls
- incorporate material mapping and selective material placement to achieve the final landform requirements that support the PMLU design and confirm viability of achieving this placement.

Future iterations of the LOM Plan will aim to refine the above strategies and investigate other opportunities to reduce the size of final void areas on closure of the Mine.

4.1.4 Summary

In summary, at closure 11 of the 13 mining voids at Meandu Mine will have been completely backfilled to the final landform. Backfill material is primarily overburden/interburden spoil; however, selected voids have been/will be backfilled with waste streams from the CHPP and Tarong power stations. K2E and K4E pits will be partially backfilled with overburden/interburden; however, residual void spaces will remain at closure in these two pits.

The overarching closure objective for Meandu Mine is to achieve a final landform that is safe and stable for humans, stock and wildlife, is non-polluting and is able to support a sustainable PMLU as described in the EA. The following sections of the void closure plan summarise the findings of investigative work conducted at Meandu Mine, showing how the proposed closure strategy described above should meet the required objectives of the EA and the PRC Plan Guideline.

5 Geotechnical stability

Several geotechnical studies have been undertaken at Meandu Mine investigating geotechnical conditions of the *in-situ* geology and the excavated mine waste, including waste streams from the CHPP. This information was used to inform a geotechnical reference report on the proposed final landforms, including rehabilitated backfilled and final voids (Sherwood Geotechnical and Research Services, 2020). This document addresses stability of all operational highwalls and spoil dump faces, and has been supplemented with additional specific requirements addressing final highwalls (Henderson Geotech, 2020) and final spoil landforms (Henderson Geotech, 2021). The findings of these reports are summarised below to address requirements of the PRC Plan Guideline *Section 3.6.3 Voids*, specifically:

- *pit wall geotechnical and geochemical stability, considering the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events; and*
- *proposed final slope angles of high wall, low wall and end walls of each final void.*

The PRC Plan Guideline requires evidence of how the final void/s will achieve post-closure slopes that will exhibit stability characteristics consistent with the planning and design of the post-closure mine void, including mechanisms for achieving acceptable geotechnical stability. Where applicable, methods and techniques for achieving safe slopes must be detailed.

Hydrological modelling has ascertained that the final voids at Meandu Mine are not at risk of inundation by floodwaters (Section 8.1); therefore, the PRC Plan requirements for stability assessments on backfilled material or final void walls are not relevant to Meandu Mine.

5.1 Final landform geometry

The current LOM Plan has established a final landform that is intended to meet the mine closure goals set in the EA EPML00709113 for the Meandu Mine, namely to achieve:

- a landform for final land uses that are:
  - safe to humans and wildlife
  - non-polluting
  - stable; and
  - able to sustain the PMLUs.

Meandu Mine has established reference geotechnical design parameters to derive recommended final landform slopes that are designed to meet the closure goals. The final landform geometry derived from the LOM Plan is shown in Figure 5.1 and has been designed so that the reshaped landforms will meet the geotechnical design parameters. Minor subsequent amendments have been made to the landform to tailor specifically to mine progress, and to ensure achievement of appropriate cover and drainage objectives.

The geotechnical design parameters were established in 2009 using historical geotechnical information, operational geotechnical experience and observational site experience. The parameters have been reviewed periodically as greater operational experience with the site geology has developed, particularly regarding the weathered materials. The most recent update was by Sherwood Geotechnical and Research Services in October 2020 (Sherwood Geotechnical and Research Services, 2020). These design requirements apply for all operational highwalls and spoil dumps. Specific additional requirements apply for final highwalls (particularly addressing upper Tertiary horizons).

The geotechnical design parameters have been based on a combination of material testing, slope stability analysis, prior design and operating experience. The resultant slope designs are intended to provide an acceptably low likelihood of ground instability and an acceptable basis for control of rockfall risks.

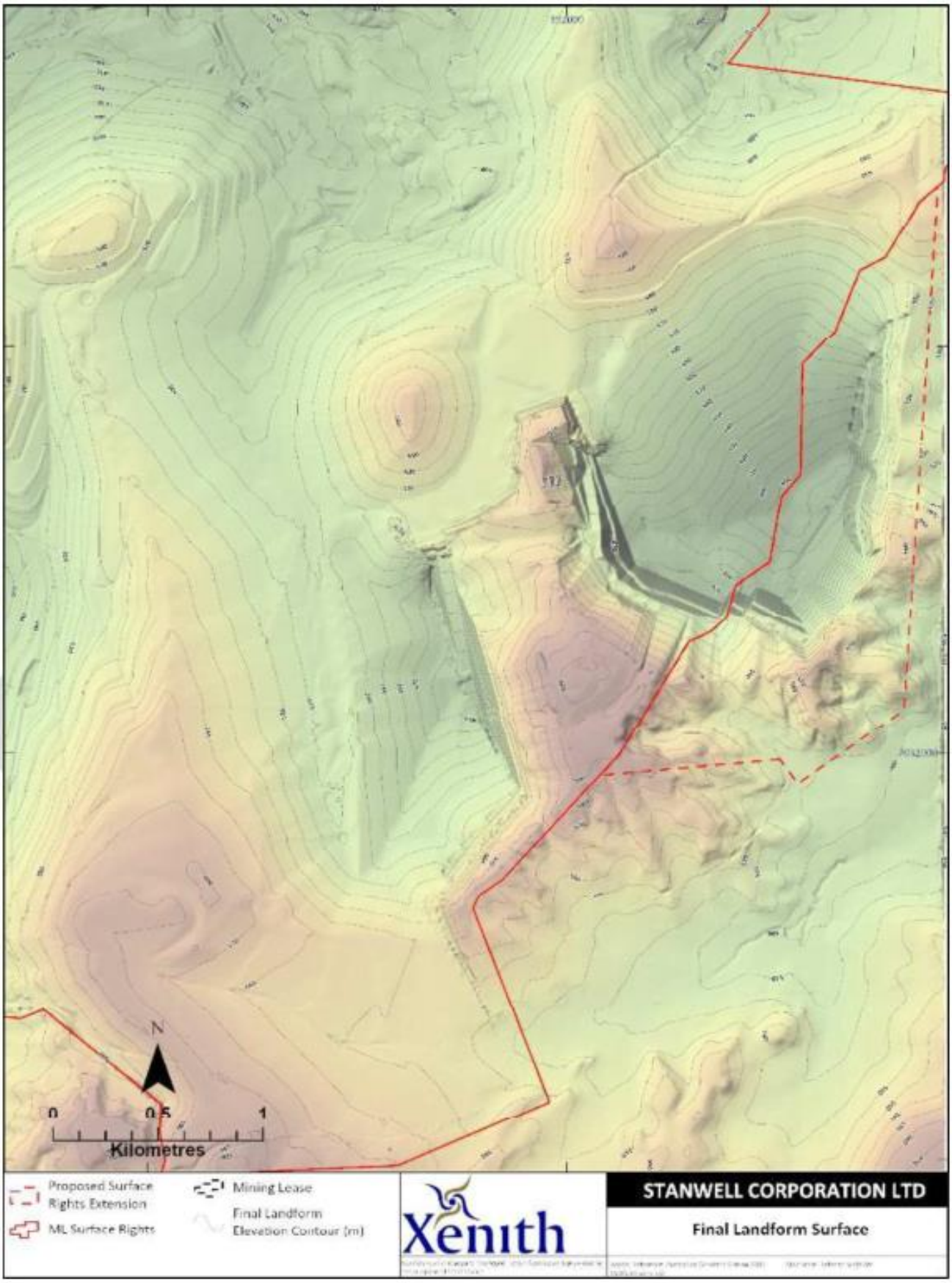

Figure 5.1 Meandu Mine final landform

The final landform slopes are described in Sections 5.1.1 and 5.1.2. The geotechnical data supporting the design is contained in Sherwood Geotechnical and Research Services (2020); however, the slope stability analyses are discussed in Section 5.2 and address requirement of the final highwall design (Henderson Geotech, 2020. Spoil landforms also meet requirements for geotechnical stability (Henderson Geotech, 2021).

5.1.1 Final void highwalls and endwalls

The geotechnical properties of the excavated highwalls and endwalls[4] for ongoing operations are dependent on the lithology of the exposed material on the wall. Geotechnical recommendations for progressive operational excavated slopes are based on a combination of back analyses of prior instabilities, design analyses based on adopted strength parameters, and observations of slope profiles that have demonstrated acceptably stable performance. The operational slope profiles are assessed to have a minimum FoS of 1.2, while the final highwalls and endwalls require a minimum FoS of 1.5 when assessed at the projected pit crest. The setback line associated with FoS 1.5 has defined the final void boundary. Depending on local geotechnical conditions and associated remediation works, the actual final highwall crest may be located between the as-mined position (designed according to the Geotechnical Reference Report) and the projected stable pit crest (at the FoS 1.5 setback line and in accordance with the final highwall report requirements).

For excavated slopes, industry-accepted definitions of slope components are set out in Figure 5.2, where:

- Batter Angle (BA) is the angle of a single batter
- Inter-Ramp Angle (IRA) is the toe-toe angle between a design sequence of catch benches between separating benches, ramps or haul road benches
- Overall Slope Angle (OSA) is the overall slope angle between toeline and crestline
- Bench Height (h) is the height of a single batter
- Inter-Ramp Height (irh) is the height of a design sequence of catch benches between ramps; and
- Overall Slope Height (H) is the overall height between slope toeline and slope crestline.

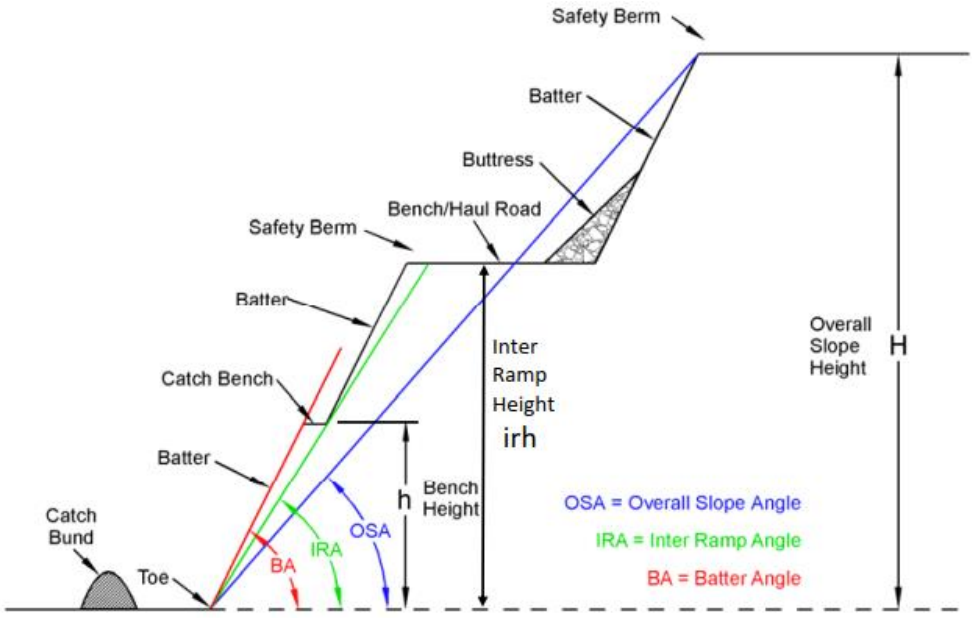

Figure 5.2 Industry definition of excavated slope geometry terms

[4] Note endwall slope design and stability assessment at Meandu Mine is the same as for highwalls; therefore, references to highwalls in this section also refer to the endwalls.

Where the upper pre-strip zone comprised of Miocene clays, Miocene weathered (extremely weathered (EW) and distinctly weathered (DW)) basalt, other volcanics and low strength sediments, and excavated faces in rehandled spoil, the slope angles and maximum slope height without a catch bench will vary with the specific lithology. The design slope and heights for these materials are listed in Table 5.1.

For all other excavated slope conditions, the design slope and heights are listed in Table 5.2. These tables provide recommended slope geometry limits which are deemed to comply with requirements for adequate stability provided that placement complies with Standard Operating Procedures and that the slopes are excavated in accordance with design.

Table 5.1 Meandu Mine upper prestrip excavated slope profile design parameters (refer to text for definition of slope terms)

Material	max. OSA	max. IRA	max. BA	max. h	max. irh	max. H
Miocene clays (red or mottled in K2E & K4E)	28°	28°	70°	6 m	24 m	48 m
Miocene EW-DW basalt, EW-FR reticulites, tuffs, ash beds, other sediments)	37°	37°	70°	6 m	24 m	48 m
Excavated Spoil (all sources mixed)	37°	37°	70°	12 m	48 m	72 m
Excavated Spoil (Triassic only)	45°	45°	70°	12 m	48 m	96 m

Table 5.2 Meandu Mine basalt and Triassic lithologies excavated slope profile design parameters

Material	max. OSA	max. IRA	max. BA	max. h	max. irh	max. H
Miocene (SW-FR basalt only)	70°	63°	70°	48 m	144 m	288 m
Triassic (EW-DW, all lithologies)	45°	45°	70°	12 m	60 m	120 m
Triassic (SW-FR, all non-coal lithologies presplit)	70°	70°	70°	72 m	72 m	144 m
Triassic (SW-FR, all non-coal lithologies softwall)	45°	45°	45°	72 m	72 m	96 m
Ace Coal roof to King Coal floor (SW-FR non-coal) Triassic Coal (SW-FR)	80°	80°	80°	48 m	72 m	96 m
Triassic King-Queen presplit (SW-FR)	70°	70°	70°	72 m	72 m	144 m
Queens Coal roof to floor (SW-FR non-coal)	80°	80°	80°	48 m	72 m	96 m

SW – slightly weathered; FR – unweathered; DW distinctly weathered.

5.1.2 Void low-walls and rehabilitated backfilled voids

As described in Section 4.1, mining practices have minimised the residual void areas at closure by the progressive backfilling of exhausted mine voids with mine spoil (and waste streams from the CHPP and ATP as appropriate). The final voids are also backfilled with spoil either stockpiled for the purpose or pushed down from the low-wall to minimise volume and depth. The placement of waste, decommissioning and rehabilitation of the backfilled voids have been designed and implemented to generate stable landforms post-closure. Specific strategies and procedures are described in Section 4.1.2. This approach to minimise void space at mine closure has the following results:

- The low-walls in the two final voids (K2E and K4E) will be formed of backfilled overburden/interburden and will be rehabilitated according to the general rehabilitation requirements for the PMLUs Native Ecosystem (K2E and K4E) and Beef Cattle Grazing (K4E only). The littoral zone for the Water Storage PMLU in each void will be revegetated in accordance with the Revegetation Management Plan, selecting a seed mix suited to periodic inundation.
- The backfilled voids will be capped and covered in accordance with the requirements of the relevant waste stream covered and the PMLU, including NAF layers and compacted NAF layers over tailings and coal combustion products. These voids will also be rehabilitated in accordance with the general rehabilitation requirements for the PMLUs Native Ecosystem and Beef Cattle Grazing.

Reshaping will be performed by dozers and scrapers to achieve the final landform. Preparation includes shaping the slope to achieve specifications outlined in the EA, contour bank construction and drain shaping. Final landform slopes (excluding final highwalls) are generally designed less than 17%, with minor areas up to a maximum of 25% to achieve tie-in with surrounding areas in accordance with EA criteria, which states that 80% of slopes in the Beef Cattle Grazing PMLU are ≤ 15%.

The average overall slope of the proposed final landform design is generally 14%. Minimum specifications for drainage structures are site-specific and determined through hydrologic and hydraulic assessment. The main objective is landform stability, which may include the removal of drainage structures (e.g. contour banks) at closure.

Contour banks will be aligned with the contours on either side of the area to ensure correct drainage and are generally 1 m high with a back slope of 17%. Contour banks are generally constructed with a longitudinal grade of approximately 1% with no ponding. This profile may be revised provided it satisfies the hydraulic capacity/stability criteria for contour banks and includes adequate freeboard to allow for settlement and sedimentation, details of which are included in the Rehabilitation Management Plan and Monitoring Program (Stanwell, 2021).

The decommissioning phase of the TSFs, including the historical NWB TSF, current K2W-N and future K4S storages includes settlement time period of approximately 18 months and, for the coal combustion products (whether with near surface underlying tailings or not), a desiccation period also of 18 months (Section 4.1.2). Geotechnical assessment is proposed post the settlement period to confirm that the tailings and coal combustion products have had sufficient time to stabilise and that no significant further settlement and subsidence is likely to occur before capping and cover materials are placed on the waste. This minimises the risk of instability of the final landform leading to movement of cover material and subsequent erosion, potentially compromising the cover over the waste.

5.1.3 Summary

The geotechnical design parameters for the excavated slopes described in Section 5.1.1 are considered suitable for the PMLU criteria for Steep Rocky Ecosystems as prescribed in EA EMPL00709113. Details on the slope stability analysis conducted in development of the LOM Plan underpinning the PRC Plan to confirm this assumption are included in Section 5.2.1.

The final landform is designed such that the slopes of rehabilitated areas over backfilled voids will meet the EA and PMLU criteria. Decommissioning of the TSFs / coal combustion product storage areas allows sufficient time to settle the material and minimise the risk of future subsidence. Slope stability analysis of the rehabilitated landforms is described in Section 5.2.2. Short-term and long-term erosion modelling has also been conducted on the final landforms, which is described in Section 6.

5.2 Slope stability analysis

Slope stability analysis has been conducted on existing and final landforms at Meandu Mine to provide a geotechnical assessment of the safety of the existing landforms (excavated slopes and placed spoil dumps) and inform the final LOM Plan with regard to long-term stability of the proposed final landforms.

Analyses were done by calculating the FoS for the modelled slopes. FoS is essentially a ratio of the strength available to hold a slope in place divided by the stresses tending to move, or destabilise, the slope. A minimum FoS of 1.5 (assessed at the projected stable pit crest) has been prescribed in the EA EMPL00709113 as the required long-term measure of stability, which represents a probability of failure of <0.1% (Henderson Geotech, 2020). Operational highwalls are designed according to the GRR that provides a FoS of 1.2. While the projected FoS setback line has defined the final void boundary and been used to assess its proximity to the lease boundary and key assets, the actual final highwall crest may be located between the FoS 1.2 design and FoS 1.5 projected setback depending on local geotechnical conditions.

5.2.1 Highwalls

Geotechnical stability of the final highwalls at Meandu Mine was assessed using limit equilibrium slope stability analysis for the range of materials and pit wall geometries described in the geological model and 2019 LOM Plan (Henderson Geotech, 2020). The stability criteria that were developed were then used to evaluate the proposed final highwalls for the 2021 LOM Plan.

Methodology and assumptions

Strength properties were collated for the various overburden and interburden materials encountered at Meandu Mine, derived from laboratory testing, back-analysis of slopes and operational experience. Material strength properties are listed in Henderson Geotech (2020). As active and future pits (K2E and K4E) have not yet reached their final void locations, no analyses was undertaken for specific actual final highwalls; instead stratigraphies for proposed wall locations were extracted from the geological model and existing operational wall geometries were applied over the range of configurations expected.

Groundwater levels in the model profiles were conservatively assumed to be at the base of weathering and a steady state finite element water pressure analysis was run for a typical highwall geometry to estimate the drawdown curve behind the void highwalls (Figure 5.3).

Limit equilibrium analyses were undertaken using the Slide™ V6.039 software package; the computational options are described in Henderson Geotech (2020). Six locations were selected along the final highwalls of K2E and K4E pits as shown on Figure 5.4, and final highwall geometries were created for each location in accordance with operational highwall designs (Section 5.1.1) and the Meandu Mine geological model. The cross-sections covered a wide range of overburden configurations, with lithological thicknesses varying from 0–90 m of residual soil, 10–120 m of weathered rock and 160–300 m pit depths.

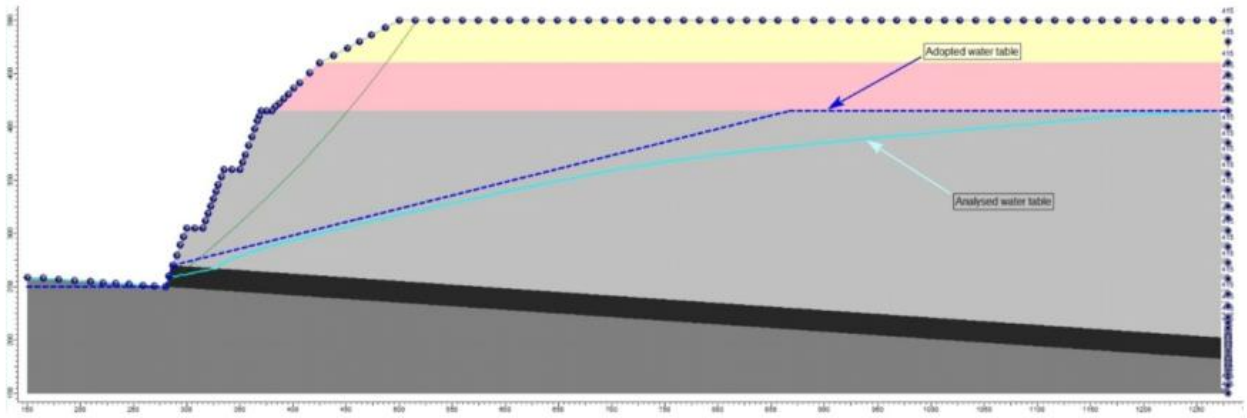

Figure 5.3 Stability analysis surface showing analysed water table and water table adopted for modelling (Henderson Geotech 2020)

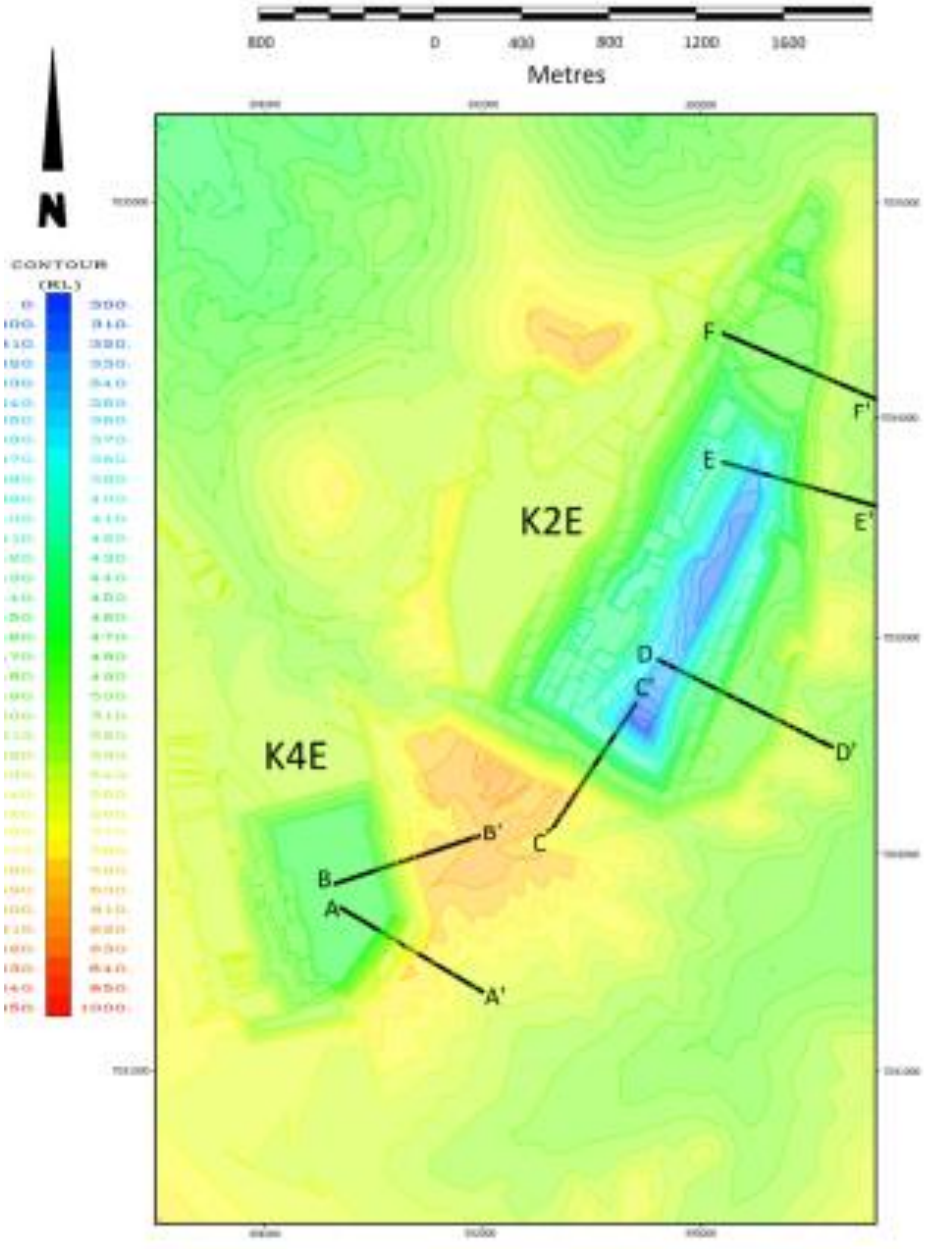

Figure 5.4 Meandu Mine highwall sections used in geotechnical stability analysis

Results

The stability analyses found that the safety envelope that provided a FoS of 1.5 was driven by the depth of the final pit coupled with the depth of weathered overburden in the final wall. Set-backs from the pit toes to attain a FoS of 1.5 range from 176 to 516 m (Henderson Geotech, 2020). Selected results are shown as cross sections in Figure 5.5 and Figure 5.6, indicating a set-back of 408 m from the toe in K4E pit and 211 m from the toe in K2E pit.

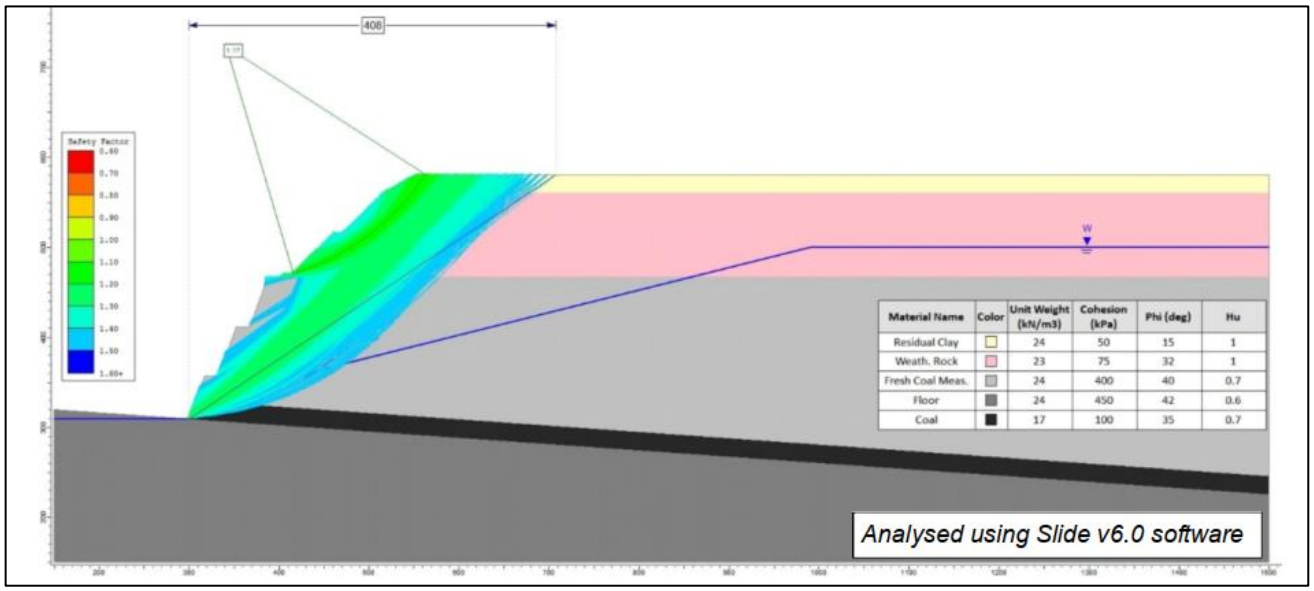

Figure 5.5 Slope stability analysis results for Section A, K4E final highwall

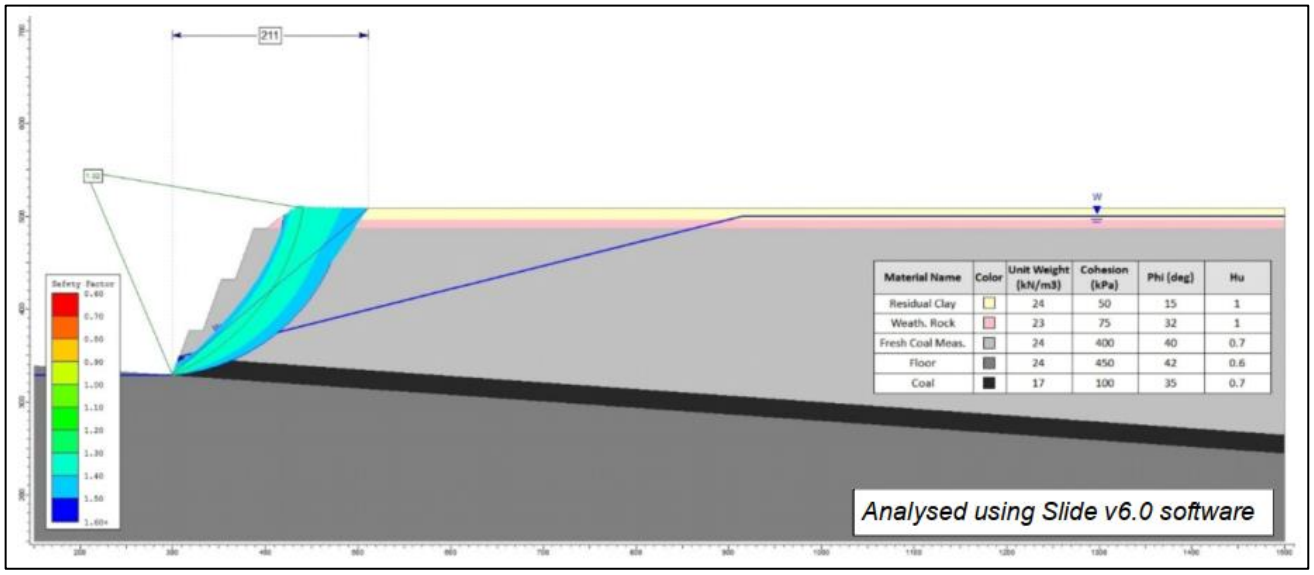

Figure 5.6 Slope stability analysis results for Section D, K2E final highwall

The FoS 1.5 set-backs are located 80–200 m behind the physical crest of the highest remaining bench in the final voids and represent the projected stable crest. Therefore, the boundary of the Steep Rocky Ecosystem PMLU footprint is assigned at the set-back distance from the physical crest to ensure no third-party assets or significant environmental values are located within the setback encompassing potential slip failures with a FOS <1.5. A nominal 50 m buffer has been provided between the Steep Rocky Ecosystem PMLU and the surface rights area boundary as a contingency.

Statistical regressions were performed on the results and the output equations were adjusted to provide slightly conservative predictions for set-back, as shown on Figure 5.7. The variables are illustrated on Figure 5.8. Set-backs from the final void highwalls have been calculated to meet the required FoS for the projected stable crest, with the Steep Rocky Ecosystem PMLU boundary defined by the set-back distances. In some instances, the final highwall bench and lift design was altered to ensure the final highwall configuration achieved the required FoS at an acceptable offset distance from the surface rights area boundary.

Quality assurance checks were conducted on the final landform 2021 LOM pit shell by cutting cross-sections at various locations along the final walls (refer Figure 5.9 for locations) and undertaking manual calculation verification to address the final highwall geotechnical criteria described above. All locations comply or are within acceptable tolerance of design criteria for the purposes of PRC Planning and will be reviewed in detail at the time of development of each final highwall. This indicates that geotechnical stability will be achieved at the nominated projected crestline and adequate standoffs to key assets have been considered.

Minimum set-back from wall toe: **S = maximum of (S3 S2 + Wf *and* S1 + Wf + Ww)**

Where:

S3 = 2.7*Tm + 2.2*Tw + 1.5*Tf – 70

S2 = 4*Tm + 2.3*Tw + 9.8*Tm/Tw – 32

S1 = 5.1*Tm – 59

Tm = *thickness of Miocene sediments (residual soil and completely weathered rock)*

Tw = *thickness of highly and moderately weathered coal measure rocks*

Tf = *thickness of slightly weathered and fresh coal measure rocks within the wall profile*

Wf = *horizontal distance from the wall toe to the top of slightly weathered and fresh coal measure rocks on the wall face.*

Ww = *horizontal distance from the base to the top of highly and moderately weathered coal measure rocks on the wall face*

Figure 5.7 Final highwall minimum set-back calculations

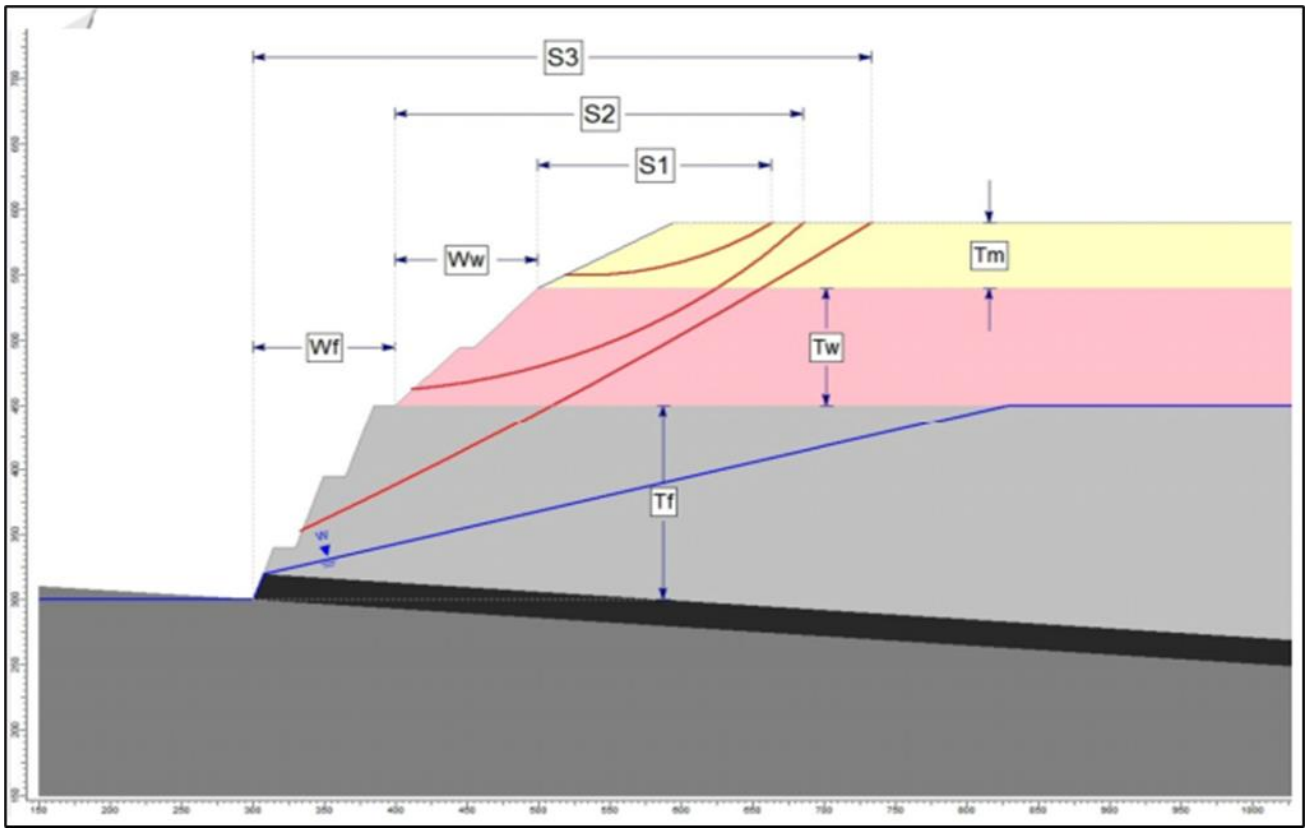

Figure 5.8 Definition of highwall stability parameters (Henderson Geotech, 2020)

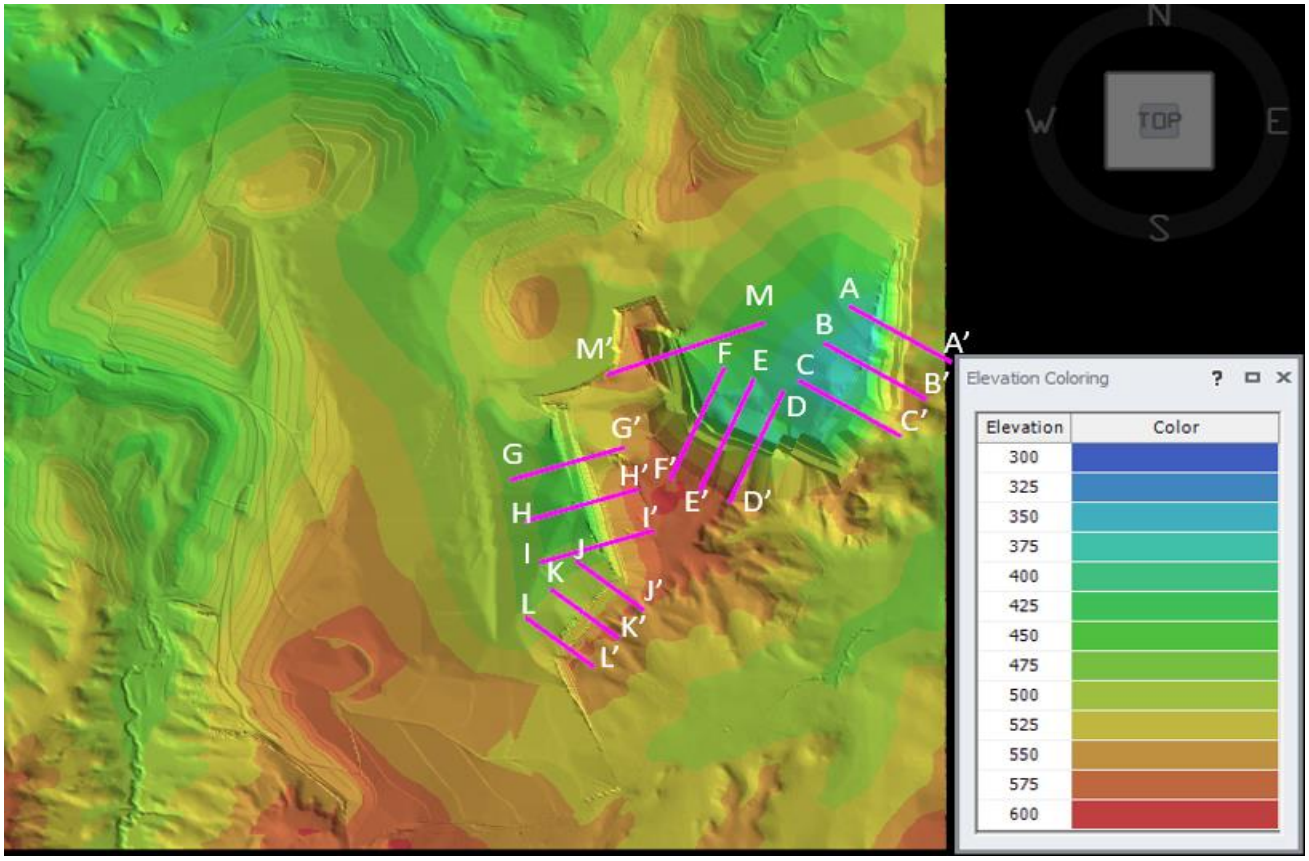

Figure 5.9 Meandu Mine final highwall stability analysis locations

5.2.2 Rehabilitated spoil landforms including low-walls

Geotechnical stability assessments of rehabilitated spoil landforms at Meandu Mine were conducted using limit equilibrium slope stability analysis for the range of likely spoil materials and final landform geometries described in the geological model and LOM Plan (Henderson Geotech 2021).

5.2.2.1 Out-of-pit landforms

Methodology and assumptions

Analyses were not conducted on specific actual landforms, rather on various possible configurations of waste material and rehabilitated spoil landforms for both out of pit and in-pit scenarios. The in-pit scenarios were designed to model the low-walls of partially backfilled voids rather than completely backfilled voids; therefore, the out-of-pit modelling has been considered in this section as representative, as the backfilled pits will be covered with rehabilitated landforms of similar design to the out-of-pit rehabilitated spoil landforms at the Meandu Mine.

Strength properties for the various spoil and overburden material encountered at Meandu Mine were collated from laboratory testing, back-analysis of slopes and site experience. To constrain the large range of material combinations possible, the study considered two main spoil types and the three weakest overburden strata, which provides a conservative assessment of likely spoil pile strengths.

The geometries of rehabilitated spoil piles as determined by the LOM Plan have a maximum height of approximately 130 m with a maximum slope of 25% but generally slopes of <17%. Angle of repose spoil slopes are stable as-dumped but may experience slip failures if conditions change, such as an increase in moisture in the spoil. Typically, they have FoS slightly greater than 1; stable but only by a small margin. Operational experience suggests that reducing the slope angles from 60% (repose) to <25% greatly increases the margin against instability. From this rationale, the FoS were first analysed using Galena™ slope stability software, with the Spencer-Wright circular failure surface method applied against a least-favourable credible configuration; if this profile achieved a FoS of >1.5 then the range of planned rehabilitated spoil heights and slopes would also meet the standard of FOS >1.5, and therefore also meet the PMLU criteria.

Initial conditions assumed for the least-favourable rehabilitated configuration were:

- height – 100 m
- slope – 25%
- material – saturated mixed spoil
- depth of residual clay under landform – 50 m; and
- rock type beneath residual clay – weathered Triassic coal measures.

Subsequent sensitivity analyses were run using Slope2 slope stability software for out-of-pit dumps up to 130 m high above in-situ ground with slopes that were over backfilled pits to varying degrees, using the other worst-case parameters previously selected.

Results

The profile and result for the least-favourable out-of-pit rehabilitated configuration with the initial 100 m dump height and 50 m of basal clay is shown on Figure 5.10, which shows a predicted minimum FoS of 1.72, greater than the minimum criteria of FoS of 1.5.

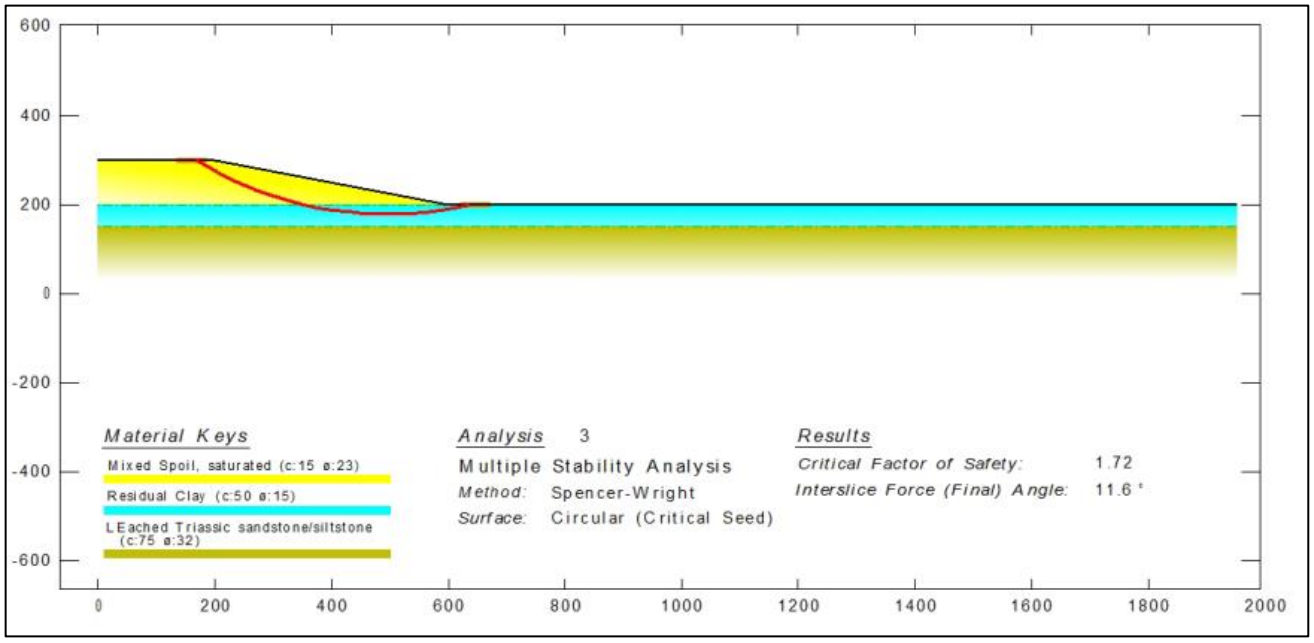

Figure 5.10 Stability analysis for Meandu Mine out-of-pit rehabilitated landform – least favourable configuration.

The sensitivity analysis results using a maximum dump height of 130 m for a dump completely out of pit returned a minimum FoS of 1.64 (refer to Figure 5.11). These results demonstrate adequate geotechnical stability for the proposed rehabilitated landforms over backfilled voids.

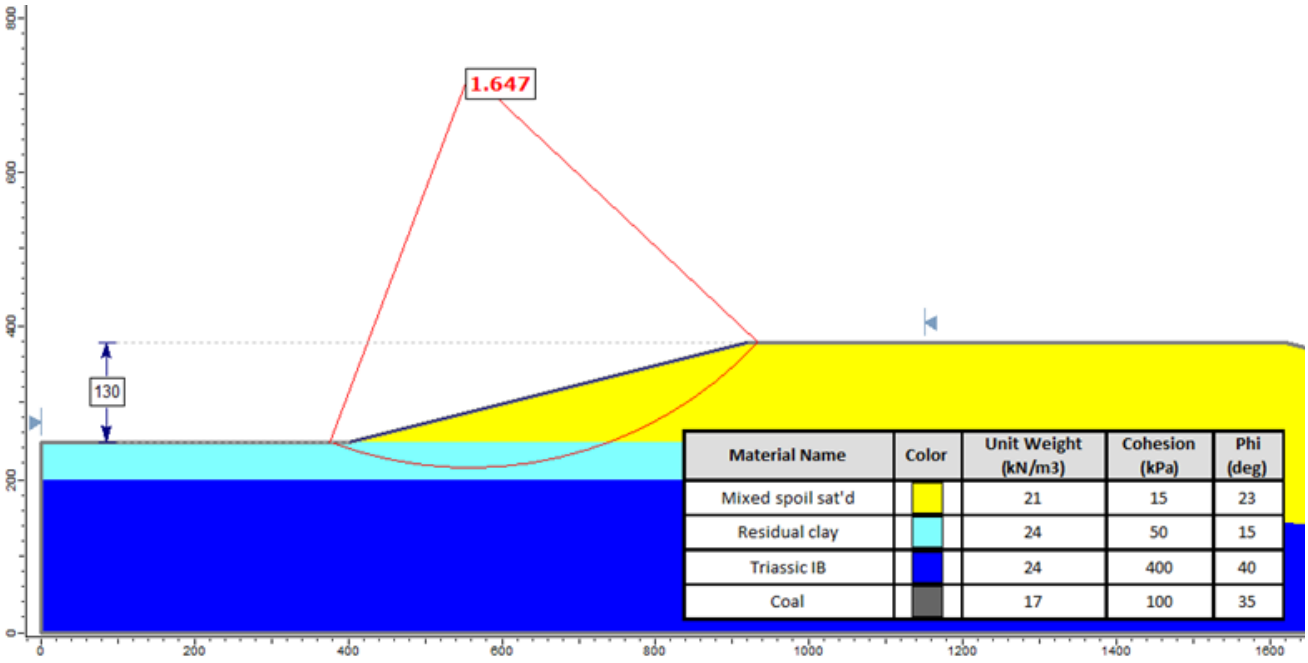

Figure 5.11 Stability analysis for Meandu Mine out-of-pit landform, sensitivity analysis

5.2.2.2 Void low-walls

Methodology and assumptions

Where spoil piles are planned to remain as the low-walls in final voids, factors additional to those considered for out-of-pit landforms need to be considered, such as pit slope, height of spoil keyed against the highwall and water table in the final void. Some of these have conflicting effects, for example water reduces the spoil strength but the weight of water in the void also counteracts some of the destabilising weight of the spoil. Consequently, a worst-case scenario could not be confidently predicted in advance of analysis.

The methodology adopted was to vary the void water level with all other parameters held constant in order to determine the water level that produced the lowest FoS. This was then held constant while landform height was varied. Finally, using the worst combination of landform height and water level, floor dip and slope were varied separately. Maximum values for certain parameters were set at the design parameters for final rehabilitated landforms, as follows:

- maximum height of low-wall above final mined floor – 370 m
- maximum slope – 25%; and
- maximum pit floor dip - 9°.

The Spencer-Wright circle method was used successfully in most scenarios; however, a few scenarios failed to converge to a sensible minimum FoS. These scenarios were re-run using Slide™ V6.039 software package.

Results

Results for void low-wall analyses are shown on Figure 5.12 and Figure 5.13. All modelled configurations for rehabilitated low-wall spoil slopes had FoS greater than 1.5. The most adverse water table was 100 m above the pit floor. Low-wall height only had an effect at lower heights. Floor dip also had a minimal effect, whereas landform slope had the most significant impact of FoS.

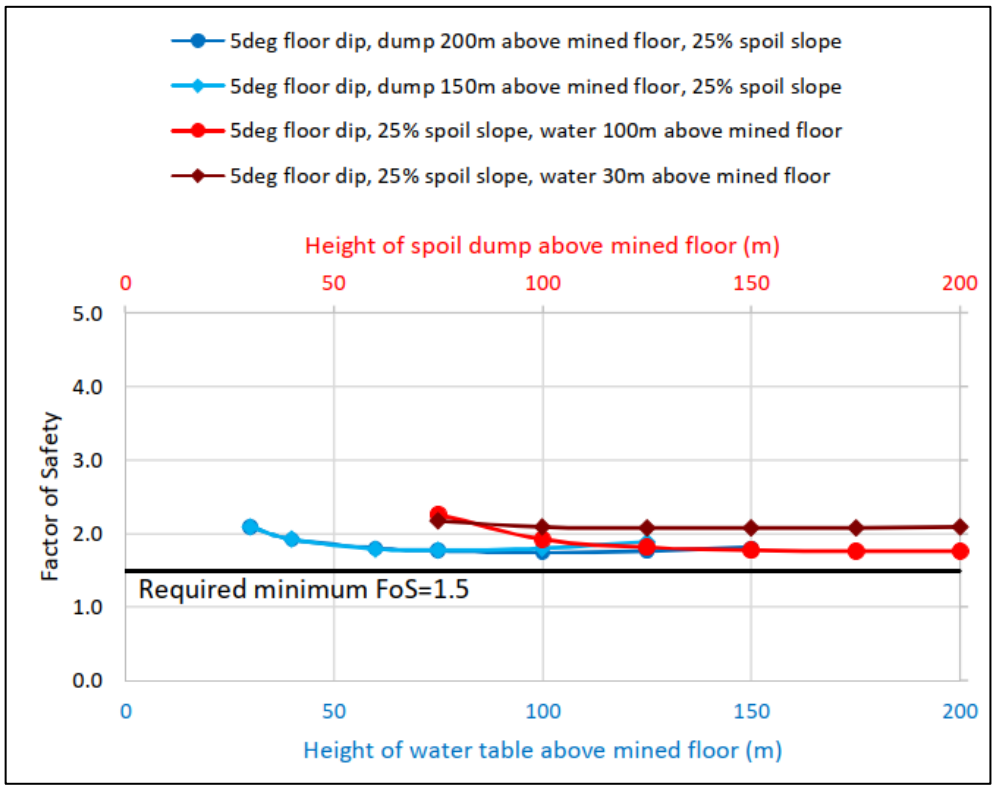

Figure 5.12 Effects of water table and spoil dump height on low-wall spoil stability

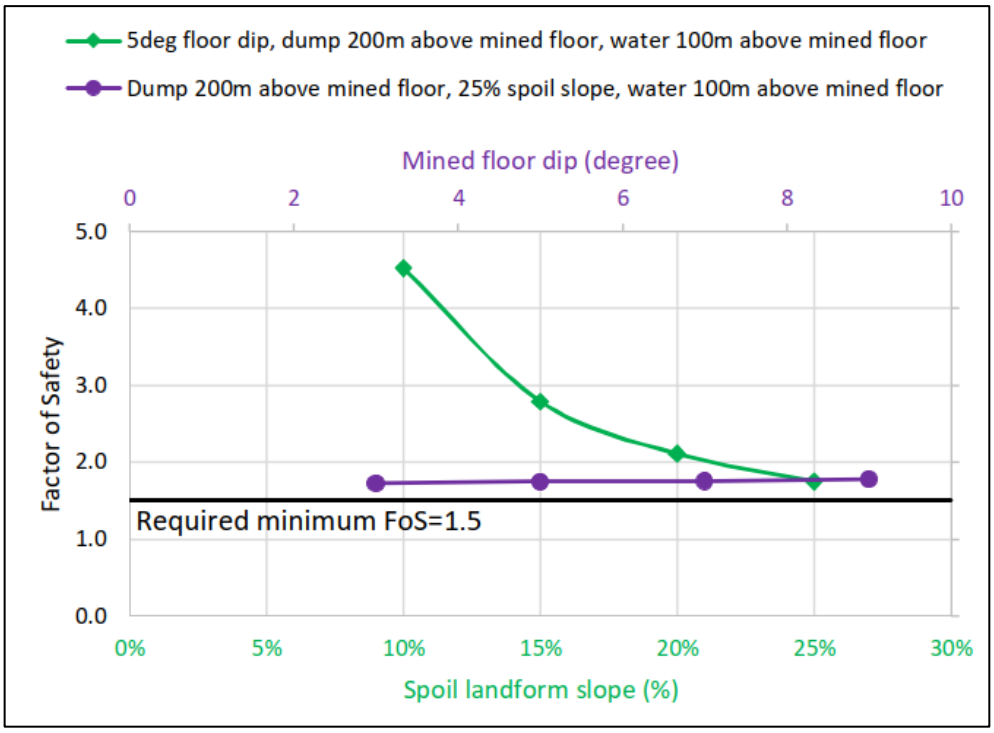

Figure 5.13 Effects of floor dip and slope angle on low-wall spoil stability

5.2.3 Summary

Final landform designs have been proposed that meet the requirements of the PRC Plan Guidelines for the PMLUs from a geotechnical perspective. Set-backs from the final void highwalls have been calculated to meet the required FoS for the projected stable crest, with the Steep Rocky Ecosystem PMLU boundary defined by the setback distances. Consequently, the volumes and characteristics of waste reflected in the LOM Plan are representative of final highwall design and volumes.

Based on the limit equilibrium analyses performed, the proposed final rehabilitated spoil landform designs exceed the minimum required FoS of ≥ 1.5 for long-term geotechnical stability both in-pit and out-of-pit and are therefore considered to meet the PMLU criteria.

6 Erosion modelling

Long-term erosion modelling has been conducted by Landloch (2022) to assess the performance of the final landform design post-closure in accordance with *Section 3.6.1 Landform design* of the PRC Plan Guideline. This modelling has included the landforms over the rehabilitated backfilled voids. Modelling was conducted in two stages:

1. two-dimensional Water Erosion Prediction Project (WEPP) Modelling (Landloch, 2021), which was calibrated by laboratory testing of site soil samples, and subsequently provided input and calibration for
2. three-dimensional landform evolution modelling utilising software package SIBERIA (Landloch, 2022).

Landloch used the following approach to the modelling:

- use data from previous erosion investigations on Meandu Mine soils used in rehabilitation as growth media to derive WEPP model parameters
- run the WEPP model to generate data sets of runoff and erosion for slopes and materials of interest using site specific climate data; and
- analyse the WEPP output to derive the landform evolution modelling parameters for SIBERIA.

A limitation of the above modelling is that the final highwalls forming the Steep Rocky Ecosystem PMLU were not specifically evaluated in the SIBERIA erodibility assessment conducted by Landloch due to:

- the varying strength properties associated with the different *in-situ* lithological units
- the difficulty in accurately modelling final highwall erosion
- the time and cost of undertaking such modelling; and
- preceding work listed below with respect to ACARP Project C26019 and the 2022 work with Central Queensland University.

The ACARP Project C26019 published in July 2018 used SIBERIA modelling to assess long-term erosional stability of as-mined highwalls that had not been disturbed for a number of years. This study included a highwall section at Meandu mine, which now incorporates reference sites for the monitoring trial of the Steep Rocky Ecosystem PMLU. Some nine cross-sections through highwalls in different pits were considered in the study, with five evaluated in detail. One section where sufficient high resolution survey data was available was also modelled in SIBERIA. Results of evaluation from the Project report suggest that steeper excavated batters will generally reduce to a shallower wall angle over the long term and that there will be some crest lowering as this occurs and the wall angles average out closer to angle of repose. The highwall crest could be expected to retreat by approximately 10 m in the weathered Triassic material and 30 m in the more erodible Tertiary material over 200 years, with some localised additional retreat associated with topographical or geological features. As a result, the evaluated crest retreat has been more generally accommodated within the projected stable pit crest setback that achieve a FOS of 1.5 for all final highwalls in the K2E and K4E pits.

Information on landform evolution of these final highwalls and how it will influence the Steep Rocky Ecosystem PMLU is considered in the report by Central Queensland University (CQU 2022). This report includes the development of a conceptual landform model for the Steep Rocky Ecosystem landscape, important components of which are the natural weathering and resultant transport of coarse (rock fall) and fine (erosion) materials and the accumulation of talus and sediment allowing soil development and vegetation establishment.

Landform erosion and soil generation is an essential requirement to support the development and sustainability of the Steep Rocky Ecosystem PMLU. Rehabilitation trials have been proposed for the Steep Rocky Ecosystem PMLU which will include erosion monitoring and ongoing geotechnical stability assessment to ensure natural erosion of the highwalls will not compromise geotechnical stability (which is in itself a success criterion for the PMLU).

6.1 Water erosion prediction modelling (WEPP)

The WEPP runoff/erosion model (the WEPP Model) is a two-dimensional hillslope model, initially developed for agricultural purposes by the United States Department of Agriculture. The WEPP Model integrates hydrology, vegetation science, hydraulics and erosion mechanics to predict erosion at the hillslope and watershed scale. The WEPP Model has been used in the design of landforms for mines across Australia.

The WEPP Model was used to simulate final landform stability parameters for a 100-year period including data for rainfall, runoff, and sediment loss for the final project landforms, including for the final voids. The WEPP Model was also used to determine percentage reductions in erosion rates from increasing vegetation cover.

6.1.1 Model design

The WEPP Model inputs include four key components: climate, soil properties, topography and surface conditions. Site specific climate data was derived from BOM and SILO databases. Soil properties were derived from previous studies of material characterisation and erodibility on the two main soil types found at the Meandu Mine (grey loams derived from sedimentary lithologies and red clay loams to light clays derived from deeply weathered basalts).

Rainfall simulation was applied on soil plots and flumes in a laboratory environment at 20% gradient with sediment runoff measured gravimetrically, to provide accurate soil erosion parameters and rates to apply to the WEPP Model for Meandu Mine. Acceptable slope lengths were determined for varying gradients and ground cover levels, the results of which were used as inputs for the detailed final landform design.

6.1.2 Results

In the long term, ground cover levels of established rehabilitation areas are expected to be approximately 70%, based on rehabilitation monitoring supporting Meandu's 2021 rehabilitation certification application that included rehabilitation ranging in age from 9 to 24 years. At these cover levels, and to achieve a tolerable soil loss rate of 5 t/ha/year, the WEPP modelling indicated that slope lengths of up to 125 m should be suitable for ferrosol topsoil and that slope lengths of up to 70 m should be suitable for grey loams. (Landloch, 2021).

The WEPP model outputs, including acceptable slope lengths for carrying slope gradients, were used as inputs for the detailed final landform design in the 2021 LOM Plan. In turn, the long-term stability of the 2021 LOM Plan final landform design was then assessed using the landform evolution software package SIBERIA. The SIBERIA model was calibrated to the WEPP output parameters using a representative gradient of 14% and batter slope lengths of 45–90 m, producing the soil erosion parameters presented in Table 6.1, where m_1 = discharge component and β_1 = sediment transport rate coefficient.

Table 6.1 Soil erosion modelling parameters derived from calibration of the SIBERIA model to WEPP model outputs for Meandu Mine

Soil type	m_1	β_1
Red Clay	0.9191	0.00143
Grey Loam	1.2067	0.0004

6.2 Landform evolution modelling

The long-term development of landforms was simulated using the SIBERIA landform evolution model to estimate erosion rates and rill/gully development on final landforms over a period up to 500 years (Landloch, 2022). The SIBERIA model simulates runoff and erosion from a landform that evolves in response to predicted erosion and deposition. It is a three-dimensional topographic evolution model, which predicts the long-term evolution of channels and hillslopes in a catchment on the bases of runoff and erosion. The location and speed of development of gullies are controlled by a channelisation function that is related to runoff and soil erodibility. A surface may commence with no gullies, but when the activation threshold (which depends on discharge and slope gradient) is exceeded, a channel develops.

6.2.1 Model design

Erosion modelling was undertaken on the final landform design that was based on WEPP model outputs. SIBERIA is a long term model that is designed to represent a mature vegetation community; therefore it is more realistic to utilise the expected long-term ground cover levels. At Meandu Mine, this represents ground cover of 90% for the Native Ecosystem PMLU and 80% for the Beef Cattle Grazing PMLU. These are inputs that are based on monitoring results and observations, trajectories, and cover levels representative of similar land uses. Red clay soil was assigned to the Beef Cattle Grazing PMLU and grey loam for the Native Ecosystem PMLU.

SIBERIA predicts the long-term average change in elevation of a point by predicting the volume of sediment lost from a node. The rate of sediment transport through a node (q_s in units of m^3/year) is determined by the equation:

$$q_s = \beta_1 q^{m1} S^{n1}$$

where β_1 = sediment transport rate coefficient, q = discharge, m_1 = the discharge component, S = slope (m/m), and n_1 = the slope exponent.

SIBERIA does not directly model runoff, but uses sub-grid effective parameterisation which relates discharge to area draining through a point as:

$$q = \beta_3 A^{m3}$$

where β_3 = coefficient between discharge and area, A = area (m^2), and m_3 = exponent of the area in discharge.

To run SIBERIA, the parameters β_1, m_1, n_1, β_3 and m_3 are usually needed. However, if the batter area to be modelled is identical to the batter for which erosion data are available for calibration β_3 and m_3 can be taken as 1.0 and a value of n_1 = 1.5 can be adopted for situations where slope gradient does not affect slope erodibility. Therefore, the two key parameters that require derivation are β_1 and m_1, which have been derived from the WEPP modelling.

6.2.2 Results

The summary modelled erosion rates are presented in Table 6.2, with the location of erosion for the 500 year simulation shown on Figure 6.1 and Figure 6.2. The results assume that no maintenance or remedial action is undertaken to prevent or repair erosion development.

The erosion summary statistics indicate that where erosion occurs occasional gullies and common rilling can be expected. As a guide for future design, the SIBERIA modelling showed that the landform is stable in the long-term (erosion rates predicted to decline from an initial 5 t/ha/y in the first 100 years to approximately 2 t/ha/y over the next 400 years). Modelled maximum gully depth is 0.85 m to 1.19 m after 100 years, which is simulated to increase to 2.61 m after 500 years. Most gully development is less than 0.3 m deep after 500 years.

Table 6.2 SIBERIA modelling summary erosion statistics

Simulation year	Maximum gully depth (m)	95th percentile rill depth	Average erosion (t/ha/y)	Cumulative erosion (mm)
100	1.19	0.32	5.4	42
200	1.62	0.12	3.2	66
300	2.00	0.16	2.4	85
400	2.30	0.20	2.1	102
500	2.61	0.22	1.9	116

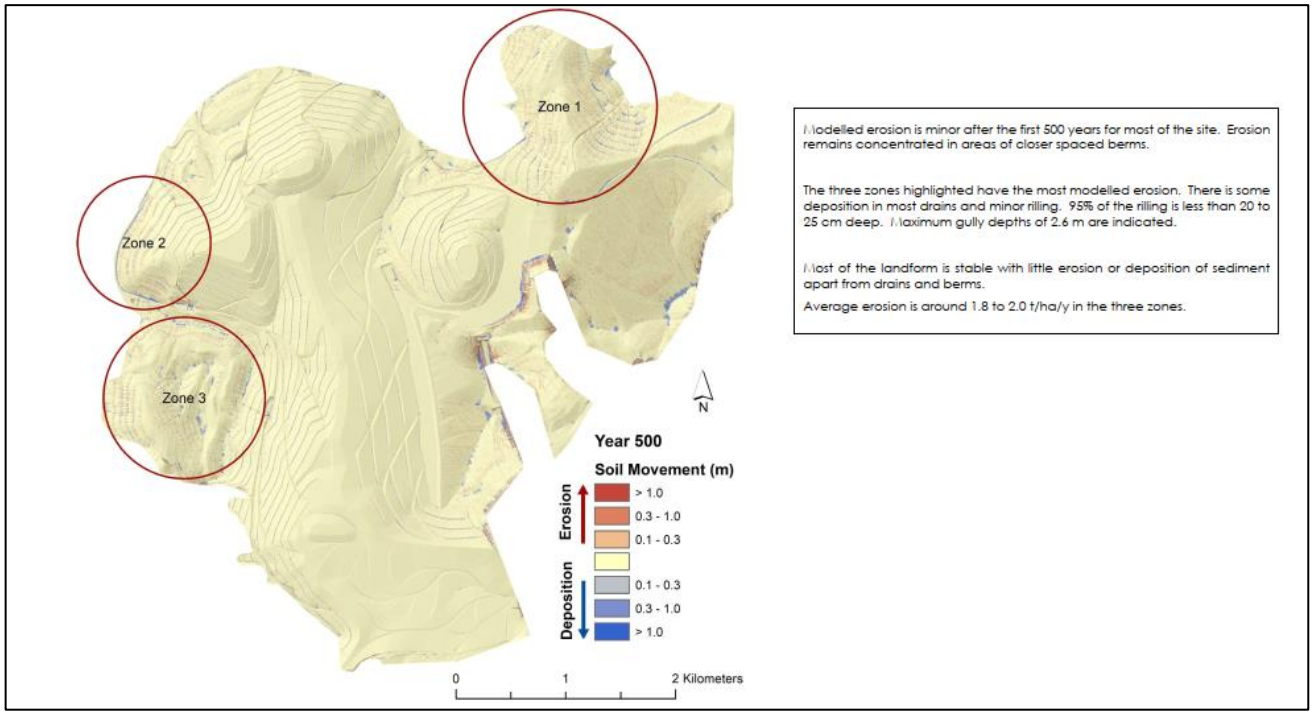

Figure 6.1 Meandu Mine SIBERIA modelled erosion after 500 years (Landloch, 2022)

6.2.3 Summary

The erosion modelling predicts that erosion rates should be near or below the rate of 5 t/ha/y for the 500 year timeframe modelled. This indicates that the current proposed final landform design is acceptable for a rehabilitated mine site and provided the assumed vegetation cover is retained, should allow for the sustained PMLUs of Beef Cattle Grazing and Native Ecosystems as prescribed in the EA. Modelling in SIBERIA will provide a guide to future design work, and to indicate the relativity in performance between areas in the model.

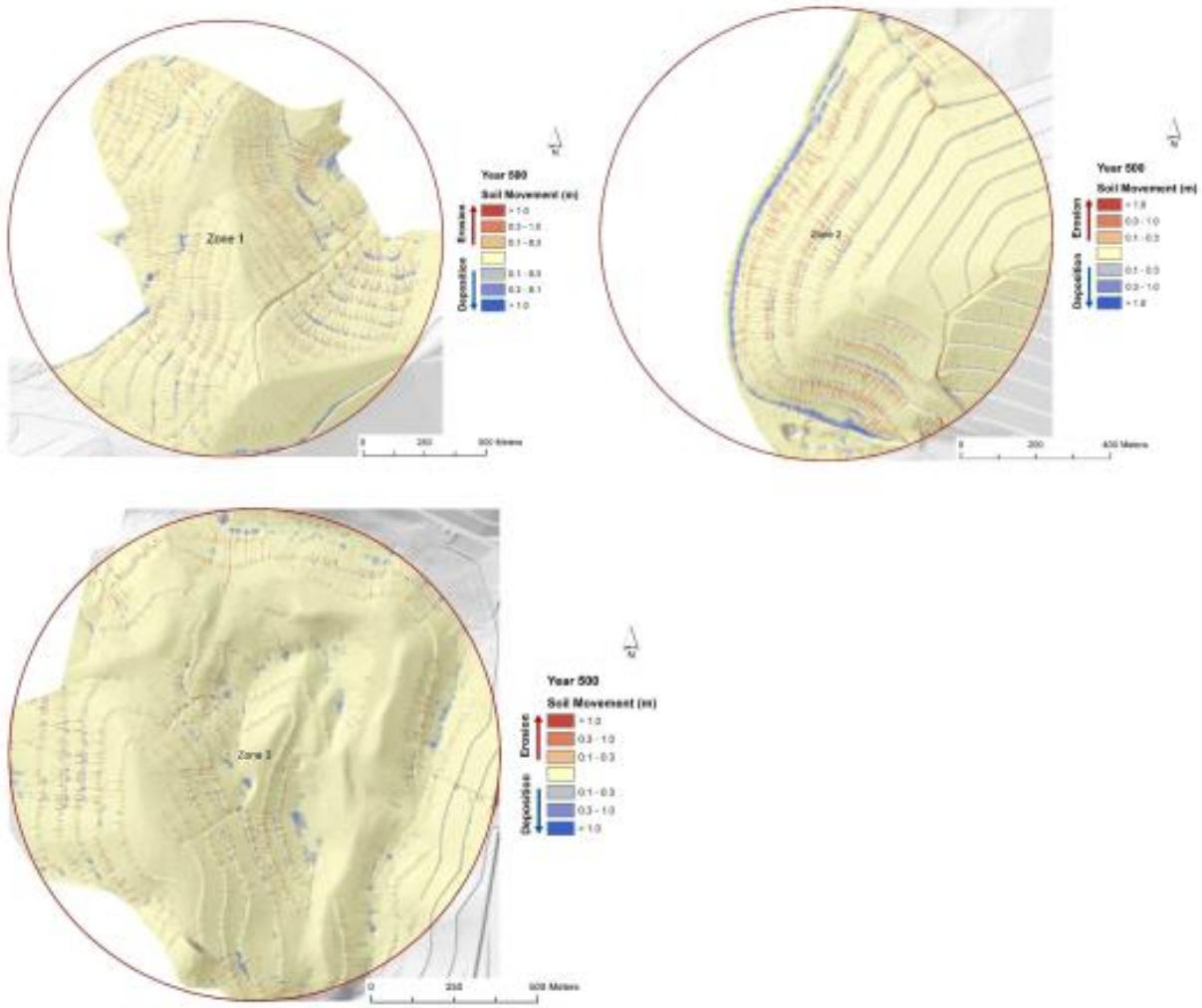

Figure 6.2 SIBERIA erosion modelling after 500 years – close up of areas with highest modelled erosion

7 Geochemical stability of mine waste material

7.1 Waste characterisation

Multiple geochemical waste characterisation studies have been undertaken at Meandu Mine since 1990, which has led to an evolving understanding of the geochemical behaviour of the rock at the mine, particularly the various waste streams. Many of the investigations were in response to AMD events and were focussed on identifying the source of the AMD; however, a more systematic program of geochemical testing has been implemented since 2016, creating a more comprehensive geochemical database of behaviours of the specific rock units and waste streams at the mine.

A waste characterisation report has been compiled based on the previous investigations to support the PRC Plan (WSP, 2021b). The report characterised the geochemical behaviour of the mined lithologies and generated wastes at the site by:

- assessment of historical surface water and groundwater quality for the 13 existing and former open pits, TSF supernatant and seepages at the Mine; and
- assessment of historical mineralogical and chemical studies at the site, including static and kinetic geochemical testing of mined lithologies and waste streams.

The results of the waste characterisation relevant to the Void Closure Plan are summarised in the following sections.

7.1.1 Surface waters

Assessment of historic surface water quality data for the 13 existing and former open pits, TSF supernatant and seepages at Meandu Mine indicated that the lithology at Meandu Mine has the capacity to generate acid, at least in some units. The propensity for acidic pit water appears to be geographically influenced, and possibly related to mine history and processes. The lowest pH and most persistent acidic pit waters were recorded early in the mine life in the northern (K1 and K2 pits) and NWA pit areas of the mine. The investigation into the acidic conditions in K1 pit water concluded the source of the AMD was linked to exposed and oxidised sulphides in coal in the pit face and mined overburden. The acidity appears to be associated with the upper Ace and King coal seams early in the mine life (WSP, 2021b).

Pit waters at Meandu Mine are generally circum-neutral (pH ~7) or slightly alkaline. Acidic conditions have not been measured in any pit water since 2004, which may reflect water management processes in the mine, but is also an indication that the lithologies mined since 2004 have a lower acid generating potential. Overburden/interburden spoil and exposed hanging wall pit faces have not created acidic conditions in Central, K4E and K4S pit waters for the life of either pit. In-pit acidic conditions have not been recorded in K2E pit since March 2000, despite the highwalls having been exposed to oxidation for several years.

Salinity was often elevated (electrical conductivity (EC) >3,000 microSiemens per centimetre (µS/cm)) early in the life of pits before steadily declining to lower levels, which suggests initial run-off into the pits might be saline due to mobilisation of readily dissolved salts precipitated on the rock and waste. Isolated events, where elevated EC readings were identified, were likely the result of evapoconcentration rather than run-off or seepage. Saline drainage may occur due to the mobilisation of sodium (Na^+) chloride (Cl^-) from both Tertiary and Triassic overburden/interburden, even in the absence of AMD.

In-pit SO_4^{2-} concentrations have been below the EA release point criteria (1,000 mg/L) in all pits throughout the mine life with only three exceptions, two of which (K2W and QW pits) are likely related to ash disposal rather than AMD. This indicates that:

- acidic pit waters have not led to elevated SO_4^{2-} concentrations; and
- elevated ECs are a result of sodium chloride (NaCl) mobilisation in surface run-off, seepage and process waters, plus evapoconcentration.

Elevated total concentrations of a number of metals (e.g., Ni, Fe, Co and Zn) have been detected in the pit waters, indicating that the waste and overburden/interburden material at the mine does has the capacity to generate elevated dissolved metal concentrations in run-off and or seepage.

Comparison of pit water quality with the water contaminant limits and release contaminant trigger investigation levels listed in the EA indicates that salinity, SO_4^{2-} and metal concentrations in pit waters have generally been lower than the release limits in most pits not influenced by ash or tailings disposal.

Tailings supernatant water qualities suggest that the tailings are unlikely to generate acidic drainage in the short-term due to their saturated state, preventing the oxidation of any entrained sulphides. Run-off waters and leachates are likely to have salinities in excess of the Mine's contaminant release criteria. Dissolved Ni and Zn concentrations in exceedance of the discharge contaminant trigger levels have also been detected in tailings supernatant water. The tailings supernatant water is recycled when possible, and the TSFs have no discharge points; therefore, the supernatant will not be released to the environment. However, the water quality results indicate that the tailings do have the capacity to generate elevated EC and dissolved metal concentrations in run-off and or seepage.

The surface water quality results indicate that the geology is capable of generating AMD (and neutral mine drainage (NMD)) from certain materials and under certain conditions. However, ongoing AMD at the site is limited to that issuing from RSA1 on Ramp 7 and Bullgang Drain. The problem at that location is considered to have been a result of the concentration of sulphidic coal rejects with little to no acid neutralisation capacity (ANC) and no landform management to prevent water (rainfall or seepage) or oxygen ingress and subsequent sulphide oxidation.

In the AMD discharge, elevated concentrations of dissolved metals are contained in the water. In the non-acidic seepages, salinity (as measured by EC) is potentially problematic at K2N seep; however, this appears to be a localised issue, resulting from entrained ash water seeping from ash storage in K2W through the separating wall into K2N (SGRS, 2015). Dissolved Ni and Zn in the saline drainage were also elevated, reinforcing the potential for seepage and run-off at the site to contain metals, even if the seepage is not acidic. Specific management procedures are in place dealing with the AMD which have reduced the volume of seepage and lowered contaminant concentrations in the AMD, thereby reducing risks associated with the seepage (WSP, 2021b). The limited information on other surface seepage at the mine indicates that seepage is not a widespread or common occurrence at the Meandu Mine.

7.1.2 Groundwater

The groundwater data reinforces the pit water and seepage chemistry results, demonstrating that the potential for AMD generation exists in certain lithologies and under certain conditions. The seepage at Ramp 7 and Bullgang Drain is interpreted to be the surface expression of groundwater that has seeped through the rejects at RSA1, mobilising sulphide oxidation products (SO_4^{2-}, Fe, Mn) and driven westwards by head from the groundwater beneath the NWBV and NWB TSF along the base of the rejects/spoil.

Groundwater associated with spoil across the site generally has slightly elevated EC but only moderately elevated SO_4^{2-}. Dissolved metal concentrations in spoil are variable across the mine, with elevated Fe (being fairly common), but Al, Mn, Ni and Zn also displaying the capacity to be mobilised into groundwater from the spoil.

There are two observed elevated EC groundwater plumes on the site, identified as the QW and Black Creek saline plumes.

The source of the elevated EC groundwater plume north-west of QW pit is unknown but may be a result of natural processes, unrecorded deposition of saline spoil and or rejects being deposited in the area during the rapid development of the historic QW pit. Monitoring of the plume is ongoing.

An area of the mine (Black Creek to the north of the former K2TSF) shows groundwater with elevated salinity and some metals, the source of which is unknown.

It should be noted that apart from the AMD at Ramp 7 and Bullgang Drain, no surface expressions of groundwater seepage are present at the mine and the elevated EC, SO_4^{2-} and metals concentrations reflect the aquifer pore water hydrochemistry and do not imply that environmental impact will result from the groundwater impact.

7.1.3 Mineralogy

Infrared spectrometry was implemented using Hylogger™ technology to investigate the mineralogical phases present in the geology. Results are largely as expected for a fluvial sedimentary domain with interbedded coal seams, with the dominant minerals throughout being quartz and kaolinite, with secondary quantities of feldspar and other clays. Carbonates (i.e., siderite, dolomite, ankerite, calcite, magnesite) were detected at trace levels only, with only a few detections of calcite in the Queen seam coals. Siderite has the lowest reactivity and buffering capacity of the carbonates present at the mine (WSP, 2021b). The presence of jarosite (iron sulphate) and gypsum (calcium sulphate) is also important as these two minerals are common by-products of pyrite oxidation (jarosite) and subsequent acid neutralisation (gypsum).

The absence of pyrite in the Hylogger™ results is of interest, given the common identification of pyrite in the geological logs. This highlights the low quantities of pyrite in the Tarong Beds at Meandu Mine. Pyrite was only identified in the geological logs in association with coal, with the exception of a 0.36 m thick interval of siltstone in the interburden of drill core 8029C.

7.1.4 Waste stream geochemistry

7.1.4.1 Overburden/interburden

The results of the static testing of the overburden/interburden indicate that the great majority of the overburden material and approximately 85% of the interburden is classified as NAF. The static testing results of the spoil also suggest that the majority of the spoil is NAF, although the material is highly heterogeneous and isolated areas of actual acidity and PAF have been identified (WSP, 2021b). Sulphidic material is limited almost exclusively to organic lithotypes in the mine stratigraphy (SRK, 2019 & 2021).

Spoil from the overburden is considered unlikely to generate significant AMD and any small pockets of acid generated should be diluted/buffered by non-acidic drainage from the majority of rock. Spoil from the interburden units has a higher potential for AMD generation due to the higher content of organic material in the rock; however, significant AMD generation is considered unlikely due to the majority of NAF material in the units.

The overburden/interburden appears to have variable potential for generating NMD/saline mine drainage (SMD), with static testing suggesting most material has a low potential for generating saline drainage and isolated parts of the Meandu Mine may generate leachate with one or more elevated metal concentrations. The kinetic leach column testing indicated the potential for saline metalliferous flushes being generated from overburden when first mined and exposed to rainfall. Ongoing drainage with elevated Se, Al and Fe may also be generated by the overburden; however, other elevated metal leaching appears to be related to sulphide oxidation.

7.1.4.2 Coarse rejects

Current consensus is that the expression of AMD at Ramp 7 and Bullgang Drain is a result of the oxidation and subsequent flushing of oxidation products from historically placed coarse rejects on RSA1 and in the NWBV generally (WSP, 2018). Static and kinetic testing confirms the coarse reject waste stream to be PAF and ongoing waste management is required to prevent further occurrences of AMD through preventing the oxidation of the coarse rejects. There is also the potential for the coarse rejects to generate NMD, even if co-mingled with tailings; therefore, prevention of oxidation of the coarse rejects is important regardless of the co-disposal strategy of the waste streams.

7.1.4.3 Tailings

The tailings at Meandu Mine are considered to be PAF; however, a combination of the addition of $Ca(OH)_2$ at the CHPP and the fine grain and low permeability of the tailings creates a significant lag time (>24 months) before the onset of acid production. The supernatant water quality from the TSFs support the conclusion that the tailings are unlikely to generate acid provided they remain saturated and/or oxygen ingress is limited (thereby reducing oxidation potential).

The tailings are considered to have a low potential for the generation of SMD in the short- and long-term. There is the potential for the tailings to generate NMD, particularly with regard to dissolved Mn, Zn and Ni; however, this will be reduced if oxidation of the tailings is prevented.

7.1.4.4 Coal combustion products

The findings of the geochemical assessment of the coal combustion products are quite definitive with regards to AMD potential, as all samples were classified as NAF and will not generate acid through sulphide oxidation. The actual acidity of the coal combustion products is neutralised during processing at the Tarong power stations. The coal combustion products appear to have the potential to generate a slightly saline “first flush” with elevated metals; however, the potential for ongoing SMD is considered to be very low. The potential for coal combustion products to develop NMD is considered low, with the exception of V, Mo and Sr.

7.1.4.5 Mixed plant rejects

Geochemically, the MPR are considered to be PAF, as both component waste streams (coarse rejects and dewatered tailings) returned geochemical classification as PAF during geochemical static and kinetic testing (WSP, 2021b). Therefore, the MPR are likely to generate AMD and/or NMD if allowed to oxidise and leach to the environment.

7.2 Implications for closure

7.2.1 Final highwalls

The current LOM Plan indicates that the K2E and K4E pits will become final residual voids that are likely to contain water beyond closure. There has been extensive static geochemical testing of material from the highwalls of these pits, collected from bore holes located near the final pit shells. The static testing verifies that at least two thirds of the samples, including some of the coal, are NAF and that the majority of the PAF material is present in the coal (WSP, 2021b). There is also an extensive history of water present in these pits, which verifies that the water bodies have retained circum-neutral pH with low to moderate salinity throughout the pit lives.

The water extraction tests on representative drill core material indicated low immediately available salinity or elevated metal concentrations in the overburden/interburden. Extractants from coal samples returned slightly acidic values (pH 4–5.8) with associated elevated concentrations of Al, Co, Fe, Mn, Ni and Zn.

Kinetic leach data suggests that longer-term drainage from the overburden/interburden is potentially highly variable, with some AMD, SMD and NMD potential. It should be noted that the material used in the KLC testing might not be representative of the greater rock mass and general K2E and K4E pit water qualities over the mine life suggests that drainage and/or runoff from pit walls does not tend to be highly saline, acidic or metalliferous. Additional kinetic testing has commenced as of September 2021 to provide more certainty on the long-term drainage water quality from the final pit highwalls.

Specific AMD management of the final highwalls is not expected to be required as geochemical testing suggests the relative volume of PAF material is insignificant at the scale of mining.

7.2.2 Backfilled voids

The geochemistry of material used historically to backfill exhausted mining voids and planned in future operations to minimise residual void volume on closure varies according to source and treatment. Particular waste streams have the potential to generate acidic, neutral or saline seepage, which could cause environmental harm if not managed appropriately. Conservative waste management procedures have been developed to minimise the risk of environmental harm caused by seepage across the mine during operation and post-closure. Each significant rock unit has been classified according to material design parameters, the management of which is assigned in mine planning procedures. Specific management procedures for each mine waste material are detailed in Section 4.1.2 and summarised as follows:

- Waste – interburden: all interburden within 2 m of the roof and floor of modelled coal seams has been classified as PAF in the model and will be placed >6 m below final landform as per the LOM Plan. The remainder of the interburden has been classified as NAF.
- Waste – overburden: classified as NAF in the forward mine plan except for separate units of coaly mudstone and lignite, which are classified as PAF and will be placed >6 m below final landform surface. NAF overburden will be used as cover material generating a capping of NAF at least 6 m thick across the final landform design. Isolated occurrences of PAF in the overburden are generally too small to be of consequence at a mine scale, but where feasible these PAF units will be segregated and placed at least 6 m below the final design landform.
- Tailings/coal rejects: classified as PAF. Tailings have a significant lag time before acid generation. SBCs have been installed to dewater tailings which will allow the majority of tailings to be co-mingled and disposed with coal rejects into dedicated disposal areas. Coal rejects are to be placed within the disposal area less than two weeks after stockpiling. Rejects disposal area to be capped with at least 6 m of NAF material and final topsoil capping to promote plant growth and restrict moisture ingress.
- TSF: Contingency tailings disposal will occur when the SBCs are off-line, with the tailings disposed into the K2W-N pit and later into K4S ASF. Tailings will be kept saturated to minimise oxidation until tailings deposition ceases at which time a layer of coal combustion products will be placed over the tailings. In order to maintain stability of the ash dam wall, contingency tailings deposition will be managed so that the tailings do not come into direct contact with the northern embankment. NAF material will form the initial layer that is in contact with the final coal combustion product layer above the TSFs, and within at least 6 m of the final landform surface to minimise infiltration of water and the likelihood of any erosion occurring to the final cover system.
- Coal combustion products: classified as NAF, coal combustion products are stored in the dedicated coal combustion products storage void K2W-N, which has a planned operational closure in 2029. Following completion of coal combustion product and contingency tailing storage in K2W-N, placement of coal combustion products and tailings in a void within K4S pit will then be undertaken. Rehabilitation will comprise a period of desiccation/consolidation following by capping with NAF spoil to a level that fits in with the surrounding final landform and has a minimum thickness of 2 m (over coal combustion products) and 6 m (over tailings), which will be free-draining and minimise infiltration of water into the landform.

The above management measures are considered sufficient to minimise the risk of significant water infiltrating through potentially reactive mine wastes stored beneath the final landform and negatively impacting the PMLUs and surrounding environmental values by seepage into surface waters and groundwaters.

8 Hydrological modelling

Hydrological modelling was conducted by SLR (2022a, 2022b) with the intent of addressing the sections of the PRC Plan Guideline related to flood risk and final void water levels (*Section 3.6.1 Flooding; Section 3.4 Voids in floodplains* (if found to be relevant)*; Section 3.6.3 Voids)*. Specifically, the hydrological modelling is intended to determine the risk of inundation by flooding of residual voids, flood risk to the stability of other final landforms such as rehabilitated spoil dumps and assessing the long-term water balance and water level in the voids, including the potential for overflow of the voids.

8.1 Voids in floodplain modelling

In order to determine whether *Section 3.4* of the PRCP Guideline applies to Meandu Mine, hydrologic modelling was undertaken to estimate runoff hydrographs at various locations throughout the catchments of Meandu and Rocky creeks (SLR, 2022b). A separate model was developed for each catchment using the Watershed Bounded Network Version 2019. Sub-catchments were defined on the post-mining model landform supplemented with publicly available LiDAR data and using BOM and Australian Rainfall and Runoff rainfall and runoff data, 50%, 2%, 1% and 0.1% Annual Exceedance Probability (AEP) storm events applied to the models to determine flow hydrographs and a PMF.

Rainfall runoff hydrographs for specific locations were developed by the Watershed Bounded Network models, which were then utilised as inflow boundaries for the hydraulic model. The industry standard hydrodynamic modelling software TUFLOW was used for this modelling. A suite of design storm events were simulated in the hydraulic models for the range of AEP events and durations between 1 and 6 hours. Peak water surface levels, depths and velocities across the model domain for each AEP event were extracted from the model.

The results show that both the proposed final K2E and K4E voids are not subject to inundation due to flooding in Meandu or Rocky creeks in any of the AEP events assessed, including the 0.1% AEP and PMF. The existing natural ridge forming the watershed between Rocky Creek and the voids is situated at approximately 50 m above the PMF flood level in Rocky Creek. The ridge line formed by the K4S back-filled void has an elevation approximately 60–80 m above the peak PMF flood level in Meandu Creek. The results also show that other features of the final landform including rehabilitated spoil dumps are very unlikely to be significantly affected by flooding in Meandu Creek.

Based on the results of the modelling there is no significant risk of ingress of flood waters to the final voids and the voids are not located on potential floodplains.

8.2 Long-term water balance model

A water balance model (WBM) has been developed by SLR (2022a) to assess the surface water system at Meandu Mine post closure. The final void WBM was developed in the GoldSim modelling package. The WBM incorporates all projected inflows, outflows and recharge rates, including stock-water demands as prescribed by the PMLU of Water Storage for the residual voids at the Meandu Mine.

8.2.1 Model design

Following closure of Meandu Mine, two final voids are expected to remain at K2E and K4E. According to the LOM Plan K2E will have a post-closure catchment area of 332 ha whilst K4E will have a post-closure catchment area of 184 ha. The direct catchment area reporting to the voids are based on a 3D topographic model representing the final landform. The catchment extent and final landform topography is shown in Figure 8.1.

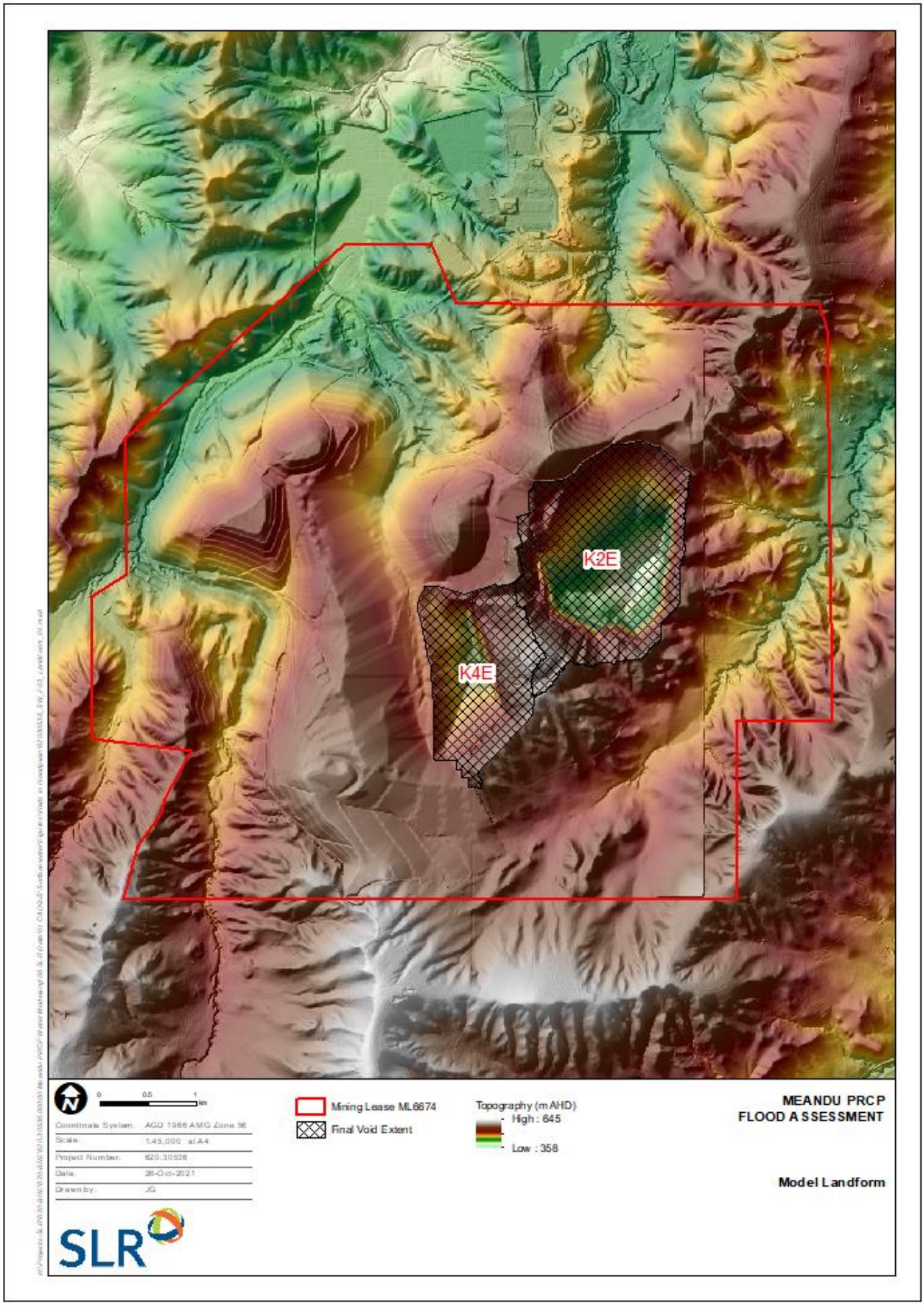

Figure 8.1 Void catchment area

Rainfall input and evaporation output for the WBM was based on data from the SILO database (DES, 2021), which was correlated against rainfall records from the three nearest BOM weather stations (Tarong, Yarraman Upper and Yarraman Post Office). Probabilistic rainfall generation was used to allow the simulation of a wide range of climatic scenarios, including climate change scenarios, over a 120-year period.

The WBM utilised the Australian Water Balance Model rainfall runoff module to calculate the rainfall and runoff inflows in each catchment, using the runoff response for two representative landuse types. AWBM parameters derived for hardstand/pit were applied to relevant areas within the Steep Rocky Ecosystem/Water Storage PMLU and those derived for rehabilitation were applied to relevant areas within the Native Ecosystem/Beef Cattle Grazing PMLUs.

Groundwater inflows to the final void WBM were derived from the groundwater model developed for the PRCP (SLR 2022a – refer Section 9). The groundwater model showed that 0.1 to 0.2 megalitres per day (ML/d) of groundwater enters the K2E final void with no seepage loss, which was modelled as a constant inflow as 0.2 ML/d in the WBM. The groundwater model showed that the K4E final void acted as a source with an average seepage rate to groundwater of 0.26 ML/d (SLR, 2022). The latter is reached by the time K4E final void reaches equilibrium. As such, the WBM assumed no seepage losses for both final voids.

Five final void WBM scenarios were simulated to assess long-term water levels in the final voids:

- Base scenario – nil water extraction from either void – natural surface and groundwater recharge and evaporation only.
- Scenario 1 – limited stock water extraction from both voids: 2.08 Ml/y of stock water extracted from K2E and K4E final voids (total of 4.16 ML/y).
- Scenario 2 – maximum water extracted from K2E final void only. No extraction from K4E final void. 1 ML/day of water is extracted from K2E final void. Water is only extracted once the depth of stored water is at least 7 m and does not allow water depth the reduce past 5 m. This was designed as an ‘upper limit’ extraction scenario to test the viability of extraction of water in the future to support PMLUs other than Beef Cattle Grazing.
- Climate change Scenario 1 – model sensitivity to increase in rainfall depths: A sensitivity analysis to climate change assessed based on Scenario 1 with a 20% increase in rainfall.
- Climate change Scenario 2 – model sensitivity to decrease in rainfall depths: A sensitivity analysis to climate change assessed based on Scenario 1 with a 20% decrease in rainfall.

8.2.2 Results

Results from Scenario 1 (Figure 8.2) show K2E final void water levels are expected to be in equilibrium at approximately 416 m Australian Height Datum (AHD) during median conditions which is approximately 36 m deep. During dry climatic conditions the levels are approximately 2 m lower whilst wet climatic conditions shows that the level is 2 m higher at 418 mAHD. This is approximately 100 m below the spillway level and the final void is not expected to overtop.

The final void water levels for K4E are expected to be in equilibrium at approximately 469 mAHD during median climatic conditions (Figure 8.3), which is approximately 20 m deep. Similar to the K2E results, the wet climatic condition water levels are approximately 2 m higher than median conditions at 471 mAHD whilst dry climatic conditions showed the final void water level sat 467 mAHD. This is approximately 30 m below the spillway level allowing significant capacity to prevent the final void from overtopping.

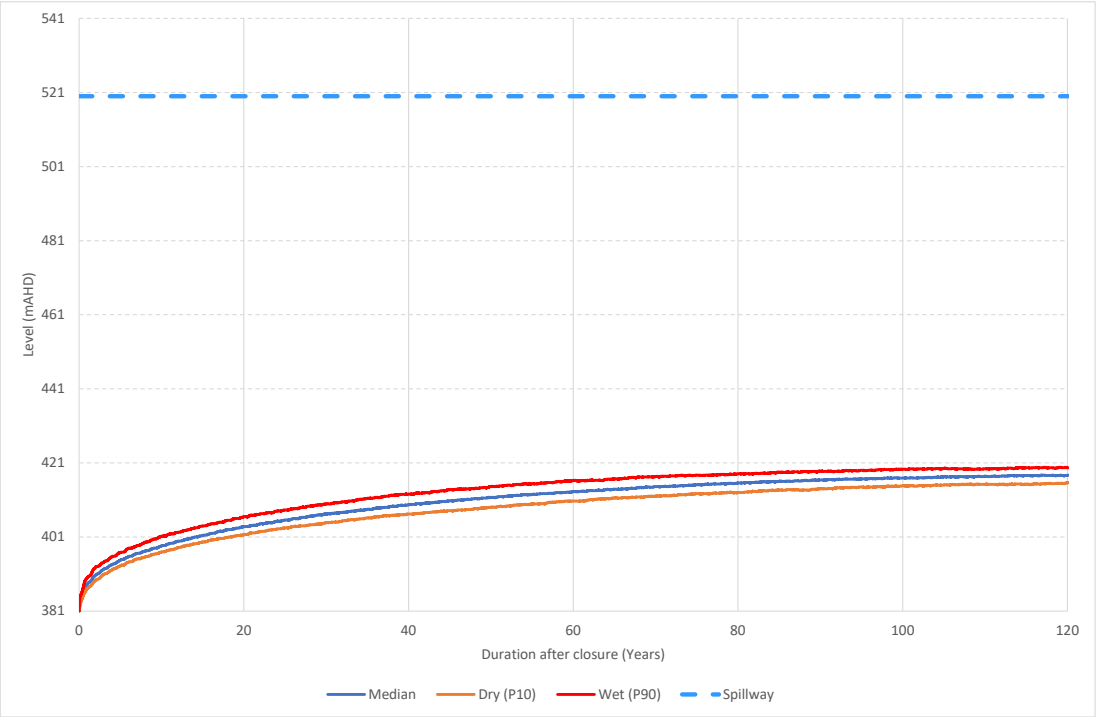

Figure 8.2 K2E Scenario 1 final void water levels

The results for the Base Scenario with no water extraction were similar to those from Scenario 1, with final void volumes increasing by up to 2% for K2E and 4.6% for K4E. This relatively small difference is attributed to the extraction volume in Scenario 1 being only a small fraction of the total inflow and evaporation rates. In addition, the evaporation rates in the Base Scenario were higher than Scenario 1 due to the increased surface area of water in the voids.

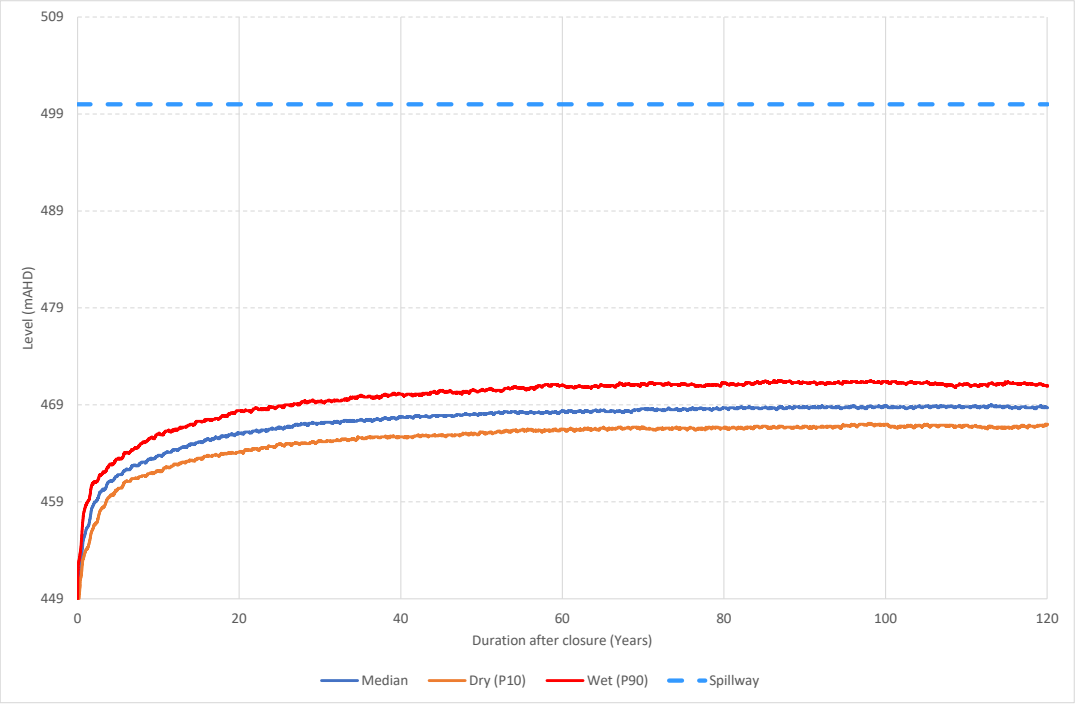

Figure 8.3 K4E Scenario 1 final void water levels

Scenario 2 for K2E resulted in much lower water levels in the final void stabilising at approximately 387 mAHD with a depth of 5–7 m during dry and wet climatic conditions, respectively. There was a negligible difference in the results for K4E in Scenario 2 compared with Scenario 1 due to the minimal impact of the water extraction in Scenario 1.

Climate Change Scenario 1 (20% increase in rainfall depth) resulted in final void water levels 15 m higher in K2E and 14 m higher in K4E compared with Scenario 1. This suggests that the results are sensitive to the 20% increase in rainfall although final voids maintained a low risk of overflow. Climate Change Scenario 2 (20% decrease in rainfall) resulted in water levels approximately 15 m and 8 m lower in K2E and K4E, respectively, with risk of overflow being very low.

8.2.3 Summary

The hydrological water balance model indicated water levels in both final voids were sensitive to the volume of water extracted and rainfall runoff; however, the risk of overflow of the voids was low for all scenarios. With the exception of Scenario 2, in which large volumes of stock water are extracted from K2E, water depths in the final voids equilibrate with water storage depths and are likely to support the Beef Cattle Grazing PMLU sustainably. As Scenario 2 is a maximum extraction scenario assuming water extraction for uses not currently covered by the PMLU for Water Storage (e.g., pasture irrigation), it is considered very likely that final void water quality will meet the PMLU criteria.

9 Groundwater modelling

Numerical groundwater modelling was undertaken by SLR (2022a) in accordance with *Section 3.6.1 Hydrogeology* of the PRC Plan Guideline. The aspects of groundwater modelling, relevant to the Void Closure Plan are listed in *Section 3.6.3 Voids* of the PRCP guideline and include:

- an assessment of void surface and groundwater interactions such as:
  - groundwater lowering/reduction in hydraulic head
  - cones of depression and associated impacts
  - a conceptual model that incorporates all projected inflows, outflows, and recharge rates; and
  - each of the major water fluxes into and out of the void.

The outputs of the groundwater model were used in conjunction with geochemical and hydrochemical data to develop an integrated water balance model (IWBM) to predict long-term water qualities of the final voids and potential seepage from back-filled voids, discussed in Section 10.

9.1 Model design

SLR adapted the groundwater model developed for the K2E Project by JBT (2021) by converting the model from MODFLOW SURFACT to MODFLOW-USG, which is the most up to date MODFLOW groundwater modelling package (SLR, 2022a). The model structure is shown on Figure 9.1 and comprises a 40 m x 40 m grid over the existing surface rights area and K2E ASA, which is extended to 80 m x 80 m cell size in the outer areas of the model. The model has 15 layers representing the hydrostratigraphic layers identified at the Meandu Mine and immediate surrounds.

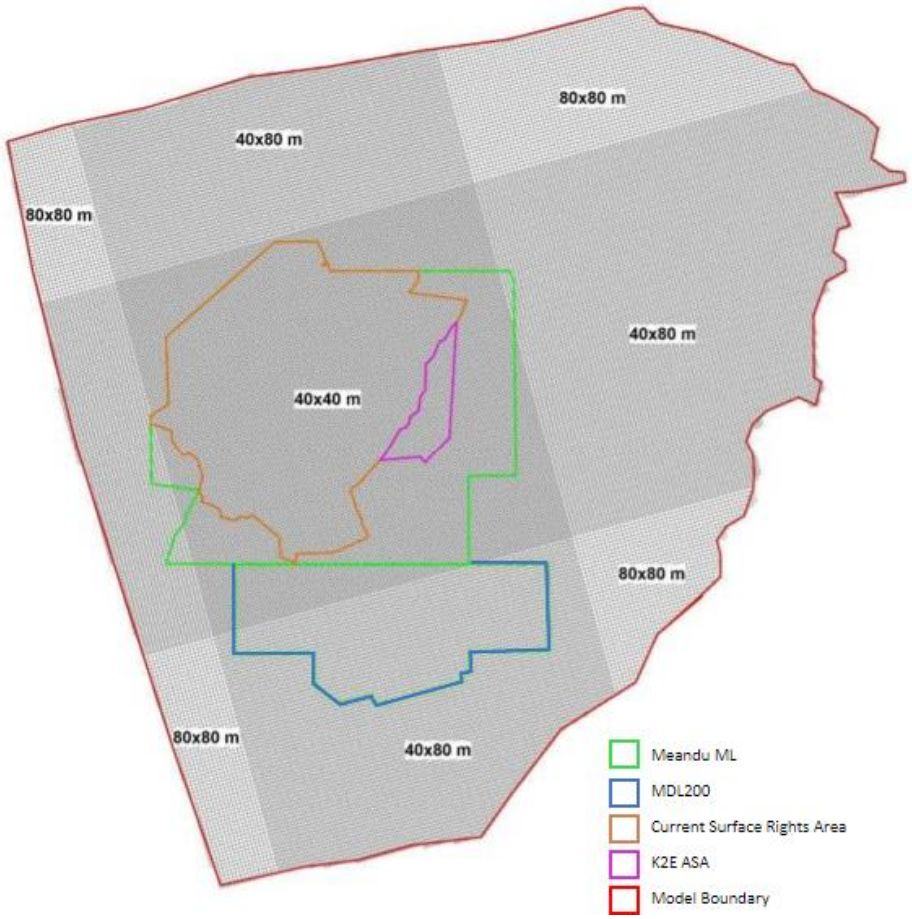

Figure 9.1 Meandu Mine groundwater model grid (JBT, 2021)

Details of the model inputs (boundary conditions, hydrogeological parameters for each layer, recharge, evaporation/ evapotranspiration, timing, calibration from existing groundwater data etc.) are included in the Groundwater Technical Report (SLR 2022a).

Two predictive models were simulated to assess the long-term impact of the Meandu Mine on the groundwater:

- Model 1: Baseline Groundwater Model (no mining):
  - All mining features in the existing calibration and predictive model were removed.
  - Recharge and hydraulic parameter zones associated with spoil and fault zones were removed (i.e., the Boulevard Fault is assumed to remain a hydraulic barrier to groundwater flow, in accordance with previous investigations reported in JBT (2021).
  - The model was run transiently for the same time period and under the same natural stresses (i.e., rainfall recharge and evapotranspiration).
- Model 2: Post-mining Groundwater Recovery Model (Long-Term Closure Scenario):
  - In order to establish initial conditions for the post mining recovery simulation, the approved and foreseeable (i.e., K2E Project) mining scenario were updated to include the progressive filling of K4S pit with coal combustion products and contingency tailings (2028–2037).
  - The top of layer 1 in the recovery model was updated to include the final landform elevation.
  - Closure simulations include:
    - Initial model – short-term recovery simulation to ascertain groundwater inflows to the residual voids based on the final landform. The initial estimate is used as an input to the final void WBM; the WBM provides the final lake elevation in the voids. An iterative process between the surface water and groundwater models is then carried out so that the groundwater inflows that are provided as an input to the surface water model match the groundwater inflows simulated using the final lake elevation output from the surface water model.
    - Predictive model – recovery simulation using information from the LOM Planning (to closure) as well as long-term modelling of the post-mining landform (integrated with inputs from the surface water model and surface water balance). A predictive mining (up to 2037) and post closure model using the final void lake elevations provided by the WBM. The two final void level scenarios used in the WBM (Section 8.2.1) based on different water extraction volumes from the voids were modelled.

The predictive model timing comprises the mining period of 2022 to 2045 and a 300-year recovery period (i.e., 2045–2345).

9.2 Results

9.2.1 Final voids

The potentiometric surface of the Queen C Seam (Layer 11 of the groundwater model) after 300 years post-mining shows the predicted groundwater flow directions in the lowermost mined unit of the Tarong Beds in K4E pit (Figure 9.2). The groundwater modelling shows that K2E final void will form a groundwater ‘sink” in all scenarios modelled, with an average calculated seepage inflow of 0.12 ML/d and seepage outflow of 0.01 ML/d. The predicted “capture zone” for K2E final void is shown on Figure 9.2. The results for scenario 2 are similar, with greater drawdown in K2E final void due to the higher stock water extraction rate.

In contrast, K4E final void has a calculated seepage inflow of 0.16 ML/d, but a seepage outflow of 0.26 ML/d, indicating it is a flow through system. Inflow to K4E final void will be from the south and south-west and outflow will predominantly be towards K2E final void to the north-east. Therefore, although outflow from K4E final void is predicted to occur post-mining, the seepage will be captured by the K2E final void and the groundwater system post-mining at Meandu Mine is predicted to act as a groundwater sink centred on K2E final void.

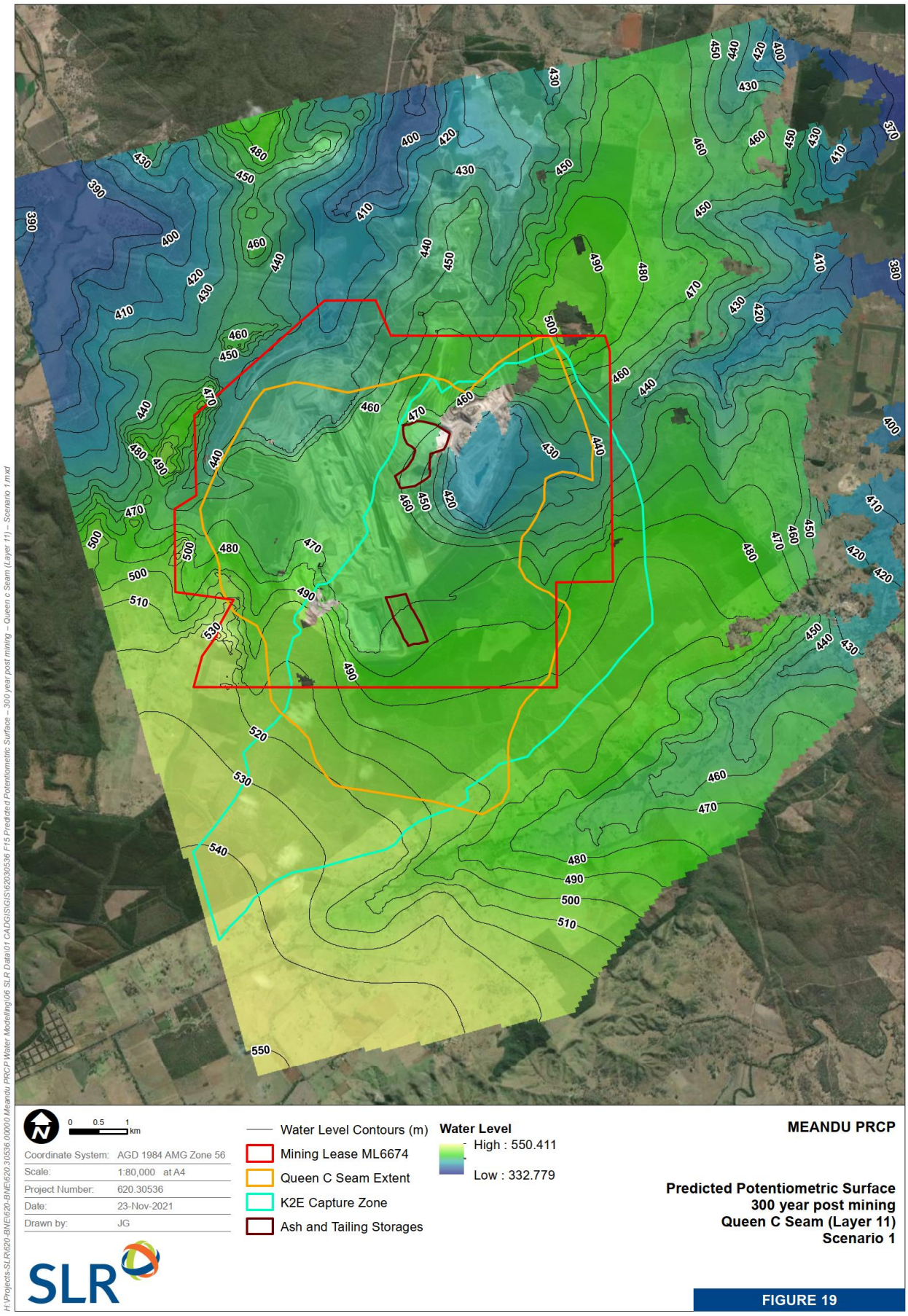

Figure 9.2 Predicted potentiometric surface – 300 years post mining – Queens C Seam (Layer 11) – Scenario 1

9.2.2 Backfilled voids

Groundwater flow direction in the backfilled voids can be visualised by the potentiometric levels of Queen C Seam, as shown on Figure 9.2. According to the modelling, the voids currently used and proposed for the future storage of co-deposited coal combustion products and contingency tailings, (K2W-N and K4S) are both within the capture zone of the K2E final void groundwater sink, indicating that should seepage emanate from these backfilled voids it will move towards the K2E final void rather than offsite into surrounding catchments. Groundwater from approximately half of the historic QW pit and Ramp 5 pit will also flow in the direction of K2E final void.

The potentiometric groundwater contours on Figure 9.2 suggest that groundwater beneath the remainder of the backfilled voids at the Meandu Mine will generally report to the west and/or north-west (with local variations) towards Meandu Creek upstream of Meandu Creek Dam. This includes NWA and NWB pits, which contain the historically placed tailings in NWA TSF, Ramp 3 TSF and NWB TSF, West pit, which contains historically placed coarse rejects and re-handled tailings, and Central pit, which contains MPR and will be a major repository of MPR in the forward LOM Plan.

9.2.3 Summary

The long-term groundwater modelling predicts that the K2E final void will act as a sink, receiving groundwater from approximately 50% of the surrounding mining area (including K4E final void, backfilled voids [K4S and K2W-N which store coal combustion product and tailings] as well as part of Ramp 5 backfilled void. The results of the model indicate that the risk of water stored in the final voids impacting on surrounding landholders is very low.

The modelling suggests that groundwater beneath the backfilled voids in the west and north-west of Meandu Mine may migrate westwards or north-westwards towards Meandu Creek upstream of Meandu Creek Dam adjacent to the Mine. This suggests that if vertical water infiltrates through the backfilled voids in the west and north of the mine and contacts potentially reactive waste material stored in those voids, there is a risk of contaminated seepage migrating towards and possibly into Meandu Creek. This scenario is currently being mitigated through planned rehabilitation and dewatering activities (Section 11).

The above conclusions are based on groundwater flow modelling without consideration of water quality. An IWBM was developed to determine likely contaminant transport within groundwater and final voids and determine potential final water qualities.

10 Hydrochemical modelling

An IWBM was developed to represent the surface water system of the mine and characterise the long-term water quality of surface waters at the site (SLR, 2022a). The IWBM is relevant to *Section 3.6.3 Voids* of the PRC Plan Guideline: specifically, the *predicted water quality in the long-term including potential stratification.* The groundwater model was also used to predict potential contaminant transport from zones of potentially reactive mine waste in backfilled voids, which is relevant to *Section 3.6.1 Hydrogeology* of the PRC Plan Guideline: specifically, *groundwater modelling to determine contaminant transport and potential changes to groundwater level from dewatering or waste storage.*

10.1 Model design

10.1.1 IWBM

The purpose of the IWBM was to represent the surface water system at the mine, and to be used to characterise the long-term water levels (in final voids K2E and K4E) and water quality (e.g., salinity) discharged from the site. The IWBM was based on the models developed by Golder and Associates (Golder) for the purposes of an Environmental Investigation Report (WSP, 2018) and by WSP (in WSP, 2021a) for the K2E Project and was recently updated by SLR (2022) to reflect post-closure conditions at Meandu Mine and for the purposes of the PRC Plan submission. Australian Water Balance Model parameters as calibrated by WSP (2021a) were also adopted in the IWBM. The IWBM catchments were based on the final landform design and runoff parameters derived from model calibration were applied to relevant areas within the PMLUs as described in Section 8.2.1. Groundwater inflow/outflow rates to the final voids were derived from the groundwater model (Section 9.2.1), assuming no seepage losses from either final void.

The recently updated IWBM model (SLR, 2022) included the following:

- updated the IWBM to represent the surface water system at, and after the closure Meandu Mine, to include the predicted seepage from groundwater modelling
- developed probabilistic climate data for the WBM based on daily time series climate data. Probabilistic rainfall data was produced for 500 replicates of 120-year rainfall data (60,000 years of probabilistic data), allowing for a wide range of climatic conditions to be simulated
- characterised the long-term water levels and quality of the proposed final voids for the 10%, 50% and 90% climate, and
- identified and reported on the predicted water quality and water quantity at compliance points CP1, CP2 and CP3 as well as at the proposed final voids for the 10th, 50th and 90th percentiles.

The IWBM incorporated a coupled water balance with water quality for the runoff from catchment areas in the model for EC (calculated as TDS) in the IWBM. The salt loading is based on modelled TDS values used in the K2E Project. Each land use type was represented by a specific TDS value which is then applied to the runoff for each land use type that reports to the final void. In addition to this, the groundwater inflow to the final voids also contribute to the salt loading. The groundwater TDS is based on the median historical samples of the spoil and coal seams that are in contact with the final void highwalls. The adopted TDS are:

- Pit/Hardstand: 1,000 mg/L
- Rehab: 200 mg/L; and
- GW Inflow: 1,364 mg/L.

An EC factor of 0.5346 was adopted to convert the TDS to EC. This is based on the IWBM developed by WSP (in WSP 2021a) and is based on laboratory analysis of over 1,350 samples from Meandu Mine.

The IWBM was linked to the groundwater model to provide sub-surface hydraulic conductivities and infiltration rates to generate seepage rates into the voids. This was linked with predicted contaminant concentrations in surface water runoff into the final voids and seepage of groundwater into the final voids to predict final void water qualities over a 120 year period post-closure. Results are discussed in Section 10.2.

10.1.2 Contaminant transport model

In order to determine contaminant transport rates and likely extent of potential contaminant transport from identified sources at the mine, a contaminant transport simulation was preformed using the transport functionality in MODLOW USG – Transport (SLR 2022a). The version of MODFLOW USG – Transport V1.4.0. was used, which includes two packages to simulate mass contaminant transport: The Block Centred Transport (BCT) package, which defines the transport parameters for the model (e.g., dispersion and porosity); and the Prescribed Concentration Boundary (PCB) package, which define the location (i.e., node) and mass concentration of the contaminant sources.

The PCB condition applies a prescribed concentration to a node, which inputs to the model as a constant source (i.e., no decay); instead of calculating concentration as a simulation result, at these nodes the concentration is given by the boundary condition value. The nodes selected as potential contaminant sources are shown in Figure 10.1. The vertical extent for each ‘constant source’ was assigned based on the vertical extent of mining, assuming that the concentration at the source is uniform throughout the backfilled material (i.e., coarse reject, tailings, spoil or coal combustion products).

To characterise the concentrations of potential contaminants at each source, results from kinetic leaching column (KLC) testing were compared with measured groundwater quality within the mine waste materials. Where available, measured groundwater data was used to define contaminant source concentrations as the concentrations in the groundwater bores were generally consistent over a six-year period, whereas the KLC leachate concentrations generally showed a strong decreasing trend. Details on the specific contaminant source concentrations chosen for each source area are included in the groundwater technical report (SLR, 2022a).

Additional model parameters for the mass transport solution included longitudinal dispersity, transverse dispersivity and effective porosity, details of which are included in SLR (2022a). The model was run for 700 years post mining to achieve near equilibrium for the contaminant transport solution. The model was run for Scenario 1 and Scenario 2 and then subsequently the Base Scenario as presented in Section 8.2.1.

The concentrations of potential contaminants at the source nodes have been set up as constant over time. The constant source approach is ‘highly-conservative’ from a risk perspective as it does not consider natural attenuation or decay which would likely occur over centuries of mobilisation.

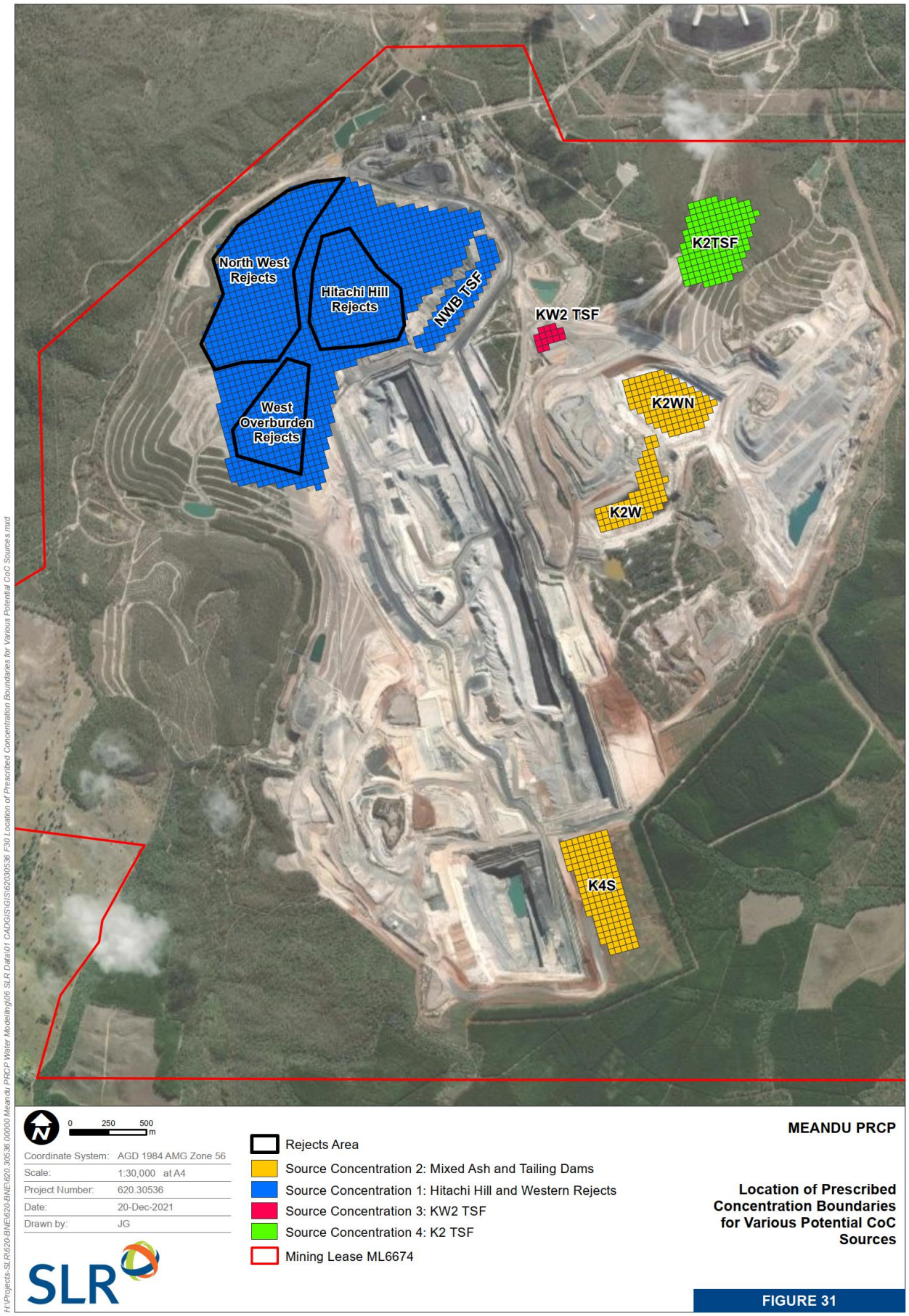

Figure 10.1 Location of prescribed concentration boundaries for potential sources at Meandu Mine

10.2 Water quality of the final voids – salinity

10.2.1 K2E final void

The predicted salinity in K2E final void over the modelled 120-year period for Scenario 1 is shown in Figure 10.2. The model shows that the EC levels in the K2E final void increases up to 5,500 µS/cm. This is significantly below the criteria for Water Storage PMLU of 9,197 µS/cm (TDS of 5,000 mg/l ÷ 0.5436); suggesting that the water is of suitable quality for stock water demands for at least the 120 years modelled.

It is noted that there is an ongoing slight upward trend in EC. This is understood to be due to the minimal clean/rehabilitated catchment runoff entering the void that can offset groundwater inflows and evaporation that increases the salinity. However, extrapolation of the trend shows that it is unlikely to breach the PMLU criteria for at least 200 years.

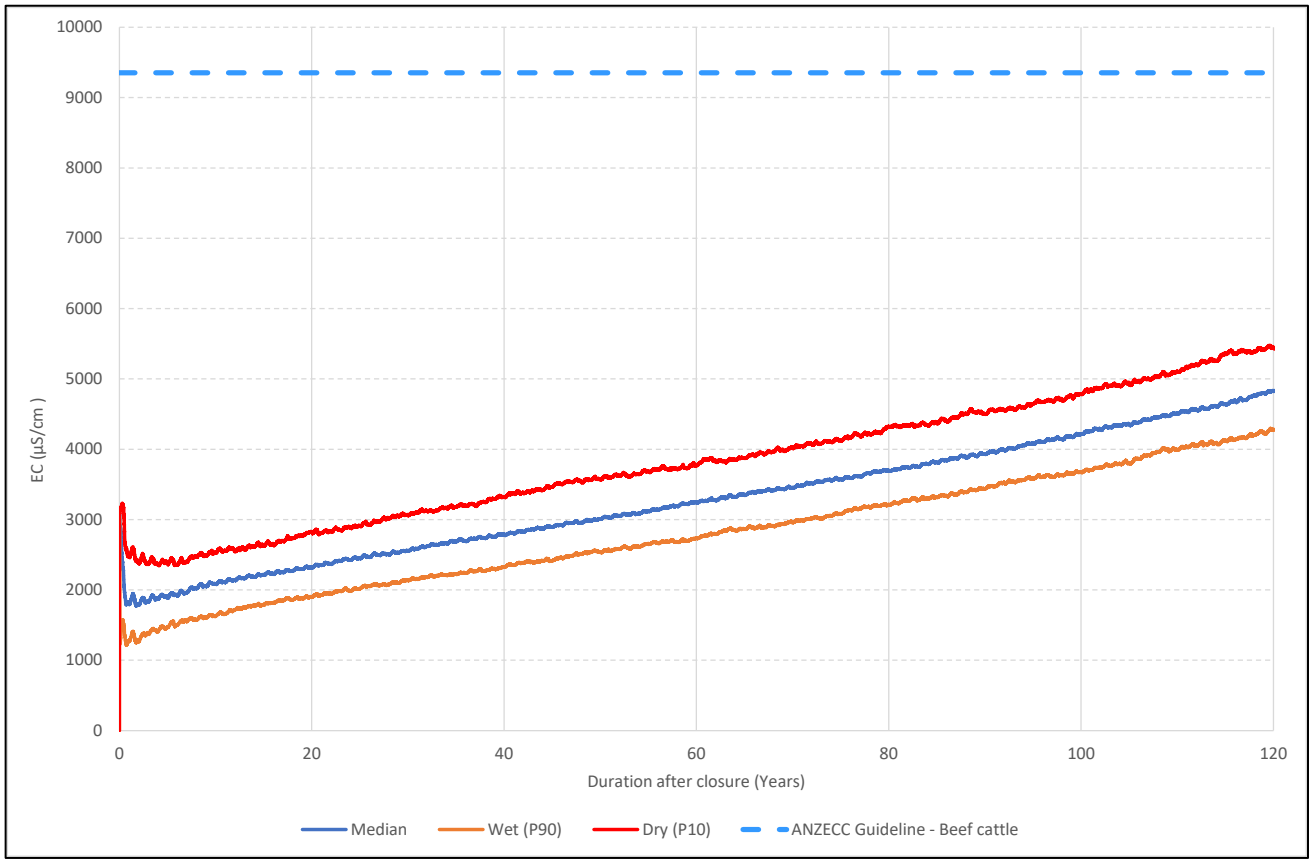

Figure 10.2 Scenario 1 EC in K2E final void post-closure

The results for the Base Scenario showed a slightly more rapid increase in EC than Scenario 1 (Figure 10.3); however, extrapolation of the trends shows that the void water is unlikely to breach the ANZECC stockwater guideline for at least 200 years.

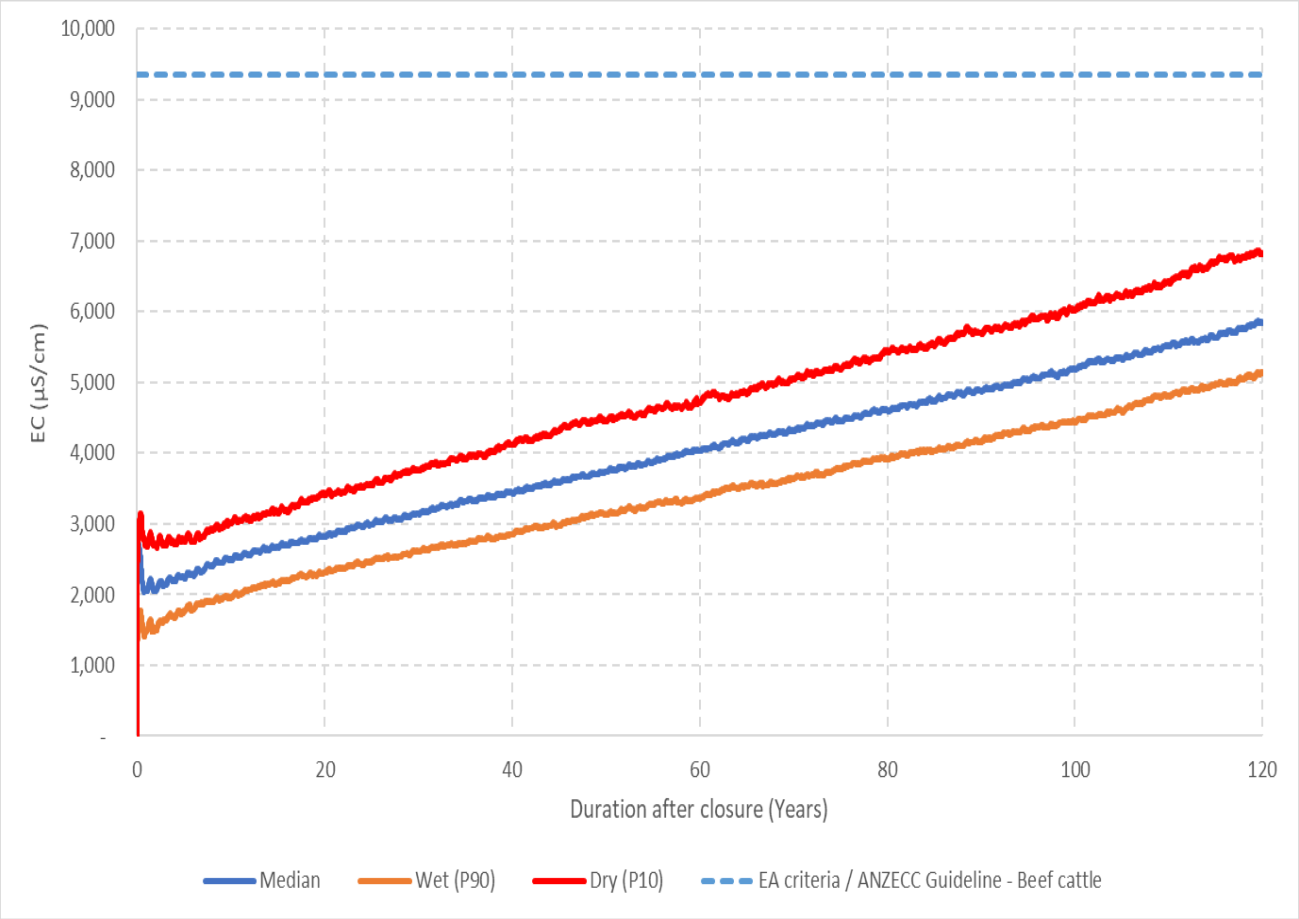

Figure 10.3 Base Scenario EC in K2E final void post-closure

The results for Scenario 2 showed a lower EC in the K2E void post-closure, stabilising at approximately 2,000 µS/cm, which is driven by the groundwater and surface water inflow ECs. This indicates that extraction of water from the void will prevent evapoconcentration and resultant increase of salinity.

In the climate change scenario with an increase in rainfall of 20% (Climate change Scenario 1), the EC of the K2E final void has an ongoing rising trend; however, the EC is only approximately 2,900 µS/cm after 120 years post-closure. This is a result of dilution by increased rainfall resulting in less evapoconcentration.

The climate change scenario with a 20% decrease in rainfall (Climate Change Scenario 2) resulted in a significant increase in K2E final void water EC, exceeding the Water Storage PMLU criteria within 100 years post-closure (Figure 10.4). The increase in salinity is a function of reduced rainfall depths and high evaporation rates. This is a pattern which is observed for regions with high evaporation rates and is exacerbated by the reduction in rainfall depths.

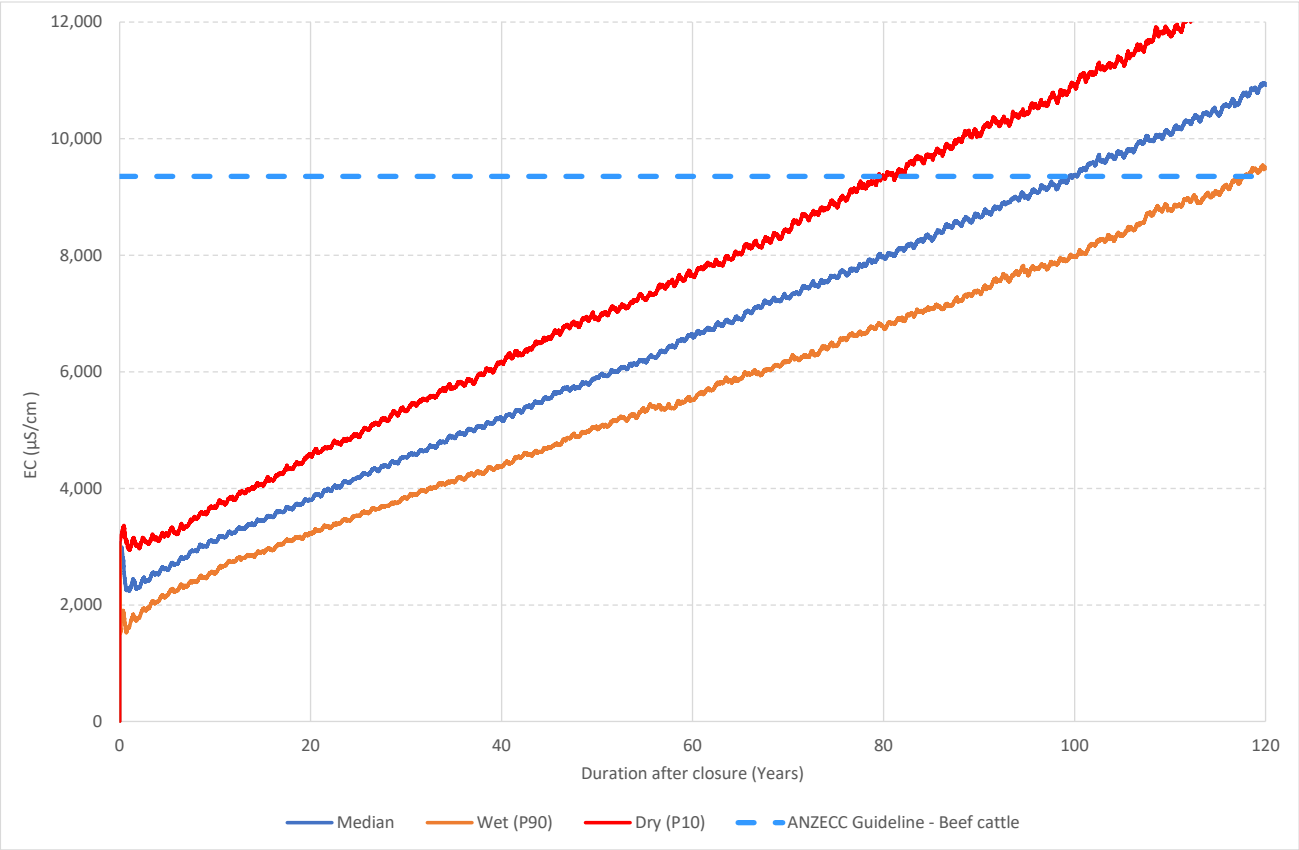

Figure 10.4 Climate change Scenario 2 EC in K2E void post closure

10.2.2 K4E

The predicted EC in the K4E final void over the modelled 120 years for Scenario 1 is shown in Figure 10.5. The EC levels increase to up to approximately 4,000 µS/cm, which is lower than that modelled for K2E final void. This is significantly below the criteria for Water Storage PMLU, suggesting that the water is of suitable quality for stock water demands for at least the 120 years modelled. Similar to K2E results, there is an upward trend to the EC due to the minimal clean/rehabilitated catchment runoff entering the final void to offset evaporation that increases the EC. However, the trend shows that it is unlikely to breach the PMLU criteria for at least 400 years.

The results for the Base Scenario and Scenario 2 were very similar to the results for Scenario 1. This indicates the extraction of water for stock use modelled in Scenario 1 (2.08 ML/y) has very little impact on final void water qualities compared with no water extraction.

In the climate change scenario with an increase in rainfall of 20%, the EC of the K4E final void appears to stabilise at approximately 1,000 µS/cm after approximately 25 years post-closure. This is a result of dilution by increased rainfall from rehabilitated areas resulting in less evapoconcentration.

The climate change scenario with a 20% decrease in rainfall resulted in a significant increase in K2E final void water EC, exceeding the Water Storage PMLU criteria shortly after 100 years post-closure (Figure 10.6).

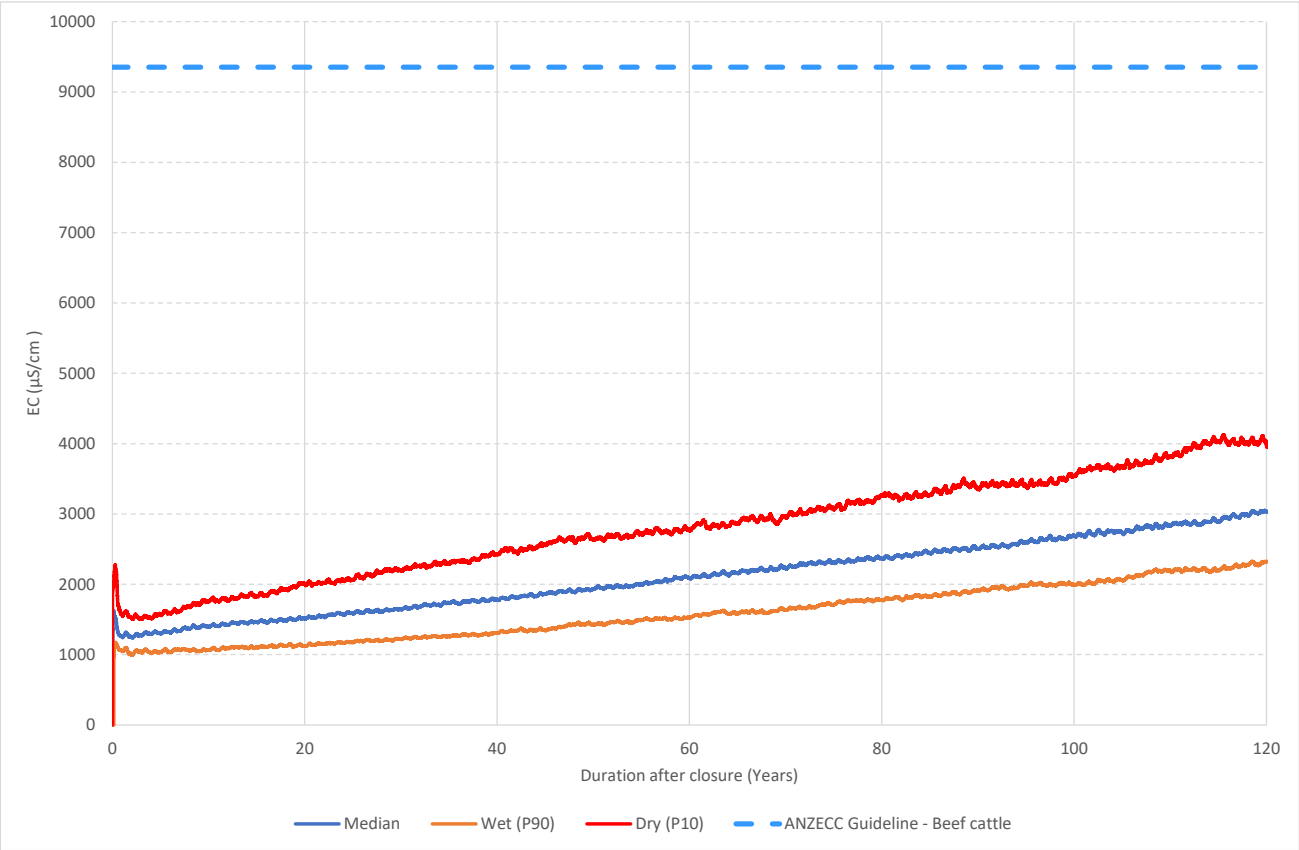

Figure 10.5 Scenario 1 EC in K4E void post-closure

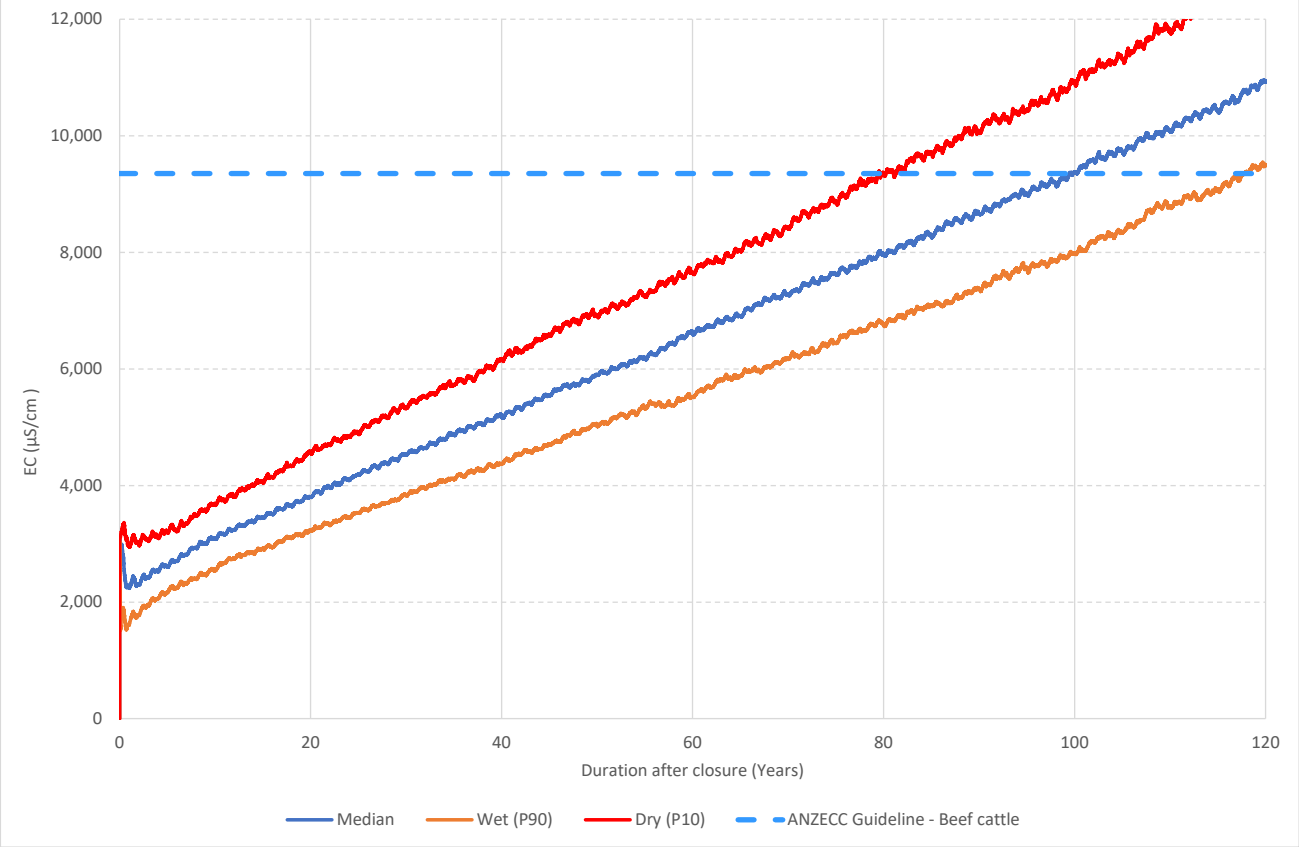

Figure 10.6 Climate change Scenario 2 EC in K4E void post-closure

10.3 Water quality of the final voids – potential contaminants

The predicted concentrations of potential contaminants of concern in the post-closure final void's surface waters are tabulated below in Table 10.1. The water quality results are presented showing the 10th, 50th and 90th percentile results for all predicted concentrations over the 120 year simulation. Where relevant, the water quality criteria for Water Storage PMLU and ANZG livestock (beef cattle) drinking water (ANZG, 2018) are listed for comparison.

Table 10.1 Modelled contaminant concentrations in final voids at Meandu Mine

Potential Contaminant	K2E modelled concentration after 120 years (mg/L)			K4E modelled concentration after 120 years (mg/L)			PMLU criteria (mg/L)
	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile	
TDS	1,830	2,130	2,460	1,020	1,290	1,660	<5,000
Calcium	58.6	67.5	77.6	44.5	55.0	68.8	<1,000
Magnesium	109	126	145	67.6	83.2	102	<2,000
Nitrate	Not modelled as no groundwater data available						<400
Nitrite	Not modelled as no groundwater data available						<30
Sulfate	311	353	403	301	369	450	≤1,000
Cobalt	0.03	0.04	0.05	0	0	0	≤1
Nickel	0.04	0.04	0.05	0.05	0.06	0.08	≤1
Zinc	0.16	0.18	0.21	0.21	0.26	0.33	≤20
Arsenic	0.001	0.001	0.002	0.0005	0.001	0.0015	<0.5
Boron	0.18	0.20	0.23	0.20	0.25	0.30	<5
Selenium	0.005	0.006	0.007	0	0	0	≤0.02
Molybdenum	0.002	0.002	0.002	0.004	0.005	0.006	<0.15
Fluoride	0.22	0.25	0.27	0.41	0.51	0.62	<2
							ANZG Livestock drinking water Criteria (mg/L)
Aluminium	1.09	1.26	1.45	0.57	0.69	0.84	<5
Beryllium	0.0004	0.0006	0.0007	0	0	0	Not determined
Cadmium	0.0002	0.0002	0.0002	0.0004	0.0005	0.0007	<0.01
Chromium	Not modelled as majority of surface water samples below detection limit						<1
Copper	0.008	0.009	0.011	0.004	0.005	0.006	<0.4
Iron	20.1	23.8	27.8	0.38	0.49	0.64	Not sufficiently toxic
Lead	Not modelled as majority of surface water samples below detection limit						<0.1

Potential Contaminant	K2E modelled concentration after 120 years (mg/L)			K4E modelled concentration after 120 years (mg/L)			PMLU criteria (mg/L)
	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	90th %ile	
Manganese	5.09	5.93	6.87	2.15	2.64	3.22	Not sufficiently toxic
Mercury	Not modelled as majority of surface water samples below detection limit						<0.0001
Uranium	Not modelled as majority of surface water samples below detection limit						<0.2
Vanadium	0.011	0.012	0.014	0.019	0.023	0.028	Not determined

The results indicate that the concentrations for each analyte are not predicted to exceed the PMLU or ANZG water quality criteria, even at the 90th percentile. The final void water qualities are unlikely to contain contaminants of concern that will negatively impact on the PMLU of Water Storage for stock watering.

10.4 Stratification

Stratification modelling in the voids was considered to assess whether seasonal stratification occurs in the warmer months and the effect of annual mixing in the upper water column and lake turnover. The concern associated with stratification is the water quality which forms within the hypolimnion layer at depths below 20 m. During a lake turnover event, this water is fully mixed throughout the water column which can lead to a decline in water quality at the surface.

The modelling typically shows the change of water quality within the water column, typically with better quality freshwater at the surface. This modelling is helpful in understanding whether the better-quality water at the surface is appropriate to support a land-use, as well as quantifying the probability of a turnover event, and length of time where water quality may not be suitable for use.

The IWBM carried out for the project (SLR, 2022a) showed that a completely mixed water column was not expected to exceed the Water Storage PMLU criteria for the TDS concentration of water used for watering stock. Therefore, it is considered that stratification modelling is not required to support the post-mining land use and has not been completed.

10.5 Contaminant transport modelling

The contaminant transport modelling results showed that near equilibrium for the contaminants of concern is reached after 700 years. The spatial distribution of contaminants of concern after the contaminant transport model was run for 700 years is presented as Figure 10.7, showing the SO_4^{2-} results as being representative of the behaviour of all contaminants.

The results for each modelled backfilled void are as follows:

- K2W-N: Contaminant migration is generally south-east towards K2E final void but does not reach the void in 700 years.
- K4S: Contaminant migration is north north-west towards K4E final void and is likely to reach the void though at diluted concentrations compared with the source.
- North-western area (NWA and NWB): Contaminant migration is to the north-west towards Meandu Creek, travelling approximately 400 m in 700 years. The model indicates that contaminant mass sourced from the backfilled pits may reach the surface waters of Meandu Creek through baseflow in the reach of the creek adjacent to the Meandu Mine north-west of the NWBV.

It should be noted that the model inputs are highly conservative as they assume large areas of homogeneous potential contaminant sources, and the model does not account for source decay or natural attenuation.

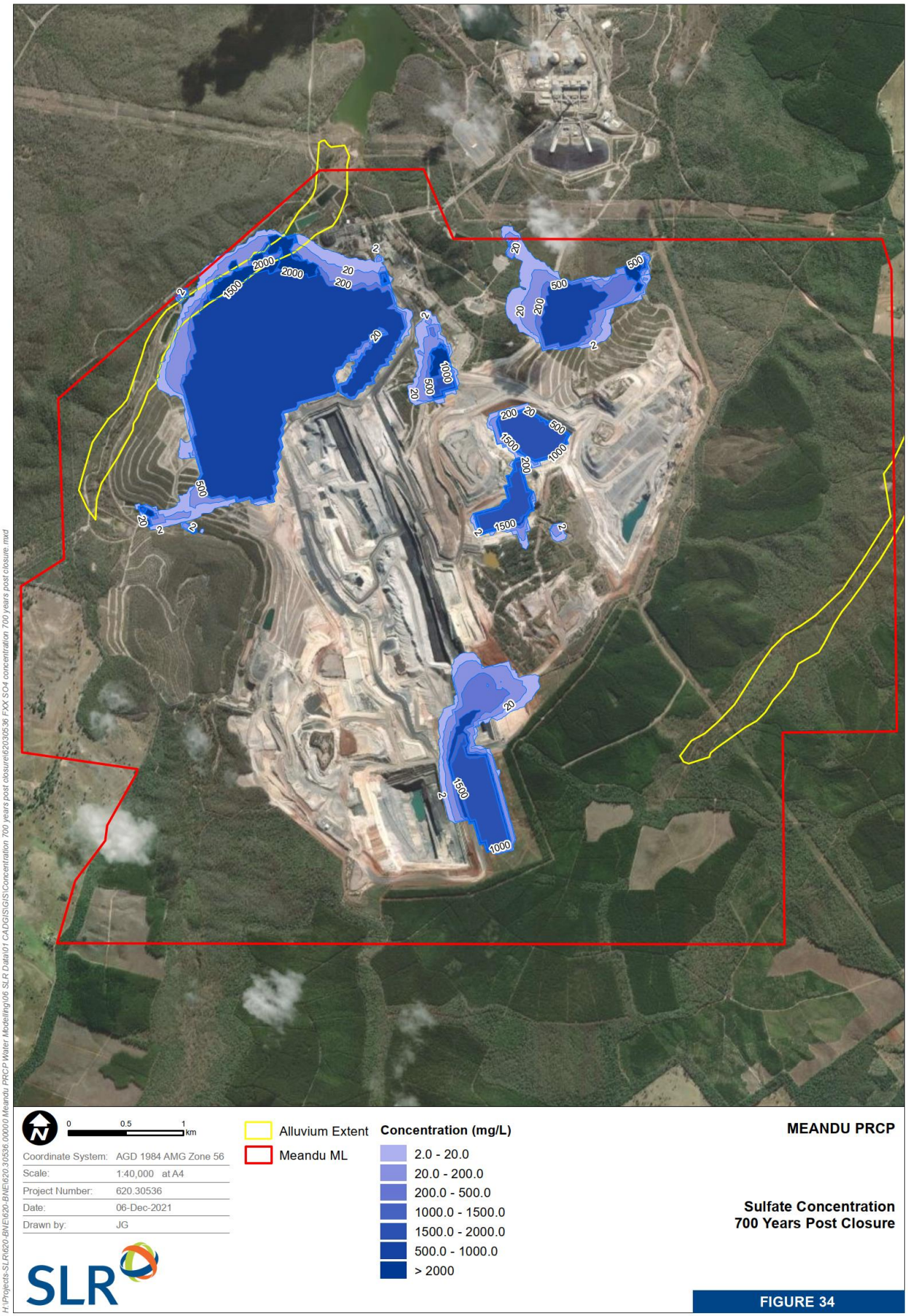

Figure 10.7 Modelled SO_4^- concentrations in groundwater at Meandu Mine 700 years post-closure

10.6 Summary

Overall, the hydrochemical modelling predicts that the water quality of the final voids will be suitable for the proposed PMLU of Water Storage for stock watering in all scenarios except for the climate change scenario with 20% decline in rainfall. Increased extraction of water for stock use appears to prevent an increase in salinity by preventing evapoconcentration of salt. Ongoing management strategies including the optimisation of water extraction balanced with water depth in the void will reduce the risk of water quality deterioration. This can be reviewed if long-term climatic evidence suggests average annual rainfall depth is decreasing in the region.

Contaminant transport modelling of the voids backfilled with potentially reactive material indicates that the majority of potential seepage will be captured by the groundwater sink formed by K2E final void. The exception is the NWA and NWB backfilled voids, modelling of which suggests that seepage may impact Meandu Creek baseflow post-closure. Minimisation of this risk is proposed through the ongoing dewatering of the NWBV to the end of mine life, with the ongoing rehabilitation of the NWBV area including a constructed cover designed to minimise future rainfall infiltration, particularly over the decommissioned NWB TSF. The dewatering of the NWBV is designed to reduce the groundwater levels in the spoil to levels lower than the final NWA mine void low-wall (WSP, 2018), thus minimising ongoing seepage from this landform[5]. The final landform constructed covers should then reduce future infiltration through the spoil, rejects and tailings such that future seepage is minimised.

[5] Ongoing monitoring of groundwater levels in NWBV and seepage at Ramp 7 and Bullgang drain suggest this strategy is already reducing seepage volumes and concentrations of potential contaminants in the seepage.

11 Rehabilitation and management strategies

11.1 Overview

Strategies for the rehabilitation and management of final and back-filled voids are described in detail in the Meandu Mine PRC Plan (Stanwell, 2022). The specific rehabilitation and management strategies are driven by the assigned PMLUs, which are as follows:

Final voids:	Water Storage Steep Rocky Ecosystem Beef Cattle Grazing Native Ecosystem
Back-filled voids:	Beef Cattle Grazing Native Ecosystem Steep Rocky Ecosystem (parts of K2W-N and SW pit only).

Summaries of the strategies to achieve sustainable PMLUs are described below.

11.1.1 Water storage

The K2E and K4E pits will form final voids in the final landform on closure. Water balance modelling (Section 8.2) indicates these voids will act as groundwater sinks that will contain water as a result of groundwater inflow and rainfall runoff. The intention for final land use is to use these water bodies as water storage for stock watering to support the Beef Cattle Grazing PMLU. The rehabilitation goals and rehabilitation success criteria for the Water Storage PMLU are listed in Table 2.1.

To achieve sustainable use of the final voids for Water Storage, the following approaches are proposed:

- Geotechnical stability assessments have been conducted on the proposed final designs for the low-walls and highwalls of the proposed final voids (Section 5). Low-walls will be keyed into the base of the final highwalls which increases the stability of the placed spoil to an acceptable FOS (>1.5), despite the spoil being saturated where in contact with the pit waters. If required, geotechnical stability of the final landforms will be further assessed by an appropriately qualified Registered Professional Engineer of Queensland post conclusion of mining to confirm the landforms on closure meet the FoS requirements of the PMLU.
- Water quality modelling (Section 10) indicates long-term water quality in the final voids is likely to remain suitable for stock watering and native wildlife use. Ongoing extraction of water from the final voids will reduce evapoconcentration from the surface waters, preventing increases in salinity and metal concentrations. Minimum depths will be maintained in the void surface waters to prevent mobilisation of basal sediments and ongoing water quality monitoring is proposed to ensure water qualities remain suitable for the PMLU.

11.1.2 Steep Rocky Ecosystem

Final highwalls will remain in the K2E and K4E final voids and on some faces of the SW and K2W-N pits. The PMLU goal for these final highwalls is the establishment of self-sustaining plant and animal assemblages and associated ecosystem processes across the post-mining steep rocky landscape. The rehabilitation goals and rehabilitation success criteria for the Steep Rocky Ecosystem PMLU are listed in Table 2.1.

To achieve a sustainable Steep Rocky Ecosystem PMLU, the following approaches are proposed:

- Final highwall designs have been assessed to be geotechnically stable (Section 5) and final highwalls will be further assessed by an appropriately qualified Registered Professional Engineer of Queensland post conclusion of mining to confirm geotechnical stability.
- A rehabilitation trial has been proposed for the Steep Rocky Ecosystem PMLU to provide data and confidence that the specific aspects of the PMLU can be achieved (Stanwell, 2022). The trial involves the monitoring of a number of exposed final benched highwalls to assess native ecosystem development (soil development, vegetation establishment and fauna development). The trial will be undertaken to assess and support development of the methodology, timing and success of the proposed rehabilitation strategy.

The current rehabilitation strategy assumes that reshaping of the benches and batters post cessation of mining will not be required, and that revegetation will be accomplished by natural colonisation of the final landform. Results of the rehabilitation trials will confirm whether additional rehabilitation methods such as seeding is required to attain a sustainable Steep Rocky Ecosystem PMLU.

11.1.3 Beef Cattle Grazing

The Beef Cattle Grazing PMLU is constrained by the requirement for the majority of final slopes to be <15% and generally <10%. Therefore, the area assigned for Beef Cattle Grazing in the final landform is the central portion of the surface rights area forming the lower slopes of the final landform. A significant portion of the Beef Cattle Grazing PMLU will be located over back-filled voids, including the proposed K4S ASF; however, a small area of Beef Cattle Grazing PMLU is located in the catchment of the K4E final void.

The rehabilitation objectives, in order to achieve sustainable Beef Cattle Grazing PMLU, are to maintain or improve land condition of the rehabilitation, prevent land degradation and to integrate the rehabilitated pasture lands with critical grazing infrastructure to create an economically viable grazing enterprise. The rehabilitation goals and rehabilitation success criteria for the Beef Cattle Grazing PMLU are listed in Table 2.1.

To achieve a sustainable Beef Cattle Grazing PMLU, the following approaches are proposed:

- Cover materials will be placed to meet the specific criteria in the EA depending on the waste material being covered as described in Section 6.1.6 of the Meandu Mine PRC Plan Section 6.1.6 (Stanwell, 2022).
- Landform reshaping of spoil piles and backfilled voids will be conducted to meet the final landform criteria, particularly with regard to slope. Geotechnical stability assessment has indicated the proposed landform design of rehabilitated spoil landforms will meet the PMLU criteria FOS >1.5 (Section 5.2.2).
- Topsoil placement as per the specifications listed in Section 6.1.4 of the Meandu Mine PRC Plan (Stanwell, 2022) to provide a growth media for pasture.
- Preparation and seeding with grass species as described in Sections 6.1.6.5 and 6.1.8 of the Meandu Mine PRC Plan (Stanwell, 2022), respectively. Pasture to be grown to meet the required vegetative cover to prevent erosion (Section 6.1).
- Rehabilitation trials are proposed to confirm the proposed rehabilitation strategy and the available topsoil and subsoil will achieve the Class 3 land suitability requirements for grazing that are required to support the target livestock carrying density to allow sustainable, economic beef cattle grazing as a PMLU. The monitoring trial results may drive alterations to the above strategy and design.
- Grazing management strategies are detailed in the Meandu Mine Revegetation Plan (WSP, 2022).

11.1.4 Native Ecosystem

The Native Ecosystem PMLU will include areas of vegetation that are similar to locally occurring regional ecosystems and align with Native Ecosystem rehabilitation that has been conducted successfully on Meandu Mine to date (including 153 ha of Native Ecosystem that received Progressive Rehabilitation Certification in 2021 – (WSP, 2022)). The majority of the area disturbed/proposed for disturbance by mining at Meandu Mine is proposed for Native Ecosystem PMLU. This includes all voids backfilled with tailings and/or coal combustion products excepting K4S ASF, which will be Beef Cattle Grazing PMLU. Portions of the catchment areas for K2E and K4E final voids will be Native Ecosystem PMLU.

The rehabilitation goals and rehabilitation success criteria for the Native Ecosystem PMLU are listed in Table 2.1.

To achieve a sustainable Native Ecosystem PMLU, the following approaches are proposed:

- Cover materials will be placed to meet the specific criteria in the EA depending on the waste material being covered as described in Section 6.1.6 of the Meandu Mine PRC Plan (Stanwell, 2022).
- Landform reshaping of spoil piles and backfilled voids will be conducted to meet the final landform criteria, particularly with regard to slope. Geotechnical stability assessment has indicated the proposed landform design of rehabilitated spoil landforms will meet the PMLU criteria FOS >1.5 (Section 5.2.2).
- Topsoil placement as per the specifications listed in Section 6.1.4 of the Meandu Mine PRC Plan (Stanwell, 2022) to provide a growth media for native vegetation.
- Preparation and seeding with native species as described in Sections 6.1.6.5 and 6.1.8 of the Meandu Mine PRC Plan (Stanwell, 2022), respectively. Native vegetation to be grown to meet the required vegetative cover to prevent erosion (Section 6.1).

11.2 Seepage

Three areas of Meandu Mine have been previously identified as potentially requiring management to mitigate seepage of acidic or saline waters from backfilled voids, NWBV (Ramp 7), QW and Black Creek. Details of the investigations into these areas are included in Section 6.1.7 of the Meandu Mine PRC Plan (Stanwell, 2022). Summaries of the management strategies for each area follow.

- NWBV: Historic acidic seepage from the NWBV reporting to the surface at Ramp 7 was captured by RD7 and RD8 and not released to RD2 until water volumes had diluted the acidity, TDS and salinity to below compliance levels. Since 2018 this seepage has been intercepted and treated with lime in the lined RD27 facility to increase the pH of the water before release to the water management network. Ongoing seepage, when present, is monitored to ensure contaminant concentrations can continue to be managed in this way.

  Dewatering of the groundwater within the NWBV is currently conducted from dedicated groundwater extraction bores screened across the saturated backfilled spoil using submersible pumps. The objective of this dewatering is to reduce the level of groundwater in the NWBV so that seepage no longer reports to the surface at Ramp 7. It also results in treatment of the extracted water and reduction in the total load of contaminants within the saturated backfill. Modelling suggests that dewatering may be required until closure to allow for treatment of the contaminants of concern from the initial charge in the basal section of the NWBV. By closure (2039–2041) the final landform will have been rehabilitated with a cover that minimises ongoing infiltration to the extent sufficient to minimise the risk of a recurrence of the seepage due to this source.
- QW: A section of the QW void has deliberately not been backfilled so it acts as a sump to facilitate water quality monitoring and as to capture seepage issuing from the neighbouring spoil piles and undisturbed ground, some of which has been identified as saline. Seepage into the sump is pumped out and delivered into the Meandu Mine water management network. Post-closure no ongoing seepage collection is proposed as groundwater modelling (SLR, 2022) indicates the majority of seepage from this area will migrate in the direction of K2E final void.

- Black Creek: An area of Meandu Mine (Black Creek to the north of the former K2TSF), shows groundwater with elevated salinity and some metals, the source of which is unknown. Additional monitoring bores have been recommended for this area to assist in the collection of data for the assessment of potential sources and extent of potential contamination, including determining whether the anomalous groundwater chemistry may be a natural phenomenon.

11.3 Rehabilitation performance and success criteria

Rehabilitation management plans have been developed that include directives for the supervision, verification and auditing of engineering/construction works carried out to achieve the post-closure void landform. QA/QC procedures within these plans have been designed to ensure construction is consistent with the geotechnical design. Details on the QA/QC procedures for the cover designs are in Section 6.1.6.7 of the Meandu Mine PRC Plan (Stanwell, 2022), with additional construction information for the decommissioning of TSF/ASF in Section 4.1.2.

Monitoring and maintenance programs have been designed and initiated for revegetation and water quality to allow confirmation of achievement of post-closure success criteria. The monitoring programs are detailed in Section 8 of the Meandu Mine PRC Plan (Stanwell, 2022).

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